TRADE GAMES: THE WTO's ROLE IN DISPUTES—THEORY AND PRACTICE

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Abstract

To many, the crowning achievement of the World Trade Organization (WTO) is its improved dispute settlement mechanism. This paper provides a theoretical and empirical analysis of the effect of the WTO adjudication mechanism on the decision to infringe another country's WTO rights, the decision of the injured party to pursue cases, and once a case is begun to negotiate a settlement or litigate it under WTO auspices. Improved case adjudication procedures have the effect of lowering processing costs to both complainant and defendant countries. Using a simple repeated Bayesian game, the paper shows that improved dispute settlement, paradoxically, leads to more infringements and more cases adjudicated. To test this prediction for empirical support, the paper examines the history of US Section 301 and WTO trade disputes. We apply Poisson and related regression-based techniques to identify the monthly incidence of trade disputes and test the hypothesis of a WTO structural break. We also implement a survival analysis and test for a structural change in dispute length. The data support the view that advent of the WTO increased the monthly incidence of trade disputes, and shortened their duration in agreement with the simple repeated game model.

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Key Words: Trade disputes, trade games, Poisson regression, survival analysis, USTR Section 301, WTO.

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TRADE GAMES

1 Introduction

During the last twenty-five years, the United States has participated in 200 international trade disputes involving 42 countries. Although reasons to initiate and pursue cases sometimes appear to be solely economic, these disputes are strongly influenced by geo-political circumstances. Evidence for the political determinants of trade disputes includes Baldwin, Chen, and Douglas (1995), Chung (1997), Norland (1999), and Grinols (1989), but none of these use an econometric-based approach. In addition, we have not found any theoretically based studies of international trade disputes explaining the incidence or duration of cases, nor the impact of the World Trade Organization (WTO) on either. Empirical studies of the effect of the WTO on disputes are also absent in the recent economic literature. It is clear that the salient features of each trade dispute may include diverse elements and one must be cautious in interpreting estimates obtained through econometric experiments. Nevertheless, a theoretical analysis coupled with a quantitative analysis can be particularly valuable to understanding the mechanics of international trade disputes.

The present paper has two goals. The first is to provide a game-theoretic model that explains country incentives when they initiate and litigate international trade disagreements. We treat trade disputes as a game involving countries α, β, and a random flow of opportunities to infringe. When an infringement opportunity of a given type is presented to country β, it makes the decision whether to infringe its WTO obligations with respect to country α, the complainant. The decision to infringe is based on the benefits to β of the infringement, β's beliefs about how α will react, and the costs of adjudication and settlement on the solution path anticipated for the case. Once an infringement has been discovered by the complainant country's affected industry, the industry brings petition to α's government to protect its WTO rights. α's trade representative then decides whether to accept the case for processing (prosecution), and chooses its strategy regarding a subsequent negotiated settlement with the defendant and whether to proceed to WTO litigation if settlement cannot be reached.

We model the dispute process as a repeated game. This introduces a role for the complainant country to develop its reputation for strong pursuit of cases. Without a credible reputation for prosecuting cases, other countries will feel free to infringe α 's WTO rights with impunity and negotiated settlements will never be reached because the defendant has no incentive to accept them. The implications of the model are derived for different beliefs about costs of litigating and the benefits of infringement, one or both of which may be WTO dependant.

The second goal of the paper is to provide an empirical analysis of the patterns of US trade disputes, seeing whether they provide a match to the implications of the suggested theoretical model. We examine three distinct trade dispute environments: Cases conducted under the USTR (United States Trade Representatives) Section 301 system which run from 1975 to 2000, cases treated under the GATT (General Agreement on Tariffs and Trade), and cases treated under the WTO, 1995-2000. The first two samples provides a longer panel of observations, but the third sample provides a larger set of recent cases and countries.

Using these samples, we characterize the monthly caseload, case arrival, and case duration of trade disputes from 1975 to 2000 using parametric, semi-parametric, and non-parametric models. We apply count data regression techniques to the distribution of cases through time, and suggest two maximum likelihood estimators (Poisson and negative binomial) and a quasi-maximum likelihood estimator (Normal) to account for overdispersion[1] in the data relative to a Gaussian model. We then conduct a duration analysis of trade disputes, using a variety of parametric models (Weibull, Exponential, Gompertz, Gamma, Log-Normal, and Log-Logistic regressions) which allow us to consider goodness of fit. We ultimately adopt a semi-parametric (Cox Proportional Hazard) format which we argue seems to best represents the data. We check the main properties of the model, and then compare its estimates with fully non-parametric (Kaplan-Meyer) survivor and (Nelson-Aalen) hazard estimates. Using those techniques, we test for the existence of structural breaks on the pattern of disputes after the WTO advent that match the predictions of the simple repeated game model.

The remainder of the paper is organized as follows. Section 2 reviews the statistics and stylized facts of trade disputes for the period 1975-2000. Section 3 discusses the theory of trade disputes as a gameplayed by representative countries (the complainant and the defendant) each of which acts strategically to achieve its own objectives. We describe the strategies, parameters, and the solution of this non-cooperative game. We then perform several experiments to see the effect of lowered litigation costs on the outcome. We show that an increase in the number of infringements and cases is likely to accompany a shortening of caselifes of the streamlined and more transparent WTO adjudication process. Section 4 empirically models the population of dispute cases. Section 5 examines the population dynamics in more detail by focusing on the birth and lifespan of cases. The data tend to confirm the outcomes suggested by the theoretical modelthat under WTO auspices there are more cases of shorter lifespan, although this conclusion is less strong for the set of US Section 301 trade disputes than it is for GATT/WTO cases. Section 7 summarizes and concludes.

[1] Overdispersion refers to an estimated conditional variance higher than the estimated conditional mean.

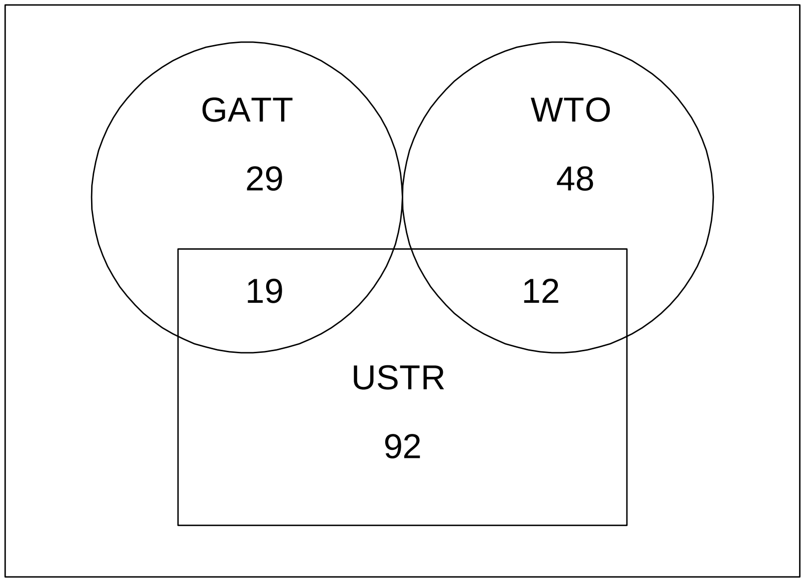


Figure 1: Number of Trade Dispute Cases in Sample Showing Overlaps

2 Trade Disputes in Practice

The advent of the WTO raises interesting questions that relate primarily to its impact on the "population demographics" of trade disputes. These include the number of active cases ("population"), the number of initiated cases ("the birth rate"), and the duration of individual cases ("lifespans"). We selected data from three "families" of cases having in common an association with the US. We found that the number of such cases seems to have increased since WTO advent, and they tend to be shorter on average with less long tails of extremely long-lived cases. The data sets we examined were US Section 301 disputes (123 cases, from July 1975 until February 2000), GATT disputes (71 cases, from September 1975 to October 1994), and WTO disputes (111 cases, from May 1995 through August 2000).[2] Of 71 GATT disputes, 44 involved the US (23 as the complainant, 21 as the defendant), while 60 of the 111 WTO cases involved the US (34 as the complainant, and 26 as the defendant). All USTR Section 301 cases, of course, involved the US as a complainant. Our data included cases if they involved the US either as complainant or as defendant. The data was collected from public sources (USTR (2000) and WTO (2000)), and contain information about

[2]During its entire life-span (1947-1994), the GATT system dealt with 102 international trade disputes. More extensive work on the topic might include the 31 GATT disputes initiated before 1975. However, the treatment of the earlier cases very likely differed from the later ones, and we felt that less would be learned from comparisons involving cases from so long ago.

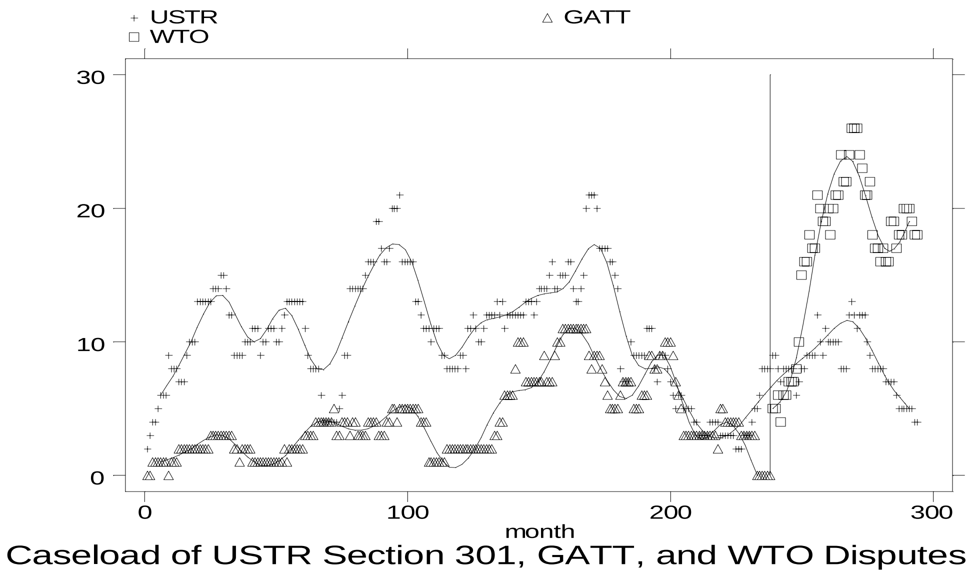


Figure 2: Case Populations

when each case started and finished and the nature of the dispute.[3] There are 17 cases of overlap between the GATT and the Section 301 data, and 12 cases of overlap between the WTO and the Section 301 data. GATT and WTO data sets do not overlap because GATT was replaced by the WTO. Figure 1 displays the relationship between the different data sets.

2.1 Population

The population of GATT, WTO, and Section 301 USTR cases is plotted in Figure 2 using a cubic spline fitting curve to display a measure of the "average" caseload for each type of case. In addition to smoothing, the cubic spline allows for a non-linear time trend for each of the series. Sample months are shown on the horizontal axis, and a vertical line marks the first month of WTO operation.

The summary statistics for the series give a flavor of the distinctions between USTR Section 301, GATT, and WTO cases. For the USTR Section 301 cases, the monthly average number of open cases was 10.04, the median number was 10.00, the 80th percentile was 14.00, the standard deviation was 4.23, skewness 0.26, and kurtosis 2.70. Therefore, the series is almost mesokurtic and symmetric, with similar mean and median, although the Jarque-Bera statistic of 4.37 (with

[3]For Section 301 cases, there are two distinct sources of initiation: cases brought by private firms and cases brought by the US Government (so-called self-initiated cases). Grinols (1989) and Grinols and Perrelli (2000) show that political variables help explain the pattern of business-initiated versus government-initiated cases through time.

