Learning by Ruling: A Dynamic Model of Trade Disputes*
(Preliminary Draft)

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Abstract

Over the WTO years, the frequency of disputes and court rulings has trended downwards. Such trends are sometimes interpreted as symptoms of a dispute resolution system in decline. In this paper we propose a theory that can explain these trends as a result of judicial learning; thus according to our theory such trends represent good news, not bad news. We then explore whether the predictions of our model are consistent with WTO trade dispute data, and we take a first step towards estimating the strength and scope of court learning.

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1. Introduction

Since the inception of the World Trade Organization (WTO) in 1995, there have been roughly 500 WTO trade disputes. The WTO is endowed with a sophisticated court system, the Dispute Settlement Body (DSB), which adjudicates disputes if governments fail to reach settlement. There is considerable variation in the outcome of these disputes: sometimes governments settle early, sometimes they “fight it out” to a DSB ruling. The stakes of disputes also vary widely across cases: sometimes stakes are small, but sometimes they involve large volumes of trade, thus it is important to understand what determines the initiation of disputes and their outcomes.

There are some interesting patterns in the initiation and resolution of disputes over time. Plot 1 shows the raw numbers of disputes and DSB rulings over the WTO years: the plot suggests a declining trend both in the frequency of disputes and in the frequency of DSB rulings, although in a more pronounced way for disputes than for rulings. The impression from Plot 1 is that countries “fight” less as the institution ages. If anything, Plot 1 understates this trend because the number of WTO members has increased over the last 20 years, and Plot 1 does not control for this. A simple way to control for the expanding WTO membership is to check whether country dyads fight less as they “age,” that is, the longer the pair of countries have both been WTO members. Plot 2 shows that indeed country dyads initiate fewer disputes and end up less frequently in court as they age.

One could interpret these declining trends in different ways. A natural interpretation is that they signal bad news for the WTO as an institution, in the sense that it is becoming less effective over time, or that governments are losing confidence in it.\footnote{In the context of the General Agreement on Tariffs and Trade (GATT), which was the precursor to the WTO, Hudec (1993, pp. 11-15) 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.} While this is certainly a possibility, in this paper we will propose a theory that can explain the declining trends in disputes and rulings as a result of institutional learning. According to our theory, these trends represent good news, not bad news.

We model a simple form of institutional learning, which we brand “learning by ruling”: we assume that, as the court accumulates experience, it becomes more accurate in evaluating the economic and political costs/benefits of trade policies. Judicial learning along these lines may occur, for example, because the court learns to use and interpret data and to make more effective 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 the WTO contract and thereby learns
to better translate the contract into the intent of the contracting parties. Formally we model
court learning as an increase in the precision with which the court observes the “state of the
world,” but similar results would obtain in a costly-state-verification setting if court learning
took the form of a reduction in the verification cost, or even in a complete-information setting
if court learning amounts to a reduction in the cost of issuing a ruling.

The importance of judicial learning has been emphasized by many legal scholars, although
typically in the context of domestic legal systems, not international institutions. 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).²

There are good reasons to believe that judicial learning may also be a phenomenon of first-
order importance in the WTO. The WTO is a relatively young institution, and the adjudication
of trade disputes is a complex task; so it is reasonable to think that, especially in the early
stages of the institution, there is significant learning by the actors involved in the WTO’s
judicial system. These actors include the Appellate Body, the Dispute Settlement panels, and
quite possibly also the WTO’s Secretariat, a group of experts that plays a key role in the dispute
settlement process.³ Our model of learning-by-ruling attempts to capture these diverse forms
of judicial learning in a transparent and tractable setting.

The key ingredients of our model are the following: (i) if a dispute is initiated, governments
(whose objective functions may include political-economy concerns) bargain “in the shadow
of the law,” subject to negotiation costs; (ii) if invoked, the court issues a ruling (with the
objective of maximizing the governments’ joint payoff) based on a noisy signal of the state of
the world; (iii) the court becomes more accurate as its experience grows, but at a diminishing
rate; and (iv) governments repeatedly engage in disputes, so they internalize the benefits of

²After describing the differences of opinion between Justices Holmes and Brandeis in an important 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 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)

³As we discuss in more detail later in the paper, the Appellate Body is a standing judicial body, so in this
case judges may learn directly from their own experience. The WTO Secretariat has considerable “institutional
memory,” so similar statements apply. But also the Dispute Settlement panel, which is a rotating body, may
learn from reading previous panel reports, as panel reports are public. Another form of learning that is probably
important as well is that governments, as they litigate repeatedly over time, may learn how the court operates
and adjudicates cases, thus they may learn to predict more accurately the outcome of a ruling. As we discuss
below, intuitively the implications of this type of learning by governments should be largely similar to those of
learning-by-ruling, but a rigorous examination would require a non-trivial extension of our model.
court learning. Our basic model focuses on continuous policies (such as tariffs) and assumes efficient international transfers, but we later consider the case of all-or-nothing policies (such as certain regulatory regimes that are essentially dichotomous in nature) and allow for the possibility of costly transfers.

Most existing models of “bargaining in the shadow of the law” explain equilibrium court intervention as bargaining failure due to incomplete information (or overconfidence about the ruling). Our model, by contrast, generates equilibrium court intervention for two different reasons. First, due to learning by ruling (and the fact that disputants may interact repeatedly in court), going to court today may imply future payoff gains; importantly, such payoff gains arise even if disputants do not go to court tomorrow, because court learning improves the disagreement point for tomorrow’s bargain. And second, if the policy is all-or-nothing in nature and international transfers are costly, an additional reason for equilibrium court intervention is the non-convexity of the bargaining set.

We focus first on the case of continuous policies (e.g. a tariff). In this case, we show that in a static setting there can never be a DSB ruling in equilibrium, but there can be a dispute, and a dispute is more likely when the DSB is less accurate. In a dynamic setting, on the other hand, the presence of court learning can give rise to rulings in equilibrium. When we examine how the likelihood of current disputes and rulings depend on court experience (cumulative rulings), we find that the relation is decreasing, at least if governments are patient enough; and even if governments are impatient, these results hold when the stock of cumulative rulings is large enough. 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 in terms of their impacts on the likelihood of current disputes and rulings. For example, in the case of current rulings, the dynamic effect of an increase in court experience makes a current ruling less likely because the future payoff gain from going to court is diminishing as the court walks down its learning curve; but the static effect goes in the opposite way because a decrease in DSB noise reduces the inefficiency of going to court today; and the dynamic effect dominates when the discount factor is sufficiently high.

Our basic two-country model focuses on the case in which court learning is general in scope, in the sense that a ruling today makes the court more accurate tomorrow regardless of which country is the defendant tomorrow. But it is possible that the scope of learning might be narrower, in that learning could be defendant-specific or complainant-specific or even
“directed-dyad-specific” (applying only to future disputes in which the same disputants play the same role in the dispute); and it is also possible that the scope of learning could be broader, in the sense that the effects of learning might spill over to disputes involving third parties. We consider these possibilities in the context of a many-country extension of our basic model. 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 and kind of court learning that is present.

Returning to the interpretive question we raised at the outset, our model suggests that the frequency of DSB use is not a reliable measure of the effectiveness of the institution. According to our theory, a declining trend in DSB disputes or rulings does not imply that the quality of the institution declines over time, in fact it is a symptom of beneficial learning. However, this is a statement about the change in the frequency of DSB use over time. Our theory also implies that a lower level of this frequency may well be a symptom of lower court accuracy: if the level of court accuracy (for given stock of cumulative rulings) is higher, the disagreement point is more likely to be above the Pareto frontier, so the likelihood of a ruling is higher.

We focus next on the case in which the trade policy is all-or-nothing in nature and international transfers are costly. Many real-world trade disputes are over regulatory regimes to which marginal changes cannot easily be made, and cash transfers as a form of compensation are rarely used in the context of settling these disputes, so this is an important case to consider. In this case, rulings can occur in equilibrium even in a static setting, and the reason lies in the non-convexity of the bargaining set: the uncertainty in the ruling may help governments share the (expected) surplus more efficiently than by using costly transfers. We show that in this case the likelihood of rulings and disputes decreases with court experience, even if governments are impatient. The reason this prediction holds regardless of the discount factor, unlike for a continuous policy, is that the static effect of an increase in DSB accuracy decreases the likelihood of a ruling, since this implies a less uncertain ruling and hence the surplus-sharing appeal of going to court is diminished. Thus the static effect and the dynamic effect of an increase in court experience go in the same direction. Furthermore, we note that when the policy is binary, introducing learning implies a “pivoting” of the time path of rulings and disputes, with more rulings/disputes occurring early on and fewer occurring later on.

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, we want to ask whether the above prediction is consistent with the data. And second, to the extent that the answer to this question is affirmative, we want 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 growth 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 productivity/accuracy of the court, so we cannot estimate directly the relationship between court experience and court accuracy; but we can use the predictions of our model to indirectly infer the importance of learning by ruling.

In particular, our model suggests that, the stronger the effect of cumulative past rulings on the likelihood of rulings and disputes, the more important learning by ruling is likely to be. While our basic model assumes only two countries and even our many-country extension assumes only one sector or issue area, in a world with many countries and many issue areas the scope of court learning might be general, or specific to the disputing countries, or specific to the disputed issue area. To operationalize the notion of “issue area” for our empirical analysis, we assume that an issue area is embodied in a GATT/WTO Article.

Our empirical findings are broadly consistent with our model of learning by ruling, and interestingly, we find evidence consistent with article-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 also find possible evidence of a “bandwagon” mechanism in dispute initiation that is outside our model. We argue, however, that our model is capable of accounting for some important features of the data that could not be fully explained by simple alternative models. In this light, we interpret our empirical findings as providing promising initial support for the proposition that court learning is an important phenomenon for understanding the pattern of WTO dispute resolution.

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

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4Our focus on learning ignores another dynamic mechanism that has a similar flavor to learning but has distinct implications and may also be present in the WTO, namely legal precedent. While our formal model abstracts from the issue of legal precedent, we consider this issue (along with several other alternative mechanisms) in the empirical part of the paper, where we argue that in principle the effect of legal precedent could explain some – but not all – of the patterns we observe in the data.
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 such as the desirability of legal precedent, while here we focus mostly on how learning affects the initiation and outcome of trade disputes. In Maggi and Staiger (2015a) 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).

By contrast, there is a large literature on the broader implications of judicial learning, but this literature is mostly informal and does not focus on international institutions. A few recent papers have developed formal models of judicial learning (see for example Baker and Mezzetti, 2012, and Beim, 2014), but the structure and focus of these models is very different from ours. In the literature on trade agreements, other models that generate trade disputes in equilibrium are Park (2011), Beshkar (2016) and Staiger and Sykes (forthcoming), 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.

On the empirical side, Guzman and Simmons (2002) examine whether disputes are more likely to end in settlement if they involve continuous rather than all-or-nothing policies. And there are other papers that examine various determinants of the initiation and outcome of trade disputes, including Busch (2000), Busch and Reinhardt (2000, 2006), Guzman and Simmons (2005), Bown (2005), Davis and Bermeo (2009), Bown and Reynolds (2014), Conconi et al. (2015), Kuenzel (2015) and Maggi and Staiger (2015a).

The rest of the paper is organized as follows. Section 2 presents our benchmark static model. 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 considers the case of binary policy. Section 6 examines the empirical content of our theory through WTO dispute data. Section 7 offers concluding remarks.

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. Home can choose an import barrier $T$, while the Foreign government is passive in this industry. For now we focus on the case in which the policy is continuous. For concreteness we assume $T$ is a tariff.

We assume the Home government maximizes a weighted welfare function which allows for political economy considerations. In particular, Home’s payoff is

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

where $CS$ is consumer surplus, $PS$ is producer surplus and $R$ is tariff revenue, and where $\theta \geq 1$ is a parameter that captures the political importance of the domestic industry. This government objective function is in the spirit of Baldwin (1987) and Grossman and Helpman (1994).

For simplicity we abstract from political economy considerations in the Foreign country, and assume the Foreign government maximizes national welfare, which in this setting is just the sum of consumer and producer surplus:

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

Placing an extra weight on producer surplus in this country would not affect our main results.

To simplify the exposition we assume that the demand and supply functions are linear in both countries. For future reference, note that $\omega^*(T)$ is decreasing and convex in $T$. Intuitively, the reason is that increasing the tariff $T$ reduces trade volume, and hence reduces the impact on foreign welfare of further increases in $T$. On the other hand, note that $\omega(T, \theta)$ is concave in $T$ provided $\theta$ is not too high: the reason is that $CS(T) + R(T)$ is concave but $PS(T)$ is convex. If $\theta$ is so high that $\omega(T, \theta)$ is convex, the unilaterally optimal tariff is prohibitive; we assume that $\theta$ does not exceed this threshold level.

We let the joint-payoff maximizing tariff be $T^{fb}(\theta) \equiv \arg \max_T [\omega(T, \theta) + \omega^*(T)]$. We will refer to this as the “first best” policy, and note that it is increasing in $\theta$. Also, we let the unilaterally optimal tariff be $T^N(\theta) \equiv \arg \max_T \omega(T, \theta)$. Clearly, $T^N(\theta)$ is increasing in $\theta$ and weakly higher than $T^{fb}(\theta)$.

