TRANSACTION COSTS AND THE ROBUSTNESS OF THE COASE THEOREM*

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This paper explores the extent to which *ex ante* transaction costs may lead to failures of the Coase Theorem. In particular we identify the basic 'hold-up problem' that arises whenever the parties to a Coasian negotiation have to pay *ex ante costs* for the negotiation to take place. We then show that a 'Coasian solution' to this problem is not available: a Coasian solution typically entails a negotiation about the payment of the costs associated with the future negotiation, which in turn is associated with a fresh set of *ex ante* costs, and hence a new hold-up problem.

The Coase theorem (Coase, 1960) has had a profound influence on the way economists and legal scholars think about *inefficiencies*. It guarantees that provided that *property rights* are allocated, fully informed rational agents involved in an inefficient situation will ensure through negotiation that there are no unexploited gains from trade and hence an efficient outcome obtains.

In its strongest formulation, the Coase theorem is interpreted as guaranteeing an efficient outcome regardless of the 'way in which property rights are assigned' (Nicholson, 1989, p. 725) and whenever the potential mutual gains 'exceed [the] necessary bargaining costs' (Nicholson, 1989, p. 726).[1]

The predictions entailed by the stronger version of the Coase theorem are startling. Whenever property rights are allocated, we should observe only outcomes that are *constrained efficient* in the sense that all potential gains from trade (net of transaction costs) are exploited. This clearly contradicts even the most casual observation of empirical facts. There are many obvious instances of situations in which Pareto improving negotiation opportunities are available, but are left unexploited by the parties involved.[2]

If we were to believe the predictions of the 'strong' Coase theorem, all these apparent inefficiencies would not be real inefficiencies at all. They should simply

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[1] This stronger version of the Coase theorem does *not* correspond to what is claimed in Coase (1960), but it is an interpretation of it that is sufficiently common to have found its way into basic microeconomic text-books such as the one quoted above.

[2] Of course, we are not claiming that these observed inefficiencies can necessarily be traced to the sources we identify in our analysis below. In many cases a simple appeal to 'irrational expectations' suffices to explain observed failures to exploit potential gains from trade. See our discussion of some anecdotal evidence that we believe fits our model well in Section 2 below.

be viewed as the result of transaction costs that are 'high' relative to the potential gains from trade. We take the view that this is not a satisfactory explanation of these observed facts.

Our aim in this article is to take issue with this strong version of the Coase theorem and show that the impact of transaction costs can extend over and above their size relative to the potential gains from trade. This stems from the *strategic role* that transaction costs may play in a Coasian negotiation. It turns out that a key factor in determining the strategic role of transaction costs is whether they are payable *ex ante* or *ex post*; after the negotiation concerning the distribution of the unexploited gains from trade takes place. We show that in the presence of *ex ante* transaction costs a *constrained inefficient* outcome may obtain.

In Anderlini and Felli (2001*a*) (henceforth AF) we introduce *ex ante* costs in each round of an alternating offers bargaining model (Rubinstein, 1982). In each period, both the proposer and the responder must pay a cost for the negotiation to proceed. If either player declines to pay, the current round of offer and response is cancelled and play moves on to the next round.

In that article we show that it is always an equilibrium for both players *never* to pay the *ex ante* costs and hence never to agree on a division of the potential surplus, although the sum of the *ex ante* costs is strictly lower than the surplus itself. Moreover, we show that this is the *unique* equilibrium outcome in both the following cases:

(1) If the sum of the *ex ante* costs is not 'too low' (but still less than the available surplus) and/or the distribution of these costs across the players is sufficiently asymmetric, and
(2) If we impose that the equilibrium must be robust to the possibility that the players might find a way to renegotiate out of future inefficiencies.[3]

Thus, in AF we show that when the distribution of surplus across contracting parties is endogenous (it is the outcome of the bargaining – if it ever takes place), transaction costs that are payable *ex ante* can have a devastating effect on efficiency.

In this article, we take it as given that if the negotiating stage is reached an agreement will result and, for simplicity, we take as (parametrically) given the parties' shares of surplus in this agreement. We then introduce transaction costs that are payable *ex ante*: the negotiation stage is reached only if these costs are paid. We find that for some combinations of bargaining power (determining surplus shares) and *ex ante* costs adding up to less than the available surplus, no agreement will take place because the costs will not be paid.

A natural further question follows at this point. Suppose that we allow the parties to negotiate some compensating transfers *before* the *ex ante* costs are payable. In

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[3] In AF we actually propose a modification of the extensive form that is meant to capture the requirement of renegotiation-proofness. This is because, there, we take the view that 'black-box' renegotiation is not an appropriate modelling ingredient in a model of the actual negotiation between players.

other words, suppose that we endow the parties with the possibility of undoing the effects of the *ex ante* transaction costs in a Coasian way ahead of time. Is it then the case that the inefficiencies we found will disappear? The answer we obtain is 'no', provided that the negotiation of the compensating transfers is itself associated with a fresh set of *ex ante* transaction costs, *regardless of how small these new costs are.*

Proceeding with a simple stripped-down model of the negotiating phase (in essence a single parameter between 0 and 1) has a two-fold advantage. First of all, it safely allows us to abstract from the problem analysed in AF, so that we know that the efficiency failures that we find here come from a different source than the one pinpointed there. Secondly, it allows us to check the robustness of our results to some basic changes in the way *ex ante* costs are payable, keeping the analysis at a very tractable level. In particular, below we show that our results are 'pervasive' in the sense that they survive when it is enough that *one* party pays, and when the *ex ante* costs are modelled as 'strategic complements'.

We begin our analysis with a brief review of the related literature (Section 1) and a discussion of the possible interpretations of the *ex ante* transaction costs (Section 2). We then proceed in Section 3 to present the simplest possible model of the basic hold-up problem associated with a surplus-enhancing negotiation. This problem is analysed in the case in which the *ex ante* costs associated with the Coasian negotiation are either complements or substitutes. In Section 4 we address the question of whether a Coasian solution to our basic hold-up problem is plausible. We do this by analysing the possibility of a negotiated transfer from one party to the other before the payment of the transaction costs that are at the origin of the hold-up problem. In Section 5 we look at how the allocation of property rights may or may not alleviate the inefficiencies stemming from *ex ante* transaction costs. Section 6 offers some concluding remarks. To ease the exposition, we have relegated all proofs to the Appendix.

1. Related Literature

What has become known as the Coase theorem (Coase, 1960) assumes the absence of transaction costs or other frictions in the bargaining process. Coase (1960) himself does provide an extensive discussion of the role of transaction costs.[4] Indeed, Coase (1992) describes the result as provocative and intended to show how unrealistic is the world without transaction costs.

Here and in AF, we go further by identifying the strategic role played by *ex ante* transaction costs (as opposed, for instance, to transaction costs that are payable *ex post*) which may lead to an outcome that is *constrained inefficient.*

The source of inefficiencies in this article is a version of the 'hold-up problem' (Grout, 1984; Grossman and Hart, 1986; Hart and Moore, 1988, among many others). The problem is particularly acute in our setting since it may be impossible for the negotiating parties to find a 'Coasian solution' to this hold-up problem. Closely linked to the literature on the hold-up problem is the literature on the

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[4] de Meza (1988) provides an extensive survey of the literature on the Coase theorem, including an outline of its history and possible interpretations.

effects of the allocation of property rights when contracts are incomplete (Grossman and Hart, 1986; Hart and Moore, 1990; Chiu, 1998; de Meza and Lockwood, 1998; Rajan and Zingales, 1998, among many others). It turns out that the effects of the allocation of property rights on the version of the hold-up problem we analyse here depends on how the parties' outside options affect the division of surplus. We devote Section 5 below entirely to this point.

