Learning by Ruling and Trade Disputes*

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Abstract

We explore the implications of judicial learning for trade disputes through a model where both the initiation of disputes and the occurrence of rulings are endogenous, governments bargain “in the shadow of the law,” and the efficiency of the court increases with experience. Judicial learning can explain litigation on the equilibrium path, since going to court today implies future payoff gains for the governments. Our model predicts that the likelihood of both disputes and rulings should tend to decrease with court experience. Trade dispute data is consistent with this prediction and suggests significant judicial learning at the WTO, but learning appears to be article-specific and disputant-specific, rather than general, in scope.

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1. Introduction

The World Trade Organization (WTO) is endowed with a sophisticated court system contained within its Dispute Settlement Body (DSB). The WTO-DSB is a relatively young judicial system, however, and the adjudication of trade disputes is a complex task, so there are good reasons to think that learning by the court is an important feature in the evolution of this institution. Such learning may occur, for example, because the court learns through past rulings to use and interpret data and to make more effective and timely use of rigorous economic reasoning in arriving at its rulings. Or it may occur because the court learns to better interpret the legal nuances of various kinds of contracts and thereby learns to better translate those contracts into the intent of the contracting parties. Court learning may also take the form of a reduction in the costs and delays associated with court investigations.\(^1\) We refer to these possible forms of learning interchangeably as “judicial learning” or “learning by ruling.”\(^2\) In this paper we present a theoretical analysis of the implications of judicial learning for the WTO, and we confront our theory with data on WTO trade disputes.

In domestic legal settings, the importance of judicial learning has been widely emphasized, both by legal practitioners and by the law and economics literature. For example, an interesting informal and personal account of this importance can be found in former Supreme Court Justice John Paul Stevens’ discussion of learning on the job (Stevens, 2006). After describing the differences of opinion between Justices Holmes and Brandeis in a legal ruling that would determine the basis for regulatory takings under U.S. law, Justice Stevens concludes: “I suspect that Justices Holmes and Brandeis would also agree that learning on the job is essential to the

\(^1\)The type of learning described above can be thought of as “methodological” learning, or “learning by doing” in investigating and adjudicating. The court may also experience a “factual” type of learning: for example, by repeatedly studying the policies of a certain country (say, China) or in a certain issue area (say, health and safety), the court may gain knowledge about persistent aspects of that country’s policy environment or of that issue area (the “state of the world”). The modeling approach we describe below is a better fit for methodological learning than for factual learning, because we will assume for tractability that the “facts” (i.e., state of the world) are \(iid\) over time; but we expect that our main insights would extend to the latter type of learning as well.

\(^2\)For each of these types of judicial learning, there is also the question of who is learning and how the knowledge is passed on over time. In the case of a standing judicial body such as the WTO’s Appellate Body, it may be that it is the judges themselves who learn directly from their own experience. But also in the case of a rotating body such as the WTO’s Dispute Settlement panels, today’s panel may learn from reading panel reports from previous cases, since such reports are publicly available. And in the WTO there is another important standing body, namely the Secretariat, which is a group of experts that plays a supporting role in the adjudication process. To the extent that the Secretariat learns how to more effectively aid in the adjudication of WTO cases over time, this too can be thought of as part of court learning.
process of judging. At the very least, I know that learning on the bench has been one of the most important and rewarding aspects of my own experience over the last thirty-five years.” (p. 1567). The law and economics literature has also emphasized the importance of legal precedent and its impact on the evolution of legal rules in the context of common law systems, stimulated by Posner’s (1973) claim that in the presence of precedent “common law will effect order from chaos” and generate a process that converges to efficient legal rules. One can think of the underlying process described by Posner as a “collective” form of judicial learning.3

A key difference between a government-to-government court system like the WTO-DSB and a domestic legal setting is that the number of potential disputants (the member governments) is small and therefore the impact of current rulings on the future quality of the court is at least in part internalized by the potential disputants. This “large players” setting means in turn that the full implications of judicial learning for a court system such as the WTO-DSB cannot be understood in settings where the potential disputants are atomistic, as has been assumed in the law and economics literature that studies court learning in the domestic legal context. Moreover, the internalization of court learning may have implications not only for the decision of whether to go to court, but also for the choices that determine whether there is a dispute in the first place. The law and economics literature does not speak to this issue, because that literature typically treats the dispute margin as exogenous. In contrast, we explore the implications of judicial learning through a simple dynamic model that endogenizes the occurrence of both disputes and rulings in a large-players setting.

The main ingredients of our model are as follows. In each period, a Home government makes a policy choice and a Foreign government decides whether or not to dispute this choice. If a

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3This form of judicial learning may well be relevant also for the WTO, although in comparison to domestic common-law systems the application of legal precedent in the WTO is thought to be more fluid (see, for example, Jackson, 2006). It should also be noted that an entire literature in law and economics has arisen to challenge and assess Posner’s (1973) claim that common law converges to an efficient system of legal rules (see, for example, Baker and Mezzetti, 2012, who emphasize the possibility of convergence to inefficient legal rules when judicial resources are scarce; Parameswaran, 2018, who shows that endogenizing the case-arrival process in a model a’ la Baker-Mezzetti introduces a further reason why legal rules may not converge to efficiency; Daughety and Reinganum, 1999, who explore the possibility of informational cascades that might preclude convergence to efficient legal rules; and Talley, 1999, for a skeptical appraisal of the likelihood that such precedential cascades would interfere with the attainment of efficient legal rules in practice; and see also Hadfield, 1992, 2011, and Beim, 2017). For our purposes, to the extent that this collective form of judicial learning is relevant for the WTO, what matters is whether it leads toward efficiency, not that it necessarily attains efficiency, and on this point the law-and-economics literature is in broad agreement under a variety of conditions (see for example, Gennaioli and Shleifer, 2007, who establish that legal evolution under a common law system of precedent is on average beneficial even if judges are motivated by personal agendas).
dispute is initiated, governments bargain “in the shadow of the law,” subject to negotiation costs. In case of disagreement, the court intervenes and issues a ruling with the objective of maximizing the governments’ joint payoff. Finally, the quality of court rulings increases with experience (cumulative rulings), and this translates into a higher joint disagreement payoff for the governments.

Our model demonstrates that the presence of judicial learning can explain litigation in equilibrium. In most existing models of “bargaining in the shadow of the law,” litigation is explained by informational frictions, either in the form of private information or of inconsistent prior beliefs about the court ruling. Our model, by contrast, generates equilibrium court intervention for a different reason: due to learning by ruling, going to court today may imply payoff gains for the governments tomorrow. Importantly, such payoff gains arise even if governments do not go to court tomorrow, because court learning improves the disagreement point for tomorrow’s bargain (an off-equilibrium effect), and arise even if governments do not have a dispute tomorrow, because court learning improves the policy that Home chooses to avoid a dispute (an “off-off-equilibrium” effect).

To demonstrate how the prospect of judicial learning can give rise to litigation, we first consider a static benchmark setting, and show that in such a setting disputes never go to court in equilibrium. In spite of the lack of rulings, however, the governments’ joint payoff increases with court quality, due to the off- and off-off-equilibrium effects described above. And while increases in court efficiency improve the governments’ joint payoff, we find that, if court efficiency is above a threshold level, further increases in court efficiency must hurt one government and benefit the other. We also find that equilibrium disputes can occur in the static setting, and the likelihood of disputes tends to be higher if the court is less efficient.

We then turn to a dynamic setting, and show that the presence of court learning can give rise to rulings in equilibrium. Furthermore, the probability of rulings is higher – other things equal – if governments are more patient.

A key prediction of our model is that the likelihood of current disputes and rulings decreases with court experience (cumulative rulings) if governments are sufficiently patient; and even if the governments’ patience is low, the likelihood of disputes and rulings decreases with court experience in an average sense. The role played by government patience is due to the fact that an increase in court experience has both a “dynamic effect” and a “static effect” that push in opposite directions. Focusing on the case of rulings, the dynamic effect of an increase in court
experience makes a ruling less likely because the future joint returns from court learning are diminishing, but the static effect pushes in the opposite direction because an increase in DSB quality reduces the inefficiency of going to court today. As we demonstrate, the static effect can dominate the dynamic effect for specific levels of court experience if governments are not very patient, but on average the dynamic effect must dominate.

Our model highlights two forces that push in the direction of diminishing joint returns from court learning. One is not surprising, and arises if learning itself occurs at a diminishing rate. But even if learning occurs at a constant rate, returns from court learning may still be diminishing, and the reason is linked to the off-off-equilibrium effect of court quality that we mentioned above: conditional on a dispute not being initiated, an increase in court quality induces the Home government to select a more efficient policy, and the associated efficiency gain is diminishing due to the concavity of the Pareto frontier.

We also find that neither the frequency of disputes nor the frequency of rulings is a good measure of the effectiveness of the institution: for example, if the frequency of rulings and disputes declines over time, this is a symptom of beneficial learning according to our model, not of a decline in the quality of the institution. It is interesting to note that empirically the frequency of disputes and rulings in the WTO has indeed declined in the last 20 years or so (see Horn et. al., 2011). Our model would suggest an optimistic interpretation of these trends.4

While in our model the likelihood of disputes and rulings tends to be decreasing in cumulative rulings, the settlement rate (likelihood of settlement conditional on a dispute) may go up or down with cumulative rulings, even if governments are patient. This suggests that it would not be appropriate to look for evidence of court learning by examining how cumulative rulings impact the settlement rate: rather, one should look at the impact of cumulative rulings on the unconditional likelihood of rulings and disputes. This will serve as guidance for the empirical work that we present later in the paper.

Our basic two-country model focuses on the case in which court learning is general in scope, in the sense that a ruling today raises the quality of a ruling tomorrow regardless of which country is the defendant tomorrow. But with many countries a range of other possibilities could arise. For example, learning could be defendant-specific or complainant-specific or even

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4And in this regard the interpretation suggested by our model would run counter to Hudec (1993, pp. 11-15), who in the context of the General Agreement on Tariffs and Trade (GATT), the precursor to the WTO, associates a declining use of the GATT dispute settlement system with a decline in the effectiveness of the system as perceived by the member governments.
“directed-dyad-specific” (applying only to future disputes in which the same disputants play the same role in the dispute). We consider these and other possibilities in the context of a many-country extension of our two-country model. This extension is motivated not only by theoretical reasons, but also by the need to make our framework more flexible in view of our empirical analysis. We show in this extended setting that our main results continue to hold, but now the pattern of the impacts of court experience on the likelihood of current rulings is also informative about the scope of court learning.

Finally, we explore the empirical content of our theory using WTO trade dispute data. We focus on a key prediction of the model, namely that the likelihood of current disputes and rulings should tend to decrease with the stock of cumulative past rulings. Our empirical investigation has a dual objective: first, to ask whether the above prediction is consistent with the data; and second, if the answer to this first question is affirmative, to use our model predictions to gauge the empirical importance of learning by ruling and assess its scope and form.

Unlike the existing empirical work on learning by doing for firms, where direct measures of productivity are available (see, for example, Irwin and Klenow, 1994, Clerides et al, 1998, Bernard and Jensen, 1999, Benkard, 2000, Thornton and Thompson, 2001, Kellogg, 2011 and Levitt et al, 2013), we cannot observe directly the quality of the court, so we cannot estimate directly the relationship between court experience and court quality; but we can use the predictions of our model to indirectly gauge the importance of learning by ruling. In particular, our model suggests that a stronger (negative) effect of cumulative rulings on the likelihood of current rulings and disputes signals the presence of stronger court learning. Furthermore, our model suggests a way to gauge empirically the scope of court learning. In a world with many countries and many issue areas, the scope of court learning might be general, or specific to the disputant countries, or specific to the disputed issue area. By exploring how the likelihood of current rulings and disputes is affected by different measures of court experience, e.g. disputant-specific, issue–area-specific, or general-scope experience, we attempt to gauge the relevant domains of court learning, following a similar empirical approach to Kellogg (2011) who looks for evidence of various forms of learning by doing in the context of drilling activity in the oil and gas industry.

Our empirical findings are broadly consistent with our model and suggest that judicial learning in the WTO is significant. Interestingly, we find evidence consistent with issue–area specific learning and with some forms of disputant-specific learning (in particular, complainant-
specific and directed-dyad-specific), while we find only weak evidence of general-scope learning. We then discuss alternative explanations for the correlations we find in the data, and we argue that these alternative explanations cannot fully account for the patterns we find.

To our knowledge this is the first paper that explores the implications of judicial learning for trade disputes, or more generally for international institutions. A related model is Maggi and Staiger (2011), but that paper does not consider learning and does not allow for bargaining or settlement, and focuses on questions of institutional design, while here we focus on how learning affects the initiation and outcome of trade disputes. In Maggi and Staiger (2015) we do allow governments to settle or fight it out in court, but the model is static, and focuses on how the outcome of trade disputes is affected by the form of the contract (property vs liability rules). Other models that generate trade disputes in equilibrium are Park (2011), Beshkar (2016) and Staiger and Sykes (2017), but these papers do not focus on the determinants of dispute outcomes (with the partial exception of Beshkar). Our model is also related to the law-and-economics literature on bargaining in the shadow of the law (e.g. Bebchuck, 1984, Reinganum and Wilde, 1986); these models however are typically static, do not focus on court learning, and are not concerned with international institutions.\(^5\)

By contrast, there is a vast law-and-economics literature on the implications of legal precedent for the evolution of common law, as we have noted. But its emphasis on whether a system of common-law precedent can deliver efficient law under conditions that typify domestic legal settings makes the focus of this literature very different. Among other things, the difference in emphasis accounts for the fact that this literature treats the potential disputants as atomistic, and therefore it is not directly relevant for the large-players setting of WTO disputes.

On the empirical side, there are papers that examine various determinants of the initiation and outcome of trade disputes, including Busch (2000), Busch and Reinhardt (2000, 2006), Guzman and Simmons (2002, 2005), Bown (2005), Davis and Bermeo (2009), Bown and Reynolds (2014), Conconi et al. (2017), Kuenzel (2017) and Maggi and Staiger (2018). But none of these papers are concerned with the dynamics of court learning.

The rest of the paper is organized as follows. Section 2 presents our benchmark static

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\(^5\)Our model also shares some features with the theoretical literature on learning by doing for firms (which includes e.g. Spence, 1981, Cabral and Riordan, 1994, and Besanko et al., 2010), a common feature being that incurring some extra cost today produces efficiency benefits in the future. But the nature of the future benefits is very different across the two settings, and there is no analog in the firm learning-by-doing setting to the off-and off-off-equilibrium effects described above.
Section 3 develops our dynamic model with learning by ruling. Section 4 develops a multi-country version of our model which allows for various forms of learning spillovers. Section 5 examines the empirical content of our theory through WTO dispute data. Section 6 offers concluding remarks. Finally, an Appendix contains several proofs not included in the body of the paper and presents a simple parametrized model that illustrates how the reduced-form assumptions we make in the main model can be “micro founded.”

2. The static model

We consider a partial equilibrium setting of trade between two countries, postponing until a later section the extension to many countries. In the industry under consideration, Home is the importing country and Foreign the exporting country. The Home government can choose an import barrier $T$, while the Foreign government has no export policy in this industry. For concreteness we will interpret $T$ as a tariff, but our analysis is valid also for a more general (possibly multidimensional) policy.

The Home government’s objective function is $\omega(T, s)$, where $s$ is a (possibly multidimensional) “state of the world” that is ex-ante uncertain. Similarly, the Foreign government’s payoff is denoted $\omega^*(T, s)$. We denote the joint government payoff by $\Omega(T, s) \equiv \omega(T, s) + \omega^*(T, s)$. The state of the world $s$ could include political-economy shocks, demand/supply parameters, or the severity of a market failure (e.g. a domestic externality) that calls for a corrective policy.\(^6\)

We assume that the Home government’s payoff $\omega(T, s)$ is strictly concave in $T$, and we denote the Home government’s unilaterally optimal policy conditional on $s$ by $T^N(s) \equiv \arg \max_T \omega(T, s)$. While we do not impose any special structure directly on the Foreign government’s payoff $\omega^*(T, s)$, below we will impose some structure on the government Pareto frontier.