We now characterize the government Pareto frontier, that is the locus of feasible government payoffs $(\omega, \omega^*)$. In the absence of government-to-government transfers, the frontier is concave for any $\theta$. Note that the frontier has a peak at the Nash tariff $T^N$ (point N) and has slope equal to -1 at the first best tariff $T^{fb}$ (point FB), as depicted in Figure 1. We label this the “no-transfer frontier.”
Now suppose that (costless) international transfers can be used. Then clearly the Pareto frontier is linear with slope -1 and tangent to the no-transfer frontier at the FB point (see Figure 1). In our basic model we assume that, if governments engage in negotiations, they can use efficient transfers, thus we label this the “negotiation frontier.”

The assumption that governments have access to efficient transfers when they negotiate simplifies the model and makes our points more transparent, but our main results would hold under the more realistic assumption that transfers are costly. 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.

We next describe the informational structure, the institutional environment and the role of the court (DSB). We consider the simplest possible environment in which the DSB plays an active role. In particular, the role of the court will be to “complete” an incomplete contract.

The political parameter $\theta$ (“state of the world”) is ex-ante uncertain, and distributed according to some distribution $f(\theta)$. We could allow for a more general multi-dimensional state of the world, but this would make the notation heavier without providing much further insight. The realization of $\theta$ is observed by governments but is not verifiable (not observed by the court), so governments cannot write a complete contingent contract. To simplify the model, we take the incompleteness of the contract to an extreme, assuming it does not specify the policy $T$ at all (discretion). However, the court is endowed with the authority to “fill the gap” of this contract ex-post. This institutional setting can be interpreted more broadly as one in which the contract imposes vague obligations and the court can interpret the contract ex-post.\footnote{In earlier work (Maggi and Staiger, 2011) we have examined the optimal design of the role of the DSB when a complete contingent contract cannot be written, and argued that under some conditions the optimal institution entails a contract that leaves discretion on trade policy and a court that plays a “gap filling” role ex-post. Another institution that may be optimal in that setting is one where the contract is vague and the court plays an “interpretation” role ex-post. As we argue in that paper, these two institutional forms have similar features and implications in many respects. An alternative possibility in that model is to let the court play only an enforcement role (non-activist court); this can be optimal if the accuracy of the court’s information is low. Thus an implicit assumption in the present model is that the accuracy of the court’s information is not too low, so that the optimal institution entails an activist court.}

More specifically, the DSB can observe a noisy signal of $T^{fb}$, given by $T^{dsb} = T^{fb} + \varepsilon$, where $\varepsilon$ is a white noise with mean zero and variance $\sigma^2$.\footnote{We could assume that the court observes a noisy signal of $\theta$ rather than a noisy signal of $T^{fb}$, at the cost of a slightly more complicated analysis. Note also that the assumption that $\varepsilon$ is independent of $\theta$ is somewhat restrictive, because it implies that the DSB can always make mistakes in either direction, so if the true $T^{fb}$ is close to 0 (free trade), it may prescribe a negative level of $T$ (import subsidy). Again, this feature could be made more realistic at the cost of a more complicated analysis.} If invoked, the DSB issues a (perfectly
enforceable) ruling to maximize the governments’ expected joint payoff conditional on its noisy information. Given our assumptions, the DSB ruling will prescribe the tariff level $T_{dsb}$. We also assume that, if governments go to court, they incur a symmetric litigation cost $C_L$.

Governments can avoid court intervention by bargaining. In particular, after observing the realization of $\theta$, they can bargain over the policy $T$ and a transfer, with a disagreement point given by the court ruling. That is, governments bargain “in the shadow of the law.”

Throughout the paper, we say that there is a “dispute” if governments engage in bargaining. 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 and settle outside the institutional framework, or in other words through informal (rather than formal) negotiations. Our model can be interpreted as applying to both formal and informal negotiations.

We can now describe the timing of the static game:

1. After $\theta$ is realized and observed by governments, Home chooses policy $T$;
2. Foreign acquiesces or initiates a dispute;
3. If a dispute is initiated, governments negotiate over policy $T$ and a transfer;
4. If the governments disagree, they each incur the litigation cost $C_L$, the DSB is invoked and a ruling is triggered.

We assume the simplest possible symmetric bargaining protocol: each government gets to make a take-or-leave offer with probability 1/2.

Government negotiations are subject to transaction costs. In particular, we assume an “iceberg” negotiation cost: a fraction $1 - \kappa$ of the bargaining surplus “melts” away. Formally, if $\omega_i^{ND}$ is government $i$’s net disagreement payoff (i.e. net of litigation costs) and $\omega_i^B$ its bargaining payoff absent negotiation costs, its payoff gain from the bargain is $\kappa \left( \omega_i^B - \omega_i^{ND} \right)$ with $\kappa \in (0, 1)$.

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7 The assumption that the DSB attempts 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. Given that international transfers are available, it is natural to suppose that this objective function is the governments’ joint payoff.

8 Alternatively we could allow the DSB to impose a maximum level of $T$, e.g. a tariff cap.

9 The cost $C_L$ does not play an important role in this basic continuous-policy model, but will play a bigger role in the binary-policy model of section 5.
The reason we need transaction costs in our model is clear: if there were no transaction costs, the disagreement point for government negotiations would be irrelevant to their joint payoff, and hence any institutional or contractual arrangement would be irrelevant as well. Later on we will consider another type of transaction cost, which is the presence of transfer costs.

Finally, we assume a veil of ignorance: from an ex-ante perspective (before \( \theta \) 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. This assumption will play an important role in the dynamic setting analyzed below.

We are now ready to characterize the equilibrium outcome of the static model. We focus on subgame perfect equilibria of the game described above. We proceed by backward induction and start with 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 DSB ruling; moreover, it lies Southeast of the \( \text{FB} \) 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, it is direct to verify that the expected disagreement payoffs are given by

\[
\omega^D = \omega(T^{FB}, \theta) + \omega_{TT} \cdot \sigma^2,
\]

\[
\omega^* = \omega^*(T^{FB}) + \omega^*_{TT} \cdot \sigma^2
\]

(with \( \omega_{TT} < 0, \omega^*_{TT} > 0 \)). These expressions make clear that increasing the DSB noise \( \sigma \) worsens Home’s threat point and improves Foreign’s threat point. Taking into account litigation costs, we can write the net disagreement payoffs as \( \omega^{ND} = \omega^D - C_L \) and \( \omega^{*ND} = \omega^*D - C_L \). These are the expected payoffs that governments get if they disagree, since in this case a ruling is triggered and governments pay litigation costs. This payoff pair \((\omega^{ND}, \omega^{*ND})\) is labeled \( ND \) in Figure 1. Since the point \( ND \) is always below the negotiation frontier, it is clear that there can never be a ruling in the static setting.

Next we examine when a dispute occurs in the static setting. Given our bargaining protocol and the iceberg negotiation cost, it is easy to derive the net bargaining payoffs in case a dispute is initiated. Letting \( \Omega \) denote joint payoff, and omitting the argument \( \theta \), we can write net
bargaining payoffs as

\[ \omega^{B_{net}} = \omega^{ND} + \kappa \cdot \frac{\Omega^{FB} - \Omega^{ND}}{2} = \omega^{FB} + \sigma^2 \cdot \left[\left(1 - \frac{\kappa}{2}\right)\omega^{TT} - \frac{\kappa}{2} \omega^{*TT}\right] - (1 - \kappa)C^L, \]

\[ \omega^{*B_{net}} = \omega^{*ND} + \kappa \cdot \frac{\Omega^{FB} - \Omega^{ND}}{2} = \omega^{*FB} + \sigma^2 \cdot \left[\left(1 - \frac{\kappa}{2}\right)\omega^{*TT} - \frac{\kappa}{2} \omega^{TT}\right] - (1 - \kappa)C^L. \]

Graphically, the net bargaining payoff point (labeled \( B_{net} \) in Figure 1) is somewhere between the ND point and its 45° projection onto the negotiation frontier.

Moving backwards to stages 1 and 2, it is easy to argue that: (i) if the \( B_{net} \) point is below the no-transfer frontier, Home chooses a tariff \( T \) such that Foreign is indifferent between complaining and not, so there is no dispute.\(^{10}\) Graphically, the outcome in this case is the vertical projection of \( B_{net} \) onto the no-transfer frontier, that is point \( B_0 \) in Figure 1. (ii) If point \( B_{net} \) is above the no-transfer frontier, Home will trigger a dispute by choosing a level of \( T \) that Foreign will complain about, the governments will settle, and the equilibrium payoffs are given by point \( B_{net} \).

Next we observe that, given \( \theta \), a dispute occurs if \( \sigma \) is above some threshold level. To see this note that, if \( \sigma \) increases, the \( B_{net} \) point moves Southeast in a linear way, starting from a point below the no-transfer frontier, and since this frontier is concave, it can only cross the frontier from the left. This is true for any \( \theta \), so we can conclude that the probability of a dispute increases with \( \sigma \). The economic intuition for the effect of \( \sigma \) on the likelihood of a dispute is that, when \( \sigma \) is high, the disagreement point is bad and skewed in favor of the exporter, so the marginal benefit of using side payments – and hence of initiating a dispute – is high.

We summarize with:

**Proposition 1.** In the static setting: (i) there is never a DSB ruling; (ii) the likelihood of a dispute is increasing in the DSB noise \( \sigma \).

We can also characterize how the governments’ payoffs change with \( \sigma \). This can be done in a graphical way. In Figure 2, the red locus depicts how the equilibrium outcome varies with \( \sigma \) for a given \( \theta \). As \( \sigma \) increases from zero, initially there is no dispute and the equilibrium payoff

\(^{10}\)We are implicitly assuming that Foreign does not complain in case of indifference.
point (which is the vertical projection of $B_{net}$ onto the no-transfer frontier) travels down along the no-transfer frontier, and after $\sigma$ crosses a threshold, the outcome is a dispute and the payoff point moves Southeast linearly with slope steeper than $-1$. It is then clear that increasing $\sigma$ leads to (i) an increase in the exporter’s equilibrium payoff; (ii) a decrease in the importer’s equilibrium payoff, and (iii) a decrease in the joint equilibrium payoff. Observe also that the joint equilibrium payoff is piecewise concave in $\sigma$.\footnote{To see this formally, focus first on the linear part of the red locus in Figure 2. Here the joint payoff is $\omega^{B_{net}} + \omega^*B_{net} = \Omega^{FB} + \sigma^2 \cdot (1-\kappa)[\omega_{TT} + \omega^*_{TT}] - 2(1-\kappa)C^L$. Since $\omega^*_{TT} + \omega_{TT} < 0$, this expression is concave in $\sigma$. Next focus on the concave part of the red locus. Here the joint payoff is $\omega^*B_{net} + G(\omega^*B_{net})$, where $G(\cdot)$ is the concave no-transfer frontier. It is easy to check that $\omega^*B_{net}$ is linear and increasing in $\sigma^2$, hence $G(\omega^*B_{net})$ is concave in $\sigma^2$, hence $\omega^*B_{net} + G(\omega^*B_{net})$ is concave in $\sigma^2$, hence $\omega^*B_{net} + G(\omega^*B_{net})$ is concave in $\sigma$.}

The following remark highlights the impact of $\sigma$ on the joint payoff; this plays an important role in the dynamic analysis to follow.

**Remark 1.** In the static setting, the equilibrium joint payoff is decreasing and piecewise concave in the DSB noise $\sigma$.

### 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. 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 in many dimensions, especially in the early stages of the institution. In this section we explore the implications of judicial learning for the dynamics of disputes and rulings.

One could consider different types of judicial learning. A first possibility is that the court can learn from its past experience. This is the notion that we refer to as *learning by ruling*. There are several mechanisms by which a court can learn from experience. One is that the court may become more accurate in conducting investigations and figuring out the economic and political costs/benefits of trade policies (and of domestic policies that have impacts on trade). This may involve learning to use and interpret data, or to choose the right experts, or just learning to use rigorous economic reasoning as such reasoning relates to the particular legal issues at hand. We can think of this as “methodological” learning, or in other words, “learning by doing” in investigating and adjudicating.

But we can also think of a “factual” type of learning by the court: 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”). Our model focuses on methodological learning, by assuming that the court’s information becomes less noisy ($\sigma$ goes down) as experience accumulates, and we shut down any factual learning by assuming that the state of the world (the parameter $\theta$ in our model) is iid over time. But the main logic of our results intuitively extends also to the case of factual learning. And as we mentioned in the Introduction, the model would deliver similar results if we assumed that the court can verify $\theta$ perfectly but at a cost, with learning taking the form of a reduction in such cost; or even if we assumed a complete-information setting where court learning takes the form of a reduction in the cost of issuing rulings.

In the case of a standing judicial body such as the WTO’s Appellate Body, it may be the judges 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 finally, 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.

