Trade Disputes, Quality Choice, and Economic Integration

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Abstract: Recent work demonstrates the importance of developing high quality output in order to compete in export markets and other recent studies verify the prevalence of fixed and ongoing trade costs while participating in those markets. I consider the joint choice of quality and export promotion costs when trade relationships are subject to temporary disputes. When transparency is low and macroeconomic instability is high, disputes arrive more frequently and, therefore, firms may inefficiently choose lower levels of quality and export promotion. These, in turn, build shallower trading relationships with less trade volumes and higher tariffs, and generate greater trade reductions during the more common trade disputes. Several institutional features of the WTO that are generally lacking in preferential trade agreements such as improved transparency, dispute investigation, and the provision to recommend asymmetric continuation payoffs can ameliorate these inefficient quality choice outcomes. Hence, lower quality output and lower quality trading relationships may be more endemic to countries that depend on preferential trading areas as opposed to the WTO.

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Key Words: Quality Choice, Irreversibilities, Economic Integration Dispute Settlement, Dynamic Games, WTO, Preferential Trade Agreements .

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Introduction

The importance of producing high-quality output has begun to receive serious attention in the international trade literature. One group of studies demonstrates that high-quality production is critical in fostering economic growth and development.[1] Another group of recent studies suggests that developing high-quality production skills is necessary for firms that export.[2] On the other hand, participating in those export markets requires ongoing trade and export promotion costs.[3] In this paper we analyze how the joint decision over export quality and the commitment to trade costs are made when trade relationships are subject to temporary disputes. Our idea is that the quality of the trading arrangement can have important and previously unrealized effects on the quality of output.

Trade disputes occur periodically in the multilateral trading system (WTO) as well as in preferential trade agreements (PTAs).[4] These disputes may be triggered by egregious actions (such as dumping), however, when trade policies are not perfectly transparent they may also be triggered by macroeconomic or preference fluctuations (and erroneous antidumping claims). Evidence that developing countries use antidumping actions in response to macroeconomic shocks is given by Bown (2007). The use of antidumping measures, however, are not at all limited to developing countries. The majority of dumping allegations have been made by OECD countries and as Prusa (1991, 1997, 2001), Blonigen and Bown (2003), Blonigen and Prusa (2003), and Prusa and Skeath (2004) have demonstrated, these claims are not usually triggered by dumping, however, they are facilitated by imperfect observability of the

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[1] See for example, Grossman and Helpman (1991), Hausman et al., (2006), and Rauch (2007). Early analyses are provided by Linder (1961) and Vernon (1966).

[2] Alvarez and Lopez (2005) provide evidence for Chile, Brooks (2006) for Colombia, and Hallak (2006) for a larger group of countries.

[3] Roberts and Tybout (1997) and Das et al. (2007) provide evidence of these costs for Columbia. Evidence for France is provided by Eaton, Kortum, and Kramarz (2006). These costs are related to the theories of export hysteresis developed by Baldwin and Krugman (1989), and Dixit (1989), and, more recently, by Alessandria et al. (2008).

[4] In this paper disputes refer to those brought about by claims of unfair trade practices such as those described in Article VI of the GATT (antidumping and countervailing duties). Disputes in the present context do not refer to safeguards for emergency protection of a threatened industry (GATT Article XIX), exceptions for moral, health or environmental concerns (GATT Article XX), or renegotiation (GATT Article XXVIII). This distinction is relevant here because we model trade disputes as being generated by the misinterpretation of macroeconomic and preference fluctuations rather than a response to a stated change in importer policy. Antidumping claims are important for consideration because they have comprised the majority of safeguard and exceptions filed under the GATT/WTO.

available evidence.

To develop the relationship between quality choice and trade disputes we consider a dynamic game of tariff liberalization between two production economies with exogenous shocks that generate periodic trade wars. The cooperative level of trade barriers (as represented by an equivalent tariff) are enforced by the threat of retaliatory punitive tariffs. In addition to opportunistic behavior, however, the terms of trade is affected by macroeconomic and preference fluctuations. Even when countries do not wish to abrogate a trade agreement these external shocks can generate disputes. We consider trigger strategies as introduced by Green and Porter (1984) and adapt them to the international trade framework using the results of Abreu et al. (1990) and Fudenberg et al. (1994). Hence, exogenous shocks generate trade wars even when both countries abide by the agreement. These fluctuations are more likely to trigger disputes when non-tariff barriers are less transparent, or when countries choose not to see them clearly.

Quality choice is made by firms at the inception of the trade agreement. We assume that the incremental, and ongoing, trade, export promotion, and product development costs are related to the quality choice. In particular, higher quality products require that a higher percentage of these costs be paid in every period, even during a period of reduced export receipts, such as those that arrive during a trade dispute. Our idea is that irreversibilities arise from developing and maintaining network and sales infrastructure in the importing country, however, they may also arise from increasing output in an export sector or fitting exports to the importing country's standards.

Our first main result is that when transparency is low and macroeconomic instability is high, so that trade disputes are more common, firms may inefficiently choose lower levels of quality and of export promotion in order to avoid the greater irreversibility that accompanies higher quality. We next show that the quality and irreversibility choices generated by stability and/ or transparency affect the quality of the trade relationship. In particular, lower-quality more easily-reversible output generates shallower trading relationships with less trade volumes and higher tariffs. Furthermore, it generates greater trade reductions during each of the more frequently occurring trade disputes. In this way trade disputes affect not only quality choice but also the resulting level of economic integration. The idea that the quality of trading relationships matters has also been examined by Ben-David (2000) who shows that it is not openness per se but rather trade intensity that leads to convergence across countries.[5]

Having identified trade disputes as the source of the quality-choice economic-integration problem we next look at dispute settlement to provide a solution. Several institutional features of the WTO's trade policy review mechanism that are generally lacking in PTAs can ameliorate these inefficient quality choice outcomes. In the WTO a standing third-party (independent) tribunal reviews policies and claims, makes binding rulings, and authorizes remedies. On the other hand, many PTAs have no provisions for any review.[6] Others only have ad hoc tribunals and in many of these cases their recommendation is not binding.[7] Only in a precious few PTAs is the review performed by a standing tribunal that makes a binding ruling, however, even in some of these most legally developed PTAs the tribunal cannot impose remedies.[8] An additional, and powerful, remedy of article 22 of the WTO's dispute settlement understanding is that it provides for selective retaliation as well as for limits on the amount of allowable retaliation.[9]

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[5] Similarly, Hoekman (2001) points out that poor land-locked countries surrounded by other poor countries do not see any growth from international trade.

[6] Examples of PTAS with no third party reviews, rulings, or remedies are the Australia New Zealand Closer Economics Relations Trade Area (ANZCERTA), the Baltic FTA, the Mano River Union (Liberia, Sierra Leone, Guinea), the Southern African Customs Union (SACU), the Central African Customs Union (UDEAC), the five Central and eastern European pacts (CEEC), and several EFTA agreements with Czech Republic, Hungary, Poland, Romania, Slovak Republic, and Turkey

[7] Examples of PTAs with non-binding third party review by ad hoc tribunals are the Caribbean Community (CARICOM), the ASEAN Free Trade Area (AFTA), the Gulf Cooperation Council (GCC) and the US-Israel Pact. Examples of ad hoc third-party tribunals that make binding reviews are Mercosur, NAFTA, the nine Mexico and Chile pacts, Organization of East Caribbean States (OECS), and the EFTA pacts with Bulgaria, Israel, Estonia, Latvia. Lithuania, and Slovenia. The OECS and these EFTA side pacts have no applicable remedies.

[8] Examples of PTAs with third party reviews performed by standing tribunals are the Andean Pact, the Central American Common Market (CACM), the Common Market for Eastern and Southern Africa (COMESA), the Economic Community of West African States (ECOWAS), the EFTA, the West African Economic Community (CEAO), Commonwealth of (former Soviet) Independent States (CIS), and the now defunct East African Community (EAC). The last three have no power to impose remedies. For more on levels of legalization in PTAs see McCall Smith (2001).

[9] It should be noted that although the signatories to the GATT recognized the importance of effective dispute settlement in the formation of the WTO they do not extend the WTO's mediation functions to settle disputes arising in PTAs. In fact, neither Article XXIV of the GATT 1947 which allowed for the formation of PTAs, nor the 1979 Enabling Clause decision (L/4903) which reduced the rules of Article XXIV to promote PTAs among developing countries provide for any sort of dispute mediation or resolution. They reinforce this point in Paragraph 12 of article XXIV which says that PTAs should try to enforce the agreements locally. The emphasis on local (and non-WTO) enforcement was reiterated in the 1994 Uruguay Round "Understanding" on the Interpretation of Article XXIV.

Our third main point is then that the quality of dispute settlement matters. First, the improved transparency in the WTO reduces the frequency of disputes. Second, the increased enforcement capability of the WTO allows them the provision to recommend targeted retaliation and temporary asymmetric continuation payoffs. These are shown here to generate superior quality and integration outcomes than the symmetric trade wars evidenced in many PTAs.[10,11] Hence, lower quality output and lower quality trading relationships may be more endemic to countries whose trade is more concentrated within an unstable PTA as opposed to the WTO. Furthermore, limited integration may help explain why many PTAs are stillborn, and many others lead to no noticeable trade creation or diversion. Even Mercosur, which is the world's largest enabling clause justified PTA, has led mostly to trade diversion of lower quality products in which the region does not have a comparative advantage (Yeats, 1998). The limited economic integration in Mercosur was well expressed as "the main rule in place within Mercosur goes something like, 'When the going gets tough, it's every country for itself.'"[12] A similar quality outcome occurred in the Central American Common Market (Fox, 2004).

This paper is most closely related to the literature on the hold-up problem in international trade and that on trade agreements. Lapan (1988) was the first to recognize that the optimal tariff after production has occurred is greater than the ex-ante optimal tariff. Internalizing this time inconsistency in tariff setting can lead to lower output levels and leave both countries worse off. In McLaren (1997), factor allocation precedes a trade agreement. Because governments can give side payments, agents do not internalize the erosion in national bargaining power caused by their actions. If free trade is expected, then factors will accumulate in the export sector causing an increase in the optimal tariff that can be levied

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[10] For example, recent WTO administered disputes over bananas, foreign sales corporations, and the distribution of antidumping duties on steel were settled with the dispensation of only the offended party levying retaliatory tariffs for an indeterminate, but finite, period of time. Alternatively, Mercosur's newest incarnation of the "refrigerator war" has generated escalating rounds of reciprocal tariff increases by Argentina and Brazil. This escalation has occurred with the help of a new bilateral trade dispute resolution process entitled "Mechanism of Competitive Adaptation" that allows these two countries to review their disputes in a separate non-Mercosur proceeding.

[11] An additional difference that we do not consider here is that several PTAs such as the Andean pact, CACM, COMESA, the EFTA, and NAFTA allow private individuals to file claims which certainly must increase the potential for trade disputes.

[12] Marcos Jank of the Institute for International Trade Negotiations, Sao Paulo cited by Clendenning (2004).

against this country. In this case, the resulting side payment in the trade agreement may be so large as to leave the country worse off under an optimistic expectation of free trade than under an expectation of a trade war. Chisik (2003) does not allow for side payments as in McLaren (1997) and shows that this can cause countries to liberalize slowly, however, as the export capacity is developed over time countries become more integrated and trade barriers are gradually eroded. Hence, in the Chisik (2003) case the hold-up problem is gradually mitigated by successful past liberalizations. The introduction of imperfect observability, instability, and trade disputes, in this paper returns us to a form of the hold-up problem, however, it is imperfections in the potential solution (the trade agreement) that allows for the problem to occur. And in this case, it is not only export levels and tariffs that are distorted but also output quality and the degree of economic integration.

Mill (1844) is perhaps the first to consider the terms-of trade rational for trade agreements and Johnson (1953-1954) is the first formalization of this idea. Recognizing that there are no "blue helmets" to enforce trade agreements (Bello, 1996) authors such as Dixit (1987) and Bagwell and Staiger (1990, 1999, 2002) began to look at trade agreements as self-enforcing outcomes in a repeated game framework. Hungerford (1991) and Riezman (1991) also consider imperfect observability of trade barriers that could generate trade wars in equilibrium, however, their focuses are distinct and both papers differ from this one in several important respects. Neither considers production, irreversibility, or quality choice, and both consider only symmetric continuation payoffs. More recent work by Bagwell and Staiger (2005), Lee (2007), and Martin and Vergote (2007) consider trade disputes in equilibrium arising in frameworks with private information about domestic concerns and political pressure. As a result of their focus on incomplete information, in a sense, their papers are more apt descriptions of safeguards brought under GATT articles XIX, XX, or XXVIII, rather than the article VI safeguards considered in this paper.[13] A larger distinction is that their focus is not on firm quality choice, irreversibilities, or integration.

[13] Martin and Vergote (2007) do consider antidumping, however, in their paper it arises from private political pressure and the desire to temporarily renegotiate the agreement as allowed for in Article XXVIII. In this paper, we are more concerned with abuse of Article VI that arises from imperfect rather than incomplete information.

Furthermore, we make a distinction between available remedies in the WTO and their relative paucity in PTAs.

The next section describes the model and derives the inefficient equilibrium in the absence of a trade agreement. The third section considers our first two main results and considers the uninformed dispute settlement that is more typical of PTAs. The fourth section considers how the WTO's informed dispute settlement can partially ameliorate the quality selection issue and it also helps to highlight the problem of selective misinterpretation of trade barriers. The fifth section contains our conclusions.

The Model

We consider a repeated tariff setting game between the governments of two production economies with production irreversibilities. The home country (x) produces and exports good x, the foreign country (y) produces and exports good y, and both produce a numeraire good which is traded to ensure trade balance.[14] Each export good can be further divided into quality levels, k. Quality levels differ in their value to consumers (θ_{jk}) and the degree of irreversibility (ρ_{jk}).

The preferences of the identical agents, in each country, over consumption of the import goods and the numeraire can be represented by a quasilinear utility function.[15] Consumer utility maximization

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[14] Irreversible production is more transparently analyzed with the inclusion of a numeraire good. The numeraire good is produced with the same constant returns to scale technology in both countries. The labor supply is assumed sufficiently large so that there is positive numeraire production in both countries and the wage is equal to the price of the numeraire good, which is normalized to one. Hence, the market value of the labor endowment is constant in all possible outcomes and is ignored.