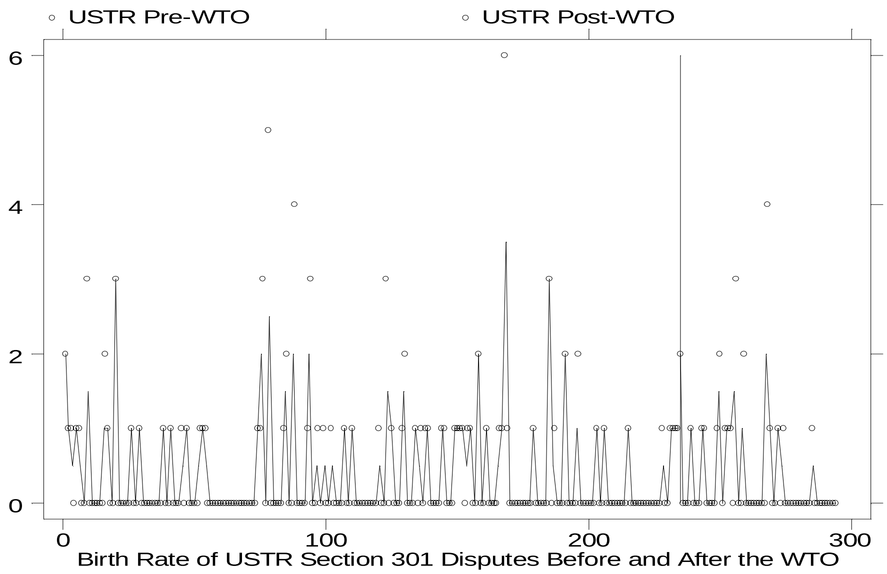


Figure 3: Section 301 Births

$\Pr(\chi_2^2) = 0.11$) shows that the series departs a little bit from the normal behavior. Moreover, the series is overdispersed (the variance of 17.92 is greater than the mean)–a common finding in the empirical literature dealing with count data. For the GATT data the main statistics are: Mean 4.10, median 3, 80th percentile 7, standard deviation 2.88, skewness 0.88, and kurtosis 2.90. The GATT data is overdispersed and presents Jarque-Bera statistics of 31.08 (with $\Pr(\chi_2^2) = 0.00$). The main statistics for the monthly caseload of WTO cases are: Mean 17.02, median 18.00, 80th percentile 21, standard deviation 5.91, skewness -0.84, and kurtosis 2.82. The WTO series is slightly negative skewed but quite mesokurtic, with mean and median nearly the same. However, like the Section 301 series, the WTO series is overdispersed (variance of 34.93). Furthermore, the departure from the normal shape is aggravated by the smaller WTO sample size (the WTO sample covers 56 months, while the USTR Section 301 sample covers 294 months and GATT 238 months). The Jarque-Bera statistic is 6.73 (with $\Pr(\chi_2^2) = 0.03$), and the null hypothesis of normality is easily rejected. As suggested by our theoretical model, WTO cases occur with greater frequency and the population of WTO cases is larger than USTR Section 301 and GATT cases, conditional on the respective time-windows of each panel.

2.2 Births

In the spirit of the previous section, we also can observe how the advent of the WTO affected the "birth rate" of international trade disputes. Figures 3 and 4 plot the number of case initiations by month for the samples up to December 1994, and for the subsequent period from January 1995

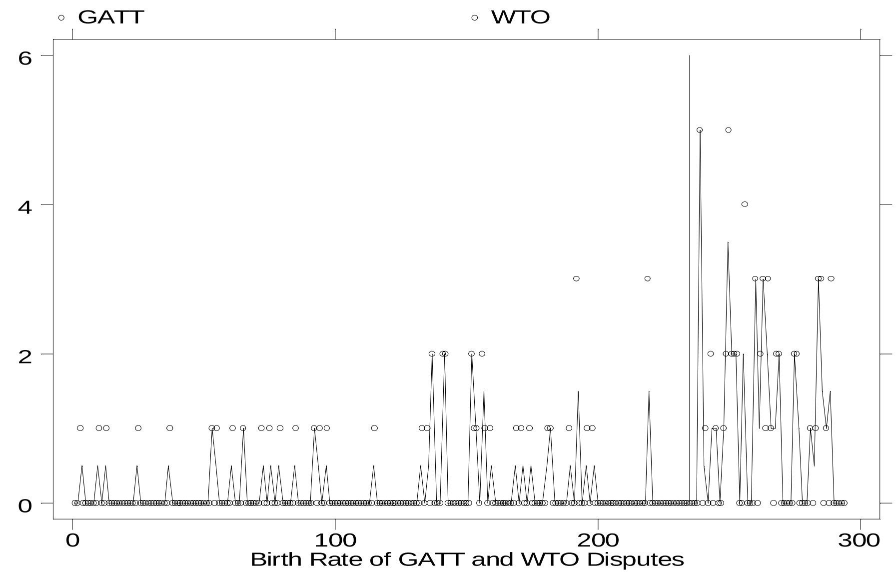


Figure 4: GATT, WTO Births

up to December 1999. There is no substantial change in the monthly birth rate of USTR Section 301 panel cases after advent of the WTO, but, there is a noticeable increase after the WTO advent in the number of WTO births compared to GATT. Later we will examine the reasons for these differences, and estimate their significance.

2.3 Lifespans

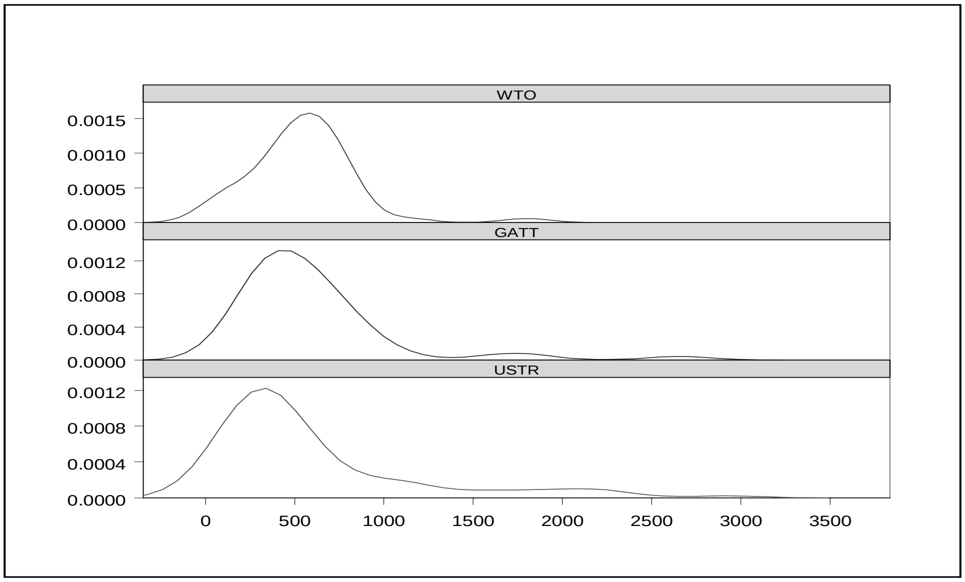
In addition to population and births, considering the lifespan of international trade disputes is important to understanding the efficiency of the dispute resolution mechanism. The raw data is described in Figure 5. A deeper study will be presented in Section 4.

The USTR Section 301 cases, consisting of the 92 cases that do not overlap with any other data in the Venn diagram of Figure 1, had an average lifespan of 588 days, with a standard deviation of 577 days. The GATT data, consisting of 48 cases, had an average lifetime of 595 days, with a standard deviation of 440 days. Finally, the WTO data, composed of 51 cases[4] had the shortest average lifespan, 544 days, with standard deviation of 290 days.

We also considered the median, skewness and kurtosis of the series. The USTR panel had a median of 378 days, skewness of 1.95 and kurtosis of 6.47. The GATT panel had a median of 470 days, skewness of 2.83, and kurtosis of 12.39. The WTO panel had a median of 562 days, skewness of 1.38, and kurtosis of 8.52. All series are clearly leptokurtic, and slightly asymmetric. Also, USTR

[4]We excluded cases not finished as of March 2001.

Figure 5: Distribution of Case Lifespans

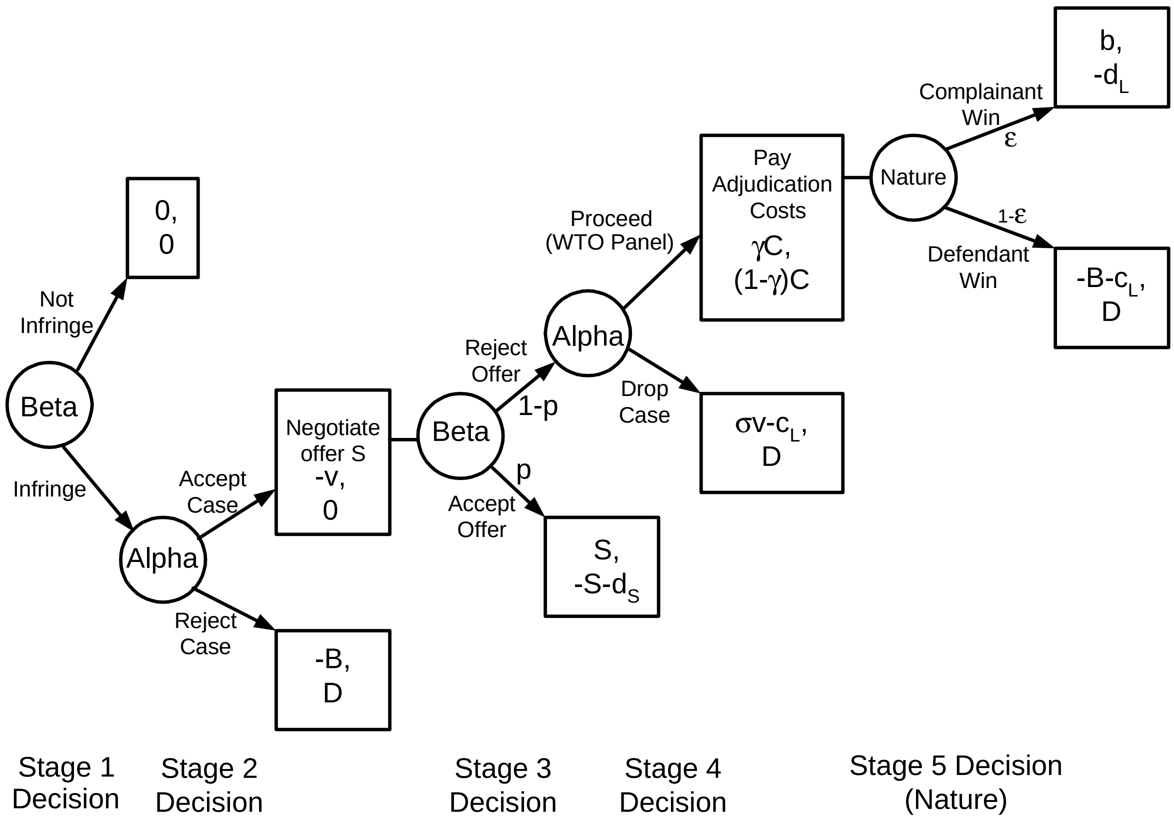


and GATT series have a long upper tail. In terms of normality, the Jarque-Bera statistic for the USTR panel is 105.00 (with $\Pr(\chi^2_2) = 0.00$), for the GATT panel is 240.90(with $\Pr(\chi^2_2) = 0.00$), and for the WTO panel is 81.24 (with $\Pr(\chi^2_2) = 0.00$). Therefore, the null hypothesis of normality is rejected for all series at the minimum level of significance. Improved dispute settlement timetables suggest that negotiators wanted WTO cases to have a shorter lifespan than GATT or USTR cases. Further tests of the significance of this hypotheisi will be provided in section 4. A comparison of the tails in Figure 5 suggests that the greatest proportion of extremely long-lived cases occured in among USTR cases, followed by GATT and WTO in that order.