Another type of learning that is probably quite relevant in the WTO is governments’ learning about the court. For example, it is possible that as governments litigate repeatedly in court, they learn how the court operates and adjudicates cases, and therefore they learn to better predict the outcome of a ruling. Intuitively, some of the implications of this type of learning should be similar to those of learning by ruling, because both types of learning imply that governments reap future gains by going to court today. However there may also be subtle differences in implications, because governments’ learning about the court does not per se increase the quality of court decisions. For this reason a formal analysis of this type of learning would be interesting in its own right, but we leave this extension for future research.

Finally, a dynamic mechanism that has a similar flavor but is quite distinct from learning is legal precedent. While it would be interesting to explore the implications of legal precedent, this too is beyond the scope of the present paper.\textsuperscript{12} We will come back to the notion of legal precedent.

\textsuperscript{12}In Maggi and Staiger (2011) we explore the implications of legal precedent for trade disputes, in a setting without any learning.
precedent, however, in the empirical section, because in principle this mechanism could explain some of the dynamic patterns observed in our data.

3.1. The two-period setting

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 \( \theta \) is \( iid \), so learning by ruling will be the only source of dynamics. The governments’ common discount factor is \( \delta \in (0, \infty) \).

We model learning by ruling in a similar fashion as in the typical models of learning by doing for firms, where increasing a firm’s current output increases its future productivity: we assume that adjudicating one more case today increases the accuracy of the court tomorrow. More specifically, if there has been a ruling at \( t = 1 \), the DSB noise (\( \sigma \)) at \( t = 2 \) is lower. This bare-bones two period model will allow us to make a couple of key points, but later in this section we consider a slightly richer version of the model to examine how the current likelihood of disputes and rulings depends on cumulative rulings.

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 generates future payoff gains.

Going by backward induction, at \( t = 2 \) the outcome is the same as in the static setting analyzed above, and hence there can be no rulings, but the situation is different at \( t = 1 \), because there is an investment value in going to court due to the learning effect. Recall from Remark 1 that, in the static setting, decreasing \( \sigma \) increases the equilibrium joint payoff. Thus, given the veil of ignorance, going to court at \( t = 1 \) implies a common future payoff gain, which we label \( \Delta \).

Notice that increasing future court accuracy benefits governments through an off-equilibrium mechanism, because at \( t = 2 \) there is no court activity in equilibrium. Making the court more accurate improves the disagreement point in case of dispute at \( t = 2 \), and the disagreement point matters because of the negotiation cost (\( \kappa \)). Moreover, even if no dispute takes place at \( t = 2 \), improving the would-be dispute outcome confers a joint-surplus benefit, because it leads to a more efficient policy choice by Home (an off-off-equilibrium effect).

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**Footnotes:**

13 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.

14 If we had a richer model with more than one period ahead of \( t = 1 \), the payoff gain \( \Delta \) would include also a direct effect of increasing court accuracy in case a ruling occurs in equilibrium.
In what follows we characterize the equilibrium outcome at \( t = 1 \). We do not use a time index, as this should not cause confusion.

At \( t = 1 \), the disagreement payoffs are \( (\omega^{ND} + \delta\Delta, \omega^{*ND} + \delta\Delta) \). Graphically, in Figure 3 we label the corresponding payoff point \( ND + \delta\Delta \). This point lies somewhere on the 45° line emanating from point \( ND \), and in general may be below or above the negotiation frontier. If point \( ND + \delta\Delta \) is above the negotiation frontier, then a dispute will end in ruling; and going backwards, Home chooses a policy \( T \) that triggers a complaint by Foreign.

Thus it is possible that a ruling will occur in equilibrium. This will be the case if the learning effect (and hence the future gain from going to court, \( \delta\Delta \)) is strong relative to the loss in joint payoff that governments incur today if they disagree and go to court (or graphically, the distance between the \( ND \) point and the negotiation frontier).

At a broad level, it is worth highlighting that the possibility of equilibrium rulings depends not only on the presence of learning by ruling, but also on the presence of “large” players who interact repeatedly in court, as well as on the implicit assumption that governments internalize the future gain from going to court. In our basic model, since there are only two countries, governments fully internalize this gain, but in a multi-country setting there could be international externalities from using the court: when a pair of countries goes to court today, there will be a benefit for other countries that use the court in the future unless the scope of court learning is confined to today’s disputant countries, and as a consequence, there is potential for “under-utilization” of the judicial system. We will return to this possibility later in the paper.

We can characterize how the occurrence of a ruling at \( t = 1 \) depends on the realization of the political economy shock \( \theta \) at \( t = 1 \). Note that the no-transfer frontier becomes less concave as \( \theta \) increases (since this increases the weight of the convex component in Home’s payoff function, \( PS \)), and hence the \( ND \) point gets closer to the negotiation frontier at \( t = 1 \); or equivalently, as \( \theta \) increases the joint payoff at \( ND \) is closer to the first best joint payoff. On the other hand, \( \Delta \) is independent of the realization of \( \theta \) at \( t = 1 \), because \( \theta \) is iid over time and \( \Delta \) is the expected future payoff gain from going to court at \( t = 1 \). Thus, as \( \theta \) increases, the \( ND + \delta\Delta \) point can only cross the negotiation frontier from below, and as a consequence a ruling occurs if \( \theta \) is above a certain threshold.\(^{15}\) Thus the model suggests that rulings are more likely to

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\(^{15}\)Formally, the difference in joint payoff between the first best and the \( ND \) point is \( \Omega^{FB} - \Omega^{ND} \), and the impact of \( \theta \) on this difference is \( \frac{\partial}{\partial \theta}(\Omega^{FB} - \Omega^{ND}) = \omega^{FB}_{\theta} \omega^{FB} - (\omega^{FB}_{\theta} + \sigma^{2}\omega_{TT}) = -\sigma^{2}\omega_{TT} < 0 \), where the sign follows from the fact that \( \omega_{TT} \) increases with \( \theta \). We also note here that the impact of \( \theta \) on the occurrence of a dispute is more ambiguous, because \( \theta \) affects not only the \( ND \) point but also the position of the no-transfer
occur, other things equal, when the importing government faces stronger political pressures from domestic import-competing producers.

What is the outcome at \( t = 1 \) if point \( ND + \delta \Delta \) is below the negotiation frontier, so there is no ruling? In this case, let \( B_{\Delta}^{net} \) denote the net bargaining payoffs at \( t = 1 \) given disagreement point \( ND + \delta \Delta \).\(^{16}\) Point \( B_{\Delta}^{net} \) lies between the \( ND + \delta \Delta \) point and its 45\(^0\) projection onto the negotiation frontier (with the distance determined by the negotiation cost). Then it is easy to argue that the outcome will be a dispute with settlement if \( B_{\Delta}^{net} \) is above the no-transfer frontier, and no dispute if \( B_{\Delta}^{net} \) is below the no-transfer frontier.

Note that, if learning is more important, in the sense that a ruling at \( t = 1 \) reduces \( \sigma \) by a bigger amount, not only the likelihood of a ruling but also the likelihood of a dispute is higher at \( t = 1 \). That a ruling is more likely when learning is more important is obvious, given our discussion thus far. The reason why also a dispute becomes more likely can be understood graphically as follows. Suppose the \( B_{\Delta}^{net} \) point is on the no-transfer frontier, so governments are at the margin between having a dispute and not: then, if \( \Delta \) increases, the \( B_{\Delta}^{net} \) point will move above the no-transfer frontier and there will be a dispute.

### 3.2. Impact of past rulings on current outcomes

How do past rulings affect the likelihood of current rulings and disputes? This question cannot be examined in the two-period scenario considered thus far, because rulings can occur only at \( t = 1 \), where there is no “past”; but a slight enrichment of the model allows us to address this question in a meaningful way.

To this end, we continue to assume two periods, \( t = 1, 2 \), but we now suppose there is an initial stock of rulings \( x \), inherited from a “past” period \( t = 0 \). To examine how past rulings affect current outcomes, we can then focus on the equilibrium outcome at \( t = 1 \) conditional on \( x \).\(^{17}\) Learning by ruling in this setting is represented by a decreasing function \( \sigma(x) \), which we assume is convex with \( \lim_{x \to \infty} \sigma(x) > 0 \). Under this assumption, learning proceeds at a diminishing rate and there is a “baseline” level of noise that cannot be removed by learning.

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\(^{16}\) More explicitly, the \( B_{\Delta}^{net} \) payoffs are the same as the \( B^{net} \) payoffs derived above in the static setting, except that the disagreement payoffs are \((\omega^D - C^L, \omega^D + \delta \Delta)\) instead of \((\omega^D - C^L, \omega^D + \delta \Delta)\).

\(^{17}\) It would be conceptually easy to endogenize the occurrence of a ruling at \( t = 0 \), but this would not add much to the question of how cumulative rulings affect current outcomes, because in a three-period setting this question is meaningful only from the perspective of the central period (\( t = 1 \)), since at \( t = 0 \) there is no past and at \( t = 2 \) there cannot be rulings.
We are now ready to study how an increase in $x$ affects the likelihood of rulings and disputes at $t = 1$. We first focus on the likelihood of a ruling.

Recall that a ruling occurs at $t = 1$ if and only if the $ND + \delta \Delta$ point is above the negotiation frontier, so we can write

$$\Pr(\text{ruling}) = \Pr(g < \delta \Delta),$$

where $g$ is the distance from the $ND$ point to the negotiation frontier along a 45° line, and

$$\Delta = E_0[\Omega_{t=2}(\sigma(x+1), \theta) - \Omega_{t=2}(\sigma(x), \theta)],$$

where $\Omega_{t=2}(\sigma, \theta)$ is the equilibrium joint payoff at $t = 2$ given $\sigma$ and $\theta$. First note that $g$ decreases with $x$, because as $\sigma$ decreases, the $ND$ point gets closer to the negotiation frontier.

We next argue that $\Delta$ also decreases with $x$. Intuitively, this follows from Remark 1, which states that $\Omega_{t=2}$ is decreasing and piecewise concave in $\sigma$, and the fact that the learning curve is convex. However, since (as we observed above) $\Omega_{t=2}$ may not be globally concave in $\sigma$, proving that $\Delta$ decreases with $x$ is not immediate. We relegate the proof of this claim to the Appendix.

Thus increasing $x$ reduces the future gain from going to court (the dynamic effect $\Delta$) but decreases today’s inefficiency from going to court (the static effect $g$). Clearly, if governments care enough about the future (i.e. if $\delta$ is sufficiently large), the dynamic effect dominates the static effect and the probability of a ruling decreases with $x$. But notice also that, even if $\delta$ is small, the probability of a ruling is decreasing in $x$ for $x$ sufficiently large,\footnote{A more precise statement is that there exist values $x_1$ and $x_2$ (with $x_1 < x_2$) such that the probability of a ruling is strictly decreasing for $x \in (x_1, x_2)$ and equal to zero for $x \in (x_2, \infty)$.} because when learning vanishes $\Delta$ goes to zero, while $g$ does not go to zero.

We just argued that if $\delta$ is sufficiently high or $x$ is sufficiently large, the frequency of rulings should decrease with $x$. But note that even if $\delta$ and $x$ are small the model does not necessarily predict that the frequency of rulings will increase. In our analysis above we have taken $x$ as given, but if $x$ were determined endogenously, the following observation would immediately apply: if $\delta$ is sufficiently small then $(\delta \Delta - g) \big|_{x=0} < 0$ for all $\theta$, so rulings would never get started in equilibrium. In this light it is not obvious whether our model could ever predict that the likelihood of rulings increases with $x$ and rulings occur in equilibrium.

Next we consider the impact of cumulative rulings on the probability of a dispute at $t = 1$. It is easy to argue that if $\delta$ is sufficiently high the likelihood of a dispute is globally decreasing in $x$. Intuitively, suppose governments are at the margin between disputing and not; this means...
that the $B^\Delta_{net}$ point defined above is on the no-transfer frontier. Increasing $x$ has two effects on $B^\Delta_{net}$: a “static” effect, that is a shift in the $ND$ point (towards the Northwest), and a “dynamic” effect (a decrease in $\Delta$). If $\delta$ is high enough, the dynamic effect dominates, so the $B^\Delta_{net}$ point dips below the no-transfer frontier, where there is no dispute.

We now argue that, regardless of $\delta$, the likelihood a dispute is decreasing in $x$ for $x$ sufficiently large. If $x$ is large, $\Delta$ is close to zero. We can focus on the dispute margin, that is the critical value of $\theta$ such that the $B^\Delta_{net}$ point is on the no-transfer frontier. It is easy to see that such a critical value of $\theta$ must exist provided that in the static setting (i.e. when $\Delta = 0$) the likelihood of a dispute is positive when $\sigma = \sigma_0$, a condition we henceforth assume. Increasing $x$ leads to a decrease in $\sigma$, which has a static effect (the $ND$ point shifts) and a dynamic effect ($\Delta$ decreases). These effects are both small, but they go in the same direction. With reference to Figure 2, which is approximately correct given that $\Delta$ is close to zero, the $B^\Delta_{net}$ line coincides (approximately) with the $B^\Delta_{net}$ line and the dispute margin corresponds (approximately) to the kink in the red locus. From this starting point, the static effect of a decrease in $\sigma$ pushes the $B^\Delta_{net}$ point below the no-transfer frontier, and the reduction in $\Delta$ also pushes the $B^\Delta_{net}$ point below the no-transfer frontier. We can thus conclude that if $x$ is sufficiently large, a further increase in $x$ must decrease the likelihood of a dispute.