[15] We can, therefore, restrict our analysis to the aggregate utility function. This utility function takes the following form: $U^i(D^i_{jkt}, D^i_{zt}) = u^i(D^i_{jkt}) + D^i_{zt}$ for $i \neq j$. The sub-utility functions are quadratic $u(D^i_{jkt}) = \theta^i_{jk} \cdot D^i_{jk} - (D^i_{jk})^2 / 2$. The large number of identical agents are each endowed with one unit of effective labor. These agents sell their labor to the firms and, as the firms' owners, they receive an equal share of the firms' profits. The agents also share equally any tariff revenue. There is no opportunity for saving and investment, and all agents are identical, therefore, there are no intertemporal or income distribution considerations, and the agents spend their entire income in every period on consumption of the firm's products. The strategic possibilities of the agents and firms are limited by their large numbers and are, therefore, ignored in the set of equilibria that we analyze below. Given the competitive behavior of the agents and the firms, each government chooses non-negative tariffs (τ^x_t, τ^y_t) to maximize national welfare over an infinite horizon.

subject to their budget constraint yields demand functions $D^i_{jk}(P^i_{jkt}) = \theta_{jk} - P^i_{jkt}$ where $i \neq j$ and P^i_{jkt} is the consumer price in the importing country in period *t*. We assume that consumers value higher quality so that θ_{jk} is larger for higher quality. Note that we do not consider a country consuming its own export good. That is, we assume that markets are segmented, and we consider the export market. Similarly, we assume that there is no import competing production. These two assumption have no effect on the results, however, it makes their derivation more transparent.

In addition to the normalized price of the numeraire good, there are four prices $P^x_{xkt}, P^x_{ykt}, P^y_{xkt}$, and P^y_{ykt} which are related by:

$$P^y_{ykt} = P^x_{ykt} - \tau^x_{ykt} - \varepsilon^x_t, \qquad P^x_{xkt} = P^y_{xkt} - \tau^y_{xkt} - \varepsilon^y_t, \tag{1}$$

or more succinctly as $P^j_{jkt} = P^i_{jkt} - \tau^i_{jkt} - \varepsilon^i_t$ where superscripts refer to countries and subscripts refer to goods. The random variables ($\varepsilon^x_t, \varepsilon^y_t$), are induced by macroeconomic or preference fluctuations, and reflect the noise inherent in observing a trade partner's policy. They are independently and identically distributed mean zero random variables with cumulative distribution functions, F^i that satisfies first-order stochastic dominance (FOSD) and densities f^i that are defined over the full support of the distribution.

Governments negotiate over a combination of observable tariff and non-tariff barriers. We assume that the non-tariff barriers can be represented by means of an equivalent tariff and we use τ^i_{jkt} to represent the sum of the direct and equivalent tariffs. Whereas tariffs are observable, non-tariff barriers are not all perfectly observable. The macroeconomic or preference fluctuations also indicate that these barrier choices cannot be perfectly inferred from price observations. In fact, although governments know their own tariff choices, the entire past history of tariff choices is never perfectly observable. Hence, the tariff game between the governments is an infinitely repeated game of imperfect public information.

In what follows we simplify notation by writing $\tau^{iE}_{jkt} = E[\tau^i_{jkt} + \varepsilon^i_t]$ as the expected tariff levied by country *i*, where the expectation is taken with respect to the macroeconomic or preference fluctuation as well as the uncertainty regarding county i's chosen tariff. From this point forward we use the fact that the tariff of country i must be on good $_{jk}$ and drop these subscripts from the tariff notation.

In an initial period firms choose a quality level and a maximum output level. Given that consumers are identical all firms will choose the same quality level. Production of the non-numeraire goods is only partially reversible so that, in any period, firms can reduce output to ρ percent of the period 1 level.

$$Q_{jk} \geq Q_{jkt} \geq \rho_{jk} Q_{jk}, \text{ for all } t \tag{2}$$

where Q_{jkt} denotes output of quality k in sector j in period t and ρ_{jk} is the good specific measure of irreversibility. We use Q_{jk} to denote Q_{jk1}. Equation 2 indicates that output levels are bounded below by the firm's period 1 decision and by the given irreversibility parameter.[16]

This irreversibility assumption can be motivated by the need to develop and maintain networks and sales infrastructure in the importing country.[17] Higher quality products involve a more detailed and harder to learn production process and they may also require more export promotion, therefore, it is reasonable to assume that higher quality is correlated with greater irreversibility. Some of these expenses are sunk at the time of export expansion, however, many are also ongoing costs whose irreversibility stems from explicit contracts (such as advertising, brand name and sales infrastructure maintenance) and implicit contracts (such as maintaining networks and political favor). Roberts and Tybout (1997) and Das et al. (2007) provide evidence that, for Colombian firms, these costs are an important component of the decision to enter an export market. In this case ρ reflects the percentage of infrastructure that needs to be maintained even during a period of lower profitability. Irreversibility may also arise from the need to fit exports to the standards of the importing country (see, for example, Chen and Mattoo, 2006). It may also

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[16] Alternatively, we could consider the case whereby firms can remove a certain percentage every period, or remove it entirely after a delay, however, the more restrictive assumptions considered here, while not changing the results proves to be more tractable in the stochastic framework that we will consider below. Chisik (2003) and Chisik and Davies (2004) consider the alternative assumptions in deterministic frameworks in order to analyze the evolution of trade agreements and tax treaties.

[17] Alternatively, firms may have implicit contractual obligations with their workers or input suppliers arising from efficiency wage arrangements or explicit contractual obligations arising, for example, from union contracts.

be interpreted as reflecting the reduced price that would be received if the exporter was forced to sell the goods at less preferential terms on the world market. In particular, we assume that $\rho(\theta)$ is a strictly increasing function of θ. Although quality is a continuous variable firms will be restricted to choosing either high or low quality. Hence, if $\theta_{jh} > \theta_{jl}$, then $\rho_{jh} > \rho_{jl}$. The high and low quality irreversibility realizations are naturally confined to the interval $0 \leq \rho_{jk} \leq 1$ and for convenience we assume that the quality realizations lie in a bounded interval, $\underline{\theta} \leq \theta_{jk} \leq \bar{\theta}$.

Each firm within each country has the same strictly increasing and strictly concave production function which yields the strictly increasing and convex aggregate cost function $C(Q_{jkt}) = Q_{jkt}^{2}/2$. Note that the cost function is the same for either quality, therefore, firms will choose lower quality only as a result of irreversibility and frequent trade disputes. It is possible to interpret the cost function as only applying to export promotion and trade costs and we make use of this interpretation. In this case, a constant marginal production cost (set to zero here) permits an identical analysis.

The equality between world demand and supply for each good combined with the pricing relationship in equation (1) defines the expected price of each good in each country as $P_{jkt}^{iE} = P_{jkt}^{i}(\theta_{jk}, Q_{jkt}, \tau_{t}^{iE}) = \theta_{jk} - Q_{jkt}$ and $P_{jkt}^{jE} = P_{jkt}^{j}(\theta_{jk}, Q_{jkt}, \tau_{t}^{iE}) = \theta_{jk} - Q_{jkt} - \tau_{t}^{iE}$. The parameter θ_{jk} can be interpreted as an index of the gains from trade that is provided by the quadratic utility and cost functions as the difference between the intercept of the supply and the demand functions. Given that the cost functions are the same for either quality, higher quality can be seen as a greater value in the index of gains from trade.

The preferences of the identical agents in each country can be represented by a social welfare function. The numeraire good provides an excess degree of freedom, therefore, in addition to requiring balanced trade we need to separately establish market clearing for each non-numeraire good in order to describe the equilibrium. Given that there is a partially irreversible production decision, equilibrium prices will be determined by the chosen maximum output levels as well as the tariffs and we can, therefore, write country i's period t social welfare function as a function of these endogenous variables:

$V(\tau_t^i, \tau_t^j, Q_{ik}, Q_{jk})$. Denoting $\delta < 1$ as the discount factor, the present value of country *i*'s payoff in some period *s* of the repeated game is:

$$G^i = \sum_{t=s}^{\infty} \delta^{t-s} \; V(\tau_t^i, \tau_t^j, Q_{ik}, Q_{jk}). \tag{3}$$

Per-period welfare can be represented as the aggregate indirect expected utility function. It is the sum of expected consumer surplus, tariff revenue, and expected producer surplus:

$$V^i(\tau_t^i, \tau_t^j, Q_{ik}, Q_{jk}) = \int_{P_{jk}^i(\tau_t^i)}^{\theta} D_{jk}^i(P)dP + \tau_t^i \cdot D_{jk}^i(P_{jk}^i(\tau_t^i)) + \int_0^{P_{ik}^i(\tau_t^j)} Q_{ik}(P)dP$$

$$= \mu_i(Q_{jk}(\tau_t^{iE}), \tau_t^{iE}) + \tau_t^{iE} \cdot Q_{jk}(\tau_t^{iE}) + r_i(Q_{ik}(\tau_t^{jE}), \tau_t^{jE}) \tag{4}$$

where $\mu_i(Q_{jk}(\tau_t^{iE}), \tau_t^{iE})$ is the expected maximized value of consumer utility, $r_i(Q_{ik}(\tau_t^{jE}), \tau_t^{jE})$ are the firm's expected profits or losses and the middle term is tariff revenue.

Timing.

In the initial period, firms choose the level of quality and export promotion of their single export good. Governments then negotiate over a level of tariff bindings. The tariff binding is a single cooperative tariff rate τ^{ic} that indicates the maximum rate for the combination of the observable tariff and the tariff equivalent of the unobservable trade barriers. It will be seen below that, although both countries may differ on the chosen level of tariff bindings, both will wish to raise tariffs to this level during a cooperative phase. After tariff bindings are set firms in each country simultaneously choose output. Whereas output is unconstrained in the first period each further output decision is constrained as in equation (2). Next, outputs are revealed and governments set their tariff rates. Finally, prices are revealed, and production and consumption take place.

Equilibrium in the absence of a trade agreement.

We focus on the set of equilibria that can be supported by sequentially rational pure strategies. Following Abreu, Pearce, and Stacchetti (1990) the set of pure strategy sequential equilibria (PSE) profiles $\{\hat{\tau}_t^i, \hat{\tau}_t^j, \hat{Q}_{ik}, \hat{Q}_{jk}\}$ for this game can be described as the largest set which solves the following one period problem:

$$V(\hat{\tau}_t^i, \hat{\tau}_t^j, \hat{Q}_{ik}, \hat{Q}_{jk}) + \hat{G}^i(\hat{\tau}_t^i, \hat{\tau}_t^j, \hat{Q}_{ik}, \hat{Q}_{jk}) \geq V(\tau_t^i, \hat{\tau}_t^j, Q_{ik}, \hat{Q}_{jk}) + G^i(\hat{\tau}_t^i, \hat{\tau}_t^j, \hat{Q}_{ik}, \hat{Q}_{jk}). \tag{5}$$

Equation (5) has two parts. The first part indicates that the static payoff from following the equilibrium strategies plus the continuation payoff induced by those strategy choices is at least as great as any other feasible strategy choice. The second part indicates that the continuation payoffs are themselves a function of equilibrium strategy choices. In this way, the continuation payoffs are credible for they are also composed of PSE strategies. It should be noted that the set of PSE profiles and resulting continuation payoffs may differ after differing histories and we have attempted to clarify this point by the notation of $\hat{G}^i$ for a continuation payoff that follows adherence to the static PSE strategies.

As in a framework with fully reversible capacity, one PSE for this dynamic tariff game is an infinite repetition of the static Nash equilibrium. In this benchmark case, firms and governments expect a Nash tariff in every period ($\tau_t^{iE} = \tau_t^{im}$) and firms choose the Nash capacity (Q_{jkt}^{m}). A PSE in these Markovian strategies is a Markov-Perfect-Equilibrium (MPE). If output decisions are fully reversible, or if no output is ever planned, then the physical environment, as described by the state variable, would look the same to the firms and the governments in every period. The unique MPE in this case would be the infinite repetition of the static Nash equilibrium. The irreversible output indicates that histories with positive output may generate different MPE outcomes. We now characterize this MPE set.

Proposition 1: *(i.) The unique MPE after a history with positive output ($Q_{jk} > 0$) is $Q_{jkt}^m = \rho_{jk} Q_{jk} \geq 0$ and $\tau_t^{iE} = \tau_t^{im}(Q_{jkt}) = \mathrm{P}_{jkt}^{imE}(\theta_{jk}, Q_{jkt}, 0) = \theta_{jk} - \rho_{jk} Q_{jk}$.*

(ii.) The unique MPE after a history with no output is $Q_{jkt}^m = 0$ and $\tau_t^{im} = P_{jkt}^i(\theta_{jk}, 0, 0) = \theta_{jk}$.

