Termination Clauses in Partnerships[*]

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Abstract

In this paper, we prove that two firms may prefer not to include a termination clause in their partnership contract, thus inducing a costly termination in case of failure of the joint project. This ex-post inefficiency induces partners to exert large levels of non-contractible efforts (investments) in order to decrease the probability of failure. Therefore, the absence of a termination clause works as a "discipline device" that mitigates the hold-up problem within the partnership. We show that writing a contract without a termination clause is a credible commitment even when partners can add such a clause in the contract in any moment of their relationship. Comparative statics analysis suggests that contracts lacking a termination clause are suited to alliances in R&D, when partners are not rivals or when they have strong technological complementarities.

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1 Introduction

Strategic alliances, in the form of joint ventures (JVs) or looser modes of cooperation, are an increasingly popular solution in order to reduce start-up costs, share risks, enter new markets or develop new technologies. According to Dyer et al. (2001) the top 500 global businesses have an average of 60 major strategic alliances each. During the nineties, the number of alliances has grown at an annual rate of over 25% in the leading industrial nations and about 20% of the revenue of the largest US and European corporations comes from partnerships (see Contractor and Lorange, 2002 and Harbison et al., 2000).

Even though the potential advantages of partnering are well known, the track record for joint ventures is not a glowing one. Instability is a commonly recognized problem affecting strategic alliances and the average life span of a JV is as little as four years (seven years for other studies) with a failure rate ranging between 50 and 70%.[1] Because of these prospects, partners should be aware of the difficulties they may encounter in managing an alliance and of the possibility of its early termination, when setting up a new relation. According to some commentators, partners should approach JVs as Hollywood marriages; they should plan their termination strategy from the very beginning by specifying in the initial agreement "what happens to assets, customers and existing contracts in the (likely) event of a break-up".[2] Indeed, as it is well documented in the business literature, a non-amicable termination of an alliance may result in very long negotiations, large expenses and bitter legal battles.[3]

Surprisingly, JV participants devote relatively little attention to predict what happens in case of termination of the alliance. A PricewaterhouseCoopers (2000) survey shows that less than half of the firms entering an alliance have a formal exit strategy. Similarly, several authors have observed that of the many aspects of alliance management, planning its termination ranks among the most ignored by partners.[4] Obviously, various might be the reasons for such a lack. Just as a pre-nuptial agreement, discussing a termination clause when forming the alliance might sour the deal; it might reveal the lack of trust of partners. In addition, also difficulties in working out the various possible contingencies that might occur and designing what parties should do in these cases may justify the absence of a termination clause in a JV contract. A possible alternative explanation for such an absence can be envisaged in the case of Concert. When negotiating the terms of their joint venture (called Concert), British Telecommunications and AT&T explicitly decided not to include a termination clause. By not determining the rules for separation, partners wanted to demonstrate their commitment into the relationship.[5]

The model we present develops formally this idea. We consider two firms that set

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[1]These figures are taken from Gonzalez (2001) and Inpken and Ross (2001).

[2]"Joint Ventures: Getting out Without Being Hurt" by A. Maitland, Financial Times 10th October, 2002.

[3]This point has been raised in many of the papers we are quoting in this section; see, for instance, Gonzalez (2001).

[4]We refer, among many others, to Roussel (2001) and Chi and Seth (2002).

[5]"Joint Ventures: Getting out Without Being Hurt", Financial Times 10th October, 2002.

up a joint venture to pursue a joint project.[6] After signing the JV-contract, firms non-cooperatively choose the levels of effort (investment) to exert. These efforts (investments) determine the likelihood of success/failure of the joint project and we assume that they are non-contractible.[7] In case of failure of the project firms terminate the partnership and decide upon the allocation of the assets belonging to the JV. If the JV-contract regulates the terms for termination then assets allotment takes place at zero cost. On the contrary, absent a termination clause, partners start a (costly) bargaining process to assign the ownership of the assets. We assume that partners have the possibility of reaching an amicable settlement and, in case they fail to agree, they come up before a Court which takes the final decision. We show that in equilibrium partners do go to Court with positive probability and bear the related legal expenses thus making the bargaining costly due to the related legal expenses.[8] The main result of our paper is that, under some circumstances, it is rational not to include a termination clause in the JV-contract. The intuition for this result is simple; by not including the clause, partners worsen their own prospects in the event of failure of the project: not only they do not succeed in pursuing their project but they also generate a costly bargaining process due to litigation before the Court. This induces partners to exert larger efforts (non contractible investments). In other words, the absence of a termination clause works as a "discipline device" that alleviates the hold-up problem.

The crucial aspect when committing to a device that induces a costly bargaining relates to the credibility of the commitment itself. In our paper, asymmetric information makes the absence of a termination clause a credible commitment. Following the argument put forward by several authors,[9] we assume that partners are asymmetrically informed about the assets' value. In particular, we assume that only one firm observes how much the assets worth; the attempt of this firm to appropriate most of the surplus during the bargaining stage induces the partner to reject an amicable settlement with positive probability so that firms resort to Court for the allotment of the assets.[10]

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[6]In this paper we focus on the strategic effects of contract clauses when parties start a partnership, in particular the effect of termination clauses on the partners' behavior. However, here we will not analyze in details why parties want to form a partnership, neither the reason why partners decide to form a partnership instead of choosing different organizational forms.

[7]Several papers, both empirical as well as theoretical ones, have highlighted the presence and the consequences of the non-contractible nature of (at least part of) partners' contributions (see Morasch, 1995 Pérez-Castrillo and Sandonís, 1996, Tao and Wu, 1997 and Veugelers, 1993). For instance, the "quality" of the researchers or labs that partners agree to assign to the JV is very difficult to be specified in a contract. These variables might be observable by partners while cooperating in the joint venture, but they might not be verifiable in a court and therefore not contractible.

[8]In principle, bargaining might be costly because of various reasons: the time spent by partners haggling over the terms of the agreement or the payments to experts/arbitrators needed for evaluating the assets. In the model, we focus on this second aspect.

[9]See for instance Chi and Seth (2002).

[10]The effect of private information on the design of the optimal property rights has a long tradition that stems from the seminal papers by Coase (1937) and Williamson (1975) and the fundamental works by Hart and Moore on incomplete contracts and hold-up problems (see, for instance, Hart and Moore, 1999). More recently, Matouschek (2004) has formalized the idea that the ownership structure should be tailored in order to minimize the size of ex-post inefficiencies caused by private information.

Review of the relevant literature

There are different strands of the economic literature that are related to our paper. The idea that the absence of a termination clause mitigates the hold-up problem is in line with the "resource commitment" argument put forward in the business literature.[11] It is argued that by devoting substantial resources to the partnership, firms increase their level of involvement and therefore they reduce the advantages of behaving opportunistically. Resource commitment can be achieved in various ways. The governance form of the alliance is one possible way and, in this respect, equity alliances are considered to require greater levels of financial as well as organizational commitment than non-equity ones. The exchange of "mutual hostages" is another way to increase commitment and therefore to stabilize the alliance; by bringing some critical assets (the hostages) to the partnership, parties become more vulnerable and therefore less prone to behave in an opportunistic manner.[12] Therefore, with reference to this strand of literature, we claim that the absence of a termination clause is a further way in which resource commitment can be obtained.

A relatively recent literature stemming from the paper of Cramton, Gibbons and Klemperer (1987) focuses on partnership dissolution; two are the main issues that are tackled: i) under what conditions there is efficient partnership dissolution (i.e. dissolve it when it is efficient to do so and assign the assets to the partner that evaluates them the most)?[13] ii) what are the relative merits of commonly used dissolution clauses such as the so-called Texas-shootout? [14] Our paper departs from this literature quite substantially. We consider the relation between the effort (investment) decision made by the partners and the possible termination of the alliance while the existing literature on partnership dissolution focuses exclusively on the break-up decision.[15] Moreover, we show that under some circumstances it is rational to induce a costly bargaining by not regulating the terms for the break-up even in case a simple termination clause would induce an efficient termination decision.

The idea that it might be beneficial to improve ex-ante efficiency (in our paper, larger effort/investment) by imposing some inefficiencies ex-post (in our paper, costly bargaining) through the absence of a termination clause is similar to the one presented in a quite different context by Bordignon and Brusco (2001). These authors show that the lack of exit rules in federal constitutions can be a commitment device; high costs of secessions (secessions are

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[11]The literature on "resource commitment" in strategic alliances is extremely vast. A comprehensive and neat discussion on this issue can be found in Buckley and Casson (1988) and Das and Rahman (2002).

[12]Williamson (1983) discusses the use of mutual hostages positions as means to stabilize relationships. For an application to joint ventures see Buckley and Casson (1988), Das and Rahman (2002) and Kogut (1989).

[13]See Fiesler, Kittsteiner and Moldovanu (2003) and McAfee (1992).

[14]In a Texas-shootout the procedure to assign the assets is such that one partner announces a price and the counterpart chooses whether to be the buyer or the seller of the assets. See Brooks and Spier (2004) and De Frutos and Kittsteiner (2004) for recent contributions on this topic.

[15]One relevant exception is represented by Li and Wolfstetter (2004) who consider both partners' contributions and possible termination of the JV. The fundamental difference with our paper and that of Li and Wolfstetter is related to the assumption about the contractibility of partners' contributions. While we assume that they are not contractible, Li and Wolfstetter assume that they are so that no hold-up problem arises.

possible only by "independence wars") increase the stability of the federation, and therefore the ex-ante benefits of joining it. Even though the underlying idea is the same, the two papers differ for at least two fundamental aspects. First in Bordignon and Brusco (2001) the lack of exit rules is a credible commitment to an ex-post inefficiency (i.e. it is renegotiation-proof) only if there exists a positive cost of renegotiation. Contrarily, in our paper the contract without termination clause induces an ex-post inefficiency even though partners are allowed to reach an amicable (i.e. with no renegotiation cost) settlement. Second, in Bordignon and Brusco (2001) parties never litigate in equilibrium (there is never secession by an independence war). However, we want to explain why in reality we observe not only contracts without termination clauses, but also partnerships which terminate with costly litigations in front of Courts.

Our paper is also related to the stream of literature which takes into consideration strategic reasons for contract incompleteness. Non-contigent contracts as a signaling/screening device are analyzed in Aghion and Bolton (1987), Diamond (1993), Hermalin (2001), Nicolò and Tedeschi (2005) and Spier's (1992). Bernheim and Whinston (1998) show that contracts which contain some "gaps" may help in establishing the appropriate incentives for parties. In a context where certain actions are observable by parties but not verifiable by Courts, then incomplete contracts that expand the set of discretionary choices/strategies may be used in order to induce parties to coordinate on Pareto superior equilibria.

The outline of the paper is as follows. In Section 2, we describe the set-up to the model. In Section 3, we derive the main results of the paper and some empirical implications of the theoretical analysis. Our model suggests that contracts lacking a termination clause are suited to alliances in R&D, when partners are not rivals or when they have strong technological complementarities. Section 4 is devoted to check the robustness of our result while in Section 5 a concluding discussion is presented. All the proofs that are not essential for a clear understanding of the main arguments of the paper are presented in the Appendix.

2   The Model

Two firms, firm 1 and 2, form a partnership to pursue a joint project. The project is a risky activity with two possible outcomes: good, i.e. the project is successful, or bad, i.e. the project fails. The good outcome occurs with probability $p(k_1, k_2) \in [0, 1]$ while the bad one with complementary probability; $k_i \geq 0$ represents the investment level chosen by partner $i = 1, 2$ and $c_i(k_1, k_2)$ is the corresponding private cost. At an intermediate stage of the project, after the investment levels have been chosen, firms observe a perfect signal of the future outcome, $\theta \in \{\theta_G, \theta_B\}$, where θ_j stands for the signal of outcome j, and may decide whether to continue or to terminate the partnership. When $\theta = \theta_G$ (where G stays for "good") firms know that the project will generate a monetary value $v_G = v$ provided that the partnership is continued and 0 in case of early termination at the intermediate stage. When $\theta = \theta_B$ (where B stays for "bad") they know that the project will generate a monetary value $v_B = 0$.

Firms' collaboration generates some intermediate result which is incorporated in an indivisible asset A. If firms choose to continue the partnership then the asset is devoted to the joint project. If firms decide for an early termination of the partnership the asset can be acquired by one of them and used for its own business. We assume that the asset has a positive private value for one firm only, that is either $\varphi_1 = 0$ and $\varphi_2 > 0$ or $\varphi_1 > 0$ and $\varphi_2 = 0$, and that the two events occur with equal probability independently from the realization of the outcome or the investment levels.[16] Moreover, we assume that when the private evaluation of firm $i = 1, 2$ is positive, it can take value $\varphi_i \in \left\{ \varphi^H, \varphi^L \right\}$ with $\varphi^H > \varphi^L > 0$ and that each realization is equally likely and independent from the outcome or the investment levels. In what follows we let $E[\varphi] \equiv \frac{\varphi^H + \varphi^L}{2}$.

Information structure and timing

We assume that the signal θ and the investment levels k_i, $i = 1, 2$, are observed by both firms even though they are not verifiable, that is, non-observable by third parties. The only source of asymmetric information between the two firms relies on the private value of the asset, since firm i for which $\varphi_i = 0$ does not observe whether the counterpart's private value is φ^H or φ^L.

The timing of the game is as follows
At **time** $t = 0$ partners decide upon the terms of their partnership contract. The contract specifies how firms share the monetary value generated by the project and might include a termination clause; this last clause determines who has the right to terminate the partnership and the rules for allocating the asset A. The cost of writing and modifying the contract is fixed and equal to ε, which is positive but arbitrarily small.[17] After agreeing on the terms of the contract, partners simultaneously choose the investment levels.

At **time** $t = 1$, firms observe the signal θ and decide whether to continue or to terminate the partnership and, in the latter case, about the allocation of the asset A, in accordance with the contract clauses. If the contract does not contain a termination clause, the commercial law determines the rules for terminating the partnership while asset allocation is left to ex-post bargaining between parties. If parties do not reach an agreement during the bargaining stage, they resort to Court which verifies the value of the asset and decides how to split this value and the overall legal expenses $2F$ between the two partners (we will be more detailed on the Court rules in section 3.2.2). We assume that the Court can verify (estimate) the value of A and the monetary value of the project, but it cannot observe neither the levels of investment, nor the signal. We interpret the legal expenses $2F$ as the cost of assessment

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[16]Note that the assumption that the asset A is worthless for one of the two partners, implies that its market value is nought.

[17]We are interested in showing that partners can choose not to write a termination clause even when the cost of writing it is negligible, otherwise there are obvious reasons why contracts do not include termination clauses.

(verification) of the asset value by means of independent experts employed by the Court.[18]

At **time** $t = 2$ the monetary or private values are realized.