We can summarize the results above with the following:

**Proposition 2.** At $t = 1$, both the likelihood of a ruling and the likelihood a dispute are decreasing in $x$ for $x$ sufficiently large, and are globally decreasing in $x$ if the discount factor $\delta$ is high enough.

Before moving on, it is worth emphasizing an important implication of the model: the frequency of DSB use is not a reliable measure of the effectiveness of the institution. This implication is illustrated most starkly in the context of the frequency of rulings: according to our theory, a declining frequency of rulings does not imply that the institution is getting worse over time, in fact it is a symptom of beneficial learning by the institution. But note that this statement 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 $\sigma(x)$ in such a way that $\Delta$ is not affected (or more generally, in such a way that the static effect of the change in $\sigma(x)$ dominates its dynamic effect): then the disagreement point is more likely to be above the
negotiation frontier, so other things equal the probability of a ruling will be higher.\textsuperscript{19}

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 intuition for this result is that the effect of an increase in $x$ on the ruling margin (which occurs when the $ND + \delta \Delta$ point is on the negotiation frontier) may be stronger or weaker than the effect of $x$ on the dispute margin (which occurs when the $B_{\Delta net}$ point is on the no-transfer frontier), depending on the probability distribution of $\theta$, and for this reason the ratio $\Pr(\text{ruling})/\Pr(\text{dispute})$ can either increase or decrease.\textsuperscript{20}

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 issuing a ruling today increases the court’s future accuracy regardless of which country is the defendant in the future. But one could consider more narrow forms of learning. For example, learning might be “directed-dyad specific,” meaning that a ruling where country $i$ is the complainant and $j$ the defendant increases the court’s future

\textsuperscript{19}At this point we can return to a statement we made earlier, namely that our qualitative results would be similar if court learning took a different form, for example a reduction in the cost of verifying $\theta$ in a costly-state-verification setting. Suppose the court can observe $\theta$ perfectly, but at a cost $C^V$ that is ultimately shared by governments with $s \in (0, 1)$ denoting Home’s share. Suppose further that court learning is captured by a decreasing and convex curve $C^V(x)$. Then it is easy to argue that: (i) increasing $x$ leads to a common future payoff gain $\Delta > 0$ through a reduction in the verification cost at $t = 2$, and that this payoff gain is decreasing in $x$, just as in our basic model; and (ii) by reducing the verification cost at $t = 1$, an increase in $x$ has a similar static effect as in our basic model. Intuitively, then, our main qualitative results should extend to this setting.

\textsuperscript{20}A more formal proof is the following. Consider a realization $\theta = \theta'$ such that $ND + \delta \Delta$ is just above the negotiation frontier. As $x$ increases, $\Delta$ decreases and hence for $\theta = \theta'$ the outcome switches from ruling to settlement. So if the probability mass of $\theta$ is concentrated around $\theta'$, then $\Pr(\text{settlement})/\Pr(\text{dispute})$ goes up. On the other hand, suppose there is zero probability mass for a small neighborhood around $\theta'$. Then a small-enough increase in $x$ does not affect $\Pr(\text{ruling})$, while it decreases $\Pr(\text{dispute})$, thus $\Pr(\text{ruling})/\Pr(\text{dispute})$ goes up and hence $\Pr(\text{settlement})/\Pr(\text{dispute})$ goes down.
accuracy only for disputes where again $i$ is the complainant and $j$ the defendant, but not if roles are reversed. This could be the case if for example the court learns about features of the political economy 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 broader forms of learning. For example, learning might be “defendant specific,” meaning that a ruling where country $i$ is the complainant and $j$ the defendant increases the court’s accuracy 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 $o$ (by which we mean “other than $i$ or $j$”).

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. With this extension we demonstrate how our theory generalizes to a setting with a rich array of possible learning forms, and we also enhance the theory’s ability to provide guidance for our empirical exploration.

We consider the simplest possible multi-country extension of our two-country partial equilibrium model: $N \geq 2$ countries, with each of the $\frac{N!}{2!(N-2)!}$ dyads trading two non-numeraire goods (one in each direction) which are themselves completely separable from each other and from all other non-numeraire goods that the countries trade, and with a freely traded numeraire good in the background that enters quasi-linearly into utility and ensures multilateral trade balance for each country. For dyad $ij$, we can then as before express the (separable) contribution from that dyad to the payoff of government $j$ as the sum of two terms, which are themselves each sums of terms: the sum of consumer surplus, producer surplus and tariff revenue associated with the product that country $j$ imports from country $i$, with the weight $\theta_{ij} \geq 1$ on producer surplus; and the sum of consumer surplus and producer surplus associated with the product that country $j$ exports to country $i$, with no extra weight on producer surplus in that sector (reflecting our assumption that political economy forces are absent in export sectors). We may similarly express the contribution of this dyad to the payoff of government $i$ given the political parameter $\theta_{ji} \geq 1$ on producer surplus associated with the product that country $i$ imports from country $j$. And as before, political parameters ($\theta_{ij}$ and $\theta_{ji}$) are ex ante uncertain. Finally, we continue to assume that there can be at most one dispute in any period.

We label $\sigma_{ij}$ the noise in the DSB signal of $\theta_{ij}$. Thus $\sigma_{ij}$ is interpreted as the court’s accuracy
in ruling on disputes brought by country \(i\) against country \(j\). We assume that \(\sigma_{ij} = \sigma(X_{ij})\), where \(\sigma(\cdot)\) is a decreasing and convex function, and \(X_{ij}\) is a composite experience variable that takes the form

\[
X_{ij} = \beta_1 x_{ij} + \beta_2 x_{ji} + \beta_3 \sum_{o \neq i,j} x_{io} + \beta_4 \sum_{o \neq i,j} x_{oj} + \beta_5 \sum_{o \neq i,j} x_{oz}.
\] (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, \(x_{io}\) the number of past rulings where \(i\) was the complainant and some third country \(o\) was the defendant, \(x_{oj}\) the number of past rulings where some third country \(o\) complained against \(j\), and \(x_{oz}\) is the number of all 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 helps the court rule with greater precision 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 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).  

We can now turn to analysis of the extended model. We start by examining how the likelihood of current rulings depends on past rulings. Under some mild further technical conditions that we introduce below, we will show that, if $\delta$ is sufficiently high, the probability of a ruling is weakly decreasing in $x_m$ for $m = ij, ji, io, oj, oz$, and strictly decreasing in particular subsets of the $x_m$ depending on the form of learning present.

Consider first the static version of our extended setting. The key observation is that, just as before, increasing court accuracy increases the defendant’s payoff, decreases the complainant’s payoff, and increases the joint payoff. This follows because Remark 1 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 $P_{ij}^{ij}$, 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 $P_{ij}^{ji}$ 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 $P_{ij}^{io}$ 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 $P_{ij}^{oj}$ 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 $P_{ij}^{oi}$ 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 $P_{ij}^{jo}$ there will be the potential for a dispute with $j$ the complainant and $o$ the defendant, in which case $X_{jo}$ increases by an amount $\beta_5$.

In light of the above considerations, what are the expected future payoff changes implied by a ruling at $t = 1$? Let us denote these future payoff changes for the complainant ($i$) and for the period-1 defendant ($j$) respectively as $\Delta_{ij}^i$ and $\Delta_{ij}^j$. We can write the joint future payoff

\[\Delta_{ij} = \Delta_{ij}^i + \Delta_{ij}^j.\]

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.
gain for today’s disputants as

\[
\Delta_{ij}^{i} + \Delta_{ij}^{j} = \\
\text{ } \\
\text{ } \\
\text{ } \\
P_{ij}^{ij}\{[\bar{\omega}_{i}^{ij}(X_{ij} + \beta_{1}) + \bar{\omega}_{j}^{ij}(X_{ij} + \beta_{1})] - [\bar{\omega}_{i}^{ij}(X_{ij}) + \bar{\omega}_{j}^{ij}(X_{ij})]\} \\
\text{ } \\
\text{ } \\
\text{ } + \text{ } P_{ij}^{ij}\{[\bar{\omega}_{i}^{ij}(X_{ji} + \beta_{2}) + \bar{\omega}_{j}^{ij}(X_{ji} + \beta_{2})] - [\bar{\omega}_{i}^{ij}(X_{ji}) + \bar{\omega}_{j}^{ij}(X_{ji})]\} \\
\text{ } \\
\text{ } \\
\text{ } + \sum_{o\neq i,j} P_{ij}^{io}[\bar{\omega}_{i}^{io}(X_{io} + \beta_{3}) - \bar{\omega}_{i}^{io}(X_{io})] + \sum_{o\neq i,j} P_{ij}^{jo}[\bar{\omega}_{j}^{jo}(X_{oj} + \beta_{4}) - \bar{\omega}_{j}^{jo}(X_{oj})] \\
\text{ } \\
\text{ } \\
\text{ } + \sum_{o\neq i,j} P_{ij}^{oi}[\bar{\omega}_{i}^{oi}(X_{oi} + \beta_{5}) - \bar{\omega}_{i}^{oi}(X_{oi})] + \sum_{o\neq i,j} P_{ij}^{ji}[\bar{\omega}_{j}^{ji}(X_{jo} + \beta_{5}) - \bar{\omega}_{j}^{ji}(X_{jo})],
\]

where \(\bar{\omega}_{r}^{rs}(\cdot)\) and \(\bar{\omega}_{r}^{sr}(\cdot)\) denote the expected (with respect to \(\theta\)) equilibrium 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 notation \(\bar{\omega}_{r}^{rs}(X_{rs}) \equiv \bar{\omega}_{r}^{rs}(\sigma(X_{rs}))\) and \(\bar{\omega}_{r}^{sr}(X_{sr}) \equiv \bar{\omega}_{r}^{sr}(\sigma(X_{sr}))\).

We know from our earlier discussion that, in a given period, a decrease in DSB noise benefits the defendant, hurts the complainant, and increases their joint payoff. It is thus clear that the \(P_{ij}^{ij}\{\cdot\}\) and \(P_{ij}^{ij}\{\cdot\}\) terms in the expression above are positive. Also, since a decrease in DSB noise benefits the defendant, the \(P_{ij}^{io}[\cdot]\) and \(P_{ij}^{jo}[\cdot]\) terms are positive as well, as these terms correspond respectively to the possibilities that \(i\) or \(j\) is a defendant in a dispute with a third party. On the other hand, since a decrease in DSB noise hurts the complainant, the \(P_{ij}^{oi}[\cdot]\) and \(P_{ij}^{ji}[\cdot]\) terms are negative, as these terms correspond respectively to the possibilities that \(i\) or \(j\) is a complainant in a dispute with a third party. Thus in principle \(\Delta_{ij}^{i} + \Delta_{ij}^{j}\) could be negative.

To simplify the exposition we impose a restriction which ensures that the four “good” effects dominate the two “bad” effects: we assume that \(P_{ij}^{ij} + P_{ij}^{ji}\) is sufficiently close to one for each dyad \(ij\). We emphasize that this assumption 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 \(\Delta_{ij}^{i}\) is not very different from \(\Delta_{ij}^{j}\)), or taking the opposite approach, by assuming enough heterogeneity across country dyads, so that \(\Delta_{ij}^{i} + \Delta_{ij}^{j}\) is positive at least some of the time (note that we need \(\Delta_{ij}^{i} + \Delta_{ij}^{j}\) to be positive only in some states of the world, not always).\(^{22}\)

\(^{22}\)Note that the ambiguity in the sign of \(\Delta_{ij}^{i} + \Delta_{ij}^{j}\) arises because the complainant/exporter likes uncertainty, and therefore benefits from a higher \(\sigma\). This feature is in turn a consequence of two assumptions: that the exporter is risk neutral, and that the policy \(T\) is one-dimensional. To understand the second statement, recall that for any realization of the DSB signal \(T_{dsb}\) the payoff outcome is on the Pareto frontier (as in Figure 1), thus conditional on \(T_{dsb}\) the possibility of DSB errors has distributional implications but does not generate inefficiencies. If \(T\) is multi-dimensional, on the other hand, it is easy to argue that DSB noise will generate
The next point is that, if \( \Delta_{ij}^i + \Delta_{ij}^j \) is large enough, a ruling will occur at \( t = 1 \). With an abuse of notation, denote \( \Delta \) the vector \( (\Delta_{ij}^i, \Delta_{ij}^j) \), and recall that the disagreement point at \( t = 1 \) is given by \( ND + \delta \Delta \). It is then clear that if \( \Delta_{ij}^i + \Delta_{ij}^j \) is large enough, \( ND + \delta \Delta \) lies above the negotiation frontier, hence a ruling occurs at \( t = 1 \).\(^{23}\)

How does an increase in \( x_m \) affect the probability of a ruling between (complainant) \( i \) and (defendant) \( j \) at \( t = 1 \)? 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) each of the experience variables \( X_m \), hence decreasing (at least weakly) the current DSB noise, 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 \( \Delta_{ij}^i + \Delta_{ij}^j \). It is easy to see that, under our assumption that \( P_{ij}^{ij} + P_{ij}^{ji} \) is sufficiently close to one, \( \Delta_{ij}^i + \Delta_{ij}^j \) is decreasing in each of the \( x_m \)'s: this follows immediately from the fact that the \( P_{ij}^{ij} \{\cdot\} \) and \( P_{ij}^{ji} \{\cdot\} \) terms dominate the remaining terms in the expression for \( \Delta_{ij}^i + \Delta_{ij}^j \), and that the expected joint surplus \( \tilde{\omega}_{ij}^{ij} + \tilde{\omega}_{ij}^{ji} \) is concave in \( X_{ij} \). Thus, as in our two-country setting, the dynamic effect works in the opposite way as the static effect: other things equal, it pushes down the probability of a ruling, because it makes it less likely that the point \( ND + \delta \Delta \) lies above the negotiation frontier.