3 Trade Disputes in Theory

From the economist's perspective, the upsurge in WTO trade disputes did not happen by chance, but was the result of rationalizing decisions by participant countries about the decision to infringe and the decision to litigate using the WTO good offices. Both decisions can be described in terms of costs and benefits and expectations about how the trading partner will respond. In this section, therefore, we construct the simplest model of a repeated game that could be used to evaluate the trade dispute decisions of trading countries.

Figure 6: The Trade Adjudication Repeated Game



3.1 Complainant's Decisions

Presume that β has infringed the WTO rights of country α and that the matter has been brought to the attention of the trade officer of α. In the United States this officer would be the US Trade Representative (USTR) and we will sometimes use this abbreviation generically when we talk of the complainant country α. The USTR must decide to accept or reject the case. There is an opportunity cost to assigning resources to the case. If the case is rejected, the USTR can use the resources for other pursuits.

According to WTO principles, negotiated resolution of disputes is the first objective. The length of time that a case takes to adjudicate, the resources needed to pursue the case, and the uncertainty of winning a case, are all elements that affect the desirability of making a settlement offer. The USTR therefore negotiates a settlement offer with the defendant country β that is preferable to full-length panel adjudication for α, which β can accept or reject. The defendant's willingness to accept the offer, in turn, depends on the defendant's type: Some defendants face higher settlement costs than others (these could be psychic or political as well as real costs). The complainant knows the distribution of defendant settlement costs, but not the precise number which is private knowledge of defendant. The USTR must therefore balance increasing the likelihood of acceptance of a less demanding offer against the worsened terms of the offer. The defendant, in turn, compares the offer to what it would receive if it refuses. If the offer is refused and the case is adjudicated further under WTO auspices, there is a cost to adjudication that is borne by both countries. The balanced or unbalancedness of adjudication costs between complainant and defendant is a determinant of the outcome. The complainant has a probability of winning the WTO case, as does the defendant.

Figure 6 outlines the process just described. The payoffs on top apply to α, the payoffs below to β.

Stage 1: **Decision to Infringe.** In stage 1 cases arrive on a random basis in parallel streams of given type. β must decide whether to use the opportunity the case arrival provides to infringe α's WTO rights. If no infringement is chosen, the payoffs to both players are zero (retain status quo). The decision to infringe initiates the remainder of the process.

Stage 2: **Case Acceptance.** The USTR (country α) chooses whether to accept the industry case against β. The opportunity cost of resources is v and the welfare cost of the infringement is B.

Stage 3: **Negotiation.** If a case is accepted, the USTR negotiates a settlement with β. We show below that the settlement terms are reached with β's willingness to accede taken into account. Once the offer is formulated, however, we can think of it as being made on a take-it-or-leave-it basis. Defendant country β accepts or rejects α's offer.

Stage 4: **Litigation.** Assuming the offer is rejected, the USTR decides whether to proceed under WTO auspices or to drop the case.

Stage 5: **Adjudication.** Assuming a case proceeds under the WTO dispute settlement mechanism, nature decides whether the complainant or defendant wins. The probabilities of a win or loss given the type of case are known to complainant and defendant.

It is helpful to refer to Figure 6 for the computation of player values at the different stages. The complainant country knows that it faces repeated plays of the game for each of the different types of cases and defendants. It is useful to think of cases arriving at random intervals in parallel streams, each case being evaluated by its type. Country β benefits from its infringement of α's WTO rights by amount D. The lost trade benefit to α of β's infringement is given by B (B and D do not have to be equal).[5] For simplicity, we summarize the steps of the solution in a series of propositions.

[5] For example, if β employed a restrictive tariff against α's product there would be welfare costs to α and possible terms of trade gains to β. One's gain would not necessarily equal the other's loss.

3.2 α's Decision to Adjudicate

We solve the game by backward induction, beginning with the stage 4 decision by α to proceed or drop the case against β. If α chooses to litigate, the WTO establishes a panel and the case proceeds to trial. Complainant pays adjudication costs $c_\alpha \equiv \gamma C$, where upper case C represents total adjudication costs under WTO auspices and γ represents complainant's share. Adjudication costs include the direct time costs and resource costs of trying a case but may also include psychic elements as well. Nature decides whether the complainant or the defendant wins the case. Complainant wins with probability ε, and defendant wins with probability $1 - \varepsilon$. The probability ε, depending on the type of case, the litigants, and the WTO's panel effectiveness is known to both countries.

If the defendant wins the WTO case, the complainant receives $-B - c_L$. That is, α loses the trade impact of the infringement,B, plus the additional costs of a case loss c_L. Costs c_L may be taken to include elements such as loss of prestige or diminished world opinion. The defendant country wins the direct benefits D of infringement. If complainant wins, α gains benefits b and β receives $-d_L$, representing loss costs (which may include loss of prestige, etc.).

The potential current-period benefits from using the resources in case adjudication must exceed their value in other uses. Should α choose to litigate at stage 4, therefore, the value of the decision is,

$$\varepsilon b + (1 - \varepsilon)(-B - c_L) - \gamma C,$$

which incorporates the win value times its probability plus the loss value time its probability, less the cost of adjudication. The value to α of dropping a case is $\sigma v - c_L$. v is the value of country resources devoted to the case and σv stands for the share of those resources retrieved for fraction of the period σ that will be obviated from use in pursuing adjudication. $-c_L$ represents the costs to complainant (possibly psychic) from dropping the case. Thus,

Proposition 1: *The condition for complainant α to prefer adjudication is $\varepsilon b + (1 - \varepsilon)(-B - c_L) - \gamma C > \sigma v - c_L$, or*

$$\varepsilon(b + B + c_L) - \gamma C - B > \sigma v. \tag{1}$$

3.3 Defendant's Decision to Accept Negotiated Settlement

We now consider stage 3 decisions. Let S stand for the value of the settlement offered to defendant by α. If the defendant accepts the offer, the decision value to the defendant is $-S - d_S$ where S is the settlement to complainant and d_S is the additional settlement cost to β. As before, cost d_S can represent both political, psychic, and real costs to the defendant of accepting the offer S. There is asymmetric information regarding settlement costs: d_S is known by the defendant but not by the complainant. The complainant does know the distribution from which d_S comes, however.

Countries facing large political difficulties with a domestic industry should they comply with the settlement offer, for example, would have high d_S. [6]

Defendants with high costs of settlement (high d_S) have harder-to-satisfy rejection bounds and will therefore reject less demanding (lower S) settlement requests. If the defendant rejects the negotiated settlement, then the value of this decision to the defendant is $\varepsilon(-d_L)+(1-\varepsilon)D-(1-\gamma)C$, the expected value from panel adjudication.

Proposition 2: *The defendant will reject a negotiated settlement* S *if* $\varepsilon(-d_L)+(1-\varepsilon)D-(1-\gamma)C > -S-d_S$ *or*

$$S > \varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C - d_S. \tag{2}$$

A settlement demand, S, that is too high, therefore, invites rejection. The rejection bound is given by the right hand side of equation (2). Notice that the right hand side of (2) can be negative. In that case, the defendant will reject *any* positive settlement.

3.4 The Negotiated Settlement

Country α takes into account the situation of the defendant in negotiating the settlement S. We assume that α is a rational complainant, balancing the size of the demand it makes against the diminished likelihood of a larger offer demand being accepted. Country α, having faced country β in disputes before, does not have know d_S, but does know the distribution from which it is drawn. We model d_S as being a binary random variable. The choice of a distribution does not change the nature of the model but does affect the specific magnitude. We assume that percentage p of the time the defendant has low settlement costs $d_S = \bar{d}_S$ and with probability $1-p$ the defendant has high settlement costs $d_S = \bar{\bar{d}}_S$ such that

$$[\varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C] - \bar{\bar{d}}_S < \varepsilon b + (1-\varepsilon)(-B-c_L) - \gamma C < [\varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C] - \bar{d}_S \tag{3}$$

The term in the middle is the least that α will accept as settlement since any lower amount would mean α would be better off going straight to adjudication. The term on the right (from (2)) is the most that β would be willing to pay (otherwise going to adjudication would be preferred to paying settlement) if β has low settlement costs ($d_S = \bar{d}_S$) and the expression on the left is the most β can afford to pay if its settlement costs are high ($d_S = \bar{\bar{d}}_S$). Condition (3) simply affirms that there is

[6] A natural extension is to consider the players' beliefs about the opponents' costs, characterizing a game with incomplete information. In the spirit of the Harsanyi (1967-68) doctrine, in Section 3.4 we include a random choice by Nature of d_S, e.g. high cost or low cost, whose ex ante probability distribution is known by all participants. The point outcome for player i's cost is observed by player i only. Mas-Colell et al. (1995) supplies a more didactic assessment of Bayesian games with a similar feature.

room for successful negotiation with low-cost defendants. If the term in the middle exceeds both other terms, there is no possible mutually acceptable settlement and the game goes straight to adjudication. If the term in the middle is lower than both other terms, all cases are settled without need of WTO panel adjudication.[7]

How high can α set S? From (2) $S = \varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C - \bar{d}_S$ is the highest settlement S that will ever be accepted. The complainant's strategy is now clear: If α offers S lower than $\varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C - \bar{d}_S$ it will not improve its chances that the offer is accepted (low-d_S defendants would be willing to take the higher $\varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C - \bar{d}_S$) but it *will* reduce the payment from offers that are accepted. If α demands *higher* payment than $\varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C - \bar{d}_S$ then the defendant will never accept the offer. Offer $S = \varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C - \bar{d}_S$ will be accepted p percent of the time, when d_S is low. The remaining $1-p$ percent of the time the offer will be rejected, the case will go to adjudication and earn (lower) value $\varepsilon b + (1-\varepsilon)(-B - c_L) - \gamma C$.

The weighted average of the acceptance value and adjudication value is higher than the value generated by any other settlement. Hence,

Proposition 3: *$S = \varepsilon(d_L) - (1-\varepsilon)D + (1-\gamma)C - \bar{d}_S$ is the unique negotiation settlement S.*

An implication of the model is that countries with low settlement costs d_S will tend to pay more in settlement and will accept settlement more frequently, according to p.

3.5 α's Decision to Accept a Case

We can now consider the stage 2 decision of the USTR to accept or reject a case brought to his attention by industry. In conformity with case arrival at country β and β's choice to infringe, cases brought to the USTR's attention will arrive in different streams according to their characteristics, $(B, C, D, b, c_L, d_L, \varepsilon, \gamma, (p, \bar{\bar{d}}_S, \bar{d}_S))$. All parameters are known to both players except that α does not know d_S which is known only to the defendant. The value to α of accepting a case is

$$\Pi \equiv p[\varepsilon(d_L) - (1-\varepsilon)D + (1-\gamma)C - \bar{d}_S] + (1-p)[\varepsilon b + (1-\varepsilon)(-B - c_L) - \gamma C] - v. \qquad (4)$$

The first square-bracketed term is the settlement value to α if the settlement offer S is accepted. The second square-bracketed term is the value of WTO adjudication if settlement is rejected and the case is adjudicated. If α rejects the case, the value is $-B$, hence

[7] We presume that the credibility condition, discussed below, holds so that a nondegenerate equilibrium applies whereby α litigates cases if its settlement offer is rejected. If the credibility condition does not hold, the threat to litigate is futile (not believed), settlements are always rejected, and cases always dropped. This leads to an equilibrium where β infringes and α does nothing but propose spurned settlements. While such an equilibrium is possible in the context of the model, it is uninteresting for our purposes.

Proposition 4: *The condition for α to accept the case is,*

$$\Pi > -B. \tag{5}$$

where Π *is given by (4).*

All of the above, of course, is predicated on the belief by the defendant that an accepted case will be pursued through litigation by the complainant if settlement is rejected. This belief must be credible in the repeated game setting. We turn now to this credibility or reputation constraint.

