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Contract, Renegotiation, and Holdup: When Should Messages be Sent? *

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Abstract

I consider a setting of complete but unverifiable information in which two agents enter a contractual relationship to induce mutually beneficial investments. As my main result, I establish that the famous irrelevance of contracting paradigm, that arises due to the detrimental effect of renegotiation, is resolved if there is a fixed point in time when actions have to be chosen and one accounts for the fact that renegotiation takes time. What drives my optimality result is that, by stipulating when the mechanism is to be played, the agents ensure that renegotiation is possible *ex ante* but not *ex post*.

Keywords: Incomplete Contracts, Mechanism Design, Holdup, Renegotiation

JEL-Classification: D86

1 Introduction

The detrimental effect of renegotiation is well known in the incomplete contracts literature. In their seminal article, Hart and Moore (1988) explain that renegotiation following unverifiable and relation-specific investments by two agents may make it impossible to write an optimal contract *ex-ante*. Using a specific example, they show that underinvestment may be part of the second best solution. Maskin and Moore (1999) reinforce this standpoint: They demonstrate that the possibility of renegotiation severely limits the set of implementable outcomes. Che and Hausch (1999) and Segal (1999) consider buyer-seller models and derive an even

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worse outcome for *ex-post* renegotiation: There exist plausible settings in which the parties cannot do better than to write no *ex-ante* contract at all. The underlying problem caused by *ex-post* renegotiation is similar in all of the aforementioned articles: To make it undesirable for both agents to deviate from the first-best equilibrium path, a mechanism must be able to punish one agent without simultaneously rewarding the other. That is, it must be able to implement inefficient outcomes as threat points to induce the agents to stay on the equilibrium path. If renegotiation takes place *ex-post*, i.e., after the mechanism is played, this is not possible: The agents renegotiate the outcome of the mechanism whenever it is inefficient.

Watson (2007), who considers a setting with a single, non-durable, trading opportunity, explains that there is a larger scope for contracting than suggested by the prior literature: He points out that the poor performance of contracting stems from the fact that much of the prior literature has modeled trade actions as public, see e.g. Che and Hausch (1999), Edlin and Reichelstein (1996), Maskin and Moore (1999), Segal (1999), or Segal and Whinston (2002). In contrast, when one models trade actions as individual, the set of implementable outcomes may become much larger.¹ To see the difference, note that in a public action model some external authority enforces the actions after having observed the messages sent by the agents. In contrast, in an individual action model the agents choose their actions and the external authority subsequently only compels transfers contingent on the messages it receives.

In the present paper, I consider an individual action model with a single, non-durable, action opportunity, the “action date”. Adding the natural assumption that renegotiation takes *time* I establish, as my main result, that the first best can be induced, irrespectively of details such as the nature of investment or the bargaining power of the agents. To induce the first best, the agents write a contract that stipulates the mechanism to be played and the point in time when it is to be played, the “message date”. By specifying the message date sufficiently close to the action date, the agents ensure that there is insufficient time to renegotiate away inefficient outcomes after the mechanism has been played. Hence, the agents can only renegotiate before they play the mechanism, a case which Watson (2007) calls “interim renegotiation”. To see why stipulating a late message date is useful, recall that Watson (2007) established that the set of implementable outcomes is considerably larger when the agents renegotiate interim, compared to situations where they may renegotiate after the mechanism is played.² The rationale behind this is that the fact that the agents may not renegotiate away inefficient outcomes of the mechanism can be used as a threat to induce them to report truthfully. Consequently it is possible to stipulate transfers such that each agent internalizes the correct marginal return to her or his investment. Given that the transfers are

¹Ellman (2006) and Buzzard and Watson (2012) model trade actions as individual and show that the one-sided cooperative investment problem of Che and Hausch (1999) may be solved. Two-sided cooperative investment is, however, more problematic.

²In the former case, public-action and individual-action models coincide. That is, it does not matter whether the agents actually take the actions or whether they are enforced by the external authority.

correctly specified, there exist many mechanisms the agents can use to induce the first best. In the main part of the paper, I use, as a leading example, an augmented “shoot-the-liar” mechanism and discuss that Moore and Repullo’s (1988) sequential mechanism also works.