Proof: Each country's period-optimal tariff, τ^{im}, satisfies the following first-order-condition:

$$\frac{\partial V^i(\cdot,\tau^j_{ik},Q_{ik},Q_{jk})}{\partial \tau^i_t} = D^i_{jk}(P^i_{jk}(\tau^{im}_t))[1-P^{i}_{jk}{}'(\cdot)] + \tau^{im}_t \cdot D^{i}_{jk}{}'(\cdot) \qquad (6)$$

There are two cases to consider. First, if $\tau^{im}_t > P^i_{jk}(\theta_{jk},0,0) = \theta_{jk} \geq D^i_{jk}(P^i_{jk}(\tau^{im}_t))$, then because $P^j_{jk} \geq 0$ it must be the case that $P^{i}_{jk}{}' = 1$ and then $D^{i}_{jk}{}' = -1$ so that $\partial V^i/\partial \tau^i_t = < 0$ for all τ which is a contradiction. For $\tau^{im}_t \leq P^i_{jk}(\theta_{jk},0,0)$, we have $P^{i}_{jk}{}' = D^{i}_{jk}{}' = 0$ so that $\partial V^i/\partial \tau^i_t > 0$ for all τ, therefore, it is optimal to set τ as high as possible or $\tau^{im}_t = P^i_{jk}(\theta_{jk},0,0)$, which implies that $P^j_{jk} = 0$. Hence $Q_{jk} = 0$, and after any other history $Q^m_{jkt} = \rho_{jk} Q_{jk}$. □

This result occurs because tariffs are chose after output choices are made and, therefore, the optimal tariff drives the expected producer price to zero. Given the firms' export decisions, consumer surplus remains the same for any optimal tariff and, therefore, the Markov-Nash tariff will maximize tariff revenue and minimize expected producer revenue. Of course, foreseeing this situation, no firm would choose to export in the absence of some sort of trade agreement (whether explicit, as in this paper, or implicit). This stark outcome is a result of our assumption of segmented markets, and tariffs being chosen after output decisions are made.[18]

The best-response tariffs are not a function of the other country's tariff, therefore, they uniquely define the Markov-Nash-equilibrium tariffs. Notice as well that they are high enough to choke off all trade. This is an interesting component of the segmented market model with production irreversibility,

[18] The main point of the paper is to address the trade agreement as opposed to the absence of the agreement and, therefore, these timing and segmented market assumptions (by yielding a simpler depiction of a trade war) afford a cleaner and more transparent representation of the analysis that follows without changing any of the results. For example, in Chisik (2003) markets are not segmented (and Markov-Nash tariffs do not reduce produce prices to zero), however, the same hold-up problem is evidenced; and, as in the current paper, it is only ameliorated through repeated interaction and history dependant strategies. Additionally, if tariffs are chosen before output, then, as long as there is production irreversibility, myopic governments would still exploit that irreversibility when choosing their Markov-Nash tariffs in the period following an irreversible output decision. Either of this alternative formulations would mildly complicate the algebra, but would not change any of the results.

where tariffs are chosen after production choices are made. In Dixit (1987) autarky is only an equilibrium in weakly dominated strategies and it only arises either because of the need for balanced trade without a numeraire good or the existence of export taxes. There is production irreversibility in Chisik (2003), however, the lack of segmented markets does not generate autarky (even in weakly dominated strategies). In the current framework, however, autarky is the unique MPE outcome and it requires both production irreversibility and segmented markets.

Trade Agreement Strategies

We assume that the written trade agreement restricts the set of PSE profiles to those that are welfare maximizing for the two countries for a chosen set of continuation payoffs. We start by considering symmetric continuation payoffs and then we explain these symmetric strategies as being given by an institutional constraint and we then relax this constraint to consider welfare maximizing asymmetric trigger strategies. We refer to both sets of these profiles as trade agreement strategies, we use the superscript c to denote their cooperative nature, and we drop the time subscript to indicate that they are the tariff bindings agreed to in the initial period: $\{\tau^{ic}, \tau^{jc}, Q_{ik}^{c}, Q_{jk}^{c}\}$.

In this uncertain environment low prices arise from unobserved tariff deviations or from macroeconomic or preference fluctuations. The imperfect tariff observability allows for countries to deviate from the agreement and blame the stochastic element. Hence, we consider trigger strategies. In particular, the trigger is given by $\tilde{P} > 0$ and, therefore, the probability that the realization of the producer price P_{jt}^{j} is less than the trigger value for a country j export is $\Pr(P_{jt}^{j} < \tilde{P}^{j}) = \Pr(P_{jt}^{i} - \tilde{P}^{j} - \tau_{t}^{i} < \varepsilon_{t}^{i}) = 1 - F(P_{jt}^{i} - \tilde{P}^{j} - \tau_{t}^{i})$. We denote $F(P_{jt}^{i} - \tilde{P}^{j} - \tau_{t}^{i}) = \varphi_{j}(\tau_{t}^{i})$ as the cumulative probability that the producer price P_{jt}^{j} is greater than the trigger price $\tilde{P}^{j}$ conditional on the chosen combined observable and unobservable tariff barriers τ_{t}^{i}. By the FOSD of F^{i} we have that the conditional distribution $\varphi_{j}(\tau_{t}^{i})$ satisfies FOSD as well so that $\varphi_{j}(\tau_{t}^{i})$ is decreasing in τ_{t}^{i}. To simplify notation we write $\varphi_{j}(\tau^{ic}) = \varphi_{j}^{c}$.

Hence the probability that both producer prices are above their trigger value, given that countries are adhering to the cooperative tariffs is

$$\phi = \varphi_j^c \cdot \varphi_i^c = [F(P_{jt}^i - \tilde{P}^j - \tau^{ic})][F(P_{it}^j - \tilde{P}^i - \tau^{jc})]. \qquad (7)$$

Hence, a dispute state is signaled in period t (to start in $t+1$) with probability $1 - \phi$. If there is no uncertainty, so that the random variables $\varepsilon_t^i = \varepsilon_t^j = 0$ for all t, then $\varphi_j^c = \varphi_i^c = \phi = 1$. Hence, we refer to φ_i^c as country i's policy perception clarity and to ϕ as a measure of trade stability.

Realized prices are bounded below by zero, therefore, the distributions $F^i(\varepsilon^i)$ limit prices to be non-negative.[19] A simple example of a distribution function that satisfies the above assumptions is where $P_j^j = P_j^i - \tau^i$ (so that $\varepsilon_t^i = 0$) with probability χ and either 0 or $2 \cdot P_j^j$ each with probability $(1 - \chi)/2$. The expectation of P_j^j is unbiased and the distribution $\varphi_j(\tau^i)$ satisfies FOSD. Note that any tariff greater than the trade agreement tariff yields an observed price below the cooperative price so that any price lower than this cooperative expected price triggers a trade war phase. Note that in this case $\varphi_j^c = (1 + \chi)/2$. Hence, when countries adhere to the trade agreement strategies a trade war will start in the next period with probability $(3 - 2\chi - \chi^2)/4$. If either country deviates a dispute is triggered with probability 1.

Uninformed Dispute Settlement

In uninformed dispute settlement (UDS) there is no trade authority who attempts to discern which country is more likely to have deviated from the agreement. UDS can, therefore, do no better than recommend symmetric punishments. These symmetric punishments are typical of the trade disputes that are evidenced in many PTAs. The UDS of PTAs may, in fact, result from the GATT articles and understandings that permit their formation. For example, the 1994 Uruguay understanding on PTAs

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[19] If we do not make this assumption, then we could employ the exporting firm's ability to not sell their product at a negative price. In this case, their expected price would be conditional on the price being greater than zero. Although the inclusion of a truncated distribution reduces the transparency of the analysis, it does not change the results.

formed under article XXIV maintains that disputes in PTAs should be settled locally (and not brought to the GATT/WTO). The 1979 enabling clause goes one step further by making no mention of dispute settlement.

Given the lack of an effective trade authority, when a dispute flares up, both countries simultaneously suspend previously granted concessions and enter a trade war phase. During UDS both countries act in their own short-term self-interest, knowing that their actions will be ignored once the dispute is settled. Hence, both countries levy Markov-Nash tariffs. Given that trade disputes are entered into with strictly positive probability in any set of PSE, it is necessary that we allow for their resolution. We model the dispute resolution as a delay in re-administering previously allowed concessions. If the countries are in a trade dispute in period t, then the probability that the dispute settlement is effective and that they resolve the dispute by period $t+1$ is given by π so that with probability $(1-\pi)$ the countries remain in a trade dispute in the following period.[20]

The UDS trade agreement strategies are straightforward. If the trade agreement has been adhered to in the past, and no external shock in the previous period triggers a withdrawal of concession stage or if the countries are in a withdrawal of concession stage and the dispute is settled, then the home country sets its current tariff according to the trade agreement. After any other history they are in a withdrawal of concession stage awaiting a dispute settlement. Firms have similar strategies. If the countries are not in a dispute stage in period t and if there is no indication that either government intends to deviate from the treaty in the current period, then firms produce according to the expected tariff. A representation of the timing of the model that also takes into account the possibility of trade wars and their settlement is given in figure 1.

UDS Payoff Functions

We are interested in describing three different stage game outcomes. When both countries abide by the trade agreement, firms expect a cooperative tariff and the payoff in period t can be written as

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[20] We could just as easily allow for finite and knowable delays so that the dispute is settled after T periods.

$$V_t^{ic}(\tau^{ic},\tau^{jc}) = V_t^{ic}(\tau^{ic}, Q_{ik}(\tau^{jc}), Q_{jk}(\tau^{ic})) = \mu_i(Q_{jk}(\tau^{ic}),\tau^{ic}) + r_{ik}(Q_{ik}(\tau^{jc}),\tau^{jc}) + \tau^{ic}\cdot Q_{jk}(\tau^{ic}).$$

If one country deviates from the agreement in period t, then the optimal deviation is given by the Markov-Nash tariff. Hence the deviating payoff can be written as

$$V_t^{id}(\tau^{ic},\tau^{jc}) = V_t^{id}(\tau_t^{im}(Q_{jk}),\tau^{jc}, Q_{ik}(\tau^{jc}), Q_{jk}(\tau^{ic})) =$$

$$\mu_i(Q_{jk}(\tau^{ic}),\tau_t^{im}) + r_{ik}(Q_{ik}(\tau^{jc}),\tau^{jc}) + \tau_t^{im}\cdot Q_{jk}(\tau^{ic}).$$

During a trade war, both countries levy Markov-Nash tariffs and reduce their capacity so that the trade war payoff can be written as

$$V_t^{iw}(\tau^{ic},\tau^{jc}) = V_t^{iw}(\tau_t^{im}(\rho_{jk}Q_{jk}),\tau_t^{jm}(\rho_{ik}Q_{ik}),\rho_{ik}Q_{ik}(\tau^{jc}),\rho_{jk}Q_{jk}(\tau^{ic})) =$$

$$\mu_i(\rho_{jk}Q_{jk}(\tau^{ic}),\tau_t^{im}) + r_i(\rho_{ik}Q_{ik}(\tau^{c}),\tau_t^{jm}) + \tau_t^{im}\cdot\rho_{jk}\cdot Q_{jk}(\tau^{ic})$$

We denote $Q_{ik}^c = Q_{ik}(\tau^{jc})$ and $r_t^{ic} = r_i(Q_{ik}^c,\tau_t^{jc})$, respectively, as the firm's chosen quantity and expected profits when expecting a cooperative tariff. Similarly, $Q_{ikt}^m = \rho_{ik}Q_{ik}(\tau^{jc}) = \rho_{ik}Q_{ik}^c$ and $r_t^{im} = r_i(Q_{ikt}^m,\tau_t^{jm})$ are the chosen quantity and expected (negative) profit when facing a Markov-Nash tariff. Writing the expected cooperative price as $P_{ikt}^{ic} = P_{ikt}^i(\theta_{ik}, Q_{ik},\tau^{jc})$ it is straightforward to verify that $r_t^{ic} = P_{ikt}^{ic}Q_{ik}^c - (Q_{ik}^c)^2/2$ and $r_t^{im} = -(Q_{ikt}^m)^2/2 = -\rho_{ik}^2(Q_{ik}^c)^2/2$. Similarly, $\mu_i^c = \mu_i(Q_{jk}^c,\tau^{ic}) = (Q_{jk}^c)^2/2$. Using Proposition 1, we have $\mu_i^w = \mu_i(\rho_{jk}Q_{jk}^c,\tau^{im}) = (\rho_{jk}Q_{jk}^c)^2/2$ and that $\mu_i^c = \mu_i^d$. We define Q_{ik}^c in equation (11) below.

Given the UDS trade agreement strategies. the value of abiding by the agreement in some period *t* is given by

$$G^{ic} = V^{ic} + \delta(\phi G^{ic} + (1-\phi)[V^{iw} + \delta(\pi G^{ic} + (1-\pi)G^{iw})]).$$

Note how we have relied upon the recursive structure of the model after the initial capacity choice. The value of the withdrawal of concession stage also affords a recursive representation and is given by:

$$G^{iw} = V^{iw} + \delta(\pi G^{ic} + (1-\pi)G^{iw})$$

Solving these two equations simultaneously yields:

$$G^{ic} = \frac{(1-\delta(1-\pi))V^{ic} + (1-\phi)\delta V^{iw}}{1-\delta(1+\phi-\pi)+\delta^2(\phi-\pi)}; \quad (8)$$

$$G^{iw} = \frac{\delta\pi V^{ic} + [1-\delta\phi]V^{iw}}{[1-\delta(1+\phi-\pi)+\delta^2(\phi-\pi)]}. \quad (9)$$

We write $\zeta = 1 - \delta(1 + \phi - \pi) + \delta^2(\phi - \pi) = [1 - \delta(\phi - \pi)][1 - \delta]$ and we note that $\zeta \in (0, 1)$.

It is straightforward to verify that in the absence of uncertainty, so that $\phi = 1$, the expression for $G^{ic} = V^{ic}/(1-\delta)$.

