

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.

JEL Classification: F13, F15, C73, K33.

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

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1. 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

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.

are not usually triggered by dumping, however, they are facilitated by imperfect observability of the 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.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. Looking at Table 1, which describes the levels of legalization in some PTAs, we see that many PTAs have no provisions for any review, rulings, or remedies.⁶ Others only have ad hoc tribunals and in many of these cases their recommendation is not binding. 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. In contrast to PTAs, two powerful remedies of article 22 of the WTO's dispute settlement understanding is that it sanctions selective retaliation and limits the amount of allowable retaliation.⁷

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 it the provision to recommend targeted retaliation and temporary asymmetric continuation payoffs. These are shown here to generate quality and integration outcomes that are superior to those engendered by the symmetric trade wars evidenced in many PTAs.^{8,9} Hence, lower

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

⁶ For more on levels of legalization in PTAs see McCall Smith (2001).

⁷ 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.

⁸ 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

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.'"¹⁰ A similar quality outcome occurred in the Central American Common Market (Fox, 2004).¹¹

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 against this country. In this case, the resulting side payment in the trade agreement may be so large as to

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.

⁹ 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.

¹⁰ Stated by Marcos Jank of Sao Paulo's Institute for International Trade Negotiations (Clendenning, 2004).

¹¹ The U.S. and Mexico have both brought NAFTA cases to the WTO when the good is covered by both agreements. No cross retaliation in sectors that are covered only in NAFTA and not the WTO have been asked for or approved by the WTO. The WTO's dispute settlement understanding (DSU) article 22, paragraph 3, allows for cross retaliation in sectors and even agreements other than the one where the dispute originated, however, it specifically subordinates more distant cross-retaliations to those that are in the same sector or at least the same agreement. Paragraph 5 of article 22 prohibits cross retaliation if the covered agreement does not allow for suspension of concessions. Other than these guidelines in paragraphs 3 and 5, the DSU provides no hard and fast rule on cross retaliation in PTAs. There has not yet been cross-retaliation in goods only covered in a PTA and not the WTO. There may at present be a separate implicit arrangement to not cross retaliate in these other agreements – the analysis of which may present an interesting direction for further research. The relationship between dispute settlement in the WTO and PTAs is well beyond the scope of this paper, however, it is an important area for further research.

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.¹² A larger distinction is that their focus is not on firm quality choice, irreversibilities, or integration.

¹² 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 weak dispute settlement that is more typical of PTAs. The fourth section considers how the WTO's strong 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.

2. 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.¹³ 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.¹⁴ Consumer utility maximization subject to their budget constraint yields demand functions $D_{jk}^i(P_{jkt}^i) = \theta_{jk} - P_{jkt}^i$ where $i \neq j$ and P_{jkt}^i is the

¹³ 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.

¹⁴ We can, therefore, restrict our analysis to the aggregate utility function. This utility function takes the following form: $U^i(D_{jkt}^i, D_{zt}^i) = u^i(D_{jkt}^i) + D_{zt}^i$ for $i \neq j$. The sub-utility functions are quadratic $u(D_{jkt}^i) = \theta_{jk}^i \cdot D_{jkt}^i - (D_{jkt}^i)^2 / 2$. 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_t^x, τ_t^y) to maximize national welfare over an infinite horizon.

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.¹⁵

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

$$P_{ykt}^y = P_{ykt}^x - \tau_{ykt}^x - \varepsilon_t^x, \quad P_{xkt}^x = P_{xkt}^y - \tau_{xkt}^y - \varepsilon_t^y, \quad (1)$$

or more succinctly as $P_{jkt}^j = P_{jkt}^i - \tau_{jkt}^i - \varepsilon_t^i$ where superscripts refer to countries and subscripts refer to goods. The random variables $(\varepsilon_t^x, \varepsilon_t^y)$, 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 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_{jkt}^i to represent the sum of the direct and equivalent tariffs. Whereas tariffs are observable, non-tariff barriers