The main contribution of my paper thus is to explain how the agents can *endogenously* avoid detrimental ex-post renegotiation without having to be able to commit not to renegotiate. Moreover, the agents must also not be able to commit to play the mechanism at the stipulated message date. That is, they could theoretically renegotiate early in order to stipulate a new message date such that there is ample time to renegotiate after the mechanism is played. However, given that the ex-post outcome is efficient, there is no scope for any type of ex-ante renegotiation. Finally, it is important to point out that my result is robust with respect to how much time it takes to renegotiate: In the main part of the paper I explain that my result continues to hold even if the time required to renegotiate approaches zero.

My paper is related to Rubinstein and Wolinsky (1992), who also add a time dimension to the model and show that hence the first best may be attainable. The crucial difference between our papers is the way time is incorporated in the model: Rubinstein and Wolinsky (1992) consider a buyer-seller model with several different points in time where the good may be traded. Because the parties are impatient, they incur a loss if they trade late. Hence, renegotiation is costly in the sense that it delays trade. In contrast, what drives my result is the interplay of the time required to renegotiate with a single, inalienable, point in time when the parties choose their actions. Another important difference is that Rubinstein and Wolinsky (1992) interweave renegotiation and the mechanism in the sense that the parties can renegotiate *while* they play the bargaining game (the mechanism). In the present paper, the agents can only renegotiate, if time permits, before or after they play the mechanism.³ Finally, Rubinstein and Wollinsky (1992) consider a somewhat narrow setting with a single good and where trade is always efficient. My setting is more general because it applies to any situation where two agents ex-ante enter a contractual relationship to induce mutually beneficial investment. The “actions” in my model can have many interpretations: For instance, they may represent the transfer of goods from a seller to a buyer or, likewise, the agents’ decision to make a bid at a license auction.⁴

My paper is also related to Evans (2012) who shows that if sending messages

³Evans (2012) argues that Rubinstein and Wollinsky’s (1992) approach seems to require significant ability of the outside enforcer to structure the negotiations. This is so because, as Evans (2012) puts it “[...] The mechanism that Rubinstein and Wollinsky (1992) use is a bargaining game with discounting and the renegotiation-proofness criterion is that at no stage should the players be able to benefit by substituting a different outcome one period in the future.” Hence, Evans (2012) explains that “[...] as part of the mechanism, it is possible for one player to make a proposal in a certain set, the other to accept it, and the payoffs to be realized, all within the same period, but it is not possible for them to agree within that period on a different (renegotiation) proposal.”

⁴The latter interpretation is perhaps best compatible with my assumption of a single, non-durable, action opportunity. For details, please refer to the discussion at the end of Section 3.

is costly, the possibility of ex-post renegotiation does not restrict the set of implementable outcomes. What makes his result strong is that it holds even when the cost of sending messages is arbitrarily small. To see the connection between our papers, recall that some of the continuation equilibria in Evans (2012) are inefficient. Hence, as in the present paper, the agents would, if they could, renegotiate away the inefficiency ex-post. Because there is no opportunity to do so, the inefficient outcome can, like in the present paper, be used as a threat point to induce truthful reporting. However, in contrast to the present paper, that the agents may have no chance to renegotiate away an inefficient outcome is a specific feature of Evan’s (2012) mechanism. In my paper, this issue arises due to the fact that the agents can stipulate when the mechanism is to be played. The rest of the paper is organized as follows: In the next section, I introduce the model before I establish my first best result in Section 3. In Section 4, I discuss the possibility of extending my result to settings of durable action opportunities and confirm the robustness of my result in a situation where not only renegotiation but also the play of the mechanism takes time. Section 5 concludes.

2 The Model

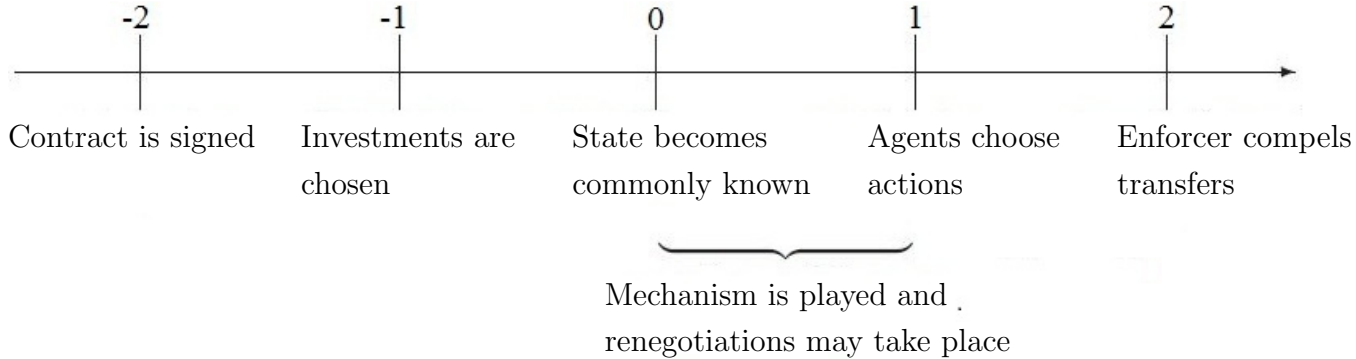


Figure 1: Timeline of the contractual relationship.