We are certainly not the first to point out that the Coase theorem no longer holds when there are frictions in the negotiation process. There is a vast literature on bargaining models where the frictions take the form of incomplete and asymmetric information. With incomplete information, efficient agreements often cannot be reached and delays in bargaining may obtain.[5] By contrast, the reduced form negotiation that we consider in our analysis is one of complete information. The source of inefficiencies in this article can therefore be traced directly to the presence of transaction costs.

Dixit and Olson (2000) are concerned with a classical Coasian public good problem in which they explicitly model the agents' *ex ante* (possibly costly) decisions of whether to participate or not in the bargaining process. In their setting they find both efficient and inefficient equilibria as opposed to the unique constrained inefficient equilibrium we derive in our setting. They also highlight the inefficiency of the symmetric (mixed-strategy) equilibria of their model.

2. *Ex Ante* Transaction Costs

We are concerned with Coasian negotiations in which the parties have to incur some *ex ante* transaction costs, before they reach the stage in which the actual negotiation occurs.

The interpretation of these *ex ante* transaction costs which we favour is that of time spent 'preparing' for the Coasian negotiation. Typically, a variety of tasks need to be carried out by the parties involved before the actual negotiation begins.

In those cases in which the negotiation of an agreement contingent on a state of nature is concerned, both parties need to conceive of, and agree upon, a suitable language to describe the possible realisations of the state of nature precisely. The parties also need to collect and analyse information about the 'legal environment' in which the agreement will be embedded. For instance, in different countries the same agreement will need to be drawn-up differently to make it legally enforceable.

In virtually all settings in which a negotiation is required, the parties need to spend time arranging a way to 'meet' and they need to 'earmark' some of their time schedules for the actual meeting.

In many cases, before a meaningful negotiation can start, the parties will need to collect and analyse background information that may be relevant to their understanding of the actual trading opportunities. These activities may range from

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[5] See Muthoo (1999) for an up-to-date coverage as well as extensive references on this strand of literature and other issues in bargaining theory.

collecting information about (for instance the creditworthiness of) the other party, to actual 'thinking' or 'complexity' costs incurred to understand the negotiation problem. We view this type of *ex ante* transaction costs as both relevant and important for the type of effects which we identify in our analysis below. However, it should be emphasised that our model does not *directly* apply to this type of costs. This is because in our model the size of the gains from trade is fixed and known to the parties. On the other hand, the lack of information and/or understanding of the negotiation setting that we have just described, would clearly make the size of the surplus uncertain for the parties involved. We have not considered the case of uncertain surplus for reasons of space and analytical convenience. However, we conjecture that the general flavour of our results generalises to this case.

Where does one look for evidence of transactions that never took place because of *ex ante* costs? This is obviously no easy endeavour, aside perhaps from small things like not inspecting a used car because the negotiation can only take place after sinking the cost of travelling to where the car is kept.

There is a well known colourful story – an anecdotal piece of evidence – that, in our view, fits the bill well enough to be mentioned here.[6] In 1980, IBM (then the unchallenged dominant player in the computer industry) decided to enter the market for Personal Computers. IBM did not have an operating system for PCs. To acquire an operating system from an outside source they sent a delegation to visit the offices of Microsoft to negotiate. At the time, however, Microsoft did not own an operating system either, and so they referred the visitors from IBM to a small company – Intergalactic Digital Research – that had a working operating system for PCs. The surprise match between IBM and Digital Research never reached the actual negotiation stage. The founder of Digital Research (Gary Kildall) refused to meet with the IBM delegation because he had 'other plans'. His wife (Dorothy Kildall) met with the representatives of IBM but refused their request to sign a non-disclosure agreement. Eventually, the IBM representatives left without any negotiation concerning the actual deal having taken place.

The interpretation of events in line with our main point in this paper is clear. If the negotiating stage had been reached, IBM's bargaining power would have been extreme. As a result Digital Research did not pay the *ex ante* costs necessary to reach the actual negotiation stage: Gary Kildall decided that his time was better employed elsewhere and Dorothy Kildall was put off by the non-disclosure agreement, a likely signal of the length and complexity of the negotiation to come, as well as a possible direct liability. The inefficiency of the outcome reached is

[6] The story was the subject of a documentary series aired in 1996 by PBS television stations in the US. The documentary was entitled *Triumph of the Nerds: The Rise of Accidental Empires*. The transcripts can be found at http://www.pbs.org/nerds/. The documentary series was in turn based on Cringely (1992). The basic facts summarised here seem to be reasonably uncontroversial. However, it should also be pointed out that the story is so widely known that differing interpretations and versions of some of its details can be found in copious amounts on the World Wide Web. These include disputed accounts of a subsequent meeting between Gary Kildall of Digital Research and IBM. If this meeting did take place, clearly it did not generate an operative deal. Of course, the interpretation of the facts that we give is our own.

apparent: ownership of the dominant operating system for PCs turned out to be worth tens of billions of dollars in the following two decades alone.[7]

We conclude this Section with an observation. In many cases the parties to a negotiation will have the opportunity to delegate to outsiders many of the tasks that we have mentioned as sources of *ex ante* transaction costs. The most common example of this is the hiring of lawyers. Abstracting from agency problems (between the negotiating party/principal and the lawyer/agent), which are likely to increase the *ex ante* costs anyway, our analysis applies, unchanged, to the case in which the *ex ante* transaction costs that we have described are payable to an agent.

3. The Basic Hold-up Problem

We focus on three basic cases in which the presence of *ex ante* transaction costs generates the hold-up problem we have outlined informally above.

The three cases we pursue in detail are chosen with a two-fold objective in mind. First of all they are the simplest models that suffice to put across the main point. Second, the range of cases they cover is meant to convey the fact that the inefficiency we find is 'pervasive' in the sense that it obtains in a whole variety of extensive forms. In Anderlini and Felli (2001*b*) we show that the basic hold-up problem identified here survives when we allow transaction costs to be continuous as opposed to the binary choice considered here.

3.1. *Perfect Complements*

Consider two agents, called *A* and *B*, who face a 'Coasian' opportunity to realise some gains from trade. Without loss of generality we normalise to one the size of the surplus realised if an agreement is reached. We also set the parties' payoffs in the case of disagreement to be equal to zero.

In the first two cases we look at, once the negotiating phase is reached the division of surplus between the two agents is exogenously given and cannot be changed by the agents.[8]

Let $\lambda \in [0, 1]$ be the share of the surplus that accrues to agent *A* if the parties engage in the negotiation and $1 - \lambda$ the share of the surplus that accrues to *B*.

For the negotiation to start, each agent has to pay a given *ex ante transaction cost*. In other words, the agents reach the negotiating phase only if they both pay a

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[7] The enormity of the value of the missed transaction raises an obvious question: were Digital Research simply 'dumb' as some of the characters involved seem to suggest in the transcripts of the documentary cited above? (see footnote 6). Our reply is two-fold. First, the value of the failed transaction was surely highly uncertain at the time. To measure it with its *realised* value more than 20 years later does not seem correct. Second, the realised value of the failed transaction is measured by the subsequent success of Microsoft. However, while Microsoft *did* supply IBM with an operating system for PCs soon after the events we have described, they did not *sell* it, but rather they *licensed* it to IBM. Microsoft concluded a deal with IBM using a contractual device that, as it turns out, shifted the division of surplus dramatically in its favour.

[8] See our introduction for a discussion of AF where the division of surplus is endogenously determined by the model.

certain amount before the negotiation begins.[9] These costs should be thought of as representing a combination of the activities necessary for the gains from trade to materialise which we discussed in some detail in Section 2.