Firms

Similarly, the expected discounted value of current and future profits for a firm, given that countries are abiding by the trade agreement is

$R^{ic} = r^{ic} + \delta(\phi R^{ic} + (1-\phi)[r^{im} + \delta(\pi R^{ic} + (1-\pi) R^{iw})])$ and the expected discounted value in a withdrawal of concession stage is given by:

$R^{iw} = r^{im} + \delta(\pi R^{ic} + (1-\pi) R^{iw})$. Solving these simultaneously we have

$$R^{ic} = \frac{(1-\delta(1-\pi))r^{ic} + (1-\phi)\delta r^{im}}{\zeta} \text{ and } R^{iw} = \frac{\delta\pi r^{ic} + [1-\delta\phi]r^{im}}{\zeta} \quad (10)$$

Maximizing R^{ic} with respect to Q for the competitive firms (taking price as given) yields the competitive quantity chosen in anticipation that countries will abide by the agreement:

$$Q_{ik}^{c} = \frac{(1-\delta(1-\pi))(\theta_{ik}-\tau^{jc})}{(1-\delta(1-\pi))2 + (1-\phi)\delta\rho_{ik}^{2}} = \frac{\gamma(\theta_{ik}-\tau^{jc})}{2\gamma+\nu_i} \quad (11)$$

where $\gamma = 1-\delta(1-\pi)$ and $\nu_i = (1-\phi)\delta\rho_{ik}^2$. It is interesting to note that if $\phi = 1$ (or δ or $\rho = 0$), then $Q_{ik}^{c} = \frac{\theta_{ik}-\tau^{jc}}{2}$ which would be the standard case where there is no uncertainty or irreversibility or firms do not care about the future. It is straightforward to verify that Q_{ik}^{c} is increasing in θ, ϕ and π and decreasing in τ and in ρ.

$$\frac{1}{2} > \frac{\partial Q_{ik}^{c}}{\partial \theta_{ik}} = \frac{\gamma}{2\gamma+\nu_i} > 0 > \frac{\partial Q_{ik}^{c}}{\partial \tau^{jc}} = \frac{-\gamma}{2\gamma+\nu_i} > -\frac{1}{2}; \frac{\partial Q_{ik}^{c}}{\partial \phi} = \frac{\gamma\delta\rho_{ik}^{2}(\theta_{ik}-\tau^{jc})}{(2\gamma+\nu_i)^2} > 0;$$

$$\frac{\partial Q_{ik}^c}{\partial \pi} = \frac{\nu_i \delta(\theta_{ik} - \tau^{jc})}{(2\gamma + \nu_i)^2} > 0 \; > \; \frac{\partial Q_{ik}^c}{\partial \delta} = \frac{-(1-\phi)\rho_{ik}{}^2(\theta_{ik} - \tau^{jc})}{(2\gamma + \nu_i)^2} < 0 \text{; and}$$

$$\frac{\partial Q_{ik}^c}{\partial \rho_{ik}} = \frac{-2\gamma(1-\phi)\delta\rho_{ik}(\theta_{ik} - \tau^{jc})}{(2\gamma + \nu_i)^2} < 0 \qquad (12)$$

The upper and lower bounds on $\frac{\partial Q_{ik}^c}{\partial \theta_{ik}}$ and $\frac{\partial Q_{ik}^c}{\partial \tau^{jc}}$ will prove useful below. Also note that Q_{ik}^c < $(\theta_{ik} - \tau^{jc})/2$. It will also be useful to assume that $\pi + \phi$ are not too low.

$$\pi + \phi > 2 - 1/\delta \qquad (13)$$

This assumption is weakly sufficient for some of the following results, however, it allows a more intuitive presentation. It can be interpreted as requiring that, if the countries adhere to the trade agreement strategies and if they care enough about the future, then they should expect to be in a trade war less than one-half of the time. Hopefully, countries in a trade agreement could manage this minimal level of stability. On the other hand, if $\delta \leq ½$, then the assumption is not at all restrictive. Note as well that (13) implies that $\gamma > \nu_i$.

Quality Choice

For every realization of high and low quality valuations $\{\theta_{ih},\ \theta_{il}\}$ and low-quality irreversibility $\{\rho_{il}\}$, there is a $\rho^U(\theta_{ih},\ \theta_{il},\ \rho_{il})$ such that if high-quality irreversibility is higher than $\rho^U(\theta_{ih},\ \theta_{il},\ \rho_{il})$, then firms will choose low quality. Hence, $1 - \rho^U(\theta_{ih},\ \theta_{il},\ \rho_{il})$ is the measure of high-quality irreversibility realizations that cause firms to choose low quality. Inserting Q_{ik}^c into the expressions for r^{jc} and r^{jm} and then substituting these resulting equations into R^{ic} allows us to state our first important result, which relates quality choice, uncertainty, irreversibility, and UDS. We show that $1 - \rho^U(\theta_{ih},\ \theta_{il},\ \rho_{il})$ has positive measure if and only if $\phi < 1$ and that $1 - \rho^U(\theta_{ih},\ \theta_{il},\ \rho_{il})$ is decreasing in ϕ.

Proposition 2: *(i.) If there is uncertainty (ϕ < 1), then there is a positive measure of realizations for high-quality irreversibility such that firms will choose lower quality.*

(ii.) If there is no uncertainty (ϕ = 1), (or irreversibility), then firms will choose high quality.

(iii.) Firms are more likely to produce lower quality when uncertainty is large (ϕ is small).

Proof: We proceed in three steps. First we show that R_k^{ic} is increasing in θ_{ik} and decreasing in ρ_{ik}. Next we show that it is supermodular in θ_{ik} and $-\rho_{ik}$ so that more irreversibility reduces the marginal benefit of greater gains from trade. Finally we show that irreversibility has no effect when there is no uncertainty and that the effect of irreversibility is increasing in the measure of instability.

$$\frac{\partial R^{ic}}{\partial \theta_{ik}} = \frac{[1-\delta(1-\pi)]^2[1-\delta(1-\pi)+(1-\phi)\delta\rho_{ik}{}^2](\theta_{ik}-\tau^{jc})}{[1-\delta(\phi-\pi)][1-\delta][1-\delta(1-\pi)2+(1-\phi)\delta\rho_{ik}{}^2]^2} = \frac{\gamma^2[\gamma+v_i](\theta_{ik}-\tau^{jc})}{\mu[2\gamma+v_i]^2} > 0. \qquad (14)$$

$$\frac{\partial R^{ic}}{\partial \rho_{ik}} = \frac{-\gamma^2[(1-\phi)^2\delta^2\rho_{ik}{}^3](\theta_{ik}-\tau^{jc})^2}{\mu[2\gamma+v_i]^3} < 0. \qquad (15)$$

$$\frac{\partial^2 R^{ic}}{\partial \rho_{ik}\partial \theta_{ik}} = \frac{-\gamma^2[(1-\phi)^2\delta^2\rho_{ik}{}^3]2(\theta_{ik}-\tau^{jc})}{\mu[2\gamma+v_i]^3} < 0. \qquad (16)$$

$$\frac{\partial^2 R^{ic}}{\partial \theta_{ik}\partial \phi} = \frac{[v_i\delta\rho_i^2\mu+(2\gamma+v_i)(\gamma+v_i)\delta(1-\delta)]\gamma^2(\theta_{ik}-\tau^{jc})}{\mu^2[2\gamma+v_i]^3} > 0 \qquad (17)$$

$$\frac{\partial^2 R^{ic}}{\partial \rho_{ik}\partial \phi} = \frac{\gamma^2[(1-\phi)\delta^2\rho_{ik}{}^3](1-\delta)(\theta_{ik}-\tau^{jc})^2}{\mu^2[2\gamma+v_i]^4}[(4-2\delta\phi+4\delta\pi-2\delta)\gamma-(1-2\delta\phi+\delta\pi+\delta)v_i] > 0. \qquad (18).$$

From equation (16) we know that two graphs of $R^{ic}(\theta_{ik})$ that differ in their value of ρ_{ik} can cross only once. From equations (10) and (11) we know that they must cross at $\theta_{ik} = 0$. Hence, for any ρ_{ik} there exists a $\theta(\rho_{ik})$ such that if $\rho_{ih} > \rho_{il}$, then $\theta(\rho_{ih}) > \theta(\rho_{il})$; and for all θ_{ik} such that $\theta(\rho_{il}) < \theta_{ik} < \theta(\rho_{ih})$ it is the case that $R^{ic}(\theta_{ik},\rho_{il}) > R^{ic}(\theta(\rho_{ih}), \rho_{ih})$. This establishes that firms would choose the quality indexed by (θ_{ik},ρ_{il}) over the quality indexed by $(\theta(\rho_{ih}), \rho_{ih})$ even when $\theta(\rho_{ih}) > \theta_{ik}$. This relationship is shown in figure 2. Hence, if $\phi < 1$, then for any realization of $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$ there is a $\rho^U(\theta_{ih}, \theta_{il}, \rho_{il}) < 1$ such that for all $\rho_{ih} > \rho^U(\theta_{ih}, \theta_{il}, \rho_{il})$ firms will choose low quality. This establishes part (i.) that $1 - \rho^U(\theta_{ih}, \theta_{il}, \rho_{il})$ has positive measure.

In addition, note that if $\phi = 1$, or if $\rho_{ik} = 0$, then equation (14) still has the same sign, but equations (15) and (16) are both identically zero. Hence, if there is no uncertainty, and trade wars are not entered into with positive probability when countries use trade agreement strategies, then irreversibility has no deleterious effect on quality choice. This establishes part (ii.) that $1 - \rho^U(\theta_{ih}, \theta_{il}, \rho_{il})$ has positive measure only if $\phi < 1$.

To establish part (iii.) note that equation (17) shows that more stability increase the slope of R^{ic} with respect to θ_{ik} and equation (18) shows that greater stability reduces the negative effect of irreversibility. (The assumption in (13) is used for determining the sign of equation (18) and is weakly sufficient for that result.) Finally, from equation (18) it is straightforward to see that $\frac{\partial^3 R^{ic}}{\partial\theta_{ik}\partial\phi\partial\rho_{ik}} = \frac{2}{\theta_{ik} - \tau^{jc}} \frac{\partial^2 R^{ic}}{\partial\rho_{ik}\partial\phi} > 0$ so that the effect in equation (17) is more pronounced when there is more irreversibility. Hence, for any $\rho_{ih} > \rho_{il}$, the distance between $\theta(\rho_{ih})$ and $\theta(\rho_{il})$, is decreasing in ϕ. Similarly, $\rho^U(\theta_{ih}, \theta_{il}, \rho_{il})$ is increasing in ϕ so that the measure of high quality irreversibility realizations that generate inefficient low-quality choices is decreasing in ϕ. □

The essence of Proposition 2 is illustrated in Figure 2. We see there that firms may choose lower quality if its output is more easily reversible. We also see that this effect is greater when there is more instability.

An interesting empirical prediction that stems from Proposition 2 is that trade would be reduced more during each trade war when trade wars are more frequent. In particular, more frequent trade disputes increase the measure of high-quality irreversibility realizations such that firms will choose low quality when it is more easily reversible. When output is more reversible, trade is reduced more during a trade war.

Proposition 3: *An increase in the probability, or frequency, of trade disputes weakly generates more trade reduction during each trade dispute.*

Proof: From Proposition 2 we know that more frequent trade disputes (a lower value of ϕ) increases the benefit of choosing lower quality only because its output is more readily reversible (a lower value of ρ). Hence, the chosen level of irreversibility is weakly decreasing in the probability of a trade dispute. From Proposition 1 we see that a lower ρ means that trade will be reduced by a greater percentage during a trade war. □

An additional interesting corollary of proposition 2 is that countries with less stable economies (or governments) may end up producing lower quality. This is because macroeconomic instability impinges on the ability to accurately observe trade policies and in this framework trade disputes are only triggered more often when observability is worse. In addition, it suggests that the trading partner's macroeconomic stability and tariff observation clarity may affect the quality decision. Furthermore, if a trade relationship developed during periods when exporters expected stability (at home or abroad), then those exporters would have been more willing to devote the necessary resources to develop higher quality goods even if those goods had greater irreversibility. Hence, even if two countries face similar levels of current trade stability, initially differing levels may explain current quality choices.

An additional empirical prediction could be made with respect to changing trade patterns during trade disputes. If a country developed goods with greater gains from trade that were more irreversible, then during a trade dispute they would not be able to reduce output as much and would choose to export to third markets rather than suffer losses by exporting to the country that is levying the high tariff. This idea of trade deflection was first introduced by Bown and Crowley (2006). The model in this paper would predict more trade deflection for countries that produce high quality goods and, therefore, for countries that industrialized in a period of expected trade stability. On the other hand, countries that industrialized while facing many changing and restrictive trade measures by their trading partners would produce lower-quality, more easily reversible, output and would simply reduce output and would not deflect trade to third countries. Interestingly enough, where as Bown and Crowley (2006) found evidence of trade deflection for Japan, in a related study (Bown and Crowley, 2007) they found no such evidence for China. These differing cases could be explained by the mechanism in this paper.

The Trade Agreement Tariffs

Given the trade agreement strategies, cooperating yields an expected current and continuation payoff of $V^{ic} + \delta[\phi G^{ic}+(1-\phi)G^{iw}]$. On the other hand, given the FOSD of $\varphi_j(\tau_t^i)$, a deviating tariff of τ^{id} reduces $\varphi_j(\tau^{ic})$ to $\varphi_j(\tau^{id})$. Denote $\phi^{id} = \varphi_i(\tau^{jc})\cdot\varphi_j(\tau^{id})$ as the probability that neither producer price triggers a trade war, given that country *i* chose a deviating tariff. A deviation, therefore, yields expected current and continuation payoffs of $V^{id} + \delta[\phi^{id}G^{ic} + (1-\phi^{id})G^{iw}]$. The one period gain from deviating in period *t* can be written as

$$\Psi_t^i = V_t^{id} - V_t^{ic} \tag{19}$$

This gain must be balanced against the cost of a future trade war:

$$\Omega_t^i = \delta(\phi - \phi^{id})(G^{ic} - G^{iw}) = \Delta(\phi, \pi, \delta)\ V_t^{ic} - V_t^{iw} \tag{20}$$

where $\Delta(\phi, \pi, \delta) = \dfrac{\delta(\phi-\phi^{d})}{1-\delta(\phi-\pi)} > 0$. It is straightforward to verify that Δ is increasing in δ and in ϕ and is decreasing in π. Note as well that $\phi - \phi^{id}$ is non-negative and non-decreasing in τ^{id}.

The trade agreement is described by tariff bindings $\{\tau^{ic}, \tau^{jc}\}$ that maximize

$$\sum_{i\in\{X,Y\}} G^{ic}(Q_{ik}^{c}, Q_{jk}^{c}, \tau^{ic}, \tau^{jc}, \theta_{ik}, \theta_{jk}, \rho_{ik}, \rho_{jk}, \phi, \pi, \delta) \tag{21}$$

subject to the constraint that the chosen cooperative tariffs and resulting capacity choices do not cause the gain from deviating from the agreement to be greater than the cost of a future trade war.

$$\Psi_t^i \le \Omega_t^i, \quad i \in \{x, y\}, \forall t\,. \tag{22}$$

It is straightforward to verify that world welfare (as defined by equation 21), is a strictly decreasing function of the tariff rates (if the countries are not too asymmetric) and, therefore, is maximized by free trade. The trade agreement, therefore, specifies the lowest tariff that satisfies the incentive constraint given by equation (22). Note that when the countries differ the incentive constraint will be binding at different tariffs for each country.