Throughout the paper we will assume that the following conditions are met:
(A1) $v > \varphi^H$ and $\varphi^L > 2F > 0$;
(A2) $\varphi^H - \varphi^L \geq 2F$;

The first inequality in (A1) implies that it is efficient to continue the partnership when $\theta = \theta_G$ while the second implies both that termination is efficient when $\theta = \theta_B$ and that firms are better-off going to Court to allocate the asset rather than disposing of it when they do not reach an agreement in the bargaining stage. Condition (A2) requires the two possible positive private values of the asset to be significantly different. In particular, it guarantees that during the bargaining stage there is a meaningful asymmetry of information between partners so that the proposer of the settlement has incentives in some circumstances to cheat and try to appropriate most of the surplus of the relationship.

In order to derive a closed-form solution for the model, in Section 3 we employ specific functional forms for the probability and cost functions. Namely, we assume that $p(k_1, k_2) = \min\{\eta(k_1 + k_2), 1\}$ and $c_i(k_1, k_2) = \frac{\gamma k_i^2}{2}$ for $i = 1, 2$. Moreover we assume that γ is sufficiently high and η sufficiently small to prevent partners to choose so large investment levels as to induce $\theta = \theta_G$ with probability 1.[19]

The set of contracts
We denote with C the set of all possible contracts that can be chosen at time $t = 0$ by the two firms. In turn, a contract is a set of clauses which contains some or all of the following provisions:
(i) the share $s \in [0, 1]$ of the monetary value that firm 1 receives at time $t = 2$ when the project is continued (and $(1 - s)$ is the share of firm 2);
(ii) an indicator function d that specifies which firm has the right to terminate the partnership: $d = i$ if firm i only has this right with $i = 1$ or 2, $d = 1 \vee 2$ if each firm is entitled to terminate the partnership unilaterally, and finally $d = 1 \wedge 2$ if termination requires unanimity;
(iii) the price $b \geq 0$ at which the asset can be acquired/sold in case of early termination of the partnership;
(iv) an indicator function f, such that if $f = i$, with $i = 1$ or 2, then partner i is entitled to choose whether to be the buyer or the seller of the asset at price b.

We call **complete** a contract that specifies all these four elements.

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[18]Namely, we assume that the cost of observing the private value of the asset is the same for the partner and the court. It could be objected that usually a firm can better estimate the partner's asset value than an external court. Nevertheless, a court have enforcing powers (for instance it can force a party to show the account books) which might reduce the cost of assessment.

[19]Relaxing this condition complicates the presentation of the results substantially without adding any interesting new insight.

3 Results

3.1 Benchmark: First Best Contract with Verifiable Investments

When investment levels are verifiable, then firms are able to draw the first best contract that induces efficient decisions both ex-post, at $t = 1$ once firms have observed the signal θ, as well as ex-ante, at $t = 0$, when they are uncertain about the success of the project.

From condition (A1), it follows that ex-post decisions are efficient if and only if:

(1) the partnership is continued, in case $\theta = \theta_G$;

(2) the partnership is terminated and the asset is assigned to firm 1 if $\varphi_1 > 0$ and to firm 2 otherwise, in case $\theta = \theta_B$.

The next couple of lemmata characterize the contractual provisions that induce ex-post efficiency. Lemma 1 states that the price b at which the asset can be acquired or sold cannot be too large in order to have always the efficient allotment of A. In fact, if b is very large then the firm entitled to take the buy/sell decision might choose to sell the asset even when it assigns a positive private evaluation to it, thus leading to an inefficient allotment.

Lemma 1 *Once termination has been decided, then a complete contract induces efficient allotment of the asset A if and only if $b \in \left[0, \frac{\varphi^L}{2}\right]$.*

Proof. See the Appendix. ■

Note that $b \in \left[0, \frac{\varphi^L}{2}\right]$ ensures the efficient allotment of A both when $f = 1$ or $f = 2$.

The next lemma states the conditions which induce the efficient continuation/termination decision and shows that they depend on how the rights to end the partnership are specified.

Lemma 2 *A contract with efficient allotment of the asset A, induces an efficient decision about the termination of the partnership if and only if the following conditions are satisfied:*

(i) if $d = 1$, then $sv \geq \varphi^H - b$;

(ii) if $d = 2$, then $(1 - s) v \geq \varphi^H - b$;

(iii) if $d = 1 \vee 2$ then $sv \geq \varphi^H - b$ and $(1 - s) v \geq \varphi^H - b$;

(iv) if $d = 1 \wedge 2$, then the decision is always efficient.

Proof. See the Appendix. ■

Lemma 2 specifies the contractual provisions that induce firms to continue their partnership when $\theta = \theta_G$. In particular, it ensures that the firm who has the right to terminate the partnership obtains a greater pay-off by choosing continuation when the observed signal is θ_G. In turn, efficient termination, that is termination in case $\theta = \theta_B$, follows from Lemma 1 that guarantees an efficient allotment of the asset; indeed, when $\theta = \theta_B$ by continuing both partners obtain zero while by terminating they both obtain a non-negative pay-off.

Ex-ante efficiency is obtained when investments are chosen in order to maximize the joint expected pay-off of the two firms. Proposition 1 defines the contractual provisions of the first best contract.

Proposition 1 *When investments are verifiable, then firms can sign the first best contract that specifies:*

i) b as defined in Lemma 1;

ii) d and s as defined in Lemma 2;

iii) $f = 1$ or $f = 2$;

iv) the investment levels $k_i = k^{FB} = \frac{(v - E[\varphi])\eta}{\gamma}$,   for $i = 1, 2$.

Proof. The contractual provisions specified in Lemmata 1 and 2 guarantee ex-post efficiency. Therefore, ex-ante efficiency requires investments to solve the following program :

$$\max_{\{k_1, k_2\}} \eta \left(k_1 + k_2 \right) v + \left(1 - \eta \left(k_1 + k_2 \right) \right) E \left[\varphi \right] - \frac{\gamma k_1^2}{2} - \frac{\gamma k_2^2}{2}.$$

From the first order conditions it follows that the efficient level of investment is $k_i^{FB} = \frac{(v - E[\varphi])\eta}{\gamma}$ with $i = 1, 2$. ∎

3.2 Non Verifiable Investments

When investments are not verifiable, then an hold-up problem arises. Firms are not able to contract on the investment levels, which in equilibrium must be incentive compatible. In what follows we first define the second best contract in the class of complete contracts that induce ex-post efficiency. Afterwords, we consider contracts that do not include a termination clause and we study whether by sacrificing ex-post efficiency firms are able to mitigate the hold-up problem and increase their expected pay-offs.

3.2.1 Ex-post Efficient Complete Contracts (C-Contract)

In this section, we focus on complete contracts that induce ex-post efficiency, that is, contracts that include all the four provisions s, d, b, f described in Section 2 and such that Lemmata 1 and 2 are satisfied. We denote with $C^{epeff} \subset C$ such set of contracts.

The next proposition characterizes the second best contract in the C^{epeff} set; namely, the contract that induces partners to choose the levels of investment that maximize their joint pay-off under the incentive compatibility constraint.

Proposition 2 *The second best contract in the set C^{epeff} provides that $s = \frac{1}{2}$. The equilibrium levels of investment chosen by partners under such a contract are $k_i^C = \frac{(v - E[\varphi])\eta}{2\gamma}$, with $i = 1, 2$.*

Proof. See the Appendix. ∎

The above result can be easily understood. Each firm has the same probability of being the buyer ($\varphi_i > 0$) or the seller ($\varphi_i = 0$) of the asset in case of termination of the partnership. Therefore, in case $\theta = \theta_B$ the two firms obtain the same expected pay-off. Given the convexity of the cost function, then it is optimal to share equally the pay-off also in case

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$\theta = \theta_G$. The reason is that in a symmetric model equal sharing of the revenues gives to the partners the same incentives to invest. Therefore it induces equal investment levels for the two firms, minimizing total costs for given level of total investment. Simple comparison between Propositions 1 and 2 highlights that partners underinvest.

3.2.2 Contracts with no Termination Clauses (NC-Contract)

In this section, we focus on the set of incomplete contracts which do not include a termination clause; that is, contracts which specify only s. We denote this set $C^{NC} \subset C$. Even though the contract is silent about d, b, and f, some provisions are regulated by the relevant laws by default. in particular, the commercial law specifies whether partnership termination can be unilaterally decided by each party, or decided by unanimity; in what follows we assume that unanimity is required.[20] However, usually the law does not establish how the asset will be assigned, that is, who will get the asset and how much it has to pay for it. We assume that once the partnership has been terminated, firms bargain over the allocation of A. Without loss of generality, in what follows we refer to 1 as the firm for which the asset has a positive value, that is, $\varphi_1 \in \left\{ \varphi^H, \varphi^L \right\}$ and $\varphi_2 = 0$.

Bargaining over Asset Ownership

We assume that the bargaining stage is as follows. Firm 1, observes the private value of the asset $\varphi_1 \in \left\{ \varphi^H, \varphi^L \right\}$ and thereafter proposes a trading price π at which it is willing to buy A. The cost of making the proposal is ε. Partner 2 can either accept or reject the offer. In case of acceptance, the terms of the proposal are enforced. In case of rejection firms go to Court. We assume that the Court uses the following rules.

The Court's Rules

The Court verifies the value of the asset (i.e. firm 1's evaluation) and then decides about: (i) the allotment of A, (ii) the compensation for the seller and (iii) the division of the legal expenses $2F$. We assume that the Court decision is efficient, that is, it assigns A to firm 1. Moreover, it compels firm 1 to pay the fair price (i.e. half of the value of the asset) to firm 2. Finally, Court allocates the legal expenses $2F$ adopting a fee-shifting rule based on pre-trial proposals. Namely, $2F$ is equally shared unless firm 1 offered a price π smaller than the fair one; in this latter case, the whole legal expenses are charged to firm 1.[21]

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[20]It can be shown that our results are not altered if unilateral termination is specified in the commercial law.

[21]Fee-shifting rules are used in many legislations (as Rule 68 of the Federal Rules of Civil Procedures in the United States). These rules give strong incentives to parties in order to reach an amicable agreement thus avoiding costly litigations in front of the court. Indeed, Spier (1994) proves that "if litigants are asymetrically informed about the merits of the case, then fee shifting rules that are based upon the settlement offers made before the trial have powerful incentive properties". Therefore they are the most unfovourable rules in order to prove that partners may fail to reach an amicable agreement before going to the court.

With a little abuse of notation, we let φ^k denote firm 1's type when it observes that the asset value is φ^k, with $k \in \{H, L\}$. Moreover, we let $\mu(\pi)$ be the probability that firm 2 assigns to the event "firm 1 is of type φ^H" after receiving an offer π. The next proposition characterizes the equilibrium of the bargaining game.

Proposition 3 *The unique Perfect Bayesian Equilibrium of the bargaining game which satisfies the divinity criterion D1 is the following:*

- *firm 1:*

  - *type φ^L offers $\frac{\varphi^L}{2}$;*
  - *type φ^H offers $\frac{\varphi^L}{2}$ with probability α and $\frac{\varphi^H}{2}$ with probability $(1-\alpha)$, where $\alpha = \frac{2F}{\varphi^H - \varphi^L}$;*

- *firm 2:*

  - *if $\pi \geq \frac{\varphi^H}{2}$ it accepts the offer;*
  - *if $\frac{\varphi^L}{2} < \pi < \frac{\varphi^H}{2}$ it rejects the offer;*
  - *if $\pi = \frac{\varphi^L}{2}$ it accepts the offer with probability β and it rejects it with probability $(1-\beta)$, where $\beta = \frac{4F}{4F + (\varphi^H - \varphi^L)}$;*
  - *if $\pi < \frac{\varphi^L}{2}$ it rejects the offer;*

- *beliefs:*

  - *if $\pi \neq \frac{\varphi^L}{2}$, then firm 2 believes that $\mu(\pi) = 1$;*
  - *if $\pi = \frac{\varphi^L}{2}$, then firm 2 believes that $\mu(\pi) = \frac{\alpha}{1+\alpha}$.*

Proof. See the Appendix. ∎

As Proposition 3 shows the equilibrium of the bargaining game is semi-separating. Type φ^L makes the fair offer while type φ^H plays mixed strategies: with probability $(1-\alpha)$ it makes the fair proposal and with complementary probability it mimics the other type in order to obtain the asset at a lower price. Firm 2 accepts to sell the asset at a price $\frac{\varphi^H}{2}$ while when $\frac{\varphi^L}{2}$ is offered it randomizes between accepting and rejecting the proposal. This last fact implies that in equilibrium there is a positive probability that a proposal is rejected and therefore the following result holds.

Corollary 1 *If firms sign an incomplete contract, in case the joint project fails, with positive probability parties solve their dispute in front of the Court; when this happens, there is an ex-post inefficiency: in order to assign the asset parties incur an additional cost $2F$, that is, the legal expenses.*

The equilibrium characterized in Proposition 3 is the only one which satisfies the divinity criterion D1. Given that we will repeatedly employ this refinement, it is worth giving an informal intuition of how it works. Consider that firm 1 makes an out-of-equilibrium proposal and consider any conjecture that this firm has about how the partner reacts. If it happens that, given any conjecture, type φ^H finds it optimal to deviate whenever it is optimal for type φ^L while the opposite does not hold, then the D1 criterion imposes to assign probability 1 that the proposer is of type φ^H. Loosely speaking, type φ^H values the asset the most and therefore it is also the one which would obtain the largest benefit in case of acceptance of an out-of-equilibrium proposal. Hence, only type φ^H has an interest in making an out-of-equilibrium proposal for a sufficiently small probability of acceptance.

The Second-best NC-Contract

Given the equilibrium at the bargaining stage we can characterize the second-best contract in the set C^{NC}.

Proposition 4 *The second best contract in the set C^{NC} provides that $s = \frac{1}{2}$. The equilibrium levels of investment chosen by partners under such a contract are*

$$k_i^{NC} = \frac{(v - E[\varphi])\eta}{2\gamma} + \frac{\eta\left(2\left(F\left(1-\beta\right)+2\varepsilon\right)+\alpha\left(\varphi^H - \varphi^L\right)\right)}{8\gamma}, \qquad with\ i = 1,2.$$

Proof. See the Appendix. ∎

The second best contract provides for an equal sharing of the monetary values generated by the project also in this case, in analogy with Proposition 2.

3.3 The Choice of the Contract

We can now compare the performances of the complete and incomplete contracts that we have considered in the previous sections. The following result shows that, under some circumstances, the incomplete contract defined in Proposition 4 outperforms in terms of efficiency any complete and ex-post efficient contract.

