# ABSTRACT

Title of dissertation:     MODELING INTERNATIONAL TRADE
                           UNDER THE THREAT OF TARIFF HIKES
                           IN GENERAL EQUILIBRIUM

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There is mounting evidence that an important element in explaining the impact of trade policy on trade patterns and the behavior of firms is the role of policy uncertainty in shaping this behavior. In a setup where firms must incur a fixed cost to export, uncertainty over future profits will decrease the incentive of firms to enter into the export market. While uncertainty over any number of factors playing into export decisions (such as demand, productivity, exchange rate, etc.) may affect exporters' incentives to export, I focus here on trade policy uncertainty, specifically tariff rates, as this allows me to quantify the impact of one particular type of policy uncertainty, and can provide insight into the effects of broader policy uncertainty. Unlike most other forms of uncertainty, it is something that can be measured empirically using tariff rates. Further, understanding the effects of uncertainty over future tariff levels is important in its own right, as there is debate over whether trade agreements that do not substantially change applied tariff rates are of any value to exporters. My dissertation will address this question, arguing that there is indeed additional value to some trade agreements beyond that simply obtained by liberalizing tariffs: namely, that there is value in reducing uncertainty over future trade policy. In order to try to quantify this additional value, I develop a general equilibrium framework consistent with the types of Computable General Equilibrium (CGE) models that are often used to evaluate the potential value of proposed trade agreements, where my model takes into account this additional uncertainty-reducing benefit of entering into a trade agreement.

Chapter 1 introduces the topic and discusses broader implications of studying tariff uncertainty. In order to motivate the inclusion of tariff uncertainty in a general equilibrium framework, I begin in Chapter 2 by presenting empirical evidence, based on a partial equilibrium framework, of a negative impact of future tariff uncertainty on exports. In this chapter, I extend previous empirical analysis of tariff uncertainty (via tariff bindings) to a large set of countries and find a negative significant effect of policy uncertainty arising from binding overhang, and that this effect is heterogeneous across importing countries. On average, I find that the ad valorem tariff equivalent imposed by uncertainty arising from binding overhang for the set of countries in my sample is 8.2%.

In Chapter 3, I extend the theoretical analysis of tariff uncertainty in general equilibrium to a setting with endogenous entry not only into exporting but also into production with multiple countries and sectors. Based on this model, I obtain numerical results for the impacts of an (exogenous) threat of reverting to a permanent non-cooperative tariff level. In a symmetric two-country setting, the effects are a 4.55% reduction in trade and a 0.02% reduction in welfare. I am further able to derive the effect of a tariff threat on third-countries and outside sectors not directly targeted, and find these effects to be small.

In Chapter 4, I use the model developed in Chapter 3 to analyze the trade and welfare impacts of a particular agreement: the Chile-US Free Trade Agreement (FTA). This extends and complements econometric analysis of the impact of uncertainty in the context of other FTAs. I find that a model without the tariff threat effect predicts that Chilean exports to the United States should increase by 5.78% and number of exporting firms should increase by 2.80% as a result of the FTA, while the model with the effect of a tariff threat predicts that exports should increase by 6.98% and the number of exporters by 7.43%.

MODELING INTERNATIONAL TRADE UNDER THE THREAT OF
TARIFF HIKES IN GENERAL EQUILIBRIUM

by

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# Chapter 1

# Introduction

There is mounting evidence that an important element in explaining the impact of trade policy on trade patterns and the behavior of firms is the role of policy uncertainty in shaping this behavior. In a setup where firms must incur a fixed cost to export, uncertainty over future profits will decrease the incentive of firms to enter into the export market. While uncertainty over any number of factors playing into export decisions (such as demand, productivity, exchange rate, etc.) may affect exporters' incentives to export, I focus here on trade policy uncertainty, specifically tariff rates, as this allows me to quantify the impact of one particular type of policy uncertainty, and can provide insight into the effects of broader policy uncertainty. Unlike most other forms of uncertainty, it is something that can be measured empirically using tariff rates. Further, understanding the effects of uncertainty over future tariff levels is important in its own right, as there is debate over whether trade agreements that do not substantially change applied tariff rates are of any value to exporters. My dissertation will address this question, arguing that there is indeed additional value to some trade agreements beyond that simply obtained by liberalizing tariffs: namely, that there is value in reducing uncertainty over future trade policy. In order to try to quantify this additional value, I develop a general equilibrium framework consistent with the types of Computable General Equilibrium (CGE) models that are often used to evaluate the

potential value of proposed trade agreements, where my model takes into account this additional uncertainty-reducing benefit of entering into a trade agreement.

In order to motivate the inclusion of tariff uncertainty in a general equilibrium framework, I begin in Chapter 2 by presenting empirical evidence, based on a partial equilibrium framework, of a negative impact of future tariff uncertainty on exports. In this chapter, I extend previous empirical analysis of tariff uncertainty (via tariff bindings) to a large set of countries and find a negative significant effect of policy uncertainty arising from binding overhang, and that this effect is heterogeneous across importing countries. On average, I find that the ad valorem tariff equivalent imposed by uncertainty arising from binding overhang for the set of countries in my sample is 8.2%.

In Chapter 3, I extend the theoretical analysis of tariff uncertainty in general equilibrium to a setting with endogenous entry not only into exporting but also into production with multiple countries and sectors. Based on this model, I obtain numerical results for the impacts of an (exogenous) threat of reverting to a permanent non-cooperative tariff level. In a symmetric two-country setting, the effects are a 4.55% reduction in trade and a 0.02% reduction in welfare. I am further able to derive the effect of a tariff threat on third-countries and outside sectors not directly targeted, and find these effects to be small.

Using the model developed in Chapter 3, in Chapter 4, I analyze the trade and welfare impacts of a particular agreement, the Chile-US Free Trade Agreement. This extends and complements econometric analysis of the impact of uncertainty in the context of other FTAs. This particular trade policy shock provides a good setting for examining the additional value of a computable general equilibrium model which takes into account not only applied tariff changes but also changes in uncertainty over future tariffs as this FTA both reduced applied tariffs faced by Chilean exporters and reduced the threat of future tariff shocks. Prior to implementation of the US-Chile FTA, Chilean exporters benefited from unilateral trade preferences into the United States under the Generalized System of Preferences (GSP) which allowed for duty free treatment of selected goods, however, these preferences were not

permanent, and were subject to suspension in the event that a beneficiary country was deemed to be in non-compliance with international labor standards. With the entry into force of the US-Chile FTA, in addition to several applied tariffs being lowered, preferential tariffs which were previously subject to unilateral revocation at any time were arguably more certain. The general equilibrium model developed in the previous chapter is calibrated using trade, tariff, and firm data from the year 2006 and then solved in both cases with and without the threat of GSP preference loss for Chilean exporters in order to evaluate the additional effect of guaranteeing preferences beyond liberalizing tariffs. I find that a model without the tariff threat effect predicts that Chilean exports to the United States will increase by 5.78%, the number of exporters will increase by 2.80% and utility for Chile will decrease by 0.233% as a result of the FTA, while the model with the effect of a tariff threat predicts that exports will increase by 6.98%, the number of exporters by 7.43% and that utility will fall by 0.231%.

The issue of tariff uncertainty is important in and of itself for several reasons. First, multilateral negotiations in the WTO are over bound tariff rates, and the results of a given negotiation may not affect certain applied tariffs at all. In light of the conclusion that trade policy agreements have value beyond applied tariff reductions by reducing policy uncertainty, there is arguably value in continuing to negotiate down bound tariff levels, even in cases where applied tariffs are already low. Second, the unilateral preference schemes (such as GSP, AGOA, etc.) offered by several developed countries to developing countries with the goal of promoting trade integration and increasing exports could better achieve this goal if the preferences offered were guaranteed to remain in place forever. Currently, these agreements tend to be approved for finite periods of time into the future, and are subject to revocation at the discretion of the preference offering country at any time. Beyond the importance of tariff and trade policy uncertainty, however, the issue focused on in this dissertation has broader implications for the analysis of policy in general. In cases where up front investments must be made under policy uncertainty, either because of institutional

uncertainty or of a lack of credibility of the policy implementer, analysis of the potential effects of any proposed policy should account not only for the applied changes induced by the policy, but also the degree of uncertainty associated with the policy.

# Chapter 2

# The Impact of Trade Policy Uncertainty on Exporting: An Empirical Study

## 2.1 Introduction

In this chapter, I extend previous empirical analysis of tariff uncertainty (via tariff bindings) to a large set of countries and find a negative significant effect of policy uncertainty arising from binding overhang, and that this effect is heterogeneous across importing countries. On average, I find that the ad valorem tariff equivalent imposed by uncertainty arising from binding overhang for the set of countries in my sample is 8.2%.

This chapter is organized as follows: Section 2.2 provides background information and the motivation for studying this issue, Section 2.3 briefly reviews the related literature, Section 2.4 outlines the model on which the empirical specification is based, Section 2.5 describes the empirical strategy, Section 2.6 describes the data and presents some basic summary statistics, Section 2.7 presents the results, Section 2.8 discusses the robustness of

these results, as well as avenues of future research, and Section 2.9 concludes.

## 2.2 Background and Motivation

When member countries negotiate tariffs in the World Trade Organization (WTO), they agree on what are known as "bound" tariff rates, that is, rates above which they agree not to raise tariffs on a given product. The tariff rate that a country applies at the border is then constrained to be less than or equal to this bound rate, and in fact, for many products and countries, the applied rate is strictly lower than the negotiated bound rate. This results in the existence of "binding overhang": a gap between the bound and applied tariff rate. While it is only the current applied tariff of a given market which affects the current period profits of a firm exporting into that market, the bound rate provides an upper bound on future applied tariff levels. In a setup where exporters must incur an irreversible fixed cost to enter an export market, the current period decision of whether or not to export will be affected by expectations about future profit levels, and thus will be impacted by expectations over future applied tariffs. What is the relationship between tariff bindings and the expected value of future applied tariffs in practice? Looking at the tariff schedules of applied and bound rates across countries, one sees a great deal of variation in the applied levels and the gap between applied and bound rates with developed countries generally exhibiting lower applied tariffs and lower gaps relative to developing countries. This difference is largely a result of developed countries having been the key players in initial multilateral negotiations where bound rates were negotiated down, as well as a policy of "special and differential treatment" afforded to developing countries in the WTO that allows them to retain higher bound rates so that they have more flexibility in tariff policy to deal with various economic (or political) shocks. The fact that higher bound rates are regarded as increasing the ability of a country to change tariff policy in response to shocks indicates that there is indeed a correlation between bound tariff rates and expected applied rates. For many products in developed countries, bound rates are exactly equal to applied rates, which implies that

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future applied rates can only remain at current levels or decrease. In cases where these rates are also zero, the bound tariff effectively removes all uncertainty over future applied tariff rates as they cannot be raised. Foletti, Fugazza, Nicita and Olarreaga (2009) conduct an empirical study of historic tariff rates to see how countries use the policy space afforded by bound rates strictly above applied rates and find that in times of economic crises, higher gaps between initial applied and bound tariff rates are correlated with higher increases in tariffs applied in response to the crisis.

In this empirical study, I ultimately aim to answer the following question: Does the uncertainty generated by a gap between bound and applied tariff rates (binding overhang) in a given market negatively impact the extensive margin of exports into that market? While previous work addressing this question exists for a single importing country (see Section 2.3), the current study aims to extend these results to multiple importing countries in order to investigate whether this uncertainty effect can be observed for other importers.

While uncertainty over any number of factors playing into export decisions (such as demand, productivity, exchange rate, etc.) may affect exporters' incentives to export, focusing on trade policy allows me to quantify the impact of one particular type of policy uncertainty, and can provide insight into the effects of broader policy uncertainty. Unlike most other forms of uncertainty, it is something that can be measured empirically (via binding overhang), and the variation in such uncertainty across products allows me to control for industry and country level effects in my estimation. Further, understanding the effects of uncertainty due to binding overhang is important in its own right, as there is debate over whether the reduction of bound rates (without changing applied tariffs) via WTO negotiations is of any value to exporters. This chapter will address this question, arguing that reducing only bound rates does increase the incentive to export.

## 2.3 Literature Review

This chapter builds on a strand of literature which includes both theoretical and empirical papers attempting to identify and quantify the effects of various forms of policy uncertainty on economic outcomes, which I briefly summarize here.

One of the first papers to model the impact of policy uncertainty on economic outcomes is Rodrik (1991) in which the author develops a purely theoretical model to explain how investment may respond to policy changes when there is uncertainty over the permanence of the new policy. Dixit (1989) and Pindyck (1991) develop theoretical models for the impact of uncertainty in a dynamic framework using an option value approach while Baldwin and Krugman (1989) develop a theoretical model trade under exchange rate uncertainty. These underlying theoretical models have since been applied in various settings including the impact of tax policy uncertainty on investment (Hassett and Metcalf (1999)), the impact of climate policy uncertainty on investment (Blyth, Bradley, Bunn, Clarke, Wilson and Yang (2007)), and the impact of exchange rate uncertainty on exports (Baldwin (1988)). One study which combines the strand of literature examining policy uncertainty and that exploring cross country institutional explanations for economic outcomes is Kenyon and Naoi (2010), in which the authors use firm-level survey data on policy uncertainty across several countries and find a U-shaped relationship between this uncertainty and political regime type. That is, they find higher policy uncertainty in hybrid regimes than in either more authoritarian regimes or established liberal democracies.

While the above studies focus on various types of policy uncertainty and on policy uncertainty in general, there are also some studies which have focused on the particular type of policy uncertainty that I study here: uncertainty over the level of applied tariffs. Foletti, Fugazza, Nicita and Olarreaga (2009) examine the extent to which countries have used policy space allowed by binding overhang during previous economic downturns and quantify how much of this policy space is meaningful. They further use their model to form a prediction of how much tariffs should be expected to increase as a result of protectionist responses

to the recent global crisis, finding this to be relatively small (on the order of 8 percent of current tariff levels). Another study looking specifically at the issue of tariff uncertainty as constrained by bound tariff rates is that of Francois and Martin (2004), however, this paper focuses mainly on the theoretical welfare implications of tariff variability rather than the its impact on trade. Evenett, Gage and Kennett (2004) provide some evidence of increased exports after WTO accession to developed countries in products with lower gaps between preferential and Most Favored Nation (MFN) tariff rates, though this evidence is somewhat mixed. Sala, Schroder and Yalcin (2009) develop a purely theoretical model, using hetero-geneous firms and an option value approach, and show that a reduction in bound rates can move forward export time and that we see a larger effect for "high risk" destination markets. Finally, the previous work which is most closely related to this study is that of Handley and Limão (2012), which finds increased entry into the export market for Portuguese exporters as a result of the reduction in uncertainty from EC accession, and Handley (forthcoming, JIE) which finds evidence that product level uncertainty negatively impacts the level and responsiveness of exports to applied tariff reductions for exports to Australia. Handley and Limão (2012) focuses mainly on the reduction in uncertainty associated with entering into a preferential trade agreement, but does not address the uncertainty arising from binding overhang. Handley (forthcoming, JIE) does focus on the uncertainty arising from binding overhang, but does so for just one import market: Australia. The current study will build on the findings of Handley (forthcoming, JIE) by determining whether these results are spe-cific to Australia, or whether they extend to a larger set of import markets. The theoretical model and empirical strategy presented in sections 2.4 and 2.5 below are based largely on Handley and Limão (2012) and Handley (forthcoming, JIE) respectively.

## 2.4  Model

The theoretical model upon which my empirical specification is based comes from Handley and Limão (2012) and its extension to tariff bindings in Handley (forthcoming, JIE), with

a slight modification to allow for multiple exporting countries (in addition to multiple importing countries). In a multi-period framework with uncertainty over future applied tariff rates, in each period, producers of differentiated good $v$ in each of the $J$ exporting countries observe the current applied tariff rates (which vary across products and importers) in each of the $I$ importing countries, as well as the bound rates (which are assumed to remain constant over time), and decide whether or not to incur the fixed cost $K_e$ required to begin exporting to a new market.

## 2.4.1  Demand

Utility in each importing country $i$ is Cobb-Douglas over a homogeneous good traded on world markets and a continuum of differentiated goods indexed by $v$:

$$U_i = q_{i,0}^{1-\mu} \left( \int_{v \in \Omega_i} q_i(v)^\alpha dv \right)^{\mu/\alpha} , \ \alpha$$
$$= \frac{\sigma - 1}{\sigma} \qquad (2.1)$$

where $\sigma > 1$ is the elasticity of substitution between differentiated goods, $\mu \in (0, 1)$ and $\Omega_i$ represents the set of available varieties in country $i$, which includes both those produced domestically and those that are imported. Consumption levels of each variety of the differentiated good and of the homogeneous good are then chosen to maximize utility subject to the budget constraint imposed by total income $Y_i$:

$$p_{i,0}q_{i,0} + \int_{v \in \Omega_i} p_i(v)q_i(v)dv \leq Y_i \qquad (2.2)$$

where $p_i(v)$ is the price paid by the consumer in country $i$ for variety $v$. This then yields the typical demand function for each variety $v$,

$$q_i(p_i) = \mu Y \frac{p_i(v)^{-\sigma}}{P_i^{1-\sigma}} \qquad (2.3)$$

where $P_i$ is the price index in country $i$ given by

$$P_i = [\int_{v \in \Omega_i} (p_i(v))^{1-\sigma} dv]^{1/(1-\sigma)} \qquad (2.4)$$

## 2.4.2  Supply

It is assumed that the homogeneous good is produced under constant returns to scale at a unit cost of $1/w_j$ in country $j$ and is freely traded. Normalizing the price of this good $p_0 = 1$ and assuming that the labor market clears then implies that the wage in each country $j$ is given by $w_j$.[1] The consumer price of a differentiated good $v$ in country $i$ will include the tariff imposed on that good by country $i$. Thus, if a producer charges $p(v)$ for the good in his domestic market, consumers in market $i$ will pay $p_i(v) = \tau_i(v)p(v)$ for this good where $\tau_i(v) \geq 1$ is one plus the MFN ad-valorem tariff imposed by country $i$ on good $v$.[2]

A firm in exporter $j$ is identified by its unit labor requirement $c_j$ which is distributed according to $G_j(c)$, and which is bounded below by $c_j^L$. The variable costs of producing $q$ units for this producer are then $w_j c_j q$ and so the operating profits from exporting into market $i$ for a firm in country $j$ with unit labor requirement $c_j$ is then

$$\pi_{ij}(p_j) = p_j q_i(\tau_i p_j) - w_j c_j q_i(\tau_i p_j) \tag{2.5}$$

Then, the firm will optimally choose to set its price $p_j = (w_j c_j)/\alpha$, the standard markup over marginal cost, and the price for the consumer in importing country $i$ for this good will be $\tau_i w_j c_j/\alpha$. Then, the per-period operating profits for firm $j$ from exporting into market $i$ are given by:

$$\pi_{ij} = A_{ij}\tau_i^{-\sigma}c_j^{1-\sigma} \tag{2.6}$$

where $A_{ij} = \frac{(1-\alpha)\mu Y_i w_j^{1-\sigma}}{[P_i\alpha]^{1-\sigma}}$ captures the exporter cost and importer demand conditions.

## 2.4.3  Decision to Enter Export Market

I assume a one-time fixed cost $K_e$ incurred by firms entering into a new export market. In this set-up, as in Melitz (2003), in each period, a subset of firms with unit costs below

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[1]Since this good is freely traded, its price will be the same for consumers in all importing countries, thus I omit the $i$ subscript and assume that $p_{i,0} = p_0 \; \forall i$.

[2]For simplicity, it is assumed that tariffs are not permitted to vary by the origin of the good, that is, the tariff applied by country $i$ on a given good $v$ must be the same regardless of which country $j$ exports the good into $i$. This reflects the "Most Favored Nation" (MFN) principle of the WTO, which requires that member countries apply the same tariff rate to all other member countries. In reality, there is some heterogeneity of applied tariffs for a given importer-good across exporters due to the existence of preferential agreements, however, the focus of this chapter is on the effect of uncertainty between non-preferential partners. Preferential partners will ultimately be excluded from the empirical analysis, as described below.

some threshold will pay this entry cost and begin exporting into a given market $i$. Also as in Melitz (2003), firms are subject to an exogenous probability $\delta$ of death in each period. Firms hit by the death shock exit the market and do not recoup the fixed cost incurred when they began exporting.

In the case of no uncertainty over tariffs (where future tariffs are certain to remain at the current level), producers will choose to export into market $i$ whenever the net present discounted value of profits from doing so is at least as great as the sunk cost incurred by entering that export market. That is, when

$$\sum_{t=0}^{\infty} \beta^t \pi_{ij} - K_e = \frac{\pi_{ij}}{1-\beta} - K_e \tag{2.7}$$
$$\geq 0$$

where $\beta = (1-\delta)/(1+\rho)$ combines the probability of death in each period and the true discount factor, $\rho$. This then defines a cutoff unit cost, below which all producers will choose to export into market $i$:

$$c_{ij}^D = \left[ \frac{A_{ij} \tau_i^{-\sigma}}{(1-\beta)K_e} \right]^{1/(\sigma-1)} \tag{2.8}$$

Now turning to the case of uncertainty, in each period, firms who have already begun exporting to a given market will continue to do so and will exit only when hit with a death shock (since they have already paid the fixed cost to export). Firms who have not previously exported to a given market $i$ will choose to enter into that export market when the net present discounted value, $V_i^1$, of being an exporter into that market exceeds the option value, $V_i^0$, of waiting to enter into that export market by at least the magnitude of the fixed cost of entry. That is, they will choose to begin exporting into market $i$ when $V_i^1 \geq V_i^0 + K_e$. The net present discounted value of exporting into a market depends on the exporter's expectations over tariff levels in that market in future periods. Expectations over future tariffs are assumed to be as follows: in each period, the applied (MFN) tariff in market $i$ will be hit with a policy shock with probability $\gamma$. In the event of such a policy shock, the new tariff, $\tau_i'$ will be drawn from (time-invariant) distribution $H(\tau_i')$, censored

above at the level of the bound tariff for the given product in market $i$.

As shown in Handley (forthcoming, JIE), solving the system of equations defined by the Value functions implies a cutoff unit cost $c_{ij}^U$ given by

$$c_{ij}^U = \Theta(\tau_i) \times c_{ij}^D \tag{2.9}$$

where $c_{ij}^D$ is the cutoff unit cost for entry into export market $i$ (for a producer in country $j$) in the deterministic setting where tariffs are equal to the current tariff, $\tau_i$ in all future periods and

$$\Theta(\tau_i) = \left[ \frac{1 - \beta + \beta\gamma\Delta(\tau_i)}{1 - \beta + \beta\gamma} \right]^{\frac{1}{\sigma-1}} \tag{2.10}$$
$$\leq 1$$

where $\Delta(\tau_i) = \frac{E\left[(\tau_i')^{-\sigma}\right] + H(\tau_i)\left[\tau_i^{-\sigma} - E\left[(\tau_i')^{-\sigma}|\tau_i' \leq \tau_i\right]\right]}{\tau_i^{-\sigma}}$. That is, relative to the deterministic case, there is a lower unit cost cutoff (higher productivity cutoff) for firms to enter into the export market under uncertainty over future tariff levels.

## 2.5   Empirical Specification

Following Handley (forthcoming, JIE), I take advantage of the fact that trade in a given importer-exporter-product (indexed by $i, j, v$ respectively) will be observed when the latent variable $Z_{ijv} = \left( \frac{c_{iv}^U}{c_{jI}^L} \right)^{\sigma-1} \geq 1$, where $c_{jI}^L$ is the unit cost of the most productive firm in industry $I$ in country $j$ and $c_{iv}^U$ is the unit cost cutoff (defined in the previous section) defining the upper bound on unit cost for which producers of good $v$ will choose (under uncertainty) to export the good into market $i$. Thus, trade in product $v$ will be observed between importer $i$ and exporter $j$ whenever $Z_{ijv} \geq 1$, otherwise, no trade is observed. Plugging in the expressions from equations (2.8) and (2.9) then gives

$$Z_{ijv} = \frac{\Theta_{iv}^{\sigma-1}\tau_{iv}^{-\sigma}A_{ij}(c_{jI}^L)^{1-\sigma}}{(1-\beta)K_{jv}}$$

Assuming that fixed costs are constant within importer-exporter-industry group (so that $K_e = K_{ijI}$), and taking logs of both sides then yields:

$$z_{jiv} = const - \sigma \ln \tau_{jiv} + \underbrace{\ln \left[ \frac{1 - \beta + \beta\gamma\Delta(\tau_{iv})}{1 - \beta + \beta\gamma} \right]}_{=\ln \Theta_{iv}^{\sigma-1}} + d_{jiI} + \varepsilon_{jiv} \tag{2.11}$$

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where $d_{ijI} = a_{ij} + (1 - \sigma) \ln c_{jI}^L - k_{ijI}$ captures the exporter cost and importer demand conditions (via the $a_{ij}$ and $\ln c_{jI}^L$ terms) and the importer-exporter-industry specific fixed costs of exporting, $\varepsilon_{jiv} \sim N(0, \sigma_\varepsilon^2)$ is iid measurement error, and trade is observed when $z_{jiv}$ is positive.[3]

Noting that the expression for $\ln \Theta_{iv}^{\sigma-1}$ in (2.11) fully captures the effect of uncertainty in the model, Handley (forthcoming, JIE) takes the first-order Taylor approximation for this expression about $\gamma = 0$ in order to obtain an expression which is linear in $\gamma$,

$$\begin{aligned}
\ln \Theta_{iv}^{\sigma-1} &= \ln \left[ \frac{1 - \beta + \beta \gamma \Delta (\tau_{iv})}{1 - \beta + \beta \gamma} \right] \\
&\simeq \frac{\beta \gamma}{1 - \beta} \left( \Delta(\tau_{iv}) - 1 \right)
\end{aligned} \tag{2.12}$$

where it can be shown that $\Delta(\tau_t) - 1 = (1 - H(\tau_t)) \left[ \frac{E\left[ \tau^{-\sigma} | \tau \geq \tau_t \right] - \tau_t^{-\sigma}}{\tau_t^{-\sigma}} \right]$.

Again, following Handley (forthcoming, JIE), to construct a measure of this last term from applied and bound tariff rates, I discretize $H(\tau)$ by assuming that with probability $p_B = 1 - H(\tau_{iv})$ an applied tariff at the level of the binding is implemented in the event of a tariff shock. Then, $\Delta(\tau_{tjiv}) - 1 = -p_B \frac{\tau_{iv}^{-\sigma} - \left( \tau_{iv}^B \right)^{-\sigma}}{\tau_{iv}^{-\sigma}} \equiv -p_B U_{iv}$ where $U_{iv} = \frac{\tau_{iv}^{-\sigma} - \left( \tau_{iv}^B \right)^{-\sigma}}{\tau_{iv}^{-\sigma}}$ is positive whenever the bound tariff is greater than the MFN (applied) tariff and represents the uncertainty resulting from the binding overhang for product $v$ in market $i$.

Substituting this uncertainty measure into (2.11) and (2.12) yields

$$z_{ijv} = const - \sigma \ln \tau_{jiv} - \frac{\beta \gamma p_B}{1 - \beta} U_{iv} + d_{jiI} + \varepsilon_{jiv}$$

## 2.5.1 Baseline Specification

In order to move from the theoretical model to the empirical specification, I make the assumption that the elasticity of substitution between varieties is constant across industries. Letting $T_{ijv} = \mathbf{1}\left[ z_{ijv} \geq 0 \right]$, I model the probability that a good is traded between a given

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[3]Note that if I instead assume only that fixed costs are constant within exporter-industry, so that $K_e = K_{jI}$, I would then write (2.11) as $z_{jiv} = const - \sigma \ln \tau_{jiv} + \ln \left[ \frac{1 - \beta + \beta \gamma \Delta(\tau_{iv})}{1 - \beta + \beta \gamma} \right] + d1_{ji} + d2_{jI} + \varepsilon_{jiv}$ where $d1_{ij} = a_{ij}$ and $d2_{jI} = (1 - \sigma) \ln c_{jI}^L - k_{jI}$. That is, the specification below would include the interaction between importer and exporter dummies as well as that between exporter and industry dummies, but not the full set of interactions between all three.

importer-exporter pair as

$$\Pr(T_{ijv} = 1) = F(const + b_\tau \ln \tau_{iv} + b_U U_{iv} + d_{jiI}) \tag{2.13}$$

where $F$ is a CDF. For now, I assume $F$ to be linear and specify the following linear probability model (LPM) as the baseline estimating equation:

$$\Pr(T_{ijv} = 1) = b_0 + b_\tau \ln \tau_{iv} + b_U U_{iv} + b_{MFNPOS} MFNPOS_{iv} + d_{ijI} \tag{2.14}$$

where I have also added an indicator for whether or not the MFN (applied) tariff is positive, to disentangle the political economy reverse causality effect between tariff levels and imports whereby we are more likely to see positive tariffs on goods that are more likely to be traded due to protectionist pressures from domestic industry.[4] Given this specification, the estimated coefficient $b_\tau = -\sigma$ (up to a scale factor) and is thus expected to be negative. The coefficient $b_U = -p_B \frac{\beta\gamma}{1-\beta}$ (up to a scale factor) is also expected to be negative and contains information about the underlying parameters $p_B$ and $\gamma$; in particular, it is proportional to $p_B\gamma$, the probability of a reversal to the binding level.[5] Finally, although not included in the theoretical framework, I expect $b_{MFNPOS} > 0$, for the political economy reasons just mentioned.

## 2.5.2   Implementation

To implement the specification defined in (2.14), I run a regression on a cross section of data for one year by pooling all observations together, including fixed effects for importer, exporter, industry, and the full set of interactions between these. While this is the most straightforward method of implementing the specification defined in (2.14), doing so essentially assigns the same weight to results from each importer and may obscure heterogeneous effects of uncertainty arising from binding overhang across importers. Thus, in addition to the pooled regression, I also run a separate regression for each importer, in order to check

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[4]See Appendix A.1 for a more detailed discussion of the rationale for including this explanatory variable and its implications.

[5]While the assumption that the CDF $F$ is linear means that $F(x) = ax + b$, specification (2.14) implicitly assumes that $a = 1$. This is done to avoid unnecessarily complicating notation, however, this means that the expressions for estimated coefficients in terms of model parameters given here are actually valid up to a scale factor. This explains why the estimated values for $b_\tau$ in the results below may not be anywhere near the assumed value $\sigma = 4$.

whether the overall effect of uncertainty is present for exports into all markets, and whether there is any heterogeneity across importers of this effect.[6]

## 2.6  Data

I use trade and tariff data to conduct a cross sectional analysis in the year 2007 of the trade policy uncertainty effect on the probability that a good is traded. The unit of observation is then an importer-exporter-product where product is defined at the HS6 level, and the dependent variable is a binary indicator of whether or not positive trade is observed for that importer-exporter-product.[7]  In order to focus on the effect of policy uncertainty arising from the gap between MFN and bound tariff rates, I include in my sample (for the baseline specification described in Section 2.5.1) only bilateral country pairs where I expect the applied tariff to be given by the MFN tariff, and where the exporting country would expect future applied tariffs in the importing country to be bound by the WTO negotiated bound rate for that country. That is, I include only bilateral pairs where: 1) both the importing and exporting country are WTO members as of 2007, 2) the importing country bound rates have gone into force as of 2007, and 3) the importer does not grant the exporter trade preferences (via a bilateral, multilateral, or unilateral trade preference agreement). In all, this results in the inclusion of 92 importing countries in my sample. In the following sections, I present a description and some basic summary statistics for trade and tariff data used in the analysis, as well as the data used to identify bilateral pairs with preferential trade agreements.

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[6]Note that by implementing the specification defined in (2.14), which includes the full set of interactions between importer, exporter, and industry dummies, I am using only variation across products within a given importer-exporter-industry to identify the effect of uncertainty arising from binding overhang. If, in fact, the variation in uncertainty levels (for a given product) across importers affects the likelihood of that product being exported into each market, the above specification would not take advantage of this additional source of variation. As noted in footnote 3, by making a stricter assumption on heterogeneity of fixed costs (namely, that fixed costs vary only across exporter-industry, but not across importer-exporter-industry), then the theoretical model yields a specification which allows me to capture this additional source of heterogeneity:

$$\Pr(T_{ijv} = 1) = b_0 + b_\tau \ln \tau_{iv} + b_{U,i} U_{iv} + b_{MFNPOS} MFNPOS_{iv} + d1_{ji} + d2_{jI} + \varepsilon_{tjiv} \qquad (2.15)$$

Results for this specification are presented below in section 2.8.2.

[7]In fact, this binary indicator is set equal to 1 only when the observed trade flow is greater than or equal to 1000 USD, and zero otherwise.

### 2.6.1 Trade and Tariff Data

Trade and tariff data are obtained through the World Integrated Trading System (WITS) maintained by the World Bank. Tariff data come from both the WTO's Integrated Database (IDB) and UNCTAD's Trade Analysis and Information System (TRAINS) while the associated trade data come from the WTO (for countries with WTO tariff data) or from either COMTRADE or TRAINS (for countries with TRAINS tariff data).[8] Import values as well as MFN, preferential and bound tariffs are obtained for all available reporters at the HS6 digit level for year 2007.[9] I define industries by HS4 subheading and assign each HS6 product to one of 1255 possible industries accordingly. The uncertainty measure $U_{iv}$ is defined (according to the theory presented above) for each product-importer as

$$U_{iv} = \frac{\tau_{iv}^{-\sigma} - \left(\tau_{iv}^B\right)^{-\sigma}}{\tau_{iv}^{-\sigma}} \tag{2.16}$$

where $\tau_{iv}$ is one plus the MFN ad-valorem tariff rate and $\tau_{iv}^B$ is one plus the ad-valorem bound tariff rate. A value of $\sigma = 4$ is assumed.[10]

#### 2.6.1.1 MFN Rates Above Bound Rate and Unbound Products

As derived in the model above, the measure of uncertainty used to capture uncertainty arising from binding overhang given by (2.16) will satisfy $0 \leq U_{iv} \leq 1$ for non-negative MFN tariff rates at or below the bound rate. Although the applied tariff rate is theoretically required to be below the bound rate, there are some instances in the data where the reported MFN applied tariff exceeds the reported bound rate. This may happen for one of several reasons. First, the bound rates which were negotiated by WTO members as part of the

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[8]See the tables in Appendix A.2 to find the trade and tariff data source used for each country. Here, the trade data source will be either WTO, CMT (Comtrade), TRN (Trains), or INV, where INV indicates that mirror export flows from COMTRADE have been used, due to the importing country not having reported imports to any of the above sources (WTO, COMTRADE or UNCTAD(TRAINS)).

[9]Since tariffs are actually applied at a more disaggregate level for most countries, the tariff rates reported at the 6 digit level are actually simple averages of the tariff rates of all tariff lines within that 6-digit line. Since the 6 digit level is the most disaggregate level for which product nomenclatures are standardizes across countries, this is the level used for this analysis.

[10]In their model, Bernard et. al. (2003) find that an assumption of $\sigma = 3.79$ (along with an assumption for the value of a parameter governing the heterogeneity of production efficiency) produces simulated results that closely match actual export, productivity and size statistics for U.S. firms. They use 458 industries defined at a 4-digit level. See Section 2.8 for a brief discussion of possible ways to test the robustness of my results to alternative elasticities or industry definitions.