In what follows we describe a simple setting where a choice of $T^N(s)$ by the Home government would be internationally inefficient, and where the Home and Foreign governments have signed a trade agreement to address this inefficiency and have agreed to abide by a dispute settlement agreement.

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\(^6\) There are three reasons we include uncertainty in the model. First, below we will introduce a trade agreement with a court to help settle disputes, and as will become clear, for the court to play a non-trivial role the trade agreement must not be a fully contingent contract, and so there must be some uncertainty in the future state of the world. Second, as will also become clear below, uncertainty in $s$ allows for variation in equilibrium outcomes and non-degenerate probabilities of disputes and court rulings. Third, in the two-period model developed in the next section we will assume a veil of ignorance, and this too requires uncertainty about the future. We also note that our results do not depend on the distribution of $s$, so we do not need to introduce explicit notation for such a distribution.
procedure under which the Foreign government may lodge a complaint with the court against the Home government’s choice of $T$. Under this arrangement, governments may or may not get into a dispute ex post over the setting of $T$; and if they do get into a dispute, they may settle their dispute with negotiations or allow the dispute to proceed to a court ruling. We model these ex-post negotiations as a Nash bargain, with a disagreement point given by the expected court ruling and Home and Foreign bargaining powers given respectively by $\sigma$ and $(1 - \sigma)$ with $\sigma \in [0, 1]$. We assume that if (and only if) governments engage in negotiations, they can use efficient transfers as a means of compensation.

Key to our analysis in this setting is the government ex post (i.e., conditional on $s$) Pareto frontier in payoff space. Consider first the case where transfers are not available. In this case, for any $s$ the Pareto frontier is traced out by varying the Home import barrier $T$ and recording the impacts on $\omega$ and $\omega^*$. We assume that this frontier is strictly concave, as shown in Figure 1. This assumption is satisfied in most models of trade policy, for example in competitive settings where $T$ is a tariff and governments maximize politically-adjusted welfare functions. We will refer to this as the “no-transfer frontier.” Note from Figure 1 that the no-transfer frontier has a peak at the unilaterally optimal policy $T^N(s)$ (point N) and has slope equal to $-1$ at the joint-payoff-maximizing (“first best”) policy $T^{fb}(s) \equiv \arg \max_T \Omega(T, s)$ (point FB).7 Consider next the case in which ex post negotiations occur and hence efficient international transfers are available. In this case, for any $s$ the Pareto frontier is linear with slope $-1$ and tangent to the no-transfer frontier at the FB point as depicted in Figure 1. We refer to this as the “negotiation frontier.” 8

Also key to our analysis is the disagreement point for government ex post negotiations, that is, the expected payoffs from going to court. We do not formalize explicitly the court’s information and decision-making process, nor the specific form of the contract over $T$ that governments sign ex-ante. Rather, we specify in reduced-form fashion the governments’ expected payoffs from triggering a court ruling. We denote these expected payoffs as $\omega^R(s; \lambda)$ for the Home government and $\omega^{*,R}(s; \lambda)$ for the Foreign government. The parameter $\lambda$ captures the

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7To be more precise, the no-transfer frontier does not include the upward sloping part of the curve drawn in Figure 1, because these points are Pareto-dominated by the N point. For this reason this part of the curve is dashed.

8Our assumption that governments have access to efficient transfers when they negotiate to settle a dispute simplifies the model and makes our points more transparent, but our main results would hold under the more realistic assumption that the transfers used for this purpose are costly. Relative to Figure 1, the only change this would imply is that the negotiation frontier would be concave (assuming a convex cost of transfers) but would still lie above the no-transfer frontier except for a tangency at the FB point.
imperfections/inefficiencies of the court system (or equivalently, the inverse of court “quality”); these may include the imperfections of the court’s information and/or the costs of delays associated with court rulings (costs of litigation). To the extent that the court ruling is uncertain from the governments’ point of view when they negotiate, $\omega^R$ and $\omega^sR$ should be interpreted as expectations over the possible rulings. We assume that $\omega^R$ and $\omega^sR$ are differentiable in $\lambda$, and take $\lambda$ to be between zero (perfect court) and some finite bound.\footnote{We are assuming that the policy chosen by Home ($T$) does not impact the disagreement payoffs. While one can think of ways in which $T$ might impact the expected payoffs from going to court in reality, abstracting from such impact seems like a natural simplification.}

The most direct interpretation of a “ruling” in this setting is that the court prescribes a specific value of $T$, but other forms of ruling are also compatible with the model; for example, the court might specify bounds on the policy $T$ (e.g. a tariff binding). What matters for our results is the governments’ expected joint payoff from going to court and how it is impacted by court quality; for this reason, our approach of working directly with the reduced-form expected payoffs $\omega^R(s;\lambda)$ and $\omega^sR(s;\lambda)$ makes the logic of our theory more transparent. As we make clear below, the core restriction of our static model is that the governments’ expected joint payoff from going to court is higher if the court is more efficient; this core assumption seems compatible with a wide variety of institutional/contractual settings.\footnote{Our reduced form approach is consistent with a number of concrete modeling environments where the quality of the court would shape the governments’ disagreement payoffs. One example is where the role of the court is to “complete” an incomplete contract along the lines of Maggi and Staiger (2011). This is an environment where governments cannot write a complete contingent contract, and the court is endowed with the authority to interpret or “fill the gaps” of the contract ex-post. Another contractual/institutional environment that could be captured by our reduced form approach is the one described in Maggi and Staiger (2018), where governments can write a contingent contract but $s$ is imperfectly verifiable, so the court – if invoked – applies the contract based on its imperfect estimate of $s$. In both of these environments, the quality of the court’s information affects the payoffs that governments can expect if they go to court.}

Finally, we assume that negotiations are subject to transaction costs. Note that, if there were no transaction costs, the disagreement point would be irrelevant to the governments’ joint payoff, and hence any institutional or contractual arrangement, as well as court learning, would be irrelevant. For simplicity we assume an “iceberg” negotiation cost: a fraction $1 - \kappa$ of the bargaining surplus “melts” away, so governments can only move part-way toward the Pareto frontier when they negotiate. A simple interpretation is that $1 - \kappa$ represents the probability that the negotiation will break down for some exogenous reason, so that the dispute will go directly to the court.\footnote{We have also considered the case of fixed bargaining costs, which seems a natural alternative to the assumption of iceberg negotiation costs. Our main qualitative results can be shown to hold also with fixed bargaining costs.} Formally, if $\omega^B(s;\lambda)$ and $\omega^sB(s;\lambda)$ are the governments’ bargaining
payoffs absent negotiation costs, the net payoffs from the bargain are

\[
\omega^{\text{B}_\text{net}}(s; \lambda) = \omega^R(s; \lambda) + \kappa[\omega^B(s; \lambda) - \omega^R(s; \lambda)], \quad (2.1)
\]

\[
\omega^{\ast\text{B}_\text{net}}(s; \lambda) = \omega^{\ast\text{R}}(s; \lambda) + \kappa[\omega^{\ast\text{B}}(s; \lambda) - \omega^{\ast\text{R}}(s; \lambda)]. \quad (2.2)
\]

For future reference, we let \( \Omega^{fb} \) denote the first-best joint payoff and \( \Omega^R \) denote the joint disagreement payoff. Noting that the joint bargaining payoff absent negotiation costs is \( \Omega^{fb} \), we can write the joint net bargaining payoff as \( \Omega^{B_{\text{net}}}(s; \lambda) = \kappa \Omega^{fb}(s) + (1 - \kappa) \Omega^R(s; \lambda) \).

We now outline the timing of the static game: (1) After the state of the world \( s \) is realized and observed by governments, Home chooses \( T \); (2) Foreign acquiesces or initiates a dispute; (3) If a dispute is initiated, governments Nash bargain over \( T \) and a transfer; (4) If governments disagree, the court intervenes and issues a ruling (which is automatically enforced).\footnote{Notice that in our model engaging in a “dispute” is synonymous with “bargaining in the shadow of the law.” In the context of the WTO, the first step of a trade dispute is indeed that governments engage in consultations and negotiation (in fact this step is mandatory according to WTO rules). However it is important to note that in practice governments may negotiate outside the institutional framework, through informal negotiations. Our model can be interpreted as applying to both formal and informal negotiations.}

In Appendix A we present a more structured model that is a special case of the environment just described. That model focuses on a standard competitive partial-equilibrium setting where the Home government maximizes a politically-adjusted welfare function that attaches an extra weight to import-competing producers. There, the state of the world \( s \) is simply the Home political-economy-shock parameter and the policy \( T \) is a tariff. The trade agreement is an incomplete contract that does not specify the exact tariff, and the court can “complete” the incomplete contract by estimating the first-best tariff \( T^{fb}(s) \) (if invoked), but does so with noise. This noise represents the key imperfection in the court system, corresponding to the \( \lambda \) parameter in the reduced-form model we present here.

We will conduct much of the analysis at a graphical level, since this will aid intuition. We start by fixing a level of court quality \( \lambda > 0 \) and a state \( s \) and identifying the disagreement point and the equilibrium bargaining payoffs for the government negotiation (stage 3). In Figure 1, point \( R \) indicates the expected payoffs from triggering a court ruling, \( (\omega^R, \omega^{\ast R}) \), point \( B \) indicates the bargaining payoffs absent negotiation costs, \( (\omega^B, \omega^{\ast B}) \), and point \( B_{\text{net}} \) indicates the net bargaining payoffs \( (\omega^{B_{\text{net}}}, \omega^{\ast B_{\text{net}}}) \). We omit the arguments \( s \) and \( \lambda \) from the labels in this figure, as this should not cause confusion. We depict \( R \) as residing below the no-transfer frontier in Figure 1; this implicitly assumes that the court ruling does not dictate that transfers...
take place.\footnote{In reality rulings by the WTO-DSB may involve the possibility of compensation. We are abstracting from this possibility in order to simplify the analysis.} Point \( B \) is the projection of point \( R \) onto the negotiation frontier, with this projection reflecting the bargaining power parameter \( \sigma \). And finally, the point \( B_{\text{net}} \) is a linear combination of point \( R \) and point \( B \), with the exact location determined by the negotiation cost parameter \( \kappa \).

Moving backwards in our game, we can now ask: Knowing that the dispute subgame would yield payoffs \( B_{\text{net}} \), what policy does Home choose at stage 1 and what action will Foreign take at stage 2? The answer follows from two observations. First, if the \( B_{\text{net}} \) point is above the no-transfer frontier as in the higher of the two \( B_{\text{net}} \) points pictured in Figure 1 – which will be the case if \( \kappa \) is sufficiently close to 1 (i.e. negotiation costs are sufficiently small) – Home will trigger a dispute by choosing a level of \( T \) that induces Foreign to complain, the governments will settle, and the equilibrium payoffs are given by the point \( B_{\text{net}} \). In this case there is a dispute but no ruling. And second, if the \( B_{\text{net}} \) point is below the no-transfer frontier as in the lower of the two \( B_{\text{net}} \) points pictured in Figure 1 – which will be the case if \( \kappa \) is sufficiently close to 0 – Home chooses the policy \( T \) that maximizes its payoff while keeping Foreign indifferent between complaining and not. Graphically, this corresponds to the vertical projection of \( B_{\text{net}} \) onto the no-transfer frontier, which we label \( B^0 \) in Figure 1. In this case, there is not even a dispute, let alone a ruling.\footnote{To be precise, if the \( B_{\text{net}} \) point lies to the left of the \( N \) point (the unilateral optimum), then the equilibrium payoff point \( B^0 \) is not the vertical projection of \( B_{\text{net}} \) onto the no-transfer frontier, but rather the \( N \) point itself. But this does not change anything of substance in our analysis.} It is intuitive, then, and straightforward to show, that for given \( s \) and \( \lambda \) a dispute will occur in the static model if and only if \( \kappa \) is above some threshold level \( \hat{\kappa}(s, \lambda) \); and it is clear that there is never a ruling in equilibrium. Summarizing:

**Proposition 1.** In the static setting, there is a dispute if and only if \( \kappa > \hat{\kappa}(s, \lambda) \), and there is never a ruling in equilibrium.

We next consider the impact of court quality \( \lambda \) on the governments’ equilibrium payoffs. This will be a key ingredient for the dynamic analysis of the next section.

Our core assumption is that decreasing \( \lambda \) leads to a higher joint disagreement payoff \( \Omega^R \) for each state \( s \). This assumption can be motivated under the interpretation that the court is attempting with its ruling to maximize the governments’ joint payoff, and a higher-quality
court is better at achieving this objective. To keep our analysis focused on the main points, we also make two technical assumptions whose specific roles will become clear below: first, a perfect court implements the first best outcome, that is \( \Omega^R(s; 0) = \Omega^{fb}(s) \); and second, Foreign’s disagreement payoff is at no point insensitive to court quality, that is \( \frac{d\omega^R}{d\lambda} \neq 0 \) for all \( \lambda \). We summarize these restrictions in:

**Assumption 1:** (i) \( \Omega^R(s; \lambda) \) is strictly decreasing in \( \lambda \); (ii) \( \Omega^R(s; 0) = \Omega^{fb}(s) \); (iii) \( \frac{d\omega^R}{d\lambda} \neq 0 \) for all \( \lambda \).

It is worth pointing out that Assumption 1 allows for the possibility that increasing court efficiency (decreasing \( \lambda \)) might decrease the disagreement payoff of one of the governments, while increasing the joint disagreement payoff. While it might seem natural that both governments should gain from greater court efficiency, it is straightforward to show that in some standard settings this is not the case, and so the generality provided by Assumption 1 in this regard is relevant.

Recalling that \( \omega^R(s; \lambda) \) and \( \omega^*R(s; \lambda) \) are represented for a fixed \( \lambda \) and \( s \) as the point \( R \) in Figure 1, in Figure 2 we depict the locus traced by the disagreement point \( R \) as \( \lambda \) varies, which we label \( R^\lambda \) (as before, we omit the argument \( s \) from the label to keep the notation simple). Note that Assumption 1 allows the \( R^\lambda \) locus to be upward or downward sloping; Figure 2 depicts the case in which the \( R^\lambda \) locus is downward sloping, but the analysis is similar if this locus is upward sloping. Also note that Assumption 1(ii) implies that the \( R^\lambda \) locus emanates from point \( FB \), while Assumption 1(iii) implies that the \( R^\lambda \) locus cannot be backward bending. The significance of this last property will become clear below.

We now turn to the impact of court quality (\( \lambda \)) on the net bargaining payoffs in the dispute subgame \( \omega^{B_{net}}(s; \lambda) \) and \( \omega^{*B_{net}}(s; \lambda) \) (which for fixed \( \lambda \) and \( s \) we represented by the \( B_{net} \) point in Figure 1). In Figure 2 we label \( B^\lambda_{net} \) the locus traced by the \( B_{net} \) point as \( \lambda \) varies. Since the \( B_{net} \) point is a linear combination of the \( R \) point and the \( B \) point in Figure 1, it is immediate

\(^{15}\)The interpretation that the court is attempting with its ruling to maximize the governments’ joint payoff seems a natural one in this setting. The idea is that governments design the institution at some ex-ante stage and endow the court with a certain objective function. As long as efficient international transfers are available at this ex-ante stage, which according to our model is the case whenever governments negotiate, and which in reality seems especially likely for ex-ante negotiations of the kind we are considering here (as distinct from the ex-post negotiations which are the topic of note 8), it is natural to suppose that this objective function is the governments’ joint payoff.