The gains from a Trade Agreement

We graph country *i*'s incentive constraint as a function of τ^{ic} in figure 3. In the proof to the following proposition we show that Ψ_t^i is strictly decreasing and convex in τ^{ic} and that Ω_t^i is strictly concave in τ_t^c. Furthermore, we show that Ω_t^i crosses Ψ_t^i from above as τ^{ic} approaches τ_1^{im}. Hence, it must be the case that Ω_t^i crosses Ψ_t^i from below at some τ^{ic} less than τ_1^{im}. The agreement is self-enforcing for all τ^i in this range and chooses τ^{ic} as the lowest τ^i in this interval. We also show that if ρ_{jk} is sufficiently high, then τ^{ic} must be greater than zero.

Proposition 4: (i.) *There exists a connected set of non-prohibitive self-enforcing tariffs.*
(ii.) If the degree of irreversibility is sufficiently high, then the smallest member of this set, τ^{ic}*, must be greater than zero.*

The proof of Proposition 4 is contained in the appendix. The basic idea of the proof to parts (i.) and (ii.) are outlined above where we describe the shape of the incentive constraint with respect to τ^{ic}. Note that zero tariffs may be self-enforcing; however, if the degree of irreversibility is sufficiently high, then we must consider the case when free trade is not self-enforcing.

We also analyze the marginal effects of quality choice and of irreversibility on τ^{ic}. It turns out that an increase in the level of the trade partner's irreversibility not only reduces the cost of deviating but it also reduces the gain from deviating.[21] Which effect dominates depends on how accurately chosen

[21] The gain to deviating from the agreement is reduced because the deviating tariff is a surprise to the other country and no output is reduced until the following period, therefore, the increased level of irreversibility only reduces the output level so that imports and tariff revenue are reduced by more in the deviating period. On the other hand, more irreversibility increases output and tariff revenue in the future and decreases the future cost of the deviation.

tariffs reflect received producer prices. We not only require that stability and policy perception clarity are reasonably high (so that trade wars are triggered with low probability when countries adhere to the agreement) but also that deviating tariffs are accurately evidenced as such and trigger disputes with reasonably high probability. Hence, we require that $\varphi_j(\tau^{id})$ and, therefore, that ϕ^d are reasonably low. It is, therefore, necessary to put some restrictions on ϕ and ϕ^d. We refer to $\omega^j = \phi(\phi - \phi^{id})/(1 - \phi)$ as country i's information representation accuracy ratio and we assume that

$$\omega^j = \frac{\phi(\phi-\phi^{id})}{1-\phi} > 1. \tag{23}$$

It is straight forward to note that along with equation (13), equation (23) implies that $\Delta\gamma > \nu_j$.

Proposition 5: *(i.) If* $\omega^j > 1$*, then the cooperative tariff is increasing in the degree of irreversibility and it is increasing faster when quality is higher.*

(ii.) If $\omega^j > 1$*, and the degree of irreversibility is above a critical level* $\rho^* < 1$*, then the cooperative tariff is increasing in the quality level and it is increasing faster when irreversibility is greater.*

The proof of proposition 5 is in the appendix. The main idea of the proof uses the implicit function theorem. First, we examine how $\Omega_t^i - \Psi_t^i$ changes with respect to τ^{ic} and then with respect to ρ_{jk} and θ_{jk} separately and together. Given the strict concavity of $\Omega_t^i - \Psi_t^i$ in τ^{ic} that we demonstrate in proposition 4, the proof is in effect examining how the graphs of Ω_t^i and Ψ_t^i shown in figure (3) change when ρ_{jk} changes by itself and with θ_{jk}. In particular, although they both shift down, Ω_t^i shifts down by more than Ψ_t^i shifts down, so that τ^{ic} is increasing in ρ_{jk} by itself and with θ_{jk}.

Economic Integration

When a country's own export good offers more gains from trade or has more irreversible production that country will be more dependant on the trade relationship. This dependence relaxes the incentive constraint so that the country will offer greater tariff concessions on their import good. The following proposition develops this idea of increasing integration between the countries.

Proposition 6: *A country will offer greater tariff concessions (τ^{ic} lower), if their own export good is higher quality and generates greater gains from trade (θ_{ik} higher), or exhibits a greater degree of irreversibility (ρ_{ik} higher).*

The proof of proposition 6 is contained in the appendix. The essence of the proof is shown in Figures 4 and 5. In Figure 4 we see that greater gains from trade on a country's export good increases the discounted future cost of a current period deviation and, therefore, lowers the lowest self-enforcing tariff that a country would charge on its import good. A similar result is obtained for an increase in the degree of irreversibility and that is shown in Figure 5.

Proposition 6 is important because it illustrates the concept of economic integration that occurs in trade agreements. If exporters choose a good with more gains from trade and more irreversibility, then they would suffer more from a temporary suspension of trade concessions. In this case the countries are more integrated and can enforce lower trade agreement tariffs.

Governments and the Quality Choice

Given that firms may inefficiently choose low quality it is natural to ask if there is a policy that governments should follow to correct this market failure. First of all, note that the absence of home consumption makes the government's quality objective similar to the firm's objective. The only possible difference is that the government can internalize the effect of quality and irreversibility on the chosen tariff. If tariffs are zero, then there is nothing to internalize and the decisions are the same. In the following proposition we also consider the secondary effects of quality and irreversibility on the cooperative tariffs and we note that if information representation transmission is reasonably accurate, then the government would also agree with the firm's decision.

Proposition 7: *(i.) Suppose that $\tau^{jc} = 0$. The government of country i will agree with the quality choice of their export firms as stated in Proposition 2.*

(iv.) Suppose that $\tau^{jc} > 0$. If $\omega^{j} > 1$, then when higher quality has much higher irreversibility, the government of country i will also prefer to export lower quality goods.

The proof to Proposition 7 is contained in the appendix. Note that for part (i.) the proof is identical to that of Proposition 2 with G^{ic} replacing R^{ic}.

Although firms may choose an inefficiently low level of quality and this may lead to a lower level of integration, Proposition 7 helps to clarify that there is no domestic market failure. That is, the quality levels are efficient at the national level so that there is no role for industrial policy to correct this type of market failure. The inefficiencies are directly tied to the trade instability and the dispute settlement procedure and, therefore, we now consider methods of improving the trade agreement.

Informed Dispute Settlement and Asymmetric Continuation Payoffs.

We now consider dispute settlement that makes careful use of the information in the public outcome. In particular, the interaction in this paper can be described as a game that has a product structure (Fudenberg et al., 1994, p. 1027). The outcomes $\{ P^{j}_{jkt}, P^{i}_{ikt} \}$ are statistically independent and depend only on the actions of player $i \neq j$. In this case a greater level of cooperation can be enforced if the country that is more likely to have deviated is also more likely to suffer during a dispute. As Abreu et al (1990) showed, optimal continuation payoffs take a bang-bang structure. Hence, if only country *j*'s producer price is low enough to trigger a dispute, then country *i* is more likely to have deviated and, therefore, they should be the only country to suffer during a dispute.

We refer to this use of information as Informed Dispute Settlement (IDS). It is straightforward to verify that IDS combined with asymmetric continuation payoffs can yield a greater level of cooperation. In this framework greater cooperation implies that free trade is supportable for a wider range of discount factors and when it is not supportable that lower tariffs are enforceable. The level of cooperation, however, is still dependant on the levels of output and irreversibility. For a high level of irreversibility free trade cannot be supported for any discount factor.

In addition to extending the results of Abreu et al. (1990) and Fudenberg et al. (1994) to this tariff setting framework with production irreversibility we show that IDS with asymmetric continuation payoffs can mitigate the quality choice problem. The application to trade agreements is particularly apt because PTAs have very limited or non-existent dispute settlement procedures as compared to those available in the WTO. In addition, the WTO has an investigative authority that has the knowledge and ability to recommend asymmetric rewards and punishments. Hence, we can think of UDS as the norm in PTAs and IDS as the rule in the WTO. We consider a simple version of this idea below.

Informed Dispute Settlement Payoffs

The cooperative stage is defined as before.

$$V_t^{ic}(\tau^{ic},\tau^{jc}) = v_i(Q_{jk}(\tau^{ic}),\tau^{ic}) + r_{ik}(Q_{ik}(\tau^{jc}),\tau^{jc}) + \tau^{ic}\cdot Q_{jk}(\tau^{ic}).$$

With probability $\varphi_j^c(1-\varphi_i^c)$ country i will receive a producer price low enough to trigger retaliation. Country i can retaliate with a Nash-tariff while country j levies a cooperative tariff.

$$V_t^{ir}(\tau^{ic},\tau^{jc}) = v_i(\rho_{jk}Q_{jk}(\tau^{ic}),\tau_t^{im}) + r_{ik}(Q_{ik}(\tau^{jc}),\tau^{jc}) + \tau_t^{im}\rho_{jk}Q_{jk}(\tau^{ic}).$$

With probability $\varphi_i^c\ (1-\varphi_j^c)$ country j receives a producer price low enough to trigger a punishment for country i. During punishment country i must levy a cooperative tariff and their producers face a Nash-tariff. It is the same as if country j deviated on them.

$$V_t^{ip}(\tau^{ic},\tau^{jc}) = V_t^{ip}(\tau_t^{jm}(\rho_{ik}Q_{ik}(\tau^{jc}),\rho_{ik}Q_{ik}(\tau^{jc}),Q_{jk}(\tau^{ic})) =$$

$$v_i(Q_{jk}(\tau^{ic}),\tau^{ic}) + r_{ik}(\rho_{ik}Q_{ik}(\tau^{c}),\tau_t^{jm}) + \tau^{ic}Q_{jk}(\tau^{ic}).$$

Finally, with probability $(1-\varphi_i^c)(1-\varphi_j^c)$ both countries receive a producer price low enough to trigger a retaliatory stage. In this case there is bad news about both countries and either or both could suffer punishment. If both countries levy Nash-tariffs, then we are in the previous trade war stage. This is clearly inefficient. There is no enforcement reduction, and expected payoffs are higher, if only one country suffers the punishments stage but the recipient is selected at random. In this case, with probability ½, country *i* will be the retaliator and with probability ½ they will be punished. So with probability $(1-\varphi_i^c)(1-\varphi_j^c)$ country *i* will receive an expected payoff of

$$(½)\,V_t^{ir}(\tau^{ic},\tau^{jc}) + (½)\,V_t^{ip}(\tau^{ic},\tau^{jc})$$

If countries are in a cooperative phase in period some period *t,* then the value of abiding by the agreement is given by

$$G^{icc} = V^{ic} + \delta(\varphi_i^c\ \varphi_j^c\ \ G^{icc} + \varphi_j^c(1-\varphi_i^c)G^{ir} + \varphi_i^c(1-\varphi_j^c)G^{ip} + (1-\varphi_i^c)(1-\varphi_j^c)(G^{ir}+G^{ip})/2.$$

Hence, with probability $\varphi_i^c\ \varphi_j^c$ they enter a cooperative phase in the next period, with probability $\varphi_j^c(1-\varphi_i^c)$ they enter a retaliatory phase, with probability $\varphi_i^c(1-\varphi_j^c)$ they enter a punishment phase, and with probability $(1-\varphi_i^c)(1-\varphi_j^c)$ they have an equal chance of entering a retaliatory or a punishment phase. The retaliation and the punishment phases also afford recursive representations and are given by:

$$G^{ir} = V^{ir} + \delta[\pi(\varphi_i^c\ G^{icc} + (1-\varphi_i^c)G^{ir}) + (1-\pi)G^{ir}].$$

$$G^{ip} = V^{ip} + \delta[\pi(\varphi_j^c\ G^{icc} + (1-\varphi_j^c)G^{ip}) + (1-\pi)G^{ip}].$$

Solving these three equations simultaneously, and writing $\gamma_i = 1-\delta(1-\pi\varphi_i^c)$ and $\gamma_j = 1-\delta(1-\pi\varphi_j^c)$, yields:

$$G^{icc} = \frac{2\gamma_i\gamma_j V^{ic} + \gamma_i(1-\varphi_i^c)(1+\varphi_j^c)\delta V^{ir} + \gamma_j(1-\varphi_j^c)(1+\varphi_i^c)\delta V^{ip}}{2\gamma_i\gamma_j(1-\delta\varphi_i^c\varphi_j^c) - \gamma_i(1-\varphi_i^c)(1+\varphi_j^c)\delta^2\pi\varphi_j^c - \gamma_j(1-\varphi_j^c)(1+\varphi_i^c)\delta^2\pi\varphi_i^c}$$

It is again straightforward to verify that without uncertainty, ($\varphi_i^c = \varphi_j^c = 1$), the expression for G^{icc} reduces to $V^{ic}/(1-\delta)$. In the symmetric misinterpretation case, when $\varphi_i^c = \varphi_j^c = \varphi$, we have

$$G^{iccs} = \frac{2(1-\delta(1-\pi\varphi)V^{ic} + (1-\varphi^2)\delta(V^{ir}+V^{ip})}{2(1-\delta)(1-\delta\varphi(\varphi-\pi))}$$

We can write the firms' expected profits as:

$$R^{icc} = \frac{[2\gamma_i\gamma_j + \gamma_i(1-\varphi_i^c)(1+\varphi_j^c)\delta]r^{ic} + \gamma_j(1-\varphi_j^c)(1+\varphi_i^c)\delta r^{ip}}{2\gamma_i\gamma_j(1-\delta\varphi_i^c\varphi_j^c) - \gamma_i(1-\varphi_i^c)(1+\varphi_j^c)\delta^2\pi\varphi_j^c - \gamma_j(1-\varphi_j^c)(1+\varphi_i^c)\delta^2\pi\varphi_i^c}$$

In the symmetric misinterpretation case, when φ_i^c = φ_j^c = φ, we can write

$$R^{iccs} = \frac{[2(1-\delta(1-\pi\varphi) + (1-\varphi^2)\delta]r^{ic} + (1-\varphi^2)\delta r^{ip})}{2(1-\delta)(1-\delta\varphi(\varphi-\pi))}$$

Maximizing R^{icc} with respect to Q for the competitive firms (taking price as given) yields the competitive quantity chosen in anticipation that countries will abide by the agreement:

$$Q_{ik}^{cc} = \frac{[2\gamma_i\gamma_j + \delta\gamma_i(1-\varphi_i^c)(1+\varphi_j^c)](\theta_{ik} - \tau^{jc})}{4\gamma_i\gamma_j + 2\delta\gamma_i(1-\varphi_i^c)(1+\varphi_j^c) + \rho_{ik}{}^2\delta\gamma_j(1-\varphi_j^c)(1+\varphi_i^c)}$$

Again we note that if $\varphi_i^c = \varphi_j^c = 1$ (or $\delta = 0$ or $\rho_{ik} = 0$), then $Q_{ik}^{cc} = \frac{\theta_{ik} - \tau^{jc}}{2}$. Although we have a similar set of comparative statics as in equation 12, the firms' quantity choices are more sensitive to quality and less sensitive to irreversibility and these differences help drive our results. In the symmetric misinterpretation case, when $\varphi_i^c = \varphi_j^c = \varphi$, we have that

$$Q_{ik}^{ccs} = \frac{[2(1-\delta(1-\pi\varphi) + \delta(1-\varphi^2)](\theta_{ik} - \tau^{jc})}{4(1-\delta(1-\pi\varphi) + (2+\rho_{ik}{}^2)\delta(1-\varphi^2)}$$

To help develop intuition as to how IDS can ameliorate the uncertainty driven quality selection problem it is perhaps most helpful to see what happens when at least one country does not misinterpret their partner's trade barriers. We, therefore, first consider the limiting case when either $\varphi_i^c = 0$ or $\varphi_j^c = 0$.