Let $c_A > 0$ and $c_B > 0$ be the two agents' *ex ante* costs. Clearly, if $c_A + c_B > 1$ then the two agents will never reach the negotiation stage that yields the unit surplus. Clearly, neither would a social planner since the total cost of the negotiation exceeds the surplus which it yields. We are interested in the case in which it would be socially efficient for the two agents to negotiate an agreement. Our first assumption guarantees that this is the case.

ASSUMPTION 1: *The surplus that the negotiation yields exceeds the total ex ante costs that are payable for the negotiation to occur. In other words $c_A + c_B < 1$.*

Our two agents play a two-stage game. In period $t = 0$ they both simultaneously and independently decide whether to pay their *ex ante* cost. An agreement yielding a surplus of size one at $t = 1$ is feasible only if both agents pay their *ex ante* costs at $t = 0$.[10] The game at $t = 1$ is a simple 'black box', yielding payoffs of λ to A and $1 - \lambda$ to B. If one or both agents do not pay their *ex ante* costs at $t = 0$, the game at $t = 1$ is trivial: the negotiation that yields the unit surplus is not feasible; the agents have no actions to take and they both receive a payoff of zero.

Throughout the article, unless otherwise stated, by equilibrium we mean a *subgame perfect* equilibrium of the game at hand. The normal form that corresponds to the two-stage game we have just described is depicted in Figure 1. From this it is immediate to derive our first Proposition, which therefore is stated without proof.

	pay c_B	not pay c_B
pay c_A	$\lambda - c_A,\ 1 - \lambda - c_B$	$-c_A,\ 0$
not pay c_A	$0,\ -c_B$	$0,\ 0$

Fig. 1.   *Normal Form of the Two-stage Game with Ex Ante Costs*

PROPOSITION 1: *If either $c_A > \lambda$ or $c_B > 1 - \lambda$ the unique equilibrium of the two-stage game represented in Figure 1 has neither agent paying the ex ante cost and therefore yields the no-agreement outcome.*

We view Proposition 1 as implying that in the presence of *ex ante* transaction costs, if the *distribution* of *ex ante* costs across the parties is sufficiently 'mis-matched' with the distribution of surplus, then the *ex ante* costs will generate a version of the hold-up problem which will induce the agents not to negotiate an agreement even though it would be socially efficient to do so.

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[9] Notice therefore that we are implicitly assuming that the agents have some endowments of resources out of which the *ex ante* costs can be paid.

[10] Notice that we are therefore assuming that the two agents' *ex ante* costs are *perfect complements* in the 'technology' that determines whether the surplus-generating negotiation is feasible or not. We examine the cases of perfect substitutes, and of strategic complements in Subsections 3.2 and 3.3 below respectively.

The intuition behind Proposition 1 is simple enough. If negotiating an agreement involves some costs that are payable *ex ante*, the share of the surplus accruing to each party will not depend, in equilibrium, on whether the *ex ante* costs are paid. Therefore, the parties will pay the costs only if the distribution of the surplus generated by the negotiation will allow them to recoup the cost *ex post*. If the distribution of surplus and that of *ex ante* costs are sufficiently 'mis-matched', then one of the agents will not be able to recoup the *ex ante* cost. In this case, an agreement will not be reached, even though it would generate a total surplus large enough to cover the *ex ante* costs of both agents.

As a polar benchmark, consider the alternative setup in which both parties can pay the costs c_A and c_B after the negotiation has occurred and an agreement is reached. In other words the transaction costs can be paid *ex post* rather than *ex ante*.[11] In this case the extensive form of the game is equivalent to a simple negotiation in which the size of the gains from trade is $1 - c_A - c_B$. The assumption we made on the black-box negotiation implies that in this case the two parties do indeed reach an agreement. Party A receives the share of surplus $\lambda (1 - c_A - c_B)$ while party B receives the share $(1 - \lambda) (1 - c_A - c_B)$. In other words when transaction costs can be paid *ex post* the strong version of the Coase Theorem holds and a constrained efficient outcome is guaranteed.

We conclude this subsection with two observations. First of all, the simultaneity in the payment of the *ex ante* costs is not essential to Proposition 1. The result applies to the case in which the *ex ante* costs are payable sequentially by the two agents before the actual negotiation begins.

Second, while the model has a unique equilibrium for the parameter configurations identified in Proposition 1, it has multiple equilibria whenever this proposition does not apply. It is clear that, whenever both $\lambda > c_A$ and $(1 - \lambda) > c_B$, the model has two equilibria. One in which the *ex ante* costs are paid and an agreement is reached, and another in which neither agent pays the *ex ante* costs simply because he expects the other agent not to pay his cost either. The equilibrium in which the agreement is reached strictly Pareto-dominates the no-agreement equilibrium. Clearly, the multiplicity of equilibria disappears if the costs are payable sequentially. The latter observation will become relevant again in Section 4 below.

3.2. *Perfect Substitutes*

We now turn to our second simple model. The next Proposition tells us that when the agents' *ex ante* costs are *perfect substitutes* our constrained inefficiency result of Subsection 3.1 still holds, although the inefficiency may take a different form.

The intuition behind the next results is straightforward. In an environment in which the *ex ante* costs may be paid by *either* agent the negotiation leads to a constrained efficient outcome if *at least one* of the two *ex ante* costs is smaller than the size of the surplus. It is then easy to envisage a situation in which the share of

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[11] These *ex post* costs could, for example, be associated with registering the agreement with the relevant authorities.

the surplus accruing to each agent is strictly smaller than his *ex ante* costs although there is enough surplus to cover the smallest of these costs. In this case, in equilibrium, the parties will not reach an agreement although it would be socially efficient to do so.

When the *ex ante* costs are perfect substitutes, a new type of inefficiency can also arise in equilibrium. In particular, it is possible that the agents reach an agreement, but the equilibrium involves the highest of the two *ex ante* costs being paid.

Formally, when the *ex ante* costs are perfect substitutes Assumption 1 needs to be modified. Assumption 2 below identifies the range of *ex ante* costs that guarantee that negotiating an agreement is socially efficient in this case.

ASSUMPTION 2. *The surplus that the agreement yields exceeds the minimum ex ante cost payable for the negotiation to become feasible. In other words* $\min\{c_A, c_B\} < 1$. *Without loss of generality (up to a re-labelling of agents) let* $c_A \leq c_B$. *Hence* $c_A < 1$.

Consider now the model with *ex ante* transaction costs that are perfect substitutes and let Assumption 2 above hold. The normal form corresponding to the new two-stage game is depicted in Figure 2.

	pay c_B	not pay c_B
pay c_A	$\lambda - c_A, \ 1 - \lambda - c_B$	$\lambda - c_A, \ 1 - \lambda$
not pay c_A	$\lambda, \ 1 - \lambda - c_B$	$0, \ 0$

Fig. 2. *Normal Form When the Ex ante Costs are Perfect Substitutes*

As we mentioned above, the inefficiency generated by the *ex ante* costs can now take two forms, which our next proposition identifies. As before, it is stated without proof since it is immediate from the payoffs in Figure 2.

PROPOSITION 2. *If* $1 > c_A > \lambda$ *and* $c_B > 1 - \lambda$ *the only equilibrium of the two-stage game represented in Figure 2 has neither agent paying the* ex ante *cost, and therefore yields the no-agreement outcome.*

If instead $1 > c_A > \lambda$ *and* $c_B < 1 - \lambda$ *then the only equilibrium of the two-stage game represented in Figure 2 has agent A not paying the ex ante cost* c_A, *and B paying the ex ante cost* $c_B > c_A$.

3.3. Strategic Complements

Our goal in this subsection is to show that the analogue of Proposition 1 holds when the *ex ante* costs are technologically perfect substitutes but are 'strategic complements' in the game-theoretic sense.[12] We conjecture that this is true more generally but limit our formal analysis to a simple model closely related to the previous two.