\(^{16}\)For example, in the special model we present in Appendix A, a decrease in court efficiency takes the form of a noisier ruling, and this benefits the exporting country because its payoff is convex in the tariff.
that the $B^\lambda_{\text{net}}$ locus in Figure 2 inherits two properties from the $R^\lambda$ locus: (a) it coincides with the $FB$ point for $\lambda = 0$, and (b) the joint payoff $\Omega^{B_{\text{net}}}(s; \lambda)$ is strictly decreasing in $\lambda$. Moreover, this second property implies that the $B^\lambda_{\text{net}}$ locus hits the $FB$ point with slope different than $-1$, and thus a third property of the $B^\lambda_{\text{net}}$ locus is that (c) when $\lambda$ is small enough, the $B^\lambda_{\text{net}}$ locus lies below the no-transfer frontier (and it may or may not cross the frontier as $\lambda$ increases).

Finally, we ask whether the $B^\lambda_{\text{net}}$ locus also inherits the property of the $R^\lambda$ locus that it cannot be backward bending. As we show in Appendix B, this is always the case if the $R^\lambda$ locus is downward sloping (as is the case for example in the special model presented in Appendix A); and if the $R^\lambda$ locus is upward sloping, this is the case provided that either the negotiation cost or Home’s bargaining power is high enough. In what follows we assume that the $B^\lambda_{\text{net}}$ locus is not backward bending, and we comment below on the qualifications to our results that would arise if this condition were not satisfied (see note 17).

We can now back up to stage 1 and examine how $\lambda$ affects the equilibrium joint payoff in the full game, which we denote by $\Omega^e(s; \lambda)$. We will argue that $\Omega^e(s; \lambda)$ is decreasing in $\lambda$. To see this recall that, if the $B_{\text{net}}$ point is below the no-transfer frontier (so that there is no dispute), the equilibrium point is the vertical projection of the $B_{\text{net}}$ point onto the no-transfer frontier, and if the $B_{\text{net}}$ point is above the no-transfer frontier (so that there is a dispute), the equilibrium point is the $B_{\text{net}}$ point itself. It follows that, as $\lambda$ increases from zero, the equilibrium point starts from the $FB$ point and moves along the outer envelope of the no-transfer frontier and the $B^\lambda_{\text{net}}$ locus, with the resulting locus depicted by the red curve in Figure 2. To confirm that $\Omega^e(s; \lambda)$ is decreasing in $\lambda$, focus first on a range of $\lambda$ such that the equilibrium point is on the no-transfer frontier: as $\lambda$ increases, the equilibrium point moves away from the $FB$ point along the frontier, and hence $\Omega^e(s; \lambda)$ decreases. Next focus on a range of $\lambda$ such that the equilibrium point is on the $B^\lambda_{\text{net}}$ locus. Recalling that $\Omega^{B_{\text{net}}}$ decreases with $\lambda$, it follows again that increasing $\lambda$ will decrease $\Omega^e(s; \lambda)$. We can thus state:

\[ \text{(17)} \]
\[ \text{This is where our assumption that the } B^\lambda_{\text{net}} \text{ locus is not backward bending comes in: if this locus were backward bending, this could induce “oscillating” movements of the equilibrium point – first moving away from the } FB \text{ point along the frontier, and then moving back toward the } FB \text{ along the frontier – over some range of } \lambda \text{ as } \lambda \text{ increases. It is easy to show, however, that even if } B^\lambda_{\text{net}} \text{ locus were backward bending, all of our results would still hold provided } \lambda \text{ is below some critical threshold.} \]

\[ \text{(18)} \]
\[ \text{We note that, if the negotiation cost were modeled as a fixed cost rather than an iceberg cost, the only change in results would be that the equilibrium joint payoff is weakly increasing in court quality, and in particular, it is constant in the dispute region and strictly decreasing in no-dispute region. All our remaining results would not be affected.} \]
Proposition 2. In the static setting, the equilibrium joint payoff is increasing in court quality, even though there is no ruling in equilibrium. This results from two effects: (i) if there is a dispute and governments settle, higher court quality improves the disagreement point, and this leads to a better bargaining outcome (an “off-equilibrium” effect); (ii) if there is no dispute, higher court quality improves the would-be bargaining outcome, thus inducing Home to choose a more efficient policy (an “off-off-equilibrium” effect).

A further implication of the model is also noteworthy, and can be understood in terms of Figure 2. Note that for $\lambda$ sufficiently low, further reductions in $\lambda$ must hurt one of the governments, because the equilibrium point slides along the no-transfer frontier. Interestingly, this is the case even if reductions in $\lambda$ do not affect the countries’ relative bargaining positions, that is, even if the $R^{\lambda}$ locus is increasing with slope equal to one. We record this implication in:

Remark 1. If court quality is above some threshold level, further improvements in court quality must hurt one of the governments (and benefit the other).

Finally, the model also yields a prediction on how court quality affects the likelihood of a dispute, under one additional regularity condition. Suppose the $B^{\lambda}_{\text{net}}$ locus crosses the no-transfer frontier at most once.\(^{19}\) Then, recalling that the $B^{\lambda}_{\text{net}}$ locus must lie below the no-transfer frontier if $\lambda$ is sufficiently close to zero, it follows that it can only cross the no-transfer frontier from below. Thus, for a given state $s$, there is a low interval of $\lambda$ such that there is no dispute, and there may be a high interval of $\lambda$ such that there is a dispute (the latter interval may be empty). This implies that, for any distribution of $s$, the likelihood of a dispute is increasing in $\lambda$. We summarize with:

Proposition 3. In the static setting, the likelihood of a dispute decreases in court quality, provided the $B^{\lambda}_{\text{net}}$ locus crosses the no-transfer frontier at most once.

To summarize the main points of this section, in the static setting disputes never go to court in equilibrium (Proposition 1), but nevertheless the governments’ joint payoff increases with court quality, due to the off- and off-off-equilibrium effects identified in Proposition 2.

\(^{19}\)Note that this will be the case if the $B^{\lambda}_{\text{net}}$ locus is convex, linear or not too concave. For example, in the Appendix A model the $B^{\lambda}_{\text{net}}$ locus is linear.
Disputes, on the other hand, can occur in equilibrium and tend to be more likely when the court is less efficient (Proposition 3). These static results will play an important role in the analysis of the dynamic setting, which we develop in the next section.

3. Learning By Ruling

As we observed in the Introduction, the WTO is a relatively young international institution characterized by a fairly sophisticated judicial system in the form of the DSB. The adjudication process that this judicial system is designed to conduct is complex and subtle, and there is little doubt that the actors involved in this system have much to learn along many dimensions, especially in the early stages of the institution. In this section we extend the static model of the previous section to a dynamic setting, and explore the implications of judicial learning for the dynamics of disputes and rulings. We introduce a notion of learning by ruling into the static model with the assumption that the court quality parameter $\lambda$ is a weakly decreasing function of the stock of prior court rulings (court experience).

We have already described the kinds of court learning that can be captured by our model. But what kinds of learning fall outside our model? One type of learning that is probably relevant in the WTO is governments’ learning about the court. For example, it is possible that as governments litigate repeatedly, they learn how the court operates and adjudicates cases, and therefore they learn to better predict the outcome of a ruling. Another type of learning that falls outside our formal model is governments’ learning about each other. In principle this type of learning could reduce asymmetric information between bargainers. Our modeling approach abstracts from these learning possibilities, but we will come back to them in the empirical section, when we discuss alternative mechanisms that might explain our empirical findings.

We consider two periods, $t = 1, 2$. In each period, the same game as described in the static setting takes place. The state of the world $s$ is iid, so learning by ruling will be the only source of dynamics. The governments’ common discount factor is $\delta \in (0, \infty)$.\(^{20}\)

In order to examine how past rulings affect current outcomes, we suppose that at $t = 1$ there is an initial stock of rulings (court experience) $x$ inherited from a “past” period $t = 0$. We model learning by ruling in a fashion similar to the typical models of learning by doing for firms, where a firm’s efficiency increases with the firms’ cumulative output: we assume that

\(^{20}\)Since we have only two periods, it is natural to allow $\delta$ to be higher than one, as the second period can be thought of as condensing a potentially long future.
the efficiency of the court increases with cumulative rulings. Formally, as we noted above, we model learning by ruling as a weakly decreasing function $\lambda(x)$.

We let $\lim_{x \to \infty} \lambda(x) \equiv \bar{\lambda} \geq 0$ (this limit clearly exists given that $\lambda(x)$ is decreasing and bounded below by zero). To simplify our formal arguments, we assume that $\bar{\lambda}$ is reached for some finite level of $x$, that is, there exists a large enough $\bar{x}$ such that $\lambda(\bar{x}) = \bar{\lambda}$ and learning is exhausted.\(^{21}\)

Finally, we assume a veil of ignorance: before the period-2 state of the world is realized, each government is equally likely to be the importer or the exporter, and hence is equally likely to be the complainant or the defendant in a dispute. The essence of the veil of ignorance is that in the future each government may find itself on either side of a trade dispute, that of complainant or that of defendant.

We start with a key observation: in contrast with the static setting, where no rulings can occur in equilibrium, the presence of learning by ruling can give rise to equilibrium rulings, because going to court today and generating a ruling delivers future payoff gains.

To establish this, we proceed by backward induction. At $t = 2$ the outcome is the same as in the static setting analyzed above, and hence there are no rulings in equilibrium at $t = 2$. But the situation is different at $t = 1$, because going to court and generating a ruling delivers payoff gains at $t = 2$ due to the learning effect. We next analyze under what conditions a ruling occurs in equilibrium at $t = 1$; we will not use a time index, as this should not cause confusion.

Recall that in the static setting, under Assumption 1, the equilibrium joint payoff is decreasing in $\lambda$. Thus, given the veil of ignorance, going to court at $t = 1$ implies a common future payoff gain for the two governments, which we denote by $\Delta$. Since a ruling at $t = 1$ changes the value of $\lambda$ at $t = 2$ from $\lambda(x)$ to $\lambda(x + 1)$, we can write this future payoff gain as

$$\Delta(x) = E_s[\Omega^e(s; \lambda(x + 1)) - \Omega^e(s; \lambda(x))]. \quad (3.1)$$

It is worth emphasizing that, much as in the static model, here governments benefit from higher future court efficiency through off-equilibrium mechanisms, because at $t = 2$ there is no court activity in equilibrium: making the court more efficient improves the disagreement point in case of dispute, and even if no dispute takes place, improving the would-be negotiation outcome leads to a more efficient policy choice by Home. But in a richer model with more than one period

\(^{21}\)Note that we allow $\bar{\lambda}$ to be zero or strictly positive; that is, once learning is exhausted the court may or may not be able to implement the first-best outcome.
ahead of \( t = 1 \), the payoff gain \( \Delta \) would include as well the direct effect of increasing court efficiency in case a ruling occurs in equilibrium.

At \( t = 1 \), the disagreement payoffs for Home and Foreign are now respectively given by \( \omega^{R} + \delta \Delta \) and \( \omega^{*R} + \delta \Delta \) (we omit the arguments \( s \) and \( x \) for simplicity), that is, the expected payoff from a court ruling in the current period plus the discounted future payoff gain. Graphically, in Figure 3 we label as \( R + \delta \Delta \) the corresponding disagreement payoff point. This point lies somewhere on the 45\(^{0}\) line emanating from point \( R \), and in general may be below or above the negotiation frontier. If point \( R + \delta \Delta \) is above the negotiation frontier (which is the case illustrated in Figure 3a), then a dispute will end in ruling; and going backwards, in this case Home chooses a policy \( T \) that triggers a complaint by Foreign.\(^{22}\)

Note from Figure 3 that a ruling occurs if and only if the distance between the \( R \) point and the negotiation frontier along a 45\(^{0}\) line is less than \( \delta \Delta \), or equivalently, if

\[
\Omega^{R}(s) - \Omega^{R}(s; \lambda(x)) < \delta \Delta(x). \tag{3.2}
\]

Given \( s \) and \( x \), (3.2) defines the ruling condition for our dynamic model. This condition is satisfied if \( \delta \) is above some threshold, therefore for any distribution of \( s \) the probability of a ruling (as viewed from the beginning of period \( t = 1 \), before \( s \) is realized) is increasing in \( \delta \). We may therefore state:

**Proposition 4.** Given \( x \), the probability of a ruling at \( t = 1 \) is increasing in \( \delta \) (and is equal to zero if \( \delta = 0 \)).

This result makes clear that in our dynamic model rulings can happen in equilibrium, and the likelihood of rulings is higher when governments care more about the future.

Next we examine how court experience \( x \) affects the likelihood of a ruling at \( t = 1 \). In what follows, we assume that learning occurs at a diminishing rate when evaluated in terms of its effect on disagreement payoffs:

**Assumption 2:** Increases in court experience have weakly diminishing marginal impact on disagreement payoffs: \( \left| \frac{d\omega^{R}(s, \lambda(x))}{dx} \right| \) and \( \left| \frac{d\omega^{*R}(s, \lambda(x))}{dx} \right| \) are weakly decreasing in \( x \) (for any \( s \)).

\(^{22}\)It is now easy to understand the role played in our model by the veil of ignorance. If we removed the veil of ignorance, the main change would be that the probability of a ruling could be lower, other things equal. The reason lies in Remark 1: while an increase in court quality increases the equilibrium joint payoff, when \( \lambda \) is sufficiently small it must hurt one of the governments. When this is the case, it would take a higher \( \delta \) for the disagreement point at \( t = 1 \) to be above the negotiation frontier.
To help interpret this assumption, note that the units of measure of court quality can be defined in an arbitrary (ordinal) way, so for a notion of diminishing rate of learning to be invariant to the units of measure, it needs to be stated in payoff terms.\(^{23}\)

Let us now examine how \(x\) affects the condition for equilibrium rulings (3.2). First note that the left-hand side of this condition, \(\Omega^H(s) - \Omega^R(s; \lambda(x))\), decreases with \(x\) – because the joint disagreement payoff \(\Omega^R\) is increasing in court quality and hence in \(x\) – and this makes a ruling more likely. This is the static effect of court experience on the likelihood of a ruling: holding \(\Delta\) fixed, increasing \(x\) decreases today’s inefficiency from going to court, thus increasing the likelihood of a ruling.

Now focus on the dynamic effect of court experience, that is the effect of \(x\) on \(\Delta\) and hence on the right-hand side of (3.2). From (3.1) it is clear that \(\Delta\) is decreasing in \(x\) if \(E_s \Omega^c\) is concave in \(x\). Recall from the static analysis and Figure 2 that, as \(x\) increases, and hence \(\lambda\) decreases, the equilibrium payoff point moves along the outer envelope of the \(B^\lambda_{net}\) locus (dispute range) and the no-transfer frontier (no-dispute range). It is easy to show that, given Assumption 2, the equilibrium joint payoff \(\Omega^c\) is strictly concave in \(x\) over the no-dispute range for any \(s\).\(^{24}\) Intuitively, this is so for two reasons: first, learning occurs at a diminishing rate; and second, conditional on there being no dispute, an increase in court quality induces the Home government to select a more efficient policy, and the associated efficiency gain is diminishing due to the concavity of the no-transfer frontier.

