Breach, Remedies and Dispute Settlement in Trade Agreements*

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Abstract

We analyze the optimal design of legal remedies for breach in the context of international trade agreements. Our formal analysis delivers a number of insights concerning the appropriate remedy for breach and optimal institutional design in light of features of the underlying economic and contracting environment. And our analysis also delivers novel predictions regarding when disputes arise in equilibrium, and how the disputes are resolved.

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1. Introduction

When governments make international commitments, what should be the legal remedy for breach under their agreement? Should a government who is harmed by the breach be able to demand specific performance of the commitment under the law, or simply the payment of damages for the harm done? In this paper we address these questions as they arise in the context of international trade agreements. Our analysis delivers a number of insights concerning the appropriate remedy for breach and optimal institutional design in light of features of the underlying economic and contracting environment, and it delivers a rich set of predictions regarding when disputes arise in equilibrium and how the disputes are resolved.

We pay particular attention to the rules of the World Trade Organization (WTO) and the General Agreement on Tariffs and Trade (GATT), its predecessor agreement. This is a natural institution on which to focus, given its prominence in the world trading system, but we emphasize that our analysis applies to international trade agreements more generally – and indeed even to agreements outside the trade policy area.

In the WTO (and GATT before it), the central international commitments made by governments relate to market access,[1] and answers to the questions posed above help to define the nature of the entitlements over access to foreign markets that governments can expect to secure for their exporters by contracting with other governments. Two related issues can be identified. A first issue concerns the design of dispute settlement procedures and the mandate of the Dispute Settlement Body (DSB). When the terms of the contract are breached, should the DSB if invoked be asked to enforce contract performance? Or should it rather be asked to specify a level of damages and allow a choice between performance or a damage payment and breach? A second issue concerns the design of escape clauses built in to the terms of the contract itself: When should an escape clause be made available, and what should a government be legally obliged to pay in order to exercise it?

Behind these issues lies the important possibility that governments may bargain to settle their differences without recourse to a DSB ruling: in this case the legal rules and remedies themselves do not directly determine the outcome, but they do impact the outcome indirectly by shaping what governments can expect if their attempts at settlement fail. And in the presence of transaction costs, these legal rules and remedies can have important efficiency consequences

[1] The only WTO commitments that do not derive their purpose from market access concerns are those related to intellectual property rights protection and found in the TRIPs agreement.

even when bargaining and settlement is the dominant outcome.

Analogous questions and issues have been extensively studied in a domestic context as they relate to the actions of private agents in two related literatures in law and economics. A fundamental question in the literature concerned with domestic contracts (see, for example, Schwartz, 1979, Ulen, 1984, and Shavell, 2006) is when contracting parties would want specific performance as a remedy for contract breach and when they would instead prefer damage payments. There is also a vast literature (the seminal contributions are Calabresi and Melamed, 1972, and Kaplow and Shavell, 1996) that is concerned with the related question of when property rules, under which an entitlement can only be removed from its holder through a voluntary transaction, are preferred to liability rules, whereby the entitlement can be removed from its holder for the payment of objectively determined damages.

In the domestic context that is the focus of these literatures, the transaction costs that underlie the efficiency consequences of the choice of legal rules are typically associated with private information or other bargaining frictions. Such frictions are surely present as well in international bargaining, but in the international context there is an additional feature that is particularly salient and that distinguishes the international environment from its domestic counterpart: in the international government-to-government setting, there generally do not exist efficient transfer mechanisms that can be used to make damage payments, either to settle disputes or to compensate for the exercise of escape clauses. In the GATT/WTO, the typical means by which one government achieves compensation for the harm done by another government's actions is through "counter-retaliation," that is, by raising its own tariffs above previously negotiated levels. Such compensation mechanisms entail important inefficiencies (deadweight loss) that, while plausibly absent in the domestic private agent context, introduce a novel transaction cost in the international context through which the choice of legal rules and remedies can have efficiency consequences.[2]

A major point of departure of our model is precisely this difference between the domestic private agent setting and the international government-to-government setting. In particular, we

[2]Other possible means of compensation are a further reduction of previously-negotiated trade barriers in other sectors by the breaching government, or changes in non-trade policies. Both of these mechanisms are likely to entail deadweight losses. Even with cash transfers between governments, which are extremely rare in the context of the settlement of trade disputes (see note 6), the revenue must still be collected, and unless lump-sum tax instruments are available to governments these transfer mechanisms will have efficiency costs too. Our point here is simply that, unlike in the domestic private-agent context, the transfer mechanisms available to governments will often entail important efficiency costs (see, however, note 10).

consider a setting where governments, operating in the presence of ex-ante uncertainty about the joint benefits of free trade (which could be positive or negative, due to the possible presence of political-economy factors), contract over trade policy and define a mandate for the DSB in the event that contract disputes should arise ex post, once uncertainty has been resolved and trade policies are chosen. We assume that transfers between governments are costly and that the marginal cost of transfers is (weakly) increasing in the magnitude of the transfer. And finally, to highlight the implications of costly transfers, we abstract from the ex-post bargaining frictions that are typically emphasized in the domestic context.

We consider agreements that specify a baseline commitment to free trade but allow the importing government to escape (breach) this commitment by compensating the exporter with a certain amount of damages. If the level of damages is set either at zero or at a level so high that the importing government would never choose to breach, then we may interpret this as a property rule in which either the entitlement to protect is assigned to the importing government or the entitlement to free trade is assigned to the exporting government. Alternatively, if damages are set at an intermediate level, then we may interpret this as a liability rule.[3]

We assume that the DSB, if invoked, observes a noisy signal of the benefits of protection for the importer and the costs of protection to the exporter – and hence the joint benefits of free trade – which we interpret as arising from a DSB investigation. Based on this imperfect information, the DSB issues a ruling which is summarized by a level of damages that must be paid by the importing government if it wishes to breach its commitment to free trade. At the time when the DSB can be invoked, the governments are uncertain about the outcome of the DSB investigation and hence about the DSB ruling, and subject to this uncertainty must decide whether to invoke the DSB or to settle. And if a DSB ruling is reached, the governments can renegotiate the ruling; this is a further possibility for renegotiation and settlement, in addition to the possibility before any DSB ruling which we already mentioned.

These two features of our model – the possibility that governments negotiate an early settlement under uncertainty about the DSB ruling, and the possibility of renegotiating a DSB ruling – constitute a second important point of departure from the law-and-economics

[3]There are two equivalent interpretations of our formalization of damages for breach. The first is that breach damages are specified explicitly in the contract in the form of an escape clause, so that the contract in effect specifies a *menu* of choices for the importing government (choosing free trade, or choosing protection and paying damages to the exporter). The second is that the contract specifies a rigid free trade commitment, but the DSB is given a mandate to require the payment of damages in case of breach. As we discuss in section 2.1, both of these interpretations are relevant for the GATT/WTO.

literature we discussed above. Allowing the governments to be uncertain about the DSB ruling is important in our setting because, as will become clear, this allows for the possibility that governments may *not* settle early; and as a consequence, the model generates a variety of predictions regarding when governments settle early or a dispute arises in equilibrium, and how the disputes are resolved. Moreover, the model generates predictions about the circumstances under which a DSB ruling is renegotiated in equilibrium. This is in contrast with much of the law-and-economics literature, where parties always settle early in equilibrium.

We start by considering a benchmark scenario in which the DSB receives no information ex post. Our first result concerns the impact of ex-ante uncertainty over the joint benefits of free trade. We find that a property rule, which either demands strict performance or permits complete discretion in the choice of trade policy, is optimal when ex-ante uncertainty is low. By contrast, when ex-ante uncertainty is high, we find that a liability rule tends to be optimal.

We also find that increasing the cost of transfers has effects which are qualitatively similar to decreasing the degree of ex-ante uncertainty. For this reason, a property rule is optimal if the cost of transfers is sufficiently high, while a liability rule is optimal if the cost of transfers is sufficiently low. Recalling that the cost of transfers plays the role of transaction costs in our model, our results suggest that a property rule tends to be preferred to a liability rule when transaction costs are high. This contrasts with the findings in the law-and-economics literature that liability rules tend to be preferable to property rules when transaction costs are high (Calabresi and Melamed, 1972, and Kaplow and Shavell, 1996).[4] Moreover, in the circumstances where a liability rule is optimal, we find that it is never optimal to set damages high enough to make the exporter "whole," again contrary to the presumption in the law-and-economics literature. Our results differ from these earlier findings because of our focus on the cost of transfers as a transaction cost, a focus that as we have explained above distinguishes the international government-to-government context from its domestic counterpart.

Next we consider the more general case in which the DSB observes a noisy signal ex post about the joint benefits of free trade. In this case, if ex-ante uncertainty about the joint benefits of free trade is small, a property rule is optimal, with the assignment of entitlements contingent

[4] In the papers by Calabresi and Melamed (1972) and Kaplow and Shavell (1996), transaction costs take the form of frictions in ex-post bargaining. We examine also the impact of this type of transaction cost in our model (comparing the case of frictionless ex-post bargaining with the extreme opposite case in which ex-post bargaining is not feasible), and again our results diverge from those of the above-mentioned papers: we find that, in the presence of a cost of transfers, the introduction of frictions in bargaining may well favor property rules over liability rules.

on the signal received by the DSB; and if ex-ante uncertainty is sufficiently large, a liability rule tends to be optimal, with the DSB reducing the level of damages when it receives a signal that the joint benefits from free trade are smaller or negative. We relate these findings to the WTO Agreement on Safeguards, and suggest that they may be helpful in interpreting the WTO rules on compensation for escape clause actions.

We also establish that, if the noise in the DSB signal is sufficiently small (in an appropriate sense), a property rule is optimal, with the assignment of entitlements contingent on the signal. The strict preference for a property rule in this case again reflects our focus on the cost of transfers, and in particular the benefits of avoiding (costly) ex-post compensation from an ex-ante efficiency perspective. This finding suggests that, if the accuracy of DSB rulings increases, the optimal institutional arrangement should tend to move away from liability rules toward property rules. If one is willing to believe that the accuracy of DSB rulings has increased over time, then our model predicts a gradual shift from liability rules to property rules in connection with the evolution from GATT to the WTO. Whether or not this has been the case in reality is not obvious: we briefly discuss the differing views of legal scholars (Hippler Bello, 1996, Jackson, 1997, Schwartz and Sykes, 2002) on this point.

Next we consider when disputes arise in equilibrium and how disputes are resolved. We find that early settlement of disputes is more likely when there is more uncertainty at the time of contracting about the future joint benefits from free trade, and that early settlement occurs when the joint benefits of free trade turn out to be either very high or very low. As we noted above, DSB rulings may be renegotiated in equilibrium, and our model generates further predictions in this regard. We find that, conditional on the DSB being invoked, the ruling is implemented when the DSB receives information that the joint benefits of free trade are either very high or very low, and consequently sets a very high or very low level of damages. On the other hand, the DSB ruling is renegotiated if the realized signal, and hence the level of damages set by the DSB, lies in an intermediate range. An interesting corollary of this finding is that renegotiation of DSB rulings need not reflect a "bad" (inaccurate) ruling.

We also consider the possibility that the cost of transfers differs across the two countries, and we interpret as a developing country the country whose cost of granting transfers is higher. We find that early settlements tend to implement free trade when the developing country is the respondent (importing country), while they tend to implement protection when the developed country is the respondent. Thus, there is a tendency for developed countries to impose more protection as a result of early settlements than is the case for developing countries. We also find that, conditional on the developed country (developing country) being the respondent, the DSB tends to be invoked and a ruling issued when free trade (protection) is the first-best policy. As a consequence, there is a pro-trade (anti-trade) selection bias in DSB rulings when a developed country (developing country) is the respondent.

The last step of our analysis is to consider a more general class of contracts, which allows not only for a "stick" (payment of damages to the exporter) associated with import protection, but also for a "carrot" (compensation from the exporter) associated with free trade. We show that, if uncertainty about the joint benefits of free trade is sufficiently small or the cost of transfers is sufficiently large, there is no gain from using a carrot in addition to the stick; but if uncertainty is large or the cost of transfers is small, then it is optimal to introduce a carrot in the contract. In any event, whether or not it is optimal to include a carrot in the contract, our earlier results regarding the comparison between liability and property rules and the optimal damages for breach continue to hold.

Beyond the literature we have already mentioned, there are a number of additional papers that are related to ours. Like us, Beshkar (2008a,b) considers the possibility of efficient breach in a setting with import protection, non-verifiable political pressures and costly transfers, but his model differs significantly from ours in a number of important ways: most significantly, he does not allow for the possibility of renegotiation and settlement, which is a central focus of our analysis. Similarly, Howse and Staiger (2005) are concerned with the circumstances under which the GATT/WTO reciprocity rule might be interpreted as facilitating efficient breach, but they do not consider the possibility of settlement either. Bagwell and Staiger (2005), Martin and Vergote (2008) and Bagwell (2009) all consider models with import protection and privately observed political pressures, but they do not consider the role of a court (DSB) or issues related to renegotiation/settlement in trade disputes, and focus instead on self-enforcement issues (from which we abstract). Park (2009) does consider the role of the DSB in a setting with privately observed political pressures, but the DSB is formalized as a device that automatically turns private signals into public signals, without any filing decisions by governments, and hence his model cannot make a distinction between renegotiation/settlement and the triggering of DSB rulings. Finally, our paper is also related to Maggi and Staiger (2008). But that paper has a very different focus: it abstracts from issues of costly transfers and settlement to highlight instead issues associated with vagueness/interpretation, the role of legal precedent and the role of litigation costs, none of which are considered here.

The rest of the paper proceeds as follows. The next section lays out the basic model. Section 3 examines the nature of the optimal rules. Section 4 highlights the predictions of the model concerning the outcome of disputes. Section 5 considers a broader class of contracts. Section 6 concludes. The Appendix contains the proofs of all the formal propositions.

2. The Basic Model

We focus on a single industry in which the Home country is the importer and the Foreign country is the exporter. The government of the importing country chooses a binary level of trade policy intervention for the industry, which we denote by $T \in \{FT, P\}$: "Free Trade" or "Protection."[5] We assume that the exporting government is passive in this industry.

At the time that the Home government makes its trade policy choice, a transfer may also be exchanged between the governments, but at a cost. Here we seek to capture the feature that cash transfers between governments are seldom used as a means of settling trade disputes, while indirect (non-cash) transfers, such as tariff adjustments in other sectors or even non-trade policy adjustments, are more easily available.[6] To allow for this possibility in a tractable way, we let b denote a (positive or negative) transfer from Home to Foreign, and we let $c(b)$ denote the deadweight loss associated with the transfer level b. We assume that $c(b)$ is (weakly) convex, with the natural features that $c(0) = 0$ and that $c(b)$ is decreasing for $b < 0$ and increasing for $b > 0$. We also assume that $c(b)$ is smooth everywhere except possibly at $b = 0$ (this allows for the possibility of a linear cost function, which we feature in section 3.2). Finally, it is convenient to assume that the deadweight loss $c(b)$ is borne by the country that makes the transfer: thus,

[5] Our assumption of a binary policy instrument helps to keep our analysis tractable, and captures reasonably well a variety of non-tariff policy choices, such as regulatory regimes or product standards, that are discrete in nature. Many of the trade disputes in the GATT/WTO focus on these kinds of policy issues.

[6] The resolution of GATT/WTO disputes has, with one exception, never involved cash transfers (the one exception to date is the *US-Copyright* case; see WTO, 2007, pp. 283-286). However, in the context of a trade dispute countries do sometimes achieve the indirect payment of compensation through the WTO "self-help" method of counter-retaliation in other sectors. And WTO disputes that are settled by a "mutually agreed solution" under Article 3.6 of the WTO Dispute Settlement Understanding may involve a variety of indirect transfer mechanisms. The modeling of the cost of transfers in our formal analysis is meant to capture these circumstances. It is also sometimes possible for an importing government to use the revenue created by the protective measure in question to compensate the harmed exporter government, as when the implied quota rents are allocated to the exporters under a voluntary export restraint arrangement. Our formal analysis would also apply in this circumstance, provided that there is some cost associated with administering such arrangements and/or their revenue implications are insufficient to appropriately compensate the exporter government.

if $b > 0$ this loss is borne by Home and if $b < 0$ this loss is borne by Foreign.[7]

The importing government's payoff is given by

$$\omega(T, b) = v(T) - b - c(b)I, \tag{2.1}$$

where $v(T)$ is the importing government's valuation of the domestic surplus associated with policy T in the sector under consideration, and I is an indicator function that is equal to one if Home makes the transfer (i.e., if $b > 0$) and equal to zero otherwise. We have in mind that $v(T)$ corresponds to a weighted sum of producer surplus, consumer surplus and revenue from trade policy intervention, with the weights possibly reflecting political economy concerns (as in, e.g., Baldwin, 1987, and Grossman and Helpman, 1994). As we noted above, the exporting government is passive in this industry; its payoff is therefore

$$\omega^*(T, b) = v^*(T) + b - c(b)I^*, \tag{2.2}$$

where $v^*(T)$ is the exporting government's valuation of the foreign surplus associated with policy T, and I^* is an indicator function that is equal to one if Foreign makes the transfer (i.e., if $b < 0$) and equal to zero otherwise.