3.6 Reputation and the Credibility Constraint

Satisfying the credibility constraint is necessary to establish the reputation of α for pursuing infraction of its WTO rights. Assuming credibility, we have identified α's policy as

- Accept a case if $\Pi > -B$,
- Ask negotiated settlement $\varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C - \bar{d}_S$ if case is accepted,
- Litigate if negotiated settlement is rejected,

matched by the defendant's response,

- Accept negotiated settlement if $S \leq \varepsilon d_L - (1-\varepsilon)D + (1-\gamma)C - d_S$,

which is satisfied with probability p. β makes its choices knowing α's reputation. If β observes α to drop a case, however, it would signal that it is not in α's interest to adjudicate cases of this type. Since this will be common knowledge for similar defendants and cases, it will alter the behavior of defendants. All defendants will reject negotiated offers and cases will not be litigated. Countries will feel free to infringe α's WTO rights with impunity. Establishing a reputation for pursuing WTO cases by satisfying a credibility constraint showing self interest, therefore, is imperative to the welfare of α.

The credibility condition requires that the value of adopting a specific strategy exceeds the value of deviating from it. Assuming a "no trembling-hand condition"—the complainant does not deviate from the strategy above once a case is begun—the value to the complainant of continuing its strategy after a settlement is rejected is $[\varepsilon b + (1-\varepsilon)(-B - c_L) - \gamma C] + \sum_{t=1}^{\infty} \delta^t \Pi$. The first square-bracketed term is the value for the remainder of the period obtained by litigating and the second term is the value obtained in future periods from following α's policy where δ is the discount factor and Π is given in (4). The second term therefore represents the value to complainant of its reputation as a country that pursues its WTO cases.

If α drops a case in mid-period after a rejected settlement, let σ denote the share of value v recovered in the remainder of the period by complainant's trade representative. The value to the country of dropping a case (hence revealing that it is not in its interest to pursue adjudication in cases of this type) is $[\sigma v - c_L]$. Credibility requires that the value of adhering to the strategy exceeds the value of deviating. Thus,

Proposition 5: *The credibility condition is*

$$[\varepsilon b + (1-\varepsilon)(-B - c_L) - \gamma C] + \sum_{t=1}^{\infty} \delta^t \Pi - [\sigma v - c_L] \geq 0 \tag{6}$$

where Π *is given in equation (4).*

For future reference we will denote the left hand side of (6) as the credibility constraint function $CC(B, C, D, b, c_L, d_L, \varepsilon, \gamma), (p, \overset{=}{d}_S, \bar{d}_S)$.

3.7 The Decision to Infringe

Sections 3.1 through 3.6 described the decisions of the complainant and defendant countries after an infringement of complainant's WTO rights had occurred. We saw that nondegenerate equilibrium cases were sometimes settled by negotiation and sometimes by costly litigation. β, being aware of α's strategy (fully described at the start of section 3.6), chooses to use the arrival of a case to infringe only if it is in its *ex ante* interest.

Proposition 6: β *chooses to infringe if and only if the infringement condition is satisfied,*

$$\varepsilon(-d_L) + (1-\varepsilon)D - (1-\gamma)C > 0. \tag{7}$$

The sequencing of β's complete strategy can now also be summarized.

- Cases arrive in β's docket. All information is known to both parties, except that α does not know d_S. α does know the distribution, $(p, \overset{=}{d}_S, \bar{d}_S)$, from which d_S comes conditional on all other case characteristics.
- If $D < 0$, β does not infringe α's WTO rights.
- If $D > 0$ and the case is such that α will reject it for prosecution, then β infringes and α does not object.
- If $D > 0$ and the case is such that α will accept it for prosecution, β infringes if the infringement condition (7) is satisfied.[8]
- β accepts α's negotiated settlement if $d_S = \bar{d}_S$ and rejects settlement otherwise. Rejected cases go to adjudication where β receives D if it wins and $-d_L$ if it loses.

For future reference we will denote the left hand side of equation (7) as the infringement condition function $IC(C, D, d_L, \varepsilon, \gamma)$.

[8] This is the value to β of an opposed infringement, one which α responds to.

In summary, the infringement process delivers cases to β characterized by $x = (B, C, D, b, \gamma, c_L, d_L, (p, \bar{\bar{d}}_S, \bar{d}_S))$. B is the lost welfare experienced by α due to infringement. C is the total cost of adjudication, share γ if which is borne by α, and D is the welfare gain to β from infringement. In addition, we identified benefits to the complainant of winning a panel decision, b, costs to the defendant of losing a WTO panel decision $(-d_L)$, and costs to the defendant of negotiated settlement $(-d_S)$. The costs to the complainant of losing a case or dropping it after a negotiated offer is refused was $(-c_L)$. These costs and benefits could represent psychological or political as well as real costs.

3.8 The WTO and Trade Disputes

We now use the repeated game model solved in sections 3.2 to 3.7 to help sharpen our understanding of the impact of the WTO on trade disputes. If a case arrives in region $IC = \{x | IC(x) \geq 0\}$ (see section 3.7) country β will use it for an infringement. Arriving cases that fall outside IC will not become infringements. The set of cases that will be pursued by complainant for litigation lie in region, $CC = \{x | \, CC(x) \geq 0\}$. An increase in the value of the Infringement Constraint, IC, enlarges the set of cases that will be used as infringement vehicles by β and an increase in the value of the Credibility Condition, CC, enlarges the set of cases that will be litigated by complainant. If both regions grow there will be more infringements, and more WTO dispute cases. The effect of a change that increases one set and diminishes the other depends on which effect dominates—more infringements versus a smaller fraction that are litigated (or the reverse).

Table 1: Effect of WTO on the Infringement Constraint and the Credibility Condition

Parameter	**Infringement Constraint** $\frac{\partial \mathbf{IC}}{\partial \cdot}$	**Credibility Condition** $\frac{\partial \mathbf{CC}}{\partial \cdot}$
C	$-(1-\gamma) < 0$	$-\gamma + \frac{\delta(p-\gamma)}{1-\delta} < 0$*
b	0	$\frac{\delta(1-p)\varepsilon}{1-\delta} > 0$
d_L	$-\varepsilon < 0$	$\frac{\delta p \varepsilon}{1-\delta} > 0$
γ	$C > 0$	$\frac{-C}{1-\delta} < 0$
c_L	0	$1 - (1-\varepsilon)[1 + \frac{\delta(1-p)}{1-\delta}] > 0$**

*For δp small. **See text.

Table 1 summarizes the effects of changes to five parameters of the infringement-litigation trade game. Stricter WTO time limits compared to GATT reduce the costs of litigation to both complainant and defendant. This implies a reduction in adjudication costs C. According to the table, this leads to more infringements and more litigations. Lower litigation costs for the defendant reduce the penalty for undertaking an infraction, leading to more infractions. Lower litigation costs for the complainant make the credibility condition easier to satisfy. Both effects work in the direction of more WTO cases.

The WTO brings greater visibility and transparency to trade disputes. Heightened world opinion could work both to increase b (benefits to complainant of a win) and d_L (cost to infringer of a loss): Public wins are sweeter and public losses more agonizing. The table shows that increased b leads to more litigation given the number of infringements, but has no effect on the number of infringements according to the model. The net effect is more dispute settlement cases because of the litigation effect. Increased d_L (greater cost of losing a trade dispute case) implies less infringement but more litigation, so its effects on the number of WTO cases depends on which effect predominates.

The fourth row of Table 1 considers the effect of increasing the share of adjudication costs borne by the complainant (γ up). In this case, the overall impact on WTO caseload is indeterminate: more cases will be used as infringement vehicles by β, but the desirability of pursuing the cases by α will drop. Which effect dominates depends on specifics.

Finally, increasing the complainant's costs of losing a dispute case (higher c_L) does not affect β's choice to infringe, but does lead to an *increase* in the number of cases litigated by the WTO if the likelihood of cases being correctly decided is great.[9] The probability that the infringer will be found guilty is ε. If $\varepsilon = 1$ or is close to one, $\frac{\partial CC}{\partial c_L} > 0$. This term represents the settlement effect. It is now easier for the complainant to credibly show that it is in its interest to carry cases to adjudication because to drop a case leads to higher costs. The second term in line five (multiplied by $(1 - \varepsilon)$) represents the direct effect of losing a case once it has gone to a WTO panel. This term comes into play only if there is sufficient chance that the case will be lost in panel review. If that risk is great, of course, then the complainant is less likely to bring cases. There is no effect of a change in c_L on the decision of β to infringe, so the increase in cases results not from more infringements but from a greater number of infringements resulting in panel adjudication.

An increase in the value of a WTO win (higher b) to the complainant leads to increased litigation by α and has no effect on the decision by β to infringe. The net effect is a greater number of trade dispute cases litigated. The WTO impact on the other parameters of the model is less clear, differing by circumstances and the country involved.

[9] The social stigma of having brought an invalid accusation to panel adjudication (increase in c_L) is probably less than the effect of being shown to be an infringer of WTO rights (increase in d_L). Thus the effect of the WTO on increasing c_L is probably smaller than the effect on increasing d_L.

4 Estimating the WTO Impact on Case Population

In the theoretical model, cases were viewed as arriving randomly in a space of given characteristics for potential use as infringement vehicles. Any variable that affected the costs or benefits to the complainant or defendant country were characteristics that matter to how the case was regarded by the infringing country or the complainant. This type of information would include which country the dispute involved and characteristics of the party countries' trade. For example, it was sometimes suggested in the 1980s that the US trade deficit made the US more prone to pursue trade dispute cases, presumably because it raised the political costs to the US of inaction. Other variables that affect one or more components of x would also be candidates for inclusion as covariates.

4.1 Preparing the Data Set

In the Section 301 data set, the unit of observation was a case. Information for each observation included the beginning and ending dates of the action, the country involved, and the following variables that might have a bearing on the value of the dispute to the US or the defendant: the degree of trade openness (OPEN) measured by US exports plus imports divided by US GDP; the US trade balance (USTB); the presence of an overload of cases (OVER) captured by a dummy variable with unit value for months that the number of active Section 301 cases was greater than the 80th percentile for the series; gross trade share (GTS), the foreigner's exports to the US plus imports from the US divided by US GDP; and currency crisis (CRISIS), represented by a dummy variables equalling one for 1992, 1994, and 1997.[10] A similar methodology was applied to GATT and WTO data sets. The variables capture the main commercial characteristics of the participant countries (GTS, OPEN, USTB), controlling for exogenous (CRISIS) and endogenous (OVER) shocks.

US trade disputes in the period 1975-2000 involved 42 countries, implying that there were relatively few observations on disputes involving any given country. As a result, we grouped countries into a smaller set of seven clusters for analysis purposes according to natural geographical, political, and economic characteristics. Though clustering loses some information, the gains in estimation and economic interpretation of the results exceed the loss of information on specific countries. The groups were as follows:

- Group 1 - **NAFTA**: Canada and Mexico.

[10] All monetary variables were in nominal form and re-scaled to millions of US dollars. The monthly value of the US imports and exports, as well as its annual GDP were extracted from the International Monetary Fund (2000). Specific information about the annual traded volume of imports and exports between the US and each country were extracted from the US Bureau of Census (1999) and the Organization for Economic Development and Cooperation (1999). All annual data were converted to monthly data through the application of finite geometric series indexes commonly known. Because of this we expect more smoothed series for the first and second independent variables.

- Group 2 - **Latin America**: Argentina, Brazil, Colombia, Costa Rica, Guatemala, Honduras, Paraguay, and Venezuela.
- Group 3 - **European Union 15 (EU-15)**: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom.
- Group 4 - **Non-EU Western Europe**: Hungary, Norway, Russia, Switzerland, and Turkey.
- Group 5 - **Far East**: China, India, Indonesia, Malaysia, Pakistan, Philippines, and Thailand.
- Group 6 - **OECD Asia and Pacific**: Australia, Japan, and New Zealand.
- Group 7 - **Special Relationship**: South Korea and Taiwan.

Taiwan and Korea were treated as a special group due to the fact that the US has developed a strong economic and political strategic relationship with these countries which may have affected the incidence and the duration of trade disputes involving them. Other countries are grouped in a manner suggested by Organization for Economic Cooperation and Development (OECD) groupings.