This last point bears emphasis. The concavity of the no-transfer Pareto frontier is a key force behind the diminishing impact of court experience \(x\) on the future joint payoff, and this in turn is related to the off-off-equilibrium impacts of court quality identified in Proposition 2: conditional on there being no dispute, an increase in court quality induces the Home government to select a more efficient policy, and the associated efficiency gain is diminishing due to the concavity of the frontier.\(^{25}\) Indeed, even if Assumption 2 is not satisfied, \(\Omega^c\) may be concave in \(x\) due to the

\(^{23}\)Recall that we allow court quality \(\lambda\) – and hence court experience \(x\) – to have opposite impacts on the two governments’ payoffs, and for this reason we state Assumption 2 in terms of “diminishing marginal impact,” rather than concavity in \(x\): we need each payoff function to be concave (convex) in \(x\) if it is increasing (decreasing) in \(x\).

\(^{24}\)To see this, first note that Assumption 2 ensures that \(x\) has diminishing marginal impact on \(\omega^{*B_{net}}\), since by (2.2) this is linear in \(\omega^{*R}\) and \(\Omega^H\), and the latter does not depend on \(x\). Next recall from Figure 1 that in the no-dispute range the equilibrium point is the vertical projection of the \(B_{net}\) point onto the no-transfer frontier: letting \(\omega = F(\omega^*)\) denote the no-transfer frontier, it then follows that the joint payoff in the no-dispute range is given by \(\omega^{*B_{net}} + F(\omega^{*B_{net}})\). It is easy to show that this is concave in \(x\), given that \(x\) has diminishing marginal impact on \(\omega^{*B_{net}}\).

\(^{25}\)As described in note 24, letting \(\omega = F(\omega^*)\) denote the no-transfer frontier, the joint payoff in the no-dispute
concavity of the frontier.

Next note that, in light of the strict concavity of $\Omega^e$ in $x$ over the no-dispute range for any $s$, the expected joint payoff $E_s\Omega^e$ is guaranteed to be concave in $x$ if the probability of an equilibrium dispute at $t = 2$ is sufficiently small. Given that in reality the average frequency with which trade disputes arise between two given governments is quite low (and that this is true even accounting for informal disputes that occur outside the formal WTO procedures), it seems reasonable to restrict attention to parameter constellations that imply a small probability of equilibrium disputes. We therefore impose:

Assumption 3: The probability of an equilibrium dispute at $t = 2$ is sufficiently small.

Under Assumptions 2 and 3, the expected future joint payoff $E_s\Omega^e(s; \lambda(x))$ is concave in $x$, and hence an increase in $x$ reduces $\Delta$ (dynamic effect): this dynamic effect makes the ruling condition in (3.2) less likely to be satisfied, and therefore makes a ruling less likely.

Recalling now that an increase in $x$ also reduces $\Omega^{fb}(s) - \Omega^R(s; \lambda(x))$, the current inefficiency from going to court (static effect), and through this static effect makes a ruling more likely, it is apparent that the static effect pushes one way and the dynamic effect pushes the other. But clearly, if $\delta$ is sufficiently large the dynamic effect dominates the static effect. Since this is true for any $s$, it follows that if $\delta$ is sufficiently large then for any distribution of $s$ the probability of a ruling decreases with $x$.

Next notice that, regardless of $\delta$, the likelihood of a ruling must reach zero as $x$ reaches $\bar{x}$, and therefore the marginal impact of $x$ on the likelihood of a ruling on average must be negative. More formally, let $\pi_R(x)$ denote the probability of a ruling at $t = 1$ as a function of $x$, and suppose $\pi_R(0) > 0$. Then clearly $\pi_R(\bar{x}) = 0 < \pi_R(0)$, and hence we can write $\frac{1}{2} \int_0^\delta \pi_R'(x) dx < 0$.

The next proposition summarizes:

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range is given by $\omega^{sBnet} + F(\omega^{sBnet})$, and this is more likely to be concave in $x$ if the no-transfer frontier is more concave.

In our model the probability of an equilibrium dispute at $t = 2$ will be small if, for example, both governments benefit from a more efficient court and the negotiation cost is high; in that case, for each state $s$ the $R$ point lies southwest of the $FB$ point and the $B_{net}$ point is close to the $R$ point, so the probability of equilibrium disputes at $t = 2$ – that is, the probability that the $B_{net}$ point is above the no-transfer frontier – will be small (and may be zero).

While Assumptions 2 and 3 suffice for our result, we note that our model abstracts from a factor that is arguably empirically relevant and would contribute toward the concavity of $E_s\Omega^e$ in $x$. As observed in note 8, if we introduced the assumption of a convex cost of transfers in the context of dispute settlement negotiations, then the negotiation frontier would be concave, and this would be a force toward concavity of $E_s\Omega^e$ in $x$. 

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Proposition 5. (i) If $\delta$ is sufficiently high, the probability of a ruling at $t = 1$ is decreasing in $x$ for all $x$. (ii) Regardless of $\delta$, increases in $x$ reduce the probability of a ruling at $t = 1$ on average.

As Proposition 5 indicates, in our model there is a clear tendency for the probability of a ruling to decrease with court experience: if $\delta$ is sufficiently high, the probability of a ruling is decreasing in $x$ for any $x$; and regardless of $\delta$, this inverse relationship must hold on average provided only that the potential for learning is eventually exhausted. This latter result relies only on the basic feature of the model that equilibrium rulings can occur only if there is potential for further judicial learning.\textsuperscript{28}

Next we consider the impact of court experience $x$ on the probability of a dispute at $t = 1$. Let us first ask: what is the outcome at $t = 1$ if the disagreement point $R + \delta \Delta$ is below the negotiation frontier, as in Figure 3b, so that there is no ruling? In this case, the net bargaining payoffs at $t = 1$, which we denote $(\omega^{B}_{\text{net}}, \omega^{*B}_{\text{net}})$, can be written as follows (omitting the arguments $s$ and $x$ for simplicity):

\begin{align*}
\omega^{B}_{\text{net}} &= \kappa \omega^{B} + (1 - \kappa)(\omega^{R} + \delta \Delta) \\
\omega^{*B}_{\text{net}} &= \kappa \omega^{*B} + (1 - \kappa)(\omega^{*R} + \delta \Delta).
\end{align*}

Graphically, in Figure 3b we label $B^{\Delta}_{\text{net}}$ the point corresponding to payoffs $(\omega^{B}_{\text{net}}, \omega^{*B}_{\text{net}})$. Because of the negotiation cost ($\kappa$), point $B^{\Delta}_{\text{net}}$ lies somewhere between the disagreement point $R + \delta \Delta$ and the negotiation frontier. It is then easy to argue that the outcome is a dispute with settlement if $B^{\Delta}_{\text{net}}$ is above the no-transfer frontier (as depicted by the higher $B^{\Delta}_{\text{net}}$ point displayed in Figure 3b), and the outcome is no dispute if $B^{\Delta}_{\text{net}}$ is below the no-transfer frontier (as depicted by the lower $B^{\Delta}_{\text{net}}$ point displayed in Figure 3b).

Armed with the above observation, we can establish that a similar result as Proposition 5(i) holds also for disputes. As was the case for rulings, increasing $x$ has two effects on the likelihood of disputes at $t = 1$, a static effect (through $\omega^{R}$, $\omega^{*R}$, $\omega^{B}$ and $\omega^{*B}$) and a dynamic effect (a reduction in $\Delta$). If $\delta$ is sufficiently high, the dynamic effect dominates the static one,\textsuperscript{28}

\textsuperscript{28}As a matter of empirical interpretation, this latter result suggests that, in a world with many disputants, on average the probability of rulings should tend to decrease with court experience, in the following sense. Consider a world with many country dyads or issue areas, where court learning may be specific to the country dyad and/or the issue area, and suppose the level of court experience $x$ is heterogeneous across these country dyads and issue areas. Then according to this result, the impact of $x$ on the probability of rulings on average should be negative, regardless of the discount factors of the disputants.
so we can focus on the former. How does a reduction in $\Delta$ affect the likelihood of a dispute at $t = 1$? It is clear from (3.3) that, holding all else equal, decreasing $\Delta$ reduces $\omega^{B^\Delta_{net}}$ and $\omega^{*B^\Delta_{net}}$ by an equal amount, or in graphical terms and using Figure 3b, the $B^\Delta_{net}$ point shifts inwards along a 45 degree line. This implies that, for any given $s$, the $B^\Delta_{net}$ point can cross the no-transfer frontier only from above, not from below; and as a result the equilibrium outcome can only switch from dispute to no-dispute, but not vice-versa. We can then conclude that, for any distribution of $s$, increasing $x$ reduces the likelihood of a dispute at $t = 1$.

Finally, a similar result as Proposition 5(ii) holds also for disputes, under the regularity condition that the $B^\lambda_{net}$ locus crosses the no-transfer frontier at most once. To show this we will argue, as we did above for the case of rulings, that the likelihood of a dispute for $x = 0$ is higher than for $x = \bar{x}$. For this purpose it is useful to return to Figure 2. First note that the $B^\Delta_{net}$ point (not pictured in Figure 2) must be (weakly) above the $B^\lambda_{net}$ locus. Next note that, if we increase $x$ from zero to $\bar{x}$, we are reducing $\Delta$ to zero (dynamic effect) and reducing $\lambda$ to its minimum level $\bar{\lambda} \geq 0$ (static effect). How do these two changes affect the position of the $B^\Delta_{net}$ point? Reducing $\Delta$ to zero shifts the $B^\Delta_{net}$ point inward along a 45° line until it hits the $B^\lambda_{net}$ locus; and reducing $\lambda$ causes the $B^\Delta_{net}$ point to travel along the $B^\lambda_{net}$ locus toward the $FB$ point. It is then easy to see that, if the $B^\lambda_{net}$ locus crosses the no-transfer frontier at most once, the $B^\Delta_{net}$ point can only cross the no-transfer frontier from above, not from below. And since this is true for any given $s$, we can conclude that increasing $x$ from zero to $\bar{x}$ reduces the likelihood of a dispute at $t = 1$. Hence we have:

**Proposition 6.** (i) If $\delta$ is sufficiently high, the probability of a dispute at $t = 1$ is decreasing in $x$ for all $x$. (ii) Regardless of $\delta$, increases in $x$ reduce the probability of a dispute at $t = 1$ on average, provided the $B^\lambda_{net}$ locus crosses the no-transfer frontier at most once.

Before continuing, it is worth emphasizing an important implication of Propositions 5 and 6: the frequency of disputes and rulings is not a reliable indicator of the effectiveness of the institution. For example, according to these propositions a declining frequency of rulings or disputes does not imply that the institution is getting worse over time, in fact it is a symptom of beneficial learning by the institution. As mentioned in the Introduction, our model therefore suggests an optimistic interpretation for the observed declining trends in the frequency of rulings and disputes over the life of the WTO.

But it also bears emphasis that this interpretation concerns the change in ruling frequency.
over time. A higher level of the ruling frequency, on the other hand, is associated with higher
court efficiency according to our model. To make this point in the simplest way, suppose we
shift down the schedule $\lambda(x)$ in such a way that $\Delta$ is not affected (or more generally, in such
a way that the static effect of the change in $\lambda(x)$ dominates its dynamic effect): then for any
given $s$ the disagreement point $R + \delta \Delta$ can only cross the negotiation frontier from below, not
from above, so the probability of a ruling increases.

Our final point of this section is that the model does not yield sharp predictions regarding
the conditional likelihood of settlement:

**Remark 2.** At $t = 1$ the likelihood of settlement conditional on a dispute may go up or down
with $x$, even if $\delta$ is high.

The reason for this ambiguity is that the effect of an increase in $x$ on the probability of a ruling
may be stronger or weaker than its effect on the probability of a dispute, depending on the
exact distribution of $s$, and thus the ratio between the two probabilities can increase or decrease
with $x$.\(^\text{29}\)

According to Remark 2, it would be a mistake to look for evidence of court learning by
examining how the conditional likelihood of rulings is impacted by cumulative rulings. Rather,
according to our theory, court learning effects should show up most strongly in the impacts of
cumulative rulings on the unconditional likelihood of a ruling and of a dispute. This serves as
an important guide for the empirical work that we present later in the paper.

### 4. The scope of learning

Thus far we have assumed that court learning is general in scope, in the sense that issuing a
ruling today increases the court’s future efficiency regardless of which country is the defendant
in the future. But one could consider more narrow forms of learning. For example, learning
might be specific to the directionality of the dispute (“directed-dyad specific”), meaning that
a ruling where country $i$ is the complainant and $j$ the defendant increases the court’s future

\(^{29}\)To see this more formally, consider a realization $s = s'$ such that $R + \delta \Delta$ is just above the negotiation frontier. As $x$ increases, $\Delta$ decreases and hence for $s = s'$ the outcome switches from ruling to settlement. So if the probability mass of $s$ is concentrated around $s'$, then $\text{Pr(settlement)}/\text{Pr(dispute)}$ goes up. On the other hand, suppose there is zero probability mass around $s'$. Then a small-enough increase in $x$ does not affect $\text{Pr(ruling)}$, while it decreases $\text{Pr(dispute)}$, thus $\text{Pr(ruling)}/\text{Pr(dispute)}$ goes up and hence $\text{Pr(settlement)}/\text{Pr(dispute)}$ goes down.
efficiency only for disputes where again $i$ is the complainant and $j$ the defendant. This could be the case if for example the court learns about features of the industry in country $j$ that competes with imports from country $i$. At the same time, we have restricted our attention to a two-country world, but in a many-country world one could consider additional forms of learning. For example, in a many-country world one could distinguish between directed-dyad specific learning as defined above and “defendant specific” learning, meaning that a ruling where country $i$ is the complainant and $j$ the defendant increases the court’s efficiency for any future dispute where again $j$ is the defendant, regardless of whether the complainant in the future dispute is $i$ or some third country.

In this section we extend our analysis to allow for many countries and a range of learning possibilities that include the “undirected-dyad specific” form of learning considered in the previous sections, as well as the alternative forms of learning just described, plus a number of other possibilities. The main purpose of this extension is to enrich the model in view of our empirical exploration.

We consider the simplest possible multi-country extension of our two-country partial equilibrium model: suppose there are $N \geq 2$ countries, with each of the $\frac{N!}{2(N-2)!}$ dyads trading two non-numeraire goods (one in each direction) which are separable from each other and from all other non-numeraire goods that countries trade, and with an outside good that enters utility quasi-linearly. The payoff to a given government $j$ is then the sum of $2(N-1)$ (separable) product-specific payoff terms: for each trading partner, say country $i$, there is a payoff term associated with the product that country $j$ imports from country $i$, with state variable $s_{ij}$, and a payoff term associated with the product that country $j$ exports to country $i$, with state variable $s_{ji}$. As before, the state variables are ex ante uncertain. Finally, we continue to assume that there can be at most one dispute in any period, and we continue to assume that analogues of Assumptions 1-3 apply in this extended setting.

We denote by $\lambda_{ij}$ the court’s imperfection in ruling on disputes brought by country $i$ against country $j$. We assume that $\lambda_{ij} = \lambda(X_{ij})$, where $\lambda(\cdot)$ is a weakly decreasing function, and $X_{ij}$ is a composite experience variable that takes the form

$$X_{ij} = \beta_1 x_{ij} + \beta_2 x_{ji} + \beta_3 x_{i(nj)} + \beta_4 x_{(ni)j} + \beta_5 x_{\text{other}}. \quad (4.1)$$

Here, $x_{ij}$ is the number of past rulings where $i$ was the complainant and $j$ was the defendant, $x_{ji}$ the number of past rulings where $j$ was the complainant and $i$ the defendant, $x_{i(nj)}$ the
number of past rulings where $i$ was the complainant and the defendant was not $j$, $x_{(ni)j}$ the number of past rulings where $j$ was the defendant and the complainant was not $i$, and $x_{other}$ is the number of remaining past disputes.

All $\beta$’s are assumed weakly positive. Moreover, it is natural to assume that $\beta_1$ is at least as large as each of the other $\beta$’s, because it is plausible that direct experience is at least as relevant as indirect experience; and by a similar argument, it is natural to suppose that $\beta_2$, $\beta_3$ and $\beta_4$ are at least as large as $\beta_5$.