¹⁵ The assumption of segmented markets in trade models was first considered by Brander and Krugman (1983). Its simplicity makes it attractive. Our results do not in any way depend on this simplification, however, we employ it for the following two reasons. The most import reason is that the assumption of segmented markets allows us to return an important general equilibrium aspect to the model. Production irreversibility implies that increased output in one sector is potentially costly because it reduces future output in another sector, however, it affects export and import elasticities in a manner that necessitates a parameterization which does not afford a closed form solution in a traditional general equilibrium framework. In partial equilibrium this increased output comes from reduced output of the numeraire good so it is not directly experienced as a cost. The potential loss of profit during a trade war captures this loss, however, if the good is also consumed domestically, then the increased domestic consumption mitigates this loss. For the supply and demand functions give here, it is still a national welfare loss, however, its mitigation clutters the analysis. This increased domestic consumption is costless, however, only because of the perfectly elastic supply of labor that is available in the numeraire sector. Hence, by segmenting markets we eradicate the positive domestic consumption effect of increased output that is only possible because of a large numeraire sector (or equivalently, a large pool of qualified and unemployed labor). In a sense, the assumption of segmented markets here is like an application of Lipsey and Lancaster's (1956-1957) "Theory of the Second Best". Once we made one simplification by using a partial equilibrium economy it was better to make another simplification and segment markets. Second, and of lesser importance, is that as our model becomes more complex the stark representation of optimal tariffs with segmented markets makes it easier for the reader to follow.

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 $\tau_{jkt}^{iE} = E[\tau_{jkt}^i + \varepsilon_t^i]$ 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 country i 's chosen tariff. From this point forward we use the fact that the tariff of country i must be on good j_k 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.

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

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_{jkt} . 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

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.

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 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, we also assume a constant marginal production cost, normalized to zero, which 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 $P_{jkt}^{jE} = P_{jkt}^j(\theta_{jk}, Q_{jkt}, \tau_t^{jE}) = \theta_{jk} - Q_{jkt} - \tau_t^{jE}$. 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:

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

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:

$$\begin{aligned} V^i(\tau_t^i, \tau_t^j, Q_{ik}, Q_{jk}) &= \int_{P_{jk}^i(\tau_t^i)}^{\theta} D_{jk}^i(P) dP + \tau_t^i \cdot D_{jk}^i(P_{jk}^i(\tau_t^i)) + \int_0^{P_k^i(\tau_t^j)} Q_{ik}(P) dP \\ &= \mu_i(Q_{jk}(\tau_t^{iE}), \tau_t^{iE}) + \tau_t^{iE} \cdot Q_{jk}(\tau_t^{iE}) + r_i(Q_{ik}(\tau_t^{jE}), \tau_t^{jE}) \end{aligned} \quad (4)$$

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:

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

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 $\tau_t^{iE} = \tau_t^{im}(Q_{jkt}) = P_{jkt}^{imE}(\theta_{jk}, Q_{jkt}, 0) = \theta_{jk} - \rho_{jk} Q_{jk}$.*

(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:

$$\frac{\partial V^i(\cdot, \tau_{ik}^j, Q_{ik}, Q_{jk})}{\partial \tau_t^i} = D_{jk}^i(P_{jk}^i(\tau_t^{im}))[1 - P_{jk}^{i'}(\cdot)] + \tau_t^{im} \cdot D_{jk}^{i'}(\cdot) \quad (6)$$

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

This result occurs because tariffs are chosen 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, where tariffs are chosen after production choices are made. In Dixit (1987) autarky is only an equilibrium

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 producer 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 these alternative formulations would mildly complicate the algebra, but would not change any of the results.