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[12] Intuitively, two decision variables are strategic complements if an increase in one induces an increase in the optimal choice (the 'best response' of the opposing player) of the other. See Fudenberg and Tirole (1996, ch. 12).

At $t = 0$ both agents decide simultaneously and independently whether to pay their *ex ante* costs. If both agents decide not to pay the *ex ante* costs, then negotiation is not feasible and both receive a payoff of zero. If either agent $i \in \{A, B\}$ pays the *ex ante* cost c_i at $t = 0$ the negotiation of an agreement yielding one unit of surplus becomes feasible. If both pay their *ex ante* costs at $t = 0$ the distribution parameter λ determines the agreement that is negotiated and A's and B's payoffs are $\lambda - c_A$ and $1 - \lambda - c_B$ respectively.

However, if only one agent, say A, pays the *ex ante* cost at $t = 0$, he is allowed to make a take-it-or-leave-it offer ℓ to B at $t = 1$. The value of ℓ is interpreted as an offer to make A's and B's payoffs equal ℓ and $1 - \ell$ respectively, minus any costs paid. This can be thought of as a crude way to say that if only one agent pays the *ex ante* cost then the bargaining power shifts dramatically in his favour.

Moreover, we assume that A, if he alone has paid the *ex ante* cost, can, in principle, make some offers that would push agent B below his individual rationality constraint. In other words we assume that the take-it-or-leave-it offer ℓ must be in the interval $[-\epsilon, 1 + \xi]$ with ϵ and ξ some (possibly small) positive numbers.

At $t = 2$, B has two choices. He can either pay an *ex ante* cost $c'_B > 0$ or pay nothing.[13] If he does not pay he does not observe A's offer, but is still allowed to accept or reject it blind. If B decides to pay his *ex ante* cost, he can then observe A's offer and subsequently decide to accept or reject it.

The description of the extensive form that is played if it is B alone who pays the *ex ante* cost at $t = 0$ is symmetric to the case we have just described.

Notice that the strategic complementarity of the two agents' *ex ante* costs is built into the extensive form game we have described precisely via the shift in bargaining power that obtains when one agent alone pays the *ex ante* costs at $t = 0$.

Suppose now that the parameters λ, c_A and c_B are such that the agents would not negotiate an agreement in the model described in Subsection 3.1. Our next proposition then tells us that, in the model with strategic complementarities we have just described, they will not negotiate an agreement either.

PROPOSITION 3. *Consider the model with ex ante costs that are strategic complements described above in this subsection. Assume that either $\lambda < c_A$ or $1 - \lambda < c_B$. Then the unique equilibrium outcome of the model has neither agent paying the ex ante cost at $t = 0$, and hence the no-agreement outcome obtains.*

4. The Impossibility of a Coasian Solution

In Section 3 we have argued that *ex ante* transaction costs may give rise to a version of the hold-up problem which in turn generates an inefficient (no-agreement) outcome. The next natural question to ask is whether a Coasian solution to the hold-up problem is generally available in the present set up. In other words: is it

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[13] Notice that while Proposition 3 below restricts the values of c_A and c_B to be in an appropriate range, c'_B can take any positive (small) value.

possible to add another stage of negotiation to our model (say $t = -1$), prior to the stage in which the *ex ante* costs are incurred, in which the agents can negotiate a 'grand agreement', which will resolve the hold-up problem and hence restore efficiency?

The answer to the above question is trivially 'yes', if at $t = -1$ a *truly grand* agreement can be negotiated *costlessly*, that specifies everything, including the payment of the *ex ante* costs, *and* the division of the actual surplus at time $t = 1$. The answer, however, changes dramatically if the 'grand agreement' is itself costly.

We specify two crucial details of the grand agreement negotiation stage. First of all we assume, as seems plausible in the present context, that in order to be able to negotiate an agreement at $t = -1$ a fresh set of *ex ante* costs must be incurred by the parties before $t = -1$, say at $t = -2$. Second, we restrict the agents to negotiate a *compensating transfer* at $t = -1$. In other words, we take a specific view on the agreements that the agents can enter at $t = -1$. We restrict them to be transfers *contingent* on the payment of *ex ante* costs at $t = 0$. This seems to be in the spirit of our model of Section 3, in that, in principle, it allows the agents to transfer surplus effectively between them but it keeps the distribution of surplus in the last stage of the negotiating process, $t = 1$, exogenously fixed as before.

It is worth emphasising at this point that we find that the presence of any *strictly positive* 'second tier' *ex ante* costs is sufficient to keep the addition of a grand agreement negotiation stage from resolving the hold-up problem of Section 3. We view this as a strength of the results we present in this Section. In many situations it would be sensible to assume that the second tier *ex ante* costs are in fact at least as large as the 'first tier' *ex ante* costs, on the grounds that the negotiation of a grand agreement, in an intuitive sense, is a more complex object than the negotiation of the agreement itself.

Formally, we modify the first model of Section 3 as follows. There are now four time periods, $t \in \{-2, -1, 0, 1\}$. The sequence of decisions and events for the two agents (depicted schematically in Figure 3) is as follows. In period $t = -2$, the two agents decide simultaneously and independently whether to pay the second tier *ex ante* costs (c_A^2, c_B^2). If either or both agents decide not to pay these *ex ante* costs, the period $t = -1$ compensating transfers to be described shortly are automatically set equal to 0, and the agents effectively move directly to time $t = 0$. If, on the other hand both agents pay the second tier *ex ante* costs, then period $t = -1$ compensating transfers can be negotiated.

For simplicity, we assume that (provided that both pay the second tier costs) at $t = -1$, both agents make simultaneous offers of contingent compensating transfers to each other. Formally, each agent $i \in \{A, B\}$ chooses a real number $\sigma_i \geq 0$, which is interpreted as a commitment to transfer the amount of wealth σ_i to the other agent, $j \neq i$, if and only if j pays the first tier *ex ante* cost c_j^0 in period $t = 0$. Immediately after choosing σ_i, still in period $t = -1$, A and B simultaneously choose whether to accept or reject the other agent's offer of compensating transfer. Those offers which are accepted at this stage are binding in period $t = 0$.

The decisions and events in periods $t = 0$ and $t = 1$ are analogous to those described in Subsection 3.1. At $t = 0$, both agents choose simultaneously and independently whether to pay the first tier *ex ante* costs (c_A^0, c_B^0). If he chooses to

Simultaneous decision
on second tier costs

Simultaneous decision
on *ex ante* costs

Simultaneous
accept/reject decision

Contract
drawn up

Simultaneous
transfer offers

Transfers
take effect

If costs unpaid
skip to $t = 0$

Time
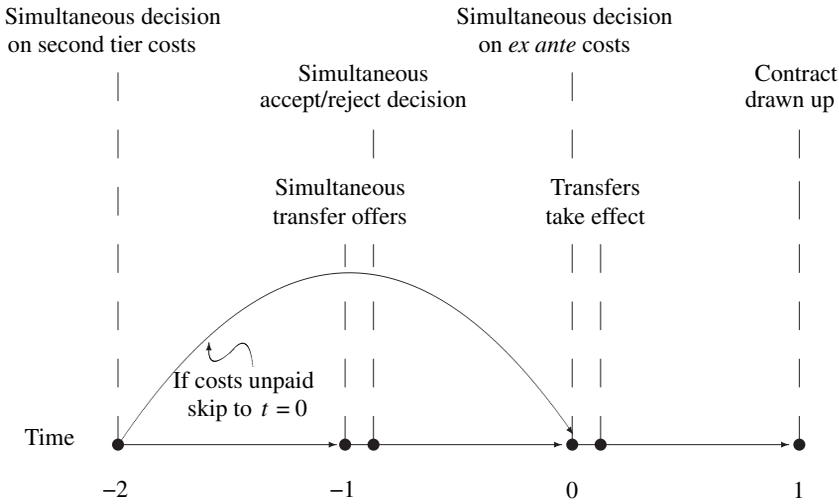
-2 -1 0 1

Fig. 3.   *Timing in the Two Tier Model*

pay, each agent $i \in \{A, B\}$ then incurs an *ex ante* cost of c_i^0 at this time, and subsequently receives a compensating transfer of σ_j from agent $j \neq i$. Only if both agents have paid the first tier *ex ante* costs does the $t = 1$ negotiation of the surplus-generating agreement becomes possible.