Using (2.1) and (2.2), the joint payoff of the two governments is denoted as Ω and given by

$$\Omega(T, b) = v(T) + v^*(T) - c(b). \tag{2.3}$$

We assume that Home always gains from protection, and we denote this gain as

$$\gamma \equiv v(P) - v(FT) > 0.$$

This gain may be interpreted as arising from some combination of terms-of-trade and political considerations. On the other hand, we assume that Foreign always loses from protection, and we denote this loss as

$$\gamma^* \equiv v^*(FT) - v^*(P) > 0.$$

[7] This assumption provides a simple way to encompass the benchmark case of non-transferable utility, which arises in the limiting case of our model as the cost of making non-zero transfers approaches infinity. Alternatively, we could assume that the deadweight loss is always borne by the country that receives the transfer, in which case the benchmark of non-transferable utility would obtain in the limit as the cost of making non-zero transfers approaches one (if the cost of making transfers was greater than one it would be impossible to transfer utility under this alternative assumption, because the receiver of the transfer must throw away more money than it receives).

The joint (positive or negative) gain from protection is then $\Gamma \equiv \gamma - \gamma^*$. With these definitions, we can think of four basic parameters (in addition to the transfer cost function $c(b)$) that characterize the economic environment: Home's valuation of the FT policy ($v(FT)$) and its gain from protection (γ), and Foreign's valuation of the FT policy ($v^*(FT)$) and its loss from protection (γ^*).

In this simple economic environment, the "first best" (joint-surplus maximizing) outcome is then easily described: if $\Gamma > 0$ (or $\gamma > \gamma^*$), the first best is $T = P$ and $b = 0$, and if $\Gamma < 0$ (or $\gamma < \gamma^*$), the first best is $T = FT$ and $b = 0$. Notice that b always equals zero under the first best, because transfers are costly to execute. For future use, we denote by Ω_{FB} the first-best joint payoff level.

We think of γ and γ^* as variables about which governments are uncertain ex ante. We assume that γ and γ^* are independent, and denote their ex-ante distributions respectively by $h(\gamma)$ and $h^*(\gamma^*)$.[8] We assume that these distributions are common knowledge, and we assume that both governments observe γ and γ^* ex post (we discuss the role of our informational assumptions in the Conclusion). Finally, to simplify the analysis we assume that γ and γ^* have the same support, which unless otherwise noted we assume to be finite. Note that this implies that the support of Γ includes the value $\Gamma = 0$.

If transfers across bargaining parties were costless (no deadweight loss), then there would be no transaction costs in the model, and governments could always achieve the first-best joint payoff level Ω_{FB} in every state of the world (γ, γ^*) by engaging in ex-post (i.e., after observing γ and γ^*) negotiations over policies and (costless) transfers.[9] Costly transfers introduce a transaction cost that, as we have indicated above, seems especially relevant in the context of international dispute resolution. In this environment, Ω_{FB} can not be achieved in general, but ex-ante joint surplus may be enhanced by writing a contract ex ante (before the state of the world (γ, γ^*) is realized), and defining a role for a Dispute Settlement Body (DSB) in the event that contract disputes arise ex post. We may then ask the question: What is the best (ex-ante-joint-surplus maximizing) contract/DSB combination (i.e., What is the best design for an international trade "institution")?[10] And we may also ask the question: When do disputes

[8] We believe that our qualitative results (with the possible exception of Proposition 5, where the stochastic interaction between γ and γ^* plays a role) do not depend on this independence assumption.

[9] We abstract from issues of enforcement here and simply assume that bargaining outcomes between the two governments are enforced.

[10] There are three ways to justify this emphasis on the maximization of the governments' ex-ante joint surplus. One possibility is to allow for costless ex-ante transfers, i.e., transfers at the time the institution is created. This

arise in equilibrium under various institutional design choices, and how are the disputes resolved (e.g., early settlement, implemented DSB ruling, renegotiation of the DSB ruling)?

Regarding the information possessed by the DSB, we assume that, like the governments, it knows the ex-ante distribution of γ and γ^*. But while the governments observe γ and γ^* ex post, the DSB does not (i.e. γ and γ^* are not verifiable). The DSB can only observe noisy signals of γ and γ^* (denoted $\hat{\gamma}$ and $\hat{\gamma}^*$) if invoked, observing these signals as the outcome of a DSB investigation.[11]

We may now describe the timing of events. The game is as follows:

0. Governments write the contract and define the role of the DSB.
1. The state (γ, γ^*) is realized and observed by the governments.
2. The importer proposes a T and a b that can differ from the terms of the contract. The exporter either accepts the proposal or files with the DSB.
3. If invoked, the DSB conducts a (noisy) investigation and issues a ruling.
4. The importer can propose a deviation from the ruling. The exporter either accepts the proposal (so that the DSB ruling is not enforced) or demands enforcement of the ruling.
5. Trades occur and payoffs are realized.

Note that we allow ex-post renegotiation of the initial contract (in stage 2) as well as renegotiation of the DSB ruling (in stage 4); and we assume that the importer makes take-or-leave offers. Opportunities for renegotiation are central to our analysis, and as we have indicated above and describe further below, they are an important feature of the dispute resolution process for international trade agreements such as the GATT/WTO. Indeed, as reflected in the game above, the critical role played by the DSB lies precisely in defining the disagreement point

justification is not in contradiction with our assumption of costly ex-post transfers, if it is interpreted as reflecting the notion that the cost of transfers can be substantially eliminated in an ex-ante setting such as a GATT/WTO negotiating round where many issues are on the table at once (see, for example, the discussion in Hoekman and Kostecki, 1995, Ch. 3). A second possibility would be to keep the single-sector model and introduce a veil of ignorance, so that ex-ante there is uncertainty over which of the two governments will be the importer and which the exporter. And a third possibility would be to introduce a second mirror-image sector.

[11] Our informational assumptions are thus similar to those in Maggi and Staiger (2008). There we introduce a state vector s, and γ and γ^* are functions of s, in order to explore a number of questions that we abstract from in this paper (see also note 15).

provided by the legal system should ex-post negotiations between the two governments fail; and it is these opportunities for governments to "bargain in the shadow of the law" that form the heart of our analysis of contract/DSB design.[12] By contrast, the assumption of take-or-leave offers makes our analysis easier, but it is not critical for our results.

2.1. The contracting options and the role of the DSB

We next describe the contracting options and the role of the DSB. Given that γ and γ^* are not verifiable, the contractual options are rather limited. Of course, governments can write a rigid $\{FT\}$ contract, or leave discretion over trade policy. But in addition to these possibilities, there is another possibility, which can indirectly achieve desirable contingent outcomes: a *menu contract* that allows the importer to choose between (i) setting FT and (ii) setting P and compensating the exporter with a payment b^D. In the language of the law-and-economics literature, this is a contract that specifies a baseline commitment (FT) but allows the importer to escape or *breach* this commitment by paying a certain amount of *damages*.

Note that the rigid $\{FT\}$ contract is a special case of a menu contract, where the damages b^D are set at a prohibitively high (or infinite) level; we will often refer to this contract as one that requires strict *performance* under all circumstances, or in short, a "performance contract." Moreover, discretion is also a special case of a menu contract where the level of damages is zero ($b^D = 0$). Thus, the level of damages b^D summarizes the contractual choice: as b^D goes from zero to prohibitive, the menu contract spans all the possibilities, ranging from discretion to a contract that stipulates (non-prohibitive) damages to a strict performance contract. When we analyze the optimal contract, we will simply choose the optimal level of b^D.

Observe as well that setting damages at either zero or a prohibitive level amounts to establishing a *property rule*, in which as a legal matter the right to protect is granted to the importer (when damages are set to zero) or the right to free trade is granted to the exporter (when damages are set at a prohibitive level). And setting damages strictly between zero and the prohibitive level amounts to establishing a *liability rule*. Therefore, in what follows we will also

[12]This phrase appeared in the title of a paper written by Mnookin and Kornhauser (1979). Like us, those authors were "...concerned primarily with the impact of the legal system on negotiations and bargaining that occur *outside* the courtroom." (p. 950, emphasis in the original). Mnookin and Kornhauser (p. 950, note 1) also quote from Hart and Sacks (1958): "Every society necessarily assigns many kinds of questions to private decision, and then backs up the private decision, if it has been duly made, when and if it is challenged before officials...". The game we analyze depicts a formal structure that is akin to the institutional setting described by Hart and Sacks.

draw links between our results and the relevant law-and-economics literature that is concerned with the choice between property rules and liability rules.

Finally, if γ and γ^* are imperfectly verifiable, in the sense that the DSB can observe only noisy signals $\hat{\gamma}$ and $\hat{\gamma}^*$, then we can consider a wider class of contracts, where b^D can be contingent on $\hat{\gamma}$ and $\hat{\gamma}^*$. Given the $b^D(\hat{\gamma}, \hat{\gamma}^*)$ schedule specified by the contract, if the DSB is invoked, it will estimate the damages due to the exporter conditional on its information. In this case, deriving the optimal contract will boil down to choosing the optimal schedule $b^D(\hat{\gamma}, \hat{\gamma}^*)$.

There are two interpretations of the optimization problem we have just outlined. The first, more direct interpretation is that governments design a *contract* that specifies a baseline commitment to free trade but includes an explicit *escape clause*. Some WTO contracts/clauses take this form, for example negotiated tariff commitments and the associated GATT Article XIX Escape Clause and/or Article XXVIII renegotiation provisions.[13] Given this interpretation, we may ask what is the appropriate remedy for breach (i.e., exceeding the negotiated tariff binding) that should be included in the contract: the answer here is relevant for the design of explicit escape clause provisions. Under this interpretation a DSB ruling simply enforces contract performance (i.e., ensures that the importing government either selects FT or abides by the contractually specified escape clause and pays b^D or $b^D(\hat{\gamma}, \hat{\gamma}^*)$).

A second interpretation of the formalism outlined above is that governments design an *institution* consisting of two parts: (i) a rigid $\{FT\}$ contract with no contractually specified means of escape; and (ii) a mandate for the DSB, which instructs the DSB to enforce a certain *remedy for breach*. The breach remedy is described by the payment b^D which the importing government must pay the exporting government in case of breach. If damages are prohibitive in all states of the world, we say that the DSB, if invoked, enforces contract performance. At the opposite extreme, if $b^D = 0$, so that the DSB permits breach at zero cost, the outcome is the same as with full discretion, just as under the previous interpretation. And again, if as the result of an investigation the DSB can observe noisy signals of γ and γ^*, then we allow the damages b^D to be contingent on $\hat{\gamma}$ and $\hat{\gamma}^*$. In the WTO, many contractual commitments are best described as rigid (e.g., the national treatment/non-discrimination obligations).[14] And

[13] The non-violation nullification-or-impairment clause of the GATT can also be interpreted along the lines of an escape clause, as it permits countries to in effect breach their negotiated market access commitments with unanticipated changes in domestic policies and pay damages to injured parties as a remedy.

[14] Rigidity is of course a matter of degree. For example, no WTO obligation is completely rigid, since there are general exceptions (e.g., GATT Article XX) that can apply to any obligation under certain circumstances.

we may then ask what is the appropriate remedy for breach of contract that should be made available by the WTO DSB: the answer is relevant for the mandate/design of the DSB.[15]

Our analysis applies equally well under either of these interpretations, i.e., whether the breach remedy is specified in the contract or rather in the DSB mandate. (In a richer model, one could imagine both coexisting, with specific breach possibilities specified in specific clauses and more general breach possibilities available more widely and determined by the mandate of the DSB). In either case, the level of the breach remedy is important for the same reason: it serves to define the disagreement point provided by the legal system should ex-post negotiations between the two governments fail.

2.2. The ex-post Pareto frontier with costly transfers

We complete our description of the basic model by describing how the ex-post Pareto frontier varies with the realized state of the world (γ, γ^*). After the state is observed by the governments (i.e., after stage 1), this frontier is pinned down, and it describes the set of feasible payoffs for the negotiations in both stages 2 and 4. The nature of the ex-post Pareto frontier therefore plays a key role in what follows.

To describe the ex-post frontier, we partition the possible states in four regions, described in Figure 1: Region I ($\Gamma << 0$), where the efficiency gains from FT are large; Region II ($\Gamma \leq 0$), where the efficiency gains from FT are relatively small; Region III ($\Gamma \geq 0$), where the efficiency gains from P are relatively small; and Region IV ($\Gamma >> 0$), where the efficiency gains from P are large. The border between Regions II and III is defined where $\Gamma = 0$ (i.e. $\gamma = \gamma^*$). For purposes of illustration Figure 1 focuses on the case in which $c'(0) = 0$.

With the importer's payoff $\omega(T, b)$ on the vertical axis and the exporter's payoff $\omega^*(T, b)$ on the horizontal axis, Figure 1 depicts the ex-post Pareto frontier for a representative realization of (γ, γ^*) in each of Regions I through IV. For each region, the Pareto frontier corresponds to the outer envelope of two concave sub-frontiers, one passing through point P (and associated with $T = P$ and various levels of b), the other passing through point FT (and associated with $T = FT$ and various levels of b): the concavity of each sub-frontier reflects the convexity of the

[15] In reality, the role of DSB investigations in a setting such as the GATT/WTO is typically twofold: first, to establish whether or not breach exists; and second, to determine damages if this becomes necessary as part of a remedy. In the model we develop here, the first role is trivially fulfilled, because we have assumed that the contractually obligated policy is clearly specified and the policy choice is publicly observable. This assumption allows us to concentrate on the second DSB role listed above (i.e., the determination of damages), which is the focus of our analysis.

transfer cost function $c(b)$. Recalling that the support of Γ by assumption includes the value $\Gamma = 0$, it follows that Regions II and III are non-empty. By contrast, Regions I and/or IV are relevant only if the support of Γ is sufficiently large.

The top left panel of Figure 1 depicts the ex-post frontier for Region I. Here, achieving the frontier always requires $T = FT$, or in other words, FT Pareto-dominates P, given appropriate transfers. Moreover, in Region I the frontier is concave, reflecting the mounting inefficiency associated with greater transfers as we move away (in either direction) from point FT (where $\omega = \omega(FT, 0)$ and $\omega^* = \omega^*(FT, 0)$). The bottom right panel of Figure 1 depicts the ex-post frontier for Region IV. Here achieving the frontier always requires $T = P$; and again, in Region IV the frontier is concave, reflecting the mounting inefficiency associated with greater transfers as we move away (in either direction) from point P (where $\omega = \omega(P, 0)$ and $\omega^* = \omega^*(P, 0)$).

Now consider the top right panel of Figure 1, which depicts the ex-post frontier for Region II. Here, the efficiency gains from FT are relatively small, and as a consequence neither policy Pareto-dominates, even if transfers are used. Pareto efficiency requires $T = FT$ for points on the frontier that favor the exporter, and $T = P$ for points on the frontier that favor the importer. Note that the frontier is piece-wise concave but globally non-concave, because *both* the policy T and the transfer b change as we move along the frontier. The lower left panel of Figure 1 depicts the ex-post frontier for Region III. Here, the efficiency gains from P are relatively small, and as a consequence Pareto efficiency requires $T = P$ for points on the frontier that favor the importer, but it requires $T = FT$ for points on the frontier that favor the exporter; and as with Region II and for the same reason, the frontier is not concave.

The features of the ex-post frontier across Regions I through IV that we just described will play a pivotal role in the analysis. For example, as we have noted, Regions I and IV are relevant only if the support of Γ is sufficiently large, and as should now be apparent, the bargaining environment in Regions I and IV is very different from that in Regions II and III; as a consequence, the degree of uncertainty over Γ will turn out to be a key determinant of the optimal breach remedy. Also, as can be seen by inspection of Figure 1 and as we explain further below, making the support of Γ larger while holding other parameters constant has effects which are qualitatively similar to making the cost of transfers smaller while holding everything else constant; hence, the cost of transfers will also be pivotal in determining the optimal breach remedy.

For now it suffices to observe that, for any realized state, whether bargaining will succeed or fail in a given (i.e., stage 2 or stage 4) negotiation – and if it succeeds, what joint surplus the agreement will deliver – is determined by the features of the relevant ex-post frontier and the position of the disagreement point for the negotiation. And as we have observed, the disagreement point is shaped by the level of damages b^D. With these preliminary observations behind us, we now turn to a complete analysis of the game.

3. The Optimal Rules

We start by asking what level of damages is optimal. We begin with a baseline scenario in which the DSB receives no information ex post, and hence damages are simply a number.

3.1. A baseline scenario: the DSB receives no information ex post

In this section we suppose that the DSB receives no information ex post. Before considering the general case in which both γ and γ^* are uncertain, it is instructive to start with the benchmark case in which the exporter's loss γ^* is known ex ante, so that γ is the only source of uncertainty. This benchmark is interesting because it represents the case that is most favorable to a liability rule and the idea of "efficient breach." Specifically, it might be thought that in this case it would be a good idea to set damages at the level of harm γ^* which would make the exporter "whole," so that the importing government could breach whenever it was willing to pay this level of damages to "buy out" the exporting government. However, we will argue that in our setting a liability rule may well be suboptimal, and that even when a liability rule is the best choice, the optimal level of damages falls short of making the exporter whole.

Given that the DSB receives no information ex post in our baseline scenario, the level of damages is simply a fixed number b^D. For a given b^D, we solve the game by backward induction, and then determine the optimal b^D as the one that maximizes ex-ante joint surplus.

The backward induction analysis is simplified considerably for our baseline scenario by observing that, since b^D is a fixed number, the outcome of the stage-4 bargain must be the same as the outcome of the stage-2 bargain. Intuitively, we have assumed that governments adopt an efficient bargaining process (with the specific and simple form of a take-or-leave offer), and so the outcome of the stage-4 subgame will be on the Pareto frontier for any state γ. Now consider what happens at stage 2 when governments – having observed the state – negotiate in anticipation of what would happen if the exporter invoked the DSB. Note that at this stage there is no uncertainty from the governments' point of view, since the state is already known and there is no uncertainty in the DSB decision (since b^D is a fixed number). We can think of the stage-4 subgame outcome as the threat point for the negotiation at stage 2. But then, since this threat point is on the Pareto frontier, there is no possible Pareto improvement that governments can achieve at stage 2 over the threat point. It follows immediately that the equilibrium outcome of the stage-2 bargain is the same as that of the stage-4 bargain. (For this reason, in our analysis of the baseline scenario we will often refer to "the" bargain without specifying the stage in which the bargain occurs.)