Uruguay Round were agreed to in 1995, and may appear in the data as the bound rate in effect for all years 1995 and later. However, because countries were allowed several years to adjust their tariff schedules to comply with these bound rates (see Bacchetta and Bora (2001)), in the years following 1995 there may be cases where the reported MFN rate remains above the negotiated bound rate.[11] Second, due to the fact that product nomenclatures change over time, it is possible for a product which was previously subject to a higher bound rate (or no bound rate) to be reclassified into an HS6 product with a bound rate below its applied level. In such cases, there may be an implementation phase as previously described, or it may be the case that WTO members have agreed that despite the reclassification, this product is not subject to the bound rate. Finally, it is conceivable that despite having negotiated a certain bound tariff for a product, a country might violate its WTO commitment by setting a tariff over this bound level. Further, because tariffs reported at the 6-digit level are generally averages of tariffs for more disaggregate products, it is possible that while some MFN lines are indeed below the bound rate for that HS6 line, a high MFN on one product at the tariff line level causes the average for that HS6 line to be over the bound rate as well.

In such cases, computing the uncertainty measure according to the above formula would yield a negative value. How to appropriately deal with this problem depends on which of the above cases we are in. In the case where applied rates are gradually being lowered in order to comply with the negotiated bound rate, it seems likely that exporters believe that future applied rates will indeed be bounded above by the negotiated bound rate, and so it may be sensible in such cases to set the uncertainty measure to its lower bound of 0. On the other hand, if the cause of the MFN rate appearing higher than the bound rate is that for whatever reason that product is not subject to the bound rate, or there are lines

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[11]I attempt to avoid including importers for whom negotiated bound rates have not yet gone into effect, using the reported implementation year for bound rates as reported in the "Data Availability" for WTO-CTS data in WITS, available at http://wits.worldbank.org/WITS/WITS/Support%20Materials/ComtradeCatalog.aspx?Page=DataCatalog. While dropping countries for whom bound rates are not yet in effect reduces the instances of MFN rates which are greater than reported bound rates, several such cases still exist. Some of these may still be due to implementation periods, as certain products may have been granted exceptions to overall implementation deadlines (see Bacchetta and Bora (2001)).

within that HS6 line not subject to the bound rate, it is conceivable for exporters of this HS6 good to assign the maximum level of uncertainty, 1, to this product. To avoid making an incorrect assumption about which of these cases we are in, in the baseline specification I drop all importer-products for which the reported MFN rate is greater than the bound rate. In section 2.8 below, I discuss the robustness of the results to instead assigning an uncertainty measure of 0 or 1 to such products.

Another case in which there is some ambiguity about how the uncertainty measure should be derived is for products for which no bound tariff rate exists. For some countries, this may be the case for most products (see Appendix A.2). Theoretically, MFN tariffs for such products could be set at arbitrarily high levels in future periods, thus it seems reasonable to assign an uncertainty measure of 1, the value corresponding to a bound rate of infinity, to such products. This is the method used for dealing with unbound product lines in the baseline results presented below, while the robustness of these results to instead dropping unbound product lines is discussed in Section 2.8.

### 2.6.1.2   AVE Tariff Rates

Some tariff rates reported in WITS are not actual ad valorem tariffs, but rather ad valorem equivalents (AVEs) computed using UNCTAD method 1.[12] For my analysis, I treat applied tariffs which are AVEs the same as actual ad valorem tariff rates, however, I drop from my sample products which exhibit AVE bound rates. This is because in my model, bound rates are fixed over time and give an upper bound on the distribution of future tariffs, however, a bound rate which is in the form of a specific tariff (or some other non-ad valorem tariff) can change over time. For most importers, less than 1% of products have bound rates with AVEs. The nine importers for whom this is not the case are listed in Table 2.1.

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[12]See http://wits.worldbank.org/WITS/wits/WITSHELP/Content/Data_Retrieval/P/Intro/C2.Ad_valorem_Equivalents.htm.

Table 2.1: Bound Tariff Ad Valorem Equivalents

| Country | Total Number of HS6 Products | Share of Products with Bound Tariff AVEs |
|---|---|---|
| Switzerland | 5051 | 85.8% |
| Norway | 5040 | 12.4% |
| United States | 4985 | 9.3% |
| Japan | 5051 | 4.2% |
| Canada | 5048 | 3.4% |
| European Union | 5019 | 3.4% |
| New Zealand | 5035 | 2.2% |
| Malaysia | 5189 | 2.1% |
| India | 5052 | 1.0% |

### 2.6.1.3 Tariff Summary Statistics

Summary statistics on applied and bound tariffs, as well as the uncertainty measure derived therefrom, are given for each country in Figures 2.1 and 2.2 and Appendix A.2.

Summary statistics of these by-importer statistics across importers are presented in Table 2.2. Unless otherwise noted, these summary statistics are computed after dropping importer-products for which the bound rate is given as an AVE or the MFN rate exceeds the bound rate, and assigning an uncertainty measure of $U_{tiv} = 1$ for importer-products which are unbound.[13]

From Table 2.2, we can see by comparing the mean and median of the share of unbound lines across countries that at least half the countries in the sample exhibit tariff bindings on the vast majority of products, but that there exist some importers with large shares of HS6 lines that are unbound. We also see that there is a higher degree of variation across countries of average and median bound tariff rates than for average and median MFN tariff rates, but within countries, there appears to be a higher degree of variation (as measured by the ratio of the standard deviation to the mean) of MFN tariff rates than of bound tariff rates. These summary statistics merely present an overall picture of the cross sectional tariff data; in order to compare the degree of variation in applied tariffs to the variation in uncertainty measure exhibited across products by each importer, Figure 2.3 depicts the

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[13]Note that in the analysis presented in section 2.7, unbound lines have been assigned the maximum uncertainty measure of $U_{tiv} = 1$ (which would be the limit of the uncertainty measure as $\tau_{tiv}^{B} \to \infty$), however the robustness of the results to different treatment of unbound lines (including dropping them from the analysis) is discussed in section 2.8.

Figure 2.1: Applied Tariff Summary Statistics
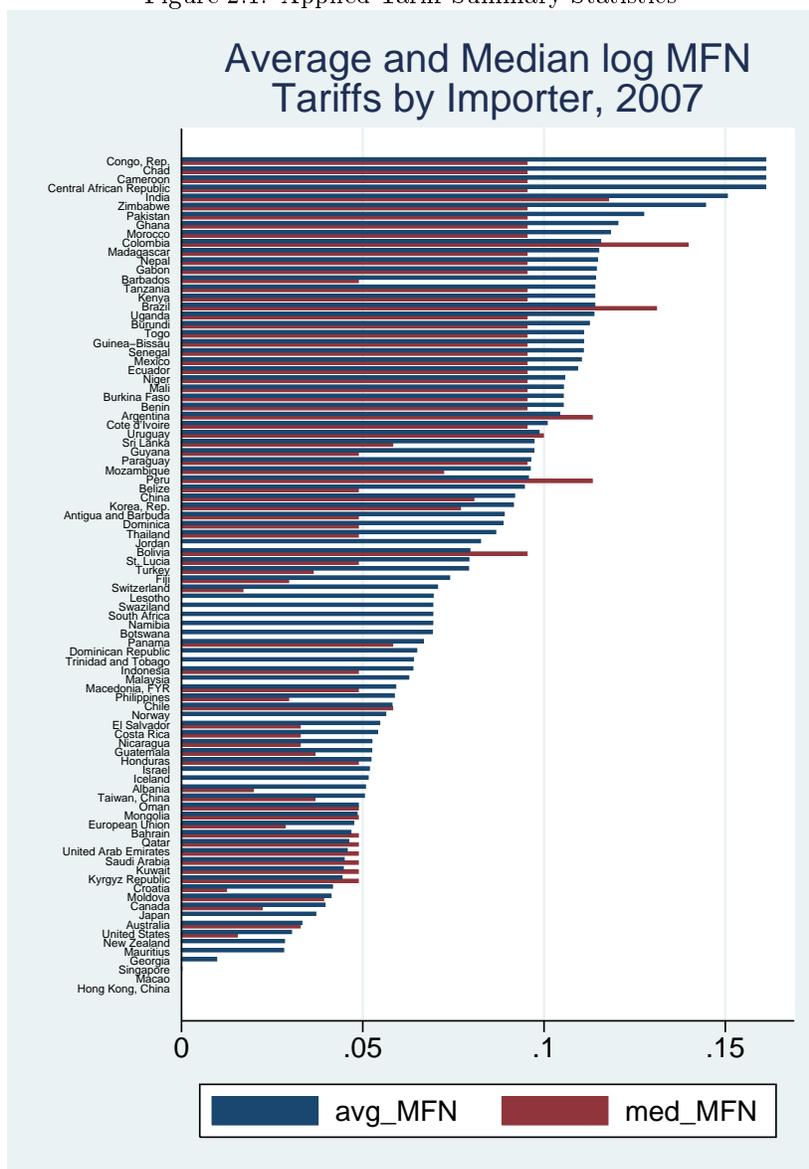
Figure 2.2: Tariff Uncertainty Summary Statistics
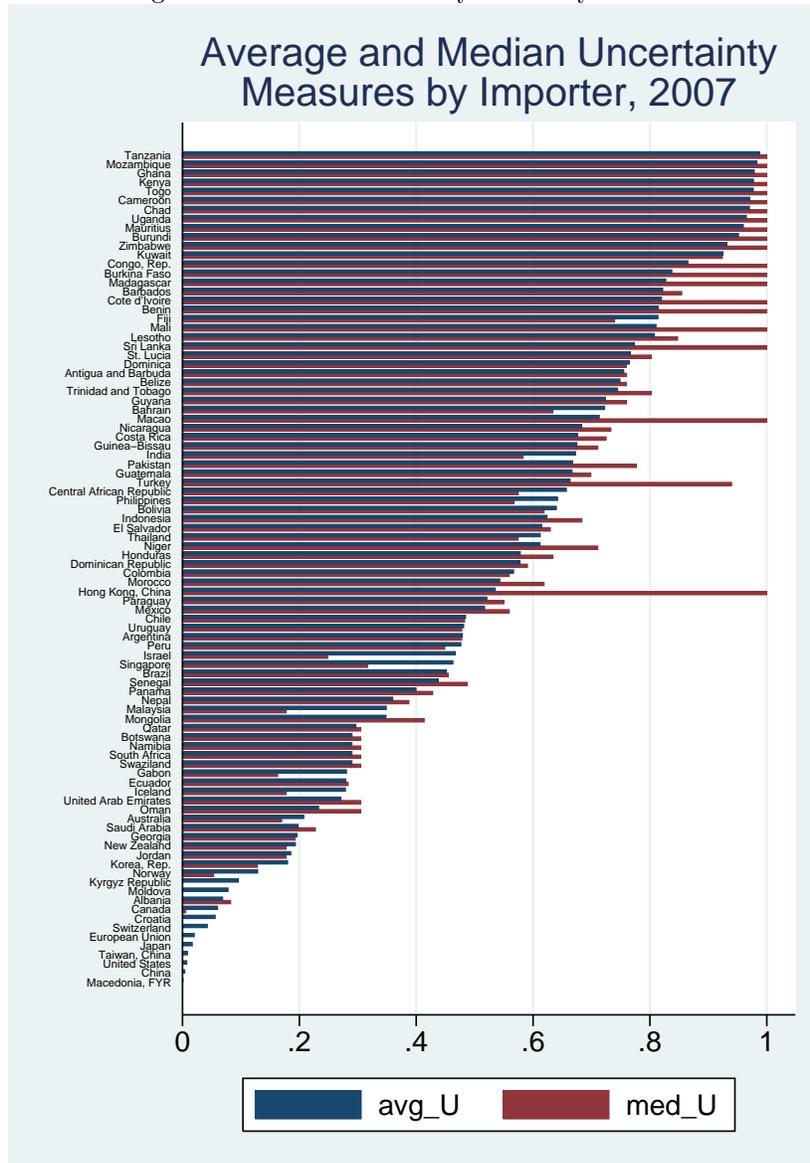
Table 2.2: Tariff Summary Statistics

| Statistic at Country Level | Mean (across Countries) | Median (across Countries) | Std Dev (across countries) |
|---|---|---|---|
| No. of Products[a] | 5083 | 5052 | 107.4 |
| Share of Lines Unbound[a] | 20.8% | 0.6% | 31.5% |
| Mean MFN Tariff | 0.078 | 0.077 | 0.039 |
| Median MFN Tariff | 0.054 | 0.049 | 0.040 |
| Std Dev of MFN Tariff | 0.068 | 0.062 | 0.034 |
| Mean Bound Tariff | 0.279 | 0.263 | 0.193 |
| Median Bound Tariff | 0.286 | 0.262 | 0.215 |
| Std Dev of Bound Tariff | 0.090 | 0.076 | 0.072 |
| Mean Uncertainty Measure | 0.525 | 0.572 | 0.302 |
| Median Uncertainty Measure | 0.548 | 0.574 | 0.347 |
| Std Dev of Uncertainty Measure | 0.176 | 0.146 | 0.107 |
| Share of Lines for which MFN exceeds Bound[a] | 3.9% | 0.4% | 8.8% |

a. The number of products and share of lines which are unbound or have MFN rates exceeding bound are all computed using the raw tariff data, that is, prior to dropping any observations. All other statistics in this table are computed on the umdrop-ub1 version of the data, that is, where lines with MFN exceeding Bound rates have been dropped and where the uncertainty measure for unbound lines has been set equal to 1, as this is the version of the data used in the baseline regressions.

Figure 2.3: Uncertainty vs. Tariff Coefficient of Variation



*Two outliers have been dropped from this graph to allow for a legible scale: Singapore, which has (cv_MFN = 58.98, cv_U = 0.81); and Macedonia, which has (cv_MFN = 1.18, cv_U = 12.38).

coefficients of variation (equal to the standard deviation divided by the mean) for applied tariffs and uncertainty measures for each importer. The fact that most importers lie below the 45 degree line in this figure indicates that most countries exhibit a higher degree of variation in MFN tariffs than for uncertainty measure, although I note that several of the exceptions to this are represented by countries which make up a large share of world trade (including the United States, the European Union, China, and Japan).

#### 2.6.1.4 Preferential Tariff Rates

In order to identify bilateral pairs for which the vast majority of applied tariff lines are MFN (rather than preferential) tariffs, indicators are created for each year at the importer-exporter-product level, indicating whether a preferential tariff rate exists, and then importer-exporter pairs are assigned a preference indicator equal to 1 whenever the share of HS6 lines for which a preferential tariff exists exceeds some cutoff, with the baseline cutoff being 25%, and cutoffs of 10% and 50% used to check the robustness of results to the cutoff level.[14] The

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[14]Depending on the source of the tariff data (either TRAINS or WTO-IDB), preferential tariffs may be identified in one of two ways. For TRAINS data, preferential tariffs are reported, and so a preference

table in Appendix A.3 lists, by exporter, the number of partners for whom the preference indicator is set to 1 in each year, using each possible cutoff value.

As a further check for the existence of preferential trade agreements (PTAs), the PTA database developed by Baier and Bergstrand (2007) is used to assign preference indicators to any bilateral pairs engaged in a Free Trade Agreement, Customs Union, Common Market, or Economic Union that may have been missed using the preferential tariff data as described in the preceding paragraph.[15] Then, in the baseline specification, importer-exporter pairs with a preference indicator equal to one will be excluded from the analysis.

## 2.7 Results

In this section, I present the results of the baseline specification, first implementing this as a pooled regression and then running separate regressions by importer. All results presented in this section are for the sample of countries identified as non-preferential partners according to the 25% cutoff and Baier Bergstrand data (see section 2.6.1.4), and, except where otherwise noted, is based on data for which products with MFN rates exceeding bound rates have been dropped and the uncertainty measure for unbound lines has been set equal to one.[16] Further, the regression is run after dropping observations within industry-bilateral pairs where either all products exhibit positive trade flows (that is, where $T_{ijv} = 1 \forall v \in I$) or no products exhibit positive trade flows (that is, where $T_{ijv} = 0 \forall v \in I$).[17] In all, this yields 4,344,637 observations at the importer-exporter-product level.

indicator is set to one for any importer-exporter-product for which such a tariff exists, even if the preferential tariff rate is equal to the MFN rate. For IDB data, preferential tariffs are not reported, however, "effective applied rates" are given at the bilateral product level, and will be different from the MFN rate whenever a preferential tariff (not equal to the MFN rate) exists. In the latter case, the existence of an effective applied rate unequal to the MFN rate is used as the criteria for assigning an indicator equal to 1 for a preferential tariff.

[15]This database is available on Jeffery Bergstrand's website, http://www.nd.edu/~jbergstr/#Links.

[16]All possible combinations of assigning uncertainty measures of 0, 1, or dropping observations with MFN > Bound, assigning uncertainty measures of 1 or dropping unbound lines, and cutoff values of 50% and 10% of HS6 lines exhibiting preferential tariffs in assigning preference indicators were implemented as well. The robustness of the results presented here to these different methods of dealing with such products is discussed in the following section.

[17]Leaving all such observations in, I still obtain significant point estimates of the expected sign for all coefficients, however, the magnitudes of these point estimates are biased down by the inclusion of these observations.

Table 2.3: Pooled Regression Results

| Coefficient and expected sign | Point Estimate† | Standard Error |
|---|---|---|
| $b_\tau$ (-) | -0.427*** | (0.0114) |
| $b_U$ (-) | -0.0914*** | (0.00243) |
| $b_{MFNPOS}$ (+) | 0.0999*** | (0.00166) |
| No. Obs. | | 4,307,329 |
| R-squared | | 0.239 |

†Significance at the 1% level is represented by ***, 5% is ** and 10% is *, using heteroskedastic-robust standard errors.

Table 2.4: Pooled Regression Results without Unbound Lines

| Coefficient and expected sign | Point Estimate† | Standard Error |
|---|---|---|
| $b_\tau$ (-) | -0.610*** | (0.0139) |
| $b_U$ (-) | -0.116*** | (0.00471) |
| $b_{MFNPOS}$ (+) | 0.110*** | (0.00177) |
| No. Obs. | | 3,452,925 |
| R-squared | | 0.240 |

†Significance at the 1% level is represented by ***, 5% is ** and 10% is *, using heteroskedastic-robust standard errors.

## 2.7.1   Pooled Regressions

As described in the previous sections, I first implement specification (2.14) on the pooled sample of all importer-exporter-product observations. That is, I run the following regression:

$$\Pr(T_{ijv} = 1) = b_0 + b_\tau \ln \tau_{iv} + b_U U_{iv} + b_{MFNPOS} MFNPOS_{iv} + d_{jiI}$$

Table 2.3 presents the results of this pooled regression. While pooling the observations together in this way assumes no heterogeneity in the marginal effects of tariffs and uncertainty across importers, it does allow me to compute overall point estimates for these effects.

These results are all significant (at the 1% level) and reflect the expected signs. While the robustness of the various results presented in this section is mainly left to the discussion below, I present here as well (in Table 2.4) the results obtained from the pooled regression after dropping all unbound lines (rather than setting the uncertainty measure equal to 1 for these lines), in order to check whether the significant effect of the uncertainty measure is due entirely to the uncertainty effect for unbound versus bound lines.

Comparing the results in Tables 2.3 and 2.4, we see that the point estimates for all three coefficients appear to be largely consistent across the two data treatments (although we do see a slight increase in the magnitude of the uncertainty effect when dropping unbound products, suggesting that assigning an uncertainty measure of 1 to unbound lines may be overstating the actual uncertainty for these products).

To interpret the magnitude of the coefficient estimates, recall that $b_\tau$ is the coefficient of the log of $\tau$ (where $\tau$ is 1 plus the ad valorem tariff). Thus, turning back to the results in Table 2.3, we can interpret the magnitude of the point estimate of $b_\tau$ to indicate that, an increase in $\tau$ of 1% (which would be about the same as a 1 percentage point increase in the ad-valorem tariff for tariffs near 0) would correspond to a decrease in the likelihood of the good being traded by 0.427 percentage points.[18] As for the uncertainty effect, again looking at the results in Table 2.3, $\hat{b}_U = -0.0914$ indicates that an increase in the uncertainty measure by one standard deviation (0.3599) would be expected to increase the probability of that good being traded by 3.3 percentage points. Keep in mind that although I estimate a linear probability model, thus assuming a linear effect of the uncertainty measure, this comes from using a linear approximation around $\gamma = 0$ (see equation 2.12) to obtain the applied specifications. As $\gamma$ increases, this approximation becomes less accurate, and in fact, we know from the true theoretical model that for $\gamma > 0$, the relationship between the probability of trade and the uncertainty measure is non-linear and concave in $U$ (see the left hand equation in 2.12).

Similarly, the results of the regression using the subset of data for which all product lines have bound rates specified, the coefficient estimates in table 2.4 indicate that a 1% increase in $\tau$ would correspond to a decrease in the probability of a good being traded by 0.61 percentage points while an increase in the uncertainty measure by one standard deviation (0.2987 for this subset of the data) would correspond to a decrease in the probability of the

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[18]In interpreting these coefficients, it is important to remember that the sample includes only products for the given importer-exporter-industry contains some products that are traded and some that are not. Thus, this prediction about the effect of a change in tariffs (or uncertainty measures) applies only to such products.

Table 2.5: By-Importer Regression Results

| Coefficient | % estimates neg | % estimates neg and sig* | % estimates pos | % estimates pos and sig* | Average Value | Average Value over sig estimates* | Median Value | Median Value over sig estimates* | Std Dev | Std Dev of sig estimates* |
|---|---|---|---|---|---|---|---|---|---|---|
| $b_\tau$ | 70.3 | 59.3 | 26.4 | 14.3 | -1.3 | -2 | -0.557 | -0.685 | 11.3 | 12.7 |
| $b_{MFNPOS}$ | 17.6 | 7.7 | 76.9 | 70.3 | 0.156 | 0.192 | 0.118 | 0.127 | 0.765 | 0.838 |
| $b_U$ | 69.2 | 54.9 | 30.8 | 19.8 | 1 | -0.0836 | -0.0995 | -0.117 | 10.2 | 0.364 |
| $b_\tau$ AND $b_U$ | 49.5 | 35.2 | 9.9 | 5.5 | | | | | | |
| R-squared | | | | | 0.218 | | 0.226 | | | |
| No. importers = 91 | | | | | | | | | | |

*Significance is at the 5% level, using heteroskedastic-robust standard errors.

good being traded by 3.5 percentage points.

To compare the relative magnitudes of the impact of a change in applied tariff versus a change in the uncertainty measure, I note that for a product with mean (across countries of country-level means) uncertainty measure 0.525, the reduction in probability of this good being traded due to uncertainty is equivalent to that which would be implied by a tariff of 11.2% ($=.525 * \frac{\hat{\beta}_U}{\hat{\beta}_\tau}$). In other words, the ad valorem tariff equivalent of the uncertainty imposed by binding overhang and unbound tariffs is 11.2% on average, based on the results of the pooled regression. Using the point estimates from the specification in which unbound tariff lines are dropped, we get that the ad valorem equivalent of the uncertainty imposed by binding overhang is equal to 8.2% ($=.429 * \frac{\hat{\beta}_U}{\hat{\beta}_\tau}$).[19]

## 2.7.2 Regressions By Importer

In addition to the regression on the pooled sample, I run an analogous regression separately for each importer. That is, the following regression is implemented for each importer $i$:

$$\Pr(T_{ijv} = 1) = b_{0,i} + b_{\tau,i} \ln \tau_{iv} + b_{U,i} U_{iv} + b_{MFNPOS,i} MFNPOS_{iv} + d_{jiI} \quad (2.17)$$

### 2.7.2.1 Summary

The results of the importer-specific estimates are summarized in Table 2.5.

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[19] In this calculation .429 is used as the average uncertainty measure rather than .525 as the latter was computed across all tariff lines setting the uncertainty measure equal to 1 for unbound lines while the former is the average uncertainty measure across only bound lines.

Overall, the by-importer regression estimates reflect the expected signs and reinforce the results of the pooled regression. From columns 2-5 of Table 2.5, we see that for all three coefficient estimates of explanatory variables, a majority of the by-importer regressions yield estimates which are significant with the expected sign.[20] The percentage of importers for which $b_\tau$ and $b_U$ are either both negative (and significant) or both positive (and significant) is also presented. We see that although 70.3% of importers yield a negative estimate for $b_\tau$ and 69.2% yield a negative estimate for $b_U$, these are not the same set of importers, as only 49.5% of importers yield negative estimates for both coefficients. Still, this is much greater than the share with positive estimates for both (9.9%), and there are 35.2% of importers which yield negative and significant coefficients for both $b_\tau$ and $b_U$, while only 5.5% yield positive significant estimates for both. At the same time, it is clear that the expected results are not obtained for all importers, and that the results of the pooled regression do in fact mask a fair amount of heterogeneity in effects across importers. This heterogeneity is also evident in looking at the standard deviation of these point estimates across importers (standard deviations across all regressions and across those for which the point estimate is significant are given in Columns 10 and 11 respectively of Table 2.5), which are larger (for all estimated coefficients) in magnitude than the coefficient mean.

Columns 6-9 of Tables (2.5) give the mean and median of the point estimates across all importers, as well as across the subset of point estimates which are significant at the 5% level in order to give some sense of the magnitude of these coefficient estimates. The median significant point estimate of -0.685 for $b_\tau$ indicates that for this median exporter, an increase in $\tau$ of 1% (which would be about the same as a 1 percentage point increase in the ad-valorem tariff for tariffs near 0) would correspond to a decrease in the likelihood of the good being traded by .685 percentage points. As for the uncertainty effect, again looking at the median significant point estimate, $b_U = -0.117$ indicates that for this median exporter,

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[20]The statistics presented here use a significance definition at the 5% level, however the patterns described here are all robust to using either 1% or 10% significance levels. At each significance level, we still find a majority of importers reflecting significant results with the expected sign with one exception: the percent of importers with negative and significant estimates for $b_U$ where significance is at the 1% level is only 44%, that is, not the majority, however this is still a much larger share than that for which this estimate is positive and significant (15.4%).

Figure 2.4: Distribution of point estimates
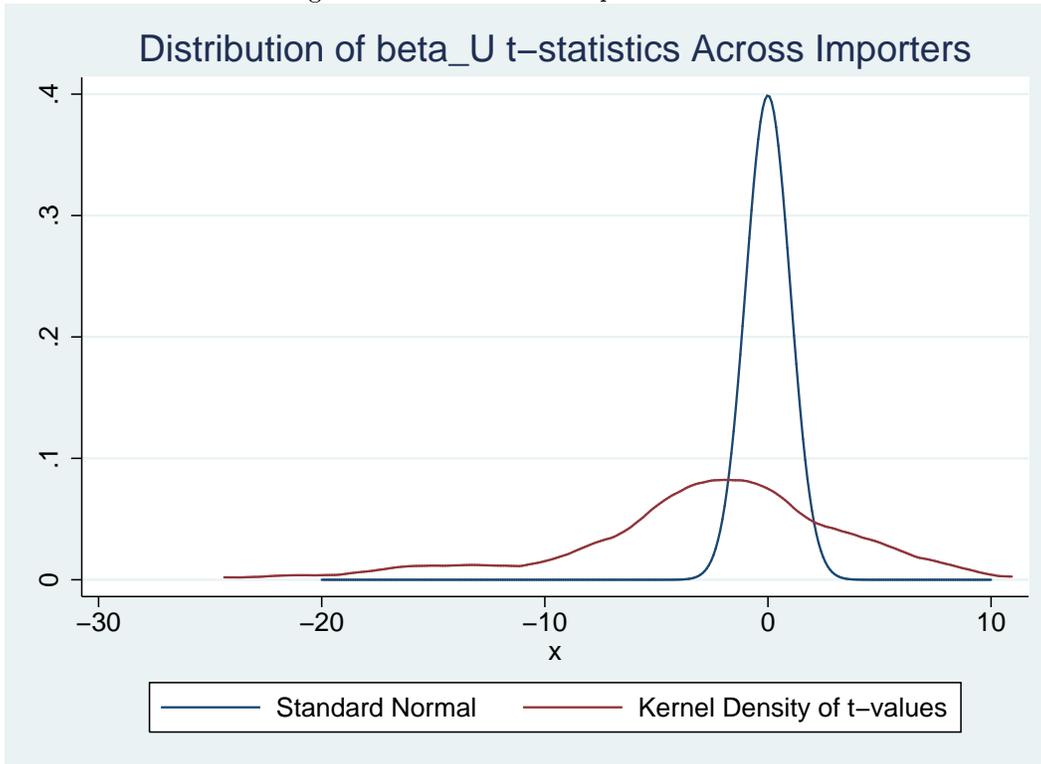


for a previously unbound tariff line (for which the uncertainty measure is set to 1) setting the bound rate at the applied rate would be expected to increase the probability of that good being traded by 11.7 percentage points. The magnitudes of these median significant coefficients are somewhat in line with the point estimates of the coefficients in the pooled regression (see Section 2.7.1), with this median estimate being larger than that from the pooled regression (by a factor of about 1.3 for $b_U$, and 1.6 for $b_\tau$).

In order to give a more complete picture of the distribution of point estimates for $\beta_U$ across importers, Figure 2.4 presents the kernel density function estimated from these normalized point estimates.

Overall, the by-importer regressions yield a majority of importers reflecting significant point estimates with the expected sign, however, they also indicate that there is fair amount of heterogeneity across importers in these effects. This heterogeneity is something that I may study and attempt to explain in future work, as discussed in Section 2.8.

Table 2.6: Australia Results

| | Baseline Data Treatment | Dropping Unbound Products |
|---|---|---|
| $b_\tau$ | -0.680*** | -0.485*** |
| | (0.159) | (0.163) |
| $b_U$ | -0.0604*** | -0.0690*** |
| | (0.0116) | (0.0169) |
| $b_{MFNPOS}$ | 0.211*** | 0.205*** |
| | (0.00906) | (0.00930) |
| | | |
| Observations | 116,235 | 111,951 |
| R-squared | 0.252 | 0.250 |

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

### 2.7.2.2   Select Importers

Due to the large number of countries, I do not include the full set of regression results for each importer as summarized in Table 2.5. Instead, I present here the results for a select few importers of interest.

First, I present the by-importer regression results where Australia is the importing country (Table 2.6) in order to compare these to the results of Handley (forthcoming, JIE), which focuses on the effect of binding overhang for exports to Australia. I include results from both the baseline treatment of the data (where products with MFN > bound rates are dropped and the uncertainty measure for unbound lines set to 1) as well as those obtained after dropping both products with MFN > bound rates and unbound products.

As in Handley (forthcoming, JIE), I find that the probability of a good being exported into Australia is positively correlated with a positive applied tariff, and is negatively impacted by the level of the applied tariff on the good as well as by level of uncertainty due to binding overhang. The underlying data used in his study is not identical to that used here; Handley (forthcoming, JIE) uses data from years 2004 and 2006 (pooling these together in one regression), while my data is for year 2007. Further, his data are at a more disaggregate level (10 digit), while mine are at the 6-digit level, implying that tariff rates used in my analysis may actually be averages of tariff rates applied at a higher level of disaggregation. Noting this, I compute the ratio of of the estimated coefficients $\frac{\hat{b}_U}{\hat{b}_\tau}$ obtained for Australia in my study, which is equal to 0.0889 in the baseline data treatment and 0.142 in the case

Table 2.7: Importers with no MFN variation

|  | Hong Kong | Macao |
|---|---|---|
| $b_U$ | -0.0868*** | -0.134*** |
|  | (0.00580) | (0.0138) |
| Observations | 110,716 | 38,336 |
| R-squared | 0.243 | 0.201 |

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

where unbound lines are dropped. The analogous ratio from the baseline regression in Handley (forthcoming, JIE) is 0.102, which is of the same order of magnitude as my estimates. Further, using the same methodology as above to write the ad valorem tariff equivalent of binding overhang uncertainty implied by these point estimates, I obtain that this AVE is 1.8% ($=.208 * \frac{\hat{b}_U}{\hat{b}_\tau}$) using the results of the baseline specification (presented in Table 2.6) and the average uncertainty measure for Australian imports in the case where unbound tariff lines are assigned an uncertainty measure of 1. In the case where unbound lines are dropped, this average uncertainty measure is .184 and so the implied AVE of uncertainty due only to binding overhang on tariff lines which are bound is given by $.184 * \frac{\hat{b}_U}{\hat{b}_\tau} = 2.6\%$. Performing the same calculation to obtain the AVE implied by the results and average uncertainty measure reported in Handley (forthcoming, JIE) yields an AVE for binding uncertainty of 2.1%, so my results match fairly well with this previous study.

I also present here the results of the by-importer regressions for two special cases that allow me to avoid any possible misspecification of how applied tariff levels enter in the decision to export. In 2007, Hong Kong and Macao have tariff schedules with an MFN tariff that is constant across all products (0% for all products in both cases). Though there is no variation in MFN rates for these countries, both exhibit variation in their uncertainty measures; only some products have tariff bindings (which are all bound at zero), while the unbound lines have uncertainty measures set to 1.

Table 2.7 presents the by-importer regression results for the importers whose tariff structures exhibit variation in the uncertainty measure but no variation in MFN tariffs. In both cases, we obtain a negative and significant point estimate for the impact of this uncertainty

on the probability of export. Noting that for these two importers, since all products have an uncertainty measure of either 0 (for lines bound at the MFN rate of 0) or 1 (for unbound lines), these point estimates of $b_U$ can be interpreted as the difference in probability of export between these two types of products. Specifically, for Hong Kong, these results would imply that for products within HS4 industries where some trade is observed with a given exporter, binding a previously unbound line at the MFN rate of 0% would increase the probability of trade of that good from the given exporter into Macao by 8.68 percentage points, while for Macao, it would increase this probability by 13.4 percentage points.[21]

### 2.7.3   Quantification

While the results presented above include some discussion of the relative magnitudes of the effects of applied tariffs versus that of uncertainty on entry into a given export market, it is not obvious how big of an overall impact changes in applied or bound tariffs would be expected to have on trade flows. To quantify this, we need to know not only the marginal effect of a tariff or uncertainty reduction on trade flows for each importer, but also the initial tariff structure in the import market being considered. Given this, one can then use the point estimates from the above regressions to quantify how much new entry into exporting one would expect to occur following a given policy change. In this section, I perform exactly this exercise for each bilateral pair, for each of the following three policy shock scenarios implemented in the importing country:

1. All applied (MFN) tariff rates are reduced to zero; bound tariffs remain in place;

2. All applied (MFN) tariff rates remain in place; bound tariffs are reduced to equal the applied rate;

3. All applied and bound tariffs are reduced to zero.

---

[21]I note here that these two import markets are also special cases in that many imports to Macao and Hong Kong are then re-exported to China, so that the incentives of firms exporting to these destinations may be different from those exporting to final destination countries.

Using the point estimates of the by-importer regressions summarized in Section 2.7.2, I compute, at the bilateral level, the number of new products for which we would expect to observe positive trade flows following such a policy change, where this number is defined as the sum over all included products of the predicted change in probability of trade.[22] Figure 2.5 shows the mean (across exporters) percent increase in number of products exported to each importer following each of the above three policy scenarios.[23] While this gives some sense of relative potential effect of tariff policy changes across importers, it is the case that some of these predictions are based on point estimates from the by-importer regressions which are not significant. Thus, Figure 2.6 shows these mean predicted increases only for importers for whom the point estimates for applied tariffs and the uncertainty measure were both significant (at the 5% level, see Table A.3 in Appendix A.4). Due to the fact that most importers with significant point estimates have estimates with the expected sign (see Section 2.7.2), we see that for most importers, each of the three policy changes results in a prediction of an increase in goods exported to these markets and that this increase caused by setting all MFN tariffs to zero is further increased by also reducing the bound rates to zero.[24] A casual comparison between the ranking of importers in Figures 2.5 and 2.6 and that in Figures 2.1 and 2.2 seems to indicate that this ranking is driven not just by initial tariff structure in importing countries, but that the heterogeneous marginal effects of tariffs and uncertainty across these importers plays a large role in determining which importers would see the largest changes in trade flows following such a policy change.