Proposition 8: *(i.) With IDS, if country j does not misinterpret country i's trade policy, then the country i firms' quantity and quality choices are efficient. Choices under UDS remain inefficient.*

(ii.) With IDS, if country i does not misinterpret country j's trade policy, then country i's firms' quantity and quality choice exhibit the same inefficiencies as in the UDS case.

Proof: (i.) When $\varphi_j^c = 1$, then $Q_{ik}^{cc} = \frac{[2\gamma_i\gamma_j + 2\delta\gamma_i(1-\varphi_i^c)](\theta_{ik} - \tau^{jc})}{4\gamma_i\gamma_j + 4\delta\gamma_i(1-\varphi_i^c)} = \frac{(\theta_{ik} - \tau^{jc})}{2}$

Similarly, $R^{icc} = \frac{[2\gamma_i\gamma_j + 2\delta\gamma_i(1-\varphi_i^c)]r^{ic}}{2\gamma_i\gamma_j(1-\delta\varphi_i^c) - \gamma_i 2(1-\varphi_i^c)\delta^2\pi} = \frac{[\gamma_j + \delta(1-\varphi_i^c)]}{\gamma_j(1-\delta\varphi_i^c) - (1-\varphi_i^c)\delta^2\pi} r^{ic}$ where the constant has no effect on the firm's optimization. Hence, the firm's optimal quantity $\frac{(\theta_{ik} - \tau^{jc})}{2}$ is increasing in θ_{ik} and is not a function of irreversibility or uncertainty. The UDS case is as given in proposition 2 with $\varphi_i^c = \phi$.

(ii.) When $\varphi_i^c = 1$, then using that $\gamma_i = \gamma$ and that $\varphi_j^c = \phi$ we have

$$Q_{ik}^{cc} = \frac{[2\gamma_i\gamma_j](\theta_{ik} - \tau^{jc})}{4\gamma_i\gamma_j + 2\rho_{ik}{}^2\delta\gamma_j(1-\varphi_j^c)} = \frac{\gamma_i(\theta_{ik} - \tau^{jc})}{\gamma_i + \rho_{ik}{}^2\delta(1-\varphi_j^c)} = \frac{\gamma(\theta_{ik} - \tau^{jc})}{\gamma + \delta(1-\varphi_j^c)\rho_{ik}{}^2} = \frac{\gamma(\theta_{ik} - \tau^{jc})}{\gamma + \delta(1-\phi)\rho_{ik}{}^2} = Q_{ik}^c$$

So that output is the same as the UDS case considered in proposition 2. Similarly,

$R^{icc} = \frac{\gamma r^{ic} + (1-\varphi_j^c)\delta r^{ip}}{1 - \delta(1-\pi+\varphi_j^c) + \delta^2(\varphi_j^c - \pi)} = R^{ic}$ so that the quality and irreversibility choice are the same as the UDS case. □

Part (i.) of proposition 8 indicates that the inefficient quality choice problem stems from the partner's trade policy misinterpretation as well as the inefficient UDS. If the partner observed the trade policy with perfect clarity, then with IDS there is no problem. Part (ii.) reinforces part (i.) by suggesting that, even when there is IDS, not misinterpreting the trade partner's policy does not help the firm's quality decision. In fact, in this limiting case the efficient IDS and the inefficient UDS are equal. It also suggests that, with IDS, countries have more of an incentive to encourage the clarity with which their trade policy is observed but have no incentive to improve their observational clarity of their partner's policy.

We now consider the symmetric misinterpretation case so that $\varphi_j^c = \varphi_i^c = \varphi$. We write $\gamma^* = (1-\delta(1-\pi\varphi))$ and we note that $\gamma > \gamma^*$. Similarly, note that $2\gamma^* > \delta(1-\varphi^2)$ if $\varphi(\varphi + 2\pi) > 3 - 2/\delta$. This assumption is weaker than equation (13) with respect to δ and π (it is trivially satisfied if $\delta \leq 2/3$), however, it does place a little more restriction on φ. Given equation (13), it is satisfied for all δ if $\varphi \geq ½$.

We show below that with IDS we also have that for all $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$ there is a positive measure of high-quality irreversibility realizations $1 - \rho^I(\theta_{ih}, \theta_{il}, \rho_{il})$ such that firms would choose low quality. The important point is that for all $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$ this measure is strictly smaller with IDS than with UDS.

Proposition 9: *The measure of measure of high-quality irreversibility realizations such that firms would choose low quality is strictly lower under IDS than under UDS. Firm are less likely to choose lower quality with IDS than with UDS.*

The proof of Proposition 9 is contained in the appendix. The idea of the proof is illustrated in figure 6. We see there that firm profits are increasing faster in quality with IDS than with UDS. In addition, the negative effect of irreversibility on profits and on quality is less pronounced under IDS than under UDS. We also see that for $\rho_{ih} > \rho_{il}$, the distance $\theta(\rho_{ih}) - \theta(\rho_{il})$ such that $R^{iccs}(\theta(\rho_{il}),\rho_{il}) = R^{iccs}(\theta(\rho_{ih}),\rho_{ih})$ is smaller with IDS than with UDS. Hence, it must be the case that $\rho^I(\theta_{ih}, \theta_{il}, \rho_{il}) > \rho^U(\theta_{ih}, \theta_{il}, \rho_{il})$ so that firms are less likely to choose low quality with IDS than with UDS.

Conclusion

In this paper we considered the joint choice of quality and export promotion costs when trade relationships are subject to temporary disputes. When transparency is low and macroeconomic instability is high, disputes arrive more frequently and, therefore, firms may inefficiently choose lower levels of quality and export promotion. These, in turn, build shallower trading relationships with less trade volumes and higher tariffs, and generate greater trade reductions during the more common trade disputes. Several institutional features of the WTO that are generally lacking in PTAs such as improved transparency, dispute investigation, and the provision to recommend asymmetric continuation payoffs can ameliorate these inefficient quality choice outcomes. Hence, lower quality output and lower quality trading relationships may be more endemic to countries that depend on preferential trading areas as opposed to the WTO.

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Appendix: Proofs.

Proof of Proposition 4: (i.) We start by writing out the expressions for the payoffs.

$$\Psi_t^i = (\tau_t^{im}(Q_{jk}^c) - \tau^{ic}) \cdot Q_{jk}^c = (\theta_{jk} - \tau^{ic} - Q_{jk}^c) \cdot Q_{jk}^c = \frac{(\gamma + \nu_j)\gamma(\theta_{jk} - \tau^{ic})^2}{(2\gamma + \nu_{jk})^2}$$

$$\Omega_t^i = \Delta[(1-\rho_{jk}{}^2)(Q_{jk}^c)^2/2 + (\tau^{ic} - \tau_t^{im}(\rho_{jk}Q_{jk}^c)\rho_{jk})Q_{jk}^c + P_{it}^{ic}Q_{ik}^c - (Q_{ik}^c)^2/2 + (\rho_{ik} \cdot Q_{ik}^c)^2/2] =$$

$$\Delta[(1-\rho_{jk}{}^2)(Q_{jk}^c)^2/2 + (\tau^{ic} - \rho_{jk}\theta_{jk} + \rho_{jk}{}^2 Q_{jk}^c)Q_{jk}^c + (\theta_{ik} - \tau^{jc} - Q_{ik}^c)Q_{ik}^c - (Q_{ik}^c)^2/2 + (\rho_{ik} \cdot Q_{ik}^c)^2/2]$$

We now consider the shape of these two functions with respect to the cooperative tariff, τ^{ic}. With respect to the current incentive to deviate, it is straightforward to verify that:

$$\frac{\partial \Psi^i}{\partial \tau^{ic}} = \frac{-2(\gamma^2 + \gamma\nu_j)(\theta_{ik} - \tau^{ic})}{(2\gamma + \nu_j)^2} < 0 < \frac{\partial \Psi^i}{\partial \theta_{jk}} = \frac{2(\gamma^2 + \gamma\nu_j)(\theta_{jk} - \tau^{ic})}{(2\gamma + \nu_j)^2};$$

$$\lim_{\tau^{ic} \to \tau_t^{im}} \frac{\partial \Psi_t^i}{\partial \tau^{ic}} = 0 = \Psi_t^i(\tau^{ic} = \tau_t^{im}) < \frac{\partial^2 \Psi_t^i}{\partial \tau^{ic2}} = \frac{2(\gamma^2 + \gamma\nu_j)}{(2\gamma + \nu_j)^2}.$$

Hence, Ψ_t^i is strictly decreasing and strictly convex in τ^{ic}. Also note that when $\tau^{ic} = 0$, $\Psi_t^i > 0$.

Furthermore, when $\tau^{ic} = \tau_1^{im}$, $Q_{jk} = 0$ so that $\tau_1^{im} = \theta_j$. Hence $\lim_{\tau^{ic} \to \tau_t^{im}} \frac{\partial \Psi_t^i}{\partial \tau^{ic}} \to 0$.

With respect to the discounted future cost of deviating, we have:

$$\frac{\partial \Omega_t^i}{\partial \tau^{ic}} = \Delta\left[\left([1+\rho_{jk}{}^2]Q_{jk}^c + [\tau^{ic} - \rho_{jk}\theta_{jk}]\right)\frac{\partial Q_{jk}^c}{\partial \tau^{ic}} + Q_{jk}^c\right]$$

$$\frac{\partial^2 \Omega_t^i}{\partial \tau^{ic2}} = \Delta\left[\left(2 + [1+\rho_{jk}{}^2]\frac{\partial Q_{jk}^c}{\partial \tau^{ic}}\right)\frac{\partial Q_{jk}^c}{\partial \tau^{ic}}\right] < 0.$$

The strict concavity of Ω_t^i arises because $\frac{\partial^2 Q_{jk}^c}{\partial \tau^{ic2}} = 0$ and because $\frac{\partial Q_{jk}^c}{\partial \tau^{ic}} \in (-½, 0)$ so that

$$2 + [1+\rho_{jk}{}^2]\frac{\partial Q_{jk}^c}{\partial \tau^{ic}} > 0.$$

Furthermore, when $\tau^{ic} = \tau_1^{im}$, $Q_{jk} = 0$ so that $\tau_1^{im} = \theta_j$. Hence,

$\lim_{\tau^{ic}\to\tau_1^{im}} \frac{\partial \Omega_t^i}{\partial \tau_1^c} = \Delta\left[\theta_{jk}(1-\rho_{jk})\frac{\partial Q_{jk}^c}{\partial \tau^{ic}}\right] < 0$ as long as ρ < 1. Hence, $\lim_{\tau^{ic}\to\tau_1^{im}} \left(\frac{\partial \Omega_t^i}{\partial \tau_1^c} - \frac{\partial \Psi_t^i}{\partial \tau_1^c}\right) < 0$. Furthermore,

because $Q_{jk} = 0$ when $\tau^{ic} = \tau_1^{im}$, we have that $\Omega_t^i = \Psi_t^i = 0$ when $\tau^{ic} = \tau_1^{im}$. We have not only established that Ω_t^i is strictly concave and that Ψ_t^i is strictly convex in τ_1^c but also that Ω_t^i approaches Ψ_t^i from above when τ_1^c approaches τ_1^{im} from below. Hence, there is a $\tau^c < \tau_1^{im}$ that is self enforcing and Pareto improving and the agreement chooses the lowest τ^{ic} in this range.