Two risk-neutral agents, 1 and 2, are engaged in a contractual relationship with a non-durable action opportunity and external enforcement. The timing of the model is as follows (see Figure 1):

At date -2, the parties write a contract stipulating (i) an ex-ante payment $p = (p_1, p_2) \in \mathbb{R}^2$, such that both agents are willing to sign the contract. Moreover, it stipulates (ii) a revelation mechanism $m \in M$ that consists of a game to be played, in which the agents send messages to the external enforcer, and an ex-post transfer payments y . This transfer, from agent 2 to agent 1, depends on the outcome of the mechanism and the agents’ ex-post actions. Finally, it (iii) stipulates a “message date” $d \in (0, 1)$ at which the revelation mechanism is to

be played and messages are to be sent.⁵ At date -1 the agents invest $e = (e_1, e_2)$ to increase their own expected benefit and/or the benefit of their contractual partner. As it will turn out, the nature of investment (cooperative, hybrid, or selfish) is not relevant in order to establish my main first-best result. Hence, I do not model it explicitly.⁶ At date 0, a state of the world ω is randomly drawn from a set of possible states Ω and becomes commonly known to both agents but not to the external enforcer. Moreover, the agents also learn each other's investment. Between dates 0 and 1, the agents play the stipulated mechanism at the stipulated message date. That is, unless they renegotiate beforehand in order to stipulate a new message date and/or mechanism. In Section 2.2, I explain in detail how the specified message date $d \in (0, 1)$ and renegotiation interact with one another. At date 1, the agents each simultaneously choose actions $a = (a_1, a_2) \in A_1 \times A_2$ to determine whether and how their relationship is consummated, where A_1 and A_2 denote the sets of possible actions.⁷ I assume that the actions, a , can be observed by the external enforcer and that, for simplicity, the sets A_1 and A_2 do not depend on the state of the world or the agents' investments. Finally, at date 2, the external enforcer compels the transfer y , depending on the agents' actions and the messages they sent when playing the mechanism.

To save on notation, let me define the ex-post "state of the relationship" $\theta \equiv (\omega, e_1, e_2) \in \Theta$, where Θ is the set of all possible states. A mechanism m consists of a game to be played by the agents in which they report the state $\theta_R = (\theta_1, \theta_2)$ to the external enforcer. Here, θ_1 denotes agent 1's report and θ_2 denotes agent 2's report, respectively. The ex-post transfer can then be written $y(a, \theta_R) \in \mathbb{R}$. That is, it depends on the agent's reports and their subsequent actions. Finally, note that the agents cannot commit to burn money. In the subsequent analysis, I am going to demonstrate that the agents can use the stipulated mechanism and the message date as instruments to fine tune their incentives such that they will report the true state at date d and choose the ex-post efficient actions at date 1.

2.1 Utility

Both agents' payoffs, at date 2, depend on the true state θ , the reported states θ_R , and are quasi-linear in money. Hence, agent 1's ex-post payoff is given by

$$U^1(a, \theta, \theta_R) = u_1(a, \theta) + y(a, \theta_R),$$

whereas agent 2's payoff amounts to

$$U^2(a, \theta, \theta_R) = u_2(a, \theta) - y(a, \theta_R).$$

⁵The agents instruct the external enforcer to disregard messages sent at any other date unless they mutually agree on a new message date in the course of the relationship, see Section 2.2.

⁶In my first-best equilibrium, both agents report truthfully. Hence, transfers can be stipulated such that both agents internalize the correct marginal returns to their investments, i.e., they become residual claimants. Thus, they invest efficiently independent of the precise nature of investment. For details, see the proof of Proposition 3.

⁷As a simple example, consider a buyer-seller relationship in which $A_1 = A_2 = \{0, 1\}$. Here, a_1 represents whether the buyer accepts delivery and a_2 represents whether the seller delivers.