The estimated changes in the number of products traded following the above policy changes in this exercise come with two important caveats. First, the empirical specification

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[22]As with the sample for the regressions, this quantification exercise is done after dropping product-exporter-importer observations where it is the case that within the given hs4 industry-bilateral pair either all products are traded or all are not traded, as for these products, the tariff/uncertainty effects are not identified. Thus, for each importer, the increase in the number of products traded by each exporter is divided by the number of included products exported by this exporter in order to determine the percent increase in number of products traded for this bilateral pair.

[23]See Table A.3 in Appendix A.4 for by Importer summary statistics on the percent increase in products traded under each policy scenario for each exporter.

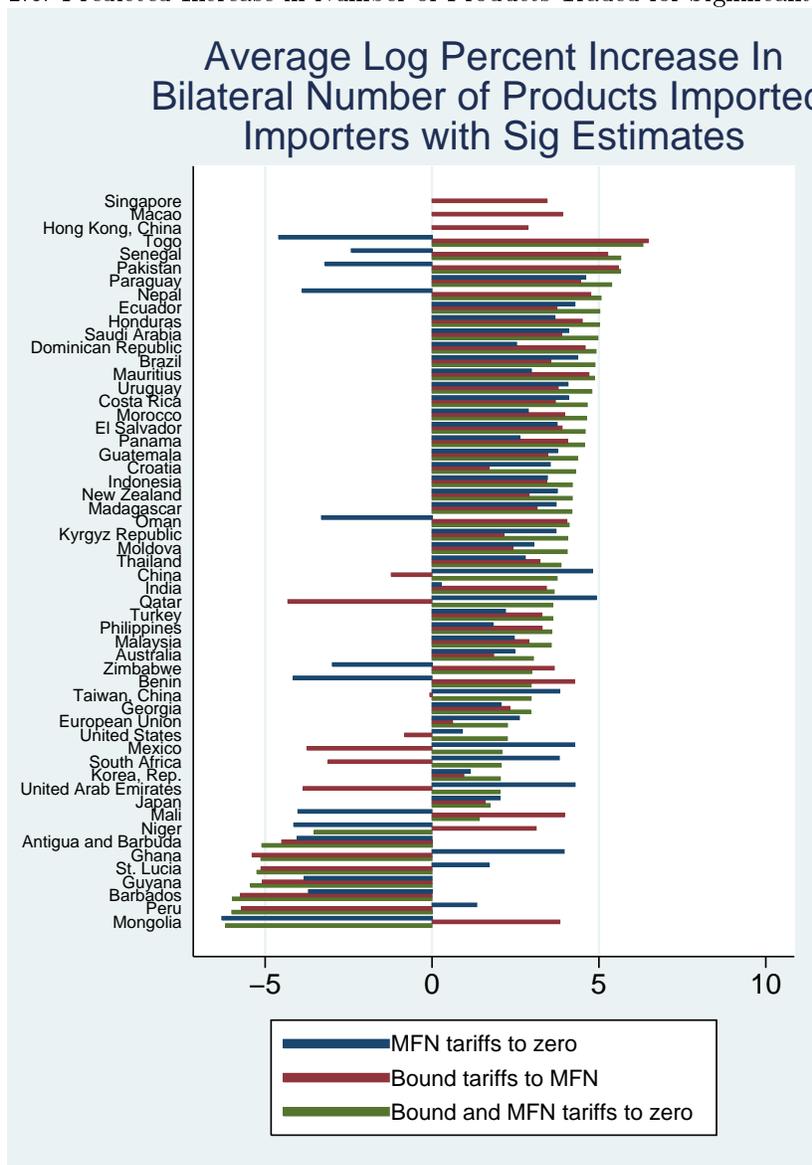[24]Note that even for importers with point estimates of the expected sign for all coefficients, we may observe a decrease in the average predicted number of products imported after setting all MFN rates to zero while leaving bound rates as is. This is possible when the effect of the increased uncertainty created by lowering these bound rates outweighs the direct effect of the lower applied rates.

Figure 2.5: Predicted Increase in Number of Products Traded
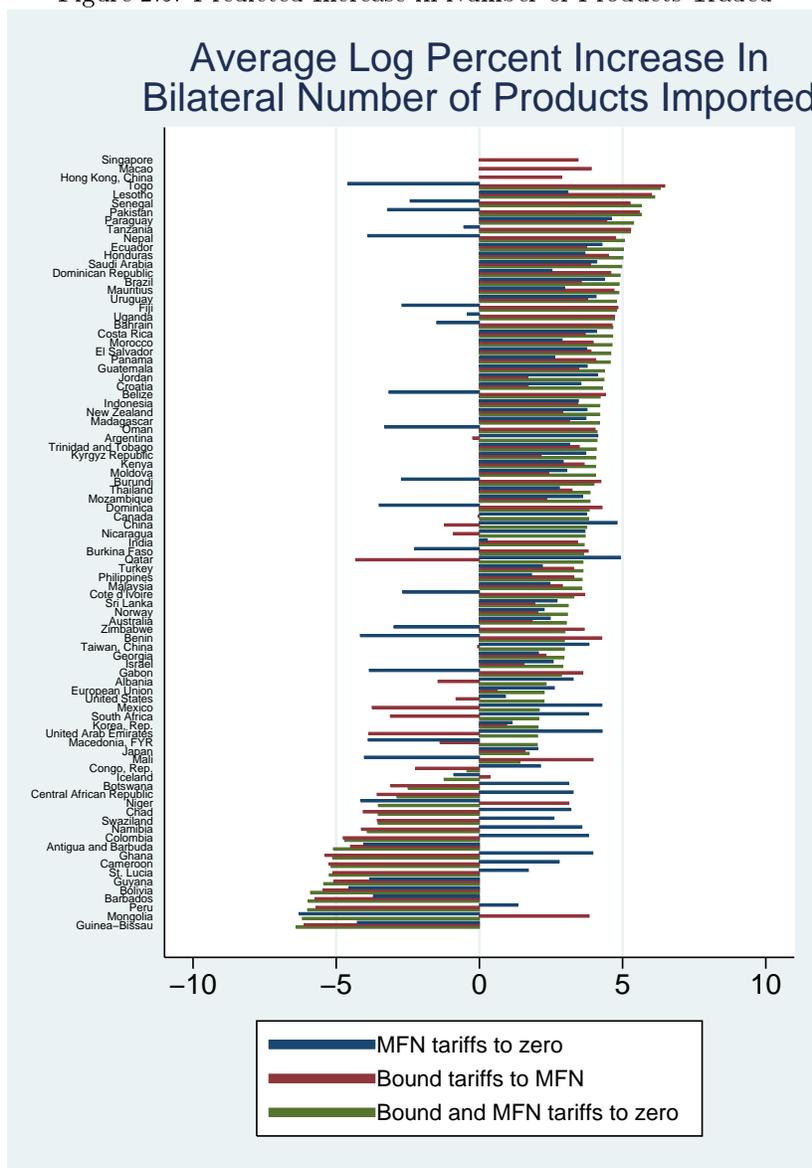


*Note: Kuwait and Chile have been dropped from this graph they are extreme outliers (with a predicted 40680% decrease and 3703% increase respectively in the number of products traded under policy scenario 3) and render the scale unreadable.

Figure 2.6: Predicted Increase in Number of Products Traded for Significant Results



Average Log Percent Increase In
Bilateral Number of Products Imported
Importers with Sig Estimates

MFN tariffs to zero
Bound tariffs to MFN
Bound and MFN tariffs to zero

from which the estimated effects of applied and bound tariff rates comes is based on a partial equilibrium theoretical model. In reality, if all exporters into a given import market face reduced tariffs and/or uncertainty, competition in this market would increase, thus offsetting some of the positive effects on exporting for each individual exporter. Second, to take the results of this quantification exercise literally, we must assume that the empirical specification does not suffer from omitted variable bias. In reality, the uncertainty measure arising from the gap between applied and bound tariff rates may be proxying for other types of uncertainty as well; for example, I would expect that products with a high degree of tariff uncertainty due to political economy pressures from domestic lobbies to maintain high bound rates might also be subject to a great deal of uncertainty on the application of other protectionist measures, such as antidumping duties. Thus, the estimate of the number of new products traded due to a reduction in uncertainty implied by a reduction in bound tariff rates should be interpreted more accurately as the number of new products that I would expect to be traded in the event that *all* uncertainty correlated with the binding overhang uncertainty were removed from that product. In other words, reducing the bound tariff rate to the applied rate may not result in as large an increase in trade as implied by this exercise if other forms of trade policy uncertainty persist.

## 2.8    Discussion

In this section I address the sensitivity of my results to various assumptions and data treatments.

### 2.8.1    Alternative Data Treatments

Recall that in the baseline data treatment on which the results presented above are based, products for which the MFN exceeded the bound rate were dropped, the uncertainty measure for products with no bound rate was set to one, and the preference indicator was defined according to a 25% (of product lines with preferences) cutoff (further supplemented by

the PTAs identified in the Baier Bergstrand dataset). In order to check the robustness of these results to alternative methods of dealing with MFN rates exceeding bound rates, unbound lines, and alternative preference cutoffs, I re-run both the pooled and the by-importer regressions under several different treatments of the data. A detailed description of these alternative data treatments as well as a table summarizing the output of each regression are contained in Appendix A.4.

Overall, the results presented in Section 2.7 appear to be robust to the alternative data treatments, with the exception of the way products with MFN rates exceeding bound rates are handled. Namely, we see strong support for the model prediction that the uncertainty arising from the gap between bound and applied tariffs rates for a given importer-product has a negative and significant impact on the probability of that good being exported into that market for various data treatments, except for the case when products with MFN rates exceeding bound rates are assigned an uncertainty measure of 1. Given the discussion of possible reasons for the existence of such lines in Section 2.6.1.1, however, it seems that the most reasonable way of dealing with such lines ex-ante would be to either drop them, or set the uncertainty measure to zero, as the reason for which the MFN tariff exceeds the bound rate seems to be due to gradual implementation. In the cases where these lines are either dropped or assigned an uncertainty measure equal to zero, we do see the expected results. It is however somewhat surprising that the treatment of such lines has such a substantial impact on the results, given the small share of products for which this problem occurs in most importers (see Table 2.2).

Despite this overall effect observed in the pooled regressions, the by-importer regressions reveal a great degree of heterogeneity in this effect across importing countries. While there are more importing countries displaying the a significant negative impact of uncertainty than there are displaying a positive significant effect, there are importers in both categories. Such heterogeneity requires explanation, and is something that I aim to explore in future work. In particular, the current specification assumes a constant value for $\gamma$, the probability of the

arrival of a tariff shock in each period, across importers. In reality, there are many reasons to think that exporters may have expectations about the probability of tariff changes that differ across different importing markets. For example, political economy characteristics such as the institutional structure of government or the degree of influence exerted by lobbying groups may differ across importers. Additionally, past behavior of governments in altering tariff schedules is likely to shape the expectations of exporters about future tariff shocks. In future work, I plan to exploit variation in such political economy characteristics and historical tariff rates across importing countries to attempt to explain the heterogeneity observed here in the impact of binding overhang levels on the probability of export.

### 2.8.2 Alternative Specifications

In this section, I summarize and interpret the results of various specifications run on different subsamples of my data in testing for the effect of uncertainty due to binding overhang on the probability of export. The different dimensions along which I change the set-up are:

- The level of interaction between the dummy variables for importer, exporter, and industry: In the baseline specification given by (2.14), I include a dummy for each importer-exporter-industry, based on the assumption that fixed costs to export vary across bilateral pair-industry. If instead, I assume that these vary only across exporter-industry, the appropriate specification would include separate fixed effects at the level of the bilateral pair, and the exporter-industry as given in (2.15), that is, $\Pr(T_{ijv} = 1) = b_0 + b_\tau \ln \tau_{iv} + b_U U_{iv} + b_{MFNPOS} MFNPOS_{iv} + d1_{ij} + d2_{jI}$. Implementing this specification allows me to use variation in uncertainty measures across products and importers (within a given industry) in estimating the effect of this uncertainty, rather than just across products within a given importer-industry. Under this set-up, I no longer assume that there are fixed importer-exporter-industry effects, so that I no longer need to drop all observations that were excluded in the baseline set-up, but rather here only observations for which all products in a given exporter-industry are

Table 2.8: Pooled Regression Results, Various Specifications

| Coefficient and expected sign | Fully Interacted, Ind = HS4 | Fully Interacted, Ind = HS2 | Separate Interactions, Ind = HS4[††] | Separate Interactions, Ind = HS2[††] |
|---|---|---|---|---|
| $b_\tau$ (-) | -0.427*** | 0.0110*** | -0.0865*** | -0.0281*** |
| $b_U$ (-) | -0.0914*** | -0.0294*** | -0.00215*** | -0.00195*** |
| $b_{MFNPOS}$ (+) | 0.0999*** | 0.0267*** | 0.0102*** | 0.00904*** |
| No. Obs. | 4,307,329 | 13,893,512 | 28,620,297 | 48,774,542 |
| R-squared | 0.239 | 0.330 | ~0.37 | ~0.33 |

[†]Significance at the 1% level is represented by ***, 5% is ** and 10% is *, using heteroskedastic-robust standard errors.
[††]Standard errors for specifications where importer-exporter and exporter-industry fixed effects are included separately are computed using a bootstrap method with 50 iterations.

not traded (or all traded), that is, to EVERY possible import partner. This allows me to include far more observations than in the previous case, but also relies on this assumption that importer-exporter-industry effects are not present.

- The definition of "industry": In the results presented above, industry is defined at the HS4 level, yielding 1255 industries. Here, I implement the same specifications described above with industry defined at the HS2 level, yielding 97 industries.

The results of the four possible combinations of interaction level and industry definition are presented in Table 2.8.

We see here that in each specification, the point estimates of all explanatory variables are significant and of the expected sign, with the exception of the coefficient for $\log \tau$ in the case with fully interacted dummies when industry is defined at the HS2 level, in which case this coefficient is significant and positive. One possible explanation for this difference (in the fully interacted specifications) is the fact that at the HS2 level, for a given exporter-importer, products may actually be complements rather than substitutes, while they are more generally substitutes at the HS4 level. The fact that this discrepancy does not occur for the HS2 definition in the case where importer-exporter and exporter-industry effects are included separately indicates that any within importer effects going in the opposite of the expected direction for applied tariff are outweighed by the between importer effects going in the expected (negative) direction. Another possibility is that this unexpectedly positive

Table 2.9: Ad Valorem Equivalent of Binding Overhang

| Fully Interacted, Ind = HS4 | Separate Interactions, Ind = HS4 | Separate Interactions, Ind = HS2 |
|---|---|---|
| 11.2% | 1.3% | 3.5% |

effect of applied tariffs on trade for the fully interacted case when industry = HS2 only occurs for certain types of products, which is explored below.

Based on the estimates in Table 2.8 above, Table 2.9 presents the ad valorem equivalent tariff rate imposed on average by uncertainty from binding overhang. I do not include here calculations for the fully interacted dummy specification with industry at the HS2 level (results for which are given in Table 2.8) as the point estimate on log tau in this case in positive (thus the ad valorem equivalent of the effect of uncertainty implied by these estimates would be positive).

Clearly, the specifications that include separate fixed effects for importer-exporter and exporter-industry (columns 2 and 3 of Table 2.9, which represent these results using industry defined at the HS4 and HS2 level respectively) yield estimates indicating a smaller magnitude of the effect of both applied tariffs and uncertainty on the probability of trade, as well as a smaller effect of uncertainty relative to that of applied tariffs. This difference may be due to the different sample of observations included in each case (that is, in the fully interacted case, column 1, I include only observations where there is variation in trade/no trade within importer-exporter-industry, thus these results may reflect a stronger effect of tariffs and uncertainty for such products relative to those where either all products or no products are traded for the particular importer-exporter-industry).

To make this point more clearly, consider the variation being captured in the specification where only importer-exporter and exporter-industry effects are included (in the case where industry = HS4, this specification corresponds to column 2 of Table 2.9). For a given exporter, this specification measures the effect of uncertainty (as well as of applied tariffs) using variation across products within a given industry both within a given importer, as

well as across importers. Now, consider an HS4 category in which country B exports at least some products, but does not export any to country A. For the specification in column 1, all observations for this HS4 category where country B is exporter will be dropped from the sample. The specification in column 2, however, adds these observations back in. What is their effect on the point estimate for uncertainty (and of applied tariffs)? Since there may be variation in the uncertainty measures (and tariffs) across these products for country A, but since no positive trade is observed for these products from country B to A, the effect of including these observations must necessarily reduce (in absolute value) the point estimate of uncertainty (and tariffs). Similarly, consider another set of observations which were excluded from the column 1 specification: where all products in a given HS4 category exhibit positive trade flows from country B to A. Again, under the column 1 specification, all products in this HS4 category with exporter = country B are thrown out of the sample. By adding them back in for the column 2 specification, we again necessarily obtain a smaller estimate of the effect of uncertainty (and tariffs), since again, these products in market A may exhibit variation in uncertainty measures and applied tariffs, but no variation is observed for this country-pair-HS4 in trade flows.

Of course, the assumptions in implementing the specification in column 2 are that a lack of variation in trade flows for a given importer-exporter-HS4, despite a variation in uncertainty across these observations, indicates a lack of uncertainty effect, and therefore that my point estimate should be reduced (relative to column 1). However, this specification, though controlling for importer-exporter effects, does not control for importer-HS4 effects, and therefore may be failing to capture the true reason for no trade (or all products traded) within a given importer-exporter-HS4. That is, there may be some characteristic of the relationship between the given importer-exporter for that particular HS4 which is not related to tariff uncertainty, but which explains the zero (or all positive) trade flows in that industry for the country pair. In other words, one might say that this industry is not "marginal" for that country pair in the sense that changes in uncertainty will not affect the

Table 2.10: Summary of Results

| | Fully Interacted | | Imp-Exp; Exp-Ind[††] | | Imp-Exp; Exp-Ind; fully interacted sample[††] | |
|---|---|---|---|---|---|---|
| | HS2 | HS4 | HS2 | HS4 | HS2 | HS4 |
| $b_\tau$ | 0.0110*** | -0.427*** | -0.0281*** | -0.0865*** | -0.0865*** | -0.267*** |
| $b_U$ | -0.0294*** | -0.0914*** | -0.00195*** | -0.00215*** | -0.0135*** | -0.0208*** |
| $b_{MFNPOS}$ | 0.0267*** | 0.0999*** | 0.00904*** | 0.0102*** | 0.0278*** | 0.0393*** |

Significance at the 1% level is represented by ***, 5% is ** and 10% is *, using heteroskedastic-robust standard errors.
[††]Significance inferred using a bootstrap method with 50 iterations.

probability of trade, due to the existence of some other factor preventing trade from being observed (or causing all products to be traded) for that particular industry and country pair. One possible way to deal with this would be to eliminate observations belonging to countrypair-industries which are not "marginal", that is, to drop observations where either all products or no products for the given importer-exporter-HS4 are traded. Indeed, by doing so, I implement the specification with importer-exporter and exporter-industry fixed effects included separately on the same sample of data that was used in the fully interacted importer-exporter-industry specification. Table 2.10 shows that indeed, by dropping observations from these importer-exporter-industries where either all products or no products are traded, we see stronger effect of both tariffs and uncertainty. Using these point estimates to compute the ad valorem equivalent of uncertainty associated with binding overhang (as presented in Table 2.9), we obtain that in the specification with separate import-exporter and exporter-HS4 fixed effects this ad valorem equivalent is 4.1% while in the case of the separate importer-exporter and exporter-HS2 fixed effects, the implied AVE of uncertainty is 8.2%. Thus, the observations included appear to account at least partly for the difference in magnitude of coefficients between the two types of specifications (although not for the finding of a positive effect of applied tariffs in the case of the fully interacted specification with industry = HS2).

In addition to the specifications above, I also check whether the effects of each explanatory variable are specific to product type by level of differentiation, separating products into

Table 2.11: Summary of Results by Rauch classification

| | Fully Interacted | | Imp-Exp; Exp-Ind | |
|---|---|---|---|---|
| | HS2 | HS4 | HS2 | HS4 |
| h_logtau | 0.0162*** | -0.333*** | -0.00787*** | -0.0418*** |
| n_logtau | -0.0304*** | -0.431*** | -0.0493*** | -0.111*** |
| h_UM | -0.0144*** | -0.0419*** | 0.012*** | 0.018*** |
| n_UM | -0.0254*** | -0.104*** | -0.00781*** | -0.0112*** |
| h_MFNpos | 0.0158*** | 0.0698*** | 0.00711*** | 0.00939*** |
| n_MFNpos | 0.0343*** | 0.114*** | 0.0104*** | 0.00989*** |
| n | 0.0303*** | 0.0267*** | 0.021*** | 0.0241*** |
| F-stats | | | | |
| h_logtau=n_logtau | 0 | 0 | | |
| h_UM=n_UM | 0 | 1.16e-06 | | |
| h_MFNpos=n_MFNpos | 0 | 0 | | |
| from specifications not allowing heterogeneous effects of explanatory vars: | | | | |
| b_log_tau | 0.0110*** | -0.427*** | -0.0281*** | -0.0865*** |
| b_U_M | -0.0294*** | -0.0914*** | -0.00195*** | -0.00215*** |
| b_MFN_pos | 0.0267*** | 0.0999*** | 0.00904*** | 0.0102*** |

homogeneous and differentiated categories based on the Rauch (1999) liberal classification scheme, and grouping Rauch's homogeneous and reference-priced goods into one category.[25] The above specifications are run using an assumed value of 4 for the elasticity of substitution between products, however, in identifying each HS6 line as either homogeneous or differentiated based on the classification provided by Rauch (1999), I now also use corrected elasticities of $\sigma_h = 3.2$, and $\sigma_n = 2.1$ based on the estimated median elasticity for each type of product in Broda and Weinstein (2006) for the liberal Rauch classification scheme. Table 2.11 presents the results of these specifications.

In general, the results of Table 2.11 seem to reflect significantly different estimates on all explanatory variables across product type (differentiated vs. not), with the results for differentiated products appearing to be stronger than for not differentiated (and in the non-fully interacted case, we also don't see the expected sign of uncertainty for the non-differentiated products).[26] One possibility for the different estimates is that exporters place different probabilities of reversion to bound tariff rates across the two product types. Another possibility

[25]Results presented here are qualitatively unaffected by using instead Rauch's "conservative" classification scheme.

[26]Note that, although not reported here, the 'anomalous' results of a positive estimate for tariffs in the fully interacted case goes away when we switch to the umdrop_ubdrop version of the data, that is, after dropping unbound lines from the analysis, rather than assigning them with the maximum uncertainty level of 1.

is that the estimates for non-differentiated products are biased towards zero due to the fact that these products are more likely to represent multiple firms, despite my assumption that there is one firm for each product. Thus, it may be the case that I am failing to capture action on the extensive margin (the decision of individual firms to enter the export market) more for these products when using the HS6 product definition to proxy for firms. To check if this is the case, I re-run the above specifications using import value (rather than the binary indicator for whether or not positive trade flows are observed) as my dependent variable. If the differences above are due to this differing number of firms for different products types, I would expect this difference in estimates to go away when looking at estimates of the effect of tariffs and uncertainty on the intensive margin (import value). The results of this (not presented here) do not provide much evidence for this hypothesis, as differences persist in estimates across the two product types. As a check for whether tariffs have tended to be more likely to increase (decrease) for one product type over another, thus lending plausibility to the idea that exporters place different probabilities of reversal to bindings on the two products types, I also analyze summary statistics (across countries) by product type of applied tariffs over the time period from 1996-2006, however, I do not find any significant differences between the two product types.

### 2.8.3 Explaining Heterogeneous Results Across Importers

Table 2.5 summarizes the results of the by-importer regressions and indicates that there is, in fact, heterogeneity across importers in these results. I have attempted to run second stage regressions on the point estimates for uncertainty from these regressions, as well as on indicators for whether or not the point estimates on applied tariffs and uncertainty were of the expected sign and significant at the 5% level in order to see if I could explain why some importers yield expected results while others do not. As the explanatory variables in this stage, I use summary statistics on the bound rate, average statistics on real interest rate and GDP of trading partners included in my sample, the number of these trading

partners, summary statistics on the number of industries per partner and risk indexes for political, economic and financial risk of the importing country. Thus far, I do not find any strong evidence suggesting that any of these factors can explain much of the variation in point estimates by importer, although there does seem to be weak evidence of a positive correlation between the average real interest rate of trading partners with probability of obtaining a negative significant estimate on the uncertainty measure as well as a negative correlation between this probability and the average bound rate of the importing country.

## 2.9 Conclusion

In this chapter, I have demonstrated that uncertainty arising from the gap between applied MFN tariffs and bound tariffs has a negative impact on exports and that this effect is present for multiple import markets. On average, I find that the ad valorem tariff equivalent imposed by uncertainty arising from binding overhang for the set of countries in my sample is 8.2%. I have further presented results indicating that the impact of binding overhang on the extensive margin of export differs across importers, however, am not currently able to explain this variation using various political and economic indexes for the importers and their trading partners.

# Chapter 3

# Trade Under the Threat of Tariff Hikes in General Equilibrium

## 3.1  Introduction

In the policy world, trade agreements are often evaluated using Computable General Equilibrium (CGE) models to simulate the effects of a particular trade policy shock. Generally, this is done by using estimates of price elasticities to simulate the effect of reducing applied tariffs as prescribed by the agreement in a general equilibrium framework. Recently, however, a strand of literature has been developed that examines a potential secondary effect of trade agreements; namely the reduction in policy uncertainty provided by such agreements. Due to the static nature of CGE models, this effect is generally not taken into account when modeling the impact of trade agreements, despite the fact that recent empirical evidence has shown that trade policy uncertainty can negatively impact a firm's entry decision into a given export market. Indeed, certain trade agreements may have no impact on applied tariff rates, while still reducing uncertainty over future applied tariffs for exporters. For example, multilateral negotiations in the WTO often include agreements on "bound" tariff rates which have no effect on applied tariff rates, but may well induce firms to enter an

export market where they have increased certainty that they will not be subjected to tariff spikes in the future. In order to evaluate the likely impact of a given trade policy agreement that takes this change in tariff expectations into account, it is necessary to build a dynamic model that is able to capture both the direct effect of applied tariff reduction and the effect of changes in tariff expectations in a general equilibrium setting. In this chapter, I extend theoretical analysis of tariff uncertainty in general equilibrium to a setting with endogenous entry not only into exporting but also into production with multiple countries and sectors. Based on this model, I obtain numerical results for the impacts of an (exogenous) threat of reverting to a permanent non-cooperative tariff level. In a symmetric two-country setting, the effects are a 4.55% reduction in trade and a 0.02% reduction in welfare. I am further able to derive the effect of a tariff threat on third-countries and outside sectors not directly targeted, and find these effects to be small.

## 3.2 Related Literature

This chapter is related to many studies modeling trade in a general equilibrium framework, though as mentioned above, typical CGE models do not include a stochastic component. It is also the case that CGE models tend to assume homogeneous firms, and therefore are not able to generate extensive margin effects of trade liberalization that have been identified as important by several empirical studies using a Melitz-type model. One exception to this is Zhai (2008) which introduces a Melitz framework with heterogeneous firms into a traditional CGE model and runs various simulations to demonstrate the additional welfare gains that may be obtained following a trade liberalization when allowing for effects through the extensive margin. Similarly, Balistreri and Rutherford (2012) develop a richer CGE model including firms heterogeneous in productivity, two factors of production and multiple industries, each of which may be modeled as either Armington, Krugman or Melitz. Arkolakis et al. (2009) investigate the theoretical implications for welfare effects of trade liberalization under various assumptions in such micro-founded models and provide condi-

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tions under which welfare implications depend on two sufficient statistics. Unlike the model presented here, however, these papers all present the results for a steady state equilibrium in a deterministic framework.

In regards to methodology, this chapter is more closely related to the strand of macro literature which simulates the effect of shocks in a DSGE framework. Alessandria and Choi (2012) attempt to infer the change in iceberg trade costs over time using US establishment data and their model's prediction that total amount exported relative to total sales among exporters is solely determined by iceberg costs. They create model with a heterogeneous firms, sunk costs of exporting, and uncertainty over both idiosyncratic productivity and fixed export costs, each of which is assumed to follow a Markov process. Another paper which develops a heterogeneous firms model in general equilibrium with uncertainty over idiosyncratic productivity is Impullitti et al. (2013), in which the authors allow for continuous time. Because the stochastic variables these models are idiosyncratic, one is able to define steady state aggregate variables which are not stochastic, which is not the case in my model, where I allow stochastic tariffs, which affect aggregate variables.

Another paper closely related to this chapter is Limão and Maggi (2013), which also explores the role of trade policy uncertainty in a general equilibrium framework. Unlike this chapter, however, their focus is primarily on the uncertainty-managing incentives to form trade agreements in an environment with underlying political economy (or economic) shocks. That is, in their model, they allow trade policy to be endogenous and explore the conditions under which an agreement maximizing joint welfare between contracting parties will reduce or increase trade policy uncertainty. In my case, I take trade policy (with a stochastic component) as exogenous and ask how the presence of the stochastic component affects endogenous variables of interest (such as utility, trade flows, etc.).

The underlying hypothesis behind constructing a model with tariff uncertainty is that this has an impact on exporter behavior. Recent empirical work provides several examples of studies that support this hypothesis while recent theoretical work provides mechanisms

through which this may occur. Evenett et al. (2004) provide some evidence of increased exports after WTO accession to developed countries in products with lower gaps between preferential and Most Favored Nation (MFN) tariff rates, though this evidence is somewhat mixed. Sala et al. (2009) develop a purely theoretical model, using heterogeneous firms and an option value approach, and show that a reduction in bound rates can move forward export time and that we see a larger effect for "high risk" destination markets. Handley and Limão (2012) find increased entry into the export market for Portuguese exporters as a result of the reduction in uncertainty from EC accession, and Handley (forthcoming, JIE) finds evidence that product level uncertainty negatively impacts the level and responsiveness of exports to applied tariff reductions for exports to Australia. Handley and Limão (2013) is perhaps most closely related to the model presented in this chapter as they examine the impact of uncertainty faced by Chinese exporters to the United States in a general equilibrium framework prior to the granting of Permanent Normal Trade Relations to China in 2001. They also provide estimates of the welfare impact of trade policy uncertainty in this context. Pierce and Schott (2014) provide further evidence that the reduction in tariff uncertainty for Chinese exporters to the United States following the granting of Permanent Normal Trade Relations to China in 2001 contributed to an increase in Chinese exports as well as a reduction in US manufacturing employment in sectors with larger reductions in tariff uncertainty.

The model I present here offers several extensions beyond what has been done in other general equilibrium frameworks. First, I allow for free entry of firms rather than assuming a fixed number of firms as is done in Handley and Limão (2013). This results in a model whose structure aligns more closely with standard CGE models used to evaluate trade agreements and allows us to understand the effects of tariff threats not only on the mass of exporters, but the number of producing firms in general equilibrium. Additionally, I am able to include arbitrarily many countries and differentiated goods industries in my model, rendering it a practical framework in which to study trade agreements which may affect trade in multiple

countries and/or industries. This also speaks to the added value of considering the effect of tariff threats in a general equilibrium as opposed to a partial equilibrium framework; while a given trade agreement may directly impact the tariffs and tariff uncertainty for a bilateral pair or regional group, in general equilibrium these tariffs/potential tariffs will affect the economies of all regions. My model allows one to quantify such effects not just for countries party to a particular agreement, but also effects on their trading partners. For example, while previous partial equilibrium or two-country general equilibrium models allow one to examine the effects of tariff uncertainty faced by China prior to joining the WTO, my model allows one to examine the effects of this tariff uncertainty on third country trading partners, such as Mexico.

## 3.3   Model

I model a world with $C \geq 2$ countries, $K$ differentiated goods industries and one industry which produces a homogenous good. In a multi-period framework with uncertain tariffs, in each period, producers of differentiated good $k$ in country $r$ decide whether or not to incur the one time sunk cost $f_{k,r,s}^{exp}$ required to begin exporting to market $s$. In this set-up, there are $K$ industries that produces differentiated goods (in all countries), and there is a continuum of differentiated goods within each industry. Consumers (in each country) have a constant elasticity of substitution between varieties, $\sigma$. Countries are indexed by $r$ or $s$, sector by $k$, and varieties by $\omega$.

### 3.3.1   Consumer Demand

It is assumed that in a given period, consumers in each region $r$ derive utility $U_r = q0_r^{\mu 0} \prod_k Q_{k,r}^{\mu_k}$ where $\mu 0 = 1 - \sum_k \mu_k$ based on a Cobb-Douglas utility function aggregating a homogenous numeraire good, $q0$ and CES aggregates of differentiated goods defined by the sub-utility function of imperfectly substitutable varieties:

$$Q_{k,r} = \left[ \sum_s \lambda_{k,s,r}^{\frac{1}{\sigma}} \int_{\Omega_{k,s,r}} q_{k,s,r}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}} \tag{3.1}$$

where $\Omega_{k,s,r}$ is the set of industry $k$ varieties produced in market $s$ available for purchase in market $r$ and $q_{s,r}(\omega)$ is the quantity consumed in $r$ of variety $\omega$ produced in $s$. Parameters $\lambda_{k,r,s}$ are preference share parameters to allow for non-symmetric preferences across domestic vs. foreign varieties.[1]

Maximizing the utility as defined in (3.1) subject to a budget constraint yields the Dixit-Stiglitz price index of differentiated goods sector $k$ in region $r$ (that is, the marginal price of $Q_{k,r}$)[2]:

$$P_{k,r} = \left[ \sum_s \lambda_{k,s,r} \int_{\Omega_{k,s,r,t}} (\tau_{k,s,r} p_{k,s,r}(\omega))^{1-\sigma} d\omega \right]^{1/(1-\sigma)} \tag{3.2}$$

Where $p_{k,s,r}(\omega)$ is the price received by the industry $k$, region $s$ firm producing variety $\omega$ and selling in market $r$. It is assumed that the consumer will pay this firm price times a factor $\tau_{k,s,r}$ for imported goods where $\tau$ represents 1 plus the ad valorem tariff (and it is assumed that $\tau_{k,r,r} = 1 \, \forall k$). Tariff revenue is paid to the government, which then redistributes all tariff revenue as a lump sum in each period to the population.

The compensated demand function for each domestic and foreign variety in each industry resulting from the maximizing utility is given by:

$$q_{k,r,s}(\omega) = \lambda_{k,r,s} Q_{k,s} \left( \frac{P_{k.s}}{\tau_{r,s} p_{k,r,s}(\omega)} \right)^\sigma \tag{3.3}$$

Because of the Cobb-Douglas utility assumption, expenditures $E_{k,r}$ on differentiated goods sector $k$ will be equal to a constant share of GDP (total expenditures in the economy):

$$E_{k,r} = \mu_k GDP_r$$

and aggregate quantity $Q_{k,r}$ can be thought of as the nominal expenditures in differentiated good sector $k$ deflated by the price index:

$$Q_{k,r} = \frac{E_{k,r}}{P_{k,r}} \tag{3.4}$$

---

[1]These parameters are included so that when applying the model to actual data, these can be calibrated to account for differing trade flows between partners which could not be accounted for in the price index $P_{k,r}$ in a model with more than two countries, as this would be fixed across bilateral pairs $(r, s)$. These preference parameters can alternatively be thought of as sector-bilateral pair specific iceberg trade costs such that for each amount $q_{k,s,r}(\omega)$ of variety $\omega$ purchased by some consumer in region $r$, only $\lambda_{k,s,r}^{\frac{1}{\sigma-1}} q_{k,s,r}(\omega)$ of the product is actually consumed (enters into the utility function).

[2]I assume that consumers are credit constrained and also do not allow for inter-temporal substitution by saving; they solve a static optimization problem in each period.