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 $\Pr(P_{jt}^j < \tilde{P}^j) = \Pr(P_{jt}^j - \tilde{P}^j - \tau_t^j < \varepsilon_t^j) = 1 - F(P_{jt}^j - \tilde{P}^j - \tau_t^j)$. We denote $F(P_{jt}^j - \tilde{P}^j - \tau_t^j) = \varphi_j(\tau_t^j)$ 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^j . By the FOSD of F^j we have that the conditional distribution $\varphi_j(\tau_t^j)$ satisfies FOSD as well so that $\varphi_j(\tau_t^j)$ is decreasing in τ_t^j . To simplify notation we write $\varphi_j(\tau^{ic}) = \varphi_j^c$. The probability that both producer prices are above their trigger value, given that countries are adhering to the cooperative tariffs, is

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

A dispute state is, therefore, 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 $P_j^i = P_j^i - \tau^i$ (so that $\varepsilon_t^i = 0$) with probability χ and either 0 or $2P_j^i$ each with probability $(1 - \chi)/2$. The expectation of P_j^i is unbiased and the distribution $\varphi_j(\tau^i)$ satisfies FOSD. 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, then a dispute is triggered with probability 1.

3. Weak Dispute Settlement

Our concept of weak dispute settlement (WDS) is adapted from Klimenko, Ramey, and Watson's (2008) idea of recurrent trade agreements. The idea is that countries agree to allow disputes to be settled by a third party that acts with some delay. By turning dispute settlement over to a third party countries effectively tie their hands with respect to renegotiation.²⁰ In WDS the trade authority does not discern which country is more likely to have deviated from the agreement. When a dispute flares up, both countries simultaneously suspend previously granted concessions and enter a trade war phase. In the trade war 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 Nash tariffs. These symmetric

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.

²⁰ Adapting the spirit of recurrent trade agreements for our WDS case is useful in several ways. First, it allows for a concise presentation of sequential equilibrium strategies in a repeated game of imperfect public information (where temporary punishments strictly dominate infinite trade disputes). Second, they provide a straightforward transition to the next section where we consider strong dispute settlement.

punishments are typical of the trade disputes that are evidenced in many PTAs. For countries to be willing to forego the possibility of renegotiation the dispute must be finite. The recurrent trade agreement strategies of Klimenko et al are not developed for the non-symmetric case or for the imperfectly observable tariffs that we consider here, therefore, our WDS trade agreement strategies should be considered as being in the spirit of their proposed recurrent trade agreement strategies.

Weak dispute resolution is, therefore, 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 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.²¹ These WDS 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.

WDS 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

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

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

²¹ We could also allow for finite and knowable delays so that the dispute is settled after T periods.

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

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

$$V_i^{iw}(\tau^{ic}, \tau^{jc}) = V_i^{iw}(\tau_i^{im}(\rho_{jk}Q_{jk}), \tau_i^{jm}(\rho_{ik}Q_{ik}), \rho_{ik}Q_{ik}(\tau^{jc}), \rho_{jk}Q_{jk}(\tau^{ic})) = \\ \mu_i(\rho_{jk}Q_{jk}(\tau^{ic}), \tau_i^{im}) + r_i(\rho_{ik}Q_{ik}(\tau^{jc}), \tau_i^{jm}) + \tau_i^{im} \cdot \rho_{jk} \cdot Q_{jk}(\tau^{ic})$$

We denote $Q_{ik}^c = Q_{ik}(\tau^{jc})$ and $r_i^{ic} = r_i(Q_{ik}^c, \tau_i^{jc})$, 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 $r_i^{im} = r_i(Q_{ikt}^m, \tau_i^{jm})$ 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 $r_i^{ic} = P_{ikt}^{ic}Q_{ik}^c - (Q_{ik}^c)^2/2$ and $r_i^{im} = -(Q_{ikt}^m)^2/2 = -\rho_{ik}^2(Q_{ik}^c)^2/2$. 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 derive Q_{ik}^c in equation (11) below.

Given the WDS 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 $\zeta \in (0, 1)$.

Note that in the absence of uncertainty (when $\phi = 1$) the expression for $G^{ic} = V^{ic}/(1 - \delta)$.

Firms

The expected discounted value of current and future profits for a firm, given that countries are abiding by the trade agreement is given by $R^{ic} = r^{ic} + \delta[\phi R^{ic} + (1 - \phi)[r^{im} + \delta(\pi R^{ic} + (1 - \pi)R^{iw})]]$. The expected discounted value in a withdrawal of concession stage is $R^{iw} = r^{iw} + \delta(\pi R^{ic} + (1 - \pi)R^{iw})$.