Recall that the agents' investment is sunk, at date 2, and note that the intrinsic utility, u_i , depends on the true state whereas the monetary transfer, y_i , depends on the reported state. Let us also assume that

Assumption 1 $(0,0)$ is a valid action profile, and $u_i(0,0,\theta) = 0 \forall \theta \in \Theta$ and $i \in \{1,2\}$.

As an example consider a buyer seller context where this assumption implies that the parties incur no intrinsic benefit if they do not trade. The jointly optimal actions $a^*(\theta) = (a_1^*, a_2^*)$ maximize the joint ex-post surplus of the contractual relationship:

$$a^*(\theta) \in \arg \max_{a \in A_1 \times A_2} W(a, \theta) = u_1(a, \theta) + u_2(a, \theta).$$

Finally, the jointly optimal investment levels, denoted by $e^* = (e_1^*, e_2^*)$, maximize expected joint surplus

$$\begin{aligned} & E[W(a^*, \theta)] - C_1(e_1) - C_2(e_2) \\ & = E[W(a^*(e_1, e_2, \omega), e_1, e_2, \omega)] - C_1(e_1) - C_2(e_2) \end{aligned}$$

in $[0, e_1^{max}] \times [0, e_2^{max}]$ contingent on an efficient action profile $a^*(\theta)$. Here, $C_1(e_1)$ and $C_2(e_2)$ denote the costs of investment.

2.2 Time and Renegotiation

When the agents renegotiate between dates 0 and 1, they may specify a new mechanism and/or a new message date.⁸ Because investments are sunk, the only issue that matters for ex-post efficiency is whether the agents choose the ex-post efficient action profile $a^*(\theta)$ at date 1. It is straightforward that, because the agents know the true state θ when they renegotiate, they can always achieve $a^*(\theta)$. In principle, they can do so by stipulating a new mechanism and/or a new message date. Because I am going to establish that the agents do not renegotiate on the first-best equilibrium path, I do not need to make an assumption about whether the agents choose to replace the mechanism or the message date if both would induce the ex-post efficient outcome. Let us first consider the case that the agents meet well before having played the stipulated mechanism and consider to replace it with a new one. Each agent's threat point is the outcome that would occur in absence of renegotiation. I denote the action profile that leads to this outcome by $a^{NR}(\theta)$. If the agents reach an agreement during renegotiation, they replace the old mechanism with a new one that they anticipate to induce the ex-post efficient action profile, $a^*(\theta)$. Consequently, the agents' renegotiation surplus amounts to

$$R(\theta) = W(a^*(\theta), \theta) - W(a^{NR}(\theta), \theta).$$

Let me denote agent 1's and agent 2's shares of this surplus by $\pi = (\pi_1, \pi_2)$, respectively. That is, I do not model renegotiation explicitly but assume that the

⁸At this point it is important to recall that the external enforcer only takes those messages into account, he received at the ruling message date.

renegotiation surplus is shared consistent with a cooperative bargaining solution. So far, I discussed the consequences of ex-ante renegotiation but not if and *when* the agents renegotiate. The main innovation of the present paper is that I take into account that renegotiation takes time. This is crucial: If the stipulated message date is sufficiently close to date 1, the agents can only renegotiate *before* but not *after* the mechanism is played. Recall that we know from the literature, e.g. Watson (2007), that the set of implementable outcomes is considerably larger in the former case. Let me formalize the idea:

Let there be one perfectly divisible unit of time between dates 0 and 1, and let me assume that renegotiation takes $\epsilon \ll 1$ units of time. Consequently, renegotiation can only take place at some point(s) in time $t \in (0, 1 - \epsilon]$.⁹ In contrast, sending messages to the external enforcer, i.e., playing the revelation mechanism, does not take any time. This assumption is not crucial and will be relaxed in Section 4. Let us, from now on, focus on the case that the parties stipulated a message date sufficiently close to date 1, such that there is insufficient time for ex-post renegotiation, $d \in (1 - \epsilon, 1)$. That is, should the agents anticipate the stipulated mechanism to induce an ex-post inefficient action profile, they renegotiate at some “early” point in time $t \in (0, 1 - \epsilon]$. In the next section, I will establish that there is no scope for ex-ante renegotiation if the stipulated message date is sufficiently close to date 1.