Provided both agents have paid their first tier *ex ante* costs their payoffs are $\lambda - \gamma_A$ and $1 - \lambda - \gamma_B$ respectively, where γ_i denotes the total *ex ante* costs paid by agent $i \in \{A, B\}$ during the entire game, minus any compensating transfer received from agent $j \neq i$, and plus any compensating transfers paid by i to j. If the surplus-generating agreement is not negotiated, then the two agents payoffs are simply $-\gamma_A$ and $-\gamma_B$ respectively.

The assumption that the total (for both tiers) of *ex ante* costs must be low enough so that it is socially efficient for the parties to negotiate a grand agreement is easy to state for this version of our model.

ASSUMPTION 3.   *Let $c_i = c_i^2 + c_i^0$ for $i \in \{A, B\}$. Then $c_A + c_B < 1$.*

It is apparent from the description of our model with compensating transfers above (cf. Figure 3) that this model, viewed from $t = 0$, is in fact identical to the simple model of Subsection 1, whenever both agents have chosen not to pay the second tier *ex ante* costs. We can therefore ask whether the parameters of our model with compensating transfers are such that according to Proposition 1, in the absence of compensating transfers, the no-agreement is the unique equilibrium outcome of the model. This motivates our first Definition.

DEFINITION 1.   *Assume that either $c_A^0 > \lambda$ or $c_B^0 > 1 - \lambda$ so that, provided that neither agent has paid the second tier ex ante cost, then no agreement is the only*

equilibrium outcome of the model (see Proposition 1 above). We then say that the model with compensating transfers 'yields the no-agreement outcome in the final stage'.

We are now ready to state our next Proposition. It tells us that, if the parameters of the model of Subsection 3.1 yield the no-agreement outcome, then adding a new stage to the model, with a second tier of positive *ex ante* costs and compensating transfers, may not solve the hold-up problem generated by the first tier *ex ante* costs. In particular, the model with compensating transfers has multiple equilibria and at least one equilibrium that yields the no-agreement outcome.

PROPOSITION 4. *Consider the model with compensating transfers. Suppose that c_A^0, c_B^0 and λ yield the no-agreement outcome in the final stage (cf. Definition 1), and assume that the second tier ex ante costs are strictly positive for both agents ($c_i^2 > 0$ for $i \in \{A, B\}$). Then the model has multiple equilibria. In particular, an equilibrium always exists in which neither agent pays either tier of ex ante costs, and hence yields the no-agreement outcome. Moreover, there is also an equilibrium in which both agents pay both tiers of ex ante costs and an agreement is negotiated.*

The reason why the model with compensating transfers always has one equilibrium in which none of the costs are paid is obvious. Recall that at each stage the two agents decide simultaneously and independently whether to pay their *ex ante* costs. Moreover an agreement is (or compensating transfers are) feasible only if both agents pay. It is then clear that if one agent expects the other not to pay his *ex ante* cost he should not pay either. The cost would be wasted since it has no effect on the remainder of the game. Therefore it is an equilibrium for both agents to pay none of the costs.

The intuition behind the existence of a subgame perfect equilibrium in which the parties do pay both tiers of *ex ante* costs and negotiate a grand agreement is less straightforward.[14]

Imagine that some compensating transfers have been agreed. If the transfers are such that the first tier *ex ante* costs are 'covered' for both agents (which is always possible in principle because of Assumption 3), then the terminal subgame of the model has two equilibria. One in which an agreement is negotiated, and another one in which neither agent pays the first tier *ex ante* cost and the no-agreement outcome obtains. Note that these equilibria are Pareto-ranked.

It is then possible to construct an equilibrium in which the agents switch (off-the-equilibrium-path) between equilibria of the terminal subgame, according to what transfers have been offered and agreed in the first stage of the game. The 'switching point' can always be constructed in such a way that it is in the interest of the agent whose share of the surplus exceeds his costs to compensate the other for the shortfall between his share of the surplus and both tiers of *ex ante* costs. The threat of switching to the inefficient equilibrium is viable because the no-agreement outcome is always one of the possible equilibrium outcomes of the terminal subgame.

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[14] We are indebted to Stephen Matthews for pointing out the existence of this type of equilibrium in the model.

Two observations come to mind with respect to the equilibrium we just described. First, even if the agreement is successfully negotiated this is done by paying two tiers of *ex ante* costs rather than one. Therefore, even when an agreement is reached the equilibrium of the model is constrained inefficient.

Second, and in our view more importantly, the equilibria of our model, with compensating transfers in which an agreement is negotiated, rely on the agents playing (off-the-equilibrium-path) an equilibrium in the terminal subgame that is strictly Pareto-dominated by another equilibrium of the same subgame. This runs against the intuition that the parties to a negotiation will be able to re-negotiate *ex post* to an equilibrium that makes them both better off when one is available.

Imagine now that we impose the restriction that in the terminal subgame the agents must play the Pareto-efficient equilibrium when the subgame has two equilibria. Then, after the second tier *ex ante* costs have been paid, they are *sunk* in a strategic sense. This means that the agent who has a 'deficit' in the last stage of the game, by subgame perfection, will accept any offer of compensating transfer that leaves him with a positive continuation payoff. Therefore in any equilibrium that obeys this new restriction, the compensating transfers will *not* take into account the second tier *ex ante* costs. Therefore, one of the two agents will find it profitable not to pay the second tier *ex ante* cost for which he would not possibly be compensated. This, in turn, means that compensating transfers will not be observed in equilibrium, and therefore yields the no-agreement outcome. This is the focus of Proposition 5 below.

The idea that some type of renegotiation-proofness is an appealing additional restriction to impose on the set of subgame perfect equilibria is not new. Examples are to be found in contract theory (Grossman and Hart, 1986; Hart and Moore, 1988; Rubinstein and Wolinsky, 1992; Segal, 1999; Che and Hausch, 1999), in the mechanism design and implementation literature (Maskin and Moore, 1999; Segal and Whinston, 2002), and in game theory in general (Farrell and Maskin, 1989; Abreu *et al.*, 1993, Benoît and Krishna, 1993) among others.

We give an informal definition of a *renegotiation-proof* equilibrium which applies to our model of this Section.

DEFINITION 2. *A subgame perfect equilibrium of the model with compensating transfers is renegotiation-proof if and only if the equilibria played in every proper subgame are not strictly Pareto-dominated by any other equilibrium of the same subgame.*[15]

Our next result says the if we restrict attention to renegotiation-proof equilibria, then the possibility of compensating transfers does not resolve the hold-up problem identified in Section 3. It is true that the model always has an equilibrium in which transfers take effect and an agreement is negotiated. But this equilibrium is not renegotiation-proof. Thus, although it may be tempting to select (in a Coasian fashion) the equilibrium with agreement among the two mentioned in Proposition 4 simply because it Pareto-dominates the no-agreement equilibrium, this type of selection is open to an objection that is, in our view, fatal.

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[15] Notice that our informal definition is made particularly simple by the fact that our model with compensating transfers only has one 'level' of proper subgames.