Solving these simultaneously we have

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

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 .

$$\begin{aligned} \frac{1}{2} > \frac{\partial Q_{ik}^c}{\partial \theta_{ik}} = \frac{\gamma}{2\gamma + \nu_i} > 0 > \frac{\partial Q_{ik}^c}{\partial \tau^{jc}} = \frac{-\gamma}{2\gamma + \nu_i} > -\frac{1}{2}; \quad \frac{\partial Q_{ik}^c}{\partial \phi} = \frac{\gamma\delta\rho_{ik}^2(\theta_{ik} - \tau^{jc})}{(2\gamma + \nu_i)^2} > 0; \\ \frac{\partial Q_{ik}^c}{\partial \pi} = \frac{\nu_i\delta(\theta_{ik} - \tau^{jc})}{(2\gamma + \nu_i)^2} > 0 > \frac{\partial Q_{ik}^c}{\partial \delta} = \frac{-(1 - \phi)\rho_{ik}^2(\theta_{ik} - \tau^{jc})}{(2\gamma + \nu_i)^2} < 0; \quad \text{and} \\ \frac{\partial Q_{ik}^c}{\partial \rho_{ik}} = \frac{-2\gamma(1 - \phi)\delta\rho_{ik}(\theta_{ik} - \tau^{jc})}{(2\gamma + \nu_i)^2} < 0 \end{aligned} \quad (12)$$

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.

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

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 $\delta \leq 1/2$, then the assumption is not at all restrictive. Note as well that (13) implies that $\gamma > v_i$.

Quality Choice

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

Proposition 2: (i.) *If there is uncertainty ($\phi < 1$), 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 ($\phi = 1$), 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.

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

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

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

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

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

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 $\rho^W(\theta_{ih}, \theta_{il}, \rho_{il}) < 1$ such that for all $\rho_{ih} > \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$ firms will choose low quality. This establishes part (i.) that $1 - \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$ 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 $1 - \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$ 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

$$\frac{\partial^3 R^{ic}}{\partial \theta_{ik} \partial \phi \partial \rho_{ik}} = \frac{2}{\theta_{ik} - \tau^{jc}} \frac{\partial^2 R^{ic}}{\partial \rho_{ik} \partial \phi} > 0 \quad \text{so that the effect in equation (17) is more pronounced when there is}$$

more irreversibility. Hence, for any $\rho_{ih} > \rho_{il}$, the distance between $\theta(\rho_{ih})$ and $\theta(\rho_{il})$, is decreasing in ϕ . Similarly, $\rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$ is increasing in ϕ so that the measure of high quality irreversibility realizations that generate inefficient low-quality choices is decreasing in ϕ . \square

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. \square

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 $\varphi_j(\tau_j^i)$, a deviating tariff of τ^{id} reduces $\varphi_j(\tau^{ic})$ to $\varphi_j(\tau^{id})$. Denote $\phi^{id} = \varphi_i(\tau^{ic}) \cdot \varphi_j(\tau^{id})$ 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 $\Delta(\phi, \pi, \delta) = \frac{\delta(\phi - \phi^{id})}{1 - \delta(\phi - \pi)} > 0$. 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 $\{\tau^{ic}, \tau^{ic}\}$ that maximize

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

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.

$$\Psi_t^i \leq \Omega_t^i, \quad i \in \{x, y\}, \forall t. \quad (22)$$

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^{ic} . 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.

Economic Integration

When a country's own export good offers more gains from trade or has more irreversible production that country will be more dependent 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 5: *A country will offer greater tariff concessions (τ^c 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 5 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 5 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.

4. Strong 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 $\{P_{jkt}^j, P_{ikt}^i\}$ 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 Strong Dispute Settlement (SDS). It is straightforward to verify that SDS 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. If free trade is not supportable, then 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 SDS 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 WDS as the norm in PTAs and SDS as the rule in the WTO.

Strong Dispute Settlement Payoffs

The cooperative stage is defined as before.