Our formulation of court learning includes several interesting possibilities. At one extreme, learning could be purely general, in the sense that prior experience improves the court’s efficiency in future disputes regardless of the identities of the disputants or the roles they play. This case of pure general learning corresponds to the case where all the $\beta$’s are equal and strictly positive. At the other extreme, court learning could be highly specific, so that prior experience is applicable only to future disputes in which the same governments play the same roles: this directed-dyad specific learning corresponds to the case where $\beta_1 > 0$ and all other $\beta$’s are zero. And in between these two extremes are the cases of undirected-dyad specific learning ($\beta_1 = \beta_2 > 0$ and all other $\beta$’s are zero), where prior experience is applicable to future disputes between the same governments regardless of the roles they play; defendant-specific learning ($\beta_1 = \beta_4 > 0$ and all other $\beta$’s are zero), where prior experience is applicable to future disputes that involve the defendant again in the role of a defendant, regardless of who the complainant is; and complainant-specific learning (only $\beta_1 = \beta_3 > 0$ and all other $\beta$’s are zero), where prior experience is applicable to future disputes that involve the complainant again in the role of a complainant, regardless of who the defendant is. And of course these possibilities are not mutually exclusive: for example, the case in which there is general learning as well as directed-dyad specific learning would correspond to $\beta_1 \geq \beta_2 = \beta_3 = \beta_4 = \beta_5 \geq 0$ (with the difference between $\beta_1$ and the other $\beta$’s interpreted as the directed-dyad specific component).

Key to the predictions of the model are the future payoff changes implied by a ruling at $t = 1$. Let us denote these future payoff changes for the period-1 complainant ($i$) and for the period-1 defendant ($j$) respectively as $\Delta^i$ and $\Delta^j$. It is easy to show that, if an increase in court

\[30\]Note an implicit restriction in our model: we are assuming that past disputes between third countries (i.e. countries other than $i$ and $j$) have the same relevance as past disputes where today’s complainant ($i$) played the role of defendant, or past disputes where today’s defendant ($j$) played the role of complainant. We could write down a more general model where these learning effects are allowed to be different, but this would substantially complicate the notation and exposition without much gain in insight.
quality improves the disagreement payoff for both the complainant and the defendant, then the joint future payoff change $\Delta^i + \Delta^j$ must be positive. However, if court quality has opposing impacts on the defendant and the complainant, as is possible in our model, $\Delta^i + \Delta^j$ in principle could be negative. In Appendix C we show that, if at $t = 2$ the probability of a potential dispute between governments $i$ and $j$ is large enough relative to the probability of a potential dispute between some other country pair – that is, if there is a large enough probability of “re-matching” between the same governments at $t = 2$ – then $\Delta^i + \Delta^j$ is guaranteed to be positive, and hence a ruling can occur in equilibrium at $t = 1$. We note that this condition is much stronger than we need, and the same result could be obtained in a variety of other ways, for example by assuming enough symmetry (so there is enough of a “veil of ignorance,” ensuring that $\Delta^i$ is not very different from $\Delta^j$), or taking the opposite approach, by assuming enough heterogeneity across country dyads, so that $\Delta^i + \Delta^j$ is positive at least some of the time (note that we need $\Delta^i + \Delta^j$ to be positive only in some states of the world, not always).\footnote{Notice that with the learning spillovers to third countries implied by the presence of complainant-specific, defendant-specific or general learning, there is potential for under-utilization of the court system when any of these forms of learning are present, in the sense that $\Delta^i + \Delta^j$ will then not fully reflect the future gains to all parties generated by a court ruling. We leave an investigation of the normative and positive implications of this observation to future work.}

Let us first focus on the impact of $\delta$ on the likelihood of rulings. It can easily be shown that Proposition 4 extends to this more general setting: intuitively, given that the joint future payoff gain from a ruling $\Delta^i + \Delta^j$ is positive, if governments care enough about the future they will go to court at $t = 1$.

Next focus on the impact of past rulings on the likelihood of current rulings and disputes: How does an increase in $x_m$ (for $m = ij, ji, i(nj), (ni)j, other$) affect the probability of a ruling between (complainant) $i$ and (defendant) $j$ at $t = 1$?

First, the impact of $x_m$ on the likelihood of a ruling on average must be negative, provided that learning eventually stops for some finite value of $X_{ij}$. More precisely, consider a given experience variable $x_m$ and let $x_{-m}$ denote the vector of all other experience variables. Clearly, for any fixed $x_{-m}$ there is a high enough value of $x_m$ at which learning stops, and hence the probability of a ruling reaches zero. Thus, applying the same logic as in the two-country model, we can state that the impact of $x_m$ on the likelihood of a ruling on average must be negative.

Furthermore, if $\delta$ is sufficiently high (and under the assumption made above that the probability of “re-matching” is high), the probability of a ruling is weakly decreasing in each $x_m$. 

for all $x_m$. Notice that, just as in the previous section, increasing $x_m$ has a static effect and a dynamic effect. The static effect is that increasing any of the $x_m$’s increases (at least weakly) current court quality, implying that the disagreement point gets closer to the negotiation frontier; other things equal, this static effect pushes up the probability of a ruling. The dynamic effect is that the increase in $x_m$ affects $\Delta^i + \Delta^j$. In Appendix C we show that, if the probability of re-matching is high, then $\Delta^i + \Delta^j$ is weakly decreasing in each of the $x_m$’s. Thus, as in our two-country setting, the dynamic effect works in the opposite way as the static effect, pushing down the probability of a ruling. It then follows that, if $\delta$ is large enough, the dynamic effect outweighs the static effect, and the probability of a ruling is weakly decreasing in each $x_m$.

Finally, we ask whether also the likelihood of a dispute is decreasing in each $x_m$. If $\beta_1$ is sufficiently close to $\beta_2$, so that learning is essentially undirected-dyad specific, it can be shown that the analog of Proposition 6 applies here: intuitively, if $\beta_1 = \beta_2$ then this multi-country setting is analogous to our two-country setting of the previous section. But in general, court experience can have a positive or negative impact on the likelihood of a dispute in this multi-country setting.\textsuperscript{32}

5. Empirical Evidence

We now investigate the empirical content of our theory with the help of data from WTO trade disputes. Our central objective is to assess the empirical importance of learning by ruling. The main challenge is that, unlike the existing empirical work on learning by doing for firms, where direct measures of productivity are available, we cannot observe directly the quality of the court, so we cannot estimate directly the relationship between court experience and court quality. We address this challenge by using the predictions of our model to indirectly gauge the importance of learning by ruling. In particular, our model suggests that if court learning is important we should find a strong negative impact of cumulative rulings on the likelihood of current rulings and disputes; and that the scope of court learning can be gauged by examining how the likelihood of current rulings and disputes is affected by different measures of court experience, e.g. disputant-specific, issue-area-specific, or general-scope experience. In our investigation we will consider the determinants of both disputes and rulings, although it should be noted that the above-mentioned predictions apply more strongly for rulings than for disputes, especially in our

\textsuperscript{32}See Appendix C for an example where court experience can have a positive impact on the likelihood of a dispute.
multi-country extension. Finally, we will also consider the plausibility of some key alternative interpretations for our empirical findings.

Our dataset consists of 388 WTO disputes initiated between 1995 and 2009 as contained in the WTO Dispute Settlement Database. Our Data Appendix describes the steps taken in constructing this dataset. We note at the outset that, while our data on the frequency of DSB rulings is quite reliable, we face a potential limitation when it comes to data on the frequency of disputes, because a dispute can either end in a DSB ruling or it can end in settlement; and as we observed in section 2, settlement in our model can be interpreted either as a deal struck within the formal WTO dispute process or as a deal struck outside this process. Unfortunately, we only have data on settlements that occur within the formal WTO dispute process, thus we face a potential sample selection issue when measuring the frequency of disputes. This sample selection issue does not impact our analysis of rulings where we examine the unconditional likelihood of rulings rather than the likelihood of a ruling conditional on a dispute; but it does cause potential problems for an analysis of disputes. Nevertheless, with this caveat in mind we will also examine how past rulings affect the current frequency of disputes.

Recall that our multi-country model of section 4 allows for a rich set of possibilities regarding the scope of court learning, including the five possibilities of directed-dyad-specific learning, undirected-dyad-specific learning, complainant-specific learning, defendant-specific learning and general-scope learning. But our model considers only one sector or issue area. For empirical purposes, it seems compelling to allow for one more dimension of learning, namely, learning may or may not be specific to the disputed issue area. To operationalize the notion of “issue area” in a simple way, we assume that an issue area is embodied in a GATT/WTO Article. If learning can be specific to the GATT/WTO Article ruled upon by the court, then we have five additional possibilities: court learning could be article specific, directed-dyad-and-article specific, undirected-dyad-and-article specific, complainant-and-article specific, and defendant-and-article specific. And of course, combinations of these different dimensions of learning might be present but in different degrees.

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33 Recall that our model yields predictions about the unconditional likelihood of rulings, while as Remark 2 highlights, the same is not true for the likelihood of rulings conditional on a dispute.

34 The initiation of a WTO dispute involves a description by the complainant country of the specific policy commitments that are the subject of the dispute, and these policy commitments are enumerated in the various GATT and WTO Articles (e.g., Article VI on antidumping measures, Article XI on quantitative restrictions). Hence our use of the GATT/WTO Articles named in the dispute as representing the dispute issue areas seems the natural approach.
Below we investigate empirically all of these different potential domains of learning, but it is instructive to organize our investigation in two stages. We first take a more parsimonious approach by treating country dyads as undirected, and focus on learning that might be general, undirected-dyad specific, article specific or undirected-dyad-and-article specific. We then turn to the possibility of directed-dyad-specific learning effects, and allow for all the potential domains of learning described above.

To facilitate the distinction between undirected and directed dyads, we use $i\overleftarrow{j}$ to index undirected dyads, and $i\overrightarrow{j}$ to index directed dyads where country $i$ is the complainant and country $j$ the defendant. And we use $k$ to index GATT/WTO Articles and $t$ to index years. For undirected dyads, we then define the following variables: $D_{\overrightarrow{i\overleftarrow{j}}, k, t}$ is the number of disputes initiated by country-dyad $i\overleftarrow{j}$ on article $k$ in year $t$; $R_{\overrightarrow{i\overleftarrow{j}}, k, t}$ is the number of country-dyad- $i\overleftarrow{j}$ disputes on article $k$ that led to an adopted panel ruling in year $t$; and $CR_{\overrightarrow{i\overleftarrow{j}}, k, t}$ is the cumulative number of country-dyad- $i\overleftarrow{j}$ disputes on article $k$ that led to an adopted panel ruling prior to year $t$. In what follows, we refer to $R_{\overrightarrow{i\overleftarrow{j}}, k, t}$ simply as the number of “rulings” for dyad $i\overleftarrow{j}$ on article $k$ in year $t$, and similarly for the variable $CR_{\overrightarrow{i\overleftarrow{j}}, k, t}$. The analogous variables for directed dyad $i\overrightarrow{j}$ are $D_{\overrightarrow{i\overrightarrow{j}}, k, t}$, $R_{\overrightarrow{i\overrightarrow{j}}, k, t}$ and $CR_{\overrightarrow{i\overrightarrow{j}}, k, t}$.

Notice that our convention is to date disputes by the year in which they are formally initiated (through a “request for consultation,” the official start of formal WTO dispute settlement proceedings), and to date DSB rulings by the year in which the DSB panel report containing the ruling is formally “adopted” (approved) by the WTO membership. The latter dating convention reflects our belief that the entire panel process – investigation, preliminary and final reports, and appeals – that leads up to final adoption of DSB rulings is a potentially important source of DSB learning.

5.1. Undirected Dyads

We begin our investigation of undirected dyads with some simple regressions. We follow an approach similar to Kellogg (2011), who looks for evidence of various forms of learning by doing in the context of drilling activity in the oil and gas industry (e.g., producer-specific, rig-specific and producer-rig-specific learning). We exploit a key prediction of our theory and look for evidence of various forms of judicial learning by regressing the current frequency of WTO rulings and disputes on various cumulative court experience variables and controls.

Any attempt to identify the effect of cumulative past rulings/disputes on the current likeli-
hood of a ruling/dispute must confront two basic issues. First, there may be spurious positive correlation due to unobserved serially-correlated shocks or cross-sectional heterogeneity. Importantly, this would introduce a bias against the prediction of our model, but at any rate we will attempt to minimize such bias by including fixed effects and other controls. Second, cumulative rulings/disputes are positively correlated with calendar time, so if there are unobserved determinants of disputes/rulings that decline over time, this will generate a spurious negative correlation that we might erroneously attribute to learning. We will address this issue by controlling for a (quadratic) time trend.

We present results from two regressions, one for disputes and one for rulings, under both logit and OLS estimation. We focus our discussion in the text on the logit results, but we point out where our logit results diverge from the OLS results and emphasize only those findings that are common to both. We estimate the dispute regression with a panel spanning the 15 years 1995-2009 and consisting of observations on each of the 126 undirected country dyads that initiated at least one WTO dispute during this period and each of the 241 GATT/WTO Articles that were disputed at least once during this period. For the ruling regression, we restrict the sample to the 55 undirected country dyads that generated at least one WTO adopted panel ruling report as a result of a dispute initiated during this period and to the 140 GATT/WTO Articles that were ruled upon at least once in an adopted panel report as a result of a dispute initiated during this period.\(^{35}\)

The dependent variable in the dispute logit regression is \(D\text{Logit}_{ij,k,t}\), defined as 1 if \(D_{ij,k,t} \geq 1\) and 0 otherwise. The dependent variable in the ruling logit regression is \(R\text{Logit}_{ij,k,t}\), defined as 1 if \(R_{ij,k,t} \geq 1\) and 0 otherwise.\(^{36}\) For both the dispute and ruling regressions, the key

\(^{35}\)Our panel is unbalanced, due to WTO accessions that occurred between the WTO’s inception in 1995 and the end of our sample period in 2009: as a result of these accessions, the number of undirected dyads for the dispute regression rises from 110 in 1995 to 126 in 2009, while the number of undirected dyads for the ruling regression rises from 50 in 1995 to 55 in 2009. For our purposes here it seems reasonable to treat accessions as exogenous, and under this assumption the unbalanced nature of our panel raises no special econometric issues (see, e.g., Wooldridge, 2010, pp 828-830). Nevertheless, to check that our unbalanced panel is not impacting our results, we have also re-estimated all of the (undirected- and directed-dyad) regressions we present below on the restricted sample of dyads between countries that were original members of the WTO (i.e., members beginning in 1995), and find that our results are unchanged. A similar issue arises with the growing membership of the EU over our sample period. To check that our results are also not impacted by this issue, we re-estimated all of the (undirected- and directed-dyad) regressions we present below on the restricted sample that excludes the disputes that involved an EU-joiner (before it joined the EU) during our sample period, and again find that none of our results are materially impacted.

\(^{36}\)The dependent variables for the OLS undirected-dyad dispute and ruling regressions are, respectively, \(D_{ij,k,t}\) and \(R_{ij,k,t}\). We have also re-estimated all of our OLS (undirected- and directed-dyad) regressions with the 0/1
The independent variables of interest are four measures of cumulative past rulings, which we denote by $CR_{ij,k,t}$, $CR_{n(ij),k,t}$, $CR_{ij,nk,t}$ and $CR_{n(ij),nk,t}$ where a subscript $nz$ denotes “not z” for index z. The variable $CR_{n(ij),k,t}$, defined as the cumulative number of rulings for dyads other than $ij$ on article k prior to year t, captures article-specific court experience. The variable $CR_{ij,nk,t}$, defined as the cumulative number of rulings for dyad $ij$ on articles other than k prior to year t, captures undirected-dyad-specific court experience. The variable $CR_{n(ij),nk,t}$, defined as the cumulative number of rulings for dyads other than $ij$ on articles other than k prior to year t, captures general court experience. Finally, the variable $CR_{ij,k,t}$ is the cumulative number of rulings for dyad $ij$ on article k prior to year t; this variable is meant to capture the narrowest form of court experience that is specific to both the disputants involved and the article that they are disputing. The top half of Table 1 provides summary statistics for each of the variables used in the undirected dyad regressions.