## 3.3.2 Supply

Turning to supply, I assume that the homogenous good is produced in each country with constant marginal product of labor, and is freely traded on world markets. I assume that each variety in a differentiated goods sector is produced using only one factor of production (labor) which has factor price $w_r$. Throughout the model, I will impose the assumption that the labor force in each country is sufficiently large that the homogenous good is produced in every country in equilibrium. This then fixes the wage in each country at $w_r = w_s$, regardless of the state of the economy, and taking the homogenous good as the numeraire, we have that $w_r = w_s = 1$. [3]

Prospective firms in an industry $k$, region $r$ face a sunk entry cost $f_{k,r}^{sunk}$ which much be paid to receive a productivity draw and begin production. Prospective firms observe the current period tariff before making their entry decision, and after paying the sunk cost, receive a random productivity draw $\varphi$ from distribution $G(\varphi)$ which determines their marginal cost of production, $w_r/\varphi$. After learning their (time invariant) productivity, the firm begins producing and sells in the domestic market. At the end of each period, the firm faces a $\delta$ probability of being hit by an exogenous death shock in which case it exits. If it survives until the next period, it can then choose to enter into export market $s$ by paying the sunk cost of exporting, $f_{k,r,s}^{exp}$. I assume no per-period fixed costs to sell in either the domestic or the export market (once the sunk cost has been paid) so that once firms have entered into production, they will always choose to sell in the domestic market, and once they have paid the sunk cost of exporting, they will continue to export for as long as they survive. Firms are monopolistically competitive, and so in any market where they choose to sell, they will charge the standard markup over marginal cost:

$$p_{k,r,s}(\varphi) = \frac{w_r}{\varphi} \left( \frac{\sigma}{\sigma - 1} \right) \tag{3.5}$$

where $\sigma$ is the constant elasticity of demand (equal to the elasticity of substitution between varieties).

---

[3]In the notation below, I retain the country specific subscript on $w$.

Gross profits for a firm with productivity $\varphi$ in sector $k$ are given by:

$$\begin{aligned}
\pi_{k,r}(\varphi) &= \sum_s \pi_{k,r.s}(\varphi) \\
&= \sum_s \frac{p_{k,r,s}(\varphi)q_{k,r,s}(\varphi)}{\sigma}
\end{aligned} \tag{3.6}$$

I define aggregate economic conditions faced by a sector $k$, country $r$ firm selling in market $s$ as

$$A_{k,r,s} \equiv \frac{1}{\sigma}\left[\left(\frac{\sigma}{\sigma-1}\right)w_r\right]^{1-\sigma}\lambda_{r,s}Q_{k,s}\left(\frac{P_{k,s}}{\tau_{k,r,s}}\right)^{\sigma}$$

so that the gross profits realized by a firm of productivity $\varphi$ in sector $k$ region $r$ are $\pi_{\varphi,k,r,r} = \varphi^{\sigma-1}A_{k,r,r}$ from domestic sales and $\pi_{\varphi,k,r,s} = \varphi^{\sigma-1}A_{k,r,s}$ from exports to country $s \neq r$, for firms sufficiently productive to export.

### 3.3.3  Tariff Process

I assume a simple tariff shock process that allows me to maintain a tractable model under the assumption of free entry. Bilateral tariffs applied to sector $k$ exports from country $s$ into country $r$ can take on only two values: $L_{k,s,r}$ or $H_{k,s,r}$, with $L_{k,s,r} \leq H_{k,s,r}$. In the initial period, tariffs are (and have always been) at $L_{k,s,r}$ in each country $r$. In each subsequent period for which tariffs have always been at $L$, there is a probability $\gamma$ that tariffs will go up to $H$. Once this happens, tariffs remain at level $H$ forever after.

The timing is as as follows: at the beginning of each period, there are $N_{k,r}$ firms in sector $k$, region $r$ who have already produced in the previous period and survived the death shock. The current period tariff is observed. Then, potential firms decide whether or not to incur the sunk entry cost and $NE_{k,r}$ new firms enter and can sell only in the domestic market for this period (they can begin exporting in the next period if they so choose). Then, the death shock arrives, killing a share $\delta$ of the $N_{k,r} + NE_{k,r}$ firms so that the state transition equation is: $N'_{k,r} = (1-\delta)(N_{k,r} + NE_{k,r})$.

I assume that prior to the arrival of the high tariff shock, the economy is in a steady state equilibrium (that is, all endogenous variables are the same in any state with low

tariffs), and so the number of firms in this state will be determined by the relationship $\frac{\delta}{(1-\delta)} N_{k,r} = NE_{k,r}$.

In this set-up, in each period the economy will be in one of the following discrete states $\zeta$: $L$ in the case that the high tariff shock has not arrived (so that tariffs are at level $L_{k,s,r}$ in country $r$ for sector $k$ goods imported from $s$), or $H^{(n)}$, $n \in 0, 1, \ldots$ where $H^{(0)}$ is the state in which the high tariff shock arrives, $H^{(1)}$ is the state the following period, etc. The state describes not only the current tariff level(s), but also the distribution and mass of firms who are present in the domestic and export markets. Because of the sunk cost to export, once a firm chooses to begin exporting, he will continue to do so even after a shock arrives that causes his profitability to fall below the profitability of the cutoff firm who is just indifferent between entering the export market or not. Thus, after the arrival of the high tariff shock, in state $H^{(0)}$, there may be exporters with productivity levels such that they would not choose to enter the export market under current conditions had they not already paid the sunk cost to export, but will continue to export in this and all future periods (until hit by the exogenous death shock); I refer to these as "legacy firms". I let $H^{det}$ refer to the steady state of the deterministic model with tariffs at level $H$ in all periods.

### 3.3.4 Preliminary Definitions

As will be shown in the following sections, in equilibrium in each state $\zeta$, there will exist a cutoff productivity $\varphi^c_{k.r.s}(\zeta)$ such that all sector $k$, country $r$ firms with $\varphi < \varphi^c_{k.r.s}(\zeta)$ will not choose to enter export market $s$, while firms with $\varphi \geq \varphi^c_{k.r.s}(\zeta)$ will want to enter into this export market. That is, I let $\varphi^c_{k.r.s}(L)$ be the cutoff productivity for a sector $k$, country $r$ firm to want to enter into export market $s$ when the state is $L$, and similarly I let $\varphi^c_{k,r,s}(H^{(n)})$ be the cutoff productivity for entering into this export market when the state is $H^{(n)}$.[4] Once the high tariff shock has arrived, legacy firms may remain, though a share $\delta$ of them will be killed in each subsequent period, and not replaced in the export market.

---

[4] Throughout the paper I maintain the assumption that the sunk cost to begin exporting in any market, $f^{exp}$, is sufficiently large that the lowest productivity firm will never choose to export.

Thus, once the high tariff shock arrives, in each subsequent period, conditions will change, and the cutoff productivity for exporting may depend on how many periods have passed since the high tariff shock was first realized. In order for the model to be tractable, I make the explicit assumption that any change in export cutoff for a given bilateral flow is either non-decreasing or non increasing in $n$, that is, I assume that for any sector $k$ and any pair of countries $r$ and $s$, it is either the case that $\varphi^c_{k,r,s}(H^{(n+1)}) \leq \varphi^c_{k,r,s}(H^{(n)}) \, \forall n = 0, 1, 2, \ldots$ or that $\varphi^c_{k,r,s}(H^{(n+1)}) \geq \varphi^c_{k,r,s}(H^{(n)}) \, \forall n = 0, 1, 2, \ldots$. Under the further assumption that the economy eventually reaches its long-term steady state equilibrium, it turns out to be the case that cutoff productivities in each high tariff state $H^{(n)}$ do not depend on $n$, that is

$$
\begin{aligned}
\varphi^c_{k,r,s}(H^{(n+1)}) &= \varphi^c_{k,r,s}(H^{(n)}) \\
&= \varphi^c_{k,r,s}(H^{det}) \\
&\equiv \varphi^c_{k,r,s}(H)
\end{aligned}
\tag{3.7}
$$

where $\varphi^c_{k,r,s}(H^{det})$ is the cutoff productivity to enter export market $s$ in a deterministic model where tariffs are at level $H$ in every period and the economy is in its steady state (see Appendix B.1 for proof of this result). Also shown in this appendix, as a corollary to this result, it will be the case that aggregate economic conditions, $A_{k,r,s}(H^{(n)})$ do not vary with $n$, and so I define $A_{k,r,s}(H) \equiv A_{k,r,s}(H^{(n)}) = A_{k,r,s}(H^{(n+1)}) = A_{k,r,s}(H^{det}) \, \forall n$.

In the limit as $n \to \infty$, the mass of legacy firms approaches zero and all endogenous variables $X$ approach their deterministic steady state level: $X(H^{(n+1)}) \to X(H^{det})$.

Under the above assumptions, each $k - r - s$ productivity cutoff to export in state $L$ versus that in state $H^{(n)}$ must be ranked in one of two ways: either

$$
\text{RANKING A}: \varphi^c_{k,r,s}(L) \quad \leq \quad \varphi^c_{k,r,s}(H)
$$

$$
\text{or} \tag{3.8}
$$

$$
\text{RANKING B}: \varphi^c_{k,r,s}(L) \quad > \quad \varphi^c_{k,r,s}(H)
$$

In a perfectly symmetric setup where the high tariff threat level is symmetric across all countries and there is only one differentiated goods industry, we will be in the first case for each country, that is, the arrival of a high tariff shock resulting in a high tariff that is the same in all countries will result in higher productivity cutoffs in all countries. As we will see below, however, in asymmetric settings (for example when the tariff shock affects only one bilateral tariff), it may be the case that the arrival of the tariff shock $H$ actually lowers the productivity cutoff to export in one of the regions. I let $1_{RankB_{k,r,s}}$ be a binary indicator equal to 1 if $\varphi_{k,r,s}^c(L) > \varphi_{k,r,s}^c(H)$ and zero otherwise.

Letting $F$ be the distribution from which productivity is drawn (which I will later assume to be Pareto) and assuming a lower bound of $b$ for the support of this distribution, I define the "average" domestic productivity of all producing firms in country $r$ as $\tilde{\varphi}_{k,r,r} = \left[ \int_b^\infty \varphi^{\sigma-1} dF(\varphi) \right]^{\frac{1}{\sigma-1}}$ which does not depend on the state since the distribution of firms remains constant over time with exit occurring only via the exogenous death shock. I also define the (state contingent) average export productivity for sector $k$ exporters[5] from $r$ to $s$ as:

$$\tilde{\varphi}_{k,r,s}(\zeta) = \left[ \frac{\int_{\varphi_{k,r,s}^c(\zeta)}^\infty \varphi^{\sigma-1} dF(\varphi)}{1 - F(\varphi_{k,r,s}^c(\zeta))} \right]^{\frac{1}{\sigma-1}} \tag{3.9}$$

Note that under the assumption that $\varphi$ follows a Pareto distribution with shape parameter $a$, it will be the case the average export productivity can be written as a constant multiple of the cutoff productivity in each state:

$$(\tilde{\varphi}_{k,r,s}(\zeta))^{\sigma-1} = \frac{a}{a+1-\sigma} \left( (\varphi_{k,r,s}^c(\zeta))^{\sigma-1} \right) \text{ for } \varphi \sim \text{ Pareto}$$

### 3.3.5 Value Functions and Entry

For a firm of productivity level $\varphi$ in sector $k$, region $r$, I let $V_{\varphi,k,r,s}(\zeta)$ be the present discounted value of selling in market $s$ in state $\zeta$, taking into account current and expected future profit flows from exporting from $r$ to $s$ (or selling domestically for $r = s$).

The value of being a sector $k$ region $r$ producer selling in region $s$ in each state for a

---

[5]Here, "exporters" means the set of firms above the productivity cutoff for exporting; it does not include legacy firms.

productivity $\varphi$ firm is then:

$$
\begin{aligned}
V_{\varphi,k,r,s}(L) &= \varphi^{\sigma-1}A_{k,r,s}(L) + (1-\delta)\left[(1-\gamma)V_{\varphi,k,r,s}(L) + \gamma V_{\varphi,k,r,s}(H^{(0)})\right] \\
\Rightarrow V_{\varphi,r,s}(L) &= \frac{\varphi^{\sigma-1}A_{k,r,s}(L) + (1-\delta)\gamma V_{\varphi,k,r,s}(H^{(0)})}{\delta + \gamma - \delta\gamma}
\end{aligned}
\tag{3.10}
$$

and

$$
\begin{aligned}
V_{\varphi,k,r,s}(H^{(n)}) &= \varphi^{\sigma-1}A_{k,r,s}(H^{(n)}) + (1-\delta)V_{\varphi,k,r,s}(H^{(n+1)}) \\
\Rightarrow V_{\varphi,k,r,s}(H^{(n)}) &= \sum_{i=n}^{\infty}(1-\delta)^{i-n}\varphi^{\sigma-1}A_{k,r,s}(H^{(i)}) = \varphi^{\sigma-1}\frac{A_{k,r,s}(H)}{\delta}
\end{aligned}
\tag{3.11}
$$

while the value of waiting to enter a given export market is:

$$
\begin{aligned}
V_{\varphi,k,r,s}^{wait}(L) &= (1-\delta)[(1-\gamma)\max\left[\left(V_{\varphi,k,r,s}(L) - w_r f_{r,s}^{exp}\right), V_{\varphi,k,r,s}^{wait}(L)\right] + \\
&\quad + \gamma\max\left[\left(V_{\varphi,k,r,s}(H^{(0)}) - w_r(H^{(0)})f_{k,r,s}^{exp}\right), V_{\varphi,k,r,s}^{wait}(H^{(0)})\right]]
\end{aligned}
\tag{3.12}
$$

and

$$
V_{\varphi,k,r,s}^{wait}(H^{(n)}) = (1-\delta)\max\left[\left(V_{\varphi,k,r,s}(H^{(n+1)}) - w_r f_{k,r,s}^{exp}\right), V_{\varphi,k,r,s}^{wait}(H^{(n+1)})\right]
\tag{3.13}
$$

For a given state $\zeta$, the value of entering into production for a firm who draws productivity $\varphi$ will be:

$$
\begin{aligned}
V_{\varphi,k,r}^{entry}(\zeta) = V_{\varphi,k,r,r}(\zeta) + (1-\delta)E_{\zeta'|\zeta}\Bigg[\sum_{s \neq r}1(\varphi \\
\geq \varphi_{k,r,s}^c(\zeta'))\left(V_{\varphi,k,r,s}(\zeta') - w_r f_{k,r,s}^{exp}\right) + 1(\varphi \\
< \varphi_{r,s}^c(\zeta'))V_{\varphi,k,r,s}^{wait}(\zeta')\Bigg]
\end{aligned}
\tag{3.14}
$$

and so the ex-ante (prior to drawing a productivity) value of entry for a prospective firm in sector $k$ region $r$ will be:

$$
V_{k,r}^{entry}(\zeta) = \int_{\varphi} V_{\varphi,k,r}^{entry}(\zeta)dF(\varphi)
\tag{3.15}
$$

I assume that the "death shock" applies equally to current and potential firms so that the same discount factor is used by all when discounting future periods. Then, the value of waiting to enter into production in a given state will be given by

$$V_{k,r}^{wait\,to\,enter}(\zeta) = 0 + (1-\delta)\max\left[\left(V_{k,r}^{entry}(\zeta') - w_r f_{k,r}^{sunk}\right), V_{k,r}^{wait\,to\,enter}(\zeta')\right] \quad (3.16)$$
$$= (1-\delta)\left[V_{k,r}^{wait\,to\,enter}(\zeta')\right]$$

where the final equality follows from the fact that in equilibrium, free entry implies that $V_{k,r}^{entry}(\zeta) - w_r f_{k,r}^{sunk} \leq V_{k,r}^{wait\,to\,enter}(\zeta) \,\forall \zeta$ (with strict inequality only in the case when the constraint $NE_{k,r}(\zeta) \geq 0$ is binding).[6] I make the assumption that no tariff shock is sufficiently large to cause the constraint $NE_{k,r}(\zeta) \geq 0$ to bind, so that in equilibrium, $V_{k,r}^{entry}(\zeta) - w_r f_{k,r}^{sunk} = V_{k,r}^{wait\,to\,enter}(\zeta)$. Writing out the expression for $V_{k,r}^{entry}(\zeta)$ and simplifying (see Appendix B.2 for details) we obtain the free entry condition determining the number of new entrants into sector $k$, region $r$ in state $L$ as:

$$\tilde{\varphi}_{k,r,r}^{\sigma-1}(L)A_{k,r,r}(L) + \sum_{s\neq r}\gamma\left(\delta + (1-\delta)(\gamma-1)\right)\left(\frac{M_{k,r,s}(H^{(0)})}{N_{k,r}(L) + NE_{k,r}(L)}\right)\left(\tilde{\varphi}_{k,r,s}^{\sigma-1}(H)\frac{A_{k,r,s}(H)}{\delta} - w_r f_{k,r,s}^{exp}\right)$$

$$+(1-\delta)\sum_{s\neq r}\left[(1-\gamma)\left(\frac{M_{k,r,s}(L)}{N_{k,r}(L)}\left((\tilde{\varphi}_{k,r,s}^{\sigma-1}(L))\left[A_{k,r,s}(L) + \gamma(1-\delta)\frac{A_{k,r,s}(H)}{\delta}\right] - (\delta + \gamma - \delta\gamma)\,w_r f_{k,r,s}^{exp}\right)\right)\right] +$$

$$+(1-\delta)\sum_{s\neq r}(1-\gamma)\gamma(1-\delta)\left(F(\varphi_{k,r,s}^c(L)) - F(\varphi_{r,s}^c(H))\right)\left(\tilde{\varphi}_{k,r,s}^{LH^{\sigma-1}}\frac{A_{r,s}(H)}{\delta} - w_r(H^0)f_{k,r,s}^{exp}\right)*1_{RankB_{k,r,s}}$$

$$= \delta w_r f_{k,r}^{sunk}$$

where

$$\tilde{\varphi}_{k,r,s}^{LH} = \begin{cases} \varphi_{k,r,s}^c(L) & ,\varphi_{k,r,s}^c(L) = \varphi_{k,r,s}^c(H) \\ \left[\dfrac{\int_{\varphi_{k,r,s}^c(L)}^{\varphi_{k,r,s}^c(H)}\varphi^{\sigma-1}dF(\varphi)}{F(\varphi_{k,r,s}^c(H)) - F(\varphi_{k,r,s}^c(L))}\right]^{\frac{1}{\sigma-1}} & ,\varphi_{k,r,s}^c(L) \neq \varphi_{k,r,s}^c(H) \end{cases}$$

is the average productivity level between high and low state cutoffs.

---

[6]Note that $V_{k,r}^{wait\,to\,enter}$ indexed by one country denotes the value of waiting to enter into production while $V_{k,r,s}^{Wait}$ indexed by two countries denotes the value of waiting to begin exporting to region $s$. These are two distinct values.

In state $H^{(n)}$, the number of new entrants is determined by:

$$\tilde{\varphi}_{k,r,r}^{\sigma-1}(H^{(n)})A_{k,r,r}(H^{(n)})$$

$$+\sum_{s\neq r}\left(\frac{M_{k,r,s}(H^{(n+1)})}{N_{k,r}(H^{(n)})+NE_{k,r}(H^{(n)})}\right)\left(\tilde{\varphi}_{k,r,s}^{\sigma-1}(H^{(n+1)}A_{k,r,s}(H^{(n+1)})-\delta w_r f_{k,r,s}^{exp}\right)=\delta w_r f_{k,r}^{sunk}$$

The complete derivations of both conditions are detailed in Appendix B.2.

### 3.3.6  Export Productivity Cutoffs

In a given state $\zeta$, sector $k$-region $r$ firms who have entered into production in some previous period will choose to incur the sunk cost $f_{k,r,s}^{exp}$ and begin exporting to $s$ if the value of exporting exceeds the value of waiting to begin exporting to $s$ by at least the amount of this sunk cost. That is, in state $\zeta$ a country $r$ firm with productivity $\varphi$ will enter export market $s$ if

$$V_{\varphi,k,r,s}(\zeta)-V_{\varphi,k,r,s}^{wait}(\zeta)\geq w_r f_{k,r,s}^{exp}$$

As shown in Appendix B.3, for a sector $k$ region $r$ with export cutoffs to $s$ ranked according to Ranking A (see 3.8):

$$\left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1}=\frac{(\delta+\gamma-\delta\gamma)\,w_r f_{k,r,s}^{exp}}{\left[A_{k,r,s}(L)+\gamma\left(\sum_{n=0}^{\infty}(1-\delta)^{n+1}A_{k,r,s}(H^{(n)})\right)\right]},\varphi_{k,r,s}^c(L) \quad (3.17)$$
$$\leq\varphi_{k,r,s}^c(H^{det})$$

Note that one can show that this cutoff is increasing in $\gamma$ (see Appendix B.4) under certain conditions. That is, for a country with $\varphi_{k,r,s}^c(L)\leq\varphi_{k,r,s}^c(H^{det})$, it is also the case that the export cutoff productivity in state $L$ is increasing in $\gamma$, the probability that the high tariff shock will arrive in any given period.

For a sector $k$ region $r$ with export cutoffs to $s$ ranked according to Ranking B, as shown in Appendix B.3 we have

$$\left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1}=\frac{(\delta+\gamma-\delta\gamma)\,w_r f_{k,r,s}^{exp}-(1-\delta)\gamma w_r(H^{(0)})f_{k,r,s}^{exp}}{A_{k,r,s}(L)},\varphi_{k,r,s}^c(L) \quad (3.18)$$
$$>\varphi_{k,r,s}^c(H^{det})$$

The cutoff productivity in high tariff states, $\varphi_{k,r,s}^c(H^{(n)})$, is derived in appendix B.1 and is given by

$$\left(\varphi_{k,r,s}^c(H^{(n)})\right)^{\sigma-1} = \frac{\delta w_r f_{k,r,s}^{exp}}{A_{k,r,s}(H^{(n)})} \tag{3.19}$$

### 3.3.7 Number of Exporters

Here, I let $M_{k,r,s}(\zeta)$ denote the mass of sector $k$ firms in country $r$ at state $\zeta$ who lie above the export cutoff $\varphi_{k,r,s}^c(\zeta)$ in that state and export to $s$. Because new entrants this period cannot export, this will be given by the share of the $N_{k,r}(\zeta)$ firms who lie above this cutoff, that is:

$$M_{k,r,s}(\zeta) = N_{k,r}(\zeta)(1 - F(\varphi_{k,r,s}^c(\zeta)) \, for \, \zeta$$
$$\in \{L, H^{(0)}, H^{(1)}, \ldots\}$$

In states where legacy firms are present, the total number of sector $k$ region $r$ exporters to $s$ will be given by $M_{k,r,s}(\zeta) + Leg_{k,r,s}(\zeta)$ where the mass of legacy exporters satisfies:

$$Leg_{k,r,s}(L) = 0$$

$$Leg_{k,r,s}(H^{(n)}) = \begin{cases} N_r(H^{(0)})(1-\delta)^n \left(F(\varphi_{r,s}^c(H^{(n)})) - F(\varphi_{r,s}^c(L))\right) & , 1_{RankB_{k,r,s}} = 0 \\ \\ 0 & , 1_{RankB_{k,r,s}} = 1 \end{cases}$$

because there will be no legacy exporters in states where the tariff remains at the low level, and in state $H^{(n)}$ only firms who were present when the high tariff shock first arrives (that is, those who form part of the mass $N_{k,r}(H^{(0)}) = N_{k,r}(L)$) and who have not been killed by the exogenous shock, and who lie above cutoff $\varphi_{k,r,s}^c(L)$ and below $\varphi_{k,r,s}^c(H^{(n)})$ will be legacy firms.

### 3.3.8 Number of New Exporters

I denote the mass of new exporters to country $s$ from country $r$ in sector $k$ and state $\zeta$ by $NX_{k,r,s}(\zeta)$. In state $L$ (for which I assume we are in a steady-state equilibrium), this will just be the mass of firms required to replace exporters killed off by the exogenous death shock:

$$NX_{k,r,s}(L) = \delta M_{k,r,s}(L)$$

For $1_{RankB_{k,r,s}} = 0$ (see (3.8)), new exporters in states $H^{(n)}$ will include the share of new entrants in the previous period who have survived and are above today's cutoff. This gives:

$$
\begin{aligned}
NX_{k,r,s}(H^{(0)}) &= (1-\delta)NE_{k,r}(L)\left(1 - F\left(\varphi^c_{k,r,s}(H^{(0)})\right)\right), 1_{RankB_{k,r,s}} = 0 \\
NX_{k,r,s}(H^{(1)}) &= (1-\delta)NE_{k,r}(H^{(0)})\left(1 - F\left(\varphi^c_{k,r,s}(H^{(1)})\right)\right) \\
NX_{k,r,s}(H^{(n)}) &= (1-\delta)NE_{k,r}(H^{(n-1)})\left(1 - F\left(\varphi^c_{k,r,s}(H^{(n)})\right)\right), n = 2,3,\dots
\end{aligned}
$$

The equations determining the number of new $k-s$ exporters in regions $r$ with cutoffs ranked according to ranking B will be the same in each state with the exception of state $H^{(0)}$ for which we have:

$$
\begin{aligned}
NX_{k,r,s}(H^{(0)}) &= (1-\delta)NE_{k,r}(L)\left(1 - F\left(\varphi^c_{k,r,s}(H^{(0)})\right)\right) \\
&\quad + N_{k,r}(H^{(0)})\left(F(\varphi^c_{k,r,s}(L)) - F(\varphi^c_{k,r,s}(H^{(0)}))\right), 1_{RankB_{k,r,s}} \\
&= 1
\end{aligned}
$$

because in this case, the cutoff export productivity in state $H^{(0)}$ is lower than that in state $L$, so firms who have already entered into production when the high tariff shock arrives and who have productivity $\varphi^c_{k,r,s}(H^{(0)}) \leq \varphi \leq \varphi^c_{k,r,s}(L)$ will also enter the export market in state $H^{(0)}$.

### 3.3.9 Price Index

The price index in country $r$, sector $k$ in state $\zeta$ will be affected by the firm level prices of domestic firms and foreign firms exporting into $r$, which themselves are made up of firms above the current state export cutoff and legacy exporters.

$$
\begin{aligned}
P^{1-\sigma}_{k,r}(\zeta) &= \lambda_{k,r,r}\left(N_{k,r}(\zeta) + NE_{k,r}(\zeta)\right)(\tilde{p}_{k,r,r}(\zeta))^{1-\sigma} + \\
&\quad + \sum_{s\neq r} \lambda_{k,s,r}\left[(M_{k,s,r}(\zeta))(\tilde{p}_{k,s,r}(\zeta)\tau_{k,s,r}(\zeta))^{1-\sigma} + Leg_{k,s,r}(\zeta)\left(\tilde{p}^{leg}_{k,s,r}(\zeta)\tau_{k,s,r}(\zeta)\right)^{1-\sigma}\right]
\end{aligned}
$$

where $\tilde{p}_{k,s,r}(\zeta)$ is the firm level price charged by the firm of average productivity $\tilde{\varphi}_{k,s,r}$, and $\tilde{p}_{k,s,r}^{leg}(H^{(n)})$ is the price charged by the country $s$ firm with average $r$ legacy productivity,

$$\tilde{\varphi}_{k,s,r}^{leg}(H^{(n)}) = \left[ \frac{\int_{\varphi_{k,s,r}^c(L)}^{\varphi_{k,s,r}^c(H^{(n)})} \varphi^{\sigma-1} dF(\varphi)}{F(\varphi_{k,s,r}^c(H^{(n)})) - F(\varphi_{k,s,r}^c(L))} \right]^{\frac{1}{\sigma-1}}$$

with each price depending on productivity according to $\tilde{p}_{\varphi,k,r,s}^{cat}(\zeta) = \frac{w_r}{\tilde{\varphi}_{k,s,r}^{cat}} \left( \frac{\sigma}{\sigma-1} \right)$, $cat \in \{\cdot, leg\}$.

### 3.3.10  Labor Market Clearing Condition

I assume that the population in each country is sufficiently large for the numeraire good to always be produced in all countries in equilibrium, which implies that wages in all countries and all periods will be pinned down at $w_r$ (which I take to be equal to 1 in each country), independent of the state $\zeta$.

### 3.3.11  Income-Expenditure Closure

Finally, in each region, total income must equal total expenditure:

$$\begin{aligned}
GDP_r(\zeta) = {} & w_r \bar{L}_r + \sum_k \sum_{s \neq r} (\tau_{k,s,r} - 1) \left[ M_{k,s,r}(\zeta) \tilde{p}_{k,s,r}(\zeta) \tilde{q}_{k,s,r}(\zeta) + Leg_{k,s,r}(\zeta) \tilde{p}_{k,s,r}^{leg}(\zeta) \tilde{q}_{k,s,r}^{leg}(\zeta) \right] \\
& + \sum_k (N_{k,r}(\zeta) + NE_{k,r}(\zeta)) \frac{\tilde{p}_{k,r,r}(\zeta) \tilde{q}_{k,r,r}(\zeta)}{\sigma} \\
& + \sum_k \sum_{s \neq r} \left[ M_{k,r,s}(\zeta) \frac{\tilde{p}_{k,r,s}(\zeta) \tilde{q}_{k,r,s}(\zeta)}{\sigma} + Leg_{k,r,s}(\zeta) \frac{\tilde{p}_{k,r,s}^{leg}(\zeta) \tilde{q}_{k,r,s}^{leg}(\zeta)}{\sigma} \right] \\
& - \sum_k w_r f_{k,r}^{sunk} NE_r(\zeta) - \sum_k \sum_{s \neq r} w_r f_{k,r,s}^{exp} NX_{k,r,s}(\zeta)
\end{aligned}$$

Here, income is equal to the sum of labor income, tariff revenue and firm level profits minus the sunk costs incurred by firms to begin production or exporting.

## 3.4  Computation

Here, I summarize the set of equations and complementarity conditions determining the equilibrium values of all endogenous variables under the tariff process and set-up described above. Recall that some of these derivations relied on the assumption that no tariff shock

is large enough to cause the condition $NE_{k,r} \geq 0$ to bind and that fixed costs of exporting are sufficiently large that the productivity cutoff to export in any market is strictly greater than the minimum productivity draw, $b$, so I must verify that this is the case in equilibrium. Appendix B.5 lists the set of complementarity conditions that define equilibrium under the assumptions of Pareto distributed productivity with parameters $a$ and $b$, and sufficiently large labor forces in each country such that the wage $w_r$ is not state-dependent.

### 3.4.1 Solution Method

The equations and complementarity conditions in the table in Appendix B.5 yield a square system of $C * (n+3) * [3 + 10KC + 2(C-1)K]$ endogenous variables and the same number of equations determining these where $C$ is the number of regions in the model, $K$ is the number of sectors, and $n = 1, 2, \ldots$ is the number of periods that have passed since the initial arrival of the high tariff shock. In order to reduce the system to a finite number of equations and unknowns, I assume that after period $n^*$ the economy has returned to its steady state "Hdet", the equilibrium of the deterministic model with tariffs at level $H$ in every period. I take $n^* = 100$, and then check that increasing this value has no effect on my equilibrium values.

This then yields a square mixed complementarity problem which is straightforward to program and solve using GAMS software. I use the PATH solver, a generalization of Newton's method to solve the system (Ferris and Munson (2000)).

### 3.4.2 Parametrization

For all results presented in this section, I assume the baseline parameter values reported in Table 3.1, except where otherwise noted. The parameter values in rows 7-11 are based on simulated data. The values reported here are those calibrated using the two-country, one differentiated good industry deterministic model with zero tariffs and assumed values in the differentiated sector of 80 for domestic sales, 20 for imports and 100 domestic firms in the

Table 3.1: Assumed Parameter Values

| Parameter | Description | Value |
|---|---|---|
| $\delta$ | Exogenous probability of death each period | 0.1 |
| $a$ | Pareto shape parameter | 4.6 |
| $b$ | Minimum Productivity Level | 0.5 |
| $\sigma$ | Elasticity of Substitution between Varieties | 3.8 |
| $\mu 0$ | Share of Total Expenditures on Homogenous Good Sector | 0.3 |
| $\gamma$ | Probability of a High Tariff Shock in each period | 0.03 |
| $\lambda_{r,r}, r = R1, R2$ | Preference parameter for domestic goods | 0.046 |
| $\lambda_{r,s}, r \neq s$ | Preference parameter for imported goods | 0.032 |
| $f_r^{sunk}, r = R1, R2$ | fixed cost to enter into production (in units of Labor) | 2.183 |
| $f_{r,s}^{exp}, r \neq s$ | fixed cost to enter into exporting (in units of Labor) | 2.059 |
| $\bar{L}_r, r = R1, R2$ | Labor Supply | 143 |

differentiated goods sector (prior to entry) with 10 of these exporting.[7]

The value chosen for $1 - \mu 0$, the share of total expenditures which go towards the differentiated goods sector, is admittedly somewhat arbitrary, though may be rationalized by assuming that the economy is comprised of agriculture, which is characterized by constant returns to scale, and manufacturing, as in Krugman (1991). Using this framework, I choose a value of 70% for expenditures on the non-agricultural sector, as this is close to the share of spending in the United States. Section 3.7 provides a detailed analysis of the sensitivity of the main results presented below to the assumed parameter values for $\delta, a, \sigma, \mu 0, \text{and} \gamma$, showing that in general, these results are not sensitive to the assumed parameter value of $\mu 0$, somewhat sensitive to the assumed values of $a$ and $\sigma$, and quite sensitive to the assumed values for $\delta$ and $\gamma$.

## 3.5 Results

In this section, I present the equilibrium values for endogenous variables of interest for various scenarios where tariffs are at level $L$ but there exists the threat of a tariff hike to level $H$, and compare these values to the equilibrium values which would be obtained in a deterministic version of the model with tariffs at level $L$ in all periods. Thus, I am able to

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[7]In the case of more than two countries, these same simulated data points are used to calibrate the model, using 80 for domestic sales, 20 for imports from any other market, and 10 of the 100 domestic firms exporting to any given market.

isolate the effect of the mere threat of a tariff hike by comparing equilibrium values from two scenarios, both of which have the same current applied tariffs, but where in one case, applied tariffs in future periods may rise. In cases where understanding the dynamics of endogenous variables following the realization of a tariff threat are useful in understanding the results of these static comparisons, I also present these dynamics.

## 3.5.1 Symmetric Two-Country, One Differentiated Industry Model

Here, I present the equilibrium of the model where it is assumed that the two countries are perfectly symmetric (including labor endowments, preference parameters $\lambda$, and high and low tariff levels). I assume that the low tariff in each region is 0%, while the high tariff (which may arrive in any subsequent period with probability $\gamma$) is assumed to be $(\tau^H - 1) * 100\%$, that is, in any period where the high tariff shock has not yet arrived, with probability $\gamma$ it will arrive and set the tariffs in both countries to 19% in the case where $\tau^H = 1.19$. This particular level is chosen as the high tariff level in this example because it corresponds to the optimal tariff which will be set by each country in a non-cooperative equilibrium.[8] As such, in interpreting the results below in Table 3.2, one can view the difference between the equilibrium where tariffs are locked in at the low tariff level and that where there exists a threat of each country imposing the optimal tariff in a non-cooperative equilibrium (that is, between columns (1) and (2) or (1) and (3)) as representing the value of a trade agreement in a scenario where without the agreement, there exists a positive probability that the countries will enter into a tariff war, ending with each country imposing the optimal tariff in the non-cooperative equilibrium.