Proposition 5 *The second-best incomplete contract Pareto dominates any ex-post efficient complete contract if:*

$$v \geq \frac{2E[\varphi] - F}{2} + \frac{F^2}{4F + \varphi^H - \varphi^L} + \frac{2\gamma}{3\eta^2}.$$

Proof. The result is obtained by comparing the joint pay-off that partners obtain under the contracts defined in Propositions 2 and 4 exploiting the fact that ε is negligible. ∎

Compared with a complete and ex-post efficient contract, the effect of not including a termination clause in the initial agreement is twofold. On the one hand, it induces an ex-post inefficiency given that with a positive probability firms will litigate in front of the Court in order to assign the asset in case of partnership termination. On the other hand, the absence

of a termination clause has also an incentive effect. The inefficiency due to litigation reduces the expected pay-off in case of failure of the project and this fact induces partners to make larger investments in order to avoid this occurrence. This second effect emerges by a simple comparison of the equilibrium investment levels defined in Propositions 2 and 4.[22] The main message of the above result is that it might be rational for firms to write an incomplete contract which will be completed in front of the Court, bearing the litigation costs. Costly litigation, induced by the absence of a termination clause, works as a "discipline device" that mitigates the hold-up problem induced by the non-contractibility of the investment levels.

3.4 Comparative Statics and Empirical Implications

Conditions that make it more likely that the incomplete contract Pareto dominates the complete one can be derived simply by inspecting the threshold value for v shown in Proposition 5: as the threshold shrinks the incomplete contract becomes more likely to be chosen. The following corollary follows from simple differentiation of the threshold level with respect to the various parameters of the model.

Corollary 2 *The set of parameters for which the second-best incomplete contract Pareto dominates any ex-post efficient complete contract enlarges with i) increases of $\left(\varphi^H - \varphi^L\right), F$ and η, and (ii) decreases of γ and $E[\varphi]$.*

Proof. Follows form simple differentiation of the threshold level for v defined in Proposition 5. ∎

The intuition for the above result follows from considering the twofold effect of the lack of a termination clause: ex-post inefficiency and greater incentives to invest. The effect of $\left(\varphi^H - \varphi^L\right)$ and F is similar. It can be shown that larger levels of $\left(\varphi^H - \varphi^L\right)$ or F increase the expected cost of litigation in the equilibrium of the bargaining game.[23] In turn, this larger ex-post inefficiency also implies that the incomplete contract is more effective in terms of increasing the incentives to invest. Under the specification of our model the latter effect dominates.

Changes in γ, η and $E[\varphi]$ do not alter the ex-post inefficiency while they have an impact on the optimal investment levels. By comparing k_i^{FB} and k_i^C one can show that the difference[24] between the two is decreasing in γ and $E[\varphi]$ and increasing in η. Hence, the under-investment problem of the complete contract is less severe when γ and $E[\varphi]$ are large and η small. Indeed, in these cases the marginal cost of the investment is large (γ high), its marginal productivity is small (η low) and an enhanced level of $E[\varphi]$ makes the effect of the project failure less severe.

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[22]In both cases the investment is lower than the efficient one; see Proposition 1.

[23]Conditional on the partnership termination, the expected cost of litigation is equal to the legal expenses, $2F$, times the probability of litigation, $\frac{1}{2}(1+\alpha)(1-\beta)$, where α and β are those defined in Proposition 3.

[24]Recall that $k_i^{FB} = \frac{(v-E[\varphi])\eta}{\gamma}$ and $k_i^C = \frac{(v-E[\varphi])\eta}{2\gamma}$ and therefore the under-investment that characterizes the complete contract is $k_i^{FB} - k_i^C = \frac{(v-E[\varphi])\eta}{2\gamma}$.

3.4.1 Empirical Implications

Following from the above comparative statics analysis it is now possible to suggest some testable implications predicted by the model.

R&D vs Production/Marketing partnerships The nature of partners' contributions as well as that of the asset A are determinant for the choice of the partnership contract. The hold-up problem due to the non-verifiability of investments is more likely to be relevant in case partners' contributions have an intangible nature (e.g. know-how or tacit knowledge) so that they are more difficult to be contracted upon; in this case we expect the incomplete contract to perform better than the complete one. Moreover, the effectiveness of an incomplete contract in dealing with the hold-up problem increases with $\left(\varphi^H - \varphi^L\right)$, as discussed in Corollary 2. Also in this case the nature of the asset is relevant. Indeed, it seems reasonable to believe that an intangible asset such as a trademark or a patent might have a very large private value (φ^H) or a very low one (φ^L) depending on the conditions under which it is employed. On the contrary for a tangible asset such as equipment or machinery the difference between the largest and smallest value should not be that large. Therefore, we expect $\left(\varphi^H - \varphi^L\right)$ to be greater in case A is an intangible rather than a tangible asset.

The above discussion suggests that the incomplete contract might be more or less suited depending on the "partnership agenda". R&D alliances are more likely to involve intangible contributions and assets rather than production or marketing ones; therefore, our model predicts that R&D alliances are more likely to sign a contract without a termination clause.

Rival Partners Pérez-Castrillo and Sandonís (1996) and Pastor and Sandonís (2002) point out that the disclosure/provision of (non-contractible) know-how has an higher opportunity cost when the partnership is between rivals: by disclosing information a firm makes the partner a stronger competitor in the product market. Interpreting $c_i(k_1, k_2)$ as the opportunity cost for firm i to provide k_i, then γ is larger when partners are competitors; therefore, an empirical implication of our model stemming from Corollary 2 is that partnerships between rival firms are more likely to be governed by complete contracts.

Riskiness of the Project Often the literature on contracts analyzes the effects of an increasing risk on the investment levels and on the choice of the contract. In this model there are two problems in addressing this issue: 1) increasing risk, per se, should not affect the behavior of risk neutral agents; 2) it is not clear what increasing risk means in our set-up, since the probability of project success is endogenous (it depends on the choice of the investment levels and, more generally, on the choice of the contract).

Let's start with the second problem. The sum of partners' revenue can take value φ_L, φ_H or v. One way of analyzing the effect of riskiness is to compare, for fixed levels of investments, two projects, 1 and 2, such that the second is a mean-preserving-spread of the first, with the following characteristics: $\varphi_1^k > \varphi_2^k$ for both $k = \{H, L\}$ and $\varphi_1^H - \varphi_1^L = \varphi_2^H - \varphi_2^L$, where the subscripts 1 and 2 refer to the projects. Clearly, these assumptions imply

that $E[\varphi_1] > E[\varphi_2]$, and, since we are assuming that the two projects generate the same expected revenues, it follows that it has to be $v_1 < v_2$. By Propositions 5 and 2, we have that the investment levels are larger in case of project 2 both under the incomplete and the complete contracts. On top of that, when project 2 is carried out by the partnership then it is more likely that the incomplete contract Pareto dominates the other. Therefore, a higher risk affects risk neutral agents' behavior since it increases the expected marginal revenue of an extra-unit of investment; moreover the incentive effects on investment are stronger with the contract without the termination clause.

The empirical prediction that follows from this analysis is that incomplete contracts are more likely to rule partnerships carrying out riskier projects, like, again, R&D partnerships, and more generally all those alliances where the difference between the revenues in case of success and failure is large.

Complementarities between investments The assumptions made in the preceding sections about the specific form of the probability and the cost function imply that the best response of each firm when choosing its investment level does not depend on the partner's choice. In fact, the marginal productivity and marginal cost of the investment are independent from the other's choice. Assume for instance that:

$$p(k_1, k_2) = \min\{\eta(k_1 + k_2 + \delta k_1 k_2), 1\}$$

where $\delta \geq 0$ is a measure of the complementarity of the investment levels. Choosing this functional form for the probability only affects the investment levels both under the complete and incomplete contracts. The main effects of δ are summarized in the following proposition.

Proposition 6 *Suppose that $p(k_1, k_2) = \min\{\eta(k_1 + k_2 + \delta k_1 k_2), 1\}$, then the following result hold:*
1) The second best investment levels induced by both contracts, that with a termination clause and that without it, increase;
2) The investment is higher and increases at a higher rate with δ in the contract without the termination clause
3) The set of the other parameter values for which the contract without the termination clause is preferred enlarges as δ increases.
4) The comparative statics with respect to the other parameters is qualitatively identical to that of the model without complementarities, i.e., the set of parameters for which the second-best incomplete contract Pareto dominates any ex-post efficient complete contract enlarges with i) increases of v, $(\varphi^H - \varphi^L)$, F and η, and (ii) decreases of γ and $E[\varphi]$

Proof. See the Appendix. ∎

The empirical implication stemming from the above proposition is that alliances where the technological complementarities of partners are strong (δ large) tend to be governed by incomplete partnership contracts.[25]

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[25]Technological complementarities are typically high in R&D activities in the aircraft industry or in development of military equipment, see Pastor and Sandonís (2002).

4   Robustness of the Results

4.1   Complete Contracts with ex-post Inefficiencies

In Section 3 we have restricted our analysis to the comparison between ex-post efficient contracts and contracts without a termination clause. In principle, partners might enhance investment incentives also by writing complete contracts that induce some other kinds of ex-post inefficiency than litigation in front of the Court. In particular, by inducing continuation when $\theta = \theta_B$ or by assigning the asset to the "wrong" firm (i.e. to the firm for which $\varphi_i = 0$), partners reduce their expected pay-off in case of failure of the project in the same manner as in the contract without a termination clause. However, the following proposition shows that ex-post inefficient complete contracts are either efficiently renegotiated by partners at time $t = 1$ or they are Pareto dominated by the complete contract defined in Proposition 2.[26]

Proposition 7 *Any complete contract that induces some inefficiency at $t = 1$ is either*
(i) efficiently renegotiated; that is there exists a new contract in the set C^{epeff} that both firms agree to sign at time $t = 1$; or
(ii) it is Pareto dominated by the contract defined in Proposition 2.

    Proof. See Appendix. ∎
    An inefficient clause is a credible commitment only if at least one of the partners rejects all the renegotiation proposals. In the proof we show that (i) when a complete contract induces inefficient allotment of the asset or inefficient continuation (that is continuation when $\theta = \theta_B$), the informed firm benefits from making a (ex-post efficient) proposal that the partner accepts; (ii) contracts which induce inefficient termination (i.e. termination when $\theta = \theta_G$) with positive probability can be renegotiation-proof. However, partners never draw these contracts since they induce an even lower level of investments than k_i^C, and therefore they are Pareto dominated by the second-best complete contract.

4.2   Renegotiation between $t = 0$ and $t = 1$

So far we have allowed partners to "complete" (i.e. agree upon a price for the asset A) their NC-contract only once the partnership has been terminated. However, in principle, renegotiation could take place at other points in time. In particular, after having chosen the level of investment and before observing θ (i.e. after $t = 0$ and before $t = 1$) partners do not face the hold-up problem any longer and therefore it would be efficient for them to agree on a termination clause in order to avoid the possible costly litigation.
    However, in Proposition 8 we show that if there exists a positive (infinitely small) probability that, between $t = 0$ and $t = 1$, one of the two firms has of already observed its

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[26]Note that here, unlike the previous sections, we say that parties renegotiate (and not bargain) their contract at time $t = 1$. In fact, we refer to bargaining as the attempt to reach a settlement when the initial contract is "incomplete" and does not specify a termination clause. For this reason here we prefer to use the word "renegotiation".

private valuation of the the asset A, then parties do not renegotiate their NC-contract. In particular, we assume that at the time of renegotiation three events might have occurred: (i) with probability $\frac{\lambda}{2}$ firm 1 only observed its private valuation of the asset (either $\varphi_1 = 0$, $\varphi_1 = \varphi^H$ or $\varphi_1 = \varphi^L$), (ii) with probability $\frac{\lambda}{2}$ firm 2 only observed its private valuation of the asset (either $\varphi_2 = 0$, $\varphi_2 = \varphi^H$ or $\varphi_2 = \varphi^L$), (iii) with probability $(1 - \lambda)$ neither firm observed its private valuation of the asset, where λ is positive but infinitely small.

We assume that the renegotiation is as follows. One of the two firms proposes to amend the initial contract by including a termination clause. If the proposal is accepted, then the new clause is enforced in case of termination. In case of rejection, the usual bargaining stage follows when the partnership is terminated. We focus on simple renegotiation proposals that induce efficient termination and efficient asset allotment; namely, the proposal is to include a price $r \in \left[0, \frac{\varphi^L}{2}\right]$ at which the asset A can be acquired/sold in case of termination of the partnership. Indeed, from Proposition 7 other proposals are, in turn, not renegotiation-proof.

Proposition 8 *Suppose that there is a positive, infinitely small probability that one firm observes its private valuation of the asset between $t = 0$ and $t = 1$, then there is a Perfect Bayesian Equilibrium satisfying the divinity criterion D1 where the NC-contract is not renegotiated efficiently.*

Proof. See the Appendix. ∎

The intuition for the above result is the following. Suppose that firm i proposes to include in the contract a price $r \in \left[0, \frac{\varphi^L}{2}\right]$ for the asset. Then, according to the divinity criterion D1, the receiver of the proposal believes that firm i has already observed that its evaluation of the asset is $\varphi_i = \varphi^H$ and, therefore, it rejects the proposal. Hence, no proposal is made in equilibrium.

4.3   Generalizing Distribution and Cost Functions

The main result of the paper is that partners might exploit contract incompleteness in order to mitigate the hold-up problem they face when investment is non-verifiable. In particular, in Section 3 we have shown that, under specific assumptions about the probability and the cost functions, the contract without a termination clause can outperform any ex-post efficient complete contract; that is, the beneficial effect of a larger incentive to invest might dominate the ex-post inefficiency that an incomplete contract induces.

The aim of this section is to generalize our main result about the incentive effect of a contract without termination clause. We provide sufficient and reasonable conditions that ensure that an incomplete contract induces larger investment levels than a complete one. Suppose that $sv - \frac{E[\varphi]}{2} > 0$ and $(1 - s)v - \frac{E[\varphi]}{2} > 0$ so that each firm prefers the success of the joint project to its failure. Moreover, suppose that the probability of success is increasing in k_i, $i = 1, 2$ and that firms benefit of weak complementarities in their investments: the marginal productivity of the investment is (weakly) increasing and its marginal cost is (weakly) decreasing in the partner's investment, that is, $\frac{\partial p(k_1, k_2)}{\partial k_1 \partial k_2} \geq 0$ and $\frac{\partial^2 c_i(k_1, k_2)}{\partial k_1 \partial k_2} \leq 0$ for

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$i = 1, 2$. Then, the investment game is a supermodular game with positive spillovers (firms' pay-offs are increasing in the level of partner's investment) and therefore it is possible to exploit existence and comparative statics results for this kind of games. In particular, for such games a Nash equilibrium in pure strategies always exists and the largest equilibrium, that is the Nash equilibrium such that the level of investments are highest, is the Pareto preferred one. Assuming that partners are able to coordinate to the Pareto preferred Nash equilibrium, then it follows that the equilibrium investment levels are increasing in the ex-post costs of litigation. The following proposition summarizes the previous discussion.