Each regression includes a quadratic time trend, as well as (undirected)-dyad- and article-fixed effects to control for unobserved heterogeneity in the disputes and rulings behavior at the level of the dyad (the countries in dyad $ij$ may have a particularly litigious relationship) and the level of the article (article k may be particularly susceptible to litigation). The results of these regressions are presented in columns 1 and 2 of Table 2 (with the corresponding OLS results contained in Columns 1 and 2 of Table 3).

Importantly, we do not include an $ijk$ fixed effect, and therefore do not control for unobserved heterogeneity at the level of the dyad and article (the countries in dyad $ij$ might have a particularly litigious relationship over article k), for two reasons. First, and most obviously, including such a fixed effect and relying only on within-$ij$ k variation over time to estimate dependent variables used in our logit regressions, and find that the results are not materially impacted. And analogously, making use of the count variables $D_{ij,k,t}$ and $R_{ij,k,t}$ and re-estimating all of our logit (undirected-and directed-dyad) regressions as Poisson or negative binomial regressions makes no material difference to our results.

37 As we noted at the outset of this section, Remark 2 and our discussion following this Remark guide us to look for evidence of court learning by examining the impacts of cumulative rulings on the unconditional likelihood of a ruling; hence we do not control for selection into rulings when estimating our ruling regressions.

38 We have also experimented with the inclusion of further controls, including variables that capture the tendency of richer (OECD) countries to be claimants in WTO disputes involving intellectual property rights (TRIPS articles) and to be respondents in WTO disputes involving subsidies (SCM articles) and technical barriers (SPS/TBT articles), as well as even more specific controls (such as disputes that involve obligations specific to China’s accession agreement to the WTO) and also more general controls (such as the bilateral real trade volume between countries i and j in year t, and measures of exchange rate overvaluation as a time-varying indicator of a country’s incentive to initiate WTO disputes over the policies of its trading partners). Our results are robust to the inclusion of these additional controls.
the regression coefficients would diminish our ability to assess the impact of those variables that exhibit little within-\(ij\)k variation over time.39 And second, for the ruling regressions the right-hand-side variable \(CR_{ij,k,t}\) is the sum of lagged values of the dependent variable, and inclusion of an \(ij\)k fixed effect would introduce an incidental parameters problem and lead to biased and inconsistent estimates for our relatively short panel.40 An implication is that, if there is important unobserved heterogeneity at the dyad-and-article level, our estimates of the coefficient on \(CR_{ij,k,t}\) will be biased upward, a bias that works against finding evidence of the most narrow form of learning.

Focusing first on the ruling logit regression in column 2 of Table 2, the estimated coefficients on \(CR_{n(\overline{ij}),k,t}\) and \(CR_{ij,nk,t}\) are negative and strongly significant, suggesting the presence of article-specific and dyad-specific DSB learning. The average marginal effects for \(CR_{n(\overline{ij}),k,t}\) and \(CR_{ij,nk,t}\) are \(-0.0008\) and \(-0.0003\), respectively, which are sizeable in light of the mean value of the dependent variable \(RLogit_{ij,k,t}\) (0.0056); for example, according to these estimates an additional ruling on article \(k\) in a dispute between \(i\) and \(j\) is all else equal predicted to lower the probability of a future dispute between these countries on article \(k\) by 15%. And while the coefficient estimate on \(CR_{n(\overline{ij}),nk,t}\) in column 2 of Table 2 is negative and significant, the corresponding OLS coefficient estimate in column 2 of Table 3 is insignificantly different from zero, suggesting overall only weak evidence of general-scope learning.41 Finally, notice that the point estimate of the coefficient on \(CR_{ij,k,t}\), our narrowest measure of DSB experience, is

39 Relatedly, we choose to include a quadratic time trend rather than year fixed effects because the inclusion of year fixed effects would interfere with our ability to assess the importance of our general learning variable. Note that our general learning variable does exhibit some within-year variation over the cross-section of \(ij\)k (because rulings occur on specific dates within each year, as do dispute initiations, and hence these events may be associated with different magnitudes of cumulative rulings even when they involve the same disputants and the same article and occur in the same year), so identification of a general learning effect in the presence of year fixed effects is possible; but this variation alone may be insufficient to detect the effect. And as we report below, even without year fixed effects we find only weak evidence of a general learning effect, and by the above logic such evidence could only further weaken if we were to include year fixed effects.

40 Letting \(T\) denote the length of the panel, the issue that arises for our ruling regressions if an \(ij\)k fixed effect is included is that for \(T\) fixed and relatively small, the estimates of the slope parameter on \(CR_{ij,k,t}\) will be biased and inconsistent even as the \(ij\) and \(k\) dimensions of the panel become large. This is because the number of \(ij\)k fixed effects to be estimated grows proportionately with the \(ij\) and \(k\) dimensions of the panel, and only the “within” dimension of the data (with \(T\) observations) can be used to estimate the slope parameter on \(CR_{ij,k,t}\); and the presence of a lagged endogenous variable ensures that this regressor will be correlated with the error term unless \(T \rightarrow \infty\). See Wooldridge (2010) for a textbook treatment of the incidental parameter problem and possible approaches to addressing it.

41 For the OLS results, we report standard errors clustered by dyad, but clustering by dyad and article makes no material difference to the results we emphasize.
positive (and strongly significant according to the OLS estimates in column 2 of Table 3). This may reflect the upward bias in this coefficient that would be expected if there is unobserved heterogeneity at the dyad-and-article level. Below we offer more evidence consistent with this interpretation.

Turning to the dispute regression, column 1 of Table 2 presents the coefficient estimates from the $DLogit_{ij,k,t}$ regression. The results are broadly similar to those of the ruling regressions. The coefficient estimates on $CR_{n(ij),k,t}$ and $CR_{ij,nk,t}$ are negative and significant, while the coefficient estimate on $CR_{n(ij),nk,t}$ is negative and significant in the logit estimation but is insignificantly different from zero under OLS (column 1 of Table 3). Thus, as with the ruling regressions, the dispute regressions are suggestive of article-specific and dyad-specific DSB learning and there is only weak evidence of general-scope learning. And now the coefficient on $CR_{ij,k,t}$, our narrowest measure of DSB experience, is positive and strongly significant.

As a partial check on the interpretation that our failure to find a negative coefficient on $CR_{ij,k,t}$ reflects the presence of unobserved heterogeneity at the dyad-and-article level, we next present estimates of the dispute regressions (logit and OLS) with an $ijk$ fixed effect. Recall that inclusion of this fixed effect will diminish our ability to assess the impact of those variables that exhibit little within-$ijk$ variation over time, but should address the upward bias in the estimated coefficient on $CR_{ij,k,t}$ induced by any unobserved heterogeneity at the dyad-and-article level; and for the dispute regressions, the inclusion of an $ijk$ fixed effect does not mechanically lead to biased or inconsistent estimates as would be the case for the rulings regressions where $CR_{ij,k,t}$ constitutes a lagged dependent variable. The results are contained in columns 1 (logit) and 2 (OLS) of Table 4. When an $ijk$ fixed effect is included in the dispute regressions the coefficient on $CR_{ij,k,t}$ turns strongly and significantly negative, consistent with our interpretation and with the presence of DSB learning even at the dyad-and-article level.

5.2. Directed Dyads

We next turn to our analysis based on directed dyads. As we discussed in section 4, DSB learning might be specific to the defendant country (which is under the magnifying glass of the DSB), or to the complainant country (e.g. because the DSB learns about the political-economic impacts of trade barriers on this country’s exporters), or even to the directed dyad itself (e.g. by adjudicating disputes brought by China against the US, the DSB may learn about sectors where China exports to the US). Our directed dyad regressions can provide evidence on the
possible importance of these finer dimensions of DSB learning.

As with the undirected dyads, we estimate two regressions, one for disputes and one for rulings, and we report both logit and OLS results but emphasize the logit results in our discussion in the text. For the dispute regressions, our panel (spanning the 15 years 1995-2009) consists of observations on each of the 156 directed country dyads that initiated at least one WTO dispute during this period and each of the 241 GATT/WTO Articles that were disputed at least once during this period. The dependent variable in the dispute logit regression is $D\text{Logit}_{ij,k,t}$ (defined as 1 if $D_{ij,k,t} \geq 1$ and 0 otherwise). And for the ruling regression, we restrict the sample to the 73 directed country dyads that generated at least one WTO adopted panel ruling report as a result of a dispute initiated during this period and to the 140 GATT/WTO Articles that were ruled upon at least once in an adopted panel report as a result of a dispute initiated during this period. The dependent variable in the ruling logit regression is $R\text{Logit}_{ij,k,t}$ (defined as 1 if $R_{ij,k,t} \geq 1$ and 0 otherwise).

The key independent variables of interest are now the 10 measures of court experience denoted by $CR_{ij,k,t}$, $CR_{(ni)j,k,t}$, $CR_{i(nj),k,t}$, $CR_{ji,k,t}$, $CR_{\text{other},k,t}$, $CR_{ij,nk,t}$, $CR_{(ni)j,nk,t}$, $CR_{i(nj),nk,t}$, $CR_{ji,nk,t}$ and $CR_{\text{other},nk,t}$. The meaning of these variables can be understood as follows. Consider first the five $k$-specific variables:

1. the variable $CR_{ij,k,t}$ captures directed-dyad-and-article specific court experience;
2. the variable $CR_{ji,k,t}$ captures court experience that is specific to the “reverse” directed dyad, i.e. where $j$ complains against $i$, and to the article (and thus, together with $CR_{ij,k,t}$, captures undirected-dyad-and-article specific court experience);
3. the variable $CR_{i(nj),k,t}$ captures complainant-and-article specific court experience;
4. the variable $CR_{(ni)j,k,t}$ captures defendant-and-article specific court experience;
5. the variable $CR_{\text{other},k,t}$ captures article specific (but not disputant specific) court experience.

The second group of five variables is analogous, except that cumulative rulings are aggregated over all non-$k$ articles. And the interpretation of these variables is also analogous, except that they capture non-article-specific court experience: for example, $CR_{ij,nk,t}$ captures directed-dyad-specific experience, $CR_{i(nj),nk,t}$ captures complainant-specific experience, and $CR_{\text{other},nk,t}$

42The dependent variables for the OLS directed-dyad dispute and ruling regressions are $D_{ij,k,t}$ and $R_{ij,k,t}$. See also notes 35 and 36.
captures general experience. The bottom half of Table 1 provides summary statistics for the variables in the directed dyad regressions.

The results of the directed-dyad logit regressions are presented in columns 3 and 4 of Table 2 (with the corresponding OLS results contained in Columns 3 and 4 of Table 3). Similarly to the undirected-dyad regressions, in both of our directed-dyad regressions we also include a quadratic time trend and article- and (directed)-dyad- fixed effects.

Focusing first on the ruling regression in column 4 of Table 2, the estimated coefficient on $CR_{other,k,t}^{-}$ is negative and strongly significant, which suggests the presence of article-specific learning. The estimated coefficient on $CR_{ij,nk,t}^{-}$ is negative and strongly significant, suggesting the presence of directed-dyad-specific learning (and the estimated coefficient on $CR_{ji,nk,t}^{-}$ is negative and significant for the logit but insignificantly different from zero with a positive point estimate for OLS, suggesting at best weak evidence for undirected-dyad-specific learning). The average marginal effects for $CR_{other,k,t}^{-}$ and $CR_{ij,nk,t}^{-}$ are $-0.0008$ and $-0.0004$, respectively, which are again sizeable as compared to $0.0043$, the mean value of the dependent variable $RLogit_{ij,k,t}$; for example, according to these estimates an additional ruling on article $k$ is all else equal predicted to lower the probability of a future ruling on article $k$ by almost 20%. The estimated coefficient on $CR_{i(nj),nk,t}^{-}$ is also negative and strongly significant, suggesting complainant-specific learning, though the average marginal effect for $CR_{i(nj),nk,t}^{-}$ is smaller, at less than $-0.0001$. And the estimated coefficient on $CR_{other,nk,t}^{-}$, while negative and significant in the logit specification, is insignificantly different from zero for OLS, suggesting at best only weak evidence of general-scope learning. Finally, the estimated coefficient on $CR_{ij,k,t}^{-}$ is positive and strongly significant, possibly reflecting as we indicated earlier an upward bias in the estimated coefficient on $CR_{ij,k,t}^{-}$ from the presence of unobserved heterogeneity at the dyad-and-article level (and the estimated coefficient on $CR_{ji,k,t}^{-}$ is negative and significant in the logit specification but insignificantly different from zero for OLS).

Turning to the dispute regression results in column 3 of Table 2, the results are broadly consistent with the ruling regressions of column 4. In particular, the estimated coefficients on $CR_{other,k,t}^{-}$, $CR_{ij,nk,t}^{-}$ and $CR_{i(nj),nk,t}^{-}$ are each negative and strongly significant, suggesting the presence of article-specific, directed-dyad-specific and complainant-specific learning. And there is no evidence of general learning from the dispute regression (the estimated coefficient on $CR_{other,nk,t}^{-}$ is statistically insignificant), reinforcing the caution with which we interpreted the coefficient on this variable in the ruling regression. And as with the ruling regression, the
estimated coefficient on $CR_{ij,k,t}$, our most narrow measure of DSB experience, is positive and strongly significant. Again to check our interpretation that this positive coefficient reflects the presence of unobserved heterogeneity at the dyad-and-article level and an upward bias in the estimated coefficient on $CR_{ij,k,t}$, we present estimates of the directed-dyad dispute regression with an $ij\,k$ fixed effect in columns 3 (logit) and 4 (OLS) of Table 4. When the $ij\,k$ fixed effect is included in the directed-dyad dispute regressions the coefficient on $CR_{ij,k,t}$ turns strongly and significantly negative, consistent with our interpretation above and with the presence of DSB learning at our most narrow level.\(^{43}\)

The one difference relative to the ruling regression results in column 4 of Table 2 is that in the dispute regression results in column 3 of Table 2 the estimated coefficient on $CR_{(ni)j,k,t}$ has switched from negative but insignificantly different from zero to positive and strongly significant. Recalling that our model (particularly in its multi-country extension) yields more ambiguous predictions about the impacts of experience variables such as $CR_{(ni)j,k,t}$ on the frequency of disputes than it does for rulings, it is possible that the positive coefficient on $CR_{(ni)j,k,t}$ in the dispute regression of column 3 is a manifestation of this ambiguity. An alternative interpretation is that this reflects a “bandwagon effect” that falls outside our model, whereby other potential complainants follow up with claims of their own once a ruling against defendant-country $j$ on article $k$ has been issued and adopted.\(^{44}\)

To summarize, our regressions reveal several important points. First, our findings are consistent with significant article-specific and disputant-specific court learning, with the latter taking the form of directed-dyad-specific and complainant-specific learning, while there is little evidence of general-scope learning.\(^{45}\) It is also worth noting that the coefficient on the linear time

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\(^{43}\)Note that when an $ij\,k$ fixed effect is included in the directed-dyad dispute regressions in columns 3 and 4 of Table 4 the estimated coefficient on the article-specific learning term $CR_{other,k,t}$ loses its significance (and in fact turns slightly positive). This likely reflects the loss of effective variation used to estimate the regression coefficient on this variable in the presence of an $ij\,k$ fixed effect. And the positive and significant coefficient on $CR_{n(i)j,k,t}$ in the undirected dyad logit estimate in column 1 of Table 4 can be similarly understood from the perspective of the directed dyad logit in column 3 as reflecting the loss of significance of the coefficient on $CR_{other,k,t}$ together with the positive and significant coefficient on $CR_{(ni)j,k,t}$, which we discuss next.