The final two columns of table 3.2, present the analogous results for a higher tariff threat level, in order to provide an idea of how a change in the magnitude of the tariff threat level

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[8]In a perfectly symmetric deterministic set-up where firms are modeled as heterogeneous in productivity and face fixed costs to sell in any given market, it turns out there is an analytic expression which implicitly defines the optimal tariff of each country in the non-cooperative equilibrium (see Felbermayr et al. (2013)). As the ratio of fixed export to fixed domestic costs approaches infinity, this expression implies an explicit expression which this optimal tariff approaches. Because I have no per period fixed costs to sell in the domestic market in my set-up, I am able to use this to obtain an explicit expression for the optimal tariff in the symmetric country set-up which depends only on the elasticity of substitution and productivity dispersion parameters. For my assumed parameters, this yields $\tau^{optimal} = 1 + \frac{\sigma-1}{a\sigma-(\sigma-1)} = 1.190736$.

Table 3.2: Symmetric Two Country Model

| Variable | Equilibrium in Deterministic Model with $\tau_{r,s} = 1$ | Equilibrium in state $\tau = L = 1$ Under Uncertainty ($\tau^H = 1.19$) | | Equilibrium in state $\tau = L = 1$ Under Uncertainty ($\tau^H = 2$) | |
|---|---|---|---|---|---|
| | $\gamma = 0$ | $\gamma = 0.03$ | $\gamma = 0.10$ | $\gamma = 0.03$ | $\gamma = 0.10$ |
| $E$ | 100.000 | 100.104 | 100.285 | 100.283 | 100.576 |
| $M$ | 10.000 | 8.651 | 7.048 | 7.272 | 4.283 |
| $N$ | 100.000 | 100.645 | 101.139 | 100.955 | 102.085 |
| $NE$ | 11.111 | 11.183 | 11.238 | 11.217 | 11.343 |
| $NX$ | 1.000 | 0.865 | 0.705 | 0.727 | 0.428 |
| $P$ | 1.000 | 1.002 | 1.006 | 1.005 | 1.014 |
| $Q$ | 100.000 | 99.921 | 99.735 | 99.752 | 99.195 |
| $U$ | 77.554 | 77.536 | 77.477 | 77.485 | 77.250 |
| $\varphi^c$ | 0.825 | 0.852 | 0.892 | 0.886 | 0.996 |

will affect the equilibrium.

The first column of Table 3.2 presents the equilibrium values of endogenous variables in a deterministic version of the model where tariffs are at their initial ($L$) level in every period. Columns two and three present these equilibrium values in the low tariff state where there is now a positive probability in each period of a high tariff shock. We can see by comparing columns one and two that the threat of a tariff hike actually causes the equilibrium mass of producing firms to increase relative to the deterministic setting. This increase in the mass of producing firms induced by uncertainty over future tariffs is however more than offset by an increase in cutoff productivity to export, yielding a smaller mass of exporters in this symmetric model with a positive threat of tariff hikes in the future. The mass of exporters in each region under the presence of a tariff threat is 13.49% lower than in the case without a tariff hike threat. Further, total utility ($U$) in each region is lower by 0.02% when there exists a positive probability of tariff hikes relative to the deterministic model. The value of exports from each region under the tariff threat is 4.55% lower than without the threat.[9] Comparing columns two and three (or four and five), we see that the direction change of endogenous variables from a scenario with no threat to one with a positive threat is the

_____

[9] Note that while this effect may seem somewhat large for only a 3% chance of tariff hike to 19%, a back of the envelope calculation shows that the expected reduction in log trade value in a deterministic model where the tariff is raised by 0.57% (the expected tariff in the next period, =0.03*0.19) is $a\frac{\sigma}{\sigma-1} * 0.0057 = 0.03558$, that is, a 3.6% reduction in trade, which accounts for most of this 4.55% reduction. That is, this reduction in trade results not from simply reducing uncertainty over future applied tariff rates, but largely from the change in expected tariff value, which in the long run, is given by the tariff threat level of 19%.

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same as from the scenario with a positive threat, to one with an even higher probability of tariff hikes.

The final two columns present more comparative statics, now for a higher magnitude tariff shock, $\tau^H = 2$, that is, an ad-valorem tariff of 100% which may arrive in any subsequent period with probability $\gamma$. As expected, the threat of a higher tariff decreases the mass of exporters and increases the export productivity cutoff, as seen by comparing columns two and four (or three and five). I note that the cumulative effect on number of exporters of both raising the tariff hike probability from 3% to 10% and raising the tariff shock magnitude from 19% to 100% is greater than the sum of each individual effect.

The positive correlation between probability (or magnitude) of a tariff hike and number of firms $N$ (or entry, $NE$) can be understood intuitively by noting that in a symmetric set-up, higher tariff levels in both regions imply less domestic competition from imports and thus higher profitability from domestic sales; this implies a direct channel through which firm entry will increase. As will be seen later in an asymmetric set-up (See section 3.5.2), in a model with asymmetric high tariff levels, the equilibrium mass of producing firms in the country threatening a tariff hike is higher than that of the other country, as these firms face less import competition in the event that the tariff threat is realized. The fact that $N$ increases in the presence of a symmetric tariff threat is also partially driven by the increase in aggregate expenditures, which themselves are a result of higher GDP. GDP increases in the presence of a tariff threat though higher domestic profits and decreased fixed cost payments of new exporters which together outweigh the decrease in export profits and increase in aggregate entry costs.[10]

As another way to measure the importance of the tariff threat on the economy in equilibrium, I compute the ad-valorem tariff(s) that would yield the same equilibrium values in column 3 for either Utility ($U$), Mass of Exporters ($M$), or Export Productivity Cutoff ($\varphi^c$) in a deterministic model. In this symmetric model, the applied tariff in each country which

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[10]This channel is not obvious in the one-sector example shown here, however, later in Section 3.5.3.2 when an outside sector is present for which domestic and export profitability do not change with the presence of a tariff threat on the other sector, we still see an increase in the equilibrium number of firms in both sectors.

Table 3.3: Applied Tariff Equivalents of Tariff Threat

| | Tariff threat: 19% | | Tariff threat: 100% | |
|---|---|---|---|---|
| Equivalence Variable | $\gamma = 0.03$ | $\gamma = 0.1$ | $\gamma = 0.03$ | $\gamma = 0.1$ |
| $U$: Utility | 1.30% (2) | 3.96% (2) | 3.63% (1) | 10.53% (1) |
| $M$: Mass of Exporters | 3.09% (5) | 7.42% (4) | 6.76% (2) | 17.97% (1) |
| $\varphi^c$: Export productivity cutoff | 3.03% (5) | 7.22% (4) | 6.56% (2) | 17.52% (1) |
| Decline in Differentiated Good Trade (share of Level in case with no threat) | 4.55% | 10.57% | 9.62% | 24.03% |

*Value in parentheses indicates number of periods in the future before expected applied tariff will be greater than this applied tariff equivalent.

would yield the same outcome utility in each country as the threat of a 19% tariff (with 0.03 probability) in a future period is 1.3%. The applied tariff which would yield the same mass of exporters is 3.09% and that which would yield the same cutoff productivity in each country is 3.03%. The value of bilateral trade in the differentiated good sector predicted by the model decreases from 20 units to 19.1 units in the case where there exists a 3% threat of a 19% tariff hike. Thus, the model indicates that the effect of the threat of a tariff hike to 19% (with a 3% chance of the shock arriving each period) in both countries is roughly equivalent to an applied tariff of between 1.3 and 3.1 percent in each country, and causes bilateral trade to be 4.55% lower than would be expected without the presence of the tariff threat. Table 3.3 presents the applied tariff equivalents as well as the share of lost trade computed for the different tariff threat scenarios discussed above in this symmetric model.

### 3.5.2   Asymmetric Case: Single Policy Active Country

Here, I present the equilibrium values of endogenous variables for the general equilibrium model with symmetric country size and parameters, but now assume that the threat of a tariff hike exists in only one of the two regions. Specifically, I assume that in the initial state tariffs in both regions are 0, and that in each subsequent period there is a probability $\gamma = 0.03$ that the tariff in region 1 will jump to 25.3%, remaining there forever after, while the region 2 tariff remains 0 in all states. This tariff threat level for region 1 is chosen because this is the tariff that maximizes R1 utility in the case where R2 is constrained to

Table 3.4: Asymmetric Case: One Policy Active Country

| Variable | Equilibrium in Deterministic Model $\tau_{R1,R2} = \tau_{R2,R1} = 1$ | | Equilibrium in state $\tau^L_{R1,R2} = \tau^L_{R2,R1} = 1$ Under R1 Threat ($\tau^H_{R2,R1} = 1.253$), $\gamma = 0.03$ | |
| | Region | | Region | |
| | $r = R1, s = R2$ | $r = R2, s = R1$ | $r = R1, s = R2$ | $r = R2, s = R1$ |
|---|---|---|---|---|
| $E_r$ | 100.000 | 100.000 | 99.970 | 100.139 |
| $GDP_r$ | 142.857 | 142.857 | 142.814 | 143.055 |
| $M_{r,s}$ | 10.000 | 10.000 | 10.534 | 7.780 |
| $N_r$ | 100.000 | 100.000 | 103.262 | 97.650 |
| $NE_r$ | 11.111 | 11.111 | 11.474 | 10.850 |
| $NX_{r,s}$ | 1.000 | 1.000 | 1.053 | 0.778 |
| $P_r$ | 1.000 | 1.000 | 0.998 | 1.004 |
| $Q_r$ | 100.000 | 100.000 | 100.140 | 99.756 |
| $U_r$ | 77.555 | 77.555 | 77.623 | 77.454 |
| $\varphi^c_{r,s}$ | 0.825 | 0.825 | 0.821 | 0.867 |

leave its tariff at zero.[11] In terms of real world examples, one can think of a case where perhaps R2 is committed to leave its tariff rates at zero in the event of a tariff hike by R1 because of some international agreement, such as MFN rates in the WTO, while R1 may have the ability to raise its rates because its initially low tariff rates were only granted as part of a unilateral preference scheme, such as the Generalized System of Preferences (GSP) schemes offered by several developed nations towards developing nations.[12]

Here we see that the effect of tariff uncertainty inducing entry into the domestic market appears to have been a consequence of the symmetric set-up previously assumed. When I allow a positive threat of a tariff hike in only one region (R1, in this case), this induces higher entry into the domestic market in R1, as one might expect given that a higher tariff in R1 reduces import competition for domestic firms. In R2, where exporters face the possibility of a high tariff level in R1 in the future, uncertainty leads to a lower equilibrium mass of firms. Similarly, uncertainty over the tariffs that will be applied on region 1 imports leads to a lower equilibrium mass of exporters and higher productivity cutoff in R2, and the opposite in R1. This is due to the expectations that the region 1 import tariff may rise, leading to improved export conditions for region 1 exporters driven by the increase in the price index

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[11]This optimal tariff is computed numerically.

[12]Of course, to properly model such a scenario would require including more than two countries, and likely more than one industry. Such an example is presented in Chapter 4 of this dissertation for the case of Chile-USA trade in the context of a four region, multi-sector model.

of the differentiated goods sector in region 2, which itself will be driven by the decrease in the number of firms producing in region 2.

For region 1, the presence of the tariff threat implies an increase in utility by 0.09%, an increase in the mass of exporters of 5.34% and an increase in the value of differentiated goods exports by 5.35%. For region 2, this tariff threat induces a 0.13% decrease in utility level, a 22.2% decrease in the mass of exporters, and a 11.1% decrease in the value of differentiated goods exports.

As in the previous section, I compute the applied tariff level that would need to be imposed by region $R1$ on imports in a deterministic model in order to yield the same equilibrium value of utility $(U)$, mass of exporters $(M)$, and export productivity cutoff $(\varphi^c)$ for region 2. These applied tariff equivalents in this case are 0.52% for equivalent utility effect, 3.01% for equivalent effect on mass of exporters 3.49% for equivalent export productivity cutoff. In terms of trade flows, the level of differentiated good exports from R2 to R1 will be 11.1% lower with the threat of the tariff hike than without, while differentiated good exports from R1 to R2 will be 5.3% higher with the threat.

**An Optimal $\gamma$**

In this example, it is clearly to region R1's benefit to maintain a threat of raising tariffs. Of course, if R1 has control over this parameter $\gamma$ (by sending signals about the likelihood of a tariff hike) it is obvious that if the goal is to maximize welfare in the current "L" state, setting $\gamma = 1$ will produce the highest utility for region 1. If, however, the policy maker in region 1 is able to credibly commit to some other $\gamma$ and cares not just about current period and long term utility levels but rather the present discounted value (PDV) of expected utility for region 1, it turns out that $\gamma = 1$ is not optimal. Under the assumption that a high shock will arrive with probability $\gamma$ in any subsequent period, the present discounted value of expected utility for a region is given by:

$$PDVEU_r = \frac{\delta}{(1 - (1 - \delta)(1 - \gamma))} \left[ U_r(L) + \gamma \sum_{n=0}^{\infty} (1 - \delta)^{n+1} U_r(H^{(n)}) \right] \qquad (3.20)$$

Figure 3.1: Utility Dynamics
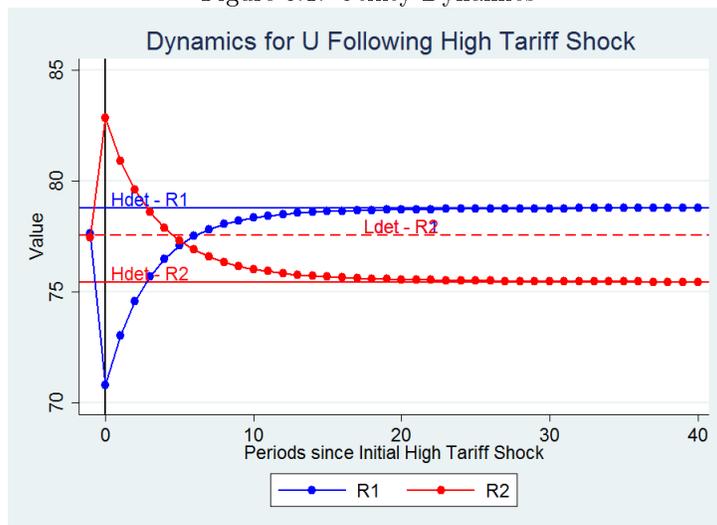
In order to understand how the utility levels $U_r(H^{(n)})$ evolve in each region following the arrival of a high tariff shock, I present here figure 3.1. We see that although the imposition of a high tariff by R1 will leave it with higher utility in the long run, transitioning from the low tariff state requires going through several periods of low utility levels. The main mechanism driving this lower utility in the short run is due to the presence of legacy firms exporting from R2 to R1, whose mass gradually decreases over time as they are randomly hit by the exogenous death shock. The presence of these legacy firms raises the price index in R1 because consumers in this region must now pay the price of the differentiated goods as well as the tariff markup resulting from the R1 imposed tariff. Figure 3.2 presents the dynamics of these two endogenous variables following a high tariff shock.

We now see from these figures and equation (3.20) that there exists a tradeoff for region 1 with respect to $\gamma$: a higher level of $\gamma$ raises current period utility $U(L)$ and utility levels further than about 6 periods into the future, however it also increases the weight given to utility in periods just after the imposition of the high tariff, which are lower. I numerically compute the optimal level of $\gamma$ from the perspective of R1 where this is the level that maximizes PDV of R1 utility, under the assumption that the high tariff shock does indeed have a probability $\gamma$ of arriving in any future period. This yields a value of $\gamma = .69$. In

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Figure 3.2: Price and Legacy Firm Dynamics
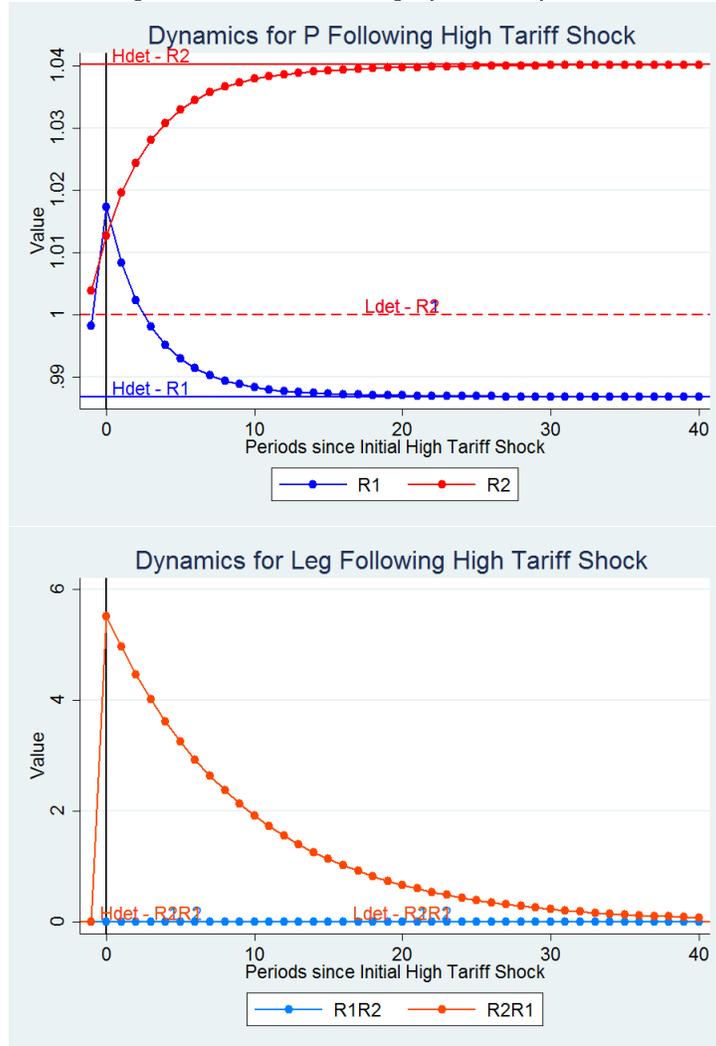
terms of real world applications, however, it is difficult to imagine a situation where a region can commit to it's probability of invoking a tariff in the future. More reasonable, perhaps, is a situation where a policy maker may intend to leave tariffs at their low level (L), and therefore optimizes only utility in this low tariff state, $U(L)$, by sending signals about raising tariffs in the future. In the example presented in this section, it is to this policy maker's advantage to generate signals as close to $\gamma = 1$ as possible, though in practice, he may experience a lack of credibility if the tariff is never raised.

### 3.5.3 Broader Tariff Threat Effects

In this section, I present the results of versions of the model that include countries or sectors not directly targeted by the tariff threat in order to assess the general equilibrium effects that such a threat has on outside countries and sectors. This is an important topic, as the effects of Preferential Trade Agreements on non member countries as well as the effects of such agreements on incentives for multilateral trade liberalization have become a topic of debate over the past two decades (see, for example, Baldwin (1997) and Bhagwati (1998)). By including the uncertainty reducing effects of trade agreements in a general equilibrium model with multiple regions and sectors, I allow for another mechanism, apart from the direct effect of applied tariffs, through which the trade, welfare, and incentive to enter into multilateral agreements of non-member countries to a given agreement may be affected by the presence of the agreement.

#### 3.5.3.1 Third Country Effects

Here I present the equilibrium values of endogenous variables for a model similar to that presented in section 3.5.1 where two symmetric countries threaten to raise tariffs against each other, but I now add in a third symmetric country (R3) whose tariffs remain at level $L$ in all periods, as do the tariffs faced by its exporters to regions R1 and R2. That is, initially all tariffs are zero (state $L$) and when the high tariff shock arrives (which happens

with probability $\gamma$ in each subsequent period), it causes only the tariffs governing region 2 exports to region 1 (R2-R1) and region 1 exports to region 2 (R1-R2) to rise to 17.5%, the non-cooperative equilibrium tariff level for R1 and R2 when all R3 imports are constrained to have zero tariffs. One may think of this as a situation where initially two of the three pairs of countries in this 3-country model, (R1,R3) and (R2,R3) have an explicit agreement (such as an FTA) constraining tariffs to remain at 0% while the zero tariffs imposed by regions R1 and R2 are not locked in by any explicit contract. In a partial equilibrium model where the effects of a tariff shock do not affect aggregate expenditure and price indexes, we would see no effect of this tariff uncertainty on the equilibrium for the third country, R3. In this general equilibrium framework, however, region 3 will be affected by the imposition of a tariff on R1-R2 bilateral trade flows, and so its state $L$ equilibrium is also affected by the mere threat of such a tariff hike. I now focus on the effect of this uncertainty over future tariffs between R1 and R2 not on the outcomes for these countries, as these will be similar to those presented in section 3.5.1, but for the outside region, R3.

Table 3.5 presents the equilibrium values of endogenous variables for region R3 in both the deterministic model with tariffs at zero in all states and the $L$ state of the model with a positive threat of a tariff hike on R1-R2 and R2-R1 trade flows in some future period. We see that although the threatened tariff hike will have no direct impact on region 3, it does affect this region in general equilibrium. Specifically, compared with the case of no tariff threat, we see a lower productivity cutoff and higher mass of exporters to regions R1 and R2 (where, in the event of the imposition high tariffs, the price index of the differentiated goods sector will rise, making it more attractive as an export market). Overall, R3 benefits from this tariff threat that directly affects only the other two countries, and realizes a utility level slightly higher than it would in the case where zero tariffs are locked in between all pairs.

Table 3.5: Third Country Effects

| Variable | Equilibrium in Deterministic Model $\tau_{r,s} = 1, \forall r, s$ | Equilibrium in state $\tau_{r,s}^{L} = 1, \forall r, s$ Under R2-R1 Uncertainty $(\tau_{R2,R1}^{H} = \tau_{R1,R2}^{H} = 1.175)$, $\gamma = 0.03$ |
|---|---|---|
| | Region $r = R3, s \neq R3$ | Region $r = R3, s \neq R3$ |
| $E_r$ | 120.000 | 119.948 |
| $M_{r,s}$ | 10.000 | 10.296 |
| $N_r$ | 100.000 | 101.677 |
| $NE_r$ | 11.111 | 11.297 |
| $NX_{r,s}$ | 1.000 | 1.030 |
| $P_r$ | 1.000 | 0.998 |
| $Q_r$ | 120.000 | 120.244 |
| $U_r$ | 93.065 | 93.186 |
| $\varphi_{r,s}^{c}$ | 0.825 | 0.823 |

### 3.5.3.2 Cross-Industry Effects

Until now, I have only presented the results of models where there is one differentiated goods sector. I now expand this to include two such sectors, labeled $K1$ and $K2$, in a two-country model, and present the equilibrium values of endogenous variables for this model when the event of a high tariff shock results in the imposition of a 19.25% tariff on all trade flows for sector $K1$ goods, where this tariff level is chosen because it is the tariff that will be optimally chosen by both regions in sector K1 in the non-cooperative equilibrium when sector K2 tariffs are constrained to remain at zero. In the results presented here, I explore whether the addition of another sector (of the same size as $K1$) which is not subject to a tariff hike qualitatively changes the effect of this tariff threat on equilibrium values in sector $K1$, as well as how the indirect general equilibrium effects of a tariff threat in sector $K1$ affect sector $K2$. As with the previous section, where there was an additional region not affected directly by the tariff shock, here, in the absence of general equilibrium effects, there would be no effect of this tariff threat on sector $K2$. We will see that this is not the case in general equilibrium, and will explore the channels through which this outside sector is affected.

I do not present here the equilibrium values of endogenous variables for sector $K1$, as

Table 3.6: Cross-Sector Effects

| $k = K1$ | Equilibrium in Deterministic Model $\tau_{k,R1,R2} = \tau_{k,R2,R1} = 1$, $k = K1, K2$ | Equilibrium in state $\tau^L_{k,R1,R2} = \tau^L_{k,R2,R1} = 1$ Under R1 Threat ($\tau^H_{K1,R2,R1} = 1.1925$), $\gamma = 0.03$ |
|---|---|---|
| | Region | Region |
| Variable | $k = K2,\, r = R1, R2\,, s \neq r$ | $k = K2,\, r = R1, R2\,, s \neq r$ |
| $E_{k,r}$ | 100.000 | 100.052 |
| $M_{k,r,s}$ | 10.000 | 10.005 |
| $N_{k,r}$ | 100.000 | 100.052 |
| $NE_{k,r}$ | 11.111 | 11.117 |
| $NX_{k,r,s}$ | 1.000 | 1.001 |
| $P_{k,r}$ | 1.000 | 1.000 |
| $Q_{k,r}$ | 100.000 | 100.071 |
| $U_r$ | 95.481 | 95.469 |
| $\varphi^c_{k,r,s}$ | 0.825 | 0.825 |

they are qualitatively the same as those found in the 2-country 1-sector model presented in section 3.5.1, namely that higher export productivity cutoffs in both regions for sector K1 and a smaller mass of exporters in this sector.

Table 3.6 shows these equilibrium values for sector $K2$. In this sector, not directly affected by the potential tariff hike, we see that export productivity cutoffs in each country remain unaffected by the threat of a tariff hike in sector 1 (see Appendix B.6 for a discussion of the hypothesis that this will hold under the assumption of Pareto distributed productivity for any sector not directly impacted by tariff changes). Thus, any effect on the number of sector $K2$ exporters occurs as a result of a change in the number of firms producing domestically in this sector. We see that the equilibrium mass of sector $K2$ firms producing in each region is higher when there exists the threat of a symmetric tariff hike on sector $K1$. This can be understood as a sort of spillover effect resulting from the slightly higher GDP, and therefore sector level expenditures resulting from the tariff threat in sector $K1$. As mentioned in the symmetric two-country one-sector model (see section 3.5.1), this higher GDP in the presence of a tariff threat is the result of higher aggregate domestic revenue in both sectors which outweighs the decreased export revenues of sector $K1$ and the increase in aggregate sunk costs which must be paid in both sectors. I note that although the number

of decimals presented in table 3.6 do not show a difference in the price index for sector $K2$, it is the case that this price is slightly lower in the presence of the sector $K1$ tariff threat (due to the increased number of domestic firms and imports in $K2$) which balances the slight increase in $Q$ in this sector such that aggregate economic conditions remain the same in $K2$ with or without the presence of a tariff threat in $K1$.

## 3.6   Discussion

In this section I discuss the added value obtained by using a general equilibrium rather than a partial equilibrium framework to model the effects of tariff threats as well as the reasons for and implications of various assumptions, and the economic forces that act to maintain constant cutoff productivities in all states after the arrival of the tariff shock, even as legacy firms decay away.

### 3.6.1   Added Value of General Equilibrium Analysis

As already noted in the results sections above, one immediate advantage to using a general equilibrium framework is that it allows us to analyze the effects of tariff threats and shocks on countries not directly impacted by the tariffs, but whose trade may be affected by the policies. Similarly, in a multi-sector setting, one can obtain results for the effects of tariff policies on sectors not directly targeted.

Beyond this, however, the general equilibrium model captures additional feedback effects that would be absent in a partial equilibrium analysis. Turning to back to the results of the two-country, one-industry model where there exists the threat of a tariff hike to 25.3% on $R1$ imports from $R2$ (see Section 3.5.2), one can ask how the general equilibrium results obtained compare with a those from a partial equilibrium framework which does not take into account general equilibrium effects on aggregate region 1 variables. Specifically, I note that the equation governing the productivity cutoff for region 2 exports to region 1 in states

prior to the arrival of the high tariff shock is given by[13]:

$$\left(\varphi_{R2,R1}^c(L)\right)^{\sigma-1} = \frac{(\delta + \gamma - \delta\gamma)\, w_{R2,R1} f_{R2,R1}^{exp}}{\left[A_{R2,R1}(L) + \frac{\gamma(1-\delta)}{\delta} A_{R2,R1}(H)\right]}$$

Recall that $A_{R2,R1}$ summarizes aggregate economic conditions for a region $R2$ exporter to region $R1$ and is defined as $A_{R2,R1}(\zeta) \equiv \frac{1}{\sigma}\left[\left(\frac{\sigma}{\sigma-1}\right)w_{R2}\right]^{1-\sigma}\lambda_{R2,R1}Q_{R1}(\zeta)\left(\frac{P_{R1}(\zeta)}{\tau_{R2,R1}(\zeta)}\right)^{\sigma}$, that is, a constant multiple of $Q_{R1}\left(\frac{P_{R1}}{\tau_{R2,R1}}\right)^{\sigma}$ in a given state. In a partial equilibrium analysis, one may assume that $Q_{R1}$ and $P_{R1}$ are unaffected by the arrival of a high tariff shock in region 1, and a tariff threat will still result in a lower export productivity cutoff in $R2$ as the forward looking exporter takes into account future economic conditions $A_{R2,R1}(H)$ which include the direct effect of the tariff, $\tau_{R2,R1}$. In general equilibrium, however, any additional feedback effects on $Q_{R1}$ and $P_{R1}$ are also taken into account when the exporter makes his decision. Using the equilibrium $Q$ and $P$ values for $R1$ from the initial $L$ state (one could think of these as observed quantity and price indexes in some initial period) we obtain that $Q_{R1}(L)\left(\frac{P_{R1}(L)}{\tau_{R2,R1}(H)}\right)^{\sigma} = 42.2$ while using the general equilibrium $Q$ and $P$ values, we obtain $Q_{R1}(H^{det})\left(\frac{P_{R1}(H^{det})}{\tau_{R2,R1}(H)}\right)^{\sigma} = 41.1$. That is, if we ignore the additional general equilibrium effects that cause $Q_{R1}$ to rise and $P_{R1}$ to fall once region 1 imposes a tariff on imports, we obtain a higher value for $A_{R2,R1}(H)$ and thus a lower cutoff productivity $\varphi_{R2,R1}^c(L)$ for region 2 exporters than if we take these feedback effects into account. In other words, in this case, using a partial equilibrium model to evaluate the effects of a tariff threat would underestimate the impact on the export productivity cutoff in the region directly impacted by the tariff. What are the mechanisms driving these feedback effects? After the high tariff shock arrives, in region 1 we have that $Q$ rises while $P$ falls (in the long term; in the short term the opposite is true, however $QP^{\sigma}$ remains constant once the shock arrives). The lower price index results from more domestic firms entering over time as import competition is decreased and (for sufficiently large $\sigma$) this effect is enough to outweigh the rise in demand, $Q$ that results, yielding a lower value of $QP^{\sigma}$ in state $H$ relative to state $L$.[14]

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[13]I have taken advantage of the fact that $A_{r,s}$ remains constant in all $H^{(n)}$ periods to simplify the expression given in (3.17). See Appendix B.1 for proof of this fact.

[14]In the short term, the mechanisms driving the higher $P$ are that import prices are now higher, as they take into account the tariff, and many $R2$ legacy firms remain, so that there are still a substantial mass of firms exporting from region 2 and driving up the price index, which also decreases demand, $Q$, in region 1.

In a similar vein, I note that without allowing the number of producing firms to be determined endogenously via the free-entry condition (as might be the case in certain partial equilibrium analyses), the post-shock mass of exporters from region 2 predicted by the model would be higher than is the case here, since in general equilibrium, fewer firms produce domestically and so for a given fraction of producers who export, this mass will also be reduced. That is, in a partial equilibrium analysis that takes the number of domestic firms as given, one would underestimate the effect of an applied tariff or a tariff threat on the mass of exporting firms.

### 3.6.2   No Per-Period Fixed Costs

The assumption of no per-period fixed costs to sell either domestically or in a given export market, though not very realistic, is made in order to maintain tractability of the model in the presence of uncertain future tariff levels. Positive per-period fixed costs to sell domestically and/or in a given export market would generate an endogenous productivity cutoff below which firms would exit the given market, and forward looking potential firms would take this into account when making their entry decision. This would greatly complicate the model, as in this case, expressions (3.10) and (3.11) would need to take into account the probability of falling below an endogenous exit cutoff when computing the present discounted value of selling in a given market. It is not clear that this added feature would allow additional insight about the mechanisms causing reduced entry in the presence of a threatened tariff hike with sunk entry costs, which is my main focus. For this reason, I do not include fixer per-period costs, but may wish to explore this in the future.

### 3.6.3   One-Period Delay to Begin Exporting

The primary rationale for not allowing firms to begin exporting until they have produced domestically for at least one period is so that firms can learn their productivity (which, in practice, would require one to actually produce) before deciding whether or not to enter a

given export market. If the timing of the model were changed so that firms could export immediately (but still know their productivity level when making the export decision), this would not affect the results in any significant way; it would simply change the mass of exporters to be the share of the $N + NE$ firms above the export cutoff (rather than the share of $N$), and would cause the consideration of potential export profits to appear in the entry decision equation without the time discount $(1 - \delta)$ coefficient. Under this alternate timing scenario, the proof that $\varphi_{r,s}^c(H^{(n+1)}) = \varphi_{r,s}^c(H^{(n)}) = \varphi_{r,s}^c(H^{det}) \forall n = 0, 1, 2, \ldots, \forall r, s$ will be slightly more complicated, as in this case the period $H^{(n)}$ free entry equation involving $\varphi_{r,s}^c(H^{(n)})$ will involve not only variables in future states but also state $H^{(n)}$, however, the result will continue to hold.

### 3.6.4 Economic Intuition of Constant Productivity Cutoffs in states $H^{(n)}$

As shown in Appendix B.1, under the assumption that the economy does eventually reach its steady state equilibrium, we have that the productivity cutoffs to enter a given export market remain constant once the high tariff shock arrives, despite the changes in other endogenous variables. What are the economic forces at work to maintain constant export cutoffs? First, the cutoffs are constant multiples of the aggregate economic conditions, $A_{k,r,s}(H^{(n)})$, which are themselves constant multiples of the term $Q_{k,s}(H^{(n)}) \left( \frac{P_{k,s}(H^{(n)})}{\tau_{k,r,s}(H^{(n)})} \right)^\sigma$. In this model, the tariff process is such that $\tau_{k,r,s}(H^{(n)})$ does not change with $n$ (once the high tariff shock arrives, it remains at that level forever), and so the question is how $Q_{k,s}(H^{(n)}) P_{k,s}(H^{(n)})^\sigma$ remains constant.