In light of this observation, to determine the optimal b^D we just need to derive the equilibrium joint surplus of the stage-4 bargain as a function of b^D, take the expectation of this joint surplus over all states γ (which yields the ex-ante joint surplus as viewed from stage 0), and optimize b^D. Here we develop the intuition for our results, relegating proofs to the Appendix. For purposes of illustration we continue to focus for now on the case where $c'(0) = 0$.

Given that FT is the first-best policy in Regions I and II while P is the first-best policy in Regions III and IV, it might be expected that efficiency considerations would push toward a high value of b^D when the state falls in Regions I or II, and toward a low value of b^D when it falls in Regions III or IV. And given this expectation, it seems natural that the optimal level of b^D would then be somewhere in the middle (i.e., a liability rule), since there is uncertainty over whether the realized state will lie in Regions I/II or Regions III/IV. But things are more complicated, in part because as we have noted the ex-post frontier can be non-concave (Regions II and III), and in part because the importer has two distinct choices under disagreement (FT with no transfer or P with transfer b^D), only one of which will be "active" under the circumstances (i.e., the choice preferred by the importer given the realized γ).

Let us examine how the outcome of the bargain depends on b^D in each of Regions I through IV. Figure 2 depicts how the outcome of the bargain is affected by the level of b^D in Regions II and III, and tracks how joint surplus Ω varies with b^D in each region. For Region II, the bold portion of the frontier in the top left panel of Figure 2 depicts the range of bargaining outcomes that are induced by varying b^D. To confirm this, the first step is to determine the disagreement point as a function of b^D. In Region II, for small b^D (between zero and the point labelled R), if negotiations failed the importer would choose to set $T = P$ and pay damages b^D (rather than FT with no transfer); this is a disagreement point on the frontier, and so the negotiation yields $T = P$ and $b = b^D$. For intermediate b^D (between the points R and J), if negotiations failed the importer would still choose to set $T = P$ and pay damages b^D; but this is now a disagreement point inside the frontier, and so the negotiations lead to a choice of $T = FT$ and a transfer from the exporter ($b < 0$) defined implicitly by $b - c(b) = b^D - \gamma^*$, and the DSB ruling is therefore renegotiated.[16] Finally, for b^D at or beyond the critical "prohibitive" level at J, if negotiations failed the importer would choose to set $T = FT$ and pay zero damages; this is a disagreement point on the frontier, and so the negotiations yield $T = FT$ and $b = 0$. An analogous interpretation applies for Region III as depicted in the bottom left panel of Figure 2.

Let $b^{reneg}(\gamma)$ and $b^{prohib}(\gamma)$ denote the levels of b^D associated respectively with points R and J for the realized state. The top right and bottom right panels of Figure 2 depict how joint surplus Ω varies with b^D in Regions II and III, respectively. Notice for each region that Ω is non-monotonic in b^D. Note also that $d\Omega/db^D = 0$ at $b^D = 0$, reflecting the fact that $b = 0$ at $b^D = 0$ and that $c'(0) = 0$. Finally, note that $b^{prohib}(\gamma) < \gamma^*$ for all states in Regions II and III.

These pictures suggest a key observation: if the support of Γ around $\Gamma = 0$ is sufficiently small, so that Γ can never be very far from zero, then only Regions II and III are relevant, and the expected joint surplus is maximized by adopting a property rule which either permits discretion ($b^D = 0$) or requires strict performance in all states of the world ($b^D \geq \bar{b}^{prohib} \equiv \max_\gamma b^{prohib}(\gamma)$); in other words, adopting a liability rule and permitting contract breach under some circumstances ($b^D \in (0, \bar{b}^{prohib})$) is never optimal. To see this more directly, focus first on the case $\Gamma = 0$, which marks the border between Regions II and III: as Figure 3 clearly indicates, a liability rule in which $b^D \in (0, \bar{b}^{prohib})$ can never be optimal. Next consider values of Γ that are slightly lower or slightly higher than zero. Let us ask: Can it be desirable to increase b^D slightly from zero? From inspection of Figure 2, it is clear that a slight increase of b^D from zero reduces joint surplus for each Γ in its support, and hence cannot be optimal. Next let us ask whether it can be desirable to decrease b^D slightly from $\bar{b}^{prohib}$: Figure 2 makes clear that this maneuver cannot increase joint surplus for any state either (and will decrease it for some state). Thus it is intuitive that a liability rule cannot be optimal in the case of small support of Γ; this intuition is confirmed by Proposition 1(i) below.

We turn next to the case of large uncertainty, in which Regions I and IV now also become

[16] There may be two solutions to the equation $b - c(b) = b^D - |\gamma^*|$ in the relevant range of $b^D - |\gamma^*|$, but only one solution is negative, and that solution defines the equilibrium transfer from the exporter ($b < 0$). We also observe that the particular level of b to which the governments renegotiate reflects our assumption that the importing government makes a take-or-leave offer to the exporting government. Alternative bargaining assumptions, such as Nash bargaining, would alter the level of b in a straightforward manner, but would not change our basic results.

relevant. Figure 4 depicts the same information for Regions I and IV that Figure 2 depicts for Regions II and III. For Region I, the bold portion of the frontier in the top left panel of Figure 4 depicts the range of bargaining outcomes that are induced by varying b^D. For this region, the bargaining outcome always entails $T = FT$; but as b^D rises from zero, the outcome moves from left to right along the bold portion of the frontier up to the prohibitive level of b^D corresponding to point J. For b^D between zero and this prohibitive level, if negotiations failed the importer would choose to set $T = P$ and pay damages b^D; this is a point inside the frontier, and so the negotiation leads to a choice of $T = FT$ and a transfer from the exporter ($b < 0$, again defined implicitly by $b - c(b) = b^D - \gamma^*$), and the DSB ruling is therefore renegotiated. For b^D at or beyond this prohibitive level, if negotiations failed the importer would choose to set $T = FT$ and pay zero damages; this is a point on the frontier, and so the negotiation yields $T = FT$ and $b = 0$. The top right panel of Figure 4 depicts how Ω varies with b^D for a given state in Region I. Notice that Ω is increasing in b^D and maximized at $b^D \geq b^{prohib}(\gamma)$, and that $d\Omega/db^D > 0$ at $b^D = 0$, reflecting the fact that $b < 0$ at $b^D = 0$. Notice also that $b^{prohib}(\gamma) < \gamma^*$ for any state in Region I.

The bottom panels of Figure 4 depict the same information for Region IV. In this region, as the bottom left panel indicates, the outcome always entails $T = P$; but as b^D rises from zero, the outcome moves from left to right along the bold portion of the frontier up to a prohibitive level of b^D corresponding to point J. For b^D between zero and this prohibitive level, if negotiations failed the importer would choose to set $T = P$ and pay damages b^D; this is a point on the frontier, and so negotiations implement the DSB ruling $T = P$ and $b = b^D$. For b^D at or beyond this prohibitive level, if negotiations failed the importer would choose to set $T = FT$ and pay zero damages; this is a point inside the frontier, and so the negotiations lead to $T = P$ and $b < b^D$, and the DSB ruling is renegotiated. The bottom right panel depicts how Ω varies with b^D for a given state in Region IV. Notice that Ω is (weakly) decreasing in b^D and maximized at $b^D = 0$, and that $d\Omega/db^D = 0$ at $b^D = 0$, reflecting the fact that $b = 0$ at $b^D = 0$ and that $c'(0) = 0$. Notice also that $b^{prohib}(\gamma) > \gamma^*$ for any state in Region IV.

Together, Figures 2 and 4 suggest a second key observation: if uncertainty about Γ is large so that Regions I through IV are all relevant, then a liability rule is optimal. To see this, first note that discretion ($b^D = 0$) cannot be optimal. This is because, as the top right panel in Figure 4 indicates, joint surplus may be raised for state realizations in Region I by increasing b^D slightly above zero and thereby requiring some payment for breach, while joint surplus in Regions II-IV are unaffected (to the first order) by this maneuver. Next note that a prohibitive level of b^D cannot be optimal either: by inspection of Figures 2-4, decreasing b^D from a prohibitive level to a level slightly below γ^* strictly improves joint surplus in Region IV while not affecting joint surplus in the other regions. And an immediate corollary of this argument is that the optimal level of b^D is strictly lower than γ^*.

With the intuition for the results developed above, we are now ready to state our first proposition. We return now to our general transfer-cost function (which does not impose $c'(0) = 0$) and we let $c'_+(0)$ denote the right derivative of $c(b)$ at zero (recall that we allow c to be non-differentiable at zero). Then we have:

Proposition 1. *Suppose the DSB receives no information ex post. In the benchmark case where γ^* is known ex ante: (i) If the support of Γ is sufficiently small, a property rule is optimal (specifically, the optimum is $b^D = 0$ if $E\Gamma > 0$ and $b^D \geq \bar{b}^{prohib}$ if $E\Gamma < 0$). (ii) If the support of Γ is sufficiently large, the optimum is a liability rule, provided $c'_+(0)$ is sufficiently small. Moreover, the optimal b^D is lower than the exporter's loss from protection: $0 < b^D < \gamma^* < \bar{b}^{prohib}$.*

Proposition 1 states that a liability rule is optimal only if uncertainty about Γ is large, and even in this case, the optimal level of damages b^D is lower than the level that makes the exporter "whole," i.e. γ^*. This result qualifies the presumption, often made in the law-and-economics literature (e.g., Kaplow and Shavell, 1996), that the efficient level of breach damages is the one that makes the injured party whole, and this qualification arises even under the conditions that are most favorable to this argument, namely that γ^* is known to the DSB. The source of this qualification comes from our assumption of costly ex-post transfers, and so it is a qualification that applies with particular force to international dispute resolution. Simply put, in the WTO context, the damages paid for breach often take the form of counter-retaliation on the part of the injured party, and this is an inefficient means of compensation that, from an ex-ante perspective, should not be permitted to an extent that the injured party is made whole.

The other interesting aspect of Proposition 1 is that, if uncertainty about Γ is sufficiently small, *any* liability rule is suboptimal (let alone the specific one with $b^D = \gamma^*$), and instead the optimum is a property rule. The intuition underlying this result is simple. If uncertainty is low and the joint benefits of free trade are never very far from zero, the overriding efficiency concern is to avoid costly transfers; getting the correct policy choice in each state of the world is secondary. Hence, a property rule, which either requires strict performance or permits discretion, and which thereby provides a disagreement point from which settlement occurs without the use of transfers in these circumstances, will be optimal.[17]

We now turn to the case in which both γ and γ^* are uncertain. In this case, all of the analysis above continues to hold, except for one important aspect. In the case of large support of Γ, it may no longer be the case that $b^D \geq \bar{b}^{prohib}$ is dominated by some lower level of b^D.

To understand this last point, recall that when γ^* is known ex ante and the support of Γ is large enough so that Regions I and IV become relevant, it cannot be optimal to set $b^D \geq \bar{b}^{prohib}$ because $b^{prohib}(\gamma) > \gamma^*$ for γ in Region IV but $b^{prohib}(\gamma) < \gamma^*$ for γ in the other regions, and so moving from a strict performance rule to a liability rule by decreasing b^D from $\bar{b}^{prohib}$ to a level slightly below γ^* strictly improves joint surplus in Region IV while not affecting joint surplus in the other regions. But when γ^* is also uncertain, this argument can only be made if Region IV is relevant for some γ when the realized γ^* takes its maximum value. And if the support of γ^* is wide enough relative to that of γ (which is the case under our assumption that γ and γ^* share the same support), Region IV cannot be relevant when the realized γ^* takes its maximum value; hence this argument does not apply. We therefore have the following result:

Proposition 2. *Suppose that the DSB receives no information ex post, and that both γ and γ^* are uncertain. Then: (i) If the support of Γ is sufficiently small, a property rule is optimal (either $b^D = 0$ or $b^D \geq \bar{b}^{prohib}$). (ii) If the support of Γ is sufficiently large, the optimum can be either a liability rule ($0 < b^D < \bar{b}^{prohib}$) or the property rule $b^D \geq \bar{b}^{prohib}$, provided $c'_+(0)$ is sufficiently small.*

Two interesting aspects of Proposition 2 should be highlighted. The first is that the presence of uncertainty about the exporter's loss from protection (γ^*) further weakens the case for a liability rule, since now even in the case of large support of Γ a property rule may be optimal. And the second is that uncertainty about γ^* favors only *one* of the property rules, namely the strict performance contract ($b^D \geq \bar{b}^{prohib}$).[18] This latter result arises because, when the support of Γ is large and γ^* is also uncertain, it cannot be assured that the impact of a non-prohibitive

[17] We have stated Proposition 1 using the support of Γ as a measure of ex-ante uncertainty. If uncertainty about Γ is small in the sense of small variance but with a large support, then the optimum will not be *exactly* a property rule, but the result will hold in an approximate sense, so the qualitative insight goes through.

[18] Put slightly differently, if uncertainty is sufficiently large and if the maximum possible loss from free trade for the importer is sufficiently greater than the maximum possible gain from free trade for the exporter, then the optimality of the strict performance contract can be ruled out and a liability rule is surely optimal. This suggests that the case for a liability rule is strongest when uncertainty is large and the importer faces asymmetrically large risk.

level of damages will be felt only in states of the world (i.e., those characterized by Region IV) where this impact is desirable from an ex-ante perspective; and as a consequence the optimality of a property rule $b^D \geq \bar{b}^{prohib}$ cannot be ruled out.

We next turn to the role of transaction costs in determining the optimal type of agreement. Consider increasing $c(b)$ for all $b \neq 0$ (while preserving the properties of $c(b)$ that we have assumed), fixing the support of Γ. It is clear by inspection of Figure 1 that Regions II and III expand, while Regions I and IV contract, and at some point Regions I and IV will disappear. Using similar arguments to those presented above, it then follows that when the cost of transfers is sufficiently high a property rule will be optimal. Next consider decreasing the cost of transfers: as Figure 1 indicates, Regions I and IV will expand, while Regions II and III will contract, and as the cost of transfers goes to zero, the probability of being in Regions I and IV must become strictly positive. Again using similar arguments to those presented above, it then follows that if the cost of transfers is small enough, the optimum can be either a liability rule ($0 < b^D < \bar{b}^{prohib}$) or the property rule $b^D \geq \bar{b}^{prohib}$.

The following proposition states the result:

Proposition 3. *Suppose the DSB receives no information ex post. Then, holding everything else equal: (i) If the cost of transfers is sufficiently high, a property rule is optimal (either $b^D = 0$ or $b^D \geq \bar{b}^{prohib}$). (ii) If the cost of transfers is sufficiently small, the optimum can be either a liability rule ($0 < b^D < \bar{b}^{prohib}$) or the property rule $b^D \geq \bar{b}^{prohib}$.*

Proposition 3 states that a property rule tends to be preferred to a liability rule when the cost of transfers is high. This result stands in contrast with the finding in the law-and-economics literature that liability rules tend to be preferable to property rules when transaction costs are high (Calabresi and Melamed, 1972, and Kaplow and Shavell, 1996). Our result differs from this earlier finding because of our focus on the cost of transfers as a transaction cost, a focus that as we have explained earlier distinguishes dispute settlement in an international context from the settlement of purely domestic disputes. To gain further intuition about this difference in results, recall that transaction costs in Calabresi and Melamed (1972) and Kaplow and Shavell (1996) take the form of bargaining frictions (the bargain fails with a certain probability); this type of transaction costs penalizes property rules more than liability rules because property rules induce more bargaining in equilibrium. In our setting, on the other hand, the presence of a transfer cost penalizes a liability rule more than a property rule because a liability rule induces more transfers in equilibrium.[19]

Even more surprisingly in light of Calabresi and Melamed (1972) and Kaplow and Shavell (1996), we now show that in the presence of a cost of transfers, higher transaction costs can favor property rules even if these transaction costs take the form of frictions in bargaining. Specifically, we compare the case of frictionless ex-post bargaining (which we have just considered) with the opposite extreme in which ex-post bargaining is not feasible. That the latter environment can be more favorable to property rules than the former environment can be established in a simple way by returning momentarily to the benchmark case in which the exporter's loss γ^* is known ex ante, so that γ is the only source of uncertainty.

Recall from Proposition 1(ii) that if the support of Γ is sufficiently large, then in this benchmark case the optimum is a liability rule. But when ex-post bargaining is not feasible, it is easily established that the property rule $b^D = 0$ can become optimal in the large-Γ-support case (with no impact in the reported results of Proposition 1(i) for the small-Γ-support case). To understand, it is helpful to return to Figure 4 and recall why $b^D = 0$ cannot be optimal in the large-Γ-support case when ex-post bargaining is frictionless: as we described above, and as the top right panel in Figure 4 indicates, joint surplus may be raised for state realizations in Region I by increasing b^D slightly above zero and thereby requiring some payment for breach, while joint surplus in Regions II-IV are unaffected (to the first order) by this maneuver. But notice from the top left panel of Figure 4 that if ex-post bargaining were not feasible, the outcome in Region I would entail $T = P$ for any non-prohibitive level of b^D, and increasing b^D slightly above zero would then have *no* (first order) impact on joint surplus for state realizations in Region I (while joint surplus in Regions II-IV would remain unaffected to the first order). Hence, when ex-post bargaining is not feasible, the property rule $b^D = 0$ becomes a local optimum in the large-Γ-support case, and it is easily shown that it can be the global optimum in the large-Γ-support case for a range of model parameters.