Proposition 9 *Suppose that* $\frac{\partial p(k_1, k_2)}{\partial k_i} > 0$ *for* $i = 1, 2$, $sv - \frac{E[\varphi]}{2} > 0$, $(1-s)v - \frac{E[\varphi]}{2} > 0$, $\frac{\partial p(k_1, k_2)}{\partial k_1 \partial k_2} \geq 0$ *and* $\frac{\partial^2 c_i(k_1, k_2)}{\partial k_1 \partial k_2} \leq 0$ *for* $i = 1, 2$, *then the investment levels that firms choose in the Pareto preferred Nash equilibrium is increasing in the cost of litigation.*

Proof. See the Appendix. ■

Obviously, given that only under an incomplete contract there is ex-post litigation, then Proposition 9 generalizes our main result; that is:

Corollary 3 *The investment levels that firms choose in the Pareto preferred Nash equilibrium is larger in case of a contract without termination clause than in case of an ex-post efficient complete contract.*

5 Discussion

This paper shows that an ex-post verification mechanism, like a Court, can be used as an ex-ante incentive device in order to reduce the hold-up problem faced in a partnership, when individual investments are not verifiable (in their quality, amount, or other relevant characteristics). In order to be a credible device, the ex-post verification mechanism has to be sustained by the presence of asymmetric information regarding the object to be verified (in our case, the value of the asset). Proposition 3 proves, in fact, that in presence of asymmetric information on the value of the commonly owned asset, partners go to Court with positive probability. Litigation in front of a Court generates a cost which decreases the value of the partnership in case of failure. Therefore it increases the ex-ante incentive to exert effort (i.e. to devote higher quality or larger amount of investments) in order to make the alliance successful (Proposition 5). Finally , alternative ways to increase investment incentives trough ex-post inefficiencies are not renegotiation proof. as shown in Proposition 7.

In the remaining part of this section, we discuss some of the assumptions we made all through the paper.

Unbounded Penalties

In Section 3.2.2 we assumed that firm 1 can only make simple offers in the bargaining stage: a price π to buy the asset. In principle, firm 1's proposals might be more sophisticated. Let $(\hat{\varphi}_1, \pi, \alpha, L)$ be firm 1's proposal at the bargaining stage, where $\hat{\varphi}_1$ is the asset value that firm 1 announces, π is the price for asset, α is the probability to go to Court, and L is a

penalty paid by firm 1 to firm 2 in case the Court verifies that $\hat{\varphi}_1 \neq \varphi_1$. If the penalty L is sufficiently large, then there exists an equilibrium in which firm 1 sets $\pi = \frac{\varphi_1}{2}$ and announces the true state of the world, firm 2 accepts the proposal and therefore parties litigate in front of the Court with probability α. The possibility of using penalties in the bargaining stage makes the contract without termination clause a less effective device, even though it can be shown that α can be set equal to 0 only if L goes to infinity, in order to have the truthful revelation equilibrium. Nevertheless, contracts with large penalties are not always feasible, for instance when firms have limited liability. Moreover, in many legislations such contracts are not enforceable in front of a Court, even though there exists a huge debate in the law and economics literature about the rationales for such limitation to the will of parties (see for instance the seminal works on liquidated damages by Shavell, 1980 and Rogerson, 1984 and for more recent contributions Aghion and Hermalin, 1990, Chung, 1992 and Che and Chung, 1999). With respect to this point, one may also interpret the result of our paper as a further argument that rationalizes the non-enforceability of unbounded penalties. Very large penalties reduce the frequency of ex-post litigation, but a certain amount of litigation is a useful discipline device to reduce the hold-up problem, and therefore having bounded penalties may turn out to be ex-ante efficient.

Bargaining and Court's Rules

In the paper we assumed that the firm which observes the value of the asset makes a proposal to its partner in order to reach an amicable agreement. In a previous version of the paper we show that litigation occurs with positive probability even if the non-informed party makes the proposal (see, Comino et al., 2004); therefore the incomplete contract enhances the investment incentives also in this case.

In Section 3.2.2, we assumed that, in order to allot the legal expenses, Courts adopt a fee-shifting rule based on the bargaining proposals. As said, these rules make easier for parties to reach an amicable settlement without resorting to Court and therefore strengthen our result. Many other rules may be taken into consideration. For instance, we could consider a two-sided rule which charges all legal expenses to the proposer of an unfair price offer, or to the party which rejects a fair one. Alternatively, we could employ the "American rule" according to which legal expenses are always split equally. It can be shown that in all these cases the one described in Proposition 3 is still an equilibrium even though other equilibria may arise. However, our main argument generally holds: litigation in front of the Court occurs in all equilibria.

Asset Value

All through the paper we assumed that the value of the asset A and that of the successful project v do not depend on the investment levels chosen by the partners, but rather they are exogenously determined. Proposition 9 can be further generalized showing that if the investment levels weakly increase v,(or more in general the difference $v - E[\varphi]$), then the investment game is supermodular and therefore Corollary 3 still holds..

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6 Appendix

Proof of Lemma 1.
Suppose that the partnership has been terminated and call i the firm that has been selected to choose whether to be the buyer or the seller of the asset. When $b \in \left[0, \frac{\varphi^L}{2}\right]$ the asset is always efficiently allotted (assuming that if a firm is indifferent between two actions it takes the efficient one); in fact, if $\varphi_i > 0$, then firm i prefers to be the buyer rather than the seller since $\varphi^k - b \geq b$ for both $k \in \{H, L\}$ (note that if $b = \frac{\varphi^L}{2}$ type φ^L is indifferent and we assume that it chooses to be the buyer, that is we assume that in case of indifference a firm takes the efficient action). If $\varphi_i = 0$, then firm i prefers to be the seller since $b \geq -b$. Suppose

that $b > \frac{\varphi^L}{2}$: when $\varphi_i > 0$, since $\varphi^L - b < b$, then type φ^L inefficiently prefers to be the seller. Hence, there is not always an efficient allotment of the asset in case of termination.■

Proof of Lemma 2:
From Section 3 we know that efficiency requires continuation of the partnership in case $\theta = \theta_G$ and termination in case $\theta = \theta_B$. Consider case (i) in the text of the Lemma; firm 1 decides to continue the partnership when $\theta = \theta_G$ provided that: (1) $sv \geq \varphi^H - b$, this ensures continuation in case $\varphi_1 > 0$; and (2) $sv \geq b$, this ensures continuation in case $\varphi_1 = 0$. From condition $b \in \left[0, \frac{\varphi^L}{2}\right]$, (1) implies (2). Moreover, firm 1 always chooses to terminate the partnership when $\theta = \theta_B$ since, by Lemma 1, it obtains $b \geq 0$ in case $\varphi_1 = 0$ and $\varphi_1 - b > 0$ in case $\varphi_1 > 0$ rather than a pay-off of 0 that it would obtain by continuing the partnership. A similar argument applies for case (ii) when firm 2 has the unilateral right to decide upon termination/continuation of the partnership. In case (iii) the efficient continuation/termination decision is always taken provided that: (a) none of the firms wants to terminate the partnership when $\theta = \theta_G$; and (b) at least one firm wants to terminate the partnership when $\theta = \theta_B$. From the analysis of cases (i) and (ii) we know that (a) is verified provided that $sv \geq \varphi^H - b$ and $(1 - s)v \geq \varphi^H - b$ while (b) is always satisfied since condition $b \in \left[0, \frac{\varphi^L}{2}\right]$ implies that both firm prefer termination when $\theta = \theta_B$. In case (iv) an efficient continuation/termination decision is always taken provided that: (a) at least one of the firms wants to continue the partnership when $\theta = \theta_G$; and (b) both firms want to terminate the partnership when $\theta = \theta_B$. Condition $v > \varphi^H$ ensures that condition (a) is always verified; indeed, consider the case $\varphi_1 > 0$ and $\varphi_2 = 0$, then at least one of the following conditions $sv \geq \varphi^H - b$, $(1 - s)v \geq b$ is verified so that there is continuation. A similar argument applies for the alternative case $\varphi_1 = 0$ and $\varphi_2 > 0$. Finally, as for cases (i) and (ii) discussed above, condition $b \in \left[0, \frac{\varphi^L}{2}\right]$ implies that both firms prefer to terminate the partnership when $\theta = \theta_B$ so that condition (b) is always met. ■

Proof of Proposition 2
Consider an ex-post efficient contract $\{s, d, b, f\}$. From Lemma 1 we know that in case of $\theta = \theta_B$ firm $i = 1, 2$ obtains $(E[\varphi] - b)$ if $\varphi_i > 0$ and b if $\varphi_i = 0$. Therefore, when choosing the investment level it solves

$$\max_{k_i} \eta (k_1 + k_2) (\sigma_i v) + (1 - \eta (k_1 + k_2)) \left(\frac{1}{2} (E[\varphi] - b) + \frac{1}{2} (b)\right) - \frac{\gamma}{2} k_i^2,$$

where, $\sigma_1 = s$ and $\sigma_2 = 1 - s$.
The benefit from marginally increasing k_i is $\eta \left(\sigma_i v - \frac{E[\varphi]}{2}\right)$, thus the optimal investment level of firm i is: 0 if $\sigma_i \leq \frac{E[\varphi]}{2v}$ and $\frac{\eta}{\gamma} \left(v\sigma_i - \frac{E[\varphi]}{2}\right)$ otherwise. The investment game has a unique equilibrium but depending on the selected values for σ_1 and σ_2 it can have different characteristics: (i) only one firm makes a positive investment or (ii) both firms make a positive investment. It can be shown that, due to the convexity of the cost function, for any

equilibrium of type (i) there is equilibrium of type (ii) which is more efficient. Therefore we consider values of σ_1 and σ_2 such that both firms are induced to invest.

The (ex-ante) efficient share of the monetary values solves

$$\max_s \eta \left(k_1 + k_2\right) v + \left(1 - \eta \left(k_1 + k_2\right)\right) E[\varphi] - \frac{\gamma}{2}k_1^2 - \frac{\gamma}{2}k_2^2,$$

$$s.t. \qquad k_1 = \frac{\eta}{\gamma} \left(vs - \frac{E[\varphi]}{2}\right)$$

$$k_2 = \frac{\eta}{\gamma} \left(v\left(1 - s\right) - \frac{E[\varphi]}{2}\right)$$

Straightforward calculations show that the $s = \frac{1}{2}$ solves the above program; plugging this value of s into the expressions of the firms' investment one obtains $k_1^C = k_2^C = \frac{(v - E[\varphi])\eta}{2\gamma}$. ∎

Proof of Proposition 3.

The proof is in three steps. First, we show the strategy profile stated in Proposition 3 is an equilibrium. Second, we show that the out of equilibrium beliefs satisfy the divinity criterion D1. Finally, we show that there are no other equilibria of the bargaining game that satisfy the divinity criterion D1. Recall that we refer to 1 as the firm for which the asset has a positive value, that is $\varphi_1 \in \left\{\varphi^H, \varphi^L\right\}$.

1. **Existence**.

Type φ^L of firm 1. In equilibrium, it proposes $\pi = \frac{\varphi^L}{2}$ and obtains

$$\beta\left(\frac{\varphi^L}{2}\right) + (1 - \beta)\left(\frac{\varphi^L}{2} - F\right) - \varepsilon = \frac{\varphi^L}{2} - F\left(1 - \beta\right) - \varepsilon$$

since the proposal is accepted with probability β and rejected otherwise. Any other proposal smaller than $\frac{\varphi^H}{2}$ is rejected and it is therefore dominated by $\pi = \frac{\varphi^L}{2}$. Making "no offer", type φ^L obtains $\frac{\varphi^L}{2} - F$, which is less than what it obtains in equilibrium provided that ε is small enough. Any proposal $\pi \geq \frac{\varphi^H}{2}$ is accepted by firm 2 but it is dominated since $\varphi^H - \varphi^L \geq 2F(1 - \beta) + 2\varepsilon$.

Type φ^H of firm 1. The proposal $\pi = \frac{\varphi^H}{2}$ is accepted and ensures a pay-off of $\frac{\varphi^H}{2} - \varepsilon$. The proposal $\pi = \frac{\varphi^L}{2}$ is accepted with probability β and ensures

$$\beta(\varphi^H - \frac{\varphi^L}{2}) + (1 - \beta)(\frac{\varphi^H}{2} - 2F) - \varepsilon.$$

Type φ^H is indifferent between proposals $\pi = \frac{\varphi^H}{2}$ and $\pi = \frac{\varphi^L}{2}$ provided that firm 2 accepts the second proposal with probability $\beta = \frac{4F}{4F + (\varphi^H - \varphi^L)}$. Any other proposal π different from $\frac{\varphi^H}{2}$ and $\frac{\varphi^L}{2}$ is dominated by $\pi = \frac{\varphi^H}{2}$; similarly, also making "no offer" at all is dominated by $\pi = \frac{\varphi^H}{2}$ provided that $\varepsilon < F$.

Firm 2. Accepting any $\pi \geq \frac{\varphi^H}{2}$ is optimal since its rejection ensures at most $\frac{\varphi^H}{2}$. Consistently with its beliefs, to reject any $\frac{\varphi^L}{2} < \pi < \frac{\varphi^H}{2}$ and any $\pi < \frac{\varphi^L}{2}$ is optimal for firm 2 since in this

way it obtains $\frac{\varphi^H}{2}$ from the Court. When receiving a proposal $\pi = \frac{\varphi^L}{2}$, firm 2 believes that the proposer is of type φ^H with probability $\frac{\alpha}{1+\alpha}$ and of type φ^L with probability $\frac{1}{1+\alpha}$. Therefore, firm 2 is indifferent between accepting or rejecting $\pi = \frac{\varphi^L}{2}$ when $\frac{\varphi^L}{2} = \frac{\alpha}{1+\alpha}\left(\frac{\varphi^H}{2}\right) + \frac{1}{1+\alpha}\left(\frac{\varphi^L}{2} - F\right)$, that is when $\alpha = \frac{2F}{\varphi^H - \varphi^L}$. It can be easily verified that $\alpha \in (0,1)$ provided that $\varphi^H - \varphi^L \geq 2F$.

2 **Divinity criterion D1.** First note that for any offer $\pi < \frac{\varphi^L}{2}$ to accept the proposal is a strictly dominated strategy. Similarly for any offer $\pi > \frac{\varphi^H}{2}$ to accept is a strictly dominant strategy and therefore beliefs over the proposer's type are irrelevant.