(ii.) We now consider if $\tau^{ic} = 0$ is possible. First, note that when $\tau^{ic} = 0$, we have

$\Psi_t^i(\tau^{ic} = 0) > 0$ and

$$\Omega_1^i(\tau_1^c = 0) = \frac{\Delta}{2(2\gamma + \nu_j)^2}[(1+\rho_{jk}{}^2)\gamma - 4\rho_{jk}\gamma - 2\nu_j\rho_{jk}]\gamma\theta_{jk}{}^2$$

$$+\Delta[(\theta_{ik} - \tau^{jc} - Q_{ik}^c)Q_{ik}^c - (Q_{ik}^c)^2/2 + (\rho_{ik}\cdot Q_{ik}^c)^2/2]$$

If ρ = 1 then the first term is negative, the second term is positive, and the entire expression is negative if the countries are not too asymmetric so that zero tariffs are not enforceable. Conversely if ρ = 0, then the first term is positive and greater than the second term so that the above expression is positive and zero tariffs are enforceable for some range of parameters. Finally, we note that Ω_t^i is increasing in τ^{ic} at τ^{ic} = 0. Using $\frac{\partial Q_{jk}^c}{\partial \tau^{ic}} \in (-½, 0)$ we have:

$$\left.\frac{\partial \Omega_t^i}{\partial \tau^{ic}}\right|_{\tau^{ic}=0} = \Delta\left[\left([1+\rho_{jk}{}^2]Q_{jk}^c(\tau^{ic}=0) - \rho_{jk}\theta_{jk}\right)\frac{\partial Q_{jk}^c}{\partial \tau^{ic}} + Q_{jk}^c(\tau^{ic}=0)\right] > 0.$$

This last condition is not necessary for our results, however, it justifies the graph of Ω_t^i as shown in figure 3. □

Proposition 5: Note that τ^{ic} is defined implicitly by $\Omega_t^i - \Psi_t^i = 0$ so that

$$\frac{d\tau^{ic}}{d\rho_{jk}} = -\frac{\frac{\partial(\Omega_t^i - \Psi_t^i)}{\partial\rho_{jk}}}{\frac{\partial(\Omega_t^i - \Psi_t^i)}{\partial\tau^{ic}}} \text{ and } \frac{d^2\tau^{ic}}{d\theta_{jk}d\rho_{jk}} = -\frac{\frac{\partial^2(\Omega_t^i - \Psi_t^i)}{\partial\theta_{jk}\partial\rho_{jk}}}{\frac{\partial(\Omega_t^i - \Psi_t^i)}{\partial\tau^{ic}}}.$$ From Proposition 4 we know that

$\frac{\partial^2(\Omega_t^i - \Psi_t^i)}{(\partial\tau^{ic})^2} < 0$ so that it has at most two zeros, τ^{ic} and τ^{im}, and it is strictly concave. We also know that

$\frac{\partial(\Omega_t^i - \Psi_t^i)}{\partial\tau^{ic}} < 0$ as $\tau^{ic} \to \tau^{im}$. It, therefore, must be the case that $\frac{\partial(\Omega_t^i - \Psi_t^i)}{\partial\tau^{ic}} > 0$ at τ^{ic}. We, therefore, only

need to examine the signs of $-\frac{\partial(\Omega_t^i - \Psi_t^i)}{\partial\rho_{jk}}$ and of $-\frac{\partial^2(\Omega_t^i - \Psi_t^i)}{\partial\theta_{jk}\partial\rho_{jk}}$ to establish the result.

$$\frac{\partial\Psi_t^i}{\partial\rho_{jk}} = (\theta_{jk} - \tau^{ic} - 2Q_{jk}^c)\frac{\partial Q_{jk}^c}{\partial\rho_{jk}} = \frac{-2\gamma\nu_j(1-\phi)\delta\rho_{jk}(\theta_{jk} - \tau^{ic})^2}{(2\gamma + \nu_j)^3} < 0;$$

$$\frac{\partial^2\Psi_t^i}{\partial\rho_{jk}\partial\theta_{jk}} = (\theta_{jk} - \tau^{ic} - 2Q_{jk}^c)\frac{\partial^2 Q_{jk}^c}{\partial\rho_{jk}\partial\theta_{jk}} + (1 - 2\frac{\partial Q_{jk}^c}{\partial\theta_{jk}})\frac{\partial Q_{jk}^c}{\partial\rho_{jk}} = \frac{-4\gamma\nu_j(1-\phi)\delta\rho_{jk}(\theta_{jk} - \tau^{ic})}{(2\gamma + \nu_j)^3} < 0$$

$$\frac{\partial\Omega_t^i}{\partial\rho_{jk}} = \Delta\left[\{(Q_{jk}^c + \tau^{ic})\frac{\partial Q_{jk}^c}{\partial\rho_{jk}}\} + \{[\rho_{jk}Q_{jk}^c - \theta_{jk}][Q_{jk}^c + \rho_{jk}\frac{\partial Q_{jk}^c}{\partial\rho_{jk}}]\}\right]$$

$$\frac{\partial^2\Omega_t^i}{\partial\rho_{jk}\partial\theta_{jk}} = \Delta\left[\{(Q_{jk}^c + \tau^{ic})\frac{\partial^2 Q_{jk}^c}{\partial\rho_{jk}\partial\theta_{jk}}\} + \{[\rho_{jk}Q_{jk}^c - \theta_{jk}][\frac{\partial Q_{jk}^c}{\partial\theta_{jk}} + \rho_{jk}\frac{\partial^2 Q_{jk}^c}{\partial\rho_{jk}\partial\theta_{jk}}]\} + \{[\rho_{jk}\frac{\partial Q_{jk}^c}{\partial\theta_{jk}} - 1][Q_{jk}^c + \rho_{jk}\frac{\partial Q_{jk}^c}{\partial\rho_{jk}}]\} + \{\frac{\partial Q_{jk}^c}{\partial\rho_{jk}}\frac{\partial Q_{jk}^c}{\partial\theta_{jk}}\}\right]$$

Remember that $Q_{jk}^c < \theta_{jk}/2$ and that from equation (12) $\frac{\partial Q_{jk}^c}{\partial\rho_{jk}} < 0 < \frac{\partial Q_{jk}^c}{\partial\theta_{jk}} < ½$. In addition $2\pi + \phi > 3 - 2/\delta$, which is weaker than $\pi + \phi > 2 - 1/\delta < 1$ as given in equation (13), is sufficient for $Q_{jk}^c + \rho_{jk}\frac{\partial Q_{jk}^c}{\partial\rho_{jk}} > 0$ and $\frac{\partial Q_{jk}^c}{\partial\theta_{jk}} + \rho_{jk}\frac{\partial^2 Q_{jk}^c}{\partial\rho_{jk}\partial\theta_{jk}} > 0$. Hence, we have both of the {} bracketed terms in $\frac{\partial\Omega_t^i}{\partial\rho_{jk}}$ and all four of the {} bracketed terms in $\frac{\partial^2 \Omega_t^i}{\partial \rho_{jk} \partial \theta_{jk}}$ are negative so that equation (13) is weakly sufficient for $\frac{\partial^2 \Omega_t^i}{\partial \rho_{jk} \partial \theta_{jk}}$ < 0 and for $\frac{\partial \Omega_t^i}{\partial \rho_{jk}}$ < 0. Comparing similar terms we also see that $\Delta(Q_{jk}^c + \tau^{ic}) > \theta_{jk} - \tau^{ic} - 2Q_{jk}^c$ is sufficient for $\frac{\partial \Omega_t^i}{\partial \rho_{jk}} < \frac{\partial \Psi_t^i}{\partial \rho_{jk}}$. Similarly, $\Delta(Q_{jk}^c + \tau^{ic}) > \theta_{jk} - \tau^{ic} - 2Q_{jk}^c$ and $\Delta \frac{\partial Q_{jk}^c}{\partial \theta_{jk}} > (1 - 2\frac{\partial Q_{jk}^c}{\partial \theta_{jk}})$ together are sufficient for $\frac{\partial^2 \Omega_t^i}{\partial \rho_{jk} \partial \theta_{jk}} < \frac{\partial^2 \Psi_t^i}{\partial \rho_{jk} \partial \theta_{jk}}$. It is straightforward to verify that $\Delta\gamma > \nu_j$ is weekly sufficient for both of these conditions. Similarly we see that $\phi(\phi - \phi^{jd}) > (1 - \phi)$ is weakly sufficient for $\Delta\gamma > \nu_j$.

Hence, $\frac{\partial(\Omega_t^i - \Psi_t^i)}{\partial \rho_{jk}} < 0$ and $\frac{\partial^2(\Omega_t^i - \Psi_t^i)}{\partial \theta_{jk} \partial \rho_{jk}} < 0$ and, therefore, $\frac{d\tau^{jc}}{d\rho_{ik}} > 0$ and $\frac{d^2\tau^{jc}}{d\theta_{ik} d\rho_{ik}} > 0$.

Finally, note that $\frac{\partial \Omega_t^i}{\partial \theta_{jk}} = \Delta\left[\left([1+\rho_{jk}{}^2]Q_{jk}^c + [\tau^{ic} - \rho_{jk}\theta_{jk}]\right)\frac{\partial Q_{jk}^c}{\partial \theta_{jk}} - \rho_{jk} Q_{jk}^c\right]$ is positive for $\rho_{jk} = 0$, negative for $\rho_{jk} = 1$ and is strictly decreasing in ρ_{jk}. Therefore, for ρ_{jk} above some critical value it must be strictly negative. This fact, coupled with $\frac{\partial \Psi^i}{\partial \theta_{jk}} = \frac{2(\gamma^2 + \gamma\nu_j)(\theta_{jk} - \tau^{ic})}{(2\gamma + \nu_j)^2}$ > 0 establishes the theorem. □

Proof of Proposition 6: $\frac{\partial \Psi_t^i}{\partial \theta_{ik}} = 0 = \frac{\partial \Psi_t^i}{\partial \rho_{ik}}$.

$$\frac{\partial \Omega_t^i}{\partial \theta_{ik}} = \Delta\left[Q_{ik}^c + \left(\theta_{ik} - \tau^{jc} - 3Q_{ik}^c + \rho_{ik}{}^2 Q_{ik}]\right)\frac{\partial Q_{jk}^c}{\partial \theta_{ik}}\right] \geq \Delta\left[Q_{ik}^c + \left(\theta_{ik} - \tau^{jc} - 3Q_{ik}^c\right)\frac{\partial Q_{jk}^c}{\partial \theta_{ik}}\right] \geq$$

$$\Delta\left[Q_{ik}^c - Q_{ik}^c \frac{\partial Q_{jk}^c}{\partial \theta_{ik}}\right] > \Delta\left[Q_{ik}^c / 2\right] > 0$$

$$\frac{\partial \Omega_t^i}{\partial \rho_{ik}} = \Delta\left[2\rho_{ik} Q_{ik}^c - 3Q_{ik}^c \frac{\partial Q_{jk}^c}{\partial \rho_{ik}} + \left(\theta_{ik} - \tau^{jc} + 2\rho_{ik}{}^2 Q_{ik}]\right)\frac{\partial Q_{jk}^c}{\partial \rho_{ik}}\right] =$$

$$\Delta\left[\left(2\rho_{ik}{}^2 Q_{ik}-3Q_{ik}^c\right)\frac{\partial Q_{jk}^c}{\partial \rho_{ik}}+2\rho_{ik}Q_{ik}^2+\left(\theta_{ik}-\tau^{jc}\right)\frac{\partial Q_{jk}^c}{\partial \rho_{ik}}\right]>0.$$

because $\left(2\rho_{ik}{}^2 Q_{ik}-3Q_{ik}^c\right)\frac{\partial Q_{jk}^c}{\partial \rho_{ik}}>0$ and $2\rho_{ik}Q_{ik}^2+\left(\theta_{ik}-\tau^{jc}\right)\frac{\partial Q_{jk}^c}{\partial \rho_{ik}}>0$ if $\pi + \phi > 2 - 1/\delta$, which is given by equation (25). □

Proposition 7: (i.) The proof is identical to that of Proposition 2 with G^{ic} replacing R^{ic}.

(ii.) Totally differentiating G^{ic} with respect to θ_{ik} and ρ_{ik} yields:

$$\frac{dG^{ic}}{d\theta_{ik}}=\frac{\partial G^{ic}}{\partial \theta_{ik}}+\frac{\partial G^{ic}}{\partial \tau^{jc}}\frac{d\tau^{jc}}{d\theta_{ik}}; \qquad \frac{dG^{ic}}{d\rho_{ik}}=\frac{\partial G^{ic}}{\partial \rho_{ik}}+\frac{\partial G^{ic}}{\partial \tau^{jc}}\frac{d\tau^{jc}}{d\rho_{ik}}$$

$$\frac{d^2G^{ic}}{d\rho_{ik}d\theta_{ik}}=\frac{\partial^2 G^{ic}}{\partial \rho_{ik}\partial \theta_{ik}}+\frac{\partial^2 G^{ic}}{\partial \tau^{jc}\partial \rho_{ik}}\frac{d\tau^{jc}}{d\theta_{ik}}+\frac{\partial^2 G^{ic}}{\partial \theta_{ik}\partial \tau^{jc}}\frac{d\tau^{jc}}{d\rho_{ik}}+\frac{\partial^2 G^{ic}}{\partial \tau^{jc2}}\frac{d\tau^{jc}}{d\rho_{ik}}\frac{d\tau^{jc}}{d\theta_{ik}}+\frac{\partial G^{ic}}{\partial \tau^{jc}}\frac{d^2\tau^{jc}}{d\theta_{ik}d\rho_{ik}}$$

From Proposition 1 we have $\tau_t^{jm}(Q_{ikt})=\theta_{ik}-Q_{ikt}$ so that $\frac{d\tau_t^{jm}}{d\theta_{ik}}=1$. Hence, because $\tau_t^{jm} > \tau^{jc}$ when $\theta_{ik} > 0$ and $\tau_t^{jm} = \tau^{jc} = 0$ when $\theta_{ik} = 0$ we must have $\frac{d\tau^{jc}}{d\theta_{ik}}<\frac{d\tau_t^{jm}}{d\theta_{ik}}=1$. Hence, because $\frac{\partial G^{ic}}{\partial \theta_{ik}}=-\frac{\partial G^{ic}}{\partial \tau^{jc}}$ we have that $\frac{dG^{ic}}{d\theta_{ik}} > 0$.