Surely, if we are willing to select among Pareto-ranked equilibria in favour of the dominating one, we should also be willing to apply the same logic to every sub-game? After all, once entered, every subgame is just like a game. However, if we apply this selection criterion to every subgame (in a recursively consistent way, of course), the only equilibrium of the entire game that survives is the constrained inefficient one, in which the no-agreement outcome obtains.

PROPOSITION 5. *Consider the model with compensating transfers. Suppose that c_A^0, c_B^0 and λ yield the no-agreement outcome in the final stage and that $c_A^2 > 0$ and $c_B^2 > 0$. Then every renegotiation-proof subgame perfect equilibrium of the model involves neither agent paying either tier of ex ante costs and therefore yields the no-agreement outcome.*

We view Proposition 5 as saying that the possibility of compensating transfers does not resolve the hold-up problem identified in Section 3 in the following sense. Either, we are willing to accept the multiple equilibria identified in Proposition 4, and therefore to accept the no-agreement equilibrium as being just as plausible as the one in which an agreement is negotiated. Or, we attempt to select among Pareto-ranked equilibria in favour of the efficient ones. However in this case, we should apply this logic consistently to every subgame, and hence single out those equilibria that are renegotiation-proof. In this case only the no-agreement outcome survives.

Notice that the multiplicity of equilibria in the terminal subgame of our model is crucially dependent on the fact that the *ex ante* costs are payable simultaneously by the agents. Therefore if the game is modified so that the costs are payable sequentially, all subgames have a unique equilibrium and the no-agreement outcome is certain to prevail.

In particular, consider the following modification of the extensive form depicted in Figure 3. At $t = 0$ A decides whether to pay the *ex ante* cost c_A^0. Then B observes A's choice and decides whether to pay the *ex ante* cost c_B^0. The rest of the extensive form is identical to the one in Figure 3. The following proposition characterises the equilibria of this modification of the model with compensating transfers.[16]

PROPOSITION 6. *Consider the modified model with compensating transfers that we have just described. Suppose that c_A^0, c_B^0 and λ yield the no-agreement outcome in the final stage and that $c_A^2 > 0$ and $c_B^2 > 0$. Then, the unique subgame perfect equilibrium of the model is for neither agent to pay either tier of ex ante costs, and hence yields the no-agreement outcome.*

5. Property Rights?

Since the seminal contribution of Grossman and Hart (1986), whenever a hold-up problem prevents contracting parties from achieving an efficient outcome, it is natural to ask whether an appropriate (re)allocation of property rights might

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[16] The alternative game, in which B decides whether to pay the *ex ante* cost before A, is just a relabelling of the one we have just described. Proposition 6 obviously applies to this extensive form as well.

alleviate the inefficiency. Our next task is to investigate whether a reallocation of property rights can fulfil this role in our set up.

First of all, we notice a key difference between our framework and the Grossman and Hart (1986) model. The hold-up problem in Grossman and Hart (1986) gives rise to inefficiently low levels of *relationship-specific investment*. These are investments that enhance the surplus available from the contractual relationship. In that framework, it is also natural to assume that, to some extent at least, the parties' investments improve their *outside options* available outside the contractual relationship.

The hold-up problem in our set up is generated by (*ex ante*) *transaction costs*. These are *uniquely* related to the potential transaction at hand. It is therefore natural to assume that whether they are paid or not has *no effect* on the value of the parties' outside options. This key difference is what drives our findings below. Our set up is one in which it is natural to assume that the allocation of property rights affects the parties' outside options, regardless of the payment of the *ex ante* transaction costs.

Once the above observation is granted, we find that whether the allocation of property rights matters or not depends on whether and how outside options matter in the division of surplus between the parties. In other words, whether and how outside options affect the bargaining outcome.

Purely for the sake of simplicity, we introduce the parties' outside options as o_A and o_B respectively and we take them to be such that $o_A + o_B = 0$.[17] An allocation of property rights in our model is then simply a choice of o_A and o_B summing to 0 as above. The obvious interpretation being that asset ownership increases what an agent can get outside of the contractual relationship.

We now consider once more our simple model of Subsection 3.1, in which both parties must pay their *ex ante* transaction costs for the surplus to materialise.

We begin with the outside options having the same role in the parties' bargaining as in Grossman and Hart (1986). In this case, if the negotiation takes place, each party receives his outside option, plus a share of the available surplus over and above the sum of the outside options (the gains from trade).[18]

Using the fact that $o_A + o_B = 0$, in this case the normal form corresponding to the two-stage game is as in Figure 4. We can then conclude that in this case, the reallocation of property rights cannot resolve the hold-up problem created by the *ex ante* transactions costs. As is apparent from the normal form in Figure 4, the model will have a unique equilibrium in which neither party pays his *ex ante* cost and hence the no contract outcome obtains *regardless* of o_A and o_B, provided that

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[17] It is easy to check that nothing we say here depends on the outside options summing to 0. All our arguments apply virtually unchanged if we assume that $o_A + o_B$ is equal to some constant k, that is less than $1 - c_A - c_B$. The analysis will change, however, if the sum of the outside options depends on the allocation of ownership rights. We briefly consider this case below at the end of the Section.

[18] There is a sizeable literature in bargaining theory on what justifies the parties outside options affecting the outcome in different ways. The Nash bargaining solution of course suggests that they should have exactly the role they have in Grossman and Hart (1986). In extensive form bargaining, their role depends on the details of the extensive form and can range from being the same as in the Nash bargaining solution to acting as a constraints that only matter if they become binding (Binmore, 1986; Binmore *et al.*, 1986; Sutton, 1986).

	pay c_B	not pay c_B
pay c_A	$\lambda + o_A - c_A$, $1 - \lambda + o_B - c_B$	$o_A - c_A$, o_B
not pay c_A	o_A, $o_B - c_B$	o_A, o_B

Fig. 4. *Normal Form with Nash Bargaining Outside Options*

the distribution of *ex ante* costs and bargaining power are sufficiently 'mis-matched' exactly as we found in Proposition 1 above.

Both de Meza and Lockwood (1998) and Chiu (1998) analyse the effect of the allocation of property rights in a hold-up model in which outside options play a different role in the bargaining outcome.[19] In these models outside options act as a *constraint* on the bargaining outcome. So, an agent's payoff will be his share in the bargaining over the whole surplus, if neither outside option is binding. If either outside option is binding, then the party for whom it is binding receives a share of surplus equal to his outside option and the other party gets the rest.

To write down the normal form corresponding to the two-stage game in this case it is convenient to consider two separate cases: $o_A > 0$ and $o_B > 0$.[20] When $o_A > 0$, it is only possible that A's outside option binds, while for B it must be not binding. Symmetrically, when $o_B > 0$, it is only possible that B's outside option binds, while for A it must be not binding. The normal form corresponding to the two-stage game therefore is either as in Figure 5, or as in Figure 6 depending on which case applies.

In this case it is immediate from the normal forms in Figures 5 and 6 that a reallocation of property rights is in fact capable of resolving the hold-up problem we have identified. In fact it is straightforward to check that, whatever $\lambda \in (0, 1)$ and c_A and c_B satisfying Assumption 1, we can always choose o_A ad o_B so that both $\lambda - c_A > o_A$ and $1 - \lambda - c_B > o_B$ hold.[21] Given these outside options from Figures 5 and 6 it is clear that the model has an equilibrium in which both A and B pay their *ex ante* transaction costs and an agreement is reached.[22]

Clearly, the two conditions we have found can be rewritten as $\lambda > c_A + o_A$ and $1 - \lambda > c_B + o_B$. Thus, in the second case we have analysed, the allocation of property rights can be used to 're-align' the distribution of *ex ante* transaction costs with the distribution of bargaining power when they are 'mis-matched'. To this end the property rights must be allocated in favour of the agent with the highest bargaining power.