Consider any offer π such that $\frac{\varphi^L}{2} < \pi < \frac{\varphi^H}{2}$. Let ρ denote the probability that firm 2 accepts the offer π. Type φ^H prefers to make such an offer than playing according to the equilibrium provided that $\rho(\varphi^H - \pi) + (1-\rho)\left(\frac{\varphi^H}{2} - 2F\right) - \varepsilon \geq \frac{\varphi^H}{2} - \varepsilon$, that is

$$\rho \geq \frac{4F}{\varphi^H - 2\pi + 4F} \equiv \bar{\rho}_H.$$

In turn, type φ^L prefers to offer π rather than playing according to the equilibrium provided that $\rho\left(\varphi^L - \pi\right) + (1-\rho)\left(\frac{\varphi^L}{2} - F\right) - \varepsilon \geq \frac{\varphi^L}{2} - F(1-\beta) - \varepsilon$. First, note that if $\pi > \frac{\varphi^L}{2} + F$, the intuitive criterion ensures that firm 2 has to assign probability one that the proposer is type φ^H. For any $\frac{\varphi^L}{2} < \pi \leq \frac{\varphi^L}{2} + F$ we have

$$\rho \geq \frac{2\beta F}{\varphi^L - 2\pi + 2F} \equiv \bar{\rho}_L.$$

One can verify that $\bar{\rho}_H < \bar{\rho}_L$: in fact, substituting $\beta = \frac{4F}{4F + (\varphi^H - \varphi^L)}$ and denoting $\pi = \frac{\varphi^L}{2} + z$ with $0 < z \leq F$, after some manipulations the condition turns to be equal to $\left(2F + \varphi^H - \varphi^L\right)z > 0$, which holds true. Therefore only the out of equilibrium beliefs stated in the Proposition satisfy the divinity criterion D1.

3 **Uniqueness.**

To prove that there are no other equilibria of the bargaining game that satisfy the divinity criterion D1 we need to check all possible equilibria: separating, pooling and semi-separating. Let π^k denote the proposal made by type $k \in \{H, L\}$ of firm 1.

A. Separating equilibria

A1 the two types of firm 1 make two different offers: by definition of separating equilibrium it has to be $\pi^H \neq \pi^L$. Moreover, firm 2 has to accept both offers otherwise the type whose offer is rejected would prefer to make "no proposal" and save ε. However, the proposed one cannot be an equilibrium since the type whose equilibrium offer is the largest prefers to deviate and mimic the other type;

A2 type φ^H makes "no proposal" while type φ^L proposes π^L: in such an equilibrium π^L has to satisfy the following conditions: $\pi^L \geq \frac{\varphi^L}{2}$, otherwise the proposal is rejected and type φ^L is better-off making "no proposal"; $\pi^L \leq \frac{\varphi^L}{2} + F - \varepsilon$, otherwise type φ^L prefers to make "no proposal". However, this cannot be an equilibrium since type φ^H prefers to propose π^L rather than to make "no proposal";

A3 type φ^L makes "no proposal" while type φ^H proposes π^H: in such an equilibrium it has to be $\pi^H = \frac{\varphi^H}{2}$. Indeed, π^H reveals that firm 1 is of type φ^H and firm accepts if and only if $\pi^H \geq \frac{\varphi^H}{2}$. Given this fact, it is optimal for type φ^H to propose $\frac{\varphi^H}{2}$. Moreover, for this to be an equilibrium, firm 2 has to reject any offer smaller than $\frac{\varphi^H}{2}$. This is the case provided that firm 2 assigns a positive probability to type φ^H when observing a proposal $\pi < \frac{\varphi^H}{2}$. However, we now prove that there exists $\tilde{\pi} \in \left(\frac{\varphi^L}{2}, \frac{\varphi^L}{2} + F \right)$ such that the divinity criterion D1 imposes that $\mu(\tilde{\pi}) = 0$. Hence given these beliefs firm 2 should accept proposal π and type φ^L would be better-off offering such a π rather then playing according to the equilibrium. Let $\tilde{\pi} \in \left(\frac{\varphi^L}{2}, \frac{\varphi^L}{2} + F \right)$ and let ρ be the probability that firm 2 accepts the proposal. The minimal probability for which type φ^H prefers to make such a proposal rather than offering $\frac{\varphi^H}{2}$ according to the separating equilibrium is such that $\rho(\varphi^H - \tilde{\pi}) + (1 - \rho) \left(\frac{\varphi^H}{2} - 2F \right) - \varepsilon \geq \frac{\varphi^H}{2} - \varepsilon$, or:

$$\rho \geq \frac{4F}{\varphi^H - 2\tilde{\pi} + 4F} \equiv \bar{\rho}_H.$$

The minimal probability for which type φ^L prefers to offer $\tilde{\pi}$ rather than, as required by the equilibrium, making no offer at all is $\rho(\varphi^L - \tilde{\pi}) + (1 - \rho) \left(\frac{\varphi^L}{2} - F \right) - \varepsilon \geq \frac{\varphi^L}{2} - F$, or:

$$\rho \geq \frac{2\varepsilon}{\varphi^L - 2\tilde{\pi} + 2F} \equiv \bar{\rho}_L.$$

For ε small enough it follows that $\bar{\rho}_L < \bar{\rho}_H$. Hence the divinity criterion D1 imposes $\mu(\tilde{\pi}) = 0$.

B. Semi-separating equilibria

As first we prove that we can have a semi-separating equilibrium only in the case in which type φ^H randomizes between two different proposals and type φ^L makes only a proposal. Then we prove that within this class of equilibria only the one stated in Proposition 3 survives to the scrutiny of the divinity criterion D1.

B1 There exists no equilibrium in which type φ^H plays "no offer" with strictly positive probability: making no offer type φ^H obtains $\frac{\varphi^H}{2} - F$. This is a dominated strategy since an offer $\frac{\varphi^H}{2}$ is accepted by firm 2 and guarantees a pay-off $\frac{\varphi^H}{2} - \varepsilon$ to type φ^H;

B2 There exists no equilibrium in which type φ^L plays "no offer" with strictly positive probability: to check that this claim is true we need to consider two cases:

- type φ^L plays "no offer" with probability 1. This cannot be the case since (by definition of semi-separating) this implies that type φ^H plays mixed strategies randomizing between "no offer" and some offer π. However, this cannot be true by what we have proven in the previous point B1;

- type φ^L plays mixed strategies randomizing between "no offer" and an offer π. Clearly, it has to be $\pi \in \left[\frac{\varphi^L}{2}, \frac{\varphi^L}{2} + F - \varepsilon\right]$ since otherwise "no offer" would dominate π. Type φ^L is indifferent between playing "no offer" and π if the latter offer is accepted by firm 2 with probability β such that $\frac{\varphi^L}{2} - F = \beta\left(\varphi^L - \pi\right) + (1 - \beta)\left(\frac{\varphi^L}{2} - F\right) - \varepsilon$, that is $\beta = \frac{\varepsilon}{\varphi^L + 2F - 2\pi}$. In a semi-separating equilibrium type φ^H should make the same offer π as type φ^L. However, it is easy to check that type φ^H prefers offering $\frac{\varphi^H}{2}$ rather than π; indeed $\frac{\varphi^H}{2} - \varepsilon > \beta\left(\varphi^H - \pi\right) + (1 - \beta)\left(\frac{\varphi^H}{2} - 2F\right) - \varepsilon$ if and only if $4F > \frac{\varepsilon}{\varphi^L + 2F - 2\pi}\left(\varphi^H + 4F - 2\pi\right)$ which is certainly true for ε small enough.

B3 There exists no equilibrium in which type φ^L plays mixed strategies randomizing between any π and $\pi + \delta$. Suppose that type φ^L plays mixed strategies randomizing between π and $\pi + \delta$. Clearly it has to be that $\pi \geq \frac{\varphi^L}{2}$ and $\pi + \delta \leq \frac{\varphi^L}{2} + F - \varepsilon$ since any other strategy is dominated. We need to distinguish the following sub-cases:

- type φ^H offers π. The offer $\pi + \delta$ reveals that firm 1 is of type φ^L and therefore it is accepted by firm 2. Therefore, type φ^L is indifferent between π and $\pi + \delta$ if and only if the former offer is accepted by firm 2 with probability β and rejected otherwise and with β such that $\varphi^L - (\pi + \delta) - \varepsilon = \beta\left(\varphi^L - \pi\right) + (1 - \beta)\left(\frac{\varphi^L}{2} - F\right) - \varepsilon$, that is, $\beta = \frac{\varphi^L + 2(F - \delta - \pi)}{\varphi^L - 2(\pi - F)}$. Given this β it is easy to verify that type φ^H prefers offering $\pi + \delta$ (pay-off $\varphi^H - (\pi + \delta) - \varepsilon$) rather than π (pay-off $\beta\left(\varphi^H - \pi\right) + (1 - \beta)\left(\frac{\varphi^H}{2} - 2F\right) - \varepsilon$) if and only if $\left(\frac{\varphi^H}{2} - \pi + 2F\right)(1 - \beta) + \delta > 0$ which is surely verified.

- type φ^H offers $\pi + \delta$. This cannot be the case since in equilibrium π would be offered only by type φ^L and would be accepted by firm 2. Therefore, both types of firm 1 prefer offering π with probability 1.

- type φ^H plays mixed strategies. First note that the two types have to randomize over the same support. On the contrary both types would be making at least one offer that reveals their own types and all such proposals should be accepted with probability one. But then this cannot be an equilibrium since there exists one type who should deviate offering the smallest revealing offer. Consider, hence, the case in which type φ^H randomizes between π and $\pi + \delta$. The proposed equilibrium has to be sustained by the following beliefs: for any $\widetilde{\pi} \in (\pi, \pi + \delta)$, $\mu(\widetilde{\pi}) > 0$. Indeed, if this is not the case then both types prefer to deviate and make such offer instead of offering $\pi + \delta$. Call ψ the probability that firm 2 accepts the

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equilibrium offer $\pi + \delta$ and consider an out of equilibrium offer $\pi + \delta - \gamma$, with $0 < \gamma < \delta$. Type φ^L is willing to make such offer provided that it is accepted at least with probability ρ such that

$\rho\left(\varphi^L - \pi - \delta + \gamma\right) + (1 - \rho)(\frac{\varphi^L}{2} - F) \geq \psi\left(\varphi^L - \pi - \delta\right) + (1 - \psi)\left(\frac{\varphi^L}{2} - F\right)$.

Similarly, type φ^H is willing to offer $\pi + \delta - \gamma$ provided that $\rho\left(\varphi^H - \pi - \delta + \gamma\right) + (1 - \rho)(\frac{\varphi^H}{2} - 2F) \geq \psi\left(\varphi^H - \pi - \delta\right) + (1 - \psi)\left(\frac{\varphi^H}{2} - 2F\right)$. Using the standard arguments it can be shown that the divinity criterion D1 imposes to assign $\mu(\tilde{\pi}) = 0$ when $\pi + \delta - \gamma$ is offered.

Finally, we have to check the case where type φ^H plays mixed strategies while type φ^L plays pure strategies. Obviously it has to be that one offer is made by both types and another offer is made by type φ^H only. In equilibrium the latter offer has to be $\frac{\varphi^H}{2}$. Moreover, the offer which is made by both types has to be no smaller than $\frac{\varphi^L}{2}$ to be accepted by firm 2. Let's denote $\frac{\varphi^L}{2} + \Delta$ the offer which is made by the two types. Note that, the case $\Delta = 0$ coincides with the equilibrium in Proposition 3 and therefore we restrict the attention to the case of $\Delta > 0$.

It can be easily shown that type φ^H is willing to randomize between $\frac{\varphi^L}{2} + \Delta$ and $\frac{\varphi^H}{2}$ provided the former offer is accepted with probability $\beta = \frac{4F}{4F - 2\Delta + (\varphi^H - \varphi^L)}$ and rejected otherwise. Moreover, these offers are equilibrium strategies if firm 2 assigns $\mu(\pi) > 0$ when receiving $\frac{\varphi^L}{2} + \Delta - \gamma$ for $0 < \gamma < \Delta$. However, in what follows we show that such beliefs do not satisfy the divinity criterion D1.

Type φ^H prefers offering $\frac{\varphi^L}{2} + \Delta - \gamma$ rather than $\frac{\varphi^H}{2}$ provided that $\rho\left(\varphi^H - \frac{\varphi^L}{2} - \Delta + \gamma\right) + (1 - \rho)\left(\frac{\varphi^H}{2} - 2F\right) - \varepsilon \geq \frac{\varphi^H}{2} - \varepsilon$; that is provided that

$$\rho \geq \frac{2F}{\frac{\varphi^H}{2} - \frac{\varphi^L}{2} - \Delta + \gamma + 2F} \equiv \bar{\rho}_H.$$

Type φ^L prefers offering $\frac{\varphi^L}{2} + \Delta - \gamma$ rather the equilibrium offer $\frac{\varphi^L}{2} + \Delta$ provided that

$$\rho\left(\frac{\varphi^L}{2} - \Delta + \gamma\right) + (1 - \rho)\left(\frac{\varphi^L}{2} - F\right) - \varepsilon \geq \beta\left(\frac{\varphi^L}{2} - \Delta\right) + (1 - \beta)(\frac{\varphi^L}{2} - F) - \varepsilon$$

that is, if:

$$\rho \geq \frac{4F(F - \Delta)}{(4F - 2\Delta + (\varphi^H - \varphi^L))(F - \Delta + \gamma)} \equiv \bar{\rho}_L.$$

It can be easily shown that $\bar{\rho}_H > \bar{\rho}_L$ given that $2F + (\varphi^H - \varphi^L) > 0$ and therefore the divinity criterion D1 imposes $\mu(\pi) = 0$ when $\pi + \Delta - \gamma$ is offered.

C. Pooling equilibria

C1 Both types make no offer. In the proposed equilibrium type φ^H obtains $\frac{\varphi^H}{2} - F$. However, an offer $\frac{\varphi^H}{2}$ is accepted by firm 2 and guarantees type φ^H a pay-off $\frac{\varphi^H}{2} - \varepsilon$.

C2 Firm 2 is willing to accept an offer provided that $\pi \geq \frac{1}{2}\left(\frac{\varphi^H}{2}\right) + \frac{1}{2}\left(\frac{\varphi^L}{2} - F\right)$, that is provided that $\pi \geq \frac{E[\varphi^L]}{2} - \frac{F}{2}$ where $E\left[\varphi^L\right] = (\frac{\varphi^H}{2} + \frac{\varphi^L}{2})$. Consider that firm 1 makes an out of equilibrium offer $\tilde{\pi} = \pi - \varepsilon$. To sustain π as a pooling equilibrium, firm 2 has to assign probability $\mu(\tilde{\pi}) > 0$. However, the divinity criterion D1 imposes $\mu(\tilde{\pi}) = 0$ and with such beliefs the one proposed cannot be an equilibrium because both types of firm 1 prefer to deviate. Consider type φ^L. It prefers to offer $\tilde{\pi}$ rather than π provided that the offer is accepted with probability ρ such that

$$\rho\left(\varphi^L - \tilde{\pi}\right) + (1 - \rho)\left(\frac{\varphi^L}{2} - F\right) - \varepsilon \geq \varphi^L - \pi - \varepsilon$$

that is:

$$\rho \geq \frac{\varphi^L - 2\pi + 2F}{\varphi^L - 2\tilde{\pi} + 2F} \equiv \overline{\rho_L}.$$

Type φ^H prefers to offer $\tilde{\pi}$ rather than π provided that

$$\rho\left(\varphi^H - \tilde{\pi}\right) + (1 - \rho)\left(\frac{\varphi^H}{2} - 2F\right) - \varepsilon \geq \varphi^H - \pi - \varepsilon$$

that is:

$$\rho \geq \frac{\varphi^H - 2\pi + 4F}{\varphi^H - 2\tilde{\pi} + 4F} \equiv \overline{\rho_H}.$$

It can be verified that $\bar{\rho}_L < \bar{\rho}_H$ provided that $\varepsilon\left(\varphi^H - \varphi^L + 2F\right) > 0$ which follows by assumption.