4.2 Estimation Stategy

The theoretical model predicts that improved dispute settlement and lowered costs of litigation should encourage more infractions and more trade disputes. A comparison of the number of active GATT versus WTO trade disputes over time seems to bear this out, although a comparison of USTR cases before and after the advent of the WTO is less clear. To model the population of cases, we applied three parametric models: the Poisson, the negative binomial, and normal. The Poisson and negative binomial distributions are traditional modelling choices for count data and for this reason we included them in our study of case initiations in the next section and here. In spite of its fine properties and natural economic interpretation, "Poissoness" implies that the conditional mean equals the conditional variance, a property that is frequently hard to attain, especially in samples that exhibit overdispersion. Among other authors, Koenker (1988) interprets this phenomenon as representing an inherent variability in the Poisson parameter λ (normally the expected number of events per unit time) around its hypothesized log linear form. He suggests the use of a negative-binomial estimator, our second form, and maximum likelihood estimation to correct the fit for overdispersion.[11] A third response is to turn to quasi-maximum likelihood estimators (QMLE). Given data where $var(y|x_i)$ is not orthogonal to x_i, nonlinear least squares estimators will lack efficiency properties for estimating conditional means, while generalized linear models calculate the conditional mean and the conditional variance of y without assuming any particular distribution (Wooldridge, 1997). For example, the Poisson QMLE is consistent for the

[11] According to Cameron & Trivedi (1998), we may assume Poisson fit if a relationship between the parameter λ and the exogenous covariates x_i, such as $\ln \lambda = \beta' x_i$, is parametrically exact, and does not comprise any endogenous term. If the relationship above is stochastic, e.g. $\ln \lambda = \beta' x_i + \varepsilon_i$we should assume an alternate mixed-Poisson model such as the negative binomial.

parameters of the conditional mean, no matter what the distribution of y conditional on x_i is. Generalized linear models (GLM) do not require a specific distribution for the study of conditionals mean and variances. The use of QMLE relaxes the poison restriction and provides consistent estimators even when the conditional distribution of y is not known. Using the normal distribution as the baseline model, in this paper, therefore, we also estimated a normal QMLE. [12]

4.3 Estimation Issues

Forms. The Poisson distribution gives the probability of observing y events in a unit time interval. The density of the Poisson distribution conditional on the observations set x is described by:

$$f(y|x,\beta) = \frac{e^{-\lambda(x,\beta)}\lambda(x,\beta)^y}{y!} \tag{8}$$

where λ is the distribution parameter, x is the set of explanatory covariates, and β is vector of regressors. The maximum likelihood estimator (MLE) is calculated by maximizing the log likelihood function:

$$\ell(\beta) = \sum_{i=1}^{N}\{y_i \log\lambda(x_i,\beta) - \lambda(x_i,\beta) - \log(y_i!)\} \tag{9}$$

where y_i is the expected number of events in a unit time interval, and x_i are the explanatory variables. Under the Poisson distribution, the conditional mean and variance are given by the trivial estimate $\hat{\lambda} = \exp(\hat{\beta}' x)$.

The negative binomial distribution describes the same probability, but in a different way. The density of the negative binomial distribution conditional on observations x is described by

$$f(y|x,\beta) = \binom{n+y-1}{y}(1-\theta(x,\beta))^y\theta(x,\beta)^n \tag{10}$$

[12]Despite the usefulness of this last model for comparison purposes, if y is not normally distributed, consistent estimates are only provided if the error terms ε_i are homoskedastic (constant variance) and the parameter λ_i is correctly specified. Pagan & Pak (1991), however, explain that there is an intrinsic heteroskedasticity in count data models, which rules out the possibility of obtaining reasonable estimates through this model. We also considered exponential and negative-binomial quasi-maximum likelihood estimators (QMLE), but tests indicated that these estimates were no better than Poisson and negative binomial maximum likelihood estimators. For example, we could not reject the hypothesis of Poissoneness at 5% level of significance for the USTR 301 sample and the Negative-Binomial model provided a superior fit in the WTO sample. See Perrelli and Grinols (2000). For a better understanding of those techniques, we provide a brief summary of the three methods. Further details omitted here are easily obtained through the suggested readings at the end of this paper.

where y is the expected number of failures before n successes, n is the number of successes in a sequence of binomial trials, θ is the probability of success at each trial, and x are covariates that determines θ. [13] The log-likelihood for the negative binomial is:

$$\ell(\beta,\theta)=\sum_{i=1}^{N}\{y_i\log(\lambda_i\theta^2)-(y_i+\theta^2)\log(1+\lambda_i\theta^2)+\log\Phi(y_i+\frac{1}{\theta^2})-\log(y_i!)-\log\Phi(\frac{1}{\theta^2})\} \quad (11)$$

where λ_i is a distribution parameter representing the exponential mean, y_i is expected number of events (failures) before the n^{th} success, θ^2 is an estimated parameter of the amount in which the variance exceeds the mean (overdispersion), and Φ is the distribution function of such parameter.

The normal distribution applied here likewise gives the probability of observing y events in a unit time interval. The density of the normal distribution conditional on observations x is described by

$$f(y|x,\beta)=\frac{1}{\sqrt{2\pi}\sigma}\exp-\frac{1}{2\sigma^2}(y-\lambda(x,\beta))^2 \quad (12)$$

where y is the expected number of events, λ is the conditional mean, σ is the conditional variance, and x is the set of covariates that explain λ. The normal quasi-MLE has the following log-likelihood form:

$$\ell(\beta)=\sum_{i=1}^{N}\{-\frac{1}{2}(\frac{y_i-\lambda_i}{\sigma})^2-\frac{1}{2}\log\sigma^2-\frac{1}{2}\log 2\pi\}. \quad (13)$$

where y_i, λ_i, and σ have the same maening as in the former equationis.

Robustness. To obtain robust standard errors, allowing for the possibility of overdispersion, we adopted for the Poisson and negative binomial distributions the Generalized Linear Model (GLM) covariance matrix, $Var_{GLM}(\hat{\beta})=\hat{\sigma}^2Var_{ML}(\hat{\beta})$ where $\hat{\sigma}^2=\frac{1}{N-K}\sum_{i=1}^{N}\frac{(y_i-\hat{y})}{\sqrt[2]{Var(\hat{\epsilon_i})}}$. For the the normal QMLE, we used the traditional Huber-White pseudo-MLE corrected standard errors, $Var_{QMLE}(\hat{\beta})=H^{-1}gg'H^{-1}$.

Model Evaluation. For model evaluation we referenced the following evaluation statistics: adjusted-R^2, log likelihood, likelihood ratio (LR), the Akaike criterion (AIC), and the Schwarz criterion (SBC)).[14] Generally, models with large log likelihood values provide lower bias, and a best fitting ability. Models with small AIC or SBC criterion present a better specification, based

[13] See Bickel & Doksum (1977) for a better discussion on probability models.

[14] Recall that $AIC=-2(\frac{l}{n})+2(\frac{k}{n})$, while $SBC=-2(\frac{l}{n})+k(\frac{\ln n}{n})$, where l is the value of the log likelihood, n is the sample size, and k is the number of parameters included in the model.

on the bayesian prior about the existence of a "true" model . For sample sizes greater than 8, the SBC criterion attributes a larger penalty for each covariate added to the model than the AIC criterion does. According Gourieroux & Monfort (1995), the SBC criterion has the advantage of being consistent. Thus, for large samples SBC provides a more parsimonious decision rule about covariate selection and model specification. Finally, for the special case of the Poisson distribution, we provide another useful criterion of econometric modelling, the Goodness-of-Fit test, which identifies inappropriate Poisson specifications when the test statistic is significant.

4.4 Results

The techniques presented above were used to test what variables really matter to explaining the number of trade disputes. The results are presented in Table 2 below.

Table 2: USTR Section 301, GATT and WTO Population Estimates

Panel	USTR Section 301			GATT & WTO		
Model	Poisson	N-Bin.	Normal	Poisson	N-Bin.	Normal
GTS	-0.9162	-0.9494	-0.8453	5.1376	5.3241	5.0490
s.e	(0.409)	(0.419)	(0.397)	(0.633)	(0.580)	(0.822)
prob	0.025	0.024	0.033	0.000	0.000	0.000
OPEN	-8.1263	-8.3622	-7.5831	17.5019	16.9062	20.4001
s.e	(2.089)	(2.192)	(1.696)	(3.104)	(3.036)	(3.108)
prob	0.000	0.000	0.000	0.000	0.000	0.000
USTB	-8.2314	-8.2324	-8.1707	-9.8655	-9.9345	-8.6391
s.e	(2.459)	(2.583)	(2.431)	(3.425)	(3.511)	(3.481)
prob	0.001	0.001	0.000	0.004	0.005	0.013
WTO	0.0896	0.1051	0.0512	0.3848	0.3800	0.3471
s.e	(0.105)	(0.110)	(0.096)	(0.157)	(0.159)	(0.119)
prob	0.394	0.340	0.597	0.015	0.017	0.004
CONST	4.0879	4.1476	3.9570	-5.6087	-5.6665	-5.9842
s.e	(0.488)	(0.517)	0.398	(0.757)	(0.722)	(1.019)
prob	0.000	0.000	0.000	0.000	0.000	0.000
Goodness-of-fit test	468.99			541.05		
GOF> $\chi_{(\cdot)}$	0.00			0.00		
Adjusted-R^2	0.11	0.11	0.12	0.65	0.64	0.65
Log-likelihood	-826.20	-810.16	-2513.567	-749.65	-711.70	-2170.07
LR $_{(\cdot)}$	65.47	97.53	657.38	925.20	1001.07	7228.39
LR> $\chi_{(6)}$	0.00	0.00	0.00	0.00	0.00	0.00
AIC	5.71	5.60	17.30	5.19	4.93	14.95
SBC	5.77	5.66	17.37	5.25	4.99	15.01
Sample Size	291	291	291	291	291	291

Consider GATT & WTO cases first. From Table 2 we can see that,in terms of log-likelihood ratio tests, all models are significant. Moreover, they present a reasonable coefficient of determination (R^2 around 65%) for generalized linear methods.

Based on the AIC and SBC criteria, the Poison and negative binomial models are superior to the Normal, and the Negative Binomial is marginally superior to the Poisson model. The Negative Binomial model generates lower log-likelihood, and consequently smaller AIC and SBC criteria. This suggests that it it has the best fitting ability, as well as being the closest one to the "true" model in the Bayesian sense, as implied by the AIC and SBC criteria. Also against the Poisson is the fact that the goodness-of-fit test rejects the null hypothesis of "Poisoness".

Regarding the selection of the variables, if we adopt the Poisson or the Negative Binomial specifications, one can interpret the estimated coefficients as the marginal contribution of each variable to the probability of observing additional cases per month. In this sense, increases in the trade share of the country group (GTS), in the US openness degree (OPEN), and in the US trade balance (USTB)—all significant at the 1% level—reduce the likelihood of disputes. Last, but not least, the advent of WTO—measured by the inter-temporal dummy variable that assumes the value of 1 after December 1994—is positive and significant at the 5 percent level. According to the regression, the WTO increased the monthly population of cases by nearly 47 percent.[15]

Contrasting panels, the results of the GATT & WTO regressions are much superior to the USTR Section 301. Although the USTR models survive the likelihood ratio test, they present a higher log-likelihood function than in the former panel. The AIC and SBC criteria are worse as well. Moreover, the coefficient of determination is very low for all model specifications (R^2 around 11%). Comparing within the USTR Section 301 panel, the Poisson model does not pass on the goodness-of-fit test, and the Negative Binomial is again superior to it, presenting the lowest log-likelihood, AIC, and SBC criteria. In terms of variable selection, all included covariates are significant at the 5 percent level, except the WTO dummy—even though it has the right sign. This result is a puzzle, given our expectations on the impact of WTO advent on the population of cases. One possible resolution of this puzzle can be found through a meticulous data analysis. Using the Venn diagram provided in Figure 1, suggests that the proportion of USTR Section 301 cases that are also GATT (19%) is much lower that the proportion of USTR Section 301 cases that are also WTO cases (55%). We ran a simple $\chi_{(1)}$-test for the difference of two proportions, and at 1% level of significance we can reject the null hypothesis of similar proportions.[16] A nice visualization of those findings is provided by the figure 6 below.