In this Section, we have so far assumed that the sum of the outside options is independent of the allocation of ownership rights. This is of course a special case.

[19] Rajan and Zingales (1998) analyse a related model in which the focus is the role of the allocation of power, defined as the control of 'access' to a physical asset.

[20] Clearly, because $o_A + o_B = 0$ these two cases are mutually exclusive. Since the case $o_A = o_B = 0$ corresponds to our previous model, the cases we consider here are also exhaustive of all configurations of interest.

[21] These conditions can be satisfied simultaneously because $o_A + o_B = 0$. In fact they can always be satisfied simultaneously provided that $c_A + c_B + o_A + o_B < 1$. This is equivalent to asserting that trade is in fact efficient, given the transaction costs and the parties' outside options. See footnote 17.

[22] As in our analysis of Subsection 3.1 above, there is always another equilibrium in which neither agent pays the *ex ante* transaction cost and no agreement is reached. As before, this equilibrium disappears if the *ex ante* transaction costs are payable sequentially.

	pay c_B	not pay c_B
pay c_A	$\max\{\lambda, o_A\} - c_A,\ 1 - \max\{\lambda, o_A\} - c_B$	$o_A - c_A,\ o_B$
not pay c_A	$o_A,\ o_B - c_B$	$o_A,\ o_B$

Fig. 5.   *Normal Form with Outside Options as Constraints: $o_A > 0$*

	pay c_B	not pay c_B
pay c_A	$1 - \max\{1 - \lambda, o_B\} - c_A,\ \max\{1 - \lambda, o_B\} - c_B$	$o_A - c_A,\ o_B$
not pay c_A	$o_A,\ o_B - c_B$	$o_A,\ o_B$

Fig. 6.   *Normal Form with Outside Options as Constraints: $o_B > 0$*

In general, the allocation of ownership rights affects the sum, as well as the distribution, of the outside options. If no deal is struck between the parties about say the common use of a tract of land, it may well be the case that the second best alternative is for one party and not the other to have access to the land. So, we now briefly consider the case in which the sum of o_A and o_B may change as we vary the allocation of property rights.

If we continue to assume that signing a contract is more efficient than not signing one so that whatever the allocation of property rights we have that $o_A + o_B < 1 - c_A - c_B$,[23] it is easy to check that nothing changes in the case of outside options as constraints summarised in Figures 5 and 6. It is still the case that some (re)allocation of property rights will in fact induce the efficient outcome (the *ex ante* costs are paid and the contract is signed) to be an equilibrium.

In the first case we considered (outside options in Nash bargaining), summarised in Figure 4 the situation is quite different. Assume that the parameters of the problem are such that either $\lambda < c_A$ or $1 - \lambda < c_B$. In this case the unique equilibrium is such that neither party pays the *ex ante* costs and hence the no contract outcome obtains. This conclusion is independent of whether the sum of the outside options is affected by the distribution of ownership rights. The efficient allocation of ownership rights is then the one that maximises the sum of the outside options. In other words, as already conjectured in Coase (1960), when transaction costs prevent the contracting parties from reaching the efficient agreement the allocation of ownership rights does matter. The property rights over the tract of land that we mentioned above should be allocated to the party that will make the most efficient (second best) use of it.

6. Concluding Remarks

If the parties involved in a Coasian negotiation need to sink some *ex ante* transaction costs before they can reach the negotiating phase of their interaction, the *ex ante* costs may generate a version of the hold-up problem. If the distribution of *ex ante* costs and the distribution of surplus generated by the negotiation are sufficiently 'mis-matched', one of the two parties to the negotiation will not find it

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[23] See footnotes 17 and 21.

to his advantage to pay the *ex ante* cost, even though the surplus generated by the agreement would be sufficient to cover the total *ex ante* costs associated with it. Therefore, in equilibrium the agreement will not be negotiated. We have verified this claim in a variety of simple models.

Unlike many other versions of this problem, under appropriate conditions, the hold-up problem generated by *ex ante* transaction costs is unlikely to have a 'Coasian solution'. This is because the Coasian negotiation that attempts to solve the hold-up problem is likely to generate a fresh set of *ex ante* transaction costs and hence a new hold-up problem.

Lastly, we have explored the effect of the allocation of property rights on the hold-up problem we identified. Whether property rights can resolve the problem or not depends crucially on the role that outside options play in the parties' bargaining.

Appendix

Proof of Proposition 3. Since either $\lambda < c_A$ or $1 - \lambda < c_B$, it is clear that there is no equilibrium in which both agents pay the *ex ante* cost at $t = 0$.

We only show that it is not possible that in any pure strategy equilibrium A alone pays the *ex ante* cost at $t = 0$. Any equilibrium in which B alone pays the *ex ante* cost at $t = 0$ can be ruled out in a symmetric way and we omit the details. Mixed strategy equilibria can be ruled out using standard arguments and we omit the details.

Suppose then that there is an equilibrium in which only A pays the *ex ante* cost at $t = 0$. There are two cases to consider. Either B pays his cost to see A's offer or he does not.

Suppose next that there is an equilibrium in which A only pays the *ex ante* costs at $t = 0$ and subsequently B either accepts or rejects A's offer without seeing it. Note that in this case B cannot condition his decision to accept or reject on the value of ℓ since he does not pay to see it. If B accepts in equilibrium, clearly A will set $\ell = -\epsilon$. But this would give an equilibrium payoff of $-\epsilon$ to B, and therefore yields a contradiction since B can always guarantee himself a payoff of zero by not paying any costs and rejecting any offer. If B rejects A's offer blind in equilibrium, then A's equilibrium payoff is $-c_A$ since no agreement is negotiated and A pays his *ex ante* cost at $t = 0$. This is again a contradiction since A can guarantee himself a payoff of zero by not paying the *ex ante* cost at $t = 0$ (and rejecting any offers made by B if he pays his *ex ante* cost).

Lastly, consider the possibility of an equilibrium in which A alone pays the *ex ante* costs at $t = 0$ and subsequently B pays his *ex ante* cost c'_B to see the value of ℓ, and then accepts or rejects A's offer. Notice that now B can condition his decision to accept or reject A's offer on the actual value of ℓ. Using subgame perfection, it is immediate to see that, in equilibrium, it must be the case that B accepts all offers that guarantee that $1 - \ell > 0$ (his *ex ante* cost is *sunk* when the accept/reject decision is made). Therefore, in equilibrium, A will offer precisely $\ell = 1$. It follows that in any equilibrium in which A alone pays the *ex ante* cost at $t = 0$ and subsequently B pays to see A's offer, B's payoff is at most $-c'_B$. But this is a contradiction since B, as before, can guarantee himself a payoff of zero by not paying any costs and rejecting any offer.

LEMMA A.1: *Consider the terminal subgame of the model with simple compensating transfers described in Subsection 4 which occurs after the pair of compensating transfers (σ_A, σ_B) has been agreed, as a function of the pair (σ_A, σ_B). If the following inequalities are satisfied*

$$\lambda - \sigma_A + \sigma_B - c_A^0 \geq 0 \tag{A.1}$$

$$1 - \lambda + \sigma_A - \sigma_B - c_B^0 \geq 0 \tag{A.2}$$

the subgame has two equilibria. If both inequalities are strict one equilibrium strictly Pareto-dominates the other. The Pareto-superior equilibrium is such that both parties pay the ex ante costs (c_A^0, c_B^0) and the agreement is successfully negotiated leaving the parties with continuation payoffs $(\lambda - \sigma_A + \sigma_B - c_A^0)$ and $(1 - \lambda + \sigma_A - \sigma_B - c_B^0)$. The inferior equilibrium is such that both parties do not pay the ex ante costs (c_A^0, c_B^0) and yields the no-agreement outcome. If either or both inequalities (A.1) and (A.2) are violated the terminal subgame has a unique equilibrium in which neither agent pays the ex ante costs (c_A, c_B), and hence yields the no-agreement outcome.