\(^{44}\)It is also interesting to note that, while the logit coefficient on $CR_{ij,k,t}$ in column 3 of Table 2 is negative but insignificant, the OLS coefficient in column 3 of Table 3 is positive and significant, providing some weak evidence for a possible “tit-for-tat” effect (e.g., if the US files an article-$k$ complaint today against China, in the future China is more likely to file an article-$k$ complaint against the US) that is outside our model. Indeed, there is some anecdotal evidence of such tit-for-tat behavior in the practice of WTO disputes (see for example the article by Jennifer Freedman in Bloomberg Business, 2012, and the discussion in Davis, 2012).

\(^{45}\)While the WTO was created in 1995, it included both the set of pre-existing GATT Articles from 1947 and also a set of new WTO Articles (such as articles related to the WTO TRIPs agreement, the Safeguard
trend is positive in all of our regressions. The fact that calendar time does not have a negative impact once we control for our measures of court experience (the CR variables) suggests that court learning can help explain the raw declining trend in disputes and rulings evidenced by Horn et al. (2011) and mentioned in the Introduction. And finally, as we have noted, there is evidence consistent with a possible “bandwagon” effect, and so a more complete empirical account of the pattern of WTO disputes and rulings may require an extended model that captures these effects in addition to the effects of court learning on the dynamics of dispute resolution.

5.3. Alternative Interpretations

Thus far we have interpreted our empirical findings as reflecting the effects of DSB learning, and of DSB learning that embodies a particular scope and form. An important question is whether there are alternative interpretations of these empirical findings. In this section we consider the plausibility of the key alternatives.

A first possibility is the presence of government learning about the court. In particular, by observing how the court operates, governments may learn to better predict the outcome of rulings. If governments’ beliefs about the outcome of rulings are initially asymmetric, they may agreement, and the SPS and TBT agreements). In this light, one might conjecture that court learning effects in the WTO era would be stronger for WTO than for GATT articles. When we estimate the regressions in Tables 2 and 3 allowing for separate learning effects for WTO versus GATT articles, we find that the learning effects are statistically indistinguishable across the two sets of articles with one exception: in our directed dyad logit ruling regression, the estimated coefficient on $CR_{i(nj),k,t}$, which captures complainant-and-article specific court experience, is negative and strongly significant for WTO articles but insignificantly different from zero for GATT articles, and the hypothesis that the two coefficients are the same is strongly rejected. This provides some evidence that court learning effects in the WTO era may indeed be stronger for WTO than for GATT articles, though our OLS estimates show no statistically significant difference across any of the learning coefficients so we interpret this evidence as at best weak and only suggestive.

46Our 1995-2009 sample period witnessed unprecedented growth in the numbers of preferential trade agreements (PTAs) to which WTO members belong, and it has been observed that such PTA membership may reduce the reliance of countries on the WTO to resolve their trade disputes (this argument is made most forcefully by Mavroidis and Sapir, 2015). To account for this possibility we have re-estimated the regressions in Tables 2, 3 and 4 with a PTA-partner variable (constructed using the NSF-Kellogg Institute Data Base on Economic Integration Agreements for September 2015) included on the right-hand side. Our results indicate the PTA partnership does indeed reduce the likelihood of WTO disputes that end in rulings (though we find no evidence that PTA partnership reduces the likelihood of WTO disputes), but inclusion of the PTA partnership variable on the right-hand side of our regressions leaves our findings relating to the cumulative rulings variables unchanged.

47Various stories about a bandwagon effect seem plausible, but the details of court remedies (e.g., how complete they are, whether they apply effectively to third parties) would matter, and as a result it is not obvious whether rulings for or rather against the defendant would be more likely to stimulate follow-up disputes by other claimants. Similar subtleties arise with tit-for-tat effects (see note 44). This points to the value of modeling such effects before going further in investigating their empirical content, a task we leave to future research.
converge as a result of this kind of learning, and as a consequence the frequency of equilibrium rulings may decline. This might be the case, for example, if governments learn about the court’s preferences and possible biases, or about the applicable legal precedent (Priest and Klein, 1984). Our model assumes that the court’s objective is given by the governments’ joint surplus and is common knowledge, but different court objectives are certainly possible in the real world. Intuitively, this type of learning might explain our findings about the impacts of cumulative rulings on the likelihood of current rulings and disputes.

As we have noted, our learning-by-ruling story requires that governments are “large players” who interact repeatedly, so they internalize the future benefits of going to court, while the government-learning-about-the-court story applies also to “small players.” This suggests that a natural approach for distinguishing between the two stories might be to check if the effects we find are strongest for large players. But this would require finding good proxies for large players, which according to our model would correspond to high-discount-factor countries in the context of trade disputes, a challenging task that we do not pursue here.\textsuperscript{48} However, if one assumes that a government learns about the court more effectively when participating as a third party in a dispute than when observing the dispute as an outsider, then there is a simple way to gauge whether this type of learning is important: a government’s experience as third-party participant in disputes that end in ruling should be a stronger predictor of the likelihood of current disputes and rulings than a government’s experience as outside observer. To consider this possibility, we have re-estimated each of our directed-dyad regressions breaking out the cumulative rulings where at least one of the disputing parties $i$ or $j$ was a third-party participant from our “cumulative ruling other” variables $\text{CR}_{other,i,k,t}$ and $\text{CR}_{other,nk,t}$. We find that the third-party experience variables do not have a stronger effect than the “other” experience variables; thus by this metric there is no evidence of government learning about the court in our data.

A second possibility is that, by repeatedly engaging in disputes, governments may learn about each other. In principle this type of learning could explain a negative impact of cumulative past rulings on the current likelihood of rulings, because reducing or eliminating private

\textsuperscript{48}In this regard, a natural conjecture might be that the strongest evidence for our theory should be found within the subsample of the most-frequent litigants. But this conjecture does not follow from our theory, because as we have indicated the future benefits of a higher-quality court are not limited to better rulings, but also arise from better settlements (off-equilibrium effects) and even better policy choices made to avoid disputes entirely (off-off-equilibrium effects). In principle, then, even a government who is observed to seek a single ruling and then never engages in another dispute may have been incentivized to seek the ruling in order to enjoy the future benefits of a better court. All that is required is that the government expects that there will be future interactions with other governments.
information may reduce the probability of bargaining failures and hence decrease the propensity
to go to court.

Our data however do not support the government-learning-about-each-other story, for two
reasons. First, an immediate implication of this story would be that governments’ learning
about each other should increase the settlement rate. Contrary to this prediction, the trend
in the settlement rate in WTO disputes has been flat or slightly negative. Second, we have re-
run the regressions in Tables 2 and 3 replacing the cumulative-stock-of-ruling $CR$ variables on
the right-hand side with analogous “$CS$” variables that measure the cumulative stock of formal
consultations (facilitated by the WTO secretariat and held in private between the disputing
parties) that settle prior to panel formation. If governments learn about each other during these
consultations and if this has an important impact on the frequency of subsequent disputes and
rulings along similar lines to the DSB learning in our model, we would expect this to show up in
negative and significant coefficients on the $CS$ variables pertaining to the dyad of the consulting
parties (that is, on the $CS_{ij,k,t}$ and $CS_{ij,nk,t}$ variables in the undirected dyad regressions, and
on the $CS_{ij,k,t}$, $CS_{ij,nk,t}$, $CS_{ji,k,t}$ and $CS_{ji,nk,t}$ variables in the directed dyad regressions). In
fact, we fail to find any robust evidence for such coefficient estimates.

Finally, one may ask whether our empirical findings admit only the interpretation we have
given them when viewed through the lens of our model. Put differently, while we do not claim to
have structurally estimated the key learning parameters (the $\beta$’s) of our model, can the model
be used to infer from our empirical findings which of the $\beta$’s are positive and which are zero?

We argue now that the answer to this question is “Yes.” To this end, we return to our multi-
country model of section 4. That model focuses on a single issue area, but the key points can be
extended to a setting with multiple issue areas if government payoffs are separable in issue ar-
 eas. Recall from expression (4.1) that there are five non-negative parameters ($\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$)
describing the nature and scope of court learning, with five corresponding experience variables
$x_m$. Suppose data can be used to estimate the derivatives of the likelihood of rulings and dis-
putes with respect to the $x_m$’s. We can interpret our regressions as estimating these derivatives:
in particular and as we have reported above, according to our empirical findings the likelihood
of a ruling where $i$ is the complainant and $j$ the defendant is decreasing in $x_{ij}$ (directed-dyad
specific court experience) and in $x_{i(nj)}$ (complainant-specific court experience), while it is es-

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49By contrast, recall from Remark 2 that our model does not imply that the settlement rate should increase
with cumulative rulings.
sentially independent of the other $x_m$’s. It can be shown that, according to the model, this implies that $\beta_1$ and $\beta_3$ are positive while the other $\beta$’s are zero.\textsuperscript{50} It is an extension of this logic to a setting with multiple issues/articles that underlies our statements above that the data is consistent with directed-dyad-specific, complainant-specific and article-specific learning.

6. Conclusion

The importance of judicial learning has been widely emphasized in the context of domestic court systems, but little attention has been paid to judicial learning in the context of international institutions such as the WTO. Judicial learning in international institutions is likely to have distinct implications from those in domestic court systems because the number of potential disputants is small and thus the impact of current rulings on the future efficiency of the court is at least in part internalized by the disputants.

We have explored the implications of learning by ruling through a two-country model where both the initiation of disputes and the occurrence of rulings are endogenous, governments bargain “in the shadow of the law,” and the efficiency of the court increases with its experience. We have shown that the presence of judicial learning can explain litigation on the equilibrium path, since going to court today may imply payoff gains for the governments tomorrow, and that the probability of rulings is higher when governments are more patient. The future payoff gains from increasing court quality occur even if governments do not go to court tomorrow, because a more efficient court implies a better disagreement point for tomorrow’s bargain (an off-equilibrium effect), and even if governments do not have a dispute tomorrow, because a more efficient court induces governments to choose better policies in order to avoid disputes (an off-off-equilibrium effect). These off- and off-off-equilibrium effects shape the implications of learning by ruling in important ways. Our model predicts that the likelihood of both disputes and rulings should tend to decrease with court experience (cumulative rulings). This prediction is sharper if governments are sufficiently patient, but holds in an average sense also if the governments’ patience is low. And we have shown how this prediction extends to a many-country setting.

\textsuperscript{50}Two important qualifications are needed here. First, the statement above is valid under the natural restriction we have assumed on the $\beta$’s, namely $\beta_1 \geq \beta_2, \beta_3, \beta_4 \geq \beta_5$, and ignoring non-generic possibilities (and in particular, the knife-edge case where the static effect of $x_m$ on the likelihood of a ruling exactly offsets the dynamic effect through $\Delta$). Second, in the text we discuss only what can be inferred about the $\beta$’s from the ruling regression, and not from the dispute regression. The reason is that, as we point out in section 4, the model predictions regarding the likelihood of disputes are somewhat more ambiguous; thus, in the absence of further restrictions it is not clear that one can make inferences on the $\beta$’s using the dispute regressions.
Underlying these results is the interplay between a “static” effect of increasing court experience, which pushes toward a higher likelihood of disputes and rulings, and a “dynamic” effect, which pushes in the opposite direction.

We have also confronted the theory with data from WTO disputes. Our empirical findings are broadly consistent with the main predictions of our model and suggest that judicial learning is an important phenomenon in the WTO. More specifically, our evidence is consistent with article-specific learning and with some forms of disputant-specific learning, but we find only weak evidence of general-scope learning. And we have argued that our learning-by-ruling model is better able to account for these patterns than simple alternative models.
7. Appendix

A. An example model

Here we present a parameterized model that is a special case of the model developed in the main text, with the purpose of illustrating how the reduced-form assumptions we make in that model can be justified in a more “structural” way.

We assume the Home government chooses a tariff $T$ to maximize a weighted welfare function which allows for political economy considerations. In particular, Home’s payoff is

$$\omega(T, s) = CS(T) + R(T) + s \cdot PS(T),$$

where $CS$ is consumer surplus, $PS$ is producer surplus and $R$ is tariff revenue, and where $s \geq 1$ is a parameter that captures the political importance of the domestic industry (in the spirit of Baldwin, 1987, and Grossman and Helpman, 1994). In this parameterized model, the “state of the world” is simply the political parameter $s$. The Foreign government is passive in this industry (it has no policy of its own) and its payoff is given by national welfare, which in this setting is just the sum of consumer and producer surplus:

$$\omega^*(T) = CS^*(T) + PS^*(T).$$

We assume the demand and supply functions are linear in both countries. Note that $\omega^*(T)$ is decreasing and convex in $T$; intuitively, this is because increasing $T$ reduces trade volume, and hence reduces the impact on foreign welfare of further increases in $T$. On the other hand, note that $\omega(T, s)$ is concave in $T$ provided $s$ is not too high: the reason is that $CS(T) + R(T)$ is concave but $PS(T)$ is convex.

It is easy to verify that the no-transfer government Pareto frontier is concave if $\omega_{TT}(s) + \omega^*_T < 0$, and this is the case if $s$ does not exceed a threshold level.\(^{51}\) In what follows we assume this condition is satisfied.

We assume that the state of the world $s$ is ex-ante uncertain, and its realization is observed by governments but is not verifiable, so governments cannot write a complete contingent contract; and we further suppose that the contract does not specify the policy $T$ at all (discretion), but the court is endowed with the authority to “fill the gap” of this contract ex-post. More specifically, denoting by $T^{fb}$ the “first best” level of $T$ that maximizes joint surplus in state $s$

\(^{51}\)Clearly, this threshold level is lower than the threshold level of $s$ below which $\omega$ is concave in $T$, but higher than one (because if $s = 1$ both governments maximize welfare).
(and where for notational simplicity we suppress the dependence of $T^{fb}$ on $s$), the court can observe a noisy signal of $T^{fb}$, given by $T^{court} = T^{fb} + \varepsilon$, where $\varepsilon$ is a white noise with mean zero and variance $\lambda$.\textsuperscript{52} If invoked, the court issues a ruling to maximize the governments’ expected joint payoff conditional on its noisy information. Given the above assumptions, the court ruling will prescribe the tariff level $T^{court}$. In this example we abstract from litigation costs, so the court-inefficiency parameter $\lambda$ captures simply the noise in the court signal. Finally, we assume that governments have symmetric bargaining powers when negotiating at stage 3.

We can now characterize the equilibrium outcome of the static model. We focus first on the dispute subgame (stage 3). Given that the no-transfer frontier is concave, the disagreement point for the negotiation is below this frontier as a result of the uncertainty in the court ruling; moreover, it lies Southeast of the $FB$ point, because the uncertainty in the ruling hurts the importer (whose payoff is concave in $T$) and benefits the exporter (whose payoff is convex in $T$). Given that payoffs are quadratic and bargaining powers are symmetric, it is direct to verify that the expected disagreement payoffs are given by

$$
\omega^R(s; \lambda) = \omega^{fb}(s) + \lambda \cdot \omega_{TT}(s),
$$

$$
\omega^*^R(s; \lambda) = \omega^{*fb}(s) + \lambda \cdot \omega_{TT}^*,
$$

where $\omega^{fb}(s) \equiv \omega(T^{fb}(s), s)$ and $\omega^{*fb}(s) \equiv \omega^*(T^{fb}(s))$. Recall from the discussion above that $\omega_{TT}(s) < 0$, $\omega_{TT}^* > 0$ and $\omega_{TT}(s) + \omega_{TT}^* < 0$ for all $s$. Thus, increasing the court noise $\lambda$ worsens Home’s disagreement payoff, improves Foreign’s disagreement payoff, and worsens the joint disagreement payoff.