In light of the above arguments, it is clear that if \( \delta \) is large enough the dynamic effect outweighs the static effect, and the probability of a ruling is decreasing in each \( x_m \). Furthermore, it is also clear that, regardless of \( \delta \), if \( X_{ij} \) is large enough the probability of a ruling is decreasing in each \( x_m \), just as in our two-country setting, because the probability of a ruling eventually must hit zero as \( X_{ij} \) gets large.\(^{24}\)

Finally, we ask whether also the likelihood of a dispute is decreasing in \( x_m \). The answer is yes if \( \beta_1 \) is sufficiently close to \( \beta_2 \) (so that learning is essentially undirected-dyad specific) and \( \delta \) is sufficiently large (this can be seen from a continuity argument and the observation that a

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\(^{23}\)It is worth noting that, to the extent that there are learning spillovers that can benefit third countries in the future (e.g. \( \beta_3 \) or \( \beta_5 \) are strictly positive) there is potential for under-utilization of the court system, in the sense that may not be large enough to generate a ruling in equilibrium even though this would be desirable from a global standpoint. While this is an interesting possibility that merits further examination, it goes beyond the scope of this paper, which is mainly positive rather than normative.

\(^{24}\)A more formal statement of this result is that there exist critical values \( x_1^m \) and \( x_2^m \) (with \( x_1^m < x_2^m \)) such that the probability of a ruling is strictly decreasing for \( x_m \in (x_1^m, x_2^m) \) and equal to zero for \( x_m \in (x_2^m, \infty) \). Note also that this result does not rely on the assumption that \( P_{ij}^{ij} + P_{ij}^{ji} \) is sufficiently close to one.
setting with $\beta_1 = \beta_2$ is analogous to our two-country setting of the previous section), but we
do not have a more general result. To see why, suppose for instance that only $\beta_1$ is positive
(directed-dyad specific learning). Suppose further that the $B_{\Delta}^{net}$ point is at the dispute margin,
i.e. on the no-transfer frontier, and suppose $\delta$ is large, so that we can ignore the static effect
and focus on the dynamic effect. Consider an increase in $x_{ij}$ or $x_{ji}$: as we argued above, in
this case $\Delta^i_{ij} < 0$, $\Delta^j_{ij} > 0$ and $\Delta^i_{ij} + \Delta^j_{ij} > 0$, and furthermore, increasing $x_{ij}$ or $x_{ji}$ reduces
$\Delta^i_{ij} + \Delta^j_{ij}$. It can also be shown that increasing $x_{ij}$ or $x_{ji}$ reduces both $\Delta^i_{ij}$ and $\Delta^j_{ij}$ in absolute
value. This implies that the $ND + \delta\Delta$ point moves Northwest with slope steeper than $-1$, and
so does the $B_{\Delta}^{net}$ point. This could lead the $B_{\Delta}^{net}$ point to dip below the no-transfer frontier or
to rise above it, thus the impact on the likelihood of a dispute is ambiguous.25

5. Binary policy

The model we have presented above generates equilibrium court intervention for a single reason:
due to learning by ruling, going to court today may imply future payoff gains. We now explore
a second reason for equilibrium rulings, which is static in nature, and which arises if policy
is discrete and transfers are costly. This will provide a “baseline” frequency of rulings which
persists even absent learning (or after learning is exhausted). And as we have argued elsewhere
(see Maggi and Staiger, 2015a, 2015b), costly transfers are a highly relevant case in the context
of trade disputes, where compensation almost never takes the form of cash payments, and many
trade disputes involve features of regulatory regimes that are arguably discrete in nature.

As in our basic model, we consider a two-country model where the importing government
($H$) chooses a policy and the exporting government ($F$) can initiate a dispute. But here we
assume that $H$ makes a binary policy choice $T \in \{FT, P\}$, where $FT$ denotes “Free Trade” and
$P$ denotes “Protection.” We continue to assume the availability of a transfer, which we denote
by $b$ (which is positive if $H$ makes a transfer to $F$), but we now assume that the transfer carries
with it a dead-weight-loss $c(b)$ borne by the government making the payment. For tractability,
we assume $c(b) = c \cdot |b|$, with $c \in (0, 1)$.

$H$’s payoff is given by $\omega = v(T) - b - c^+(b)$, where $v(T)$ is the importing government’s
payoff associated with the policy choice $T$ (and could amount to a politically weighted sum of

25It is important to observe, however, that this ambiguity arises because the complainant benefits from DSB
noise, thus, as we indicated in footnote 22, this ambiguity might be removed if we introduced risk aversion or
if we allowed for multi-dimensional policy.
producer surplus, consumer surplus and tariff revenue as in the previous section), and where \( c^+(b) = c(b) \) if \( b > 0 \) and 0 otherwise. Similarly, \( F \)'s payoff is given by \( \omega^* = v^*(T) + b - c^-(b) \), where \( v^*(T) \) is the exporting government’s payoff associated with the (Home) policy choice \( T \), and where where \( c^-(b) = c(b) \) if \( b < 0 \) and 0 otherwise.

It is useful to define the importing government’s gain from protection: \( \gamma = v(P) - v(FT) \geq 0 \). Similarly, we define the exporting government’s loss from protection: \( \gamma^* = v^*(FT) - v^*(P) \geq 0 \). We take the “state of the world” \( (\gamma, \gamma^*) \equiv \gamma \) to be uncertain ex-ante, distributed according to \( F(\gamma) \), and we assume that \( F \) is symmetric: \( F(\gamma, \gamma^*) = F(\gamma^*, \gamma) \). And we allow that the joint loss from protection \( \gamma^* - \gamma \) can be positive or negative (due, say, to political economy forces or the existence of various potential domestic market failures). When \( \gamma^* - \gamma > 0 \) the first-best (i.e. joint-payoff-maximizing) policy is \( T = FT \), and when \( \gamma^* - \gamma < 0 \) the first-best policy is \( T = P \).

As we did in the previous section, below we use \( T^{fb} \) to denote this first-best policy choice. The realized \( \gamma \) is observed by governments but is not verifiable, and the policy \( T \) is not specified in the contract. As before, we allow the court/DSB, if invoked, to “fill the gap” in the contract. As in the previous section, we assume that each government incurs the litigation cost \( C_L \) when the DSB is invoked; and if invoked, we assume that the DSB observes \( T^{fb} \) imperfectly.

In the binary policy context, we model the signal technology in a particularly simple way: we assume that the DSB makes a mistake with probability \( q \in (0, 1/2) \). So for example, if \( T^{fb} = P \) the DSB ruling is \( P \) with probability \( 1 - q \) and \( FT \) with probability \( q \). This assumption is restrictive, because \( q \) is independent of \( \gamma \), but it keeps the analysis tractable and transparent.

Finally, we focus on the case of “general” learning, as in our basic two country continuous-policy model. We let \( x \) again denote the cumulative stock of rulings, and assume that \( q \) is decreasing and convex in \( x \). Hence \( q(x) \) with \( q_x < 0 \) and \( q_{xx} > 0 \) is the DSB learning curve.

The timing is as before: (0) \( \gamma \) is realized and observed by the governments; (1) The importer chooses \( T \); (2) The exporter acquiesces or initiates a dispute; (3) If a dispute is initiated, the governments negotiate over the policy \( T \) and a transfer \( b \), subject to the negotiation cost \( \kappa \); (4) If the governments disagree, they each incur the litigation cost \( C_L \), the DSB is invoked and a ruling is triggered. We maintain the bargaining protocol from the previous section, namely, that with equal probability each government gets to make a take-or-leave offer.

In the interest of space here we only state the main results of this binary policy setting and provide some intuition, relegating the formal analysis to the Appendix. We start with a remark

\[26\]
concerning the static benchmark setting:

**Remark 3.** In the static binary-policy setting: (i) the probability of a ruling is strictly positive, provided $C^L$ is sufficiently small; (ii) as DSB accuracy increases ($q$ falls toward 0), both the frequency of disputes and the frequency of rulings goes down, while the likelihood that a dispute will end in a ruling may go up or down.

Hence, when policies are discrete and transfers are costly, disputes can result in rulings (provided $C^L$ is sufficiently small) independent of any learning effect. With continuous policies, no ruling is possible, whether or not transfers are costly; and it is easily shown that with discrete policies as in the current section, if transfers were costless rulings would again not be possible. It is the combination of these two features – discrete policies and costly transfers – that is capable of generating rulings in the static model.

The intuition for Remark 3(i) is clearest in the case where the efficiency stakes of the dispute are very low and $\gamma^* - \gamma$ is essentially zero (though the stakes for each party in the dispute, $\gamma$ and $\gamma^*$, might be very large). In this case joint surplus is hardly affected by the policy choice, and so there is essentially no cost to joint surplus of a DSB ruling that is mistaken; and here, settling the dispute with the correct policy choice but with a costly transfer will be unattractive to the disputing parties relative to the expected joint surplus that comes from allowing the DSB to issue a (possibly mistaken) ruling and avoiding the use of the costly transfer.

Remark 3(ii) highlights that, in the case of binary policy, the static effect of an increase in DSB accuracy is to depress the frequency of disputes and rulings, by increasing the predictability of the ruling. In what follows we will refer to this as the “predictability” effect.

We now turn to the dynamic setting. As before, we let $x$ denote the cumulative number of rulings that have occurred prior to period 1. In the Appendix we show the following result:

**Proposition 3.** In the dynamic binary-policy setting: (i) At $t = 1$ the likelihood of disputes and rulings is globally decreasing in $x$, provided $C^L$ is sufficiently small (but the likelihood that a dispute ends in a ruling can go up or down); (ii) The presence of learning increases the likelihood of period-1 disputes and rulings (but does not necessarily increase the likelihood that disputes end in a ruling in period 1).

Part (i) of Proposition 3 extends our central result regarding the impact of cumulative rulings to a binary policy setting. Notice that in this setting the result holds for any $\delta$, and the
reason is that the static effect of an increase in $x$ (the predictability effect) goes in the same direction as the dynamic effect (a reduction in $\Delta$). Proposition 3(ii) highlights that introducing learning generates a “pivoting” of the time path of rulings/disputes, in the sense that there are more early on and fewer later on.

Comparing the findings of this with the previous section, our model suggests that (i) disputes and rulings should be more frequent for binary than continuous policies (two reasons to go to court instead of one), and (ii) the negative effect of $x$ on the likelihood of disputes and rulings should be stronger for binary than continuous policies, because with binary policies the static and dynamic effects of a change in $x$ go in the same direction, whereas for continuous policies these two effects counteract each other; as a result, with continuous policy the effect of $x$ is guaranteed to be negative only for high $\delta$, whereas with binary policies it is negative for any $\delta$.

6. Empirical Evidence

We now provide an initial assessment of the empirical content of our theory, examining patterns in WTO dispute behavior and focusing on the theory’s most central prediction: if there is DSB learning, the likelihood of current disputes and rulings should tend to decrease with the stock of cumulative past rulings. This prediction emerges from our basic model and each of the various extensions that we have considered, though for the case of current disputes some qualifications arise in our multi-country extension. Our empirical investigation has a dual objective. First, we want to ask whether our theory’s central prediction is consistent with the data. And second, to the extent that the answer to this question is affirmative, we want to gauge the empirical importance of learning by ruling and assess its scope and form.

Recall that our many-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 directed-dyad-and-article specific, undirected-dyad-and-article specific, complainant-and-article specific, defendant-and-article specific, and
article specific. And of course, combinations of these different dimensions of learning might be present but in different degrees.

We will attempt to investigate empirically all of these different potential domains of learning. But as a first pass, we simplify and distinguish only among three domains: article/issue area, undirected dyad, and general.

We also 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 potentially important sample selection problem when measuring the frequency of disputes. Nevertheless, with this caveat in mind, we will examine how past rulings affect the current frequency of both rulings and disputes.