3 First Best

To ease the presentation of this section, let us assume that the agents stipulate the following simple shoot-the-liar-mechanism: If the reports match, *and* the agents chose the efficient action profile contingent on the reported state, $a = a^*(\theta_R)$, the mechanism compels a transfer of

$$y^*(\theta_R) = u_2(a^*(\theta_R), \theta_R) - W(a^*(e_1^*, e_2^R, \omega_R), e_1^*, e_2^R, \omega_R)$$

from agent 2 to agent 1. Here, e_2^R is the report about agent 2’s investment. I explain why it is optimal to stipulate exactly this transfer in the proof of Proposition 3 below. If reports match but an agent chooses $a_i \neq a^*(\theta_R)$, this agent must pay a very large transfer to the other agent. If reports do not match, the transfer is zero and the action profile $(0, 0)$ is enforced: If an agent chooses a different action, he is yet again obliged to transfer a large sum of money.¹⁰ An undesirable, and well known, property of shoot-the-liar mechanisms is that they admit multiple equilibria. Hence, after having established that the first best is indeed an equilibrium, I will argue that one can establish the first best as the unique equilibrium by

⁹I do not consider partial renegotiation. That is, renegotiation must be concluded before date 1. In theory, the agents can renegotiate multiple times between date 0 and date 1. As I will argue next section, they do not have an incentive to do so on the first-best equilibrium path.

¹⁰I use a slightly altered version of the standard shoot-the-liar mechanism because I consider an individual action model. In a public action model the mechanism would simply enforce the aforementioned action profiles.

using a more complex mechanism such as Moore and Repullo's (1988) sequential mechanism.

Let us tackle the problem using backwards induction, starting from date 1, which is the agents' last decision node. I work under the premise that both agents have previously reported the true state at some date $d \in (1 - \epsilon, 1)$ and invested efficiently at date -1. It is obvious that the agents choose the ex-post efficient action profile $a^*(\theta)$, since the mechanism punishes any deviation. Now let us consider date $d \in (1 - \epsilon, 1)$, when the agents play the mechanism. I can establish that

Proposition 1 *To report truthfully, $\theta_1 = \theta_2 = \theta$, is a Nash equilibrium of the augmented shoot-the-liar mechanism if $W(a^*(e_1, e_2, \omega), e_1, e_2, \omega) \geq W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega)$. Given truthful reporting, agent 1 anticipates an ex-post payoff of*

$$U^1(a, \theta, \theta_R) = u_1(a^*(\theta), \theta) + u_2(a^*(\theta), \theta) - W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega),$$

whereas agent 2 anticipates to receive

$$U^2(a, \theta, \theta_R) = u_2(a^*(\theta), \theta) - u_2(a^*(\theta), \theta) + W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega).$$

Proof. Let us show that truthful reporting is an equilibrium. Given that agent 1 reports truthfully, agent 2's payoff amounts to

$$\begin{aligned} U^2(a, \theta, \theta_R) &= \begin{cases} u_2(a^*(\theta), \theta) - y^*(\theta), & \text{if } \theta_2 = \theta \\ 0, & \text{if } \theta_2 \neq \theta \end{cases} \\ &= \begin{cases} u_2(a^*(\theta), \theta) - u_2(a^*(\theta), \theta) \\ + W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega), & \text{if } \theta_2 = \theta \\ 0, & \text{if } \theta_2 \neq \theta. \end{cases} \end{aligned}$$

That is, it is optimal for agent 2 to report truthfully whenever $W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega) \geq 0$, which is always the case.¹¹ Given that agent 2 reports truthfully, agent 1's payoff can be written as

$$\begin{aligned} U^1(a, \theta, \theta_R) &= \begin{cases} u_1(a^*(\theta), \theta) + y^*(\theta), & \text{if } \theta_1 = \theta \\ 0, & \text{if } \theta_1 \neq \theta \end{cases} \\ &= \begin{cases} u_1(a^*(\theta), \theta) + u_2(a^*(\theta), \theta) \\ - W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega), & \text{if } \theta_1 = \theta \\ 0, & \text{if } \theta_1 \neq \theta \end{cases} \\ &= \begin{cases} W(a^*(e_1, e_2, \omega), e_1, e_2, \omega) - W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega), & \text{if } \theta_1 = \theta \\ 0, & \text{if } \theta_1 \neq \theta. \end{cases} \end{aligned} \tag{1}$$

¹¹Recall that W is zero if $a = (0, 0)$.