We summarize this discussion with:

Remark 1. *In the presence of a cost of transfers, the introduction of bargaining frictions can favor the use of property rules over liability rules.*

We return now to the general case in which both γ and γ^* are uncertain. While the previous remark established a possibility result – which arises if γ^* is known ex ante, – in this general

[19] Recall that a property rule induces transfers in equilibrium only in regions I or IV (i.e. if Γ takes very low or very high values), whereas a liability rule induces transfers in equilibrium in any region.

case the introduction of bargaining frictions may not favor property rules over liability rules. However, it continues to be true that if ex-post bargaining is not feasible, the property rule $b^D = 0$ can be optimal in the large-Γ-support case. Moreover, it can also be established that the property rule $b^D \geq \bar{b}^{prohib}$ *cannot* be optimal in the large-Γ-support case when ex-post bargaining is not feasible. To see this intuitively, consider Figure 4: as the bottom left panel indicates, when ex-post bargaining is not feasible, setting b^D at its prohibitive level simply forces $T = FT$, and the joint surplus is thereby discretely reduced, rather than discretely increased as Figure 4 indicates is the case when ex-post bargaining is frictionless. Furthermore, it can be shown that the optimal b^D must be strictly lower than the expected value of γ^*. The result that in the large-Γ-support case the strict performance rule $b^D \geq \bar{b}^{prohib}$ cannot be optimal when ex-post bargaining is not feasible is interesting because, as Proposition 2(ii) indicates, when ex-post bargaining is frictionless, it is the property rule $b^D = 0$ that cannot be optimal and the property rule $b^D \geq \bar{b}^{prohib}$ that *can* be optimal in the large-Γ-support case. This leads to:

Proposition 4. *If ex-post bargaining is not feasible, then: (i) If the support of Γ is small, a property rule is optimal; (ii) If the support of Γ is large, the optimum can be either a liability rule $b^D \in (0, E\gamma^*)$ or the property rule $b^D = 0$. Thus, removing the possibility of ex-post bargaining tilts the use of property rules away from strict performance contracts ($b^D \geq \bar{b}^{prohib}$) and towards discretion ($b^D = 0$).*

It is not immediately obvious why bargaining frictions should work in a biased way against strict performance contracts relative to discretion, as reflected in Proposition 4. After all, while bargaining frictions reduce the opportunities for ex-post negotiation, this applies whether the ex-post negotiations begin from a position of $T = FT$ (as in strict performance contracts) or $T = P$ (as in discretion). What accounts for this bias is the fact that the elimination of ex-post bargaining opportunities pushes for a lower optimal b^D, both around b^D slightly above 0 and around $b^D = \bar{b}^{prohib}$, and this implies that $b^D = 0$ is more likely to be optimal and $b^D \geq \bar{b}^{prohib}$ is less likely to be optimal when ex-post bargaining is infeasible.

3.2. Noisy DSB investigations

We now move beyond our baseline scenario and turn to the more general case where the DSB, if invoked, can conduct an investigation which yields noisy signals of γ and γ^*. In this case, damages can be conditioned on the signals, but not on the true state of the world, and hence the problem is to find the optimal schedule of damages $b^D(\hat{\gamma}, \hat{\gamma}^*)$.

In analogy with the independence assumption made in the previous section, we assume that the pair of random variables $(\gamma, \hat{\gamma})$ is independent of the pair $(\gamma^*, \hat{\gamma}^*)$. We impose a minimum of structure on the conditional density functions, by requiring that $h(\gamma|\hat{\gamma})$ and $h^*(\gamma^*|\hat{\gamma}^*)$ are log-supermodular; this condition is relatively standard and is satisfied by several common distributions (see Athey, 2002). We also assume $\lim_{\hat{\gamma}^* \to \infty} \Pr(\gamma^* < \gamma|\hat{\gamma}, \hat{\gamma}^*) = 0$ and $\lim_{\hat{\gamma} \to \infty} \Pr(\gamma^* > \gamma|\hat{\gamma}, \hat{\gamma}^*) = 0$; in words, the posterior probability that $\gamma^* < \gamma$ approaches zero as the signal realization $\hat{\gamma}^*$ becomes infinitely large (holding $\hat{\gamma}$ fixed), and an analogous interpretation applies to the second condition.

Notice that, unlike the baseline scenario considered in the previous section, when governments bargain in stage 2 they face some uncertainty over what would happen if the exporter invoked the DSB, because that depends through $b^D(\hat{\gamma}, \hat{\gamma}^*)$ on the signals that the DSB receives if and when it is invoked. Hence, the backward induction analysis required to solve the game in the case of noisy DSB investigations is more involved than it was under our baseline scenario. For tractability here we impose a linear cost of transfers: $c(b) = c \cdot |b|$. The reason the analysis is simplified when the cost of transfers takes a linear form is that, as we establish below, the problem of finding the $b^D(\hat{\gamma}, \hat{\gamma}^*)$ schedule that maximizes the ex-ante joint surplus is equivalent to a simpler problem, namely finding the $b^D(\hat{\gamma}, \hat{\gamma}^*)$ that maximizes the expected joint surplus as viewed from stage 4, when the true γ and γ^* are unknown, but conditional on observing signals $\hat{\gamma}$ and $\hat{\gamma}^*$. With a nonlinear cost of transfers, this equivalence need not hold, and the problem is more complex. We leave the analysis of the more general case for future research (but we believe that our qualitative insights will continue to hold).

To state this result, we let $\Omega_4(b^D; \gamma, \gamma^*)$ denote the joint payoff in the stage-4 subgame given b^D and the realized state, and we define the expected joint surplus as viewed from stage 4, when the true state is unknown, but conditional on the signals as

$$E[\Omega_4(b^D|\hat{\gamma}, \hat{\gamma}^*)] = \int \int \Omega_4(b^D; \gamma, \gamma^*) h(\gamma|\hat{\gamma}) h^*(\gamma^*|\hat{\gamma}^*) d\gamma d\gamma^*.$$

We may now state:

Lemma 1. *If $c(b^D) = c \cdot |b^D|$, then the ex-ante optimal $b^D(\hat{\gamma}, \hat{\gamma}^*)$ maximizes $E[\Omega_4(b^D|\hat{\gamma}, \hat{\gamma}^*)]$.*

Armed with Lemma 1, we can now characterize the qualitative properties of the optimal $b^D(\hat{\gamma}, \hat{\gamma}^*)$. A first observation is easily established. If the supports of γ and γ^* are sufficiently small, then as in part (i) of Proposition 2 the optimum is either the property rule $b^D = 0$ or the property rule $b^D \geq \bar{b}^{prohib}$, with the choice between these two being contingent on the realized values of the signals $\hat{\gamma}$ and $\hat{\gamma}^*$.

We focus the rest of this section on the large-uncertainty case and assume that each of the random variables $\gamma, \hat{\gamma}, \gamma^*, \hat{\gamma}^*$ has full support, that is $[0, \infty)$. Intuition suggests that as $\hat{\gamma}$ rises and a higher value of γ therefore becomes more likely, the optimal b^D conditional on the signal $\hat{\gamma}$ should fall; and similarly, as $\hat{\gamma}^*$ rises and it becomes more likely that the value of γ^* is higher, it seems intuitive that the optimal b^D conditional on the signal $\hat{\gamma}^*$ should rise. As it turns out, this intuition is correct for $\hat{\gamma}$, but for $\hat{\gamma}^*$ it need not hold without further conditions, because when $\hat{\gamma}^*$ rises it is possible in principle that the higher expected γ^* makes a slightly higher b^D *less* attractive, and so it cannot be ruled out that the optimal b^D might be falling in $\hat{\gamma}^*$ over some range. A condition which is sufficient to rule out this possibility is that the signal $\hat{\gamma}^*$ is sufficiently precise.[20]

Summarizing, the following proposition states properties of the optimal $b^D(\hat{\gamma}, \hat{\gamma}^*)$:

Proposition 5. *Suppose the DSB can observe noisy signals of γ and γ^*. Then: (i) $b^D(\hat{\gamma}, \hat{\gamma}^*)$ is (weakly) decreasing in $\hat{\gamma}$. (ii) $b^D(\hat{\gamma}, \hat{\gamma}^*)$ is (weakly) increasing in $\hat{\gamma}^*$ provided that the signal $\hat{\gamma}^*$ is sufficiently precise .(iii) $b^D(\hat{\gamma}, \hat{\gamma}^*) \to 0$ as $\hat{\gamma} \to \infty$, and $b^D(\hat{\gamma}, \hat{\gamma}^*) \to \infty$ as $\hat{\gamma}^* \to \infty$.*

According to Proposition 5, the level of damages should be higher when, other things equal, the signal of the importer's gain from protection is lower or the signal of the exporter's loss from protection is higher (provided the latter signal is sufficiently precise). Moreover, if the former is very high relative to the latter (i.e., as $\hat{\gamma} \to \infty$ for fixed and finite $\hat{\gamma}^*$), the damages for breach that the importer should be required to pay approach zero; whereas if the latter is very high relative to the former (i.e., as $\hat{\gamma}^* \to \infty$ for fixed and finite $\hat{\gamma}$), the damages for breach that the importer should be required to pay approach a strict performance rule.

[20] More specifically, when $\hat{\gamma}^*$ rises there are three effects that work in the intuitive direction toward making a slightly higher b^D more attractive, and one effect that works in the opposite direction. This counterintuitive effect arises because there may be a non-negligible probability that the true state (γ, γ^*) falls in Region IV *and* the optimal damages $b^D(\hat{\gamma}, \hat{\gamma}^*)$ are prohibitive. In this case, as can be confirmed using the bottom panel of Figure 4, in Region IV the increase in joint payoff triggered by an increase from $\bar{b}^{prohib} - \varepsilon$ to $\bar{b}^{prohib}$ is *decreasing* in γ^*. For this reason, it is possible in principle that a higher $\hat{\gamma}^*$ makes a slightly higher b^D less attractive, and as a consequence b^D could be falling in $\hat{\gamma}^*$ over some range. If the signal $\hat{\gamma}^*$ is sufficiently precise, the probability that the optimal damages are prohibitive in Region IV can be driven arbitrarily close to zero (as our discussion leading up to Proposition 1 suggests), thus ruling out the possibility discussed above.

An interesting feature of the results reported in Proposition 5 is that the damages for breach should be responsive to both the level of harm that the breach is estimated to cause the exporter ($\hat{\gamma}^*$) *and* the level of benefit that the breach is estimated to provide the importer ($\hat{\gamma}$). This feature suggests a possible interpretation of the WTO Agreement on Safeguards. According to the Safeguards Agreement, an importing government may temporarily impose tariffs as a response to injury to its domestic import-competing producers, and need not compensate the impacted foreign exporters under certain conditions which are meant to establish a direct link between the injury and foreign exports.[21] If these conditions are interpreted as indicating circumstances in which the imposition of tariffs would be an effective way of addressing the injury, then under these conditions the benefits of protection to the importer could reasonably be thought to be high. And if the DSB receives a signal that this is indeed the case, then Proposition 5 would suggest that the level of damages should be low or even approach zero, broadly in line with what the Agreement on Safeguards stipulates in this case.

We conclude this section with a result concerning the role of the noise in the DSB information for the optimal schedule of damages $b^D(\hat{\gamma}, \hat{\gamma}^*)$: if the DSB information is sufficiently precise, then it is not hard to show that it is optimal to adopt a contingent property rule, as the following proposition states:

Proposition 6. *If the signals observed by the DSB are sufficiently precise, in the sense that the support of $\hat{\gamma}$ (resp. $\hat{\gamma}^*$) around the true value of γ (resp. γ^*) is sufficiently small, then the optimum is a property rule (contingent on $\hat{\gamma}$ and $\hat{\gamma}^*$).*

The intuition for this result is straightforward: if the noise in the DSB information is small, the uncertainty about the true state (γ, γ^*) conditional on the signal realizations is small, and a logic similar to that which led to Proposition 2(i) applies.

Propositions 5 and 6 together suggest that as the accuracy of DSB rulings increases, the optimal institutional arrangement should move away from liability rules which provide for breach and the payment of damages in some circumstances, toward property rules in which

[21] In particular, the Safeguards Agreement specifies that no compensation need be paid by the importing government for 3 years when reimposing protection in response to injury of its domestic import-competing industry, provided that the injury is associated with an *absolute* increase in imports; whereas if the level of imports has fallen but the level of domestic production has fallen by more, so that injury is associated with an increase in imports only *relative* to domestic production, trade protection can still be reimposed but the importing government must compensate the impacted exporters from the start (in either case, this compensation may take the form of the temporary withdrawal of equivalent concessions by the exporter).

parties are obligated to perform and cannot simply buy their way out of the legal commitment with the payment of damages. If one accepts that the accuracy of legal rulings has increased from the time of GATT's inception to the creation of the WTO, then we may ask whether or not the evolution from GATT to the WTO has indeed been in the direction away from liability rules and toward property rules. Here opinions differ among legal scholars, and we do not take a stand on the merits of the different views that have been expressed.[22] Rather, we simply note that the implications of our model suggest circumstances under which a preference for one system or the other should arise.

4. The Outcome of Disputes

In this section we consider the implications of our model for the outcome of trade disputes. To this end, we first link more directly the stages of our game with the stages of a WTO dispute.

4.1. The stages of WTO disputes

Broadly speaking, the key steps in a WTO dispute are as follows. In a first phase, the complainant must request consultations with the respondent. If consultations fail to settle the dispute within 60 days of the request, then the complainant may request that a Panel be established. In a second phase, the Panel gathers information on the dispute and issues a ruling which may be appealed to the Appellate Body, leading to a final ruling. And in a third phase, governments may engage in negotiations over the extent and modalities of compliance with the DSB ruling (with a "compliance panel" available in case of further disagreements).

[22] On the one hand, Jackson (1997, pp. 62-63) expresses the view that, while the early GATT years were ambiguous on this point, "...by the last two decades of the GATT's history..., the GATT contracting parties were treating the results of an adopted panel report as legally binding...," and that the WTO "...clearly establishes a preference for an *obligation to perform* the recommendation..." (emphasis in the original). This view seems broadly consistent with the direction suggested by our normative results under the assumption that the accuracy of legal rulings in the GATT/WTO has increased over time. On the other hand, Hippler Bello (1996) and Schwartz and Sykes (2002) view the changes in the DSB that were introduced with the creation of the WTO differently. According to Schwartz and Sykes, the GATT was devised to operate according to a liability rule that permitted efficient breach, where the penalty for breach in practice took the form of unilateral retaliation, but in the GATT's final years unilateral retaliation became excessive and discouraged efficient breach. The changes in the DSB that were introduced with the creation of the WTO were motivated, according to Schwartz and Sykes, by a need to *reduce* the penalty for breach, thus returning the system to one based squarely on liability rules. As Schwartz and Sykes (p. 201) put it, "What the new system really adds is the opportunity for the losing disputant to 'buy out' of the violation at a price set by an arbitrator who has examined carefully the question of what sanctions are substantially equivalent to the harm done by the violation."

Below we seek to develop the predictions of our model, and at a broad level match these predictions to the various possible outcomes under WTO-like contracts and dispute settlement procedures. To this end we now offer interpretations of model outcomes in terms of observable outcomes of the WTO dispute settlement procedures.

Let us consider first the interpretation of stages 2 and 3 in our model. Given that the WTO DSB requires that governments "consult" prior to requesting that a formal dispute Panel be formed for the purpose of issuing a ruling, it is natural to think of the consultation phase of the WTO dispute settlement process as being reflected in a stage 2 negotiation. The interpretation of stage 3 of our model seems equally straightforward: it is natural to think of a stage-3 ruling by the DSB as corresponding to the issuance of the Panel/Appellate Body final ruling.

Next, we turn to the interpretation of stage 4, and in particular the difference between the outcome where the DSB ruling is implemented and the outcome where the DSB ruling is renegotiated. In the former case, the DSB ruling defines a disagreement point for the subsequent negotiations which is on the Pareto frontier, and so there is nothing to gain from renegotiating the DSB ruling. In the latter case, the DSB ruling defines a disagreement point that is inside the Pareto frontier, and so in this case renegotiations take place: in particular, the DSB announces a breach payment under which (i) the home country would prefer to choose P and make the DSB-mandated breach payment rather than the alternative of FT with no payment, but (ii) the home country would prefer a third alternative to the two choices under the DSB ruling, namely, a policy of FT combined with a payment from the exporter. In this light, it seems natural to interpret a renegotiation that occurs in stage-4 as corresponding to a settlement in which the appropriate level of compensation is worked out between the disputants prior to the importer agreeing to bring its policies into compliance by adopting FT.[23]

4.2. Predictions from the basic model

Having described the broad link from our model outcomes to stages of WTO disputes, we now return to the formal analysis of our model. There are three possible model outcomes to

[23] A good illustration of what we have in mind here is provided by the compliance settlement for the U.S.-EU "Banana" dispute in the WTO (see USTR, 2001). In reaching a settlement for this dispute, the EU (respondent) stated on April 11, 2001, when the dispute was settled/resolved, that it would come into compliance with the DSB ruling, but not fully until January 1, 2006. Hence, during this intervening period, the United States (a claimant) – by accepting the EU's non-to-partial compliance over this period – essentially allowed the EU to take some compensation (by being able to unilaterally deviate from its WTO commitment over this period) in exchange for the promise by the EU to fully comply by January 1, 2006. We thank Chad Bown for pointing us to this dispute as a suggestive illustration of our model result.

consider: (i) *Early Settlement*, which occurs when the importer's offer at stage 2 is accepted; (ii) *DSB is Invoked and the DSB Ruling is Implemented*; and (iii) *DSB is Invoked but the DSB Ruling is Renegotiated.*[24]

We focus in this and the next subsection on the more general case in which the DSB can observe noisy signals of γ and γ^*, and we keep the assumptions we made in section 3.2

A first observation is that, for realizations of Γ in Regions I and IV governments settle early, while for realizations of Γ in Regions II and III governments go all the way to a DSB ruling. With this observation, we may state:

Remark 2. *Early settlement occurs if* Γ *is very low or very high, while a DSB ruling occurs in equilibrium for intermediate values of* Γ.