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

With probability $\phi_j^c(1-\phi_i^c)$ 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.

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

With probability $\phi_i^c(1-\phi_j^c)$ 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.

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

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

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, which is clearly inefficient. If, instead, only one country suffers the punishment stage but the recipient is selected at random, then there is no enforcement reduction, and expected payoffs are higher. In this case, with probability $1/2$, country i will be the retaliator and with probability $1/2$ they will be punished. So with probability $(1-\varphi_i^c)(1-\varphi_j^c)$ country i will receive an expected payoff of

$$(1/2)V_i^{ir}(\tau^{ic}, \tau^{jc}) + (1/2)V_i^{ip}(\tau^{ic}, \tau^{jc})$$

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 $\varphi_i^c = \varphi_j^c = \varphi$, 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 SDS 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 6: (i.) *With SDS, if country j does not misinterpret country i 's trade policy, then the country i firms' quantity and quality choices are efficient. Choices under WDS remain inefficient.*

(ii.) *With SDS, 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 WDS case.*

The proof of Proposition 6 is in the appendix. Part (i.) of proposition 6 indicates that, with SDS, the inefficient quality choice problem stems from the partner's trade policy misinterpretation. If the partner observed the trade policy with perfect clarity, then with SDS there is no problem. Of course with WDS the problem would remain. Part (ii.) reinforces part (i.) by suggesting that, even when there is SDS, not misinterpreting the trade partner's policy does not help the firm's quality decision. In fact, in this

limiting case SDS and WDS are equal. The proposition also suggests that, with SDS, 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 $\varphi \geq 1/2$. 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 $1 - \rho^S(\theta_{ih}, \theta_{il}, \rho_{il})$ 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 SDS than with WDS.

Proposition 7: *The measure of measure of high-quality irreversibility realizations such that firms would choose low quality is strictly lower under SDS than under WDS. Firm are less likely to choose lower quality with SDS than with WDS.*

The proof of Proposition 7 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 SDS than with WDS. In addition, the negative effect of irreversibility on profits and on quality is less pronounced under SDS than under WDS. 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 SDS than with WDS. Hence, it must be the case that $\rho^S(\theta_{ih}, \theta_{il}, \rho_{il}) > \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$ so that firms are less likely to choose low quality with SDS than with WDS.

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.

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

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

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:

$$\begin{aligned} \frac{\partial \Psi_t^i}{\partial \tau^{ic}} &= \frac{-2(\gamma^2 + \gamma \nu_j)(\theta_{ik} - \tau^{ic})}{(2\gamma + \nu_j)^2} < 0 < \frac{\partial \Psi_t^i}{\partial \theta_{jk}} = \frac{2(\gamma^2 + \gamma \nu_j)(\theta_{jk} - \tau^{ic})}{(2\gamma + \nu_j)^2}; \\ \lim_{\tau^{ic} \rightarrow \tau_1^{im}} \frac{\partial \Psi_t^i}{\partial \tau^{ic}} &= 0 = \Psi_t^i(\tau^{ic} = \tau_1^{im}) < \frac{\partial^2 \Psi_t^i}{\partial \tau^{ic2}} = \frac{2(\gamma^2 + \gamma \nu_j)}{(2\gamma + \nu_j)^2}. \end{aligned}$$

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 $\lim_{\tau^{ic} \rightarrow \tau_1^{im}} \frac{\partial \Psi_t^i}{\partial \tau^{ic}} \rightarrow 0$.

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

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

The strict concavity of Ω_t^i arises because $\frac{\partial^2 Q_{jk}^c}{\partial \tau^{ic2}} = 0$ and because $\frac{\partial Q_{jk}^c}{\partial \tau^{ic}} \in (-1/2, 0)$ 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,

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

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^{ic} 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, if $\tau^{ic} = 0$, then $\Psi_t^i(\tau^{ic} = 0) > 0$ 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 $\rho = 1$ 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 $\rho = 0$, 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, note that Ω_t^i is increasing in τ^{ic} at $\tau^{ic} = 0$.