If the agents invested efficiently ex-ante, I can plug in e_1^* and e_2^* in (1) and conclude that agent 1 reports truthfully whenever $0 \geq 0$. Hence, agent 1 reports truthfully whenever $0 \geq 0$. Or in other words, he is indifferent between reporting truthfully and misreporting. Technically this means that to report truthfully is a best reply for agent 1. The agents can get rid of the indifference problem in those cases where $W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega)$ is strictly larger than zero in all states of the world. In that case, the agents can add a constant $K < W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega)$ to the transfer agent 1 receives from agent 2 if reports match. Or in other words, to report truthfully is a strict best reply for both agents if the ex-post joint surplus, given that the agents choose the ex-post efficient action profile, is strictly positive in all states of the world. Now let us consider the case where the agents did not invest efficiently ex-ante. Given agent 2 reports truthfully, agent 1 does so whenever $W(a^*(e_1, e_2, \omega), e_1, e_2, \omega) - W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega) \geq 0$. As before, agent 2 reports truthfully because $W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega) \geq 0$. ■

In my setting, the shoot-the-liar mechanism only induces the agents to report truthfully when $W(a^*(e_1, e_2, \omega), e_1, e_2, \omega) \geq W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega)$, which holds true in many applications.¹² A prominent example is Che and Hausch's (1999) analysis of the no-renegotiation case in their buyer-seller model of hybrid investments. Nonetheless, the agents can avoid this problem, and also the problem that the shoot-the-liar mechanism may admit multiple equilibria, by using Moore and Repullo's (1988) sequential mechanism.¹³ So far, I have established that the agents choose the ex-post efficient action profile and, anticipating this, report truthfully. It directly follows that

Proposition 2 *The agents do not renegotiate before the mechanism is played.*

The rationale behind this simply is that there is no scope for ex-ante renegotiation because the agents anticipate that they will choose the ex-post efficient action profile $a^*(\theta)$ at date 1. Finally, let me establish that

Proposition 3 *Anticipating that they will report truthfully, $\theta_1 = \theta_2 = \theta$, and will subsequently choose the ex-post efficient action profile $a(\theta) = a^*(\theta)$, the agents invest efficiently at date -1, $e_1 = e_1^*$ and $e_2 = e_2^*$.*

Proof. Anticipating truthful reporting and an efficient action profile, the agents invest efficiently at date -1 because the mechanism provides them with the correct marginal returns to their investments: Given that agent 2 invests efficiently, $e_2 = e_2^*$, and using that $\theta = (e_1, e_2, \omega)$, agent 1's expected utility can be

¹²In those cases where $W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega) > 0 \forall \theta \in \Theta$, the agents can yet again add a constant K to the transfer agent 1 receives from agent 2. Then, agent 1 reports truthfully whenever $W(a^*(e_1, e_2, \omega), e_1, e_2, \omega) - W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega) + K \geq 0$, which relaxes the condition stated in the proposition.

¹³It is straightforward to show that by using Moore and Repullo's (1988) mechanism, the agents can implement truthful reporting as a unique equilibrium in my setting.

written as

$$\begin{aligned}
& E[U^1(a^*(e_1, e_2^*, \omega), e_1, e_2^*, \omega)] - C_1(e_1) = \\
& E[u_1(a^*(e_1, e_2^*, \omega), e_1, e_2^*, \omega) + u_2(a^*(e_1, e_2^*, \omega), e_1, e_2^*, \omega) - W(a^*(e_1^*, e_2^*, \omega), e_1^*, e_2^*, \omega_R)] \\
& - C_1(e_1) = \\
& E[W(a^*(e_1, e_2^*, \omega), e_1, e_2^*, \omega)] - E[W(a^*(e_1^*, e_2^*, \omega), e_1^*, e_2^*, \omega_R)] - C_1(e_1).
\end{aligned}$$

Note that agent 1's expected utility amounts to expected joint surplus plus/minus a term that is constant with respect to her investment. Hence, because (e_1^*, e_2^*) maximizes expected joint surplus, $e_1 = e_1^*$ must be a best reply for agent 1. Suppose agent 1 invests efficiently. Then, agent 2's expected surplus can be written as

$$E[W(a^*(e_1^*, e_2, \omega), e_1^*, e_2, \omega_R)] - C(e_2).$$

Once again, because (e_1^*, e_2^*) maximize expected joint surplus, $e_2 = e_2^*$ must be a best reply for agent 2. ■