Looking at the two-country, one-industry results presented in section 3.5.2 as an example, we see that after the arrival of the high tariff shock imposed on region 1 imports, the price index in region 2 gradually rises as entry into production in that region becomes less valuable with the imposition of the tariff, and so the number of firms decreases as firms die and are not completely replaced by new entrants (see figure 3.3). This fall in the price index increases

Figure 3.3: Dynamics for Selected Endogenous Variables
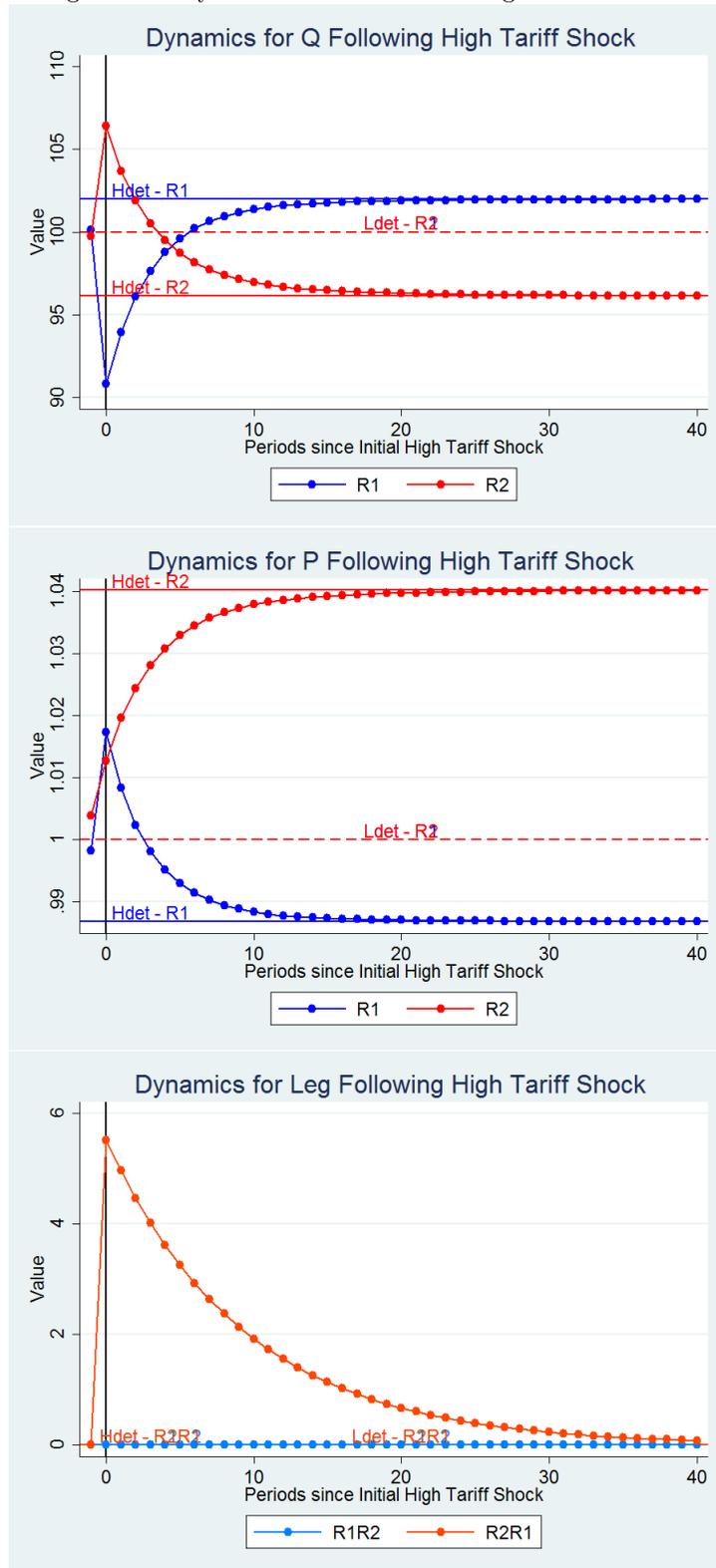
demand $Q$ so that the aggregate quantity $QP^\sigma$ remains constant. That this remains constant across periods where the tariff is not changing is a direct result of the free-entry condition and the assumption of no fixed costs to produce domestically. As conditions change over time following the arrival of of the high tariff shock, the number of new entrants into production adjusts until the value of entry into production (minus the value of waiting to enter) is exactly equal to the sunk cost of entry; because exit is entirely exogenous, this value is directly linked to the aggregate economic conditions in each country, and so the number of new entrants adjusts until $QP^\sigma$ is at its constant (over $n$ for all states $H^{(n)}$) level.

## 3.7  Robustness to Alternative Parametrization

In order to assess the sensitivity of the results presented above to the parameter values assumed, I allow several parameters to vary within a certain range, and see how this changes the magnitude of the impact of a tariff hike threat on utility, mass of exporters, and total trade value. Recall that for my assumed baseline parameters of $a = 4.6$, $\sigma = 3.8$, $\mu 0 = 0.3$, $\delta = 0.1$, $\gamma = 0.03$, the model indicated that for the 2-country, 1-industry model presented in section 3.5.1, a reversion to the non-cooperative equilibrium that was feared to occur with probability $\gamma$ in any future period had the effect of reducing each country's utility by 0.02%, the mass of exporters by 13.49%, and the value of exports by 4.55%. Below, I allow the parameters to vary between the following values: $3.6 \le a \le 5.6$, $2.8 \le \sigma \le 4.8$, $0.1 \le \mu 0 \le 0.4$, $0.05 \le \delta \le 0.5$, $0.01 \le \gamma \le 0.2$ and look at the range of percent changes in utility, mass of exporters, and total trade value implied by this range of parameters for this symmetric 2-country, 1-industry model.[15] In the graphs presented in this section, I show how variables of interest change along with a given parameter for every other possible combination of parameter values in this set, highlighting the case where all other parameters are at their baseline value. In general, I find that the results presented above are not sensitive to the assumed parameter value of $\mu 0$, somewhat sensitive

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[15] Similar graphs for other scenarios with results presented above are available upon request.
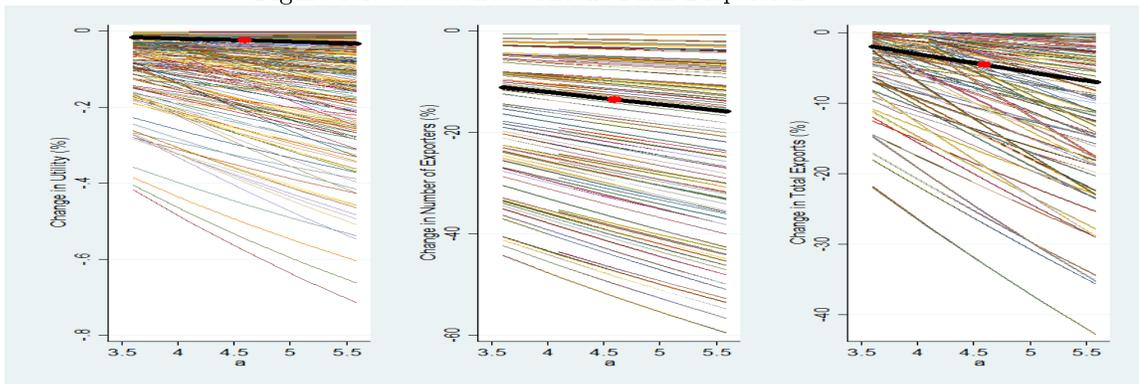
to the assumed values of $a$ and $\sigma$, and quite sensitive to the assumed values for $\delta$ and $\gamma$.

## 3.7.1 Productivity Dispersion Parameter

The Pareto parameter $a$ governs the shape of the Pareto distribution from which firm level productivity is drawn. As $a$ increases, the dispersion of firm productivity decreases such that as $a \to \infty$, we reach the degenerate distribution where all firms share the same productivity level, while as $a$ decreases, the distribution becomes closer to a uniform distribution. Figure 3.4 shows the relative change in utility, exporter mass, and trade value obtained in the symmetric model by going from a model with no tariff threat to one with a tariff hike threat, for various values of $a$, holding all other parameters constant. The black line shows these values for the set of parameter values where all other parameters are at their baseline value (the values assumed for results presented above) while the red marker on this line represents the point where all parameters (including $a$) are at these baseline values. We see that the higher the value of $a$ , that is, the more compressed the productivity distribution such that there is less dispersion in productivity, the larger the effect of a tariff threat on all three measures. For the baseline values assumed for all other parameters, allowing the Pareto shape parameter to vary between 3.6 and 5.6, we obtain relative losses in utility of between 0.02%-0.03%, in exporter mass of 11.1%-15.8%, and in trade value of 2%-7.1%.

Figure 3.5: Robustness Check: Elasticity of Substitution
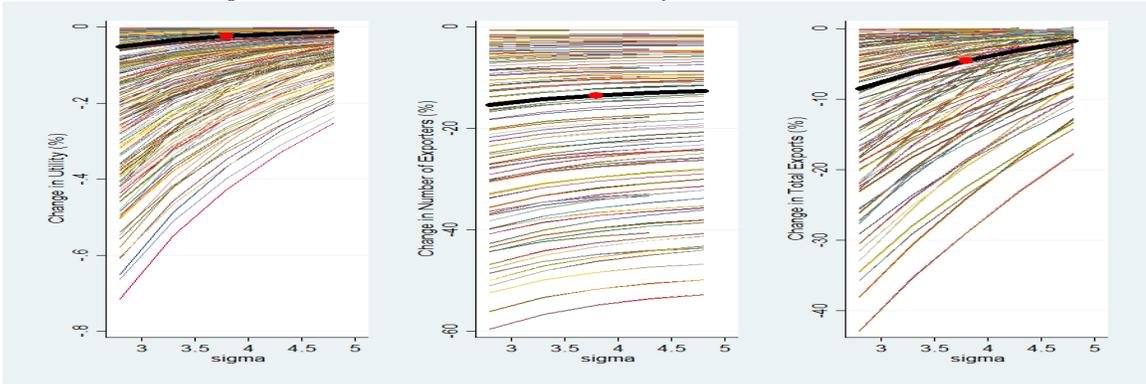


### 3.7.2 Elasticity of Substitution

The parameter $\sigma$, which governs substitutability between varieties of goods in consumers' utility function, is varied between 2.8 and 4.8. As this assumed parameter value increases, that is, goods become more substitutable, we see that there are smaller effects of the tariff threat on utility, exporter mass and total export value. Allowing all other parameters to remain fixed at their baseline values, we see that as $\sigma$ varies between 2.8 and 4.8, the decrease in utility goes from 0.05% to 0.01%, the decrease in exporter mass from 15.3% to 12.6%, and the decrease in export value from 8.5% to 1.8%.

### 3.7.3 Share of Expenditures towards Homogenous Good Sector

Here, I allow the parameter governing the share of expenditures going towards the homogenous good, $\mu 0$, to vary between 0.1 and 0.4. In general, this parameter has very little effect on the overall effect of a tariff threat for utility, and especially for exporter mass and trade value. For baseline values of other parameters, as $\mu 0$ increases from 0.1 to 0.4, the utility, exporter mass, and trade value decrease resulting from a tariff hike threat increases only very slightly in magnitude, with all exhibiting the same percent change (to one decimal place).

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Figure 3.6: Robustness Check: Expenditure Share on Homogenous Good Sector
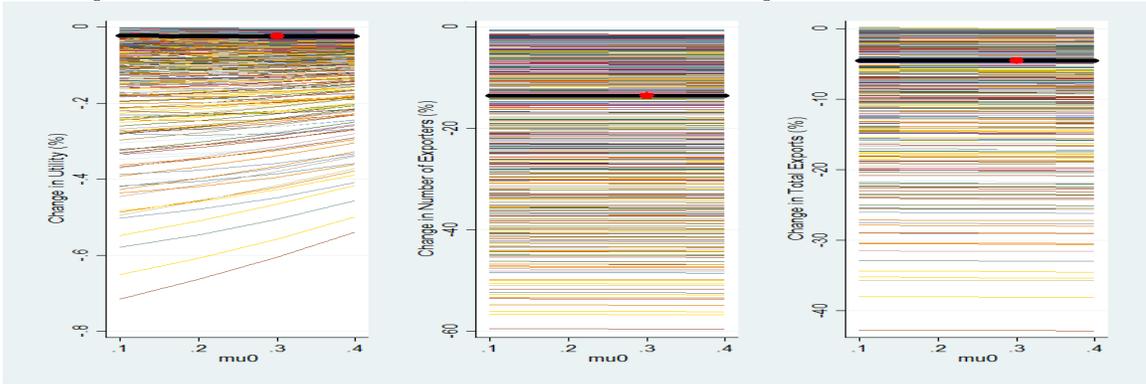


Figure 3.7: Robustness Check: Discount Factor
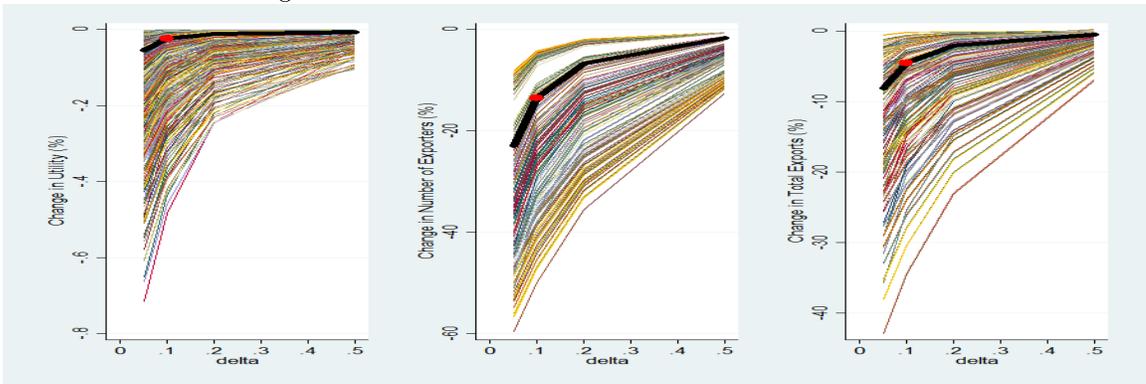


### 3.7.4 Discount Factor

The discount factor $1 - \delta$ governs the rate at which agents in the model discount future periods. For high values of $\delta$, forward looking agents (such as profit maximizing firms) place less weight on expected values in future periods, and so it makes sense that as $\delta$ increases, we see the magnitude of the effect of a tariff threat on utility, exporter mass, and export value decrease. That is, in a limiting case where $\delta \to 1$, firms making export decisions based on beliefs about the future will act just like firms in a deterministic model with fixed tariffs because they are concerned only with their profits in the current period. As I allow $\delta$ to vary between 0.05 and 0.5 (holding all other parameters constant at baseline values), I obtain a negative effect of tariff threat presence in the model of between 0.054% and 0.007% for utility, between 22.9% and 1.68% for exporter mass, and between 8.2% and 0.4% for trade value.

Figure 3.8: Robustness Check: Probability of Tariff Hike
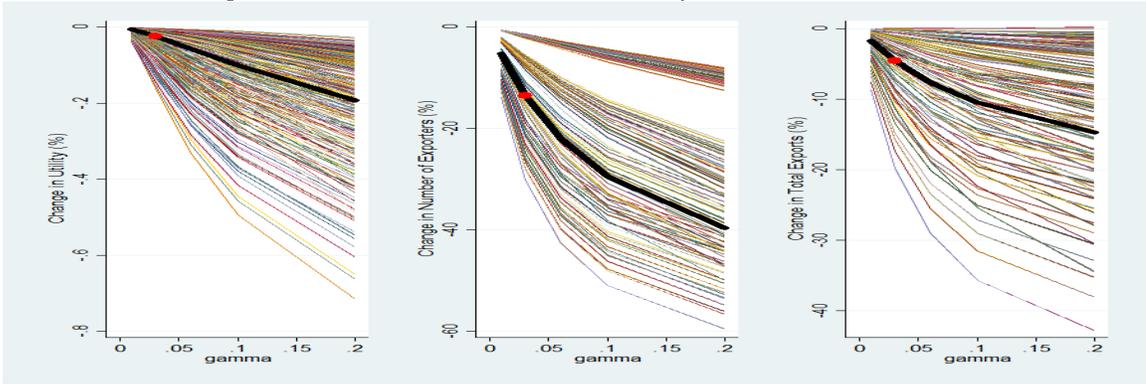


### 3.7.5 Probability of Realization of Tariff Threat

Finally, I experiment with various assumed values for $\gamma$, the parameter governing the probability with which agents believe a the tariff threat may be realized in any subsequent period. As would be expected, larger values of $\gamma$, meaning a more likely high tariff imposition, lead to a larger magnitude effect of a tariff hike threat on utility, exporter mass, and export value. Holding other parameters constant at assumed baseline values, varying $\gamma$ between 0.01 and 0.2 yields an effect of the tariff threat that reduces utility by between 0.006% and 0.193%, reduces exporter mass by between 5.3% and 39.7% and reduces export value by between 1.7% and 14.7%.

## 3.8 Conclusion

I have presented a simple multi-country, multi-industry general equilibrium model of trade with heterogeneous firms in which exporters face uncertainty over future tariff levels and must incur a sunk cost to begin exporting. In this set-up, assuming a simple Markov process for tariffs, I have shown that in a steady state equilibrium where tariffs have been at their current level for all time, the equilibrium number of firms who choose to export is lower when there exists a threat of a tariff hike on the tariff that they will face in future periods relative to the case where tariffs are deterministic and remain at current levels in all periods. For the parameter values assumed, the model finds that for a global economy with one differentiated

goods industry and two identical countries, compared with the equilibrium where tariffs are set at zero and expected to remain there forever, in an equilibrium where there exists a 3% chance that in any future period the countries will revert to the non-cooperative equilibrium (of each imposing a 19% tariff on the differentiated good sector), utility levels for each region will be lowered by 0.02%, the mass of exporters will be lowered by 13.49%, and the value of exports will be lowered by 4.55%. This corresponds to an applied tariff equivalent to generate the same utility loss of 1.3%, an applied tariff equivalent of 3.09% with respect to mass of exporters, and of 3.03% with respect to export productivity cutoff level.

# Chapter 4

# Simulating the Effect of the US-Chile Free Trade Agreement on Chilean Exporters

## 4.1 Overview

In this chapter, I present an application of the CGE model developed in Chapter 3 which incorporates the impact of tariff uncertainty faced by Chilean firms exporting to the US market. Specifically, I simulate the impact on the economy of the reduction in both applied tariff rates and tariff uncertainty experienced by Chilean firms as a result of the entry into force of the US-Chile Free Trade Agreement (FTA). This particular trade policy shock provides a good setting for examining the additional value of a computable general equilibrium model which takes into account not only applied tariff changes but also changes in uncertainty over future tariffs as this FTA reduced applied tariffs faced by Chilean exporters and the threat of future tariff shocks. Prior to implementation of the US-Chile FTA, Chilean exporters benefited from unilateral trade preferences into the United States under the Gen-

eralized System of Preferences (GSP) which allowed for duty free treatment of selected goods, however, these preferences were not permanent, and were subject to suspension at the discretion of the United States. With the entry into force of the US-Chile FTA, in addition to several applied tariffs being lowered, preferential tariffs which were previously subject to unilateral revocation at any time became arguably more certain. The general equilibrium model developed in the previous chapter is calibrated using trade, tariff, and firm data from the year 2006 and then solved in both cases with and without the threat of preference loss for Chilean exporters in order to evaluate the additional effect in the model beyond liberalizing tariffs of guaranteeing preferences. For certain parameter assumptions, I find that a model without the tariff threat effect predicts that Chilean exports to the United States will increase by 49.40%, the number of exporters will increase by 8.91% and utility for Chile will increase by 0.057% as a result of the FTA, while the model with the effect of a tariff threat predicts that exports will increase by 53.41%, the number of exporters by 15.26% and utility by 0.064%.

This chapter is organized as follows: Section 4.2 reviews related literature, Section 4.3 provides background on US-Chile trade and trade policy, Section 4.4 presents some reduced form evidence motivating the application, Section 4.5 summarizes the key features of the theoretical model, Section 4.6 describes the data used as well as the calibration methodology, Section 4.7 presents the results of the simulation and compares with data, Section 4.8 discusses the sensitivity of the results to various assumptions as well as the possible reasons for discrepancies with observed data, and Section 4.9 concludes.

## 4.2   Related Literature

Prior to the implementation of the Chile-US FTA, several studies using Computable General Equilibrium (CGE) models were conducted in attempt to quantify the probable effects of this and related agreements, including Brown et al. (1995) , Harrison et al. (1997), and USITC (2003). The latter two models employed in these studies assume constant returns

to scale while Brown et al. (1995) includes monopolistic competition and allows for variety effects of trade liberalization, however none include firms heterogeneous in productivity as in the Melitz model. Furthermore, these studies quantify the expected impact of certain trade agreements based on the level of applied tariff liberalization and do not address any potential impact via reduction of trade policy uncertainty, as I do in this dissertation.

One closely related study to the application presented in this chapter is Handley and Limão (2012) in which the authors analyze the impact on trade from the accession of Portugal to the EC in 1986. Employing a heterogeneous firms framework similar to that in the model presented in Chapter 3, they find that despite very little change in applied preferences to the European market, Portuguese exports to Europe increased substantially as a result of the accession, and they show empirical support for a model in which the accession increases export incentives by decreasing trade policy uncertainty. Unlike the model presented here, however, the model in Handley and Limão (2012) does not include endogenous determination of the number of producing firms and general equilibrium effects. Furthermore, the focus in their study is on the effects of the accession on Portugal. While I primarily focus on the trade and welfare effects of the Chile-US FTA for Chile, I am also able to assess the impact of the agreement on countries not party to the agreement.

## 4.3  Background on Chile-US Trade

### 4.3.1  Trade Patterns

For most of the first half of the period from 1997 to 2013, the United States represented the largest export market by value for Chilean exports, followed by Japan and China. From 2007 on, China has overtaken as the largest export market, followed by the US, Japan, Brazil and Korea. The largest export sector by value throughout the period is metals, followed by minerals and then vegetables, wood, food products, animals, and chemicals. Considering only export flows to the United States, metals became the largest sector after 2004, while

prior to this metals and vegetables alternated for the top position, followed closely by wood and animal products.

## 4.3.2 History of US Tariff Preferences for Chile

The United States Generalized System of Preferences (GSP), a set of unilateral trade preferences afforded to developing countries by the United States, was first enacted in 1976, at which time Chile was included in the list of designated beneficiary countries. GSP provides duty free treatment for selected goods, including most manufactured products as well as select agricultural products. Because these preferences are extended unilaterally by the United States and for a fixed time period, they are arguably viewed by exporters as uncertain, in that they may expire or be revoked. In a June 2003 interview with Bloomberg Businessweek, Osvaldo Rosales, director of international economic relations at Chile's Foreign Relations Ministry stated:

> "Under the Generalized System of Preferences (GSP), many Chilean products [already] entered the U.S. with zero tariff, but GSP is a voluntary, unilateral mechanism that can be revoked. Under this new trade agreement, all of those products will have permanent zero tariffs. That permanence changes our investment panorama radically."[1]

In fact, Chile's GSP beneficiary status was revoked by the United States in 1988 for failure to satisfy workers' rights conditions, and was reinstated three years later. Negotiations for a bilateral agreement between Chile and the US began in the early 1990s, and aspirations to add Chile as a member party to NAFTA during the Clinton administration failed to be realized when the president was unable to get "Fast-Track" authority from Congress to negotiate a deal.[2] On August 1, 2002, the U.S Senate granted fast-track authority to President George W. Bush, paving the way for a deal to be negotiated with Chile. On

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[1] See O'Connell (2003)

[2] "Fast-track" or Trade Promotion Authority (TPA) grants the executive branch of the US government the ability to negotiate trade deals and them submit them to Congress for an up-down vote, without allowing Congress to amend the agreement.

December 11, 2002, the U.S Trade Representative Robert Zoellick announced that such an agreement had been reached, and by late January 2003, President Bush had signaled his intention to sign the agreement within 90 days.

On January 1, 2004, the US-Chile Free Trade agreement went into effect, thus replacing GSP preferences for Chilean exports to the United States with the equal or better preferences allowed under the FTA. The preferences afforded under the bilateral free trade agreement are arguably more certain than those under the GSP program as unlike GSP, the program has no expiration date and cannot be unilaterally revoked by the United States. Though it does contain conditionalities similar to those found in GSP (for example, minimum workers' rights policies), in the event of a violation, the agreement triggers a bilateral dispute settlement mechanism, rather than allowing one party to withdraw from the agreement. The tariff free treatment on bilateral trade flows agreed to under this FTA is phased in over a period of 12 years, so that it is not until 2016 that zero tariffs on substantially all goods will be realized. However, as shown below in table 4.1, by 2006 (the post-FTA year for which data is fed into the model), most sectors have US tariffs for Chilean exports equal 0 to zero.

The free trade agreement with the United States is not the only FTA in force for Chile; indeed there are many others. In the simulation presented in this chapter, I focus primarily on the effect of the implementation of the US-Chile agreement. For the period of time under consideration (the few years prior to and several after the implementation of the US-Chile FTA), there are other major trading partners with whom Chile enters into an FTA, most notably the European Union, which implements an FTA with Chile in 2003, and China, which implements an FTA with Chile in 2006 and goes on to become Chile's largest trading partner thereafter. This is important to keep in mind when interpreting the simulation results below; though the applied tariffs resulting from these other FTAs are included in the model when calibrating on 2006 data, the simulated equilibria in 2001 (with CHL-USA tariff uncertainty and without) do not account for any tariff uncertainty faced by Chilean exporters to non-US markets at the time.

Table 4.1 presents both the applied tariffs pre and post FTA agreement that governed Chilean exports into the US as well as the MFN tariffs in place prior to the FTA, which I treat as the tariff "threat" level to which tariffs would revert in the event that unilateral GSP preferences to Chile are revoked by the United States. This is the relevant "threat" level because in the event that GSP preferences were taken away, the US would still be bound under WTO rules to apply the same tariffs offered to all other non-preferential WTO partners to Chile; these common tariffs are the "Most-Favored Nation" or MFN tariffs. The tariff levels presented here represent "effectively applied tariff rates" as computed by TRAINS, which means that these tariff rates take into account the actual preference program under which a product enters the US market.[3] These are the sector-level tariff rates which are later fed into the general equilibrium model.[4]

### 4.3.3 Use of Preference Schemes by Chilean Exporters to US

In figure 4.1, we can see the breakdown by preference scheme of imports from Chile into the US in terms of value. Use of GSP was fairly consistent over the period until it was replaced by the Chile-US FTA preferences in 2004. After the implementation of this FTA, the value of trade flows from Chile to the US increased dramatically until 2006, after which there was a sizable contraction in trade during the global recession, and then by 2011 trade flows appear to have recovered to their pre-recession levels. We see that the increase in trade following implementation of the Chile-US FTA does appear to be driven by an increase

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[3]That is, were I instead to report the trade-weighted averages of GSP tariffs in 2001, this may under-report the actual tariff faced by exporters, as some products which qualify for GSP based on the product code may not actually enter under GSP for a variety of reasons including administrative barriers faced by the exporter, or failure to meet Rules of Origin requirements. See table C.2 in Appendix C.3 for a comparison of the two tariff aggregation methods.

[4]In general, applied tariffs remain the same or are lowered by the implementation of the FTA, even prior to full implementation. There are however several exceptions to this. The applied tariff on Base Metals for Chilean exports to the US is actually higher in 2011, under the FTA, than the effectively applied tariff in 2001. This is mainly due to the tariffs being reported as their effectively applied rates across the sector, such that if tariffs don't change greatly between the two years but products with higher tariffs represent a larger share of the import basket, the tariff will appear to increase. There are, however, also specific products for which applied tariffs under the FTA during the phase-in period are in fact higher than was the case in 2001 under GSP. Examples of this include, in the Plastics sector, products 40112010 and 40111010, certain pneumatic rubber tires which had received tariff free treatment under GSP, exhibited a tariff of 4% in 2006, the MFN level. In the vegetable products sector, tariffs on Avocados were also raised well above GSP levels (and in fact higher that 2001 MFN levels, as the MFN levels were also increased) during phase-in years of the agreement.

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Table 4.1: US Tariffs on Chilean Exports

| Section | SectionName | Effectively Applied Tariff in 2001 | MFN Tariff in 2001 | Effectively Applied Tariff in 2006 | Share of Chile-US Exports, 2006 |
|---|---|---|---|---|---|
| 1 | Live Animals | 0.2% | 0.5% | 0.1% | 9.8% |
| 2 | Veg Products | 0.8% | 1.0% | 0.7% | 15.2% |
| 3 | Fats and Oils | 0.2% | 3.8% | 0.0% | 0.0% |
| 4 | Prepared Food | 1.6% | 2.7% | 2.2% | 4.0% |
| 5 | Minerals | 0.7% | 0.3% | 0.1% | 4.4% |
| 6 | Chemicals | 0.0% | 2.1% | 0.0% | 2.8% |
| 7 | Plastics | 0.1% | 3.8% | 1.3% | 0.8% |
| 8 | Hides and Skin | 1.8% | 6.3% | 0.6% | 0.0% |
| 9 | Wood | 0.3% | 1.1% | 0.0% | 11.0% |
| 10 | Pulp | 0.0% | 0.3% | 0.0% | 0.5% |
| 11 | Textiles | 15.0% | 17.4% | 0.0% | 0.4% |
| 12 | Footwear | 6.2% | 7.7% | 0.7% | 0.0% |
| 13 | Stone/Ceramics | 0.0% | 3.7% | 0.1% | 0.4% |
| 14 | Precious Stones/Metal | 0.0% | 0.0% | 0.0% | 4.5% |
| 15 | Base Metals | 0.8% | 0.9% | 0.0% | 45.1% |
| 16 | Machinery | 0.0% | 1.3% | 0.0% | 0.5% |
| 17 | Vehicles | 0.0% | 1.0% | 0.0% | 0.1% |
| 18 | Precision Instruments | 0.0% | 1.4% | 0.0% | 0.0% |
| 19 | Arms and Ammunition | 0.0% | 0.0% | 0.0% | 0.0% |
| 20 | Misc. Manufacturing | 0.0% | 0.0% | 0.0% | 0.5% |

Source: TRAINS effectively applied tariff data, including AVEs computed using UNCTAD method 1.

Figure 4.1: US Imports from Chile by Preference Scheme
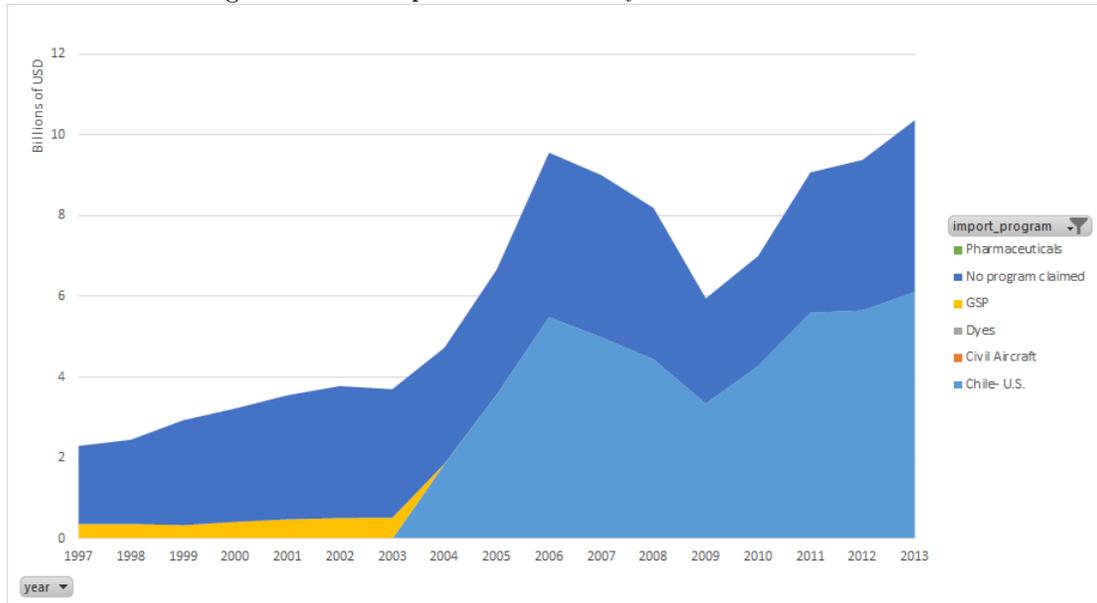


Source: US International Trade Commission.

in trade of products that receive preferential treatment under the FTA. See figure C.1 in Appendix C.1 for a breakdown of preference use by number of products traded.

In order to get a sense of how important preferences were at the sector level under GSP and later under the Chile-US FTA, figure 4.2 presents the share of Chile-US exports in 2001 that entered under GSP and the share in 2006 that entered under the Chile-US FTA for each sector. The sectors for which the largest share of Chilean exports to the US market enter under GSP preferences in 2001 are Plastics, Stone/Ceramics, Fats and Oils, Hides and Skins, and Chemicals. For each of these sectors, the share of of goods entering under GSP is over 60% (see figure 4.2) and in each of the top three sectors, preferences continue to be heavily used under the FTA in 2006. Thus, these are the sectors in which I might expect to see a substantial effect of the reduction tariff uncertainty implied by the FTA. In other sectors, such as Textiles, Minerals, and Base Metals where use of the FTA preferences are much larger than the use of GSP preferences, I would expect the FTA to have an effect mainly via applied tariff reduction, and less so via uncertainty reduction. For the analogous graph showing preference use in each sector by value rather than share, see figure C.2 in Appendix C.1.

Figure 4.2: US Imports from Chile by Preference Scheme
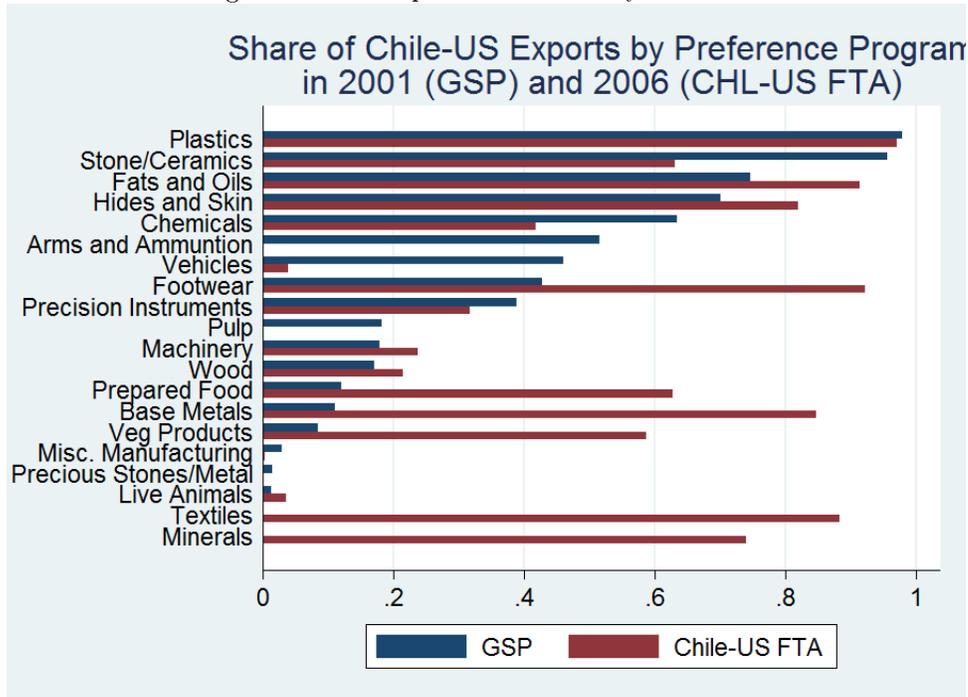


Source: US International Trade Commission.

### 4.3.4 Firm Level Trade Patterns

From 2003 until 2009, the United States represented the largest export destination for Chile both in value and number of exporters. In 2007, China surpassed the US as the largest export market by value. After the US, Peru, Argentina, and Bolivia represent the markets with the largest number of Chilean exporters over this period.[5] Figure 4.3 presents the number of firms exporting from Chile to the US in sectors with an average of over 150 exporters in each year. We see that the largest export sectors by firm count are Vegetable Products, Machinery and Electronics, and Prepared food, and that most sectors experienced a noticeable increase in number of exporters around 2002, the year in which it was announced by the US Trade Representative that an agreement for a Free Trade Agreement with Chile had been reached.

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[5]Source: Exporter Dynamics Database, World Bank.