Using $\frac{\partial Q_{jk}^c}{\partial \tau^{ic}} \in (-1/2, 0)$ we have:

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

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

Proof of Proposition 5: $\frac{\partial \Psi_t^i}{\partial \theta_{ik}} = 0 = \frac{\partial \Psi_t^i}{\partial \rho_{ik}}$.

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

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

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

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

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

by equation (25). \square

Proof of Proposition 6: (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 WDS 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 WDS case considered in proposition 2. Similarly,

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

WDS case. \square

Proposition 7: 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

$$\begin{aligned}
& 128\gamma^2\gamma^{*2} + (192 + 96\rho_{ik}^2)\gamma^2\gamma^{*2}\nu + (96 + 96\rho_{ik}^2 + 16\rho_{ik}^3 + 8\rho_{ik}^4)\gamma^2\gamma^*\nu^2 + \\
& (16 + 24\rho_{ik}^2 + 12\rho_{ik}^4 + 2\rho_{ik}^6)\gamma^2\nu^3 > \\
& 32\gamma^3\gamma^{*2} + 32\gamma^3\gamma^*\nu + 8\gamma^3\nu^2 + 2\rho_{ik}^4\gamma\nu^3 + 24\rho_{ik}^4\gamma\gamma^{*2}\nu^2 + 24\rho_{ik}^4\gamma\gamma^*\nu^3 + 48\rho_{ik}^2\gamma^2\gamma^{*2}\nu + 48\rho_{ik}^2\gamma^2\gamma^*\nu^2 + \\
& 12\rho_{ik}^2\gamma^2\nu^3 + 4\rho_{ik}^4\gamma\nu^4 + 4\rho_{ik}^6\gamma^{*2}\nu^3 + 4\rho_{ik}^6\gamma^*\nu^4 + \rho_{ik}^6\nu^5.
\end{aligned}$$

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

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

$\delta(1 - \varphi^2) > \delta^2[(1 - \varphi^2)(\varphi^2 + \pi - 2\varphi\pi)]$ 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 $\rho^S(\theta_{ih}, \theta_{il}, \rho_{il}) < 1$ such that for all $\rho_{ih} > \rho^S(\theta_{ih}, \theta_{il}, \rho_{il})$ 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 SDS, for any $\rho_{ih} > \rho_{il}$

such that $R^{iccs}(\theta_{ih}, \rho_{il}) > R^{iccs}(\theta(\rho_{ih}), \rho_{ih})$ 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 SDS the corresponding $\rho^S(\theta_{ih}, \theta_{il}, \rho_{il}) > \rho^W(\theta_{ih}, \theta_{il}, \rho_{il})$ so that the

measure of high-quality irreversibility realizations $1 - \rho^S(\theta_{ih}, \theta_{il}, \rho_{il})$ that generate inefficient low-quality

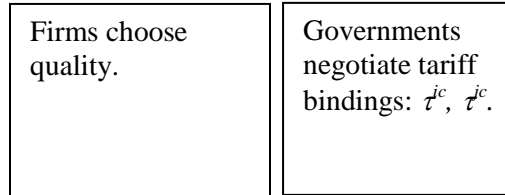
choices is lower under SDS than under WDS. \square