The agents invest efficiently because the transfer is fine-tuned in such a way that both agents become a residual claimant. What makes the result strong is that it holds independent of the nature of investment. That is, it does not matter whether investment is of a purely cooperative, hybrid, or selfish nature. At this point it is worth recalling that it is well known that the agents can achieve the first best if they can commit not to renegotiate, see e.g. Che and Hausch (1999) or Maskin and Tirole (1999). Hence, the main contribution of the present paper is to point out how the agents can avoid renegotiation endogenously without needing to be able to commit. In theory, the agents could stipulate the message date, d , such that there is sufficient time to renegotiate after the mechanism is played, but choose not to. The key ingredients needed to obtain my result are that (i) renegotiation takes a small amount of time and (ii) that there is a deadline after which renegotiation is impossible. The existence of the deadline directly follows from the non-durability of the agents' actions. For instance, agent 1 may be an upstream firm that has to "win" an auction in order to supply agent 2, the downstream firm. Clearly, the agents' cannot renegotiate agent 1's action (the bid) after the auction day has passed.¹⁴

There is an interesting connection between my result and Watson (2007), who compares a situation where the agents renegotiate before messages are sent, interim renegotiation, to one where they renegotiate after they are sent, ex-post renegotiation. Recall that Watson (2007) finds that the set of implementable outcomes is the largest in case of no renegotiation, followed by interim renegotiation, and ex-post renegotiation. My result suggests that the fact that the set of

¹⁴Politics may also be a prominent example: Action (decision) opportunities are often non-durable because it would be prohibitively costly to reschedule a new meeting in case an agreement cannot be reached. For instance, consider summits of the European Union, where decisions are often made late at night, at the very end of the summit. Like in the present paper, there comes a point in time where it becomes impossible, or at least very costly, to renegotiate decisions made.

implementable outcomes is smaller in case of interim renegotiation, compared to no renegotiation, does not matter for efficiency. As mentioned, in my model the agents could renegotiate interim but choose not to do so on the equilibrium path.

4 Robustness

Durable Action Opportunity

Even though I have provided examples for non-durable action opportunities, one may argue that actions are often of a durable nature in “normal” trade relationships, that is, unless the agents can commit themselves to a certain deadline. For instance, suppose agent 1 is a seller who decides not to deliver his product at date 1. Obviously, the agents should have the opportunity to renegotiate after date 1 in order to induce the seller to deliver the product at a later point in time. An interesting question for future research thus is if and how my result can be generalized to a setting with durable action opportunities. Whereas to tackle this question in detail is beyond the scope of the present paper, the following cases seem to be straightforward:

(i) Suppose the agents are perfectly patient and can choose their actions at any point in time between date 1 and some point T . In that case, it would be optimal for the agents to set the message date sufficiently close to point T , such that there is, yet again, insufficient time to renegotiate after the agents played the mechanism.

(ii) Suppose the agents may choose their actions at any point after date 1, but, by doing so, risk that an exogenous event may end their (trade) relationship. Even if the risk of such an exogenous breakdown is low, it may induce the agents to report truthfully when playing the mechanism. To see this, consider an agent’s decision problem when playing the shoot the liar mechanism close to date 1. The agent anticipates, given that the other agent reports truthfully, the consequences of reporting truthfully: Both agents will choose the ex-post efficient action profile at date 1. Not to report truthfully has a positive and a negative effect: If the agent misreports, the default is that the STL mechanism “enforces” the null actions (zero trade) and zero transfer. Hence, the agents will try to meet in order to renegotiate the anticipated inefficient outcome. Consequently, by misreporting strategically, the agent may be able obtain some additional surplus in the renegotiations that follow. The negative effect is that the agents’ relationship may break down before they have the time to renegotiate the null actions. That is, with a certain probability the undesirable outcome of the STL mechanism persists. If that expected loss exceeds the potential benefit of the positive effect described above, it is optimal for both agents to report truthfully. In that case, the first-best contract of the present paper remains optimal.

Playing the mechanism takes time

In the previous section, I have used the simplifying assumption that playing the mechanism does not take any time. Let me now relax this assumption by assuming that playing the mechanism takes $\tau < \epsilon \ll 1$ unit of time. That is, playing the mechanism takes time, but less than renegotiating a new contract. I can directly establish the following lemma:

Lemma 1 *If the contract stipulates some message date $d \in (1 - \tau, 1)$, the agents renegotiate at some point in time $t \in (0, 1 - \tau - \epsilon)$ in order to replace d with some new message date $d^{NEW} \in (t + \epsilon, 1 - \tau)$.*