The arguments that establish the first part of this Remark are straightforward. Extreme values of Γ correspond to Regions I and IV, and in these regions stage-2 uncertainty about the DSB's signal realization (and hence level of damages) does not place the disagreement point above the Pareto frontier, as the top left and bottom right panels of Figure 5 confirm: as a result, governments have no reason to seek a ruling. Intuitively, when the joint surplus associated with FT is either very large and positive or very large and negative, the equilibrium policy choice will be independent of the level of damages determined by the DSB, and so governments have nothing to gain by letting their dispute proceed to a DSB ruling.

More subtle is the reason why the DSB is invoked in equilibrium for intermediate values of Γ. First observe that intermediate values of Γ correspond to Regions II and III, where the joint surplus associated with FT may be positive or negative but it is moderate in size. For this reason, equilibrium policy *does* depend on the level of damages determined by the DSB, and as a consequence the Pareto frontier is convex, as the top right and bottom left panels of Figure 5 confirm.

The next step is to understand why a convex frontier leads to a DSB ruling in equilibrium. Graphically, given stage-2 uncertainty about the DSB's signal realization (and hence level of damages), the disagreement point is above the stage-2 Pareto frontier, as the top right and bottom left panels of Figure 5 confirm, and hence the importer prefers to trigger a DSB ruling

[24] By construction, in our model governments always engage in stage-2 "consultations," and for this reason, we focus on the model's predictions concerning early settlement and renegotiation of DSB rulings. Our model could be extended to consider the issue of whether or not governments initiate consultations; a natural possibility in this regard would be to introduce a cost of consultation. We leave this extension to future research.

rather than settle early. To gain a more direct intuition for this insight, consider the extreme case in which c is infinite, so that transfers are not feasible. Then the frontier is made of two points, P and FT, and any payoff combination between those two points is not feasible. In this case, invoking the DSB brings about an (expected) payoff combination that lies between points P and FT, due to the random nature of the DSB ruling; and since this is the disagreement point, there is no scope for early settlement. In essence, then, the role of the DSB ruling is analogous to that of a transfer, in that it makes feasible certain intermediate payoff combinations that would not otherwise be feasible.

It is also worth pointing out that the prediction that disputes *ever* proceed to a ruling (i.e., "go to court") – and hence the ability to make statements about when early settlement is likely to occur – distinguishes our model from much of the law-and-economics literature concerned with liability rules versus property rules. For example, Kaplow and Shavell (1996) consider the case of a perfectly uninformed and perfectly informed court, but they do not consider the case of an imperfectly informed court (our case of noisy DSB investigations) and so disputes are always settled early in their analysis.

Remark 2 highlights ex-post conditions under which governments either settle early or pursue a dispute through to the ruling stage. But it is also interesting to examine the ex-ante probability of early settlement versus DSB ruling. To this end, note that $\Pr(Settlement) = 1 - \Pr(Ruling)$. Thus we can focus on the determinants of $\Pr(Settlement)$, as the determinants of $\Pr(Ruling)$ are mirror images of the former.

If we define an increase in uncertainty over Γ as a mean-preserving spread of its distribution, and assume for simplicity that $E\Gamma = 0$, a direct implication of the arguments made above is the following:

Remark 3. *As uncertainty over Γ increases and/or the cost of transfers decreases, the probability of early settlement increases.*

The intuition for Remark 3 is similar to Remark 2, and can be understood again with the aid of Figure 5. In particular, this result is a direct consequence of the fact that, as long as there is any uncertainty in the DSB ruling, i.e. $b^D(\hat{\gamma}, \hat{\gamma}^*)$ is not constant, there will be settlement in equilibrium *if and only if* Γ falls in Regions I or IV. But the probability of Regions I and IV combined is higher when Γ is more uncertain and/or when the cost of transfers is lower, and the result then follows.

We next turn to consider the probability that a DSB ruling will be implemented versus renegotiated. We focus on ex-post conditions under which rulings are implemented or renegotiated:

Remark 4. *Conditional on a DSB ruling being triggered, the ruling is renegotiated when the DSB-assessed damages $b^D(\cdot)$ fall in an intermediate range, while it is implemented when $b^D(\cdot)$ takes very low or very high values.*

The intuition for this Remark can be understood as follows. First, recall from Remark 2 that the ruling stage is reached in equilibrium only for realized Γ in Regions II and III. Second, recall that renegotiation of the DSB ruling occurs when (i) Home would prefer to choose P and make the DSB-mandated breach payment rather than the alternative of FT with no payment, but (ii) Home would prefer a third alternative to the two choices under the DSB ruling, namely, a policy of FT combined with a payment from the exporter. And finally note that, as Figure 6 confirms, for Regions II and III this occurs for intermediate levels of the damages $b^D(\cdot)$. Hence, according to Remark 4, DSB rulings should be renegotiated when the DSB issues a "close" ruling, i.e., a ruling that does not suggest either very high or very low joint surplus associated with the FT policy.

Note also an interesting implication of Remark 4: it may well happen that compliance with the DSB ruling becomes an issue and the ruling is ultimately renegotiated even though the DSB ruling "gets it right" (i.e. $(\hat{\gamma}, \hat{\gamma}^*)$ is close to (γ, γ^*)). In other words, our model indicates that the renegotiation of DSB rulings does not come about because rulings are "bad."

4.3. Differential cost of transfers between developed and less-developed countries

As illustrated by Remark 3 above, an interesting feature of our model is that the cost of international transfers can have important implications for predictions concerning the outcomes of disputes. If we introduce the further assumption that the cost of granting a (positive) transfer is higher for less-developed countries than it is for developed countries, then our model can be used to generate predictions of the variation in outcomes that would arise when disputes are between two developed countries, between two developing countries, or between a developed and a developing country with the developing country playing the role either of the respondent (and hence the importer in our model) or the complainant (and hence the exporter in our model).[25] Horn and Mavroidis (2008) document the interesting variation in outcomes of WTO

[25] It is not immediately apparent that the efficiency cost of a transfer from the developing country to the developed country should be higher than the efficiency cost of a transfer from the developed country to the

disputes depending on the developed/less-developed status of the disputants.

Here we consider the model's predictions regarding a dispute between a developed and a less-developed country, assuming that the cost of transfers c is higher for the less-developed country. For the following discussion we also assume for simplicity that the distribution of Γ is symmetric about zero.

We first observe that, under these assumptions, the model predicts that if the developed country is the respondent (importer), then with relatively high probability we will be in Regions II or IV. This is because, as can be confirmed by graphical inspection, if the developed country is the importer then Region II consists of an interval of Γ that is larger than Region III, and similarly Region IV consists of an interval of Γ that is larger than Region I, owing to the relatively low (high) cost of transfers for the developed (less-developed) country. On the other hand, if the less-developed country is the respondent (importer), then the model predicts that with relatively high probability we will be in Regions I or III, for analogous reasons.

These observations carry several implications. First we consider the implications of asymmetric costs of transfer for the observed outcomes of disputes between developed and developing countries under early settlement. We may state:

Remark 5. *Conditional on the developed country being the respondent, early settlements result with higher probability in a policy of P (with compensation paid by the developed country to the developing country). Conditional on the less-developed country being the respondent, early settlements result with higher probability in a policy of FT (with compensation paid by the developed country to the developing country).*

Thus, according to Remark 5, there is a tendency for developed countries to end up imposing more protection in equilibrium as a result of early settlements than is the case for less-developed

developing country. But it can be argued that such a presumption is warranted provided that the shadow cost of funds is higher in the developing country than in the developed country, and that the shadow cost of funds in the developed country is sufficiently low. To see this, consider first the efficiency cost associated with a financial transfer from the developed to the developing country ($c_{\$}^{DC}$) and the efficiency cost associated with a financial transfer from the developing to the developed country ($c_{\$}^{LDC}$). Clearly, we have $c_{\$}^{LDC} > c_{\$}^{DC}$ provided that the shadow cost of funds is higher in the developing country than in the developed country, and so the presumption holds in this case. Still, in light of the high shadow cost of funds in the developing country, a more efficient means of effecting a transfer from the developing country to the developed country may be for the developed country to utilize the WTO "self-help" method of counter-retaliation and raise a tariff (see note 6): this will be the case if the efficiency cost of a transfer from the developing to the developed country via this mechanism ($c_{\Delta\tau>0}^{DC}$) is lower than $c_{\$}^{LDC}$. But provided $c_{\$}^{DC}$ is sufficiently low, we still have $c_{\Delta\tau>0}^{DC} > c_{\$}^{DC}$ and the presumption is still warranted.

countries. This Remark follows directly from the fact that if the developed country is the respondent, then the probability is higher that the realized Γ will be in Region IV than that it will be in Region I, and vice versa if the less-developed country is the respondent.

We next consider the implications of asymmetric costs of transfer for the observed outcomes of disputes between developed and developing countries that proceed all the way to a DSB ruling. We may state:

Remark 6. *Conditional on the developed country being the respondent, DSB rulings tend to occur when* $\Gamma < 0$*, that is, when* FT *is the first-best policy. Conditional on the less-developed country being the respondent, DSB rulings tend to occur when* $\Gamma > 0$*, that is, when* P *is the first-best policy.*

Thus, according to Remark 6 there is a pro-trade (anti-trade) selection bias in rulings when a developed country (less-developed country) is the respondent. This follows directly from the fact that if the developed country is the respondent, then the probability is higher that the realized Γ will be in Region II than that it will be in Region III, and vice versa if the less-developed country is the respondent.

5. Extension: A More General Class of Contracts

Thus far we have restricted our analysis to a menu contract that gives the importing government a choice between setting P and compensating the exporting government with a payment b^D, or setting FT. In this section we consider a richer menu contract that allows the importer to choose between (P, b^D) and (FT, b^{FT}): that is, the importing government is given a choice between setting P and compensating the exporting government with a payment b^D, or setting FT and making the associated payment b^{FT}. Intuitively, in addition to the "stick" implied by the payment of damages $b^D > 0$ when the importer chooses P, it might be optimal to include a "carrot" implied by $b^{FT} < 0$ when the importer chooses FT. Notice, though, that the carrot, like the stick, is an ex-post transfer and hence costly in our model; and so it is not obvious that ex-ante efficiency would in fact be served by the inclusion of a carrot in the menu contract.

We focus here on the case where the DSB receives no information ex post, so that b^D and b^{FT} must be noncontingent. We return to the assumptions made in section 3.1 with both γ and γ^* uncertain, and in addition we assume that $c(b)$ is smooth everywhere, for ease of exposition.

Intuition for our findings can be developed by returning to Figures 3 and 4. Recall that Figure 3 depicts the case in which $\Gamma = 0$, which marks the border between Regions II and III. By inspection of the right panel of Figure 3, if the support of Γ around zero is sufficiently tight, then even with our more general class of contracts it will still be optimal to adopt a property rule which either permits discretion or requires strict performance in all states of the world. But then, introducing a carrot ($b^{FT} < 0$) for FT could never be helpful, because it would simply introduce the equilibrium payment of a costly transfer ($b^{FT} < 0$) which would accompany FT when FT would have been chosen in equilibrium anyway and no transfer would have been paid.

Now consider Figure 4, which depicts the same information for Regions I and IV. As we have observed, when uncertainty over Γ is large, these regions also become relevant. And it again can be verified that, when uncertainty over Γ is large the optimal level of b^D is strictly positive. But then as can be confirmed using the top left panel of Figure 4, offering a carrot ($b^{FT} < 0$) for FT can now be beneficial, because when the realized Γ lies in Region I the DSB ruling will then be renegotiated less often and the equilibrium transfer paid by the exporting government to the importing government will be smaller as a result.

The following result confirms the intuition developed above:

Proposition 7. *Suppose the DSB receives no information ex post, and consider menu contracts of the type* $\{(P, b^D), (FT, b^{FT})\}$*: (i) If the support of* Γ *is sufficiently small, or the cost of transfers is sufficiently large, it is optimal to set* $b^{FT} = 0$*, and the optimal level of* b^D *is either* $b^D = 0$ *or* $b^D \geq \bar{b}^{prohib}$*; and (ii) If the support of* Γ *is sufficiently large, or the cost of transfers is sufficiently small, the optimal levels of* b^D *and* $|b^{FT}|$ *are strictly positive.*

According to Proposition 7, if uncertainty over Γ is sufficiently small, then there is no gain in expanding the simple menu contract that we analyzed in previous sections to include the possibility of a carrot for FT. Intuitively, introducing a carrot induces ex-post transfers in equilibrium, which are costly, and provides no benefits. On the other hand, using a carrot can help if uncertainty in Γ is large, because in this case costly ex-post transfers occur in equilibrium, and the introduction of a carrot can then reduce the size of these transfers.[26]

[26] Observe that the contract class we consider in this section is equivalent to a revelation mechanism $T(\tilde{s}), b(\tilde{s})$, where $\tilde{s}$ is the importer's report of the state of the world $s = (\gamma, \gamma^*)$. This is not the most general class of mechanisms within our game, however. We have focused on contracts whereby only the importer makes a choice of policy/transfer or an announcement. Theoretically we could do better by setting up some kind of revelation game that involves also the exporter. For example, suppose that governments simultaneously announce the

It is interesting to consider whether this kind of carrot mechanism is observed in actual trade agreements such as the WTO. On the one hand, when a government agrees to reduce its tariffs as a result of a trade negotiation, it typically considers this to be a concession that is only valuable to it in exchange for similar concessions from other governments. So it is clearly the norm for a government to receive some form of compensation from other governments when it agrees to a policy of free trade. According to this observation, the findings recorded in Proposition 7 could potentially be interpreted as suggesting a novel role played by the compensations for trade liberalization that we observe. But when interpreting the carrot $|b^{FT}|$, it must be remembered that this is an ex-post transfer, which is contractually specified to be executed after the state of the world γ has been observed as an additional (ex post) reward for contract performance. This, of course, rules out transfers that are made as part of an ex-ante negotiation. When put this way, it is less clear whether the kind of carrot-for-performance mechanism represented in Proposition 7 can be found along side the "stick" of damages-for-breach in existing trade agreements. Ultimately, this is an empirical question that we cannot address here.

Overall, then, our consideration of this more general class of contracts raises some interesting new questions. Nevertheless, the broad message that emerges from our analysis is that, while it may well be optimal under some circumstances to include a carrot b^{FT} in the contract, this does not invalidate our results from earlier sections regarding the optimal level of damages (b^D) and the conditions under which either liability rules or property rules would be most desirable.

6. Conclusion

In this paper, we analyze the optimal design of legal remedies for breach in the context of international trade agreements, with a particular focus on the GATT/WTO. Our formal analysis delivers sharp conclusions concerning the appropriate remedy for breach and optimal institutional design in light of features of the underlying economic and contracting environment. And our analysis also delivers novel predictions regarding when disputes arise in equilibrium, and how the disputes are resolved.

value of s to the DSB and, if the reports are different, both governments are hit with steep penalties. Clearly this kind of mechanism can implement the first best, because it is an equilibrium for the governments to reveal the true value of s. But we believe it is reasonable to abstract from this kind of mechanism, because in reality the WTO DSB does not have the power to impose penalties on governments for the policies they choose, let alone for the announcements they make. See Maggi and Staiger (2008) for a discussion of self-enforcement issues in related contexts.

In order to preserve tractability and focus on the main points, we have made a number of strong assumptions, and it will be important to extend our results to more general settings. For example, we have derived some of our predictions under the assumption that transfer costs are linear, and while we believe that these predictions extend to more general specifications, this remains to be established. We have also assumed that there is no cost to initiating disputes, but incorporating such costs into our model could yield some interesting additional predictions concerning the conditions under which disputes arise in equilibrium (see note 24).

We have made the strong assumption that there is no private information possessed by either government, an assumption that has helped to bring the distinctive features of our analysis into sharp relief. Allowing for privately informed governments would introduce an additional transaction cost in the form of a bargaining friction into our analysis; unlike the transfer costs that we have emphasized, such bargaining frictions are not specific to the international setting which is our focus, but they are surely important in real-world trade agreements.

Among the most interesting bargaining frictions from which we have abstracted is the possible hold-up problem that could arise for the government of an importing country under a property rule, when there are many exporting governments that hold an entitlement to its markets. As Schwartz and Sykes (2002) have argued, this consideration may be particularly relevant for the GATT/WTO in light of its nondiscrimination rules, and it weighs in favor of a liability-rule interpretation of GATT/WTO commitments. A formal analysis of this issue within our framework would require extending the model to a multi-country setting. We view this as a particularly important extension that we leave for future work.