This result suggests that the USTR is using the WTO dispute settlement mechanism more

[15]One can calculate the marginal contribution of the WTO dummy variable, given the other covariates, by the difference between the first-order derivative of the regression under the presence of WTO, $e^{0.3848*WTO==1} = 1.4693$, and the same derivative under the absence of WTO, $e^{0.3848*WTO==0} = 1.0000$.

[16]In the one hand, from the 102 USTR Section 301 cases initiated up to December 1994, 19 are also GATT cases. In the other hand, from the 22 USTR Section 301 cases opened after December 1994, 12 are also WTO cases. The $\chi_{(1)}$ test statistic for the difference of proportions is 12.4513, and the critical is 6.6349.

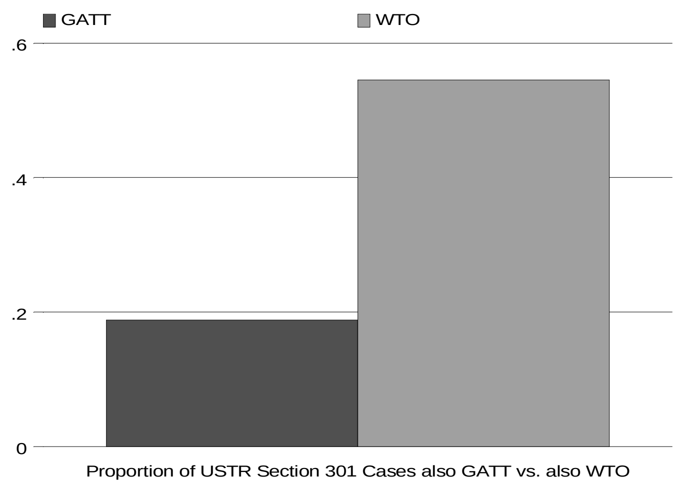


Figure 7: USTR Use of WTO in Trade Disputes

frequently than it had used the GATT apparatus. for this reason, a great number of USTR Section 301 cases are also WTO cases nowadays, and there is a significant probability that a potential new USTR Section 301 case is converted into a WTO case before its initiation. Possibly this explains the correct sign but the non-significance of the covariate WTO in the USTR Section 301 panel regressions.

5 Estimating the WTO Impact on Case Births and Lifespans

So far we have tested for the impact of the WTO advent on the population of international trade disputes. The impact was positive and significant for the GATT&WTO panel, and positive but not significant for the USTR Section 301 panel. Population is a function of the difference between the number of births and deaths. It therefore reflects information from both variables, but does not provide separatel information on each. Further analysis of births and deaths of trade disputes, or equivalently, births and lifespans, provides more detail on dynamics.

5.1 Births: A Count Data Analysis

Using the same data we presented in the population study, we implemented a new count data study on the birth of trade disputes. Instead of using the number of open cases as the dependent variable, we used the number of new cases per month (births) as the dependent variable. Also we used the WTO inter-temporal dummy variable as the only covariate of the model. This choice was made after testing for the significance of all the other covariates that we included in the population study, and finding insignificant contribution of those covariates to the birth of cases at a given date. Retaining just the WTO covariate provided results on the role of the WTO advent.

To test whether the simple model of Section 3 accurately predicted the effect of the WTO on the birth of cases, we ran three different models of count data: the Poisson, the Negative Binomial, and the Normal. According to the trade game model, the smaller cost of adjudication provided by the advent of WTO should be followed by an increased incidence of cases. The results are shown in table 3 below.

Table 3: USTR Section 301, GATT and WTO Birth Rates Estimates

Panel	**USTR Section 301**			**GATT & WTO**		
Model	**Poisson**	**N-Bin.**	**Normal**	**Poisson**	**N-Bin.**	**Normal**
WTO	-0.0561	-0.0561	-0.0561	1.6052	1.6052	1.6052
s.e	(0.290)	(0.290)	(0.302)	(0.239)	(0.239)	(0.265)
prob	0.847	0.847	0.853	0.000	0.000	0.000
CONST	-0.8602	-0.8602	-0.8602	-1.6052	-1.6052	-1.6051
s.e	(0.132)	(0.132)	(0.130)	(0.165)	(0.165)	(0.247)
prob	0.000	0.000	0.000	0.000	0.000	0.000
Goodness-of-fit test	347.94			288.48		
GOF> $\chi_{(\cdot)}$	0.014			0.547		
Adjusted-R^2	0.00	0.00	0.00	0.15	0.15	0.15
Log-likelihood	-267.34	-252.90	-373.93	-219.93	-210.05	-353.95
LR $_{(\cdot)}$	0.06	0.04	0.02	65.41	45.12	30.50
LR> $\chi_{(6)}$	0.80	0.83	0.87	0.00	0.00	0.00
AIC	1.83	1.73	2.56	1.51	1.44	2.42
SBC	1.85	1.76	2.58	1.53	1.47	2.45
Sample Size	294	294	294	294	294	294

From Table 3 we can see that a simple count data regression containing only the WTO variable can no longer describe the behavior of birth rates in the USTR Section 301 panel. The dummy variable is not significant and, because of that, almost nothing remain valid in the regressions. However, a different result is provided under the GATT&WTO panel: the WTO dummy variable is positive and significant. Moreover, the model passes on the likelihood ratio test. According to those results, the advent of WTO increased the likelihood of new cases per month by approximately 398 percent.[17] Nevertheless, the coefficient of determination is still low (around 15%) when compared

[17] I.e., the difference between $e^{1.6052*WTO==1}$ = and $e^{1.6052*WTO==0} = 1.0000$.

with the regressions for the population of trade disputes.

5.2 Dispute Lifespans: A Survival Analysis

One of the ways that the WTO can reduce adjudication costs is through shorter case timetables enforced by the WTO. In this section we test whether stricter WTO time limits have resulted in shorter caselength. The study of event durations is an ideal candidate for a technique known as survival analysis. Often applied in the medical field, a standard question might be what would the survival rates of a group of bacteria be and after patients are vaccinated by a particular drug. Survival rates might differ by the type of patient as well as their treatment.[18] We are asking a similar question here: Bacteria are replaced by trade dispute cases, the length of time a case is negotiated and litigated is the "survival" time or lifespan of the bacteria, and the change in treatment is the introduction of WTO rules and services to client nations. Since survival might also vary by type of patient, we must be prepared to take account of such variations when we identify the effects of the WTO.

Survival analysis is closely connected to the use of hazard rates. In the medical context, hazard rates are found by monitoring the rate of bacteria deaths per time period after the introduction of a new vaccine. In our setting, they correspond to the rate of cases solved per month after the WTO advent. If the WTO is effective, we expect that the number of solved cases relative to the total monthly caseload (hazard rate) will increase and the duration of the cases (survival probability) will decrease after the application of WTO rules. Our study compared the lifespan of WTO trade disputes to the lifespan of USTR Section 301 cases.

Following Neumann (1997), we used a nonnegative random variable, T, to describes the length of time until a trade dispute is finished. The cumulative distribution and the probability density functions of T are given, respectively, by:

$$F(t) = Prob(T < t), 0 < t < \infty \tag{14}$$

$$f(t) = \lim_{dt \to 0} \frac{Prob(t \leq T \leq t + dt)}{dt} = \frac{\partial F(t)}{\partial t} \tag{15}$$

One can interpret $F(t)$ as the probability that a trade dispute will last no longer than t days. The conditional probability that a trade dispute will last t periods or longer, which is called the Survivor function, is given by:

$$S(t) = Prob(T \geq t) = 1 - F(t) \tag{16}$$

[18]A number of interesting duration studies have appeared in different economic fields. Keenan (1985) provides one of the leading essays in the area, introducing survival analysis to explain the duration of strikes in labor economics. Surprisingly, we could not find any study about the duration of international trade disputes. Nevertheless, it seems clear that a quantitative analysis of the issue can be particularly worthwhile to understanding the mechanics of international trade disputes.

From the survivor function one can obtain the instantaneous rate of failure at T=t, conditional upon survival to time t, as the Hazard function, $h(t)$:

$$h(t) = \lim_{dt \to 0} \frac{Prob(t \leq T < t + dt | T \geq t)}{dt} = \frac{f(t)}{S(t)} \tag{17}$$

Finally, through the integrated form of the Survivor function, we can obtain the Integrated Hazard $\Lambda(t)$ as follows:

$$S(t) = exp(-\int_0^t h(s)ds) = exp(-\Lambda(t)) \tag{18}$$

According to Heckman & Borjas (1980), the shape of the Hazard function provides a characterization of the underlying stochastic process. There is a positive duration dependence - i.e., higher probability of failure as the time goes by - if $\partial h(t)/\partial t > 0$. The survival process is said to be memoryless when this first derivative equals zero, and negatively duration dependent otherwise. Theoretically we expect to find a positive duration dependence in the trade disputes, because as longer the arbitration process as higher the costs of extending the trade game.

Choosing Between Fixed or Time-Varying Covariates. Although there is no previous study about the determinants of the length of trade disputes, it seems clear that some variables that affect macroeconomic policies as well as volume of trade across countries could help explain the duration of these conflicts. For this reason, we tested the bargaining power of the opponents (GTS), the US openness degree to trade (USOPEN), and the US trade balance (USTB) as potential explanatory variables. Intrinsically, they are time-varying covariates. However, to avoid possible bias due to the pseudo-smoothing pattern artificially imposed to them in the conversion of annual to monthly data, those variables were chosen as time-fixed covariates. They were evaluated at at their final magnitude, i.e., their value at the failure month.

This estimation decision seems to be more accurate and, actually, more plausible because the impulse response functions of changes in those variables are fairly smoothed and their effects take a long time to be completed absorbed. Therefore, it eliminates the spurious correlation between a drastic change in any of these variables at a given month and the failure event rate on that month. By nature, trade disputes are events that take a long time to be solved, and the response of these events to external facts are delayed by bureaucratic and political aspects that surround the disputes.

Besides this set of exogenous variables, we also test the significance of some dummy variables in the explanation of the lifespan of trade disputes. We consider dummies for whether the U.S. is the plaintiff of the dispute, for the years of generalized foreign currency crises, for the period of the GATT Uruguay Round, and for the months of case overload (i.e, when the number of open cases is greater than the 80th percentile of its own series). More details on the estimations, hypothesis testing, and main results will be introduced through the next sections.

5.2.1 Parametric Modelling

Given the general framework above, we can start applying the duration analysis to study the length of trade disputes. Since we do not have any a priori about the behavior of these disputes, neither any relative literature provides a consistent analysis of them, we think that it is useful to start with the fully parametric models of duration. In the parametric cases, the error term of the hazard function is supposed to behave according some parametric probability distribution function. For the present paper we consider the following distribution functions: Weibull, Exponential, Gompertz, Gamma, Log-Normal, and Log-Logistic.

Traditionally, the fully parametric survival analysis can be subdivided in two main branches: the Accelerated Failure-Time (AFT) models and the Proportional Hazard Rate (PHR) models. The general equation of AFT models is given by:

$$\ln(t_j) = x_j\beta + \varepsilon_j \tag{19}$$

where t_j is the survival time, x_j is a vector of covariates, and ε_j is the error term, which is assumed to be parametrically distributed. In the same way, the general equation of PHR models is given by:

$$h(t_j) = h_0(t)e^{x_j\beta} \tag{20}$$

where $h(t_j)$ is the hazard rate function, $h_0(t)$ is the baseline function, and $e^{x_j\beta}$ is the relative risk exposure.