Table 1: Legal Aspects of PTAs

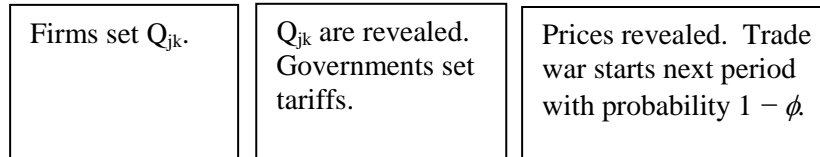
PACT		REVIEWER	RULING	REMEDY
ANZCERTA	(Australia-New Zealand)	None	–	–
BALTIC FTA	(Estonia, Latvia, Lithuania)	None	–	–
CEEC Pacts (5)	(Central and East European Countries)	None	–	–
CEFTA	(Central European Free Trade Agreement)	None	–	–
EEA European Economic Area		None	–	–
1992 EFTA pacts (6)	(Central Europe and Turkey)	None	–	–
Mano River Union	(Liberia, Sierra Leona, Guinea)	None	–	–
SACU	(Southern African Customs Union)	None	–	–
UDEAC	(Central African Customs and Economic Union)	None	–	–
AFTA	(ASEAN Free Trade Area)	Ad Hoc	Not Binding	Comp & Sanc
CARICOM	(Caribbean)	Ad Hoc	Not Binding	Sanctions
EFTA 1960		Ad Hoc	Not Binding	Sanctions
GCC	(Gulf Cooperation Council)	Ad Hoc	Not Binding	NONE
U.S.-Israel Pact		Ad Hoc	Not Binding	Sanctions
(9) Chile & Mexico Pacts		Ad Hoc	Binding	Sanctions
EC associations (12)		Ad Hoc	Binding	NONE
EC-Israel Pact		Ad Hoc	Binding	NONE
EFTA Agreements	(Baltics, Bulgaria, Israel, Slovenia)	Ad Hoc	Binding	NONE
MERCOSUR		Ad Hoc	Binding	Sanctions
NAFTA		Ad Hoc	Some Binding	Direct, Fines, Sanctions
OECS	(Organization of East Caribbean States)	Ad Hoc	Binding	NONE
CEAO	(West African Economic Community)	Tribunal	Binding	NONE
CIS	(Commonwealth of Independent States)	Tribunal	Binding	NONE
EAC	(East African Community)	Tribunal	Binding	NONE
ECOWAS	(Economic Community of West African States)	Tribunal	Binding	Sanctions
Andean Pact		Tribunal	Binding	Direct & Sanctions
CACM	(Central American Common Market)	Tribunal	Binding	Direct
COMESA	(Common Market for Eastern and Southern Africa)	Tribunal	Binding	Sanctions
EC		Tribunal	Binding	Direct
EFTA 1992		Tribunal	Binding	Direct