And finally, we have assumed that DSB rulings are automatically enforced. This is a strong assumption, since in reality DSB rulings must be self-enforcing. Extending our analysis to a setting of self-enforcing agreements is bound to be a complex task, but we can make one simple point here. Suppose the importing country can in principle choose to deviate from the DSB ruling (e.g. choose policy P and make a payment lower than the DSB-mandated damages b^D), but this deviation can be met with a penalty: What is the optimal size of this penalty? In our model, the answer is simple: this penalty should be prohibitive, i.e., sufficiently high to deter this kind of breach in any state of the world. Thus, as a normative matter, our model suggests that the optimal penalties for breach may be non-prohibitive (i.e., induce breach in some states of the world) when it comes to breaching a contractually specified commitment, but should always be prohibitive when it comes to breaching a DSB ruling.

7. Appendix

Proof of Proposition 1: We start by describing how the outcome of the stage-4 subgame varies with γ for a given level of b^D (notice that in the text we adopted a different perspective to develop the intuition graphically, and described there how the outcome of the stage-4 subgame varies with b^D for a given level of γ). We need to consider separately two cases: $b^D \leq \gamma^*$ and $b^D > \gamma^*$:

(a) If $b^D \leq \gamma^*$: It is convenient to think of the importer as having two threat points: FT with no transfer, and P with transfer b^D. For a generic value of γ, only one of the two threat points is "active": the one that gives the importer a higher payoff (of course there is a threshold value of γ for which the importer is indifferent). Given b^D, there are two critical levels of γ, $J(b^D)$ and $R(b^D)$, with $J(b^D) < R(b^D)$, such that: (I) for $\gamma \in [0, J(\cdot)]$, the FT threat point is active, and the outcome is a policy of FT with no compensation paid by either party; (II) for $\gamma \in [J(\cdot), R(\cdot)]$, the (P, b^D) threat point is active, but the DSB ruling is renegotiated and the governments agree on a policy of FT and a transfer $b(b^D - \gamma^*)$ defined implicitly by $b^D - \gamma^* = b - c(b)$; and (III) for $\gamma > R(\cdot)$, the (P, b^D) threat point is active and the DSB ruling is not renegotiated, hence the importer chooses P and compensates the exporter with payment b^D. Note that, as γ crosses the level $J(b^D)$, the level of compensation "jumps" from zero to strictly negative. It can be shown that $J(0) = 0 < R(0) < \gamma^*$, and that J and R are increasing functions with $J(b^D) < R(b^D)$ for $b^D \in [0, \gamma^*)$ and $J(\gamma^*) = R(\gamma^*) > \gamma^*$.

(b) If $b^D > \gamma^*$: In this case, the only change relative to case (a) is that $J(b^D) > R(b^D)$, as can be confirmed by graphical inspection. As a consequence, the equilibrium outcome is as follows: for $\gamma \in [0, R(\cdot)]$, the FT threat point is active, and the equilibrium outcome is a policy of FT with no transfer; for $\gamma \in [R(\cdot), J(\cdot)]$, the FT threat point is active, but the DSB ruling is renegotiated and the equilibrium outcome is P with a transfer of γ^*; and for $\gamma > J(\cdot)$, the (P, b^D) threat point is active and the DSB ruling is not renegotiated, hence the equilibrium outcome is (P, b^D).

Now we can proceed by backward induction. As we argued in the text, the equilibrium outcome of the stage-2 subgame is the same as that of the stage-4 subgame. The next step is to derive the level of b^D that maximizes the ex-ante expected joint payoff. We denote $\Omega(b^D, \gamma)$ the joint payoff as viewed from stage 2, and (with a slight abuse of notation) $E\Omega(b^D)$ the expectation of $\Omega(b^D, \gamma)$ with respect to γ (i.e. the ex-ante joint payoff). It is easy to show that

$E\Omega(b^D)$ is differentiable in b^D. We have to distinguish between cases (a) and (b):

(a) If $b^D \leq \gamma^*$, we can write

$$\begin{aligned} E\Omega(b^D) &= \int_0^{J(b^D)} V(FT)h(\gamma)d\gamma + \int_{J(b^D)}^{R(b^D)} [V(FT) - c(b(b^D - \gamma^*))]dH(\gamma) \\ &\quad + \int_{R(b^D)}^{\infty} [V(FT) + \gamma - \gamma^* - c(b^D)]dH(\gamma) \end{aligned}$$

where $V(FT) \equiv v(FT) + v^*(FT)$ and $H(\gamma)$ is the cdf of γ. Differentiating, we get

$$\frac{dE\Omega}{db^D} = -\frac{\partial c(b(b^D - \gamma^*))}{\partial b^D}[H(R(b^D)) - H(J(b^D))] - c'(b^D)(1 - H(R(b^D)) + J'(b^D)h(J(b^D))c(b(b^D - \gamma^*)) \tag{7.1}$$

Equation (7.1) can be understood by noting that a small increase in b^D affects the equilibrium outcome through its impact on the active threat point. For $\gamma < J(\cdot)$ a small increase in b^D has no effect because in this case the active threat point is FT, which is independent of b^D; for $\gamma \in (J(\cdot), R(\cdot))$, an increase in b^D leads to a reduction in the compensation that the exporter pays in equilibrium (whose initial level is $b(b^D - \gamma^*)$), and hence leads to cost savings of $-\frac{dc(b(b^D - \gamma^*))}{db^D} > 0$; for $\gamma > R(\cdot)$, an increase in b^D translates directly into cost savings of $c'(b^D)$; and finally, an increase in b^D results in a shift forward of the "jump" point $J(b^D)$, which in turn implies cost savings of $J'(b^D) \cdot c(b(b^D - \gamma^*))$. The cost changes just described are weighted by their respective probabilities (and by the density $h(J(\cdot))$ in the case of the jump point).

(b) If $b^D > \gamma^*$, we can write

$$\begin{aligned} E\Omega(b^D) &= \int_0^{R(b^D)} V(FT)h(\gamma)d\gamma + \int_{R(b^D)}^{J(b^D)} [V(FT) + \gamma - \gamma^* - c(\gamma^*)]dH(\gamma) \\ &\quad + \int_{J(b^D)}^{\infty} [V(FT) + \gamma - \gamma^* - c(b^D)]dH(\gamma) \end{aligned}$$

Differentiating, we get

$$\frac{\partial E\Omega}{\partial b^D} = -c'(b^D)(1 - H(J(b^D)) + J'(b^D)h(J(b^D))[c(b^D) - c(\gamma^*)] \tag{7.2}$$

In this case, an increase in b^D has no effect if $\gamma < J(\cdot)$; it leads to an increase in the equilibrium transfer if $\gamma > J(\cdot)$, resulting in a cost increase of $c'(b^D)$; and it shifts the jump point forward, which implies cost savings of $J'(b^D)[c(b^D) - c(\gamma^*)]$.

We are now ready to consider the two cases of "large" and "small" support of γ. It is convenient to start with the case of large support of γ.

Let us first show that the optimal b^D is strictly lower than γ^*. Note first that the value $b^D = \gamma^*$ weakly dominates all higher values of b^D. This can be easily seen from Figure 1: in Region IV, setting $b^D > \gamma^*$ is weakly dominated by setting $b^D = \gamma^*$, and in Regions I-III the joint payoff is constant for $b^D \geq \gamma^*$. Next note from (7.1) that $\frac{\partial E\Omega}{\partial b^D}|_{b^D=\gamma^*} = -c'(\gamma^*)(1-H(R(\gamma^*)) < 0$ (where we have used the fact that $J(\gamma^*) = R(\gamma^*)$), and hence there is a strict gain from lowering b^D below γ^*.

Next let us consider whether it can be optimal to set $b^D = 0$. Evaluating (7.1) at $b^D = 0$ and recalling that $J(0) = 0 < R(0)$, we have $\frac{dE\Omega}{db^D}|_{b^D=0} = -c'(-\gamma^*)H(0) - c'_+(0)(1 - H(0)) + \frac{\partial J}{\partial b^D}c(\gamma^*)h(J(0))$. Clearly, this derivative is positive if $c'_+(0)$ is sufficiently small.[27] Part (ii) of the proposition follows immediately.

Let us now consider the case of small support of γ (around γ^*). Let us focus first on the knife-edge case $\gamma = \gamma^*$. Letting $J^{-1}(\cdot)$ and $R^{-1}(\cdot)$ denote the inverse functions of $J(\cdot)$ and $R(\cdot)$, respectively,[28] we have

$$\Omega(b^D, \gamma^*) = \begin{cases} V(FT) - c(b^D) & b^D < R^{-1}(\gamma^*) \\ V(FT) - c(b(b^D - \gamma^*)) & R^{-1}(\gamma^*) < b^D < J^{-1}(\gamma^*) \\ V(FT) & b^D > J^{-1}(\gamma^*) \end{cases}$$

Clearly, in this case any value $b^D \in (0, J^{-1}(\gamma^*))$ is strictly dominated by $b^D = 0$ and $b^D \geq J^{-1}(\gamma^*)$. Note that $b^D = 0$ and $b^D \geq J^{-1}(\gamma^*)$ both yield the first best outcome. Moreover, the only other values of b^D that yield a joint payoff "close to" the maximum are those in a right neighborhood of $b^D = 0$; all other values of b^D yield a joint payoff that is discretely lower than the maximum (including those in a left neighborhood of $J^{-1}(\gamma^*)$, because there is a jump at $J^{-1}(\gamma^*)$).

Now let us move beyond the knife-edge case and consider a small support of γ around γ^*, say $(\gamma^* - \varepsilon_1, \gamma^* + \varepsilon_2)$, where ε_1 and ε_2 are small positive numbers. Focus first on values of b^D that are strictly positive but close enough to zero: clearly, for such values of b^D we have $\frac{\partial\Omega(b^D,\gamma)}{\partial b^D} < 0$ for all $\gamma \in (\gamma^* - \varepsilon_1, \gamma^* + \varepsilon_2)$, and hence no such value of b^D can be optimal. Next focus on a value of b^D that is not close to zero and that is lower than $J^{-1}(\gamma^* - \varepsilon_1)$ (i.e. non-prohibitive for all values of γ): such value of b^D is suboptimal, because by continuity it yields

[27] There is a small loose end here. The point $(\gamma = 0, b^D = 0)$ is a knife-edge point, because the importer is indifferent between the two threat points. If the indifference is broken in favor of P the term $\frac{\partial J}{\partial b^D}c(\gamma^*)h(J(0))$ will appear, otherwise it will not. But the result goes through in both cases.

[28] Note that the function $J^{-1}(\gamma)$ is the same as the function $b^{prohib}(\gamma)$ that we used in the main text, and $R^{-1}(\gamma)$ is the same as $b^{reneg}(\gamma)$. Here we use the J^{-1} and R^{-1} notation to emphasize that these are the inverse functions of J and R respectively.

a joint payoff that is discretely lower than the maximum, for each value of γ in its support. Finally consider a value of b^D that is prohibitive for some values of γ but not for others, i.e. $b^D \in (J^{-1}(\gamma^* - \varepsilon_1), J^{-1}(\gamma^* + \varepsilon_2))$: such value of b^D is clearly dominated by a fully prohibitive value, i.e. by $b^D > J^{-1}(\gamma^* + \varepsilon_2)$, because of the jump that occurs at $J^{-1}(\gamma)$. This establishes that in the case of small support only a property rule can be optimal. **QED**

Proof of Proposition 2: The backward induction analysis in the case where both γ and γ^* are uncertain proceeds in the same way as in the case where only is γ uncertain (see proof of Proposition 1), except that we need to highlight how $J(\cdot)$ and $R(\cdot)$ depend on γ^* .It is not hard to show that R is increasing in γ^* and J is independent of γ^*. We will therefore write $J(b^D)$ and $R(b^D, \gamma^*)$.

Moving to stage 0, given that both γ and γ^* are uncertain, we do not need to write two separate expressions of the expected joint surplus for the cases $b^D > \gamma^*$ and $b^D < \gamma^*$. Instead, we have a single expression that involves the expectation over γ^*, and its derivative with respect to b^D can be written in the following way:

$$\begin{aligned}\frac{dE\Omega}{db^D} = J'(b^D)h(J(b^D))[\int_{b^D}^{\infty} c(b(b^D - \gamma^*))dH^*(\gamma^*) + \int_0^{b^D} (c(b^D) - c(\gamma^*))dH^*(\gamma^*)] \\ - \int_{b^D}^{\infty} [\frac{d}{db^D} c(b(b^D - \gamma^*)) \Pr(J(b^D)) < \gamma < R(b^D, \gamma^*))]dH^*(\gamma^*) \\ - c'(b^D) \Pr(\gamma > \max\{R(b^D, \gamma^*), J(b^D)\})\end{aligned}$$

In the case of small support of Γ (i.e. when γ and γ^* cannot be far from each other), it can be shown using a similar argument as in the proof of Proposition 1 that a property rule is optimal.

Let us focus now on the case of large support of Γ. We evaluate $\frac{dE\Omega}{db^D}$ at $b^D = 0$. Recall that $J(0) = 0$ and note that $h(0) = 0$, hence $h(J(0)) = 0$. And recalling that $\frac{d}{db^D} c(b(b^D - \gamma^*)) < 0$, it follows that if $c'_+(0)$ is sufficiently small then $\frac{dE\Omega}{db^D}|_{b^D=0} > 0$. This implies that the optimal b^D is strictly positive, as claimed. It can be shown by examples that the optimal b^D can be either prohibitive or non-prohibitive. **QED**

Proof of Proposition 3: Consider increasing $c(b)$ for all $b \neq 0$ (while preserving the properties of $c(b)$ that we have assumed), fixing the support of Γ. It is clear by inspection of Figure 1 that Regions II and III expand, while Regions I and IV contract, and at some point Regions I and IV will disappear. With the cost-of-transfers sufficiently high so that only Regions II and III are relevant, it then follows that there will be no transfers in equilibrium under the property rules $b^D = 0$ and $b^D \geq \bar{b}^{prohib}$, while there will be non-zero transfers in equilibrium under a liability rule. But then, the cost of transfers can always be made sufficiently high that their cost outweighs the gain in joint surplus associated with inducing the correct policy choice. More specifically, consider a level b^D that is strictly between 0 and $\bar{b}^{prohib}$. By inspection of Figure 2 it is clear that we can make the cost of transfers high enough that this level of b^D will be dominated in terms of joint surplus by $b^D = 0$. This shows that the optimum must be a property rule if the cost of transfers is high enough.

Next consider decreasing the cost of transfers: as Figure 1 indicates, at some point the probability of being in Regions I and IV will become strictly positive. Thus, using a similar argument as the one in the proof of Proposition 2, it follows that if the cost of transfers is small enough, the property rule $b^D = 0$ can be improved upon, and hence the optimal b^D is strictly positive. **QED**

Proof of Proposition 4: If the support of Γ is small, it can be shown using a similar argument as in the proof of Proposition 1 that a property rule is optimal. Focusing next on the case of large support, $\frac{dE\Omega}{db^D}$ can be written as:

$$\begin{aligned} \frac{dE\Omega}{db^D} &= -c'(b^D)[1 - H(J(b^D))] + J'(b^D)h(J(b^D)) \int_{b^D}^{\infty} [J(b^D) - \gamma^* - c(b^D)] dH^*(\gamma^*) \quad (7.3) \\ &= -c'(b^D)[1 - H(b + c(b^D))] - (1 + c'(b^D))h(b + c(b^D))(b^D - E\gamma^*), \quad (7.4) \end{aligned}$$

where we have used the fact that $J(b^D) = b + c(b^D)$.

Clearly, for $b^D \geq E\gamma^*$ we have $\frac{dE\Omega}{db^D} < 0$,and hence the optimal b^D must be lower than $E\gamma^*$.

Also note that $\frac{dE\Omega}{db^D}|_{b^D=0} = 0$ (since $c'(0) = 0$ and $h(0) = 0$), but $\frac{dE\Omega}{db^D}|_{b^D=\varepsilon} < 0$, where ε is an arbitrarily small but positive value. This establishes that $b^D = 0$ is a local maximum. It can be shown by examples that the globally optimal b^D can be either zero or positive. **QED**

Proof of Lemma 1: Consider an arbitrary schedule $b^D(\hat{\gamma}, \hat{\gamma}^*)$. At stage 4 this schedule induces equilibrium payoffs $(\omega_4(\hat{\gamma}, \hat{\gamma}^*, \gamma, \gamma^*), \omega_4^*(\hat{\gamma}, \hat{\gamma}^*, \gamma, \gamma^*))$. Clearly, all of these payoff pairs lie on the ex-post Pareto frontier given (γ, γ^*). Moving back to stage 2, consider the expected payoffs conditional on (γ, γ^*) if stage 4 is reached (i.e. if the DSB is invoked). We denote these expected payoffs as $(E[\omega_4(\cdot)|\gamma, \gamma^*], E[\omega_4^*(\cdot)|\gamma, \gamma^*])$. In this proof we omit the argument b^D from the payoff functions, as this should not cause confusion.

Let us consider the four possible regions of (γ, γ^*). Given the assumption of linear cost of transfers, the ex-post frontiers in each region are piece-wise linear (see Figure 5). As before, the shaded portion of each frontier depicts the range of stage-4 bargaining outcomes that are induced by varying $(\hat{\gamma}, \hat{\gamma}^*)$ – and hence b^D – in each region. In Regions II and III, the equilibrium payoff point $(\omega_4(\cdot), \omega_4^*(\cdot))$ traces a convex locus in (ω, ω^*) space. This implies that the expected payoff point $(E[\omega_4(\cdot)|\gamma, \gamma^*], E[\omega_4^*(\cdot)|\gamma, \gamma^*])$, labeled $E[D]$ in each panel, lies outside the ex-post frontier for given (γ, γ^*). As a consequence, there is no settlement at stage 2 for realized (γ, γ^*) in these regions, and the DSB is invoked. Thus the equilibrium payoffs at stage 2 are given by $(E[\omega_4(\cdot)|\gamma, \gamma^*], E[\omega_4^*(\cdot)|\gamma, \gamma^*])$ for realized (γ, γ^*) falling in either Region II or Region III.