When the baseline follows a Weibull, Exponential, or Gompertz probability distribution, the PHR model is adopted. Otherwise, i.e., when the error term follows a Gamma, Lognormal or Log-Logistic probability distribution, the AFT model is used. In the special case that the baseline hazard function $h_0(t)$ is unspecified, we have the Cox Proportional Hazard Model, which we will introduce as a semi-parametric approach in the next subsection.

Empirical Results. We conduct the survival study in the same fashion we have adopted so far in this paper, i.e., separating the data sets in two main panels – one containing only USTR Section 301 cases, and another containing only GATT or WTO cases. As we saw in the Venn diagram of Section 1, there is no intersection between the 48 GATT cases and the 60 WTO cases of our sample. Nevertheless, from the 123 USTR Section 301 cases, 19 also adopted the GATT dispute settlement mechanism, 12 also adopted the WTO dispute settlement mechanism, and 92 never resorted to GATT nor WTO assistance. In the GATT & WTO panel we use one dummy variable to distinguish between those two types of case. In the USTR panel, we use two dummy variables to distinguish between three different categories: USTR_{ONLY}, USTR_{GATT}, and USTR_{WTO}.

Table 4 shows the results of the parametric models of duration cited in this paper. In the first panel, the benchmark category is USTR_{ONLY}. Therefore, all dummy explanatory variables should be compared with this category. In the second panel, the benchmark category is the set of GATT cases, and the used dummy is contrasted with such category. Non-dummy covariates apply to all categories, and should be interpreted as a general characteristic of the model.

Regarding to model specification, the Weibull, the Exponential, and the Gompertz models follow the PHR general equation, and consequently they do not provide any intercept. On the other hand, the Gamma, the Lognormal, and the Log-Logistic models are on the AFT form, and provide their respective intercepts. For the choice of the best model, we select the one with the greater log likelihood (i.e., best fitting ability) and the smallest AIC and SBC criteria[19]. The AIC and SBC criteria can be used as a proxy to the mean-square error approach, because they provide an equilibrium between bias and variance – large models (with too many explanatory variables) provide less bias but more variance, while short models provide the reverse effect. AIC and SBC point out to the more balanced model, penalizing the use of too many parameters at the same time that awarding large log-likelihood estimates. Theoretically, the model with lower AIC and SBC criteria provides the best approximation of the "true" Bayesian a prioristic model among the parametric choices presented here.

[19]For survival parametric models, the AIC and SBC criteria include all model-specific ancillary parameters.

Table 4: Fully Parametric Models for the Duration of Trade Disputes

Model	Weibull	Expo	Gompertz	Gamma	LogNormal	LogLog
			Panel A – USTR Section 301 Cases			
$USTR_{GATT}$	0.5575	0.6014	0.5693	0.5548	0.6186	0.6500
s.e	(0.144)	(0.127)	(0.140)	(0.220)	(0.244)	(0.215)
prob	0.024	0.016	0.022	0.012	0.011	0.003
$USTR_{WTO}$	0.6580	0.6838	0.6655	0.4500	0.6217	0.5398
s.e	(0.196)	(0.161)	(0.184)	(0.230)	(0.194)	(0.175)
prob	0.160	0.108	0.142	0.050	0.001	0.002
GTS	0.0250	0.0564	0.0361	2.5227	1.7148	1.7467
s.e	(0.034)	(0.057)	(0.046)	(1.157)	(1.026)	(0.980)
prob	0.008	0.005	0.009	0.029	0.095	0.075
CONST				5.9057	5.7313	5.7637
s.e				(0.134)	(0.154)	(0.118)
prob				0.000	0.000	0.000
Log-likelihood	-158.78	-162.40	-161.57	-156.76	-160.83	-156.36
Wald$\chi_{(3)}$	15.64	19.25	15.09	18.74	16.57	20.33
Wald$> \chi_{(3)}$	0.00	0.00	0.00	0.00	0.00	0.00
AIC	2.74	2.80	2.79	2.71	2.78	2.70
SBC	2.81	2.87	2.86	2.78	2.85	2.77
Sample Size	118	118	118	118	118	118
			Panel B – GATT & WTO Cases			
WTO	1.5698	1.2130	1.4543	-0.1895	-0.2227	-0.0567
s.e	(0.311)	(0.151)	(0.213)	(0.121)	(0.140)	(0.122)
prob	0.023	0.120	0.010	0.118	0.111	0.641
GTS	0.128	0.3601	0.1938	1.007	0.9246	0.8738
s.e	(0.139)	(0.224)	(0.156)	(0.613)	(0.704)	(0.576)
prob	0.059	0.100	0.041	0.100	0.189	0.129
CONST				6.1965	6.0612	6.0472
s.e				(0.135)	(0.135)	(0.114)
prob				0.000	0.000	0.000
Log-likelihood	-81.36	-100.06	-93.91	-78.93	-82.46	-77.99
Wald$\chi_{(2)}$	10.58	5.23	12.56	5.46	4.36	2.60
Wald$> \chi_{(2)}$	0.01	0.07	0.00	0.07	0.11	0.27
AIC	1.96	2.40	2.26	1.90	1.99	1.88
SBC	2.02	2.46	2.31	1.96	2.04	1.94
Sample Size	85	85	85	85	85	85

Considering the model selection criteria provided on Table 4, for the Panel A – USTR Section 301 cases – the Gamma model seems to be the more appropriate. The main reason is that, besides the very low AIC and SBC criteria (almost the lowest among the specifications), the Gamma model also provides significant regressors at 5% level. The Gamma model passes on the Wald test for joint significance as well. If we choose the Gamma model as our compass, according to the AFT general equation we can interpret the regressors as follows: The marginal contribution of the GTS is extremely positive – as higher the bargaining power of the opponent, as longer will be the expected lifespan of a dispute. Also, the marginal contributions of resorting to GATT or WTO assistance will have a positive impact on the duration of the case. This result is expected because the USTR Section 301 cases that resort to GATT or WTO dispute settlement body are, in average, the most complicated cases and it is natural to expect a higher lifespan for them when compared to USTR_{ONLY} cases. Nevertheless, the bottom line of those results is that the impact of the WTO assistance is more effective than the GATT assistance, in the sense that it can solves a case faster and, therefore, its marginal contribution to the lifespan of USTR Section 301 cases is smaller than GATT's contribution.

Regarding to Panel B – GATT & WTO cases – the most appropriate model seems to be the Weibull. Although this model is the third best in terms of AIC and SBC criteria, its rivals do not pass on the Wald test of joint significance of regressors. The Weibull is the only one that provides significant covariates plus reasonable Log-likelihood, AIC, and SBC criteria. This model is in a PHR form, and from the results we can see that the proportional hazard rate of WTO cases is much higher than the adopted benchmark (GATT cases). Being a WTO case increases the proportional hazard rate in near 57%. Therefore, the lifespan of WTO cases is, in average, much shorter than the lifespan of GATT cases. Also the bargaining power of the opponents (GTS) is crucial here: As higher the bargaining power, as lower the hazard rate, as higher the survival time, and as longer the case!

The results above are quite satisfactory, and according to the theoretical model we sketched in Section 2. However, the requirement of being fully parameterized is quite strong. Moreover, some of the regressors are not significant across all specifications, and to avoid type I error when solving our hypothesis testing, we have to adopt a high level of significance for those cases. Therefore, it seems that we have enough reasons to go further and implement a semi-parametric approach, with more relaxed assumptions.

5.2.2 Semi-Parametric Alternative: The Cox Approach

The Cox Proportional approach estimates a hazard model without impose a parametric specification for the baseline hazard function h_0. The Cox hazard function is simply given by:

$$h(t) = h_0(t)e^{\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k} \tag{21}$$

where the x_j are the covariates. The main advantage of the Cox model is that it reasonably combines the fully non-parametric characteristics of intrinsically empirical hazard estimators, like the Nelson-Aalen, with theoretically structured parametric models (see Greene, 1999). This fairness provided by the Cox model offers a significant advantage to deal with trade disputes data, when compared with the best parametric specifications we obtained in the last section.

Semi-Parametric Empirical Results. Table 5 shows the estimates for the Cox Proportional hazard model. There, we also can see the results of the test of proportional hazard assumption, based on Grambsch & Therneau (1994), which checks if the log hazard ratio function is constant over time. If it is not, a stratified Cox regression would be required.

From the results of Table 5 we can see that, for the Panel A – USTR Section 301 cases – every single explanatory variable is significantly different than zero at 5% level. Moreover, the individual test of proportional hazard performed for each variable shows that none of them violates the proportional hazard hypothesis required by the Cox approach. The global test statistic for the whole equation also attends to this requirement. The results obtained show that being a USTR_{GATT} case reduces the hazard rate to almost 52% of the benchmark hazard (USTR_{ONLY}), while being a USTR_{WTO} reduces to near 60% of the original hazard. This supports our previous finding: USTR Section 301 cases that resort to GATT mechanism are longer than USTR Section 301 cases that resort to WTO mechanism. Moreover, USTR cases that do not resort to any of those mechanisms are even shorter than their counterparts.

For the Panel B – GATT & WTO cases – the diagnostic is not so clear. Both regressors have the right sign and dimension expected in our theoretical model and supported by the selected Weibull parametric regression. Both regressors pass on the rank test of proportional hazard rate along time, as the whole model does in the global test. Nevertheless, none of the regressors are significantly different from zero at 5% level of significance, in this Cox semi-parametric specification. Under this scenario, we cannot affirm that WTO cases have a higher hazard rate that GATT cases, as we have done before.

However, from the results above we detect that the selected parametric models[20] for each panel present superior performance according to the AIC, SBC, Log-likelihood, and Wald criteria. Also the regressors are significantly different from zero at acceptable significance levels. Therefore, parametric modelling is quite reasonable in this case.

To elucidate any remaining question about what approach shall be used, in the next subsection we contrast the parametric and semi-parametric results with the empirical (fully non-parametric) findings, and check which specification matches the data better.

[20]As discussed in the previous subsection, they are: AFT Gamma for USTR Section 301 cases, and PHR Weibull for GATT & WTO cases

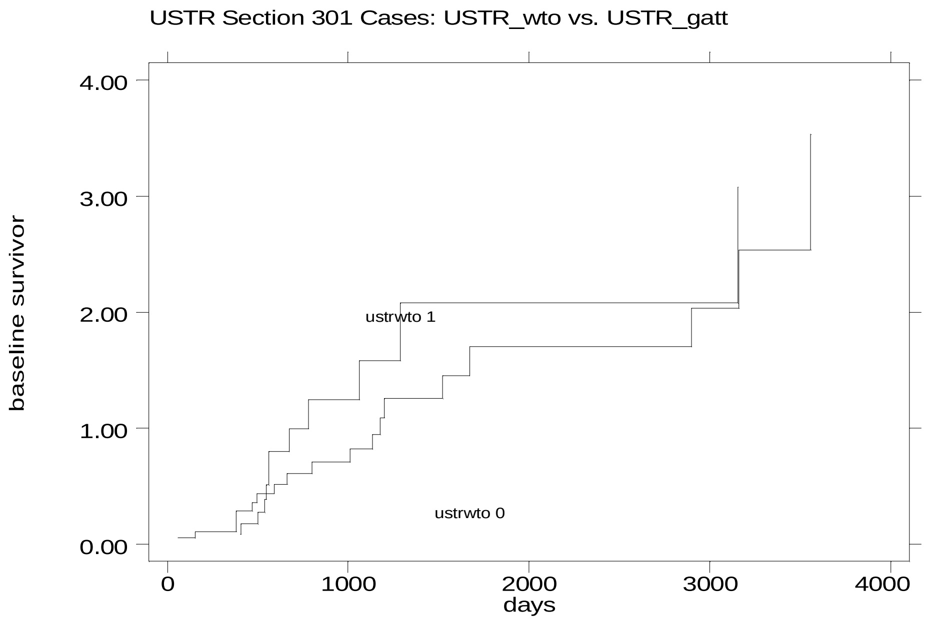


Figure 8: Comparison of the Hazard Rate of Section 301 Cases Under GATT vs WTO

5.2.3 Nonparametric Test of Model Validity

This section compares the parametric and semi-parametric results with the empirical data. Using the Kaplan-Meier cumulative survivor function and the Nelson-Aalen cumulative hazard function, we plot the last two estimates and check in which extent the parametric models and the Cox model estimates differ from these empirical estimates. The Kaplan-Meier survivor function is given by the following non-parametric maximum-likelihood estimate:

$$\hat{S}(t) = \prod_{j|t_j \leq t} (\frac{n_j - d_j}{n_j}) \tag{22}$$

where n_j is the number of open cases at time t_j and d_j is the number of finished disputes at this time. In the same way, the Nelson-Aalen cumulative hazard function is defined as:

$$\hat{H}(t) = \sum_{j|t_j \leq t} \frac{d_j}{n_j} \tag{23}$$

The plots of the empirical survivor and hazard functions are correlated in an opposite way: as steeper the hazard rate function, as smoother the survival function. Therefore, we will present here only the graphs concerning the hazard function (a.k.a. Nelson-Aalen plots). The results for both panels are shown on the figures below.