Figure 1: Timing

Timing in Initial Period



Timing in Period 1



Timing in Period $t > 1$

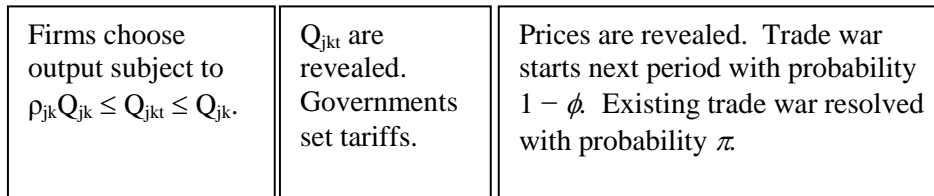


Figure 2: Inefficient Quality Choice

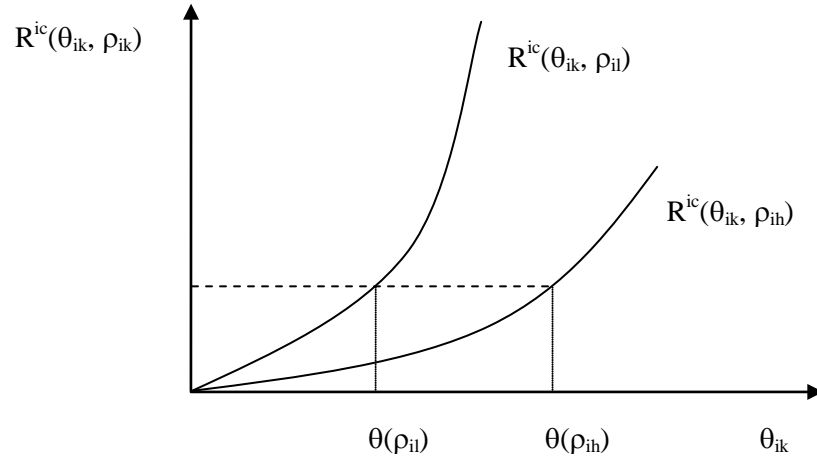


Figure 3: Determination of τ^{ic}

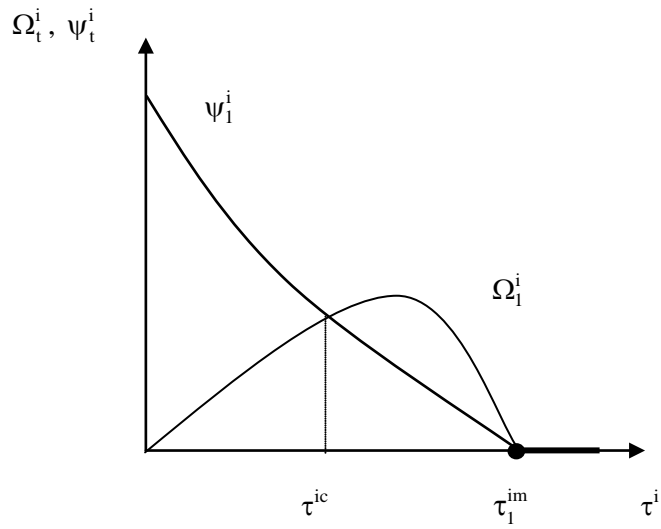


Figure 4: $\theta_{ih} > \theta_{il}$.

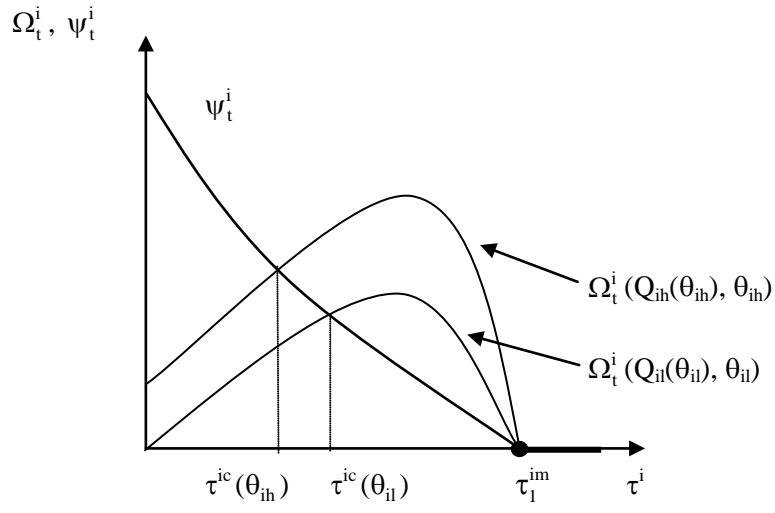


Figure 5: $\rho_{ih} > \rho_{il}$.

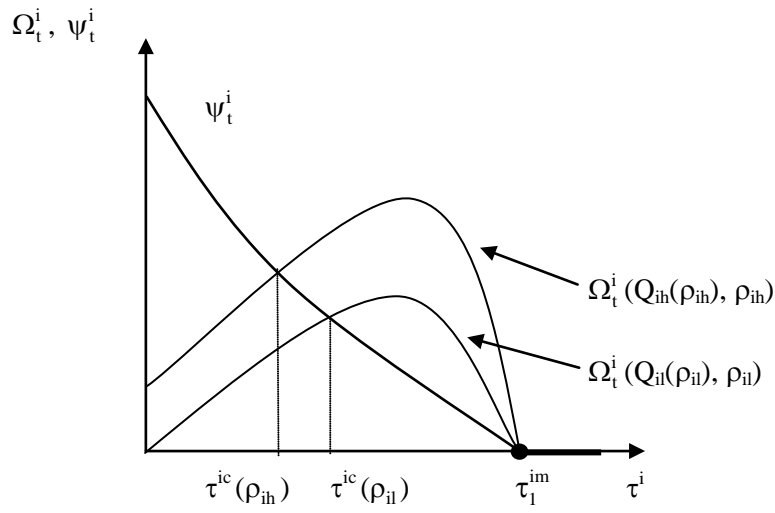


Figure 6: SDS vs. WDS Quality Choice