Figure 4.3: Chilean Exporters to USA by Sector
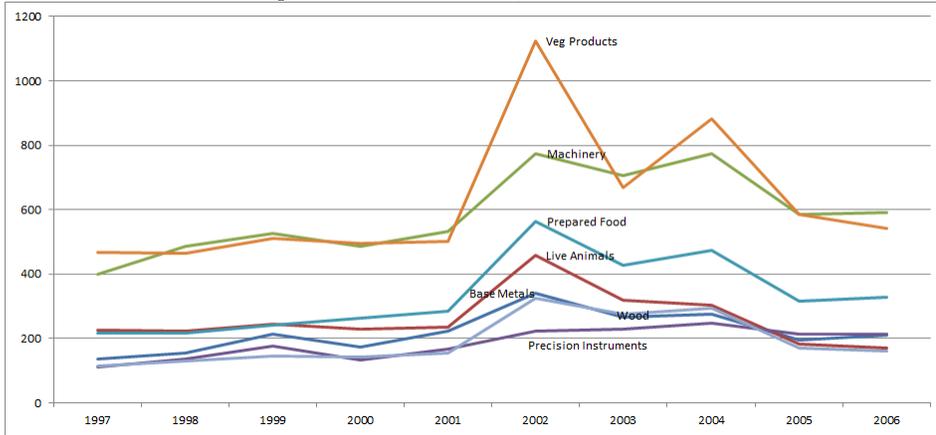
Source: Aduenas Chile

## 4.4 Reduced Form Evidence

In order to motivate the inclusion in a general equilibrium model of the tariff uncertainty reducing effect for Chile of entering into a bilateral FTA with the United States, I present here some reduced form evidence that this effect exists. Looking first at trade flow values of Chilean exports to all export destinations over the period of time from 1997 to 2013, I run a simple difference in difference regression, controlling for year and importer specific effects, on the increase in trade value between 1997 and each year, including a binary explanatory variable indicating whether or not Chile had entered into a free trade agreement with the partner country in the given year. That is, I implement the following specification:

$$\Delta LogExports_{t,s} = \beta_o + \beta_t + \beta_s + \beta_{FTA}FTA_{t,s} + \epsilon_{t,s}$$

where $FTA_{t,s}$ is a binary indicator equal to one if a free trade agreement is in force in year $t$ between Chile and country $s$.

Columns (1) and (2) of table 4.2 present the results of this regression (1), as well as a second specification (2), where indicators for years one and two years prior to the implementation of the FTA are also included. These lags are included because in some cases, expectations that a free trade agreement will be implemented in the near future may be high in the years just before implementation; it is conceivable that one might see an effect on trade in these years. Here, we do not see any significant effect on log trade value of having

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Table 4.2: Regression Results: FTA Impact on Trade

| Dependent Var: | Change in Log Export Value | | Change in Log No. Exporters | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Year | 0.158*** | 0.159*** | 0.0619*** | 0.0549*** |
| | (0.00563) | (0.00577) | (0.00580) | (0.00594) |
| FTA | -0.147* | -0.0795 | 0.273*** | 0.0284 |
| | (0.0819) | (0.138) | (0.0685) | (0.0981) |
| FTAlag1 | | -0.0177 | | 0.116 |
| | | (0.178) | | (0.118) |
| FTAlag2 | | -0.0892 | | 0.297*** |
| | | (0.138) | | (0.0940) |
| Constant | -315.8*** | -318.1*** | -123.7*** | -109.6*** |
| | (11.29) | (11.56) | (11.61) | (11.89) |
| | | | | |
| Observations | 2,021 | 2,021 | 1,572 | 1,572 |
| R-squared | 0.754 | 0.754 | 0.669 | 0.675 |

Standard errors reported in parentheses; significance reported as *** p<0.01, ** p<0.05, * p<0.1

entered into an FTA with Chile (except for a negative effect in the first specification).[6] This seems to be driven by the smaller exporters to Chile; re-running these two specifications weighted by trade value yields a positive significant effect in the year that the FTA is implemented, both in the specification with and without indicators for years leading up to the FTA implementation (see Appendix C.2). I interpret this as indicating that there does seem to be a positive significant effect of having an FTA on trade flows to Chile, but this effect seems to be present only for large trade partners. Further, the fact that this effect appears only once the FTA is implemented, rather than prior to implementation, seems to indicate that the increase in trade flow values provide evidence of an effect of the FTA via applied tariff but not necessarily through a reduction in tariff uncertainty. The two specifications are now repeated using the log number of exporting firms from Chile as the dependent variable rather than the log trade flow value, with the results reported in columns (3) and (4) of table 4.2. Here, there appears to be a positive significant effect on the number of exporters to a given destination of having a FTA in force, and in this case, including indicators for

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[6]Note that the indicator FTAlagn is equal to 0 more than n years prior to the implementation of an FTA and equal to one in all other years. Thus, a positive significant effect on FTAlag2 but no significant effect on FTAlag1 (as in the case of results in column (4)) does not mean that there is no positive effect on exporters in the year prior to FTA implementation, rather, it means that there is no *additional* effect in this year beyond the effect of being in year FTAlag2 or later. Several alternate specifications with more FTA lag years and/or post-FTA year indicators were also run; none yielded any significant effect of any post FTA year or pre-FTA years farther than 2 years prior to implementation.

one and two years preceding the official implementation of an FTA, we see that the effect on exporters occurs two years in advance of the official implementation. Together, these results seem to indicate a strong effect on the extensive margin of exporting two years prior to an FTA being officially implemented, with a strong effect on the intensive margin (for large trade partners) once the agreement has gone into force.

Of course the results presented in 4.2 are merely suggestive, and do not disentangle the effect on trade of an FTA via applied tariff liberalization and tariff uncertainty reduction. To focus more on this effect and on the FTA between Chile and the US specifically, I present here the results of another simple specification where each observation is now the change in log export value (or change in log number of exporters) from Chile to the United States in a given sector year relative to the base year, 1997. Including year and sector specific effects, I now include as well the applied tariff level and a binary indicator for whether the FTA was in force in the given year interacted with the share of exports for the given sector that entered the US under GSP preferences in 2001. That is, I implement the following specification:

$$\Delta LogExports_{t,k} = \beta_o + \beta_t + \beta_k + \beta_{FTAGSP} FTA_t * GSPshr_k + \epsilon_{t,k}$$

where $k$ indexes sector, $t$ time, and $GSPshr_k$ is the share of sector $k$ exports from Chile to the US that entered under GSP preferences in year 2001. The motivation for this regression is that the tariff should capture all of the applied liberalization effects of the FTA, while any additional tariff uncertainty reducing effect should be strongest in sectors where GSP (the uncertain preferences) was important. Table 4.3 presents the results of this specification. Although the interacted FTA*GSPshare has a positive estimate, the standard error is large. We also see that the tariff variable points to a problem of endogenous tariff levels; higher tariffs here correspond to larger export values, reflecting a tariff increasing behavior by the United States for sectors with increased imports from Chile.

Columns (3) and (4) of table 4.3 present the results of this regression where the dependent variable is now the log change in number of exporting firms. We see again here that there

Table 4.3: Regression Results: Chile-US FTA Impact on Trade

| Dependent Var: | Change in log Export Value | | Change in log No. Exporters | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Year | 0.0539*** | 0.0560*** | 0.0497*** | 0.0363*** |
| | (0.0119) | (0.0123) | (0.00915) | (0.00975) |
| tariff | 0.0448* | 0.0470* | 0.00921 | 0.00294 |
| | (0.0254) | (0.0256) | (0.0116) | (0.0113) |
| FTA*GSPshr | 0.213 | 0.194 | -0.169 | -0.235* |
| | (0.229) | (0.391) | (0.105) | (0.137) |
| FTAlag1*GSPshr | | 0.347 | | -0.186 |
| | | (0.504) | | (0.163) |
| FTAlag2*GSPshr | | -0.423 | | 0.467*** |
| | | (0.388) | | (0.132) |
| Constant | -107.8*** | -112.0*** | -99.14*** | -72.41*** |
| | (23.92) | (24.60) | (18.31) | (19.51) |
| | | | | |
| Observations | 315 | 315 | 176 | 176 |
| R-squared | 0.751 | 0.752 | 0.659 | 0.687 |

Standard errors reported in parentheses; significance reported as *** $p<0.01$, ** $p<0.05$, * $p<0.1$

appears to be a large, significant effect on the number of exporters not in the year the FTA is implemented, but rather two years prior to this, in sectors where GSP preferences are heavily used. In the case of the Chile-US FTA, FTAlag2 goes from zero to one in year 2002. That this would be the year in which we see the largest effect on exporters concerned about the uncertainty of GSP preferences makes sense, as this was the year in which the US Trade Representative announced that an agreement had been reached, and in which the President obtained "fast-track" authority to sign such a deal, thus rendering the probability of the agreement much higher (see section 4.3.2).

## 4.5  Model

In order to simulate the effects of this particular Free Trade Agreement in a framework comparable to the CGE framework commonly used to assess the direct impact of FTAs via applied tariff reduction, I construct a general equilibrium model of trade between four regions where firms, which are heterogeneous in productivity in a Melitz-type framework, observe current tariff levels and have some expectations about future tariff draws. In the context of this example, prior to the FTA, Chilean firms that export to the US receive

preferential treatment under GSP for certain products, however, they have the expectation that in each period for which the preferences persist, there is a probability $\gamma$ that the GSP preferences will be unilaterally revoked by the US, in which case the tariffs faced will be given by the MFN tariff rate for the given product. The entry into force of the Chile-US FTA in this model will generate increased trade due to the reduction in applied tariffs as well as through the elimination of uncertainty over future tariff levels for Chilean exports to the US. For details on the model I have mind, please refer to Chapter 3.

## 4.6   Data

In order to calibrate the model, I use a variety of data sources on trade, tariffs, firm level exports and macro economic statistics. All raw data (unless otherwise noted) are obtained in the Harmonized System nomenclature for traded products and are then aggregated up to the sector level, where each sector contains one or more HS2 chapters and is defined according to the 21 standard sections.[7] The model is calibrated using year 2006 data and so the simulated equilibrium in year 2006 will be identical to reported data in year 2006. Given the parameters of the calibrated model, the equilibrium values of endogenous variables are solved for in year 2001 in both a model where there exists a threat of a future tariff hike and one without. Given these equilibrium values, in the results presented in the next section, I compare the difference between 2001 and 2006 values of endogenous variables produced by the model with a tariff threat to that without.

### 4.6.1   Trade and Tariff Data

Trade and tariff data is downloaded from Comtrade and TRAINS respectively via WITS. Trade values are simply summed up to the sector level while applied tariff data is the "Effective Applied Tariff" as reported in WITS at the HS2 level, then aggregated to the sector level

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[7]For a list of these sections, see http://hts.usitc.gov/. Throughout the analysis, I drop sector 21 "Works of Art", as this does not seem to fit well into the differentiated manufactured good model I have in mind.

using bilateral trade weights.[8] MFN tariffs for the United States in year 2001, as reported at the HS2 level in WITS, are aggregated up to the sector level using trade flow weights. These are the tariff "threat" levels faced by Chilean exporters prior to implementation of the Chile-US FTA.[9]

### 4.6.2 Firm Level Data

I obtain customs data from Aduenas Chile which provides the HS6 code, destination country, and firm id for firms exporting from Chile over the period from 1997 to 2006.[10] In order to obtain a count of the number of firms exporting from the other three regions in each sector, I make the assumption that the sector specific average value exported per firm, as computed from the customs data for Chilean exporters in each sector to the ROW region, is the same for each bilateral flow. I then use the value of each trade flow, as reported by Comtrade, to obtain a count of the number of exporting firms.

Next, to get the number of producing firms in each sector-region, $N_{k,r}$, I divide the number of exporters to ROW, $M_{k,r,ROW}$ by the share of firms in the given country-sector that export, $ShExp_{k,r}$. For USA, data for this share parameter is taken from Bernard, Jensen, Redding and Schott (2007), which provides the share of US firms by NAICS industry that are (either direct or indirect) exporters in year 2002. For Chile, I take the share of exporting firms by sector in 2007 (the most recent year available) from Pellandra (2013) which reports these as descriptive statistics computed using data from the manufacturing survey Encuesta Nacional Industrial Anual (ENIA) and administrative customs data. For

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[8]As an alternative to the effective applied tariff, I have also aggregated tariff line level applied tariffs for CHL-USA flows where the applied tariff is taken to be the minimum of any preferential tariffs and the MFN tariff on a given tariff line and aggregated up to the sector level using bilateral trade flows as weights. The two methods can yield somewhat different applied tariff levels at the sector level, due to the fact that the latter assumes that the applied tariff is the lowest reported tariff for the given product, while in reality some products that appear to qualify for preferential treatment may fail to do so because of rules of origin, or exporters may choose not to use the preferential tariff due to administrative barriers. For this reason, I use the effective applied tariff as the applied tariff level fed into my model. For most sectors, this does noes not make a large difference, with the exception of Sector 1, Live Animals., and to a lesser degree, Sector 4, Food Products. See Table C.2 in Appendix C.3 for a comparison of the sector level tariff found using each aggregation method.

[9]See the last paragraph of section 4.3.2 for an explanation of why this is the relevant "threat" tariff.

[10]Thank you to Ricardo Espinoza, a graduate student at University of Maryland, for providing access to this data.

Mercosur, I use the share of exporting firms by sector for Brazil as reported in the World Bank Enterprise Survey for 2009.[11] Finally, for the share of ROW firms that export, I assume that 5% of firms in each sector export to the United States. Generally, because the ROW region contains all countries apart from USA and Chile, one would expect a substantially lower share of total firms to export to one particular destination relative to the share of firms who export at all. This is why I assume a low value for the share that export to the US. Note that such a small percentage of firms exporting to a particular destination is equivalent to assuming a very high calibrated fixed cost to export from ROW to either of the other two regions. This is sensible given that taking ROW as one aggregate region in this set-up, one would expect that the cutoff to export to either of these two specific regions is sufficiently high up the distribution that general equilibrium changes in this cutoff resulting from a change in the CHL-USA tariff schedule will be relatively small. Indeed, when the cutoff is high, we are on a relatively flat portion of the Pareto distribution, and so an assumption of a small number of exporters to USA or CHL from ROW relative to the total number of producers in ROW leads to this sensible prediction.

Table 4.4 lists the data used to calibrate the model and the source for each, while the following subsections detail the methodology used in computing certain parameters.

### 4.6.3 Parametrization and Calibration

The parameter values governing the Pareto distribution of firms, the elasticity of substitution and the discount factor are all taken from Balistreri and Rutherford (2012), who in turn draw from a variety of other sources in the literature. As shown in Chapter 3, the results of a given simulation may be sensitive to these parameter values (see Section 3.7).

Normalizing all prices in the base year to $P = 1$, I am able to calibrate the deterministic version of my current model using the data and parameters as given in Table 4.4; that is, I can extract the preference, fixed and sunk cost, and input stock (Labor) parameters using

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[11] See www.enterprisesurveys.org.

Table 4.4: Data and Sources for Model Calibration

| Parameter | Description | Source/Methodology |
|---|---|---|
| $vx0_{k,r,s}, r \neq s$ | fob export value for sector $k$ exports from $r$ to $s$ in base year | Comtrade |
| $\tau_{k,r,s}$ | 1+ad valorem applied tariff in $s$ for sector $k$ imports from $r$ | TRAINS (effective applied tariff and reported MFN) |
| $M0_{k,r,s}$ | number of sector $k$ firms in $r$ exporting to $s$ in base year | Aduenas Chile data for CHL, assumption using \$/firm for all other bilateral flows |
| $GDP0_r$ | GDP of country $r$ in base year | WDI |
| $N0_{k,r}$ | number of sector $k$ firms operating in $r$ | Using M0 and data on share of firms that export [USA-Bernard et al. (2007); CHL-Pellandra (2013); MERC - World Bank Enterprise Survey for Brazil; ROW-assume 5%] |
| $\mu0_r$ | share of total expenditures going towards the homogeneous goods sector in country $r$ | assumed = 0.3 |
| $\mu_{k,r}$ | share of total expenditures going towards sector $k$ in country $r$ | Proxied by import value shares in year 2006 (Comtrade) |
| $a$ | Pareto shape parameter | assumed = 4.6 (see section 4.6.3) |
| $b$ | Lower bound on productivity | assumed = 0.5 (see section 4.6.3) |
| $\sigma$ | Elasticity of Substitution | assumed = 3.8 (see section 4.6.3) |
| $\delta$ | Exogenous Death Rate | assumed = 0.1 (see section 4.6.3) |

equations that follow from the equilibrium conditions.[12] A list of these equations is given in Appendix C.6.

The parameter value for $\gamma$ used in the simulations below is chosen by minimizing an objective function based comparing simulated to actual trade changes between Chile and the US. The first is based on the sector-wise percent increase in number of exporters from Chile to the US, while the second is based on the sector-wise percent increase in trade value. In the first case, $(\gamma, \delta)$ is chosen to minimize the sum over all sectors of the square of the difference between the observed increase in the log number of exporters and the simulated log increase in the number of exporters. That is, the model is solved repeatedly for various

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[12]Were this exercise actually being conducted prior to the implementation of the FTA, such that post-FTA data was not available for calibrating the model, one would have to use pre-FTA year data for calibration. The calibration equations listed in Appendix C.6 assume that the data comes from a deterministic steady state where applied tariffs are expected to remain the same forever. This is why I use a post-FTA year to calibrate the model, as I assume that these tariffs are expected to remain in place forever. If one did not have access to post-FTA year data, the model could theoretically only be calibrated, taking into account the uncertainty over future tariffs, by using calibration equations taken from the full model with uncertainty in Chapter 2, however, doing so would require data on the equilibrium values of trade flows and firm numbers in the hypothetical "High tariff" state, which will generally not have been realized (at least in the case of the Chile-US FTA). Thus, in order to implement the type of analysis done here prior to the implementation of an FTA, a reasonable approximation for model parameter values may be those obtained by calibrating using pre-FTA year data, assuming that tariffs are deterministic and not expected to change.

values of $\gamma$ between 0 and 1 and $\delta$ between 0 and 1, and then using the results of each simulation, I compute

$$\Delta_M \equiv \sum_k (Minc_{k,CHL,USA} - Msiminc_{k,CHL,USA})^2 \qquad (4.1)$$

where

$$Minc_{k,CHL,USA} = \frac{1}{5} \sum_{y=1997}^{2001} [\ln(M_{k,CHL,USA,2006}) - \ln(M_{k,CHL,USA,y})]$$

is approximately the average (over years $y = 1997 - 2001$) percent increase in the number of Chilean exporters to the US in sector $k$ between years $y$ and 2006 as observed in the customs data, and

$$Msiminc_{k,CHL,USA} = \frac{1}{5} \sum_{y=1997}^{2000} [\ln(M_{k,CHL,USA,2006}) - \ln(Msim_{k,CHL,USA,y})]$$

is the average percent increase between the steady state equilibrium value of the number of exporters from Chile to the US in sector $k$ in the steady state where tariffs are at level "L" (that is, GSP preferences are in place as reported in year $y$) and there exists a $\gamma$ probability each period of tariffs being permanently set to MFN levels versus the simulated steady state under the Free Trade Agreement (which will be the equilibrium in a state where all US $<->$ Chile trade flows are subjected to zero tariffs while all other trade flows are subject to the applied tariff rate that was in force in pre-FTA year $y$).

To compute the parameter values for $\gamma$ and $\delta$ which most closely match trade data, the analogous objective function, $\Delta_{vx}$ is minimized where

$$\Delta_{vx} \equiv \sum_k (VXinc_{k,CHL,USA} - VXsiminc_{k,CHL,USA})^2 \qquad (4.2)$$

where $VX$ stands for value of exports,

$$VXinc_{k,CHL,USA} = \frac{1}{5} \sum_{y=1997}^{2001} [\ln(VX_{k,CHL,USA,2006}) - \ln(VX_{k,CHL,USA,y})]$$

is approximately the average (over years $y = 1997 - 2001$) percent increase in the value of Chilean exports to the US in sector $k$ between years $y$ and 2006 as observed in the customs data, and

$$VXsiminc_{k,CHL,USA} = \frac{1}{5} \sum_{y=1997}^{2000} [\ln(VX_{k,CHL,USA,2006}) - \ln(VXsim_{k,CHL,USA,y})]$$

Figure 4.4: Choice of $\gamma$ Parameter
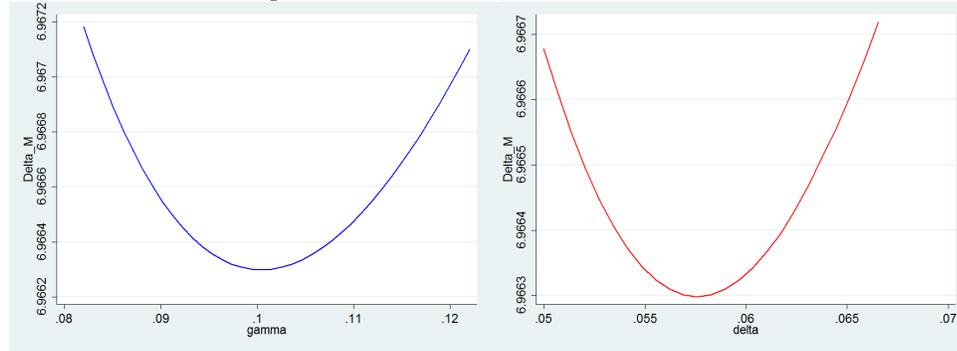


is the average percent increase between the steady state equilibrium value of exports from Chile to the US in sector $k$ in the steady state where tariffs are at level "L" (that is, GSP preferences are in place as reported in year $y$) and there exists a $\gamma$ probability each period of tariffs being permanently set to MFN levels versus the simulated steady state under the Free Trade Agreement (which will be the equilibrium in a state where all US <-> Chile trade flows are subjected to zero tariffs while all other trade flows are subject to the applied tariff rate that was in force in pre-FTA year $y$).

Figure 4.4 shows the values of $\Delta_M$ plotted for various values of $\gamma$, given that $\delta = 0.0571$ and various values of $\delta$, given that $\gamma = 0.0998$.[13] The values of $\gamma$ and $\delta$ which yield a simulation output with increases in the number of exporters closest to those observed in the data is $\gamma = 0.0998$, $\delta = 0.0571$, while the value which minimizes the criteria based on export value from Chile to the US is $\gamma = 1$, $\delta = 0.06$.[14] In the simulation results presented below, parameter values of $\gamma = 0.0998$, $\delta = 0.0571$ are assumed. I note that these are not econometric estimates of the true parameter values, but rather each is a parameter that I have crudely backed out of my general equilibrium model by minimizing (4.1). In

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[13]These values were found numerically by simulating the model multiple times across a increasingly finer grids of $(\delta, \gamma)$ values and choosing the point at which the objective function was minimized.

[14]The fact that $\gamma = 1$ minimizes the objective function based on trade flow values can be understood to reflect the fact that in general across sectors, trade flow values increased by more in the data than the model predicts, such that the model is brought closest to the data by setting the probability of GSP preference loss prior to the FTA equal to its maximum possible value. There are several possible reasons for this: first, the simulation that I run assumes a policy change that only eliminates bilateral tariffs between Chile and the US, leaving all others untouched, while in reality, other tariffs changed over this period. This is not the only explanation, however, as running the analogous simulation where post-FTA tariffs are predicted perfectly (using 2006 tariff data) still yields a value of $\gamma = 1$ as being the parameter value which brings the model simulation closest to observed increased in trade flows. Another factor may be nominal growth (inflation) over this period, as well as real growth, which the model does not take into account at all.

addition to minimizing the objective function based on increases in exporter mass across sectors presented in (4.1), I have also found parameter values that minimize a weighted version of this expression where each sector is weighted by the level of trade flows from Chile to the US in 2006. In this case, the $\gamma$ value which minimizes this objective function is $\gamma = 0.102$, while the $\delta$ value is $<0.001$. In order to check the robustness of the results presented below to the parameter values assumed for $\delta$ and $\gamma$, I run simulations over a range of these values, with $\delta$ ranging from 0.01 to 0.16 and $\gamma$ ranging from 0.05 to 0.30.[15] Thus, I present the example in this chapter as an illustration of how including tariff threats in a general equilibrium model with heterogeneous firms can impact the simulation results of a trade policy shock and provide the magnitude of these effects for certain assumed $\gamma$ values, however these magnitudes should be not be taken too literally. In future evaluations of preferential trade agreements which use this methodology to assess the potential impacts of the agreement through both applied tariff reduction and the reduction in policy uncertainty, $\gamma$ should ideally be estimated econometrically and then fed into the model.

## 4.7   Results

In this section I present the simulation results for a four region, twenty sector model of a policy shock that sets all tariffs to zero on Chile<->US trade flows and all other tariffs at effectively applied rates reported in 2001. The four regions are Chile (CHL), United States (USA), Mercosur (MERC), and Rest of World (ROW). To be clear, I calibrate the model using 2006 data, taking into account reported applied tariffs in this year, in order to obtain values for sunk costs and preference parameters $\lambda$. I then use the model, given its calibrated parameters, to simulate the equilibrium prior to the FTA (assuming tariffs are at 2001 levels), and after the implementation of the FTA (assuming all tariffs remain the same except for US<->Chile tariffs which are set to zero). I do this once using a model that assumes no tariff threat is present in 2001, and again assuming that there exists a 9.98%

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[15]See section 4.8.

threat of tariffs on Chile-US moving from GSP to MFN levels. In each case, in computing

the pre-FTA equilibrium, I assume that agents expect all non CHL-US bilateral tariffs to

remain at year 2001 applied levels forever. I then compute, for certain variables of interest,

the difference between the pre-FTA equilibrium and post-FTA equilibrium, first in the case

where there is no tariff threat in the pre-FTA simulation, and the in the case where there

exists a 9.98% tariff threat prior to FTA implementation. In doing so, I am able to compare

how my model would evaluate the impacts of this particular Free Trade agreement relative

to another model which is identical in all respects except for the fact that it does not take

into account the effect of the tariff hike threat.[16]

## 4.7.1  Chile-US Results

Table 4.5 presents the equilibrium values of utility, total trade value, and number of exporters

in the post-FTA equilibrium, and in the pre-FTA equilibrium, where the simulated pre-

FTA values are generated once under the assumption of no tariff threat and once under the

assumption of a 9.98% chance of losing GSP preferences. For trade flows from Chile to the

US, the model simulates an increase in trade value of 5.78% and an increase in exporter

mass of 2.8% from applied tariff changes following implementation of the FTA, and a 6.98%

increase in trade value and 7.43% increase in exporter mass from applied tariff changes plus

the removal of the tariff threat. Utility is predicted to fall by 0.233% in Chile following

the implementation of the agreement, under the assumption that no tariff threat is initially

present, while it is predicted to fall by slightly less, 0.231% in the case where the tariff threat

existed prior to the FTA.

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[16]I have also conducted a closely related simulation in which the policy shock removes the threat of a tariff hike on CHL-USA tariffs and sets all USA-CHL tariffs to zero, but now sets all other applied tariffs at their 2006 levels. The results of this steady state equilibrium can be compared to the two counterfactuals as described above, and yield qualitatively similar results of the effects of including the effect of a tariff hike threat. In the results presented below however, as I am conducting an exercise in evaluating the effects of the FTA ex-ante, I assume that that non Chile-US tariffs in the years following the FTA implementation are not known.

Table 4.5: Simulation Results: Chile-USA

| Year | Utility | Total Trade Value (Millions of USD) | Number of Exporters |
|---|---|---|---|
| post FTA simulation | 17,428 | 10,141 | 3,158 |
| pre-FTA simulation without Tariff Uncertainty | 17,400 | 7,135 | 3,041 |
| pre-FTA simulation with Tariff Uncertainty | 17,400 | 7,055 | 2,909 |
| Percent Increase, pre to post FTA without tariff uncertainty | -0.233 | 5.78 | 2.80 |
| Percent Increase, pre to post FTA with tariff uncertainty | -0.231 | 6.98 | 7.43 |

#### 4.7.1.1 By-Sector Impact: Firm Counts

One of the primary endogenous variables of interest in this model is the number of firms exporting from Chile to the United States, as this is negatively affected by the presence of a tariff hike threat on Chilean imports into the US. Figure 4.5 presents the model simulation results for the percentage increase in the number of exporters from Chile to the US by sector under the two alternative models, while figure 4.6 presents these same results after dropping the textile/apparel and footwear sectors as these each experience much larger predicted growth following the FTA to to the elimination of relatively high tariffs faced prior to the agreement. The first set of bars, shown in blue, represent the percent increase in the mass of exporters resulting from the implementation of the Chile-US FTA obtained by only taking into account the effect of the applied tariff liberalization resulting from eliminating tariffs between Chile and the US. The red bars indicate the percentage increase implied by the model once the additional effect of the uncertainty over unilateral preferences prior to the establishment of the FTA is taken into account.

We see that in sectors where applied tariff changes are smaller, the elimination of the tariff threat present prior to the implementation of the Chile-US FTA can have a non-negligible impact on entry into the export market relative to the impact resulting only from applied tariff changes. Indeed, in some sectors, Chemicals, Plastics, and Stone/Ceramics, a heterogeneous firms model which does not account for a positive probability of preference loss prior to the FTA will simulate a contraction in the mass of exporters from Chile to the USA following the FTA, while the additional effect of eliminating the tariff hike threat

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Figure 4.5: Simulated Increase in Exporters: CHL to USA
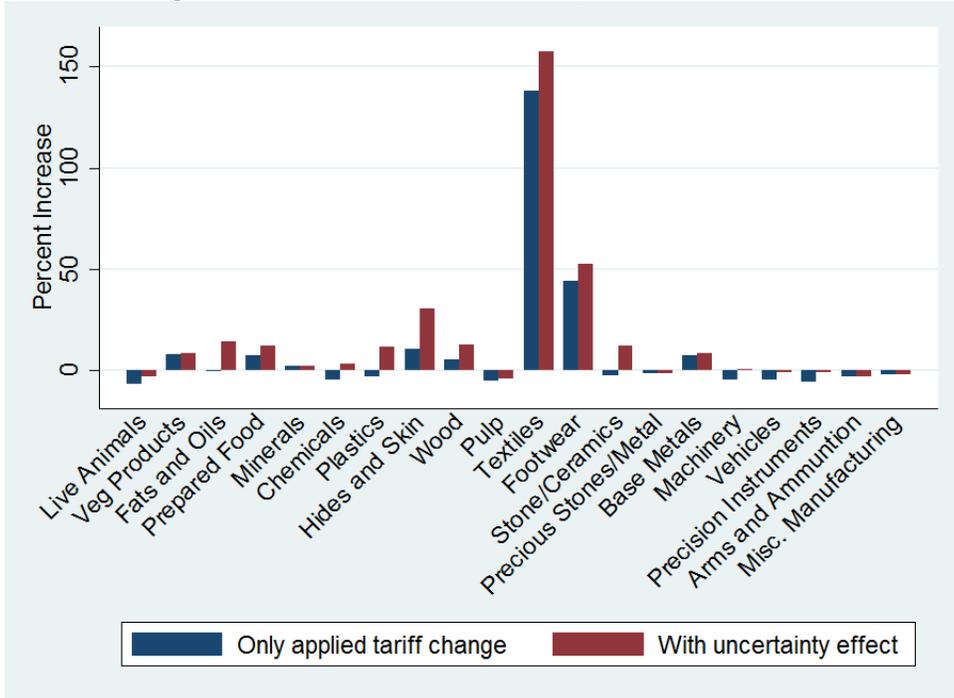


Figure 4.6: Simulated Increase in Exporters: CHL to USA
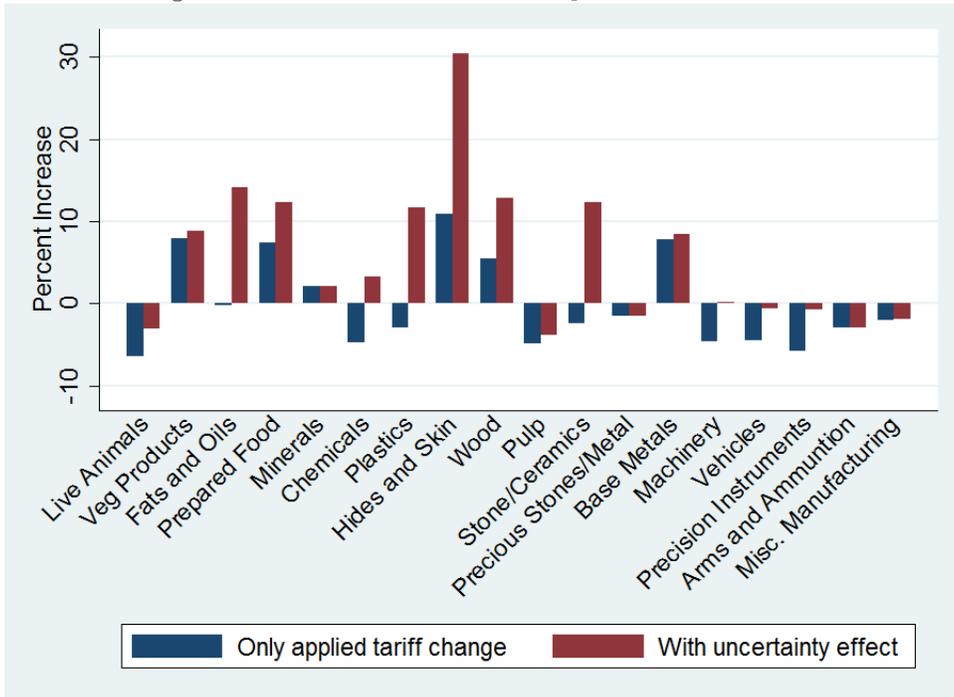
counters this effect of applied tariff changes and yields a net positive effect on exporting. The contraction in exporter mass resulting from the change in applied tariffs associated with the FTA in this sector is itself a result of the fact that under unilateral GSP preferences, Chile already received zero (or close to zero) applied tariffs while imposing a positive tariff on US imports. Following the implementation of the FTA, experiencing no change in the tariff faced to export to the US, but liberalizing the import tariff creates more competition in this sector in Chile, lowering the equilibrium mass of domestic firms in that sector, which in turn results in a smaller mass of firms exporting from Chile to the US. These are the mechanisms leading to a contraction of exporter mass in these sectors in a model which doesn't take into account the negative effect on exporter mass of the presence of a tariff hike threat. Taking this into account, in this case assuming a 9.98% chance in any given period that unilateral preferences for Chile to the US market will be revoked, we see that the combined effect of liberalizing tariffs and eliminating this tariff hike threat now results in an increase in the mass of exporters from Chile to the US in these sectors.

To see how these simulated changes in the number of exporters per sector from Chile to the US compare with the data, figure 4.7 presents a scatter plot of these predicted increases versus the increase observed in the data for $M_{k,CHL,USA}$, the number of exporters from Chile to the US for each sector $k$ along with the 45 degree line showing where the two would match exactly. Simulated increases are shown for two models, one showing the increase in $M$ from the deterministic steady state in 2001 to the new deterministic steady state in 2006, and the other, the increase from the steady state in 2001 where there exists the threat of tariff hikes, to the deterministic steady state in 2006. I note that the sector for which including the effect of uncertainty makes the biggest difference in terms of reducing the distance between the data and the model simulation is Plastics, which is also the sector in which GSP preferences were most heavily used by Chilean exporters prior to the FTA (see Figure C.2). For this sector, the model without tariff uncertainty predicts a decrease in the mass of exporters form Chile to the US, however, once the added effect of the elimination of

Figure 4.7: Simulated vs. Actual Change in Exporters
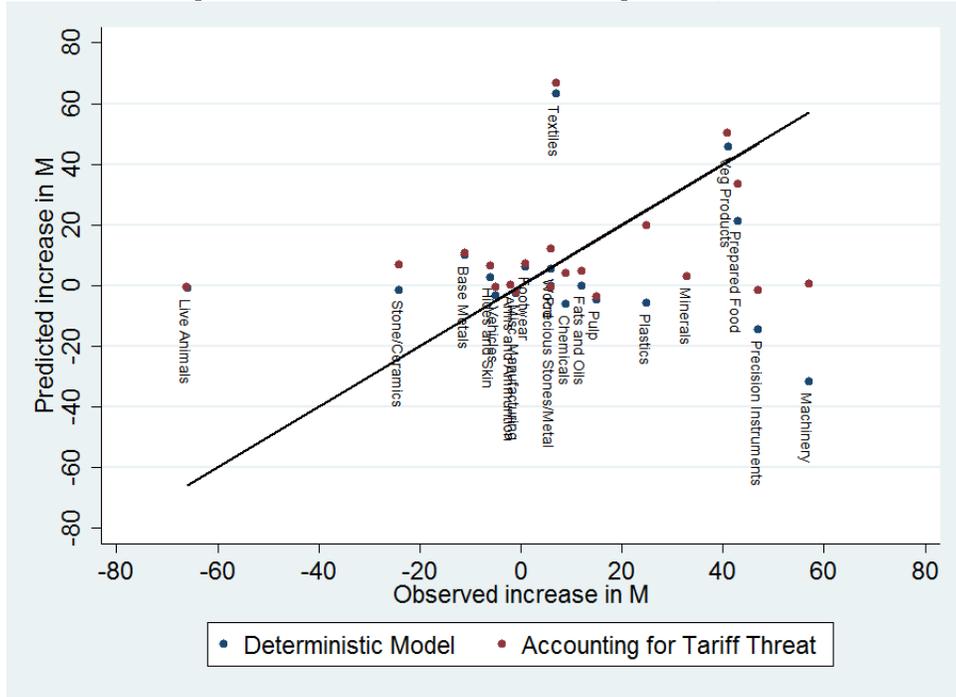


future tariff hikes is included, the model predicts that following implementation of the FTA the mass of exporters will increase.