Our dataset consists of 388 WTO disputes initiated between 1995 and 2009 as contained in the WTO Dispute Settlement Database and described in Maggi and Staiger (2015a). Letting \( i \) index country dyads that have had at least one WTO dispute over our sample period, \( k \) index GATT/WTO Articles that were disputed at least once over our sample period, and \( t \) index years in our sample period, we define the following variables: \( D_{i,k,t} \) is the number of disputes initiated by country-dyad \( i \) on article \( k \) in year \( t \); \( R_{i,k,t} \) is the number of country-dyad-\( i \) disputes on article \( k \) that led to an adopted panel ruling in year \( t \); and \( CR_{i,k,t} \) is the cumulative number of country-dyad-\( i \) disputes on article \( k \) that led to an adopted panel ruling prior to year \( t \). In what follows, we refer to \( R_{i,k,t} \) simply as the number of “rulings” for dyad \( i \) on article \( k \) in year \( t \), and similarly for the variable \( CR_{i,k,t} \).

Notice that our convention is to date disputes by the year in which they are formally initiated

\[27\text{Specifically, starting with the 426 WTO disputes initiated between 1995 and August 2011 covered in the WTO Dispute Settlement Database, we follow Maggi and Staiger (2015a) and drop the 24 disputes in this data set initiated after January 1 2010 (to avoid truncation of dispute outcomes in the dataset). And like Maggi and Staiger, we drop as well 8 cases where the issue formally returns in a later dispute (which we include) or is simply handled formally in another dispute (which we include). And finally, we drop the 6 multi-complainant cases in this dataset – the 5 described in Maggi and Staiger, plus the additional multi-complainant case DS35 which was dropped by Maggi and Staiger on other grounds – that were each treated as a single dispute by the WTO (i.e., each of the claimants against the common respondent was listed under the same WTO dispute number), on the grounds that these cases reflect especially tight links across the claimants that would likely impact dispute behavior through channels about which our model is silent.}\]
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. Our primary goal is to explore the possibility that $D_{i,k,t}$ and $R_{i,k,t}$ might vary with cumulative past rulings in ways that could reflect the impacts of DSB learning.

6.1. Some simple plots

We begin with some simple plots, focusing on rulings. The analogous plots for disputes are somewhat weaker but reflect broadly similar patterns.

In Plot 3 we depict on the vertical axis $R_{i,k,t}$, the number of rulings for any dyad on article $k$ in year $t$, and on the horizontal axis we depict $CR_{i,k,t}$, the cumulative number of rulings for any dyad on article $k$ prior to year $t$. The appearance of a negative relationship in Plot 3 is suggestive of the presence of article-specific DSB learning according to our model.

In Plot 4 we depict on the vertical axis $R_{i,.t}$, the number of rulings for dyad $i$ (on any article) in year $t$, and on the horizontal axis we depict $CR_{i,.t}$, the cumulative number of rulings for dyad $i$ (on any article) prior to year $t$. The appearance of a negative relationship in Plot 4 is suggestive of the presence of undirected-dyad-specific DSB learning according to our model, though this relationship seems weaker than the relationship in Plot 3.

Finally, in Plot 5 we depict on the vertical axis $R_{i,.t}$, the number of rulings for dyad $i$ (on any article) in year $t$, and on the horizontal axis we depict $CR_{.,.t}$, the cumulative number of rulings – on any article and for any dyad – prior to year $t$. Unlike for Plots 3 and 4, Plot 5 shows no discernible relationship between current rulings and cumulative past rulings, and hence no suggestion of general DSB learning according to our model.

6.2. Regressions

We next turn to some basic regressions, in order to probe the visual impressions suggested by Plots 3-5. We will consider both undirected dyads and directed dyads. To facilitate this distinction, we now use $\overleftarrow{ij}$ instead of $i$ to index undirected dyads and introduce the notation $D_{\overleftarrow{ij},k,t}$ in place of $D_{i,k,t}$ to refer to the undirected dyad version of this variable, and similarly we now use $R_{\overleftarrow{ij},k,t}$ and $CR_{\overleftarrow{ij},k,t}$ to refer respectively to $R_{i,k,t}$ and $CR_{i,k,t}$. We will then use $\overrightarrow{ij}$
to index directed dyads, where country $i$ is the complainant and country $j$ is the defendant, and use $D_{ij,k,t}$, $R_{ij,k,t}$ and $CR_{ij,k,t}$ to represent the directed dyad versions of these variables.

Below we present results from 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.

**Undirected Dyads**  Focusing first on undirected dyads, we present two regressions, one for disputes and one for rulings. 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. The dependent variable in the dispute logit regression is $D_{ij,k,t}$, defined as 1 if $D_{ij,k,t} \geq 1$ and 0 otherwise. 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. The dependent variable in the ruling logit regression is $R_{ij,k,t}$, defined as 1 if $R_{ij,k,t} \geq 1$ and 0 otherwise. For both the dispute and ruling regressions, the key independent variables of interest are four measures of cumulative past rulings, which we denote by $CR_{ij,k,t}$, $CR_{n(\overrightarrow{ij})},k,t$, $CR_{ij,nk,t}$ and $CR_{n(\overrightarrow{ij}),nk,t}$, where a subscript $nz$ denotes “not $z$” for index $z$.

We capture *article-specific* court experience with the variable $CR_{n(\overrightarrow{ij})},k,t$, defined as the cumulative number of rulings for dyads other than $\overrightarrow{ij}$ on article $k$ prior to year $t$. We capture *undirected-dyad-specific* court experience with the variable $CR_{ij,nk,t}$, defined as the cumulative number of rulings for dyad $\overrightarrow{ij}$ on articles other than $k$ prior to year $t$. And we capture *general* court experience with the variable $CR_{n(\overrightarrow{ij}),nk,t}$, defined as the cumulative number of rulings for
dyads other than $ij$ on articles other than $k$ prior to year $t$. 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.

The results of the undirected dyad 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). 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).

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-$ijk$ variation over time to estimate the regression coefficients would diminish our ability to assess the impact of those variables that exhibit little within-$ijk$ variation over time. 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 $ijk$ fixed effect would introduce an incidental parameters problem and lead to biased and inconsistent estimates for our relatively short panel. An implication is that if

$^{29}$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 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, available on request, are robust to the inclusion of these additional controls.

$^{30}$Relatively, 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 (which exhibits little within-year variation over the cross-section of $ijk$).

$^{31}$Letting $T$ denote the length of the panel, the issue that arises for our ruling regressions if an $ijk$ 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 $ijk$ 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
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 $CR_{n(\tilde{ij}),k,t}$ and $CR_{\tilde{ij},nk,t}$ are negative and strongly significant, confirming the visual impressions of Plots 3 and 4 and suggesting the presence of article-specific and dyad-specific DSB learning. And while the coefficient estimate on $CR_{n(\tilde{ij}),nk,t}$ 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, in line with the visual impression of Plot 5. Finally, notice that the point estimate of the coefficient on $CR_{ij,k,t}$, our narrowest measure of DSB experience, is 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 $CR_{n(\tilde{ij}),k,t}$ and $CR_{\tilde{ij},nk,t}$ are negative and significant, while the coefficient estimate on $CR_{n(\tilde{ij}),nk,t}$ 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 $\tilde{ij}k$ fixed effect. Recall that inclusion of this fixed effect will diminish our ability to assess the impact of those variables that exhibit little within-$\tilde{ij}k$ 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 $\tilde{ij}k$ fixed effect does not mechanically lead to biased or inconsistent estimates as would be the case for the rulings problem and possible approaches to addressing it.

32 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.
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 $k$ 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.

**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 for the directed dyads, 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 $DLogit_{ij,k,t}$ (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 $RLogit_{ij,k,t}$ (defined as 1 if $R_{ij,k,t} \geq 1$ and 0 otherwise).\footnote{The dependent variables for the OLS directed-dyad dispute and ruling regressions are $D_{ij,k,t}$ and $R_{ij,k,t}$.}

For both the dispute and ruling regressions, the key independent variables of interest are now the 10 measures of cumulative past rulings denoted by $CR_{ij,k,t}$, $CR_{(ni)j,k,t}$, $CR_{(nj)i,k,t}$, $CR_{ji,k,t}$, $CR_{other,k,t}$, $CR_{ij,nk,t}$, $CR_{(ni)j,nk,t}$, $CR_{(nj)i,nk,t}$, $CR_{ji,nk,t}$ and $CR_{other,nk,t}$. The meaning of these variables can be understood as follows. There are two groups of five $CR$ variables, the first group specific to article $k$ and the second to all other articles (not $k$). Consider first the five $k$-specific variables, which correspond to five subsets of the universe of directed dyads:

1. the same directed dyad as in the dependent variable ($ij$); the corresponding variable


$CR_{ij,k,t}$ captures directed-dyad-and-article specific court experience;

(2) the “reverse” directed dyad, i.e. where $j$ complains against $i$; the corresponding variable $CR_{ji,k,t}$ captures court experience specific to the reverse directed dyad and the article (and thus, together with $CR_{ij,k,t}$, captures undirected-dyad-and-article specific court experience);

(3) directed dyads where $i$ is the complainant but the defendant is not $j$; the corresponding variable $CR_{i(nj),k,t}$ captures complainant-and-article specific court experience;

(4) directed dyads where $j$ is the defendant but the complainant is not $i$; the corresponding variable $CR_{(ni)j,k,t}$ captures defendant-and-article specific court experience;

(5) all the remaining directed dyads; the corresponding variable $(CR_{other,k,t})$ 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 $CR_{other,nk,t}$ 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 again 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 estimated coefficient on $CR_{i(nj),nk,t}$ is also negative and strongly significant, suggesting complainant-specific learning. 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 $CR_{\text{other},k,t}$, $CR_{ij,nk,t}$, and $CR_{n(j),nk,t}$ 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 $CR_{\text{other},nk,t}$ 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 $ijk$ fixed effect in columns 3 (logit) and 4 (OLS) of Table 4. When the $ijk$ 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.\footnote{Note that when an $ijk$ 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 $CR_{\text{other},k,t}$ 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 $ijk$ fixed effect. And the positive and significant coefficient on $CR_{n(j),nk,t}$ 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 $CR_{\text{other},k,t}$ together with the positive and significant coefficient on $CR_{(mi)j,k,t}$, which we discuss next.}

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 $CR_{(mi)j,k,t}$ has switched from negative but insignificantly different from zero to positive and strongly significant. Recalling that our model (with continuous policies in its multi-country extension) yields more ambiguous predictions about the impacts of experience variables such as $CR_{(mi)j,k,t}$ on the frequency of disputes than it does for rulings, it is possible that the positive coefficient on $CR_{(mi)j,k,t}$ 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.\textsuperscript{35}

Overall, the results of our regressions reveal several important points. We find robust evidence consistent with article-specific and disputant-specific court learning (with the latter taking the form of directed-dyad-specific and complainant-specific learning), while we find only weak evidence of general-scope learning.\textsuperscript{36} It is also notable that the coefficient of the linear time trend is positive in all of our regressions. The fact that controlling for our measures of court experience (the $CR$ variables) wipes out the negative effect of calendar time suggests that court learning can indeed explain the raw declining trend in disputes and rulings that was evidenced in Plots 1 and 2, as we hypothesized at the outset. And finally, 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.\textsuperscript{37}

\textbf{6.3. 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.

\textsuperscript{35}It is also interesting to note that, while the logit coefficient on $CR_{ji,k,t}$ 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).

\textsuperscript{36}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. 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.

\textsuperscript{37}Various stories about a bandwagon effect seem plausible, but the details of court remedies (e.g., how complete they are, whether they apply effectively to $3^{rd}$ 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 35). This points to the value of modeling such effects before going further in investigating their empirical content, a task we leave to future research.
We begin with the most narrow version of this question: Can we be sure that, when viewed through the lens of our model, our empirical findings admit only the interpretation we have given them? 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 is “Yes.” To this end, we return to our multi-country, continuous-policy 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 areas. 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 disputes with respect to the \(x_m\)'s. We can interpret our regressions as estimating these derivatives: in particular, we find that 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 \(x_{io}\) (complainant-specific court experience), while it is essentially 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.\(^{38}\) 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.