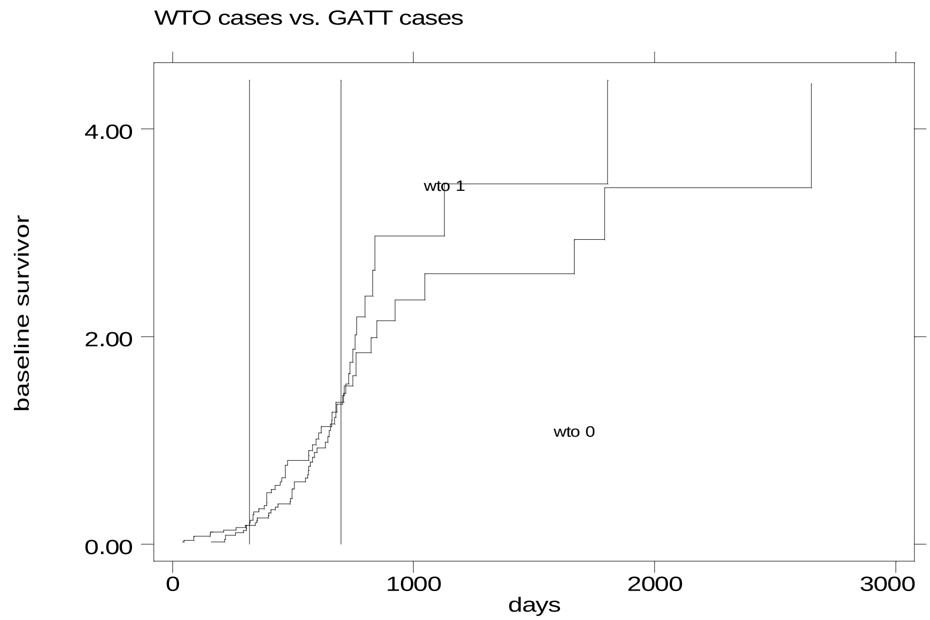


Figure 9: Comparison of the Hazard Rate of GATT Cases vs WTO

For the first panel – USTR Section 301 cases, we consider only USTR cases that resort to WTO assistance or to GATT assistance. Contrasting them, we can see that the hazard rate of USTR cases that resort to WTO assistance is significantly higher than the hazard rate of USTR cases that resort to GATT assistance. It means that the latter type of case has a longer lifespan than the former. Therefore, the advent of WTO contributed to reduce the duration of USTR Section 301 cases that resort to international dispute settlement mechanisms. Those empirical findings support both the parametric and semi-parametric estimated results of the previous sections.

For second panel – GATT & WTO cases, we simply compare the hazard rate function of WTO cases against GATT cases. The result shows that, if we subdivide the lifespan grid in three parts, the first from zero to 320 days, the second from 321 to 700 days, and the third from 701 to 3600 days, we obtain three different relationships between the hazard functions of disputes. It the first and third intervals, the WTO hazard rate is superior to the GATT hazard rate. In the second interval, the result is reversed. Thus, the hazard rate functions cross each other at two points of the sample. By this reason we can not affirm that WTO cases are shorter than GATT cases in the whole sample, but only in the first and third intervals[21].

[21] A suggested parametric approach to deal with such alternation along the sample is the use of quantile regressions. Survival analysis quantile regression is being currently studied by Koenker and Bilias (2001).

6 Conclusion

We have presented a theoretical and empirical analysis of the population, birth, and lifespan of US trade disputes under three regimes: Section 301 trade law, GATT, and the WTO. The game-theoretical model of disputes between two representative countries, a complainant (α) and the infringer (β), involved the random arrival of opportunities to infringe in a typical Bayesian non-cooperative game. β's decision to infringe was based on the benefits that β might obtain, and also on β's beliefs about how α would respond. Once an infringement has been discovered, α's trade representative decides whether to accept the case for processing (prosecution), and chooses α's strategy regarding a subsequent negotiated settlement with the infringer and whether to proceed to WTO adjudication if settlement cannot be reached. A credibility condition and an infringement constraint were crucial to the players in the repeated game. Without a credible reputation for prosecuting cases, α will allow other countries to feel free to infringe its WTO rights with impunity. If so, negotiated settlements will never be reached because the defendant has no incentive to accept them. The model was examined for its implications for changes to several types of costs to players. In general, the move to a regime with lower adjudication costs results in more decisions to infringe and more dispute litigations. Since the WTO rules imposes strict timetables on trade disputes, we expected that the presence of the WTO should result in more cases of shorter length.

The paper was also devoted to identifying a common pattern of trade disputes, primarily through the use of count data models and survival analysis applied to US cases. We were interested in modeling the population, births, and lifespan of trade dispute cases, testing for the impact of the WTO on each. Three types of data were examined: USTR Section 301 disputes (1975-2000), GATT trade disputes (1975-1994) involving the US as complainant or defendant, and WTO trade disputes (1995-2000) involving the US as complainant or defendant. We placed the opponent countries into seven groups, according to geographical clusters suggested by the OECD. We fitted a Poisson, negative binomial, and a Normal quasi-MLE model to the data. For the WTO cases the negative binomial performed better than the pure Poisson due to the *overdispersion* phenomenon commonly verified in empirical applications.

The bottom line of the population and birth experiments was that the WTO appears to have increased the numer of cases, consistent with the view that it lowered adjudication costs and shortened caselength. This agrees with the predictions of a simple repeated game model of infringements.

We also implemented a survival analysis. Starting with six fully parametric alternatives, we found that the Gamma model best represented the lifespan of USTR Section 301 cases and that the Weibull model best represented the GATT and WTO cases. Relaxing some of the restrictions of the fully parametric approaches, we estimated a semi-parametric (Cox Proportional Hazard) model. For the USTR Section 301 cases, the explanatory variables that worked well in the Gamma model continued to perform well. For the GATT and WTO cases, the variables that worked well in the Weibull model also appeared in the semi-parametric setting with the same signs and magnitudes, but individuall were no longer significant at the five percent level. The Cox model passed a proportional hazard test based on the methodology suggested by Grambsch & Therneau (1994). Finally, we calculated cumulative hazard (Nelson-Aalen) estimates, and found that the WTO significantly shortened USTR Section 301 cases but had only marginally impact on GATT cases. What the estimates show is that the probability of a USTR Section 301 case terminating in the following month is 20 percent higher if the case is handled under WTO auspices than if the same case were handled by GATT. Comparing GATT vs WTO cases showed that the probability of a WTO case terminating in the following month was 25 percent higher, but the estimated coefficient was not statistically significant.

There were 19 cases of overlap between the USTR Section 301 and GATT samples and 12 cases of overlap between Section 301 and WTO samples. Section 301 only cases are shorter than Section 301-WTO cases which are shorter than Section 301-GATT cases. We also found that a statistically significantly larger proportion of Section 301 cases became WTO cases than was true for Section 301 cases in the GATT era. It thus appears that

1. the data support the view that the WTO has shortened the lifespan of a typical trade dispute,
2. that the US is using the WTO more heavily than it used GATT, and that
3. it is the harder, and therefore more lengthy, cases that are resolved through the WTO.

We hope the theoretical model and the econometric results presented here provide some insights about the economic rationale of international trade conflicts, and their implications for the population, birth rate, and lifespan of international trade disputes.

Appendix

- Proportional Hazard Cases

  The Weibull and the Exponential PH functions are given by the equation 20 above, where $h_0(t) = pt^{p-1}$ for the Weibull case and $h_0(t) = 1$ for the Exponential case. In those cases, p is the shape parameter and should be estimated direct from the data. The Gompertz PH model is given by

  $$h(t_j) = e^{\gamma t_j + x_j \beta} \tag{24}$$

  where γ is an ancillary parameter to be estimated from the data. These three specifications are useful for monotone hazard rates.

- Accelerated Failure Time Cases

  For the Gamma AFT model, the survivor function is given by

  $$S(t) = 1 - I(\kappa, \kappa \cdot exp(\frac{z}{\sqrt{\kappa}})) \tag{25}$$

where $z = \frac{\ln(t)-\lambda}{\sigma}$, and κ and σ are ancillary parameters to be estimated from the data. The Gamma hazard function is quite flexible, depending on the magnitude of the ancillary parameters. For example, when $\kappa = 1$, the Gamma hazard has the Weibull shape; when $\kappa = 1$ and $\sigma = 0$, the Gamma hazard has the Exponential shape, and when $\kappa = 0$ the Gamma hazard has the Lognormal shape.

In the case of the Lognormal AFT model, the survivor and hazard functions are, respectively,

$$S(t) = 1 - \Phi(\frac{\ln(t) - \mu}{\sigma}) \tag{26}$$

and

$$h(t) = \frac{\frac{1}{t\sigma\sqrt{2\pi}} exp(-\frac{1}{2\sigma^2}(\ln(t) - XB)^2)}{1 - \Phi(\frac{\ln(t)-XB}{\sigma})} \tag{27}$$

where σ is the standard deviation, $\Phi(\cdot)$ is the standard normal cumulative distribution, and X are the covariates.

Finally, the Log-Logistic the survivor and the hazard functions are given by

$$S(t) = \frac{1}{1 + (\lambda t)^{\frac{1}{\gamma}}} \tag{28}$$

and

$$h(t) = \frac{\lambda^{\frac{1}{\gamma}} t^{\frac{1}{\gamma}-1}}{\gamma(1 + (\lambda t)^{\frac{1}{\gamma}})} \tag{29}$$

where $\lambda = e^{-x_j\beta}$ and γ is an ancillary parameter to be estimated from the data.

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Table 5: Cox Proportional Hazard Ratio for the Duration of Trade Disputes

Cox Model		Rank Test			
Variable	**Hazard Ratio**	ρ	χ^2_1**-stat**	**d.f.**	**Prob>** χ^2_1
	Panel A – USTR Section 301 Cases				
$USTR_{GATT}$	0.5185	0.100	0.98	1	0.322
s.e	(0.128)				
prob	0.008				
$USTR_{WTO}$	0.6023	0.178	1.93	1	0.165
s.e	(0.144)				
prob	0.034				
GTS	0.0407	-0.142	2.46	1	0.117
s.e	(0.050)				
prob	0.009				
Global Test			4.88	3	0.181
Log-likelihood	-439.66				
Wald$\chi_{(3)}$	18.50				
Wald> $\chi_{(3)}$	0.00				
AIC	7.50				
SBC	7.57				
Sample Size	118				
	Panel B – GATT & WTO Cases				
WTO	1.253	0.127	1.24	1	0.266
s.e	(0.282)				
prob	0.318				
GTS	0.1583	0.055	0.22	1	0.643
s.e	(0.203)				
prob	0.150				
Global Test			1.24	2	0.537
Log-likelihood	-294.20				
Wald$\chi_{(2)}$	4.78				
Wald> $\chi_{(2)}$	0.09				
AIC	6.97				
SBC	7.03				
Sample Size	85				