In Regions I and IV, the equilibrium payoff points $(\omega_4(\cdot), \omega_4^*(\cdot))$ lies on a single straight line for given (γ, γ^*). This implies that the expected payoff point $(E[\omega_4(\cdot)|\gamma, \gamma^*], E[\omega_4^*(\cdot)|\gamma, \gamma^*])$ lies on the ex-post frontier, as the points labeled $E[D]$ in these two panels indicate. And this implies again that the equilibrium payoffs at stage 2 are given by $(E[\omega_4(\cdot)|\gamma, \gamma^*], E[\omega_4^*(\cdot)|\gamma, \gamma^*])$.

Now let us consider the optimization problem at stage 0. The objective function is $E_{\gamma,\gamma^*}(E[\Omega_4(\cdot)|\gamma, \gamma^*])$, which we can write as follows:

$$\int\int\left[\int\int \Omega_4(\cdot)h(\hat{\gamma}, \hat{\gamma}^*|\gamma, \gamma^*)d\hat{\gamma}d\hat{\gamma}^*\right]h(\gamma, \gamma^*)d\gamma d\gamma^* = \int\int\left[\int\int \Omega_4(\cdot)h(\gamma, \gamma^*|\hat{\gamma}, \hat{\gamma}^*)d\gamma d\gamma^*\right]z(\hat{\gamma}, \hat{\gamma}^*)d\hat{\gamma}d\hat{\gamma}^*$$

where $z(\hat{\gamma}, \hat{\gamma}^*)$ is the marginal density of $(\hat{\gamma}, \hat{\gamma}^*)$, $h(\gamma, \gamma^*)$ the marginal density of (γ, γ^*), and the notation for the conditional densities has the intuitive meaning Clearly, maximizing the objective boils down to maximizing $\int\int(\omega_4(\cdot) + \omega_4^*(\cdot))h(\gamma, \gamma^*|\hat{\gamma}, \hat{\gamma}^*)d\gamma d\gamma^*$ for each given pair $(\hat{\gamma}, \hat{\gamma}^*)$. **QED**

Proof of Proposition 5: We start by deriving $\frac{dE(\Omega_4|\hat{\gamma},\hat{\gamma}^*)}{db^D}$. Plugging in the linear cost specification, we have:

$$\frac{dE(\Omega_4|\hat{\gamma}, \hat{\gamma}^*)}{db^D} = J'(b^D)[\int_{b^D}^{\infty} \frac{c}{1+c} \cdot (\gamma^* - b^D)dH^*(\gamma^*|\hat{\gamma}^*) + \int_0^{b^D} c \cdot (b^D - \gamma^*)dH^*(\gamma^*|\hat{\gamma}^*)] \cdot h(J(b^D)|\hat{\gamma})$$
$$+\frac{c}{1+c} \cdot \Pr[J(b^D)) < \gamma < R(b^D, \gamma^*)|\hat{\gamma}, \hat{\gamma}^*] - c \cdot \Pr[\gamma > \max\{R(b^D, \gamma^*), J(b^D)\}|\hat{\gamma}, \hat{\gamma}^*], \tag{7.5}$$

where we have used the fact that $c(b(b^D - \gamma^*)) = \frac{c}{1+c} \cdot (\gamma^* - b^D)$ given the linear cost.

We next argue that $\frac{dE(\Omega_4|\hat{\gamma},\hat{\gamma}^*)}{db^D}$ is decreasing in $\hat{\gamma}$ when evaluated at the FOC ($\frac{dE(\Omega_4|\hat{\gamma},\hat{\gamma}^*)}{db^D} = 0$). Note that the first and second terms in (7.5) are positive, while the third term is negative. By the assumption that $h(\gamma|\hat{\gamma})$ is log-supermodular, as $\hat{\gamma}$ increases, $h(\gamma|\hat{\gamma})$ increases proportionally more for higher values of γ. This implies that as $\hat{\gamma}$ increases the negative term in (7.5) increases proportionally more than the sum of the two positive terms. Coupled with the fact that, when evaluated at the FOC ($\frac{dE(\Omega_4|\hat{\gamma},\hat{\gamma}^*)}{db^D} = 0$), the negative term is equal in magnitude to the sum of the positive terms, this implies that as $\hat{\gamma}$ increases the negative term increases in magnitude by more than the sum of the positive terms, and hence $\frac{dE(\Omega_4|\hat{\gamma},\hat{\gamma}^*)}{db^D}$ decreases. Given that we were starting from an optimal (interior) level of b^D, it follows that the optimal b^D decreases with $\hat{\gamma}$.[29]

We next argue that, if the signal $\hat{\gamma}^*$ is sufficiently precise, the optimal b^D is increasing in $\hat{\gamma}^*$. The key is to consider the limiting case in which $\hat{\gamma}^*$ is perfectly accurate, so that the DSB effectively observes the true γ^*. Then by our Proposition 1 we know that the optimal b^D is strictly lower than γ^*, and we can write:

$$\frac{dE(\Omega_4|\hat{\gamma},\gamma^*)}{db^D} = \frac{c}{1+c}J'(b^D)h(J(b^D)|\hat{\gamma})(\gamma^*-b^D)+\frac{c}{1+c}[H(R(b^D,\gamma^*)|\hat{\gamma})-H(J(b^D)|\hat{\gamma})]-c[1-H(R(b^D,\gamma^*)|\hat{\gamma})] \tag{7.6}$$

Noting that (i) $J'(b^D) > 0$, (ii) $R(b^D, \gamma^*)$ is increasing in γ^*, and (iii) H is an increasing function, it follows immediately that $\frac{dE(\Omega_4|\hat{\gamma},\gamma^*)}{db^D}$ is increasing in γ^*. It is then not hard to show that the same result continues to hold if we add a sufficiently small noise to the signal $\hat{\gamma}^*$.

Part (ii) is a direct consequence of the assumptions $\lim_{\hat{\gamma}^*\to\infty} \Pr(\gamma^* < \gamma|\hat{\gamma},\hat{\gamma}^*) = 0$ and $\lim_{\hat{\gamma}\to\infty} \Pr(\gamma^* > \gamma|\hat{\gamma},\hat{\gamma}^*) = 0$. Let us focus on the case $\hat{\gamma}^* \to \infty$. It is clear that if $\Pr(\gamma^* < \gamma|\hat{\gamma},\hat{\gamma}^*) = 0$, then $b^D = 0$ is optimal. One can then show that, if we make $\Pr(\gamma^* < \gamma|\hat{\gamma},\hat{\gamma}^*)$ slightly positive, the optimal b^D will be close to (or equal to) 0. A similar argument can be made for the case $\hat{\gamma} \to \infty$. **QED**

Proof of Proposition 7: It is easy to show that it cannot be optimal to set $b^D < 0$ or $b^{FT} > 0$, so we can focus on the case $b^D \geq 0$, $b^{FT} \leq 0$. To keep the notation more intuitive we will think of the choice variables as being the absolute transfer levels, b^D and $|b^{FT}|$.

We start by describing how the outcome of the stage-4 subgame varies with γ and γ^* for given levels of b^D and $|b^{FT}|$. We need to consider separately four regions in (γ, γ^*) space. Again we can think of the importer as having two threat points: (P, b^D) and $(FT, |b^{FT}|)$; for a generic value of γ, only one of the two threat points is active. Let us define $\gamma = J(b^D, |b^{FT}|)$ as the level of γ such that the importer is indifferent between the two threat points; as in the case where $b^{FT} \equiv 0$, it can be verified that J does not depend on γ^*. Also, in analogy with the case

[29] If the initial optimal level is $b^D = 0$ and the FOC is not satisfied, then a small change in $\hat{\gamma}$ or $\hat{\gamma}^*$ will have no impact on the optimum – hence the weak monotonicity statements.

where $b^{FT} \equiv 0$, let $\gamma = R(\gamma^*, b^D, |b^{FT}|)$ denote the level of γ such that the active threat point is just on the ex-post Pareto frontier; this is the border of the region where governments will renegotiate. Notice that (as before) R is increasing in γ^*. Finally, let $\gamma^* = \phi(b^D, |b^{FT}|)$ be the level of γ^* for which the curves $\gamma = J(b^D, |b^{FT}|)$ and $\gamma = R(\gamma^*, b^D, |b^{FT}|)$ intersect.

Consider now the four relevant regions in (γ, γ^*) space, for given b^D and $|b^{FT}|$: (A) In the region where $\gamma < \min\{J(\cdot), R(\gamma^*, \cdot)\}$, the $(FT, |b^{FT}|)$ threat point is active, and there is no renegotiation, so the outcome is a policy of FT with the exporter paying $|b^{FT}|$; (B) In the region where $J(\cdot) < \gamma < R(\gamma^*, \cdot)$, the (P, b^D) threat point is active, but the DSB ruling is renegotiated and the equilibrium outcome is a policy of FT with the exporter making a transfer to the importer, which we denote $b(b^D, \gamma^*)$; (C) In the region where $\gamma > \max\{J(\cdot), R(\gamma^*, \cdot)\}$, the (P, b^D) threat is active and there is no renegotiation, hence the outcome is a policy of P with the importer paying b^D; (D) In the region where $R(\gamma^*, \cdot) < \gamma < J(\cdot)$, the $(FT, |b^{FT}|)$ threat is active, but there is renegotiation and the equilibrium outcome is a policy of P with the importer making a transfer to the importer, which we denote (with a slight abuse of notation) $b(|b^{FT}|, \gamma^*)$.

As in the case considered in section 3.1, the equilibrium outcome of the stage-2 subgame is the same as that of the stage-4 subgame. Moving back to stage 0, we let $E\Omega(b^D, |b^{FT}|)$ denote the ex-ante expected joint payoff. Using a similar logic as in the proof of Proposition 2, we can write

$$\begin{aligned} \frac{\partial E\Omega}{\partial b^D} &= -c'(b^D)\Pr(\gamma > \max\{J(\cdot), R(\gamma^*, \cdot)\}) - \frac{\partial}{\partial b^D} c(b(b^D, \gamma^*))\Pr(J(\cdot) < \gamma < R(\gamma^*, \cdot)) \\ &\quad + \frac{\partial J}{\partial b^D} h(J(\cdot))\Big[\int_0^{\phi(\cdot)} [c(b^D) - c(b(|b^{FT}|, \gamma^*))]dH^*(\gamma^*) - \int_{\phi(\cdot)}^{\infty} [c(b(b^D, \gamma^*)) - c(-|b^{FT}|)]dH^*(\gamma^*)\Big] \end{aligned} \tag{7.7}$$

and

$$\begin{aligned} \frac{\partial E\Omega}{\partial |b^{FT}|} &= c'(-|b^{FT}|)\Pr(\gamma < \min\{J(\cdot), R(\gamma^*, \cdot)\}) - \frac{\partial}{\partial |b^{FT}|} c(b(|b^{FT}|, \gamma^*))\Pr(R(\gamma^*, \cdot) < \gamma < J(\cdot)) \\ &\quad + \frac{\partial J}{\partial |b^{FT}|} h(J(\cdot))\Big[\int_0^{\phi(\cdot)} [c(b^D) - c(b(|b^{FT}|, \gamma^*))]dH^*(\gamma^*) - \int_{\phi(\cdot)}^{\infty} [c(b(b^D, \gamma^*)) - c(-|b^{FT}|)]dH^*(\gamma^*)\Big]. \end{aligned} \tag{7.8}$$

Let us first prove claim (ii) of Proposition 7. Focus on the case of large support of Γ. A necessary condition for $|b^{FT}| = 0$ to be optimal is that the partial derivative $\frac{\partial E\Omega}{\partial |b^{FT}|}$ be non-positive when evaluated at $|b^{FT}| = 0$ and $b^D = \tilde{b}^D$, where $\tilde{b}^D$ is the optimal value of b^D conditional on $|b^{FT}| = 0$. Recall from section 3.1 that $\tilde{b}^D \in (0, \bar{b}^{prohib})$ when the support of

Γ is large enough. Note that (a) $\frac{\partial J}{\partial b^D} > 0$ and $\frac{\partial J}{\partial |b^{FT}|} > 0$; (b) the jump terms $[c(b(b^D, \gamma^*)) - c(-|b^{FT}|)]$ and $[c(b^D) - c(b(|b^{FT}|, \gamma^*))]$ are positive; (c) $c'(0) = 0$ (since we assumed $c(b)$ is smooth everywhere); and (f) $\frac{\partial}{\partial |b^{FT}|} c(b(|b^{FT}|, \gamma^*)) < 0$. Putting these observations together, it is direct to conclude that $\left| \frac{\partial E\Omega}{\partial |b^{FT}|} \right|_{|b^{FT}|=0, b^D=\tilde{b}^D} > 0$, and hence the optimal $|b^{FT}|$ must be strictly positive. With a similar argument one can show that the optimal value of b^D is strictly positive.

The claim that the optimal b^D and $|b^{FT}|$ are strictly positive if the cost of transfers is small enough (holding everything else equal) can be shown with a similar argument as in the proof of Proposition 3.

We can now turn to claim (i) of Proposition 7. Consider first the knife-edge case $\Gamma = 0$, or $\gamma = \gamma^*$. Let us characterize how $\Omega(b^D, |b^{FT}|; \cdot)$ depends on b^D and $|b^{FT}|$. Clearly, in this knife-edge case, an optimum requires that no transfer occur in equilibrium, and either policy P or FT is optimal. Therefore there are two sets of points $(b^D, |b^{FT}|)$ that are optimal: (i) any pair such that $b^D = 0$ and $|b^{FT}| \leq \gamma_{\min}$ will induce the policy P with zero transfer in equilibrium, and hence it is optimal; (ii) any pair such that $b^{FT} = 0$ and $b^D \geq \bar{b}^{prohib}$ will induce the policy FT with zero transfer in equilibrium, and hence it is optimal.

Following a similar logic as in the proof of Proposition 2, we can ask what are the points $(b^D, |b^{FT}|)$ – other than the first-best points that we identified above – that yield a joint payoff "close to" the first best in this knife-edge case. The answer is: (a) those such that $|b^{FT}| \leq \gamma_{\min}$ and $b^D > 0$ is close to zero, and (b) those such that $b^D > J^{-1}(|b^{FT}|, \gamma_{\max})$ and $|b^{FT}| > 0$ is close to zero (where $J^{-1}(|b^{FT}|, \cdot)$ is the inverse of $J(|b^{FT}|, \cdot)$). All other pairs $(b^D, |b^{FT}|)$ yield a joint payoff that is discretely lower than the first best.

We are now ready to move beyond the knife-edge case and consider a small support of Γ around 0, say $(-\varepsilon_1, +\varepsilon_2)$. Focus first on pairs $(b^D, |b^{FT}|)$ of the type (a) described just above. For these pairs, $\frac{\partial \Omega}{\partial b^D} < 0$ for all $\Gamma \in (-\varepsilon_1, +\varepsilon_2)$, and hence no such pair can be optimal. Focus next on pairs $(b^D, |b^{FT}|)$ of the type (b) described above; for these pairs, $\frac{\partial \Omega}{\partial |b^{FT}|} < 0$ for all $\Gamma \in (-\varepsilon_1, +\varepsilon_2)$, and hence no such pair can be optimal. All other pairs must be suboptimal too, because by continuity they yield a joint payoff that is discretely lower than the first best for all $\Gamma \in (-\varepsilon_1, +\varepsilon_2)$, whereas we know that we can achieve a joint payoff close to the first best with, for example, $|b^{FT}| = 0$ and $b^D > \bar{b}^{prohib}$. This proves that, if the support of Γ is small enough, it is optimal to set $|b^{FT}| = 0$ and the optimal b^D is either zero or prohibitive. That the same result obtains if the cost of transfers is high enough (holding everything else constant) can be shown with a similar argument as in the proof of Proposition 3. **QED**