Note that, for any $s$, $\Omega^R(s; \lambda) = \Omega^{fb}(s) + \lambda[\omega_{TT}(s) + \omega_{TT}^*]$ is strictly decreasing in $\lambda$, $\Omega^R(s; 0) = \Omega^{fb}(s)$, and by the expression for $\omega^R(s; \lambda)$ above, $\frac{d\omega^R}{d\lambda} \neq 0$ for all $\lambda$; thus our reduced-form Assumption 1 is satisfied. Next note that the net bargaining payoffs are

$$
\omega^{Bnet}(s; \lambda) = \omega^{fb}(s) + \lambda \cdot [(1 - \frac{K}{2})\omega_{TT}(s) - \frac{K}{2}\omega_{TT}^*],
$$

$$
\omega^{*Bnet}(s; \lambda) = \omega^{*fb}(s) + \lambda \cdot [(1 - \frac{K}{2})\omega_{TT}^* - \frac{K}{2}\omega_{TT}(s)].
$$

Clearly, these payoffs are linear in $\lambda$ for any $s$, hence the $B^{\lambda}_{net}$ locus is linear, it cannot be backward bending and can cross the no-transfer frontier at most once. It follows that Propositions 1, 2 and 3 hold in this example model.

\textsuperscript{52}We could assume that the court observes a noisy signal of $s$ rather than a noisy signal of $T^{fb}$, at the cost of a slightly more complicated analysis.
Finally consider the dynamic setting. Here we do not need to impose any additional structure relative to our more general model. Note that, while Assumption 3 needs to be imposed just as in the more general model, Assumption 2 is automatically satisfied here, because disagreement payoffs are linear in $\lambda$, and $\lambda$ is convex in $x$. As discussed in the main text, Assumption 3 directs attention to what seems to be the empirically relevant case given that the frequency of disputes is empirically very low. Under this assumption, all the results of the dynamic setting hold in this example model.

**B. Conditions under which $B^\lambda_{\text{net}}$ is not backward bending**

Clearly the $B^\lambda_{\text{net}}$ locus is not backward bending if $\frac{d\omega^*_{B_{\text{net}}}}{d\lambda} \neq 0$ for all $\lambda$. To check under what conditions this is satisfied, we use

$$\omega^*_{B_{\text{net}}} = \omega^* R + \kappa(1-\sigma)(\Omega^f - \Omega^R)$$

to derive

$$\frac{d\omega^*_{B_{\text{net}}}}{d\lambda} = (1 - \kappa(1 - \sigma))\frac{d\omega^* R}{d\lambda} - \kappa(1 - \sigma)\frac{d\omega^R}{d\lambda}.$$   

With this we may conclude that $\frac{d\omega^*_{B_{\text{net}}}}{d\lambda} \neq 0$ for all $\lambda$ if and only if

$$\frac{d\omega^R/d\lambda}{d\omega^*R/d\lambda} \neq \frac{1 - \kappa(1 - \sigma)}{\kappa(1 - \sigma)} \text{ for all } \lambda. \quad (7.1)$$

To evaluate this condition, first note that the left-hand side is the slope of the $R^\lambda$ locus, which can be either positive or negative but which is finite by Assumption 1(iii). Next note that the right-hand side of this condition is non-negative, and goes to infinity if $\kappa(1 - \sigma)$ goes to zero. Hence, the condition is automatically satisfied when the $R^\lambda$ locus is downward sloping (as in the special model described in Appendix A). And if the $R^\lambda$ locus is upward sloping, the condition will still be satisfied provided that either the negotiation cost is large enough or Home’s bargaining power is high enough.

**C. Derivation of $\Delta^i + \Delta^j$ in the multi-country setting**

Consider first the static version of our extended setting. A key observation is that, for a given country pair $(i, j)$, the equilibrium joint payoff is decreasing in $\lambda_{ij}$ and $\lambda_{ji}$. This follows because Proposition 2 and the discussion preceding it apply also to our extended setting.

Next consider the dynamic setting. Suppose that at $t = 1$ a dispute occurs in which country $i$ is the exporter/complainant and country $j$ is the importer/defendant, and consider the future
impacts of a ruling in this dispute. At $t = 2$ there are six possibilities that we need to consider for the future impacts on countries $i$ and $j$: (i) with probability $P^{ij}$, there will be the potential for a dispute with country $i$ the complainant and country $j$ the defendant, in which case the relevant court experience $X_{ij}$ increases by an amount $\beta_1$; (ii) with probability $P^{ji}$ there will be the potential for a dispute with $j$ the complainant and $i$ the defendant, in which case $X_{ji}$ increases by an amount $\beta_2$; (iii) with probability $P^{io}$ there will be the potential for a dispute with $i$ the complainant and some third country $o$ the defendant, in which case $X_{io}$ increases by an amount $\beta_3$; (iv) with probability $P^{oi}$ there will be the potential for a dispute with $j$ the defendant and $o$ the complainant, in which case $X_{oj}$ increases by an amount $\beta_4$; (v) with probability $P^{jo}$ there will be the potential for a dispute with $o$ the complainant and $i$ the defendant, in which case $X_{oi}$ increases by an amount $\beta_5$; and (vi) with probability $P^{jo}$ there will be the potential for a dispute with $j$ the complainant and $o$ the defendant, in which case $X_{oj}$ increases by an amount $\beta_6$.

In light of the above considerations, we can write the joint future payoff gain for today’s disputants, $\Delta^i + \Delta^j$, as:

$$\Delta^i + \Delta^j = P^{ij}\{[\tilde{\omega}^{ij}_i(X_{ij} + \beta_1) + \tilde{\omega}^{ij}_j(X_{ij} + \beta_2)] - [\tilde{\omega}^{ij}_i(X_{ij}) + \tilde{\omega}^{ij}_j(X_{ij})]\}$$

$$+ P^{ji}\{[\tilde{\omega}^{ji}_i(X_{ji} + \beta_2) + \tilde{\omega}^{ji}_j(X_{ji} + \beta_3)] - [\tilde{\omega}^{ji}_i(X_{ji}) + \tilde{\omega}^{ji}_j(X_{ji})]\}$$

$$+ \sum_{o\neq i,j} P^{io}[\tilde{\omega}^{io}_i(X_{io} + \beta_3) - \tilde{\omega}^{io}_i(X_{io})] + \sum_{o\neq i,j} P^{oi}[\tilde{\omega}^{oi}_j(X_{oj} + \beta_4) - \tilde{\omega}^{oi}_j(X_{oj})]$$

$$+ \sum_{o\neq i,j} P^{ao}[\tilde{\omega}^{ao}_i(X_{oi} + \beta_5) - \tilde{\omega}^{ao}_i(X_{oi})] + \sum_{o\neq i,j} P^{ia}[\tilde{\omega}^{ia}_j(X_{jo} + \beta_5) - \tilde{\omega}^{ia}_j(X_{jo})],$$

where $\tilde{\omega}^{rs}_r(\cdot)$ and $\tilde{\omega}^{sr}_r(\cdot)$ denote the expected equilibrium (sub-)payoffs for country $r$ when country $r$ is respectively the period-2 complainant or period-2 defendant in a dispute with country $s$, and where we use the shorthands $\tilde{\omega}^{rs}_r(X_{rs}) \equiv \tilde{\omega}^{rs}_r(\lambda(X_{rs}))$ and $\tilde{\omega}^{sr}_r(X_{sr}) \equiv \tilde{\omega}^{sr}_r(\lambda(X_{sr})).$

As the expression for $\Delta^i + \Delta^j$ makes clear, if both complainant and defendant benefit from higher court quality, then $\Delta^i + \Delta^j$ must be positive, because every term in the expression for $\Delta^i + \Delta^j$ is then positive. But consider the case where court quality has opposing impacts on the defendant and the complainant: then the $P^{ij}\{\cdot\}$ and $P^{ji}\{\cdot\}$ terms in the expression above are positive, but of the four additional terms, up to two could be negative.\textsuperscript{53} Thus, in principle

\textsuperscript{53}This follows because these four additional terms are associated with cases where either $i$ or $j$ is either a
Δ^i + Δ^j could be negative. As mentioned in the main text, this ambiguity can be resolved by assuming that P^ij + P^ji is sufficiently close to one for each dyad ij. This ensures that the four “good” effects dominate the two “bad” effects, and hence Δ^i + Δ^j is positive.

In light of the above arguments, it is clear that the probability of a ruling must be decreasing in each x_m in an average sense as described in the main text, provided learning gets exhausted for a finite level of X_{ij}.

Next note that, assuming P^ij + P^ji is sufficiently close to one, and under analogous conditions as Assumptions 2 and 3, Δ^i + Δ^j is decreasing in each of the x_m’s; this follows immediately from the fact that the P^ij \{\} and P^ji \{\} terms dominate the remaining terms in the expression for Δ^i + Δ^j. If furthermore δ is large enough, so that the dynamic effect dominates, we can conclude that the probability of a ruling is decreasing in each x_m.

Finally, turning to the impact of x_m on the likelihood of a dispute, we can show that this impact in general is ambiguous. Suppose for instance that only β_1 is positive (directed-dyad specific learning), and that an increase in court efficiency is beneficial to the defendant but hurts the complainant, as is possible (see note 16): in this case, Δ^i < 0, Δ^j > 0 and Δ^i + Δ^j > 0. Focus on a parameter configurations such that the B^net point is at the dispute margin, i.e. on the no-transfer frontier, and consider increasing x_m to a level such that learning is exhausted. This implies that Δ^i and Δ^j are brought to zero, therefore the R + δΔ point moves Northwest with slope steeper than −1, and so does the B^net point. This could lead the B^net point to dip below the no-transfer frontier or to rise above it, thus the impact on the likelihood of a dispute is ambiguous.

8. Data Appendix

The data used in this paper comes from the WTO Dispute Settlement Database (see Horn, Johannesson and Mavroidis, 2011 for a description). This data set is maintained by the World Bank, and its current coverage includes each of the 426 documented WTO disputes between 1995 and August 2011.\textsuperscript{54} We exclude from our analysis the 24 disputes that were initiated defendant or a complainant with a third party. If complainants are hurt by an increase in court efficiency, then the two defendant terms must be positive, because the joint defendant-and-complainant payoff increases with the increase in court efficiency. And if defendants are hurt by an increase in court efficiency, then the two complainant terms must be positive, for the same reason.

\textsuperscript{54}Each dispute is associated with a unique DSnumber, which is the official case number recorded in WTO documents. Thus this data set includes disputes from DS1 to DS426.
after January 1 2010 (to avoid truncation of dispute outcomes in the dataset); and we exclude as well the 8 cases where the issue returns in a later dispute (which we include) or is simply handled in another dispute (which we include). And finally, we drop the 6 multi-complainant cases in this dataset that were each treated as a single dispute by the WTO (i.e., each of the claimants against the common respondent was listed under the same WTO dispute number), on the grounds that these cases reflect especially tight links across the claimants that would likely impact dispute behavior through channels about which our model is silent. After this set of exclusions we are left with 348 WTO disputes.

55 The 8 excluded cases are DS3, DS16, DS52, DS101, DS106, DS185, DS228, DS271, which respectively return or are handled in DS41, DS27, DS65, DS132, DS126, DS187, DS230, DS270.
56 The 6 excluded cases are DS27, DS35, DS58, DS158, DS217, DS234.
References


Figure 1: Equilibrium payoffs in the static setting
Figure 2: Impact of court quality in the static setting
Figure 3: Two-Period Setting

Figure 3a: When a ruling occurs in equilibrium

Figure 3b: When a ruling does not occur in equilibrium
<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Dispute Regression</th>
<th>Ruling Regression</th>
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<tr>
<td></td>
<td>N</td>
<td>mean</td>
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<tr>
<td>Undirected Dyads</td>
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<tr>
<td>Dependent Variable (ols)</td>
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<td>$CR_{ij,nk,t}$</td>
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<td>$CR_{n(i,j),nk,t}$</td>
<td>439,584</td>
<td>264.3</td>
</tr>
</tbody>
</table>

| Directed Dyads |       |       |       |     |     |       |       |       |     |     |
| Dependent Variable (logit) | 545,142 | 0.00486 | 0.0696 | 0   | 1   | 149,520 | 0.00431 | 0.0655 | 0   | 1   |
| Dependent Variable (ols) | 545,142 | 0.00512 | 0.0755 | 0   | 5   | 149,520 | 0.00443 | 0.0684 | 0   | 3   |
| $CR_{ij,k,t}$ | 545,142 | 0.00713 | 0.0970 | 0   | 5   | 149,520 | 0.0260  | 0.184  | 0   | 5   |
| $CR_{n(i,j),k,t}$ | 545,142 | 0.00567 | 0.0879 | 0   | 5   | 149,520 | 0.0187  | 0.161  | 0   | 5   |
| $CR_{ij,nk,t}$ | 545,142 | 0.0920  | 0.602  | 0   | 13  | 149,520 | 0.246   | 0.993  | 0   | 13  |
| $CR_{ij,nk,t}$ | 545,142 | 0.0661  | 0.392  | 0   | 10  | 149,520 | 0.143   | 0.572  | 0   | 10  |
| $CR_{ij,nk,t}$ | 545,142 | 0.938   | 2.583  | 0   | 34  | 149,520 | 1.460   | 2.990  | 0   | 34  |
| $CR_{ij,nk,t}$ | 545,142 | 1.712   | 5.197  | 0   | 66  | 149,520 | 3.615   | 7.069  | 0   | 66  |
| $CR_{ij,nk,t}$ | 545,142 | 1.361   | 5.104  | 0   | 66  | 149,520 | 2.598   | 6.999  | 0   | 66  |
| $CR_{ij,nk,t}$ | 545,142 | 22.07   | 51.90  | 0   | 265 | 149,520 | 34.17   | 63.52  | 0   | 264 |
| $CR_{ij,nk,t}$ | 545,142 | 15.87   | 26.93  | 0   | 117 | 149,520 | 19.93   | 29.39  | 0   | 117 |
| $CR_{ij,nk,t}$ | 545,142 | 225.0   | 194.4  | 0   | 631 | 149,520 | 202.9   | 177.4  | 0   | 631 |
## Table 2: Logit

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<th>Directed Dyad</th>
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Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

$ijFE$ are undirected dyad fixed effects. kFE are article fixed effects.
### Table 3: OLS

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<tr>
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<th>Observations</th>
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<td>Y</td>
</tr>
<tr>
<td>CE</td>
<td>i</td>
<td>i</td>
<td>CE</td>
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<td>i</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

$iFE$ ($ij FE$) are undirected (directed) dyad fixed effects. kFE are article fixed effects.
CE are standard errors clustered by undirected or directed dyads.
### Table 4: Dispute Regressions with Dyad-and-Article Fixed Effects

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<td>OLS</td>
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<td>$D_{ij,k_t}$</td>
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<tr>
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<td>-0.000593* (0.000304)</td>
</tr>
<tr>
<td>$CR_{n(ij),nk,t}$</td>
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<tr>
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<tr>
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<tr>
<td>Constant</td>
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</table>

Observations
(Pseudo) $R^2$

---

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<th>Directed Dyad</th>
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</table>

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

$i$/$j$ kFE ($i$/$j$ kFE) are undirected (directed) dyad-and-article fixed effects.

CE are standard errors clustered by undirected ($i$/$j$) or directed ($i$/$j$) dyads.