We next ask whether there are alternative interpretations of our empirical findings based on alternative models. One plausible candidate is that there is learning going on, but that it takes the form of governments learning about each other. To consider this alternative interpretation, 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

\(^{38}\)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.
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 $CS_{j,k,t}$ variables in the undirected dyad regressions, and on the $CS_{ij,k,t}$, $CS_{i,j,k,t}$, $CS_{j,i,k,t}$ and $CS_{j,i,n,k,t}$ variables in the directed dyad regressions). In fact, we fail to find any robust evidence for such coefficient estimates.\footnote{One might alternatively conjecture that learning about each other reduces the governments’ negotiation costs in the future (e.g., by eliminating within-dyad persistent private information). This conjecture could be captured within our model in a reduced form way with the assumption that \(\kappa\) rises when governments learn about each other. But it is not hard to show in the context of our model that an increase in \(\kappa\) increases the settlement rate (by increasing the likelihood of disputes and reducing the likelihood of rulings). Contrary to this prediction, the trend in the settlement rate in WTO disputes has been flat or slightly negative.}

A second plausible candidate that could provide an alternative interpretation of at least \textit{some} of our findings is the impact of legal precedent. Under this interpretation, court rulings help to complete the incomplete WTO contract (as for example in Maggi and Staiger, 2011), so as the stock of rulings accumulate, there are fewer and fewer contingencies that are left uncovered by the contract, thus the frequency of rulings may naturally decrease. More specifically, suppose that a given WTO article \(k\) is initially incomplete and is silent about a set \(M_0\) of contingencies, out of the total set of contingencies \(M\). Suppose further that, in each period of time, one contingency is randomly selected out of the set \(M\), and if this contingency is not covered by the contract, the court may be called upon to specify the contractual obligations for this contingency. Then, in this simple scenario, as the stock of rulings accumulates the probability of new rulings goes down. Admittedly, the legal precedent interpretation may well explain part or even all of our empirical findings with regard to effects we attribute to article-specific learning.\footnote{An interesting possibility to distinguish between these two interpretations of our findings regarding article-specific effects might be to investigate whether these effects are also present in the early GATT era, when legal precedent was by all accounts not operative (see, for example, the discussion of the views of GATT/WTO legal scholars on this point in Maggi and Staiger, 2011). We view this as a promising avenue for further research.} But importantly, this explanation does not seem compelling as an alternative to our DSB learning story when it comes to our findings regarding defendant- and complainant-specific effects. Hence, we view legal precedent as plausibly being part, but \textit{only} part, of the explanation of our empirical findings above.

A third candidate is the presence of government learning about the court. It is useful to distinguish between two types of learning within this category. A first possibility is that, by observing how the court operates, governments may learn to better predict the outcome of rulings (a possibility we mentioned previously in section 3). This might be the case, for example, if governments learn about the court’s preferences and possible biases. 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. However one can view this type of learning as falling into a broader notion of “institutional learning,” and so we view this interpretation as broadly complementary – rather than competing – with our interpretation of judicial learning.

Another possibility is that governments might learn about the court’s accuracy (σ), and in particular one might hypothesize that, as a result of past rulings, governments have become more pessimistic about the quality of court rulings. This is essentially the “bad news” story we mentioned in the Introduction. One issue that makes this candidate interpretation unappealing is that if one is willing to assume systematically biased prior beliefs, virtually anything can be explained. But even putting this issue aside, while it is possible that a formal version of this story could deliver predictions that match the main features of the data, this is not necessarily the case. To see this, consider the simplest two-country version of this story, where governments initially think the court learning curve is \( \sigma(x) \), and then they receive bad news that leads them to believe \( \sigma(x) \) is higher than previously thought. And let us suppose for simplicity that \( \sigma(x) \) shifts up in a way that preserves the initial \( \Delta \) (or \( \Delta \) doesn’t change enough to outweigh the static effect). Then the probability of a ruling will go down, but the probability of a dispute will go up (because intuitively, as we have noted before, when \( \sigma \) is high the disagreement point is bad and skewed in favor of the exporter, so the marginal benefit of using side payments – and hence of initiating a dispute – is high); and the second implication is inconsistent with our data (as is the additional implication that the settlement rate will rise – see note 39).

Finally, it is possible that the increasing complexity of WTO disputes combined with a fixed resource constraint faced by the WTO court could account in a mechanical way for the overall declines in the numbers of WTO disputes and rulings that are depicted in our Plots 1 and 2. But our regressions are picking up something more: a resource-constraint story would not predict that declines in disputes and rulings would be systematically related to our \( CR \) variables, but rather this story would naturally show up along with other factors in our time trends; and even if one were to argue that our \( CR \) variables somehow reflect this explanation,

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41 The average number of stages in a WTO dispute at which a ruling is issued (e.g., panel, appeal, compliance panel) is growing over time. This is another dimension on which the demands placed on the WTO court for handling a given WTO dispute has increased. Plots 1 and 2 indicate the numbers of WTO disputes that are initiated and the number of disputes that result in rulings, so these plots do not reflect this added dimension.
it would presumably be the general $\text{CR}$ effect, not a disputant-specific or article-specific $\text{CR}$ effect, where this explanation would be reflected, and we don’t find strong general effects.

7. Conclusion

Over the two decades that the WTO has been in existence, the frequency of WTO disputes and court rulings has trended downwards. Such trends are sometimes interpreted as symptoms of a dispute resolution system in decline. In this paper we have proposed a theory that can explain these trends as a result of judicial learning. And according to our theory, such trends represent good news, not bad news. We have also confronted the theory with data from WTO disputes. We interpret our empirical findings as supporting the proposition that court learning is an important phenomenon for understanding the pattern of WTO dispute resolution.

Beyond providing support for the theory, our empirical findings shed some light on the scope and form that learning by ruling may take in the WTO. As interpreted through the lens of our model, we have found robust evidence in the pattern of WTO disputes and rulings that is consistent with article-specific learning and with some forms of disputant-specific learning, but 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. Still, we have only focused empirically on the most central prediction of our theory, and have therefore only scratched the surface of exploring the potential role of court learning in accounting for the dynamics of dispute resolution. Based on the promising results from our initial empirical exploration, a deeper empirical analysis of the impacts of court learning on the dynamics of disputes and rulings seems an important task for future research.

The theory itself can also be extended in interesting ways. For example, we have abstracted from the possibility of free-rider issues in the context of court learning, and the fact that we find only weak evidence of general-scope learning suggests that at least the most extreme free-rider possibilities may not arise in practice. Moreover, one might expect free-rider issues to become more severe over time as the WTO membership has expanded, and yet according to our estimates the time trends in the frequency of WTO disputes and rulings are positive, suggesting at most a more modest role for free-rider effects. But incorporating free-rider issues into our model could nevertheless yield interesting further implications, including predictions about how the frequency of disputes and rulings depend on the probability of future interaction (persistence of matches), the size of countries (bigger countries internalize more the benefits of
learning) and the total number of countries in the agreement.

8. Appendix

A. Proof that $\Delta$ decreases with $x$ in the case of continuous policy: Ignoring the integer nature of $x$, we approximate $\partial \Delta / \partial x$ as:

$$\frac{\partial \Delta}{\partial x} = \frac{\partial}{\partial x} E_\theta[\Omega(\sigma(x+1), \theta) - \Omega(\sigma(x), \theta)] \approx \frac{\partial^2}{\partial x^2} E_\theta \Omega(\sigma(x), \theta) = E_\theta[\Omega_{\sigma \sigma}(\cdot)](\sigma'(x))^2 + E_\theta[\Omega_{\sigma}(\cdot)]\sigma''(x),$$

where we omit the superscript $t = 2$ from the joint payoff $\Omega$, as this should not cause confusion. Remark 1 above implies $\Omega_{\sigma}^{t=2} < 0$ for all $\sigma$, and since the learning curve is convex, the second term of the above expression is negative. We now prove that $E_\theta[\Omega_{\sigma}^{t=2}(\sigma, \theta)] < 0$ for all $\sigma$.

Let $\sigma_{kink}(\theta)$ denote the critical level of $\sigma$ at which $\Omega(\sigma, \theta)$ has a kink (that is, the kink in the red locus of Figure 2) as a function of $\theta$. To simplify the proof we assume that $\sigma_{kink}(\theta)$ is invertible, and let $\theta_{kink}(\sigma)$ denote the inverse function. We then distinguish between two cases:

Case 1: $\theta'_{kink}(\sigma) > 0$. Let us derive $\frac{\partial^2}{\partial \sigma^2} E_\theta[\Omega(\sigma, \theta)]$, keeping in mind that $\Omega_{\sigma}(\sigma, \theta)$ is discontinuous at $\theta_{kink}(\sigma)$. Applying the Leibnitz rule, we can write:

$$= \frac{\partial}{\partial \sigma} \int_{\theta_{\min}}^{\theta_{\max}} \Omega_{\sigma}(\sigma, \theta) f(\theta) d\theta$$

$$= \frac{\partial}{\partial \sigma} \left[ \int_{\theta_{\min}}^{\theta_{kink}(\sigma)} \Omega_{\sigma}(\sigma, \theta) f(\theta) d\theta + \int_{\theta_{kink}(\sigma)}^{\theta_{\max}} \Omega_{\sigma}(\sigma, \theta) f(\theta) d\theta \right]$$

$$= \int_{\theta_{\min}}^{\theta_{kink}(\sigma)} \Omega_{\sigma}(\sigma, \theta) f(\theta) d\theta + \theta'_{kink}(\sigma) \Omega^-_{\sigma}(\sigma, \theta_{kink}(\sigma)) f(\theta_{kink}(\sigma))$$

$$+ \int_{\theta_{kink}(\sigma)}^{\theta_{\max}} \Omega_{\sigma}(\sigma, \theta) f(\theta) d\theta - \theta'_{kink}(\sigma) \Omega^+_{\sigma}(\sigma, \theta_{kink}(\sigma)) f(\theta_{kink}(\sigma))$$

$$= \int_{\theta_{\min}}^{\theta_{\max}} \Omega_{\sigma}(\sigma, \theta) f(\theta) d\theta + \theta'_{kink}(\sigma) f(\theta_{kink}(\sigma)) [\Omega^-_{\sigma}(\sigma, \theta_{kink}(\sigma)) - \Omega^+_{\sigma}(\sigma, \theta_{kink}(\sigma))$$

where $\Omega^-_{\sigma}$ and $\Omega^+_{\sigma}$ denote respectively the left and right derivative of $\Omega$ at the kink, and $f(\theta)$ is the density of $\theta$. Note that in this case $\Omega^-_{\sigma}(\sigma, \theta_{kink}(\sigma)) < \Omega^+_{\sigma}(\sigma, \theta_{kink}(\sigma)) < 0$, so given $\theta'_{kink}(\sigma) \geq 0$ we can conclude that $\frac{\partial^2}{\partial \sigma^2} E_\theta[\Omega(\sigma, \theta)] < 0$.

Case 2: $\theta'_{kink}(\sigma) < 0$. In this case the equation above still holds, but now $\Omega^+_{\sigma}(\sigma, \theta_{kink}(\sigma)) < \Omega^-_{\sigma}(\sigma, \theta_{kink}(\sigma))$, and hence again $\frac{\partial^2}{\partial \sigma^2} E_\theta[\Omega(\sigma, \theta)] < 0$. QED

It is easy to extend the argument to take into account the integer nature of $x$. 

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B. Formal analysis for the case of binary policy. Before we begin the analysis, it is useful to describe graphically the negotiation frontier in $(\omega, \omega^*)$ space. As Figure 4 illustrates, for any given state of the world and with our assumptions on the transfer $b$, the negotiation frontier is given by the outer envelope of two concave sub-frontiers, with one sub-frontier emanating from the point $(v(P), v^*(P))$ labeled $P$ in Figure 4, and the other sub-frontier emanating from the point $(v(FT), v^*(FT))$ labeled $FT$. Figure 4 illustrates three particular state realizations that together span the possible shapes of the negotiation frontier. In the top left panel, $FT$ is the joint surplus maximizing policy choice, and the joint gains from $FT$ relative to $P$ are sufficiently large that the $FT$ sub-frontier everywhere dominates the $P$ sub-frontier; and the negotiation frontier is therefore concave. It is easy to show that this corresponds to state realizations satisfying $\frac{\gamma}{\gamma'} < \frac{1}{1+c}$. In the top right panel, $P$ is the joint surplus maximizing policy choice, and the joint gains from $P$ relative to $FT$ are sufficiently large that the $P$ sub-frontier everywhere dominates the $FT$ sub-frontier; and the negotiation frontier is again concave. This corresponds to state realizations satisfying $\frac{\gamma}{\gamma'} > 1 + c$. Finally, the bottom panel illustrates the case where $\frac{1}{1+c} < \frac{\gamma}{\gamma'} < 1 + c$ and the joint surplus from $P$ and $FT$ are sufficiently similar that neither sub-frontier dominates everywhere; here the negotiation frontier has a region of convexity.

We are now ready to analyze the model. We begin by analyzing the static benchmark, and consider first the subgame where a dispute has been initiated, and governments negotiate over the policy $T$ and a transfer $b$, subject to the negotiation cost $\kappa$. When will governments settle at the negotiation stage (stage 3), and when will their negotiations end in disagreement and trigger a DSB ruling?

Recall that a ruling will occur if and only if the expected net disagreement point $ND$ lies above the negotiation frontier. In terms of Figure 4, if litigation costs were zero the expected disagreement point would lie on the line segment connecting the points $P$ and $FT$; and with positive litigation costs the point $ND$ then lies somewhere below this line segment. It then follows immediately by inspection of the top left and top right panels of Figure 4 that a ruling will never be triggered for state realizations satisfying $\frac{\gamma}{\gamma'} < \frac{1}{1+c}$ or $\frac{\gamma}{\gamma'} > 1 + c$.