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Figure 1

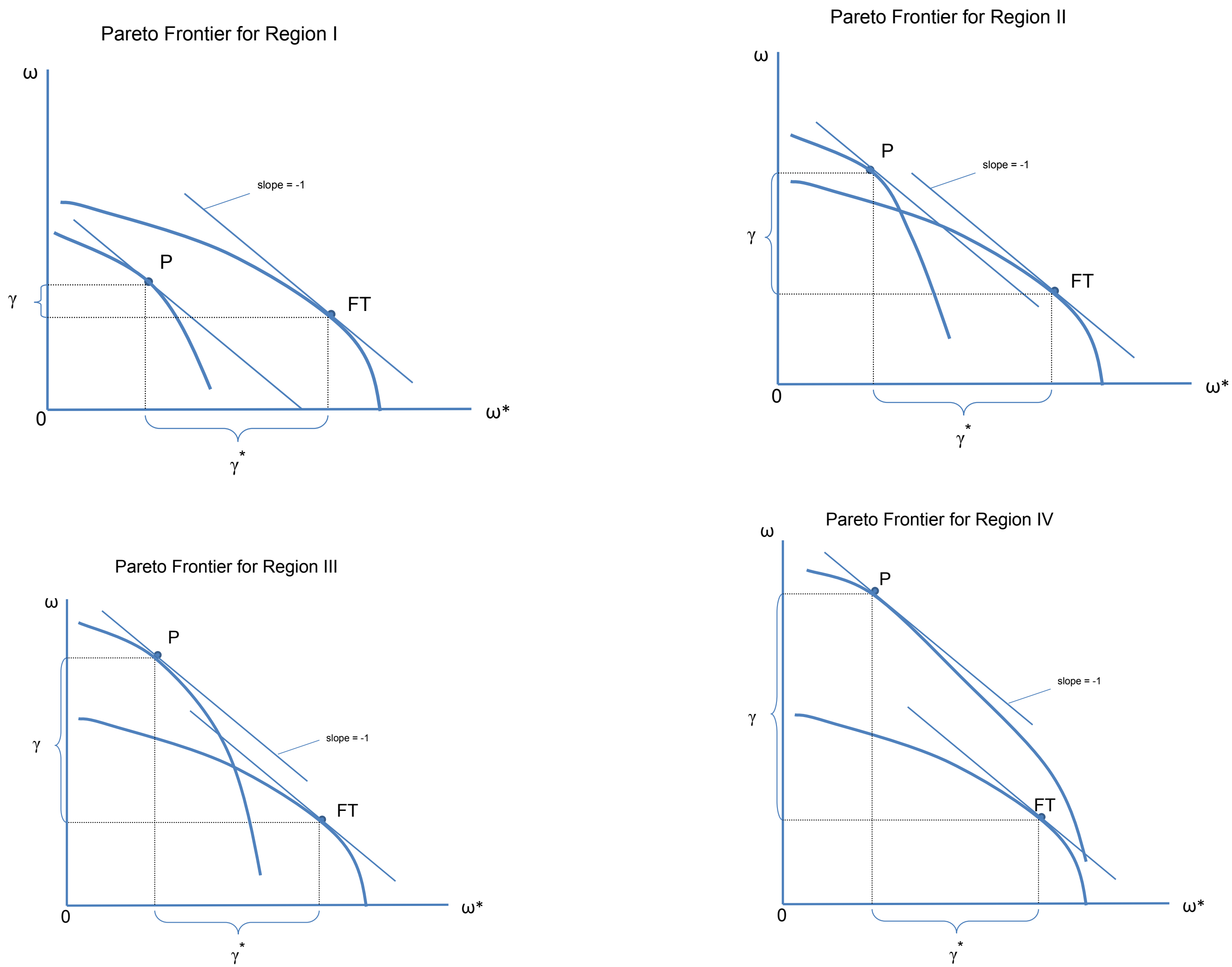
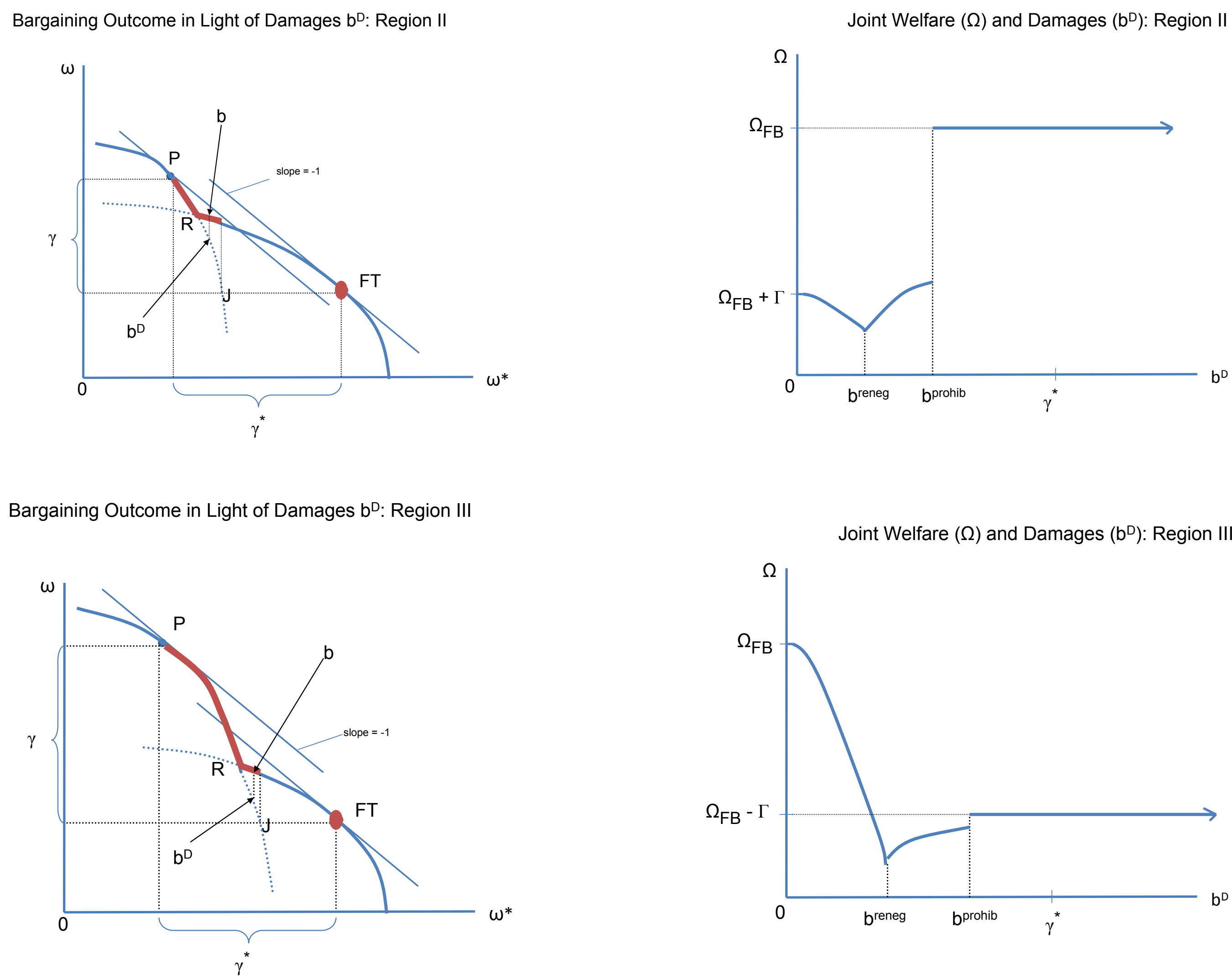

Pareto Frontier for Region I
ω
slope = -1
P
γ
FT
0
ω*
γ*
Pareto Frontier for Region II
ω
P
slope = -1
γ
FT
0
ω*
γ*
Pareto Frontier for Region III
ω
P
slope = -1
γ
FT
0
ω*
γ*
Pareto Frontier for Region IV
ω
P
slope = -1
γ
FT
0
ω*
γ*

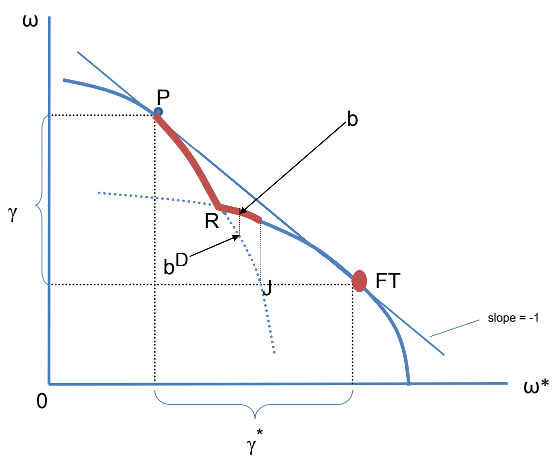
Figure 2



Bargaining Outcome in Light of Damages b^D: Region II
ω
ω*
0
P
R
J
b
b^D
FT
slope = -1
γ
γ*
Joint Welfare (Ω) and Damages (b^D): Region II
Ω
Ω_FB
Ω_FB + Γ
0
b^reneg
b^prohib
γ*
b^D
Bargaining Outcome in Light of Damages b^D: Region III
ω
ω*
0
P
R
J
b
b^D
FT
slope = -1
γ
γ*
Joint Welfare (Ω) and Damages (b^D): Region III
Ω
Ω_FB
Ω_FB - Γ
0
b^reneg
b^prohib
γ*
b^D

Figure 3

Bargaining Outcome in Light of Damages b^D: Region II/III Border



Joint Welfare (Ω) and Damages (b^D): Border of Regions II/III

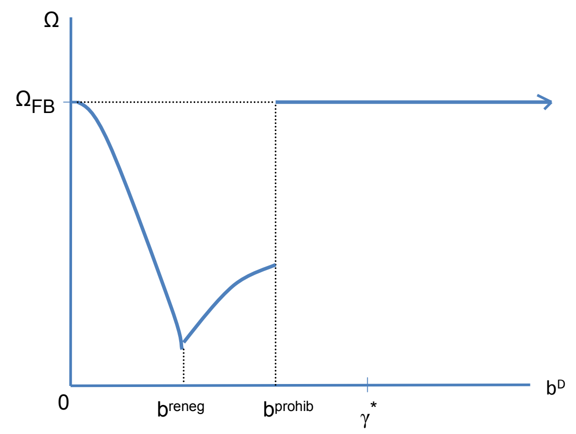
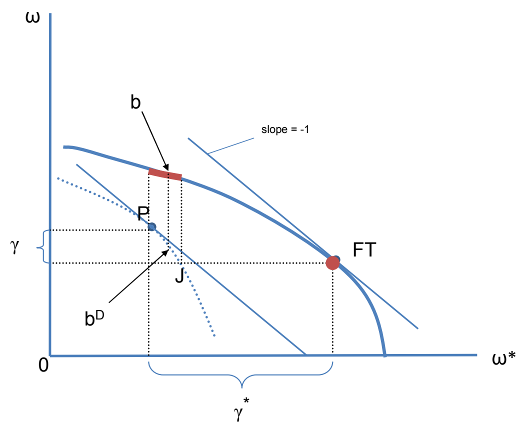
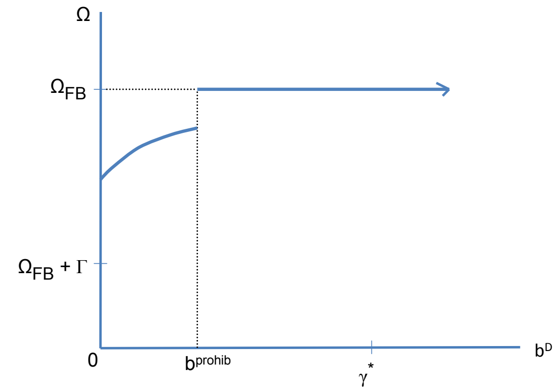


Figure 4

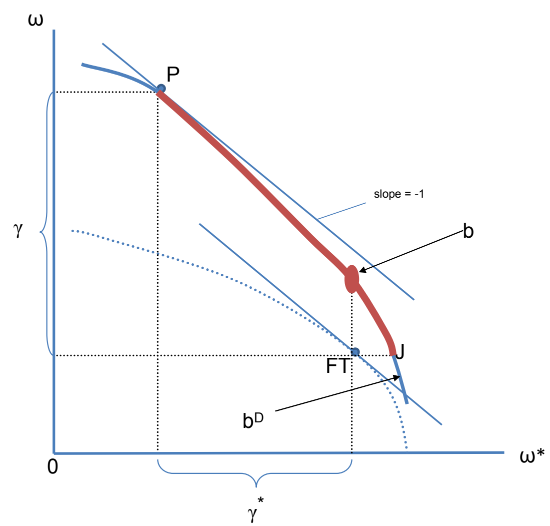
Bargaining Outcome in Light of Damages b^D: Region I



Joint Welfare (Ω) and Damages (b^D): Region I



Bargaining Outcome in Light of Damages b^D: Region IV



Joint Welfare (Ω) and Damages (b^D): Region IV

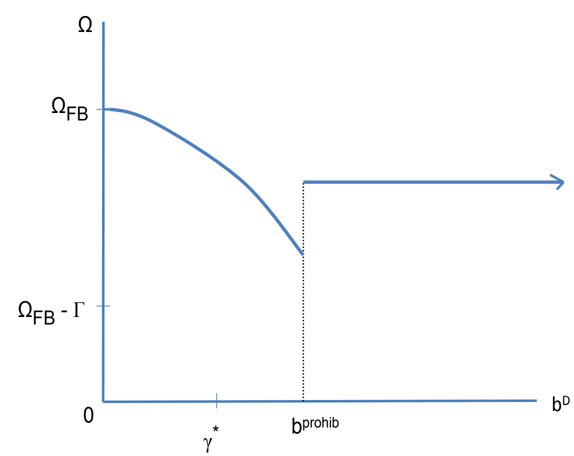


Figure 5

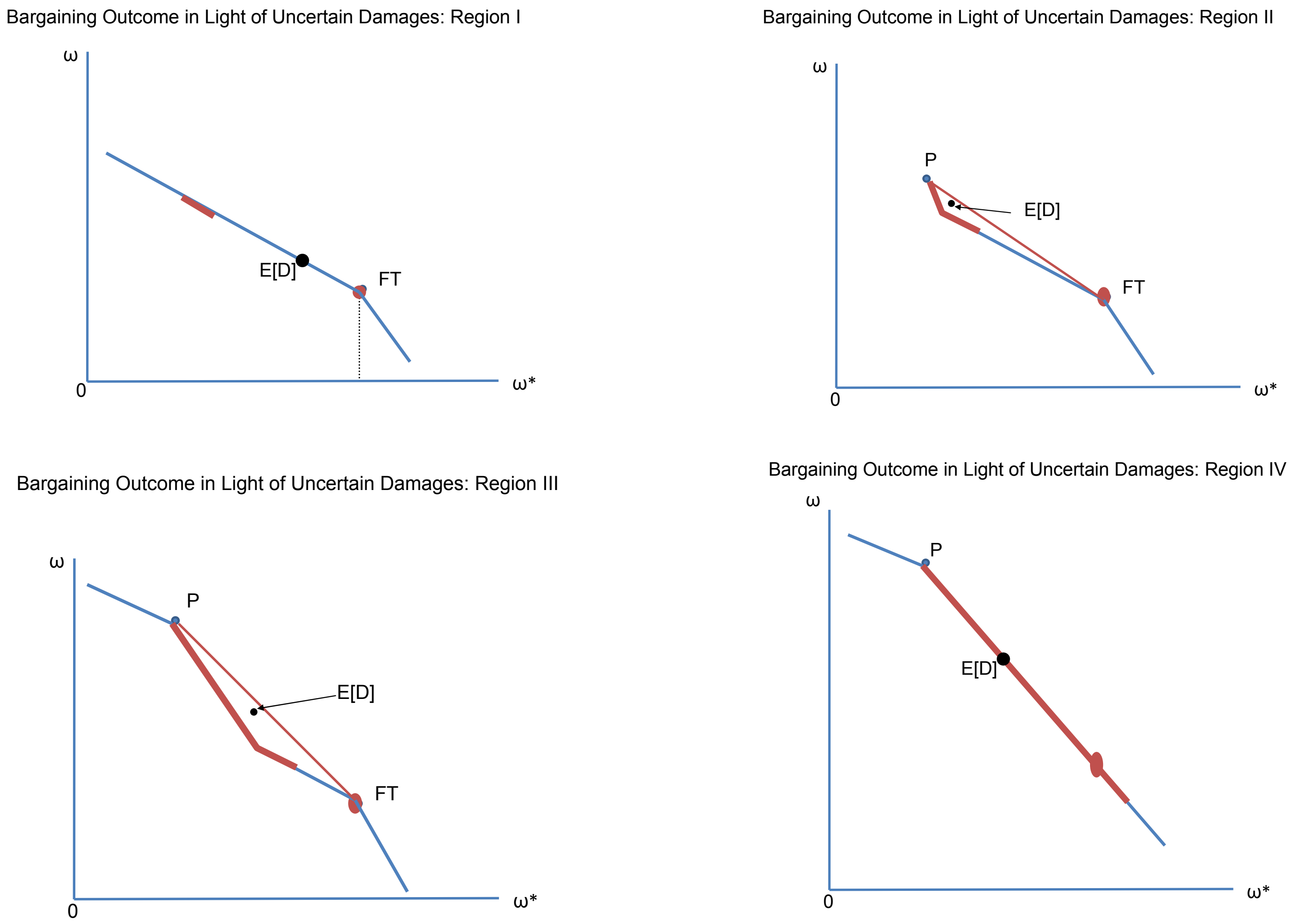
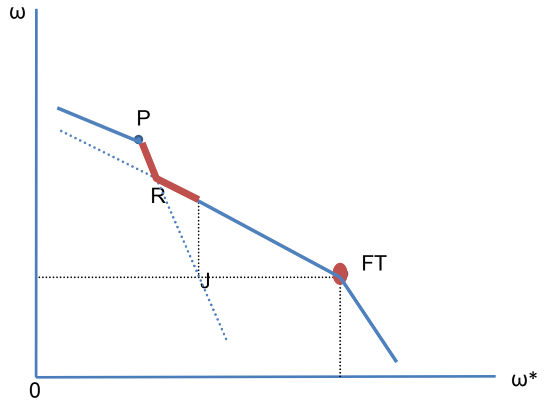

Bargaining Outcome in Light of Uncertain Damages: Region I
ω
E[D]
FT
0
ω*
Bargaining Outcome in Light of Uncertain Damages: Region II
ω
P
E[D]
FT
0
ω*
Bargaining Outcome in Light of Uncertain Damages: Region III
ω
P
E[D]
FT
0
ω*
Bargaining Outcome in Light of Uncertain Damages: Region IV
ω
P
E[D]
0
ω*

Figure 6

Bargaining Outcome in Light of Uncertain Damages: Region II



Bargaining Outcome in Light of Uncertain Damages: Region III