Both types of firm 1 play mixed strategies randomizing between no offer and π. Firm 2 is not willing to accept any offer smaller than $\frac{\varphi^L}{2}$ while type φ^L does not make any offer larger than $\frac{\varphi^L}{2} + F - \varepsilon$. Given that the offer has to satisfy these restrictions, then type φ^L is indifferent between offering π and making "no offer" provided that π is accepted with probability ψ such that $\psi\left(\varphi^L - \pi\right) + (1 - \psi)\left(\frac{\varphi^L}{2} - F\right) - \varepsilon = \frac{\varphi^L}{2} - F$, that is provided that $\psi = \frac{2\varepsilon}{\varphi^L - 2\pi + 2F} \equiv \psi_L$. Similarly, type φ^H is indifferent between offering π and making "no offer" provided that π is accepted with probability ψ' such that $\psi'\left(\varphi^H - \pi\right) + (1 - \psi')\left(\frac{\varphi^H}{2} - 2F\right) - \varepsilon = \frac{\varphi^H}{2} - F$, that is provided that $\psi\prime = \frac{2(\varepsilon + F)}{\varphi^H - 2\pi + 4F} \equiv \psi_H$. Therefore, the proposed one can be an equilibrium only when $\psi_H = \psi_L$ and this is not true for $\varepsilon > 0$ small enough. ∎

Proof of Proposition 4
In case $\theta = \theta_B$, firm $i = 1, 2$ is the buyer $(\varphi_i > 0)$ or the seller $(\varphi_i = 0)$ of the asset

with equal probability. In the former case it observes either φ^H or φ^L and obtains $\frac{\varphi^H}{2} - \varepsilon$ or $\frac{\varphi^L}{2} - F(1-\beta) - \varepsilon$ respectively, as defined in Proposition 3; therefore firm $i = 1, 2$ anticipates that in case of being the buyer it will obtain

$$\frac{1}{2}\frac{\varphi^H}{2} + \frac{1}{2}\left(\frac{\varphi^L}{2} - F(1-\beta)\right) - \varepsilon = \frac{E[\varphi]}{2} - \frac{F(1-\beta)}{2} - \varepsilon.$$

In turn, in case firm i is the seller of the asset it obtains $\frac{\varphi^L}{2}$ when the partner has observed φ^L, and $\frac{\varphi^L}{2}\alpha + \frac{\varphi^H}{2}(1-\alpha)$ when the partner has observed φ^H, as defined in Proposition 3; therefore, firm $i = 1, 2$ anticipates that in case of being the seller it will obtain

$$\frac{1}{2}\frac{\varphi^L}{2} + \frac{1}{2}\left(\frac{\varphi^L}{2}\alpha + \frac{\varphi^H}{2}(1-\alpha)\right) = \left(\frac{E[\varphi]}{2} - \frac{\alpha}{4}\left(\varphi^H - \varphi^L\right)\right).$$

When choosing k_i firm $i = 1, 2$ solves the following maximization problem:

$$\max_{k_i} \quad \eta(k_1 + k_2)\sigma_i v + (1 - \eta(k_1 + k_2)) \cdot$$
$$\left[\frac{1}{2}\left(\frac{E[\varphi]}{2} - \frac{F(1-\beta)}{2} - \varepsilon\right) + \frac{1}{2}\left(\frac{E[\varphi]}{2} - \frac{\alpha}{4}\left(\varphi^H - \varphi^L\right)\right)\right] - \frac{\gamma}{2}k_i^2$$

where, $\sigma_1 = s$ and $\sigma_2 = 1 - s$. The benefit from increasing marginally k_i is $\eta\left(\sigma_i v - \frac{Q}{2}\right)$, where:

$$Q \equiv E[\varphi] - \left(\frac{F(1-\beta)}{2} + \varepsilon\right) - \frac{\alpha}{4}\left(\varphi^H - \varphi^L\right)$$

thus the optimal investment level of firm i is:

$$k_i(\sigma_i) = \begin{cases} 0 & \text{if} \quad \sigma_i \leq \frac{Q}{2v} \\ \eta\frac{v\sigma_i - \frac{1}{2}\left[E[\varphi] - \left(\frac{F(1-\beta)}{2} + \varepsilon\right) - \frac{\alpha}{4}\left(\varphi^H - \varphi^L\right)\right]}{\gamma} & \text{otherwise} \end{cases}$$

The investment game has a unique equilibrium but depending on the selected values for σ_1 and σ_2 it can have different characteristics: (i) only one firm makes a positive investment or (ii) both firms make a positive investment. It can be shown that, due to the convexity of the cost function, for any equilibrium of type (i) there is equilibrium of type (ii) which is more efficient. Therefore we consider values of σ_1 and σ_2 such that both firms are induced to invest.

The (ex-ante) efficient share of the monetary values solves

$$\max_s \quad \eta[k_1(s) + k_2(1-s)]v +$$
$$+[1 - \eta[k_1(s) + k_2(1-s)]]\left[E[\varphi] - \left(\frac{F(1-\beta)}{2} + \varepsilon\right) - \frac{\alpha}{4}\left(\varphi^H - \varphi^L\right)\right]$$
$$-\frac{\gamma}{2}[k_1(s)]^2 - \frac{\gamma}{2}[k_2(1-s)]^2$$

Direct calculations show that the $s^{NC} = \frac{1}{2}$ solves the above program; plugging this value of s into the expressions of the firms' investment one obtains that in case of an (ex-ante) efficient without termination clause:

$$k_1^{NC} = k_2^{NC} = \frac{(v - E[\varphi])\eta}{2\gamma} + \frac{\eta\left(2\left(F\left(1 - \beta\right) + 2\varepsilon\right) + \alpha\left(\varphi^H - \varphi^L\right)\right)}{8\gamma}. \blacksquare$$

Proof of Proposition 6

In the contract with the termination clause firms' problem is:

$$\max_{k_i} \eta\left(k_1 + k_2 + \delta k_1 k_2\right)\sigma_i v + \left(1 - \eta\left(k_1 + k_2 + \delta k_1 k_2\right)\right)\frac{1}{2}E[\varphi] - \frac{\gamma}{2}k_i^2$$

whose first order condition is:

$$\left(v\sigma_i - \frac{1}{2}E[\varphi]\right)\left(1 + \delta k_j\right)\eta - \gamma k_i = 0$$

$$\text{for} \quad i, j = 1, 2 \quad \text{and} \quad i \neq j$$

and solving the system of the two first order conditions we obtain:

$$k_i = \eta\left(E[\varphi] - 2v\sigma_i\right)\frac{2\gamma - \delta\eta E[\varphi] + 2\delta v\eta\sigma_j}{\left(E[\varphi]^2 + 4v^2\sigma_1\sigma_2 - 2vE[\varphi]\left(\sigma_1 + \sigma_2\right)\right)\delta^2\eta^2 - 4\gamma^2} \tag{1}$$

$$\text{for} \quad i, j = 1, 2 \quad \text{and} \quad i \neq j.$$

By direct computation, considering that $\sigma_1 = s$ and $\sigma_2 = 1 - s$, the maximization of the joint profits yields $s = \frac{1}{2}$. In fact the joint profit can be written as:

$$\eta\left(k_1 + k_2 + \delta k_1 k_2\right)\left(v - E[\varphi]\right) + E[\varphi] - \frac{\gamma}{2}k_1^2 - \frac{\gamma}{2}k_2^2$$

and considering that the two k_i's are symmetric with respect to σ_i and σ_j, one obtains the result. Substituting $s = \frac{1}{2}$ into (1) one obtains:

$$k_i^C(\delta) = \frac{\frac{(v - E[\varphi])\eta}{2\gamma}}{1 - \frac{(v - E[\varphi])\eta}{2\gamma}\delta}, \qquad i = 1, 2$$

which for $\delta = 0$, that is $k^C(0)$, is identical to that found in Proposition 2 and it is increasing in δ. Therefore we already proved point 1) of the proposition for the contract with termination clause. Finally notice that:

$$k_i^C(\delta) = \frac{k_i^C(0)}{1 - \delta k_i^C(0)} \tag{2}$$

In the contract without the termination clause firms' problem is:

$$\max_{k_i} \quad \eta\left(k_1 + k_2 + \delta k_1 k_2\right)\sigma_i v + \left(1 - \eta\left(k_1 + k_2 + \delta k_1 k_2\right)\right) \cdot$$

$$\frac{1}{2}\left(E[\varphi] - \frac{F(1 - \beta)}{2} - \varepsilon - \frac{\alpha}{4}\left(\varphi^H - \varphi^L\right)\right) - \frac{\gamma}{2}k_i^2$$

whose first order condition is:

$$\frac{1}{8}\left(2F\left(1-\beta\right)+4\varepsilon-4E\left[\varphi\right]+8v\sigma_i+\alpha\left(\varphi^H-\varphi^L\right)\right)\left(1+\delta k_j\right)\eta-\gamma k_i=0$$

$$\text{for}\qquad i,j=1,2\qquad\text{and}\qquad i\neq j$$

Solving the system of the two first order conditions we obtain:

$$k_i=Q_i\frac{\gamma+\delta Q_j}{\gamma^2-\delta^2 Q_1 Q_2} \qquad (3)$$
$$\text{for}\qquad i,j=1,2\qquad\text{and}\qquad i\neq j$$

where:

$$Q_i=\left(v\sigma_i-\frac{1}{2}\left(E\left[\varphi\right]-\frac{F\left(1-\beta\right)}{2}-\varepsilon-\frac{1}{4}\alpha\left(\varphi^H-\varphi^L\right)\right)\right)\eta,\qquad i=1,2$$

By direct calculations, also in this case, the first order condition for s is satisfied in $s=\frac{1}{2}$, considering that $\sigma_1=s$, $\sigma_2=1-s$, and furthermore $Q_1=Q_2$ and $k_1=k_2$ for $s=\frac{1}{2}=\sigma_1=\sigma_2$. Substituting this result in (3) we obtain:

$$k_i^{NC}\left(\delta\right)=\frac{\frac{\eta}{2\gamma}\left[v-E\left[\varphi\right]+\frac{F(1-\beta)}{2}+\varepsilon+\frac{\alpha}{4}\left(\varphi^H-\varphi^L\right)\right]}{1-\frac{\eta}{2\gamma}\left[v-E\left[\varphi\right]+\frac{F(1-\beta)}{2}+\varepsilon+\frac{\alpha}{4}\left(\varphi^H-\varphi^L\right)\right]\delta}$$

which for $\delta=0$, that is $k_i^{NC}\left(0\right)$, is identical to that found in Proposition 4 and it is increasing in δ. Therefore we proved point 1) of the proposition for the contract without termination clause. Notice that:

$$k_i^{NC}\left(\delta\right)=\frac{k_i^{NC}\left(0\right)}{1-k_i^{NC}\left(0\right)\delta} \qquad (4)$$

Moreover, we have that:

$$k_i^{NC}\left(\delta\right)-k_i^{C}\left(\delta\right)\quad=\quad\frac{k_i^{NC}\left(0\right)}{1-k_i^{NC}\left(0\right)\delta}-\frac{k_i^{C}\left(0\right)}{1-k_i^{C}\left(0\right)\delta}=$$

$$\frac{k_i^{NC}\left(0\right)-k_i^{C}\left(0\right)}{\left(1-k_i^{NC}\left(0\right)\delta\right)\left(1-k_i^{C}\left(0\right)\delta\right)}\quad>\quad 0$$

since we already proved that $k_i^{NC}\left(0\right)-k_i^{C}\left(0\right)>0$. Finally notice that, given (2) and (4), we have:

$$\frac{\partial}{\partial\delta}k_i^{C}\left(\delta\right)=\left(k_i^{C}\left(\delta\right)\right)^2,\qquad\frac{\partial}{\partial\delta}k_i^{NC}\left(\delta\right)=\left(k_i^{NC}\left(\delta\right)\right)^2$$

therefore the investment with the incomplete contract is always higher, it increases with δ at a higher rate and therefore point 2 of the proposition is proven. We now have to

compare the two profit levels. In the case of contract with termination clause and after some manipulations, the equilibrium profits are:

$$\eta \left(k_i + k_i + \delta k_i k_i\right) \left(\frac{1}{2}v\right) + \left(1 - \eta \left(k_i + k_i + \delta k_i k_i\right)\right) \frac{1}{2} E[\varphi] - \frac{\gamma}{2} k_i^2 =$$

$$\left[(2 + \delta k_i) \frac{\eta}{2\gamma} \left(v - E[\varphi]\right) - \frac{1}{2} k_i\right] \gamma k_i + \frac{1}{2} v - \frac{1}{2} v + \frac{1}{2} E[\varphi]$$

Substituting $k_i = \frac{k_i^C(0)}{1 - \delta k_i^C(0)}$ and recalling the definition of $k_i^C(0)$ with simple manipulations we obtain:

$$\left[\left(2 + \delta \frac{k_i^C(0)}{1 - \delta k_i^C(0)}\right) k_i^C(0) - \frac{1}{2} \frac{k_i^C(0)}{1 - \delta k_i^C(0)}\right] \gamma \frac{k_i^C(0)}{1 - \delta k_i^C(0)} + \frac{1}{2} v - \frac{\gamma}{2\eta} k_i^C(0) =$$

$$\frac{\gamma}{2} \left[\frac{k_i^C(0)}{1 - \delta k_i^C(0)}\right]^2 \left(3 - 2\delta k_i^C(0)\right) + \frac{1}{2} v - \frac{\gamma}{2\eta} k_i^C(0)$$

While the corresponding in the case of the contract with no termination clause are:

$$\eta \left(k_i + k_i + \delta k_i k_i\right) \frac{1}{2} v +$$

$$\left(1 - \eta \left(k_i + k_i + \delta k_i k_i\right)\right) \frac{1}{2} \left(E[\varphi] - \frac{F(1 - \beta)}{2} - \varepsilon - \frac{\alpha}{4} \left(\varphi^H - \varphi^L\right)\right) - \frac{\gamma}{2} k_i^2 =$$

$$\frac{1}{2} \left[2\gamma (2 + \delta k_i) \frac{\eta}{2\gamma} \left(v - E[\varphi] + \frac{F(1 - \beta)}{2} + \varepsilon + \frac{\alpha}{4} \left(\varphi^H - \varphi^L\right)\right) - \gamma k_i\right] k_i +$$

$$\frac{1}{2} v - \frac{1}{2} v + \frac{1}{2} \left(E[\varphi] - \varepsilon - \frac{1}{2} F(1 - \beta) - \frac{1}{4} \alpha \left(\varphi^H - \varphi^L\right)\right)$$