Similarly, we have that $\frac{\partial^2 G^{ic}}{\partial \rho_{ik}\partial \theta_{ik}}=-\frac{\partial^2 G^{ic}}{\partial \rho_{ik}\partial \tau^{jc}}$ so that $\frac{\partial^2 G^{ic}}{\partial \rho_{ik}\partial \theta_{ik}}+\frac{\partial^2 G^{ic}}{\partial \tau^{jc}\partial \rho_{ik}}\frac{d\tau^{jc}}{d\theta_{ik}}<0$. Next we note that $\frac{\partial^2 G^{ic}}{\partial \theta_{ik}\partial \tau^{jc}}=-\frac{\partial^2 G^{ic}}{\partial \tau^{jc2}}<0$ so that $\frac{\partial^2 G^{ic}}{\partial \theta_{ik}\partial \tau^{jc}}\frac{d\tau^{jc}}{d\rho_{ik}}+\frac{\partial^2 G^{ic}}{\partial \tau^{jc2}}\frac{d\tau^{jc}}{d\rho_{ik}}\frac{d\tau^{jc}}{d\theta_{ik}}<0$ if $\frac{d\tau^{jc}}{d\rho_{ik}}>0$. Note as well that $\frac{\partial G^{ic}}{\partial \tau^{jc}}<0$ so that both $\frac{dG^{ic}}{d\rho_{ik}}<0$ and $\frac{d^2G^{ic}}{d\rho_{ik}d\theta_{ik}}<0$ if $\frac{d\tau^{jc}}{d\rho_{ik}}>0$ and $\frac{d^2\tau^{jc}}{d\theta_{ik}d\rho_{ik}}>0$. □

Proposition 9: The key to the proof is showing that $\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} > \frac{\partial R_k^{ic}}{\partial \theta_{ik}}$, that $\left|\frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik}\partial \theta_{ik}}\right| < \left|\frac{\partial^2 R_k^{ic}}{\partial \rho_{ik}\partial \theta_{ik}}\right|$ and that $\left|\frac{\partial R_k^{iccs}}{\partial \rho_{ik}}\right| < \left|\frac{\partial R_k^{ic}}{\partial \rho_{ik}}\right|$. Proceeding as in Proposition 2, and using the envelope result on the optimal choice of Q_{ik}^{ccs} we have that

$$\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} = \frac{[2\gamma^* + \delta(1-\varphi^2)]^2[2\gamma^* + (1+\rho_{ik}{}^2)\delta(1-\varphi^2)]^2(\theta_{ik} - \tau^{jc})}{[4\gamma^* + (2+\rho_{ik}{}^2)\delta(1-\varphi^2)]^2\, 2(1-\delta)(1-\delta\varphi(\varphi-\pi))} > 0 .$$

$$\frac{\partial R_k^{iccs}}{\partial \rho_{ik}} = \frac{(2\gamma^* + \delta(1-\varphi^2))(-Q_{ik}^{ccs}\frac{\partial Q_{ik}^{ccs}}{\partial \rho_{ik}}) - \delta(1-\varphi^2)\rho_{ik}(Q_{ik}^{ccs})^2}{2(1-\delta)(1-\delta\varphi(\varphi-\pi))} =$$

$$\frac{-[2\gamma^* + \delta(1-\varphi^2)]^2\rho_{ik}{}^3\delta^2(1-\varphi^2)^2(\theta_{ik}-\tau^{jc})^2}{[4\gamma^* + (2+\rho_{ik}{}^2)\delta(1-\varphi^2)]^2\, 2(1-\delta)(1-\delta\varphi(\varphi-\pi))} < 0.$$

$$\frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik}\partial \theta_{ik}} = \frac{-[2\gamma^* + \delta(1-\varphi^2)]^2\rho_{ik}{}^3\delta^2(1-\varphi^2)^2(\theta_{ik}-\tau^{jc})}{[4\gamma^* + (2+\rho_{ik}{}^2)\delta(1-\varphi^2)]^2(1-\delta)(1-\delta\varphi(\varphi-\pi))} < 0.$$

We will also define for the future the term $\nu = (1-\phi)\delta$ so that $\nu_i = \nu\rho_{ik}{}^2$.

That $\left|\frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik}\partial \theta_{ik}}\right| < \left|\frac{\partial^2 R_k^{ic}}{\partial \rho_{ik}\partial \theta_{ik}}\right|$ and $\left|\frac{\partial R_k^{iccs}}{\partial \rho_{ik}}\right| < \left|\frac{\partial R_k^{ic}}{\partial \rho_{ik}}\right|$ reduces after some algebra to showing that

$128\gamma^2\gamma^{*2} + (192 + 96\,\rho_{ik}{}^2)\gamma^2\gamma^{*2}\nu + (96 + 96\,\rho_{ik}{}^2 + 16\,\rho_{ik}{}^3 + 8\,\rho_{ik}{}^4)\gamma^2\gamma^*\nu^2 +$

$(16 + 24\,\rho_{ik}{}^2 + 12\,\rho_{ik}{}^4 + 2\,\rho_{ik}{}^6)\gamma^2\nu^3 >$

$32\gamma^3\gamma^{*2} + 32\gamma^3\gamma^*\nu + 8\gamma^3\nu^2 + 2\,\rho_{ik}{}^4\gamma\nu^3 + 24\,\rho_{ik}{}^4\gamma\gamma^{*2}\nu^2 + 24\,\rho_{ik}{}^4\gamma\gamma^*\nu^3 + 48\,\rho_{ik}{}^2\gamma^2\gamma^{*2}\nu + 48\,\rho_{ik}{}^2\gamma^2\gamma^*\nu^2 +$

$12\,\rho_{ik}{}^2\gamma^2\nu^3 + 4\,\rho_{ik}{}^4\gamma\nu^4 + 4\,\rho_{ik}{}^6\gamma^{*2}\nu^3 + 4\,\rho_{ik}{}^6\gamma^*\nu^4 + \rho_{ik}{}^6\nu^5.$

The above inequality holds because $1 > \gamma > \gamma^* > 0$, $1 > \gamma > \nu > 0$, and $2\gamma^* > \nu$.

When $\rho_{ik} = 0$, $\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} = \frac{[2\gamma^* + \delta(1-\varphi^2)](\theta_{ik} - \tau^{jc})}{8(1-\delta)(1-\delta\varphi(\varphi-\pi))} > \frac{\partial R_k^{ic}}{\partial \theta_{ik}} = \frac{\gamma(\theta_{ik} - \tau^{jc})}{4(1-\delta)(1-\delta(\varphi^2-\pi))}$ if

$\delta(1-\varphi^2) > \delta^2[(1-\varphi^2)(\varphi^2 + \pi - 2\varphi\pi)]$ which is true because $(\varphi^2 + \pi - 2\varphi\pi) < 1$ for all values of π and φ

< 1. Now using that $\left|\frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik} \partial \theta_{ik}}\right| < \left|\frac{\partial^2 R_k^{ic}}{\partial \rho_{ik} \partial \theta_{ik}}\right|$ we have that $\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} > \frac{\partial R_k^{ic}}{\partial \theta_{ik}}$ for all values of ρ_{ik}.

Proceeding as in Proposition 2, we see that for any realization of $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$ there is a $\rho^I(\theta_{ih}, \theta_{il}, \rho_{il}) < 1$ such that for all $\rho_{ih} > \rho^I(\theta_{ih}, \theta_{il}, \rho_{il})$ firms will choose low quality. Because $\frac{\partial R_k^{iccs}}{\partial \theta_{ik}} > \frac{\partial R_k^{ic}}{\partial \theta_{ik}}$,

$\left|\frac{\partial^2 R_k^{iccs}}{\partial \rho_{ik} \partial \theta_{ik}}\right| < \left|\frac{\partial^2 R_k^{ic}}{\partial \rho_{ik} \partial \theta_{ik}}\right|$, and $\left|\frac{\partial R_k^{iccs}}{\partial \rho_{ik}}\right| < \left|\frac{\partial R_k^{ic}}{\partial \rho_{ik}}\right|$ it is straightforward to verify that, under IDS, for any $\rho_{ih} > \rho_{il}$ such that $R^{iccs}(\theta_{ik}, \rho_{il}) > R^{iccs}(\theta(\rho_{ih}), \rho_{ih})$ for all $\theta_{ik} \in [\theta(\rho_{il}), \theta(\rho_{ih})]$, the distance $\theta(\rho_{ih}) - \theta(\rho_{il})$ is smaller . Hence for any $\{\theta_{ih}, \theta_{il}, \rho_{il}\}$, under IDS the corresponding $\rho^I(\theta_{ih}, \theta_{il}, \rho_{il}) > \rho^U(\theta_{ih}, \theta_{il}, \rho_{il})$ so that the measure of high-quality irreversibility realizations $1 - \rho^I(\theta_{ih}, \theta_{il}, \rho_{il})$ that generate inefficient low-quality choices is lower under IDS than under UDS. □

Figure 1:Timing

Timing in Initial Period

Firms choose quality.	Governments negotiate tariff bindings: τ^{jc}, τ^{jc}.

Timing in Period 1

Firms set Q_{jk}.	Q_{jk} are revealed. Governments set tariffs.	Prices revealed. Trade war starts next period with probability $1 - \phi$.

Timing in Period t > 1

Firms choose output subject to $\rho_{jk}Q_{jk} \leq Q_{jkt} \leq Q_{jk}$.	Q_{jkt} are revealed. Governments set tariffs.	Prices are revealed. Trade war starts next period with probability $1 - \phi$. Existing trade war resolved with probability π.

Figure 2: Inefficient Quality Choice

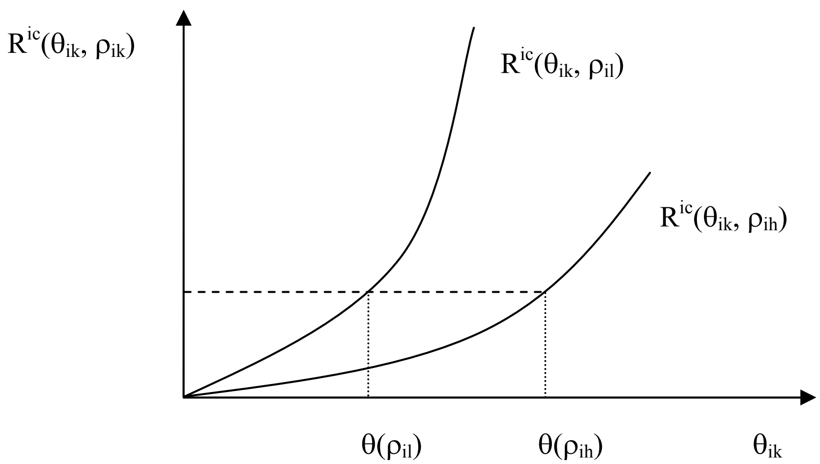

Figure 3: Determination of τ^{ic}

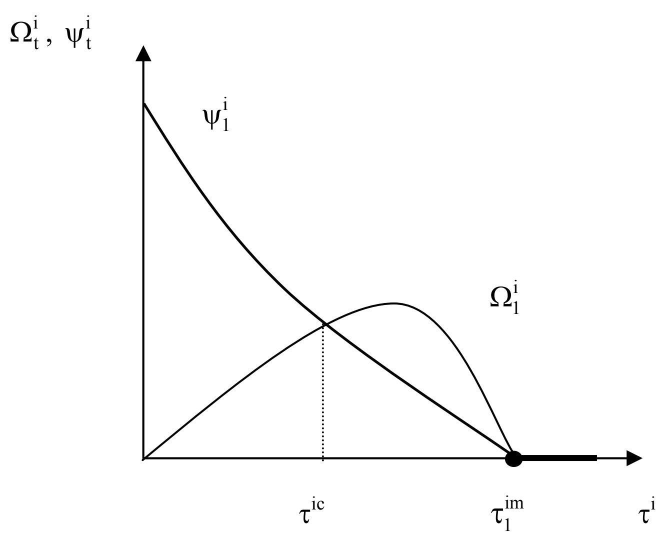

Figure 4: $\theta_{ih} > \theta_{il}$.

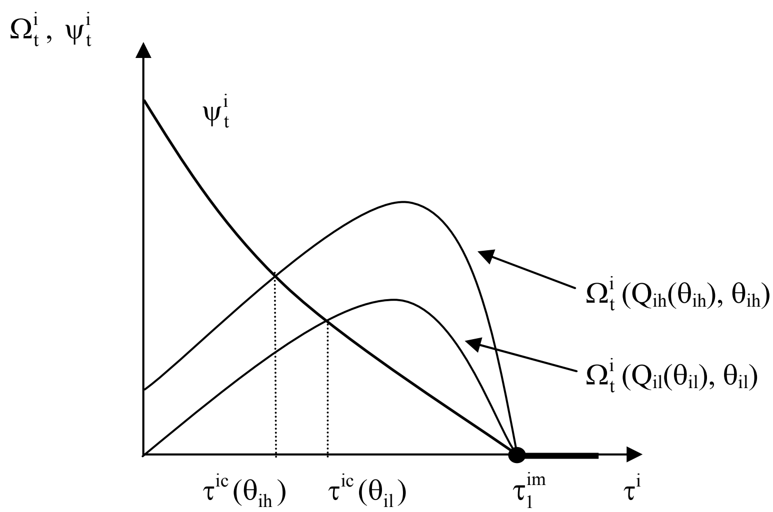

Figure 5: $\rho_{ih} > \rho_{il}$.

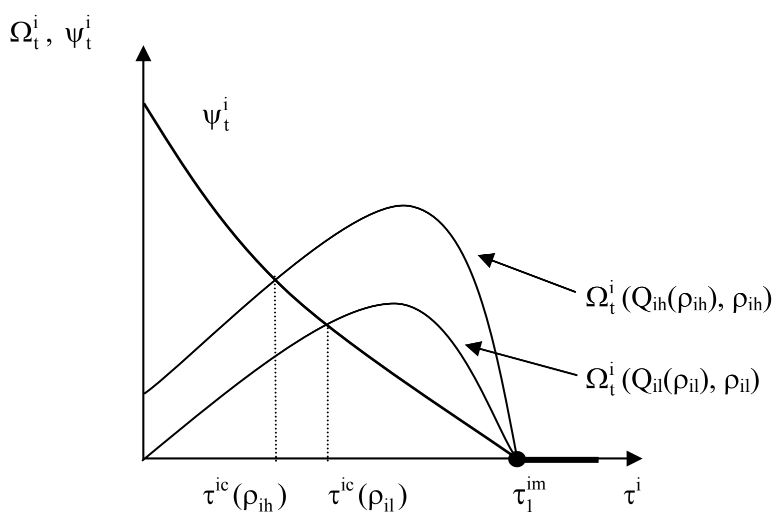

Figure 6: IDS vs. UDS Quality Choice