To see when a ruling will be triggered, we may therefore focus on the range of state realizations satisfying $\frac{1}{1+c} < \frac{\gamma}{\gamma'} < 1 + c$, where the negotiation frontier is illustrated in the bottom panel of Figure 4. To characterize the conditions where rulings occur, we need expressions for the expected net disagreement payoffs and the negotiation frontier over this range of state realizations. The expected net disagreement payoffs for the negotiation are easily derived. For
$\gamma > \gamma^*$ within this range, the expected net disagreement payoffs are:

$$\omega^{ND} = v(P) - q\gamma - C^L \quad \text{and} \quad \omega^{*ND} = v^*(P) + q\gamma^* - C^L. \quad (8.1)$$

For $\gamma < \gamma^*$ within this range, the expected net disagreement payoffs are:

$$\omega^{ND} = v(FT) + q\gamma - C^L \quad \text{and} \quad \omega^{*ND} = v^*(FT) - q\gamma^* - C^L. \quad (8.2)$$

It is direct to derive that, for $1 + c < \frac{1}{y}$, if a dispute occurs, then a ruling is triggered iff

$$(1 + c)\gamma^* - \gamma > \frac{(2 + c)C^L}{q} \quad \text{and} \quad (1 + c)\gamma - \gamma^* > \frac{(2 + c)C^L}{(1 - q)}. \quad (8.3)$$

while for $\frac{1}{1+c} < \frac{1}{\gamma} \leq 1$, if a dispute occurs, then a ruling is triggered iff

$$(1 + c)\gamma^* - \gamma > \frac{(2 + c)C^L}{(1 - q)} \quad \text{and} \quad (1 + c)\gamma - \gamma^* > \frac{(2 + c)C^L}{q}. \quad (8.4)$$

The “ruling region” is the set of states characterized by (8.3) and (8.4). Notice that as DSB noise decreases (i.e., as $q$ falls from $\frac{1}{2}$ toward 0), the ruling region shrinks. Hence, increasing DSB accuracy makes a ruling less likely, and $\Pr(\text{ruling}) \to 0$ as DSB noise vanishes. Also, an increase in $C^L$ clearly decreases the likelihood of a ruling. Finally, notice that as the ruling region is contained in the cone $\gamma/\gamma^* \in (\frac{1}{1+c}, 1 + c)$, it follows that DSB rulings can be triggered only if “efficiency stakes” are relatively small.

We now move backwards to stage 2 and examine when a dispute occurs. We let $\omega^D, \omega^{*D}$ denote the expected equilibrium payoffs in the dispute subgame (net of bargaining and litigation costs). Does $F$ initiate a dispute? If $H$ has chosen $FT$, $F$ does not complain. If $H$ has chosen $P$, $F$ complains iff $\omega^{*D} > v^*(P)$. Backing up, $H$ chooses $P$ if either $\omega^{*D} < v^*(P)$ (so $F$ will acquiesce) or $\omega^{*D} > v^*(P)$ and $\omega^D > v(FT)$ (so $F$ will complain but $H$ is better off in a dispute than under $FT$ and no transfer). Otherwise $H$ will choose $FT$.

Collecting these points, we have the following: (i) if $\omega^{*D} > v^*(P)$ and $\omega^D < v(FT)$, $H$ chooses $FT$ and there is no dispute; (ii) if $\omega^{*D} < v^*(P)$, $H$ chooses $P$ and there is no dispute; (iii) if $\omega^{*D} > v^*(P)$ and $\omega^D > v(FT)$, $H$ chooses $P$ and there is a dispute. Thus, there is dispute iff $\omega^D > v(FT)$ and $\omega^{*D} > v^*(P)$.

Now let’s consider the state realizations for which a dispute arises. First note that, if $\gamma$ is in the ruling region, clearly there is a dispute, because in this case $\omega^{ND} > v(FT)$ and $\omega^{*ND} > v^*(P)$. So we can focus on the remaining regions, that is, the case where the $ND$ point is below
the negotiation frontier. In this case, there is a dispute iff \( \omega^{B_{net}} > v(FT) \) and \( \omega^{*B_{net}} > v^*(P) \); and here governments will settle. Our remaining task is therefore to characterize the state realizations for which settlement occurs, which we refer to as the “settlement region.”

Given our bargaining protocol, the gross expected payoff from the bargain for \( H \) is \( (\omega^{TOL} + \omega^{ND})/2 \), where \( \omega^{TOL} \) is \( H \)’s gross payoff when \( H \) makes the take-or-leave offer; and similarly, the gross expected payoff for \( F \) is \( (\omega^{*TOL} + \omega^{*ND})/2 \). Taking into account negotiation costs, the net bargaining payoffs are easily shown to be \( \omega^{B_{net}} = \frac{\kappa}{2}\omega^{TOL} + (1 - \frac{\kappa}{2})\omega^{ND} \) and \( \omega^{*B_{net}} = \frac{\kappa}{2}\omega^{*TOL} + (1 - \frac{\kappa}{2})\omega^{*ND} \). Given \( \gamma > \gamma^* \), the settlement region is defined by the conditions

\[
\frac{\kappa}{2}\omega^{TOL} + (1 - \frac{\kappa}{2})\omega^{ND} > v(FT) \quad \text{and} \quad \frac{\kappa}{2}\omega^{*TOL} + (1 - \frac{\kappa}{2})\omega^{*ND} > v^*(P),
\]

whenever the \( ND \) point is below the negotiation frontier (otherwise the take-or-leave payoffs are not defined, and we are in the ruling region). The dispute region of course is the sum of the settlement region and the ruling region. Finally, given the symmetry of the model, in the octant \( \gamma < \gamma^* \) the dispute region is the mirror image of the one in the region \( \gamma > \gamma^* \).

As a special case, note that if \( \kappa = 0 \) the dispute region boils down to the region where \( \gamma > \frac{C_L}{q} \) and \( \gamma^* > \frac{C_L}{q} \). In the opposite benchmark case of no negotiation costs, \( \kappa = 1 \), it is easy to show that there is always a dispute. For general \( \kappa \), it can be shown that decreasing \( q \) shrinks the dispute region. This can be established easily by a graphical argument based on the negotiation frontiers in Figure 4. Fix a state \( \gamma \) and consider a decrease in \( q \). There is a dispute iff the \( B_{net} \) point is in the quadrant defined by the \( P \) point and the \( FT \) point. By graphical inspection of Figure 4, as \( q \) falls, the \( B_{net} \) point can only move from inside this quadrant to outside it, not vice-versa. This is true both if the frontier has a convex portion (as in the bottom panel of Figure 4) and if it does not. Since this is true for any \( \gamma \), it follows that a reduction in \( q \) decreases the likelihood of dispute.

We now focus on the dynamic setting. Let \( I \) be an indicator variable that takes the value 1 if there is a ruling in period 1 and takes the value 0 otherwise. At \( t = 2 \), we have the static outcome characterized above, therefore \( x \) affects \( Pr(\text{Dispute}) \) and \( Pr(\text{Ruling}) \) at \( t = 2 \) only through the static predictability effect (which by Remark 3(ii) is negative).

Let us consider the probability of a ruling in period 1. At \( t = 1 \), \( Pr(\text{Ruling})=Pr(g < \delta\Delta) \), where as before \( g \) is the distance between the \( ND \) point and the negotiation frontier along the 45° line, and where \( \Delta = E_{\gamma}[\Omega_t^{=2}(x + 1, \gamma) - \Omega_t^{=2}(x, \gamma)] \) is the gain in future joint payoff associated with increased DSB accuracy (the same across \( H \) and \( F \) given the veil of ignorance).
Increasing $x$ increases $g$ (the static predictability effect). How does $x$ affect $\Delta$? As we argued previously, this effect is negative if $\Omega^{t=2}$ is concave in $x$.

A complication is that, as $x$ rises and $q(x)$ goes down, at the dispute margin there is a jump up in the joint payoff as we go from the no-dispute region (where the outcome is either at the $P$ point or the $FT$ point in the bottom panel of Figure 4) to the dispute region (where the expected outcome will in general not correspond to either of these two points). This is a source of convexity in $\Omega^{t=2}$ with respect to $x$, and depending on the probability distribution of $\gamma$ it could swamp the other effects. However this effect is muted if $C_L$ is sufficiently small, which we assume in Proposition 3. Focusing for the moment on $C_L = 0$, it is then easy to see that $\Omega^{t=2}$ is continuous in $x$, and in fact the no-dispute region vanishes. Notice also from our derivation of (8.3) and (8.4) that $\Omega^{t=2}$ is continuous at the ruling margin for any $C_L$. Hence, when $C_L$ is small, we need consider only two effects: (i) how $x$ affects $\Omega^{t=2}$ inside the ruling region; and (ii) how $x$ affects $\Omega^{t=2}$ inside the settlement region. We will show that both effects are concave.

Let us first consider state realizations inside the ruling region. We focus on realizations such that $\gamma^* - \gamma > 0$ (the same argument applies for states such that $\gamma^* - \gamma < 0$). The expected joint payoff conditional on $\gamma$ is $(1 - q(x))\Omega(P) + q(x)\Omega(FT)$. This is clearly concave in $x$ for any $\gamma$, and hence concave in expectation.

Next consider state realizations inside the settlement region. We again focus on realizations such that $\gamma^* - \gamma > 0$. The disagreement payoffs are $\omega^D = (1 - q(x))v(P) + q(x)v(FT)$ and $\omega^*D = (1 - q(x))v^*(P) + q(x)v^*(FT)$. The gross bargaining payoffs are $\omega^B = \frac{1}{2}(\omega^{TOL} + \omega^D)$ and $\omega^*B = \frac{1}{2}(\omega^{TOL} + \omega^*D)$, where $\omega^{TOL}$ is $H$'s payoff if it makes a take-or-leave offer. It is straightforward to show that $\omega^{TOL}$ and $\omega^{*TOL}$ are linear in $q$. Finally, the net bargaining joint payoff is $\Omega^D + (1 - \kappa)(\Omega^B - \Omega^D)$, which of course preserves linearity in $q$. We can conclude again that expected joint payoff is concave in $x$. With this we may conclude that, provided $C_L$ is sufficiently small, the likelihood of a ruling is decreasing in $x$ for any $\delta$.

Next we examine how $\Pr(\text{Dispute})$ at $t = 1$ depends on $x$. Recall that a dispute happens if the $B_{net}$ point $(\omega^{Bn}, \omega^{*Bn})$ is outside the quadrant defined by the $P$ and $FT$ points in the bottom panel of Figure 4, where now the $B_{net}$ point is based on the disagreement point $ND + \delta \Delta$, that is, $\omega^{Bn} = \frac{\kappa}{2}\omega^{TOL} + (1 - \frac{\kappa}{2})[\omega^{ND} + \delta \Delta]$ and $\omega^{*Bn} = \frac{\kappa}{2}\omega^{*TOL} + (1 - \frac{\kappa}{2})[\omega^{*ND} + \delta \Delta]$. We have established just above that $\Delta$ is decreasing in $x$. And as we observed above, as $x$ increases and $q(x)$ falls, the $ND$ point can only move from inside the quadrant to outside it. And the reduction in $\Delta$ associated with the increase in $x$ only strengthens this effect, ensuring that the
$B^{net}$ point can only move from inside this quadrant to outside it, not vice-versa. So we can conclude that, provided $C^L$ is sufficiently small, the likelihood of a dispute is decreasing in $x$ for any $\delta$. To prove the last part of Proposition 3(i), it is easy to construct examples where the likelihood of settlement conditional on a dispute goes up or down with $x$.

Finally, the proof of Proposition 3(ii) is straightforward. From the perspective of $t = 1$, comparing the case of learning with the benchmark case of no learning, we move from $\Delta = 0$ to $\Delta > 0$, and this clearly increases the likelihood of period-1 disputes and rulings.

References


Figure 1: Continuous policy (static setting)
Figure 2: Continuous policy (static setting)
Figure 3: Continuous policy (two period setting)
Figure 4: Binary policy, Pareto frontier

Case 1: $\frac{\gamma}{\gamma^*} < \frac{1}{1+c}$

Case 2: $\frac{\gamma}{\gamma^*} \in (\frac{1}{1+c}, 1+c)$

Case 3: $\frac{\gamma}{\gamma^*} > 1+c$
Note: The vertical axis records the ratio X/Z, where X is the average number of disputes or rulings involving dyads of a given age, and Z is the average trade volume of dyads in this age group.
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Standard errors in parentheses

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

\_ijFE (i\_jFE) are undirected (directed) dyad fixed effects. kFE are article fixed effects.
### Table 3: OLS

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CE $i$ $i$ $i$ $i$

Standard errors in parentheses

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

$iFE$ (i$FE$) are undirected (directed) dyad fixed effects. kFE are article fixed effects.

CE are standard errors clustered by undirected ($i$) or directed ($i$) dyads.
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\(i\bar{i}\)kFE (\(i\bar{i}\)kFE) are undirected (directed) dyad-and-article fixed effects.

CE are standard errors clustered by undirected (\(i\bar{i}\)) or directed (\(i\bar{i}\)) dyads