Proof. The claim follows immediately from the fact that an agreement is feasible only if both A and B pay the *ex ante* costs (c_A^0, c_B^0), and from the observation that either agent i can guarantee a continuation payoff of zero by not paying his *ex ante* cost c_i^0.

LEMMA A.2: *Consider the model with simple compensating transfers described in Section 4. If there exists an equilibrium of the model in which both $\sigma_A > 0$ and $\sigma_B > 0$, then there exists another, payoff equivalent, equilibrium of the model in which the transfers take the values $\tilde{\sigma}_A = \sigma_A - \sigma_B$ and $\tilde{\sigma}_B = 0$ if $\sigma_A \geq \sigma_B$, and $\tilde{\sigma}_A = 0$ and $\tilde{\sigma}_B = \sigma_B - \sigma_A$ if $\sigma_B \geq \sigma_A$.*

Proof. We only examine the case in which $\sigma_A \geq \sigma_B$. The other case is a simple re-labelling of this one. To construct the new equilibrium, let the strategies of both agents be identical to the strategies in the original equilibrium, except for the way actions are conditioned on the other agents' compensating transfer offer. In the new equilibrium, each agent $i \in \{A, B\}$ responds to any offer $\tilde{\sigma}_j$ (with $j \neq i$) exactly as he would respond to the offer $\tilde{\sigma}_j + \sigma_i$ in the original equilibrium.

Proof of Proposition 4. Recall that both tiers of *ex ante* costs are payable simultaneously by the agents and that an agreement (compensating transfer) is feasible only if both agents have paid the first (second) tier of *ex ante* costs. Therefore it is obvious that a pair of strategies that prescribe not paying any *ex ante* costs for both agents (and some equilibrium behaviour off-the-equilibrium-path) constitutes an equilibrium. This proves our first claim.

We now move to the construction of a subgame perfect equilibrium of the model with simple compensating transfers in which the parties do negotiate an agreement.

We only deal with the case in which $1 - \lambda < c_B^0$. The case in which $\lambda < c_A^0$ is a simple re-labelling of this one and we omit the details.

Consider the subgame occurring after the transfers (σ_A, σ_B) have been agreed. If $\sigma_B \geq \sigma_A$ the only equilibrium of this subgame is such that both parties do not pay the *ex ante* costs (c_A^2, c_B^2). If instead $\sigma_A \geq \sigma_B$ then by Lemma A.2 we can restrict attention to transfers that satisfy $\sigma_A > 0$ and $\sigma_B = 0$.

If σ_A is such that inequalities (A.1) and

$$1 - \lambda + \sigma_A \geq c_B^0 + c_B^2 \tag{A.3}$$

are satisfied, we assume that the agents play the Pareto-superior of the two equilibria described in Lemma A.1 in which the agreement is successfully negotiated. If instead σ_A is such that inequality (A.3) is *not* satisfied while (A.1) and (A.2) are satisfied we assume that the agents play the Pareto-inferior of the two equilibria described in Lemma A.1 that yields the no-agreement outcome. If either or both (A.1) and (A.2) are violated then the agents play the unique subgame perfect equilibrium of the subgame.

Proceeding backwards, it is then a best reply for B to accept any offer $\sigma_A > 0$ such that inequality (A.3) is satisfied. Indeed, if B rejects the offer his continuation payoff is zero while by accepting the offer his continuation payoff is non-negative.

It is then optimal for A to make an offer σ_A such that

$$\sigma_A = c_B^2 + c_B^0 - (1 - \lambda). \tag{A.4}$$

This offer is associated with a positive continuation payoff for A. A higher offer is associated with a smaller continuation payoff while a lower offer is associated with a continuation payoff of zero, since the parties expect to play the inefficient equilibrium whenever (A.3) is violated.

Therefore, in equilibrium both parties pay the second tier *ex ante* costs (c_A^2, c_B^2). Paying the cost, B obtains the payoff of zero that coincides with the payoff he gets by not paying. By paying, A gets a strictly positive payoff while he gets a payoff of zero by not paying. This concludes the proof.

Proof of Proposition 5. We only deal with the case in which $1 - \lambda < c_B^0$. The case in which $\lambda < c_A^0$ is a simple re-labelling of this one and we omit the details.

Since we are assuming that the parameters of the model yield the no-agreement outcome in the final stage, any renegotiation-proof subgame perfect equilibrium that yields an agreement as an outcome must have both agents paying both tiers of *ex ante* costs.

Assume by way of contradiction that such an equilibrium exists and denote by a superscript '*' the equilibrium values of all variables in this equilibrium.

Notice first of all that if $\sigma_B^* \geq \sigma_A^*$ we have an immediate contradiction since in this case $\gamma_B^* > c_B$ and therefore B's equilibrium payoff must be negative. Since B can guarantee a payoff of zero by not paying any of the *ex ante* costs this is a contradiction.

By Lemma A.2, we can then assume without loss of generality that $\sigma_A^* > 0$ and $\sigma_B^* = 0$.

Next, consider the subgame that starts after the transfers (σ_A^*, σ_B^*) have been agreed. We now claim that every renegotiation-proof subgame perfect equilibrium must be such that

$$1 - \lambda + \sigma_A^* - c_B^0 = 0. \tag{A.5}$$

To see this notice that Definition 2 and Lemma A.1 imply that every renegotiation-proof subgame perfect equilibrium must prescribe that in this subgame when

$$\lambda - \sigma_A - c_A^0 > 0 \tag{A.6}$$

$$1 - \lambda + \sigma_A - c_B^0 > 0 \tag{A.7}$$

are satisfied the parties play the Pareto superior equilibrium. This equilibrium involves both agents paying the costs (c_A^0, c_B^0), negotiating an agreement and obtaining the strictly positive continuation payoffs: $1 - \lambda + \sigma_A - c_B^0$ and $\lambda - \sigma_A - c_A^0$. However, any offer σ_A that satisfies (A.7) cannot be payoff maximising for A. Therefore the only renegotiation-proof subgame perfect equilibrium offer has to satisfy (A.5).

It follows directly from (A.5) that B's payoff in this renegotiation-proof subgame perfect equilibrium would be $-c_B^2$. But this is a contradiction since B can guarantee a payoff of zero by not paying any *ex ante* costs. This is enough to prove the proposition.

Proof of Proposition 6. The proof can be constructed in a way that is completely analogous to the one of Proposition 5 once we observe that when inequalities (A.6) and (A.7) are satisfied the unique subgame perfect equilibrium of the terminal subgame starting at $t = 0$ is for both parties to pay the costs (c_A^0, c_B^0), negotiated an agreement and obtain payoffs: $1 - \lambda + \sigma_A - c_B^0$ and $\lambda - \sigma_A - c_A^0$.

Indeed, if A has paid his cost c_A^0 it is optimal for B to pay the cost c_B^0 as well, given that B obtains a strictly positive continuation payoff by doing so, while he gets a continuation payoff of zero by not paying. On the other hand, if A does not pay his *ex ante* cost c_A^0 then it is optimal for B not to pay his cost c_B^0 either. If B does not pay he gets a payoff of zero while if he does pay he gets a negative payoff. Therefore the unique subgame perfect equilibrium of this subgame is for both parties to pay their costs (c_A^0, c_B^0) and negotiate an agreement.

We omit the details of the remaining part of the proof.

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