Recalling that in equilibrium $k_i = \frac{k_i^{NC}(0)}{1 - \delta k_i^{NC}(0)}$ and the definition of $k_i^{NC}(0)$ we can transform the above expression as:

$$\left[2\gamma \left(2 + \delta \frac{k_i^{NC}(0)}{1 - \delta k_i^{NC}(0)}\right) \frac{\eta}{2\gamma} \left(v - E[\varphi] + \frac{F(1 - \beta)}{2} + \varepsilon + \frac{\alpha}{4} \left(\varphi^H - \varphi^L\right)\right) - \gamma \frac{k_i^{NC}(0)}{1 - \delta k_i^{NC}(0)}\right] \cdot$$

$$\frac{1}{2} \frac{k_i^{NC}(0)}{1 - \delta k_i^{NC}(0)} + \frac{1}{2} v - \frac{\gamma}{2\eta} k_i^{NC}(0) =$$

$$\frac{1}{2} \left(2\gamma \left(2 + \delta \frac{k_i^{NC}(0)}{1 - \delta k_i^{NC}(0)}\right) k_i^{NC}(0) - \gamma \frac{k_i^{NC}(0)}{1 - \delta k_i^{NC}(0)}\right) \frac{k_i^{NC}(0)}{1 - \delta k_i^{NC}(0)} +$$

$$\frac{1}{2} v - \frac{\gamma}{2\eta} k_i^{NC}(0) =$$

$$\frac{1}{2} \left(3 - 2k_i^{NC}(0)\delta\right) \left[\frac{k_i^{NC}(0)}{1 - \delta k_i^{NC}(0)}\right]^2 \gamma + \frac{1}{2} v - \frac{\gamma}{\eta} k_i^{NC}(0)$$

We want to find the conditions for which:

$$G\left(k_i^{NC}\left(0\right),\delta\right) \geq G\left(k_i^{C}\left(0\right),\delta\right)$$
$$G\left(x,\delta\right) = \frac{\eta}{2}\left[\frac{x}{1-\delta x}\right]^2 \left[3 - 2\delta x\right] - x \tag{5}$$

By definition, for $\delta = 0$, the above condition is identical to that in Proposition 5. Therefore for $\delta = 0$ and

$$v \geq \frac{2E[\varphi] - F}{2} + \frac{F^2}{4F + \varphi^H - \varphi^L} + \frac{2\gamma}{3\eta^2} \tag{6}$$

(5) is satisfied. Now we have to prove what happens as δ increases and in particular we wish to check whether the derivatives of the lhs are greater than those of the rhs. Notice that:

$$\frac{\partial}{\partial\delta}G\left(x,\delta\right) = x^3\frac{\eta}{\left(1-x\delta\right)^3}\left(2 - x\delta\right) > 0$$

$$\frac{\partial^2}{\partial\delta\partial x}G\left(x,\delta\right) = x^2\frac{\eta}{\left(1-x\delta\right)^4}\left(x^2\delta^2 + 6 - 4x\delta\right) > 0$$

where the two inequalities are implied by the fact that in equilibrium we must have $k_i^{NC}\left(0\right) > 0$, whose necessary condition is $1 - \delta k_i^{NC}\left(0\right) > 0$, and hence $1 - x\delta > 0$. Therefore $G\left(\cdot\right)$ increases with δ and increases at increasing rate if also x increases. But we know that $k_i^{NC}\left(0\right) \geq k_i^{C}\left(0\right)$, therefore (5) is more easily satisfied when δ increases.

As for the other parameters, notice that:

$$k_i^{C}\left(0\right) = \frac{\eta}{2\gamma}\left(v - E\left[\varphi\right]\right)$$

$$k_i^{NC}\left(0\right) = \frac{\eta}{2\gamma}\left(v - E\left[\varphi\right] + \frac{F}{2}\frac{\left(\varphi^H - \varphi^L\right)}{4F + \left(\varphi^H - \varphi^L\right)} + \varepsilon + \frac{F}{2}\right)$$

where in $k_i^{NC}\left(0\right)$ we substituted the equilibrium values of α and β. There are parameters which enter only in $k_i^{NC}\left(0\right)$ and others, which influence both. As for the former notice that:

$$\frac{\partial}{\partial x}G\left(x,\delta\right) = \frac{\left(x^3\delta^2 - 3\delta x^2 + 3x\right)\left(\delta + \eta\right) - 1}{\left(1 - x\delta\right)^3}$$

$$\frac{\partial^2}{\partial x^2}G\left(x,\delta\right) = 3\frac{\eta}{\left(1 - x\delta\right)^4} > 0$$

Therefore G is a continuous function (since we need to impose $1 - x\delta > 0$) and convex in x. It is difficult, though, to determine the sign the first derivative. Notice however that if $\frac{\partial}{\partial x}G\left(x,0\right) \leq 0$ for $x = k_i^{NC}\left(0\right)$, then the derivative would be negative for all values before it, given the convexity of G. Therefore it would be true that:

$$G\left(k_i^{NC}\left(0\right),0\right) < G\left(k_i^{C}\left(0\right),0\right)$$

but we know that this is false for (6). Hence, for this condition we must have: $\frac{\partial}{\partial x}G\left(x,0\right) > 0$ for $x = k_i^{NC}\left(0\right)$. Finally recall that $\frac{\partial^2}{\partial\delta\partial x}G\left(x,\delta\right) > 0$ therefore $\frac{\partial}{\partial x}G\left(x,\delta\right) > 0$ for any $\delta > 0$.

This implies that an increase (decrease) of all those parameter which make $k_i^{NC}(0)$ increase (decrease), but leave $k_i^C(0)$ unchanged will reinforce (5). Notice however that

$$\frac{\partial k_i^{NC}(0)}{\partial F} = \frac{8F^2 + 4F(\varphi^H - \varphi^L) + (\varphi^H - \varphi^L)^2}{(4F + \varphi^H - \varphi^L)^2} > 0$$

$$\frac{\partial k_i^{NC}(0)}{\partial(\varphi^H - \varphi^L)} = \frac{2F^2}{(4F + \varphi^H - \varphi^L)^2} > 0$$

and therefore the comparative statics for these parameters is the same as in the model with no complementarity, $\delta = 0$. For the parameters which influence both $k_i^C(0)$ and $k_i^{NC}(0)$ notice that convexity implies:

$$G(x + \Delta, \delta) - G(x, \delta) > G(y + \Delta, \delta) - G(y, \delta) \qquad \text{if} \qquad x > y \qquad (7)$$

which in turn implies:

$$G(x + \Delta', \delta) - G(x, \delta) > G(y + \Delta, \delta) - G(y, \delta) \qquad \text{if} \qquad x > y \qquad \text{and} \qquad \Delta' > \Delta \quad (8)$$

Recalling the definitions of $k_i^C(0)$ and $k_i^{NC}(0)$, there are four parameters which influence both: $v, E[\varphi], \gamma$ and η. A change in the first two (an increase in v and a decrease in $E[\varphi]$), induces the same increase in absolute value of two investment levels, therefore (7) applies and (5) is reinforced. A change of γ and η (an increase of η and a decrease of γ) induces a proportional increase of $k_i^C(0)$ and $k_i^{NC}(0)$. This implies that the latter (which is bigger) increases more than the former. Therefore (8) applies and (5) is again reinforced. Hence the comparative statics for γ parameters is the same as in the model where $\delta = 0$. η enters also in the definition of G. However it is easy to check that an increase in η reinforces (5) even holding $k_i^C(0)$ and $k_i^{NC}(0)$ constant. Therefore also for η the comparative statics is unchanged with respect to the model with $\delta = 0$. ∎

Proof of Proposition 7
Without loss of generality, let firm 1 be the firm for which the asset has a positive value, that is $\varphi_1 \in \{\varphi^H, \varphi^L\}$. We distinguish between two cases, according to whether the inefficiency occurs when $\theta = \theta_B$ or $\theta = \theta_G$.

Case 1: Inefficient decisions when $\theta = \theta_B$. We consider two sub-cases: contracts with an inefficient allotment of the asset A and contracts with inefficient continuation of the partnership.

1.1 *Contracts with an inefficient allotment of the asset A*
An inefficient allotment of the asset occurs whenever the asset is not assigned to firm 1. Consider the case where $b \geq 0$. Note first that in this case an inefficient allotment of A might occur only when the buy/sell decision is taken by firm 1 since firm 2 always chooses to sell A. Therefore, we consider the case in which firm 1 has been selected to choose whether to buy or to sell the asset. Two cases are possible:

1. $b > \frac{\varphi^H}{2}$;both types of firm 1 prefer to sell the asset given that $\varphi^k - b < b$ for both $k = \{H, L\}$. The expected pay-off of firm 1 is b while that of firm 2 is $-b$. In this case the contract can be efficiently renegotiated in the following way: firm 1 proposes to set a new price $\hat{b} = -b$. Provided that the proposal is accepted, then firm 1 buys the asset and obtains $\varphi^k - \hat{b} > b$ for $k = \{H, L\}$. Firm 2 is indifferent between accepting or rejecting the offer and therefore accepting it is a best response.

2. $\frac{\varphi^L}{2} < b \le \frac{\varphi^H}{2}$; type φ^H is willing to buy the asset thus obtaining $\varphi^H - b$ while type φ^L is sells A thus obtaining b. The expected pay-off of firm 2 is $\frac{1}{2}(b) + \frac{1}{2}(-b) = 0$ and there is an inefficient allotment of the asset with probability $\frac{1}{2}$. The following proposal is beneficial for both firms and leads to an efficient allotment of the asset: firm 1 proposes to set a new price $\hat{b} = 0$. More precisely, the (pooling) equilibrium is such that firm 1 offers $\hat{b} = 0$ independently of its type and firm 2 accepts this proposal. Note that, independently of its beliefs, firm 2 rejects any renegotiation proposal $\hat{b} < 0$. Finally suppose that the initial contract specifies a negative price for acquiring the asset: $b < 0$. In this case there is inefficient allotment of the asset whenever firm 2 takes the buy/sell decision. Indeed, firm 2 inefficiently buys the asset and the pay-off of firm 1 and 2 is $-b$ and b respectively. This contract can be efficiently renegotiated in the following way: firm 1 propose $\hat{f} = 1$, $\hat{b} = 0$ and pays $-b$ to firm 2 conditional upon acceptance of the proposal.

1.2 *Contracts with inefficient continuation of the partnership*

An inefficient continuation of the partnership occurs whenever a firm which can veto the termination of the partnership prefers to continue it when $\theta = \theta_B$.

1. Firm 2 prefers to continue the partnership. Suppose that firm 2 prefers to continue the partnership once $\theta = \theta_B$ occurred. Then both firms obtain 0. However, the contract can be efficiently renegotiated in the following way: firm 1 proposes to include the following termination clause: $\hat{d} = 1, \hat{b} = 0$ and $\hat{f} = 1$. If the proposal is accepted, firm 1 terminates the partnership and buys the asset at price $\hat{b} = 0$; therefore its expected pay-off is $\varphi^k > 0$ for both $k = \{H, L\}$. Firm 2 is indifferent between accepting or rejecting the proposal and thus accepting is optimal.

2. Firm 1 prefers to continue the partnership. Consider that $\theta = \theta_B$ occurred. We need to consider two subcases.

   (a) Both types of firm 1 prefer to continue the partnership (this happens for instance when $d = 1$, $b > \varphi^H$ and $f = 0$) and then both firms expect to obtain 0. In this case the initial contract can be efficiently renegotiated in the following way: firm 1 proposes to include the following clause: $\hat{d} = 1, \hat{b} = 0$ and $\hat{f} = 1$. If the proposal is accepted, firm 1 terminates the partnership and buys the asset at the price $\hat{b} = 0$; therefore its expected pay-off is φ^k for both $k = \{H, L\}$. Firm 2 is indifferent between accepting or rejecting the proposal and thus accepting it is optimal.

(b) Only type φ^L prefers to continue the partnership (this happens for instance when $d = 1$, $\varphi^L < b \le \varphi^H$ and $f = 0$). In this case firm 2 expects to obtain $\frac{b}{2}$ and the partnership is inefficiently continued with probability $\frac{1}{2}$. The following proposal by firm 1 eliminates this inefficiency: $\hat{d} = 1$, $\hat{b} = \frac{b}{2}$ and $\hat{f} = 1$. More precisely, the (pooling) equilibrium is the following. Independently of its type, firm 1 offers $\hat{b} = \frac{b}{2}$; firm 2 accepts $\hat{b} = \frac{b}{2}$ and any $\hat{b} \ge b$, and rejects otherwise. Firm 2 believes that $\mu\left(\hat{b} \ne \frac{b}{2}\right) = 1$ and $\mu\left(\hat{b} = \frac{b}{2}\right) = \frac{1}{2}$. Consider firm 1. According to the equilibrium it obtains a pay-off equal $\varphi^k - \frac{b}{2} - \varepsilon$ for $k = \{H, L\}$. Offering $\hat{b} \ne \frac{b}{2}$ cannot be part of the equilibrium, since either the proposal is rejected or it is dominated by $\hat{b} = \frac{b}{2}$. Making no proposal firm 1 obtains a pay-off equal to 0, if it is of type φ^L, or equal to $\varphi^H - b < \varphi^L$, if it is of type φ^H, where b is the price of the asset A in the original inefficient contract (which is greater than φ^L). Both payoffs are less than the equilibrium payoff. Consider firm 2. Firm 2 is indifferent between accepting the proposal $\frac{b}{2}$, and rejecting it. Moreover, accepting any $\hat{b} \ge b$ is a dominant strategy. Finally, the equilibrium beliefs satisfy the D1 criterion. In fact, let ρ denote the probability that the proposal is accepted. First note that to offer $\hat{b} > b$ is a dominated strategy for both types of firm 1; $\mu\left(\hat{b} \ne \frac{b}{2}\right) = 1$ follows directly by the intuitive criterion if $\varphi^L < \hat{b} \le b$. Consider any $\hat{b} \le \varphi^L$; type φ^H is willing to make such an offer if

$$\rho(\varphi^H - \hat{b}) + (1 - \rho)\left(\varphi^H - b\right) - \varepsilon \ge \varphi^H - b$$

which implies

$$\rho \le \frac{\varepsilon}{b - \hat{b}} \equiv \bar{\rho}_H$$

Type φ^L is willing to offer $\hat{b}$ if

$$\rho(\varphi^L - \hat{b}) - \varepsilon \ge 0$$

which implies

$$\rho \le \frac{\varepsilon}{\varphi^L - \hat{b}} \equiv \bar{\rho}_L$$

Since $\bar{\rho}_H < \bar{\rho}_L$, the D1 criterion applies.