Proof. If $d \in (1 - \tau, 1)$, the agents have no time to play the stipulated mechanism. Hence, they renegotiate early to stipulate a new message date such that the mechanism can be played. They must do so at some point in time $t \in (0, 1 - \tau - \epsilon)$ because renegotiation takes ϵ time and must be concluded before point in time $1 - \tau$. ■

In the previous section, it is optimal for the agents to stipulate a sufficiently late message date, $d \in (1 - \epsilon, 1)$. If renegotiating takes time, any point in time after $1 - \tau$ cannot be optimal because the agents have insufficient time to play the mechanism. Hence, the optimal contract now stipulates some message date $d \in (1 - \epsilon, 1 - \tau)$:

Proposition 4 *If the contract stipulates some message date $d \in (1 - \epsilon, 1 - \tau)$, (i) the agents do not renegotiate the original message date, and (ii) the first best is still attainable.*

The reasoning behind why the agents do not renegotiate the message date is similar to before: In order to induce ex-post efficiency, it suffices to replace the original mechanism m with a new one m^{NEW} . Given that the agents do not renegotiate the message date, there is insufficient time to renegotiate after the mechanism is played. Hence, as is the case in Section 3, mutually bad outcomes of the mechanism cannot be renegotiated. Consequently, it is not too surprising that the agents report truthfully. We can deduce from Proposition 4 that accounting for the fact that playing the mechanism takes time may shrink the set of optimal message dates from $d \in (1 - \epsilon, 1)$ to $d \in (1 - \epsilon, 1 - \tau)$.¹⁵ The first best is, however, still attainable.

5 Discussion

In the present paper, I argue that the fact that the external enforcer receives messages from the agents has not been properly exploited in the preexisting literature: If he is able to receive messages, it makes sense to assume that he also knows *when* the messages have been received. Hence, the agents can write a contract

¹⁵This conjecture should, however, be read with a grain of salt. To see why, note that I did not establish that there do not exist other optimal equilibria in the range $d \in (0, 1 - \epsilon)$.

to stipulate a certain message date, instructing the external enforcer to disregard messages received at any other point in time. Using the natural assumption that renegotiation takes time, even if very little, it is thus possible for the agents to stipulate the message date such that there is insufficient time to renegotiate the mechanism after it has been played. Hence, inefficient outcomes can be used as a threat point to ensure that both agents report truthfully. My paper is part of a strand of the literature that argues that the well known irrelevance of contracting paradigm only arises in very specific situations. By taking small details into account, that are important in practice, one is able to reduce or eliminate the detrimental effect of renegotiation. As mentioned, Watson (2007) shows that the set of implementable outcomes expands if renegotiation takes place ex-post and trade actions are modeled as individual. Moreover, Evans (2012) demonstrates that if sending messages involves a small cost, renegotiation does not restrict the set of implementable outcomes.

As in Watson (2007), I assumed that there is a fixed point in time when the agents choose their actions. Hence, if the message date is close to this point in time, there is insufficient time to renegotiate inefficient out-of-equilibrium play of the mechanism. This, of course, is incompatible with the concept of renegotiation-proofness. Note, however, that the same problem occurs in Watson's (2007) analysis of interim renegotiation. The important difference between Watson's (2007) case of interim renegotiation and the present paper is that the fact the agents may not renegotiate after having played the mechanism is an endogenous outcome of my model. That is, the agents could stipulate the message date such that there is ample time to renegotiate, but find it in their best interest not to do so. On the equilibrium path, the outcome is, of course, always ex-post efficient.

The augmented shoot-the-liar mechanism used in the proof of Proposition 3 could be criticized for admitting multiple equilibria and for being impractical. Note, however, that there is a crucial difference between the present paper and much of the mechanism-design literature. The latter's aim is to come up with some clever designed mechanism that solves the problem under consideration, see e.g. Evans (2012). In contrast, I focus on the interplay between message date, mechanism, and renegotiation. Because it is in the agents' best interest to endogenously avoid ex-post renegotiation, there are many possible mechanisms that the agents can use to induce the first best.

Finally, one may argue that, due to the non-durable action opportunity, it is not too surprising that the first-best can be attained. My answer to this is that my paper incorporates important but previously overlooked issues, like that renegotiation takes time, that are important in practice. The aim of this paper is to pinpoint what this implies for the interplay of the action opportunity and the message date. In a second step, one should think of how well my optimality result can be extended to settings of durable action opportunities. In Section 4, I sketched two cases in which my optimality result continuous to hold. I conjecture that these two examples are far from exhaustive. This should, however, be analyzed in detail in future research.

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