Case 2: Inefficient decision when $\theta = \theta_G$ occurred.
There is inefficiency at $t = 1$ once $\theta = \theta_G$ occurred when the partnership is terminated with some positive probability. There exists at least one case in which such a contract is renegotiation-proof. Suppose that firm 1 has the unilateral right to terminate the partnership (namely $d = 1$ or $d = 1 \vee 2$), $\varphi^H - b > sv$ and $\varphi^L - b \le sv$. In this case type φ^H chooses termination and type φ^L chooses continuation. This contract is renegotiation-proof. Indeed, the contract could be efficiently renegotiated only if firm 2 would accept a lower share of the

profits in order to induce type φ^H to continue the partnership. However it can be checked that according to the divinity criterion D1, any proposal with a new share $s' < s$ is rejected by firm 2 since it assigns probability one that the proposer is type φ^L. Therefore whenever firm 1 is of type φ^H there is inefficient termination when $\theta = \theta_G$ occurred. Nevertheless, we show that the contract defined in Proposition 2 Pareto dominates any contract which induces inefficient termination with positive probability. Let τ the probability that the partnership is continued when $\theta = \theta_G$ and $(1 - \tau)$ the probability that it is terminated. In this latter case the selling firm obtains b while the buyer obtains $\varphi_i - b$. As shown in the first part of this proof the contract either provides for an efficient termination and allotment of the asset or it is efficiently renegotiated when $\theta = \theta_B$. Suppose that parties wrote a contract that induces inefficient termination with probability $(1 - \tau)$ when $\theta = \theta_G$. Then firm 1 and firm 2 choose k_1 and k_2 in order to maximize:

$$p\left(k_1, k_2\right)\left(\tau s v + (1 - \tau)\left(\frac{E[\varphi]}{2}\right)\right) + (1 - p\left(k_1, k_2\right))\left(\frac{E[\varphi]}{2}\right) - \frac{\gamma k_1^2}{2},$$

$$p\left(k_1, k_2\right)\left(\tau\left(1 - s\right) v + (1 - \tau)\left(\frac{E[\varphi]}{2}\right)\right) + (1 - p\left(k_1, k_2\right))\left(\frac{E[\varphi]}{2}\right) - \frac{\gamma k_2^2}{2},$$

respectively. From the first order condition one can derive

$$k_1\left(s, \tau\right) = \frac{\tau\left(s v - \frac{E[\varphi]}{2}\right)}{2\gamma}, k_2\left(s, \tau\right) = \frac{\tau\left((1 - s) v - \frac{E[\varphi]}{2}\right)}{2\gamma}$$

and check that $k_1\left(s, \tau\right) + k_2\left(s, \tau\right)$ is increasing in τ. This means that the overall investment (and the probability of $\theta = \theta_G$) is largest if there is always efficient continuation when $\theta = \theta_G$.
∎

Proof of Proposition 8
First we show that there exist a PBE in which the initial contract is not renegotiated; afterwords we show that the beliefs that support such equilibrium satisfy the divinity criterion D1. Let Φ_i denote the type of firm i that has not observed its valuation of the asset and O_i, L_i, H_i denote the type of firm i that has observed that its valuation is 0, φ^L and φ^H respectively and with $i = 1, 2$. Without loss of generality, let firm 1 be the proposer during the renegotiation stage. Firm 1 can make no proposal or it can propose to set a price r for the asset that induces efficient allotment in case of termination, that is $r \in \left[0, \frac{\varphi^L}{2}\right]$.

Equilibrium strategies
Firm 1 does not make any renegotiation proposal; type Φ_2 of firm 2 rejects any renegotiation proposals and holds the following beliefs: $\mu\left(H_1/r\right) = 1$ for all $r \in \left[0, \frac{\varphi^L}{2}\right]$.[27] Consider firm

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[27]To prove formally this result we should specify what is the best response of types $(0)_2, (L)_2, (H)_2$ when receiving a proposal r. However, given that the probability that firm 2 has already observed its type is infinitely small what types $(0)_2, (L)_2, (H)_2$ do is not relevant to characterize the equilibrium choice of firm 1.

1. Type Φ_1 knows that a proposal is rejected at least with probability $\left(1 - \frac{\lambda}{2-\lambda}\right)$, which is the probability that firm 2 is of type Φ_2 conditional on the fact that firm 1 is of type Φ_1. Therefore, for λ infinitely small the probability of acceptance tends to zero and type Φ_1 prefers not to make a proposal in order to avoid the cost of making the proposal, ε. The same argument holds for types O_1, L_1 and H_1. Consider firm 2. Given its beliefs, when it receives an offer $r \in \left[0, \frac{\varphi^L}{2}\right]$ type Φ_2 expects to obtain r by accepting; by rejecting such proposal it expects to obtain $\frac{\varphi^H}{2}$ since in the ensuing signalling game it will face type H_1 with probability 1. Therefore, rejecting r is optimal for type Φ_2 given its beliefs.

Beliefs

We show now that $\mu(H_1/r) = 1$ satisfies the divinity criterion D1.

Consider type H_1; making an offer $r \in \left[0, \frac{\varphi^L}{2}\right]$ which is accepted by firm 2 with probability ρ is a best response provided that:

$$p(k_1, k_2)(sv) + (1 - p(k_1, k_2))\left(\rho\left(\varphi^H - r\right) + (1 - \rho)\left(\frac{\varphi^H}{2} - \varepsilon\right)\right) - \varepsilon \geq$$

$$p(k_1, k_2)(sv) + (1 - p(k_1, k_2))\left(\left(\frac{\varphi^H}{2} - \varepsilon\right)\right)$$

Consider what happens in case $\theta = \theta_B$. If firm 1 has made an offer that has been accepted, then it will buy the asset at the price r. If the proposal has been rejected, then firm 2 believes that it faces type H_1 and, in the ensuing bargaining, it will accept only offers equal or larger than $\frac{\varphi^H}{2}$. On the contrary, if type H_1 does not make any offer then, in case of $\theta = \theta_B$ the equilibrium of Proposition 3 follows. Rearranging the above inequality, type H_1 is better-off making a proposal provided that it is accepted with probability

$$\rho \geq \frac{2\hat{\varepsilon}}{\varphi^H - 2r + 2\varepsilon} \equiv \overline{\rho_{H_1}}$$

where $\hat{\varepsilon} = \frac{\varepsilon}{1 - p(k_1, k_2)}$.

Consider type L_1; making an offer $r \in \left[0, \frac{\varphi^L}{2}\right]$ which is accepted by firm 2 with probability ρ is a best response provided that:

$$p(k_1, k_2)(sv) + (1 - p(k_1, k_2))\left(\rho\left(\varphi^L - r\right) + (1 - \rho)\left(\frac{\varphi^L}{2} - F\right)\right) - \varepsilon \geq$$

$$p(k_1, k_2)(sv) + (1 - p(k_1, k_2))\left(\frac{\varphi^L}{2} - F(1 - \beta) - \varepsilon\right).$$

Note that in this case if the proposal is rejected then in case of $\theta = \theta_B$, in the ensuing bargaining game, type L_1 does not make any offer and firms litigate in front of the Court; indeed, after rejecting the proposal firm 2 believes with probability 1 that it faces type H_1

and accepts only offers equal or larger than $\frac{\varphi^H}{2}$. Rearranging the above inequality, type L_1 is better-off making a proposal provided that it is accepted with probability

$$\rho \geq \frac{2\left(F\beta - \varepsilon + \hat{\varepsilon}\right)}{\varphi^L - 2r + 2F} \equiv \overline{\rho_{L_1}}$$

Consider type O_1; making an offer $r \in \left[0, \frac{\varphi^L}{2}\right]$ which is accepted by firm 2 with probability ρ is a best response provided that:

$$p\left(k_1, k_2\right)(sv) + \left(1 - p\left(k_1, k_2\right)\right)\left(\rho\left(r\right) + (1 - \rho)\left(\frac{1}{2}\left(\frac{\varphi_2^L}{2}\right) + \frac{1}{2}\left(\alpha\frac{\varphi^L}{2} + (1-\alpha)\frac{\varphi^H}{2}\right)\right)\right) - \varepsilon \geq$$

$$p\left(k_1, k_2\right)(sv) + \left(1 - p\left(k_1, k_2\right)\right)\left(\frac{1}{2}\left(\frac{\varphi^L}{2}\right) + \frac{1}{2}\left(\alpha\frac{\varphi^L}{2} + (1-\alpha)\frac{\varphi^H}{2}\right)\right).$$

In case $\theta = \theta_B$, if the proposal has been accepted, then firm 1 will sell the asset at the price r; if the proposal has been rejected then type O_1 knows that it is facing type L_2 or type H_2 with equal probability (note that, when making the renegotiation proposal type O_1 knows that it is facing type Φ_1); therefore in case of rejection firms will play the bargaining game specified in Proposition 3, where firm 1 is the firm that receives the proposal. Rearranging the above inequality it can be shown that type O_1 is better-off making a proposal provided that it is accepted with probability

$$\rho \geq \frac{4\hat{\varepsilon}}{4r - 2E[\varphi] + \alpha\left(\varphi^H - \varphi^L\right)} \equiv \overline{\rho_{O_1}}$$

Finally consider type Φ_1. This type of firm 1 ignores the type of firm 2 that it is facing; conditional upon the fact that firm 1 has not observed its type, then the probability that firm 2 has already observed its type is $\frac{\lambda}{2-\lambda}$ while the probability that 2 is of type Φ_2 is $\left(1 - \frac{\lambda}{2-\lambda}\right)$. For λ infinitely small then only what type Φ_2 is relevant. Therefore, type Φ_1 is better-off making an offer r which is accepted by firm 2 with probability ρ provided that:

$$p\left(k_1, k_2\right)(sv) + \left(1 - p\left(k_1, k_2\right)\right)\left\{\rho\left[\frac{1}{2}\left(E[\varphi] - r\right) + \frac{1}{2}\left(r\right)\right] + \right.$$

$$(1 - \rho)\left[\frac{1}{2}\left(\frac{1}{2}\left(\frac{\varphi^L}{2} - F\right) + \frac{1}{2}\left(\frac{\varphi^H}{2} - \varepsilon\right)\right) + \right.$$

$$\left.\left.\frac{1}{2}\left(\frac{1}{2}\left(\frac{\varphi^L}{2}\right) + \frac{1}{2}\left(\alpha\frac{\varphi^L}{2} + (1-\alpha)\frac{\varphi^H}{2}\right)\right)\right]\right\} - \varepsilon \geq$$

$$p\left(k_1, k_2\right)(sv) + \left(1 - p\left(k_1, k_2\right)\right)\left[\frac{1}{2}\left(\frac{1}{2}\left(\frac{\varphi^L}{2} - F(1-\beta) - \varepsilon\right) + \frac{1}{2}\left(\frac{\varphi^H}{2} - \varepsilon\right)\right) + \right.$$

$$\left.\frac{1}{2}\left(\frac{1}{2}\left(\frac{\varphi^L}{2}\right) + \frac{1}{2}\left(\alpha\frac{\varphi^L}{2} + (1-\alpha)\frac{\varphi^H}{2}\right)\right)\right].$$

Consider what happens in case of $\theta = \theta_B$. When making the renegotiation proposal firm 1 ignores whether it will be the buyer or the seller of the asset. If the proposal is accepted, then

with probability $\frac{1}{2}$ firm 1 will be the buyer thus obtaining $E[\varphi]-r$, and with probability $\frac{1}{2}$ it will be the seller thus obtaining $\frac{1}{2}$. Similarly, in case of rejection of the proposal with equal probability firm 1 will be the buyer or the seller of the asset; in the former case, firm 2 will accept only proposals larger than $\frac{\varphi^H}{2}$ while in the latter the two firms play the bargaining game specified in Proposition 3 with firm 2 being the proposer. Finally, if no renegotiation proposal is made, then the usual bargaining game of Proposition 3 is played with firm 1 and firm 2 being the proposer with probability $\frac{1}{2}$. Rearranging the above inequality, one obtains that type Φ_1 is willing to make a renegotiation proposal provided that firm 2 accepts it at least with probability:

$$\rho \geq \frac{2\left(4\hat{\varepsilon} + F\beta - \varepsilon\right)}{2F + 2\varepsilon + \alpha\left(\varphi^H - \varphi^L\right)} \equiv \bar{\rho}_{\Phi_1}.$$

It is easy the verify that for ε small enough $\bar{\rho}_{H_1}$ is smaller than $\bar{\rho}_{L_1}$ and $\bar{\rho}_{\Phi_1}$. Moreover, $\bar{\rho}_{H_1} < \bar{\rho}_{O_1}$ provided that $r < \frac{1}{8}\left(2\varphi^H + 4\varepsilon + 2E[\varphi] - \alpha\left(\varphi^H - \varphi^L\right)\right)$ which is verified since

$$\frac{\varphi^L}{2} < \frac{1}{8}\left(2\varphi^H + 4\varepsilon + 2E[\varphi] - \alpha\left(\varphi^H - \varphi^L\right)\right)$$

■

Proof of Proposition 9
Consider the investment game. The utility that firm $i = 1$ or 2 obtains is $u_i\left(k_1, k_2, \xi\right) = p(k_1, k_2)\sigma_i v + (1 - p(k_1, k_2))\left(\frac{E[\varphi]}{2} - \xi\right) - c_i\left(k_1, k_2\right)$, where $1 > \sigma_i > 0$ denotes the share of the monetary value v assigned to firm i while ξ denotes the expected cost of litigation; ξ is positive and bounded above when firms sign an incomplete contract and litigate with positive probability if the project fails, as shown in Proposition 3 while it is zero in case of a complete contract. The assumptions of Proposition 9 guarantee that $\frac{\partial u_i(k_i, k_{3-1}, \xi)}{\partial k_i \partial k_{3-i}} \geq 0$ for both $i = 1, 2$ which, in turn, imply that investment game is supermodular and, therefore, that a Nash equilibrium in pure strategies exists. Moreover, note that in case firms sign an incomplete contract, $\frac{\partial u_i(k_i, k_{3-1}, \xi)}{\partial k_i \partial \xi} = \frac{\partial p(k_i, k_{3-i})}{\partial k_i} > 0$ and, then, it follows that the utility function $u_i\left(k_i, k_{3-1}, \xi\right)$ has increasing differences in (k_i, ξ). Therefore, by well-known results on supermodular games (see Vives, 1999 for a review), since the investment game is a supermodular game indexed by ξ, the largest (and the smallest) Nash equilibria are increasing in ξ. Finally, given that $\frac{\partial u_i(k_i, k_{3-i}, \xi)}{\partial k_{3-i}} = \frac{\partial p(k_i, k_{3-i})}{\partial k_{3-i}}(\sigma_i v - \frac{E[\varphi]}{2} + \xi) > 0$, then the investment game is supermodular with positive spillovers, hence the largest Nash equilibrium is the Pareto-preferred. ■