For results by sector on the implied impact of the FTA from the two simulations for Chilean trade with the Rest of World (ROW) region and on the number of domestic producers in Chile, see Appendix C.4.

### 4.7.1.2    By-Sector Impact: Trade Flow Values

Another question which is often the focus when evaluating potential trade agreements is the how the volume of trade between countries will change as a result of the agreement. In order to evaluate how the current model (taking into account the effect of eliminating a tariff hike threat) would simulate trade flows relative to a model that does not include this additional potential effect, I present here analogous results to those presented in the previous section, now for trade flow value between bilateral pairs. Figure 4.8 presents the percent increase in trade flow value from CHL to USA under the two different model simulations. The percent increases here are highly correlated with the changes in the mass of exporting firms shown

Figure 4.8: Simulated Increase in Trade: CHL to USA
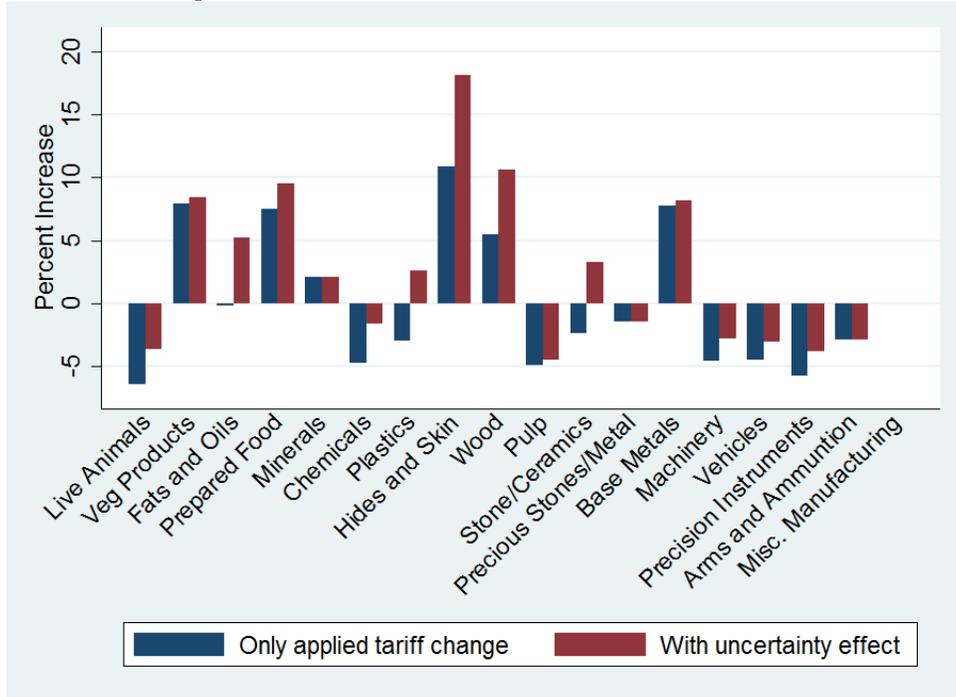


*Textiles/apparel and footwear sectors have been dropped to allow for a more legible scale, as each is simulated to experience large increases in export value following implementation of the FTA.

in Figure 4.5, though not identical. In the case of the Chemicals sector, for example, the model taking into account the elimination of the tariff threat simulates an increase in the mass of exporters, but a decrease in the total value of exports, indicating that the FTA causes the export cutoff productivity to fall such that the mass of exporters increases, but the average productivity of the set of exporters then falls sufficiently such that total revenue falls. For by-sector results in levels rather than percentages, see figure C.5 in Appendix C.4.

As done for exporter mass, figure 4.9 shows the predicted increase in (log) trade value from Chile to the US under the two model simulations against the actual change observed in the data.

### 4.7.2 Third-Country Effects

To illustrate one of the desirable features of using a general equilibrium model to study the impact of preferential trading agreements, I present here the results of the model for

Figure 4.9: Simulated vs. Actual Change in Log Trade Flows
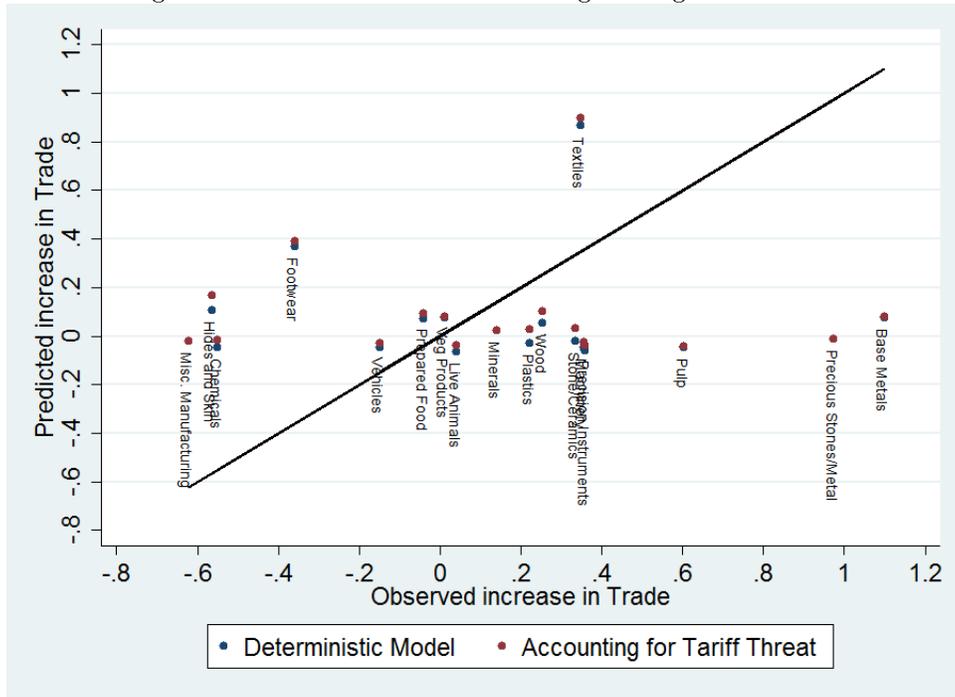
Sectors Arms and Ammunition and Fats and Oils, which exhibit large decreases and increases in trade respectively, are dropped here to allow for a more legible scale.

simulated impacts on third-party countries that are not directly affected by the implementation of the agreement. In the case of the Chile-US FTA, I have included Mercosur, a large regional trading partner of Chile in order to assess how including the additional effect of eliminating tariff uncertainty of Chile's US tariffs affects the trade of this outside region. Tables 4.6 and 4.7 present the equilibrium values of utility, exports to Chile (US, respectively), and number of exporting firms to Chile (US, respectively) in each the post-FTA simulated equilibrium, the pre-FTA simulated equilibrium without a tariff threat, and the pre-FTA simulated equilibrium with a tariff threat. In percentage terms, the differential effects on utility, trade flows and exporter mass between the models with and without a tariff threat on CHL-USA trade flows are much smaller than the effects on Chile, as one might expect. For results by sector on the implied impact of the FTA from the two simulations for Mercosur trade with the Rest of World (ROW) region and USA, see Appendix C.5.

Table 4.6: Simulation Results: MERC-CHL

| Year | Utility | Total Trade Value (Millions of USD) | Number of Exporters |
|---|---|---|---|
| post FTA simulation | 156,868 | 9,192 | 12,704 |
| pre-FTA simulation without Tariff Uncertainty | 156,290 | 7,210 | 8,897 |
| pre-FTA simulation with Tariff Uncertainty | 156,290 | 7,202 | 8,893 |
| Percent Increase, pre to post FTA without tariff uncertainty | -0.0015 | -0.9810 | -0.2285 |
| Percent Increase, pre to post FTA with tariff uncertainty | -0.0016 | -1.0922 | -0.2791 |

Table 4.7: Simulation Results: MERC-USA

| Year | Total Trade Value (Millions of USD) | Number of Exporters |
|---|---|---|
| post FTA simulation | 32,031 | 59,965 |
| pre-FTA simulation without Tariff Uncertainty | 31,053 | 61,105 |
| pre-FTA simulation with Tariff Uncertainty | 31,050 | 61,104 |
| Percent Increase, pre to post FTA without tariff uncertainty | -0.0555 | -0.0357 |
| Percent Increase, pre to post FTA with tariff uncertainty | -0.0640 | -0.0375 |

### 4.7.3 Trade Restrictiveness Index

In order to provide another frame of reference for the quantitative effect of the threat of losing GSP preferences into the United States on Chilean welfare and exports into the US, I compute a Trade Restrictiveness Index (TRI) for each model based on either welfare, total value of trade from Chile to the US, or total number of exporters from Chile to the US. The TRI is computed to be the tariff level that would have to be imposed uniformly across all sectors on Chilean exports into the United States in order to generate the same i) welfare level in Chile, ii) total value of exports from Chile to the United States, or iii) total number of exporters from Chile to the United States as that which is realized with actual applied rates plus the threat of tariff hikes. The TRIs in year 2001 (before the FTA was implemented, and there was a risk for Chile of losing GSP status) computed using first the model without the threat of tariff hike and then with the threat (assuming again that $\gamma = 0.0998$) are presented in Table 4.8.

The first thing to note from this index, in the case of the first model which takes into account only the effect of applied tariffs, is that the uniform tariff which would result in the same effects as the year 2001 applied tariffs on Chilean goods exported to the US are

Table 4.8: Trade Restrictiveness Index (TRI) for CHL-USA Exports

|  | Utility | Total Exports | Total No. Exporters |
|---|---|---|---|
| Deterministic Model without Threat of Tariff Hikes | 0.72% | 0.58% | 0.72% |
| Dynamic Model with Threat of Tariff Hikes | 0.75% | 0.65% | 1.19% |

quite low, reflecting the fact that Chilean exporters already enjoyed relatively low applied tariff rates into the US market, prior to the implementation of the Chile-US FTA. Indeed, for this very reason, the argument was made in the US Congress in favor of passing the agreement because it would not offer any real new advantage to Chile but rather to the US, who which would experience much larger applied tariff cuts on exports to Chile.[17] This argument ignores the effect of the FTA in locking in preferences for Chilean exporters, and the relative importance of this effect, under the assumed model parameters, is reflected in comparing the TRI for the dynamic model with that of the static model. In terms of total number of exporters, the TRI computed taking into account the prospect of losing GSP is nearly double that based only on applied tariff rates.

## 4.8   Discussion

As mentioned above, the quantitative values of this simulation are subject to several caveats. The assumed values of $\gamma = 0.0998$ and $\delta = 0.0571$ are chosen as they minimize the sum of the distance between model simulations and actual data on the number of Chile-US exporters in each sector, however as mentioned above, this value is sensitive to the minimization criteria and pre-FTA years of data used to compute changes pre and post agreement. For this reason, all results presented above are replicated for a range of $\gamma$ and $\delta$ values around this point with $\delta$ ranging from 0.01 to 0.16 and $\gamma$ ranging from 0.05 to 0.30. Figures 4.10 and 4.11 present the effect of allowing $\gamma$ and $\delta$ to vary over this range on the simulated increase in utility, mass of exporters, and total export value from Chile to the US generated by the model where there exists a positive threat of preference loss prior to the FTA. In each graph, the dotted black line indicates the change in utility, number of exporters, or value of exports

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[17]See http://www.gpo.gov/fdsys/pkg/CRPT-108hrpt224/html/CRPT-108hrpt224-pt2.htm.

Figure 4.10: Robustness Check: Probability of Tariff Hike
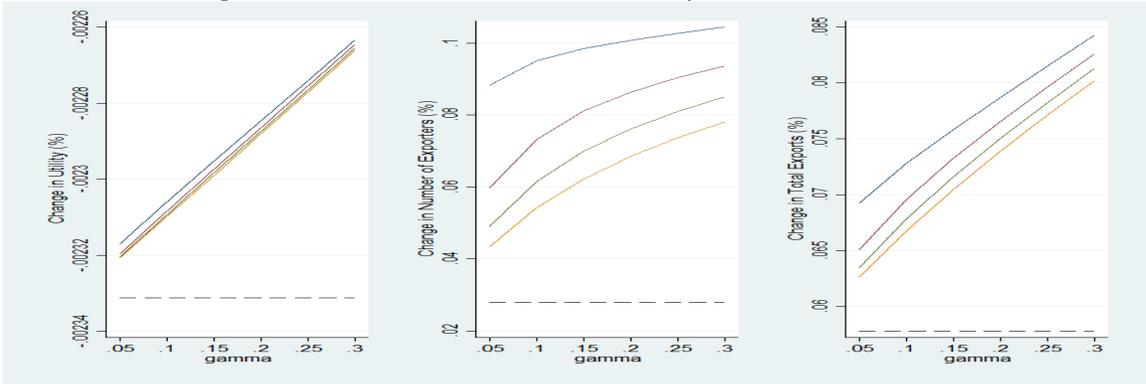


Figure 4.11: Robustness Check: Probability of Death Shock
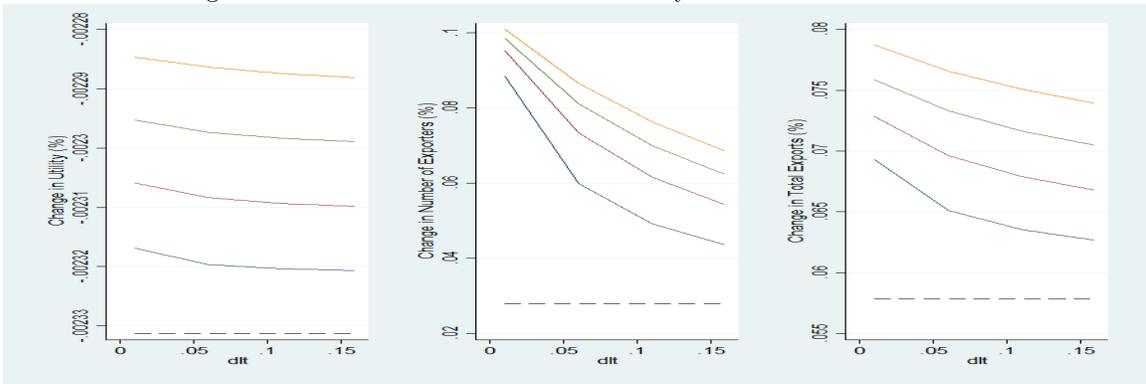


respectively simulated by the model where no threat of preference loss exists prior to the FTA. We see that an increase in either $\gamma$, the probability with which exporters expect they may lose GSP preferences in any given period, or in $1 - \delta$, the weight assigned to future periods, the increase in utility, exporters and exports are all larger, with changes in utility ranging from -0.226% to -0.232%, changes in the mass of exporters ranging from 4.35% to 10.44%, and changes in the value of exports ranging from 6.27% to 8.43%.

In addition to the sensitivity of the magnitude of predicted changes to various parameter values, it is important to keep in mind that there are many factors not modeled in this framework which are likely to have also impacted firm entry and export value, including aggregate growth (in my model I assume no growth in aggregate productivity between 2001 and 2006), expectations about trade policy with other countries apart from the United States, and intermediate linkages between sectors, which I do not have in this model. On a

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similar note, data are applied to this model at a fairly aggregate level (HS section), whereas in reality, tariffs are imposed on at least a six digit product disaggregation, and thus I may be missing important trade-offs made between products within the same sector that have different tariff rates. The challenge in applying this framework to a more disaggregated dataset is not obtaining the data, but rather solving a Mixed Complementarity problem such as this becomes computationally infeasible for large numbers of sectors. This is something I hope to pursue and improve on in future work.

## 4.9   Conclusion

In this Chapter, I have presented an application of the CGE model developed in Chapter 3 which incorporates the impact of uncertainty faced by Chilean firms on firm entry into the US market. After calibrating this model using trade, tariff, and firm data from the year 2006 and then solved for the equilibrium in both cases with and without the threat of preference loss for Chilean exporters, I find that a model without the tariff threat effect predicts that Chilean exports to the United States will increase by 5.8%, the number of exporters will increase by 2.8% and utility for Chile will decrease by 0.233% as a result of the FTA, while the model with the effect of a tariff threat predicts that exports will increase by 7.0%, the number of exporters by 7.4% and that utility will fall by 0.231%.

# Appendix A

# Chapter 2 Appendix

## A.1  Endogeneity of Applied Tariffs

As mentioned in section 2.5.1, I include an indicator, $MFNPOS$, for whether or not product

has a positive applied MFN tariff, as an independent variable that contributes to explaining

the probability of whether or not positive trade flows are observed for the given bilateral

pair-product. The assumption underlying this is that tariffs are not exogenous to trade

flows, and in fact, it is reasonable to think that products for a given bilateral pair can be

classified into two categories: one for which no political pressure has ever been applied to

demand a tariff to protect the domestic industry, and the other comprised of products for

which political pressure (lobbying) has resulted in the imposition of a non-zero tariff. In

reality, lobbying groups may exert their influence in order to affect not only whether or not

a tariff is imposed, but may also affect the level of the tariff chosen. However, in order to

maintain a tractable specification, I make the assumption that in the underlying political

economy model, lobbying groups for domestic industries may lobby their government to

impose a tariff or not, but have no control over the level of the tariff applied. Given this

assumption, one would expect the relationship between import flows and applied tariffs to

resemble that depicted in figure A.1, that is, zero imports result in no lobbying and therefore

Figure A.1: Imports vs. Applied Tariffs
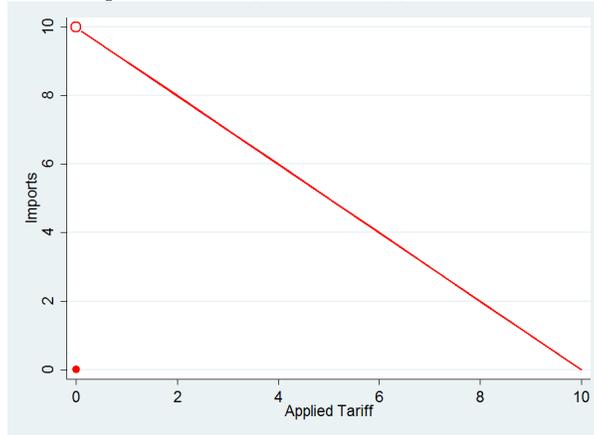
no (or zero) tariff being imposed, while for positive import levels, domestic groups lobby for

a positive tariff, which I then assume to be imposed by the government, exogenous to trade

flows. Then, for these products, one would expect a negative relationship between tariffs

and import flows, as higher tariffs decrease profitability for exporters.

The inclusion of the $MFNPOS$ indicator in the empirical specification determining the

probability that a good is traded will then account for the differential probability that a

good is traded given that it has a zero applied tariff, which under the assumptions above,

means that it has no domestic opposition specifically because it is not imported. Without

the inclusion of this variable, because of the presence of many zero tariff products in the

data, one would expect, assuming the relationship depicted in figure A.1, that there may

be an overall positive correlation between applied tariffs and probability of positive trade.

Indeed, this is reflected in a positive coefficient on $\ln \tau$ in such a specification. What about

the effect on the estimated coefficient for the uncertainty measure, $U$? If we take as given

the assumed relationship between applied tariffs and imports as arising from the lobbying

story described above, it would be reasonable to expect that products with applied tariffs

of zero (due to lack of domestic lobbying for positive tariffs) would either remain unbound

(as there are no imports in the given product and therefore no foreign lobbying pressure

to bind the tariff rate), or be bound at zero, as there is no political cost to the domestic

government of imposing a zero binding. In the first case, the uncertainty measure would be

equal to 1 in the baseline results, however, these lines would all have been dropped in the alternative data treatment where unbound lines are dropped from the sample. The results continue to hold in both cases. If instead we are in the second case, where products with a zero applied tariff rate also have a zero bound rate, then $U = 0$, and we would expect the same differential relationship between imports and the level of the uncertainty measure as depicted for tariffs in figure A.1. That is, for these products with zero applied tariffs and uncertainty measure equal to 0, there are no imports; the lack of imports is what led to a lack of domestic lobbying and therefore a zero applied tariff.

Of course to fully understand the implications of the endogeneity of tariffs, a more complex political economy model would need to be developed. For the current empirical analysis, it would also be useful to analyze the results of a similar regression allowing for differential uncertainty effects across the two types of products (zero vs. positive tariff products) or to examine the results of a similar regression run on the sub-sample of products for which applied tariffs are positive. I have not yet implemented this, but will explore these ideas further in future research.

## A.2   Tariff Summary Statistics By Importing Country

All tariffs in the table below are for year 2007 and are reported in log points.

Table A.1: Tariff Summary Statistics by Importing Country

| Albania | TRAINS | CMT | 5219 | 0.0% | 0.051 | 0.020 | 0.052 | 0.069 | 0.049 | 0.058 | 0.069 | 0.082 | 0.068 | 5.4% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Antigua and Bar- buda | IDB | WTO | 5113 | 2.1% | 0.089 | 0.049 | 0.077 | 0.455 | 0.405 | 0.115 | 0.755 | 0.760 | 0.098 | 0.2% |
| Argentina | TRAINS | CMT | 5224 | 0.0% | 0.104 | 0.113 | 0.062 | 0.277 | 0.300 | 0.050 | 0.479 | 0.478 | 0.140 | 0.4% |

| Country | Tariff Data Source | Trad Data Source | No. of Products | Share of Lines Unbound | Mean MFN Tariff | Median MFN Tariff | Std Dev, MFN Tariff | Mean Bound Tariff | Median Bound Tariff | Std Dev, Bound Tariff | Mean Uncertainty Measure | Median Uncertainty Measure | Std Dev, Uncertainty Measure | Share of Lines with MFN > Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | TRAINS | CMT | 5051 | 2.9% | 0.033 | 0.033 | 0.039 | 0.090 | 0.088 | 0.091 | 0.208 | 0.170 | 0.220 | 0.3% |
| Bahrain | TRAINS | TRN | 5025 | 27.2% | 0.047 | 0.049 | 0.043 | 0.294 | 0.300 | 0.072 | 0.723 | 0.634 | 0.190 | 0.3% |
| Barbados | TRAINS | CMT | 5221 | 2.2% | 0.114 | 0.049 | 0.136 | 0.571 | 0.531 | 0.104 | 0.822 | 0.854 | 0.134 | 0.2% |
| Belize | TRAINS | CMT | 5199 | 2.1% | 0.095 | 0.049 | 0.089 | 0.452 | 0.405 | 0.101 | 0.749 | 0.760 | 0.121 | 0.0% |
| Benin | TRAINS | TRN | 5052 | 60.9% | 0.105 | 0.095 | 0.060 | 0.289 | 0.405 | 0.203 | 0.814 | 1.000 | 0.340 | 29.5% |
| Bolivia | TRAINS | CMT | 5224 | 0.0% | 0.080 | 0.095 | 0.027 | 0.336 | 0.336 | 0.004 | 0.640 | 0.619 | 0.035 | 0.0% |
| Botswana | TRAINS | INV | 5030 | 4.0% | 0.069 | 0.000 | 0.097 | 0.162 | 0.140 | 0.139 | 0.290 | 0.305 | 0.253 | 0.8% |
| Brazil | TRAINS | CMT | 5052 | 0.0% | 0.114 | 0.131 | 0.054 | 0.272 | 0.300 | 0.058 | 0.452 | 0.455 | 0.135 | 0.3% |
| Burkina Faso | TRAINS | TRN | 5052 | 60.8% | 0.105 | 0.095 | 0.060 | 0.398 | 0.693 | 0.303 | 0.838 | 1.000 | 0.339 | 29.4% |
| Burundi | TRAINS | CMT | 5205 | 78.0% | 0.113 | 0.095 | 0.077 | 0.577 | 0.693 | 0.218 | 0.952 | 1.000 | 0.169 | 20.5% |
| Cameroon | TRAINS | TRN | 5031 | 86.7% | 0.161 | 0.095 | 0.080 | 0.587 | 0.588 | 0.012 | 0.971 | 1.000 | 0.078 | 0.0% |
| Canada | TRAINS | CMT | 5048 | 0.5% | 0.040 | 0.022 | 0.079 | 0.055 | 0.048 | 0.085 | 0.060 | 0.006 | 0.108 | 2.6% |
| Central African Republic | TRAINS | INV | 5031 | 38.1% | 0.161 | 0.095 | 0.080 | 0.306 | 0.262 | 0.063 | 0.657 | 0.574 | 0.308 | 0.0% |
| Chad | TRAINS | INV | 5031 | 86.5% | 0.161 | 0.095 | 0.080 | 0.587 | 0.588 | 0.004 | 0.970 | 1.000 | 0.079 | 0.0% |
| Chile | TRAINS | CMT | 5223 | 0.0% | 0.058 | 0.058 | 0.003 | 0.224 | 0.223 | 0.014 | 0.485 | 0.483 | 0.018 | 0.0% |
| China | TRAINS | CMT | 5035 | 0.0% | 0.092 | 0.081 | 0.062 | 0.093 | 0.085 | 0.062 | 0.004 | 0.000 | 0.019 | 2.8% |

| Country | Tariff Data Source | Trad Data Source | No. of Products | Share of Lines Unbound | Mean MFN Tariff | Median MFN Tariff | Std Dev, MFN Tariff | Mean Bound Tariff | Median Bound Tariff | Std Dev, Bound Tariff | Mean Uncertainty Measure | Median Uncertainty Measure | Std Dev, Uncertainty Measure | Share of Lines with MFN > Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Colombia | TRAINS | CMT | 5224 | 0.0% | 0.116 | 0.140 | 0.061 | 0.347 | 0.300 | 0.128 | 0.567 | 0.559 | 0.145 | 0.0% |
| Congo, Rep. | TRAINS | INV | 5031 | 83.8% | 0.161 | 0.095 | 0.080 | 0.239 | 0.262 | 0.061 | 0.865 | 1.000 | 0.320 | 0.2% |
| Costa Rica | TRAINS | CMT | 5052 | 0.0% | 0.054 | 0.033 | 0.068 | 0.355 | 0.372 | 0.082 | 0.676 | 0.725 | 0.151 | 0.1% |
| Cote d'Ivoire | TRAINS | TRN | 5052 | 66.6% | 0.101 | 0.095 | 0.059 | 0.105 | 0.068 | 0.062 | 0.820 | 1.000 | 0.363 | 49.2% |
| Croatia | TRAINS | CMT | 4986 | 0.1% | 0.042 | 0.012 | 0.052 | 0.057 | 0.049 | 0.048 | 0.056 | 0.000 | 0.092 | 3.9% |
| Dominica | TRAINS | CMT | 5223 | 5.3% | 0.089 | 0.049 | 0.103 | 0.453 | 0.405 | 0.124 | 0.765 | 0.760 | 0.112 | 0.0% |
| Dominican Republic | TRAINS | CMT | 5052 | 0.0% | 0.065 | 0.000 | 0.081 | 0.297 | 0.336 | 0.077 | 0.578 | 0.590 | 0.153 | 0.0% |
| Ecuador | TRAINS | CMT | 5224 | 0.0% | 0.109 | 0.095 | 0.058 | 0.195 | 0.203 | 0.064 | 0.280 | 0.284 | 0.125 | 0.2% |
| El Salvador | TRAINS | CMT | 5052 | 0.0% | 0.055 | 0.033 | 0.066 | 0.309 | 0.336 | 0.085 | 0.615 | 0.630 | 0.148 | 0.0% |
| European Union | TRAINS | CMT | 5019 | 0.7% | 0.047 | 0.029 | 0.079 | 0.049 | 0.032 | 0.077 | 0.020 | 0.000 | 0.105 | 7.9% |
| Fiji | IDB | WTO | 4995 | 48.9% | 0.074 | 0.030 | 0.077 | 0.337 | 0.336 | 0.004 | 0.814 | 0.740 | 0.206 | 0.0% |
| Gabon | TRAINS | TRN | 5031 | 0.0% | 0.114 | 0.095 | 0.060 | 0.213 | 0.140 | 0.137 | 0.281 | 0.163 | 0.207 | 38.0% |
| Georgia | TRAINS | CMT | 5203 | 0.0% | 0.010 | 0.000 | 0.032 | 0.068 | 0.063 | 0.047 | 0.196 | 0.193 | 0.145 | 0.0% |

| Country | Tariff Data Source | Trad Data Source | No. of Products | Share of Lines Unbound | Mean MFN Tariff | Median MFN Tariff | Std Dev, MFN Tariff | Mean Bound Tariff | Median Bound Tariff | Std Dev, Bound Tariff | Mean Uncertainty Measure | Median Uncertainty Measure | Std Dev, Uncertainty Measure | Share of Lines with MFN > Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ghana | TRAINS | CMT | 5209 | 85.6% | 0.120 | 0.095 | 0.061 | 0.649 | 0.688 | 0.116 | 0.979 | 1.000 | 0.060 | 0.0% |
| Guatemala | TRAINS | CMT | 5052 | 0.0% | 0.052 | 0.037 | 0.059 | 0.346 | 0.372 | 0.100 | 0.667 | 0.699 | 0.129 | 0.0% |
| Guinea-Bissau | TRAINS | INV | 5052 | 2.3% | 0.111 | 0.095 | 0.061 | 0.396 | 0.405 | 0.023 | 0.675 | 0.711 | 0.105 | 0.0% |
| Guyana | IDB | WTO | 5051 | 0.0% | 0.097 | 0.049 | 0.097 | 0.443 | 0.405 | 0.097 | 0.724 | 0.760 | 0.137 | 0.1% |
| Honduras | TRAINS | CMT | 5052 | 0.0% | 0.052 | 0.049 | 0.059 | 0.280 | 0.300 | 0.056 | 0.578 | 0.634 | 0.137 | 0.2% |
| Hong Kong, China | TRAINS | CMT | 5052 | 53.5% | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.535 | 1.000 | 0.499 | 0.0% |
| Iceland | TRAINS | CMT | 5048 | 8.0% | 0.052 | 0.000 | 0.188 | 0.111 | 0.049 | 0.158 | 0.279 | 0.177 | 0.320 | 0.7% |
| India | TRAINS | TRN | 5052 | 29.7% | 0.151 | 0.118 | 0.096 | 0.376 | 0.336 | 0.210 | 0.673 | 0.583 | 0.277 | 1.5% |
| Indonesia | TRAINS | INV | 5041 | 3.4% | 0.064 | 0.049 | 0.066 | 0.312 | 0.336 | 0.076 | 0.624 | 0.684 | 0.156 | 0.1% |
| Israel | TRAINS | CMT | 4766 | 30.0% | 0.052 | 0.000 | 0.096 | 0.132 | 0.072 | 0.185 | 0.467 | 0.249 | 0.403 | 3.0% |
| Japan | TRAINS | CMT | 5051 | 0.4% | 0.037 | 0.000 | 0.105 | 0.042 | 0.000 | 0.136 | 0.017 | 0.000 | 0.104 | 8.1% |
| Jordan | TRAINS | CMT | 5023 | 0.0% | 0.082 | 0.000 | 0.114 | 0.141 | 0.140 | 0.108 | 0.185 | 0.177 | 0.178 | 14.2% |
| Kenya | TRAINS | CMT | 5214 | 85.4% | 0.114 | 0.095 | 0.101 | 0.666 | 0.693 | 0.086 | 0.977 | 1.000 | 0.067 | 0.0% |
| Korea, Rep. | TRAINS | CMT | 5022 | 5.4% | 0.092 | 0.077 | 0.167 | 0.132 | 0.122 | 0.185 | 0.180 | 0.128 | 0.249 | 3.2% |
| Kuwait | TRAINS | INV | 4994 | 0.1% | 0.045 | 0.049 | 0.016 | 0.693 | 0.693 | 0.000 | 0.925 | 0.924 | 0.014 | 0.0% |

| Country | Tariff Data Source | Trad Data Source | No. of Products | Share of Lines Unbound | Mean MFN Tariff | Median MFN Tariff | Std Dev, MFN Tariff | Mean Bound Tariff | Median Bound Tariff | Std Dev, Bound Tariff | Mean Uncertainty Measure | Median Uncertainty Measure | Std Dev, Uncertainty Measure | Share of Lines with MFN > Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kyrgyz Republic | TRAINS | CMT | 5222 | 0.4% | 0.044 | 0.049 | 0.045 | 0.071 | 0.095 | 0.044 | 0.096 | 0.000 | 0.132 | 0.5% |
| Lesotho | TRAINS | INV | 5030 | 0.0% | 0.069 | 0.000 | 0.096 | 0.550 | 0.470 | 0.209 | 0.807 | 0.847 | 0.120 | 0.0% |
| Macao | IDB | WTO | 5052 | 71.3% | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.713 | 1.000 | 0.452 | 0.0% |
| Macedonia, FYR | TRAINS | CMT | 4993 | 0.0% | 0.059 | 0.049 | 0.070 | 0.059 | 0.049 | 0.070 | 0.001 | 0.000 | 0.011 | 9.7% |
| Madagascar | TRAINS | CMT | 5048 | 70.0% | 0.115 | 0.095 | 0.056 | 0.243 | 0.262 | 0.043 | 0.827 | 1.000 | 0.280 | 1.6% |
| Malaysia | TRAINS | CMT | 5189 | 16.2% | 0.063 | 0.000 | 0.088 | 0.159 | 0.095 | 0.273 | 0.349 | 0.177 | 0.343 | 2.2% |
| Mali | TRAINS | TRN | 5052 | 60.0% | 0.105 | 0.095 | 0.060 | 0.290 | 0.470 | 0.194 | 0.811 | 1.000 | 0.340 | 28.7% |
| Mauritius | TRAINS | TRN | 4964 | 81.9% | 0.028 | 0.000 | 0.071 | 0.632 | 0.798 | 0.296 | 0.960 | 1.000 | 0.169 | 1.0% |
| Mexico | IDB | WTO | 5194 | 0.6% | 0.110 | 0.095 | 0.100 | 0.299 | 0.300 | 0.034 | 0.517 | 0.559 | 0.177 | 0.2% |
| Moldova | IDB | WTO | 5151 | 0.1% | 0.041 | 0.039 | 0.047 | 0.064 | 0.063 | 0.045 | 0.078 | 0.000 | 0.120 | 0.3% |
| Mongolia | TRAINS | CMT | 5049 | 0.0% | 0.048 | 0.049 | 0.006 | 0.161 | 0.182 | 0.052 | 0.348 | 0.414 | 0.149 | 1.0% |
| Morocco | TRAINS | CMT | 5224 | 0.0% | 0.118 | 0.095 | 0.108 | 0.338 | 0.336 | 0.085 | 0.543 | 0.619 | 0.206 | 24.7% |
| Mozambique | TRAINS | CMT | 5224 | 86.4% | 0.096 | 0.072 | 0.065 | 0.680 | 0.693 | 0.090 | 0.983 | 1.000 | 0.063 | 0.6% |
| Namibia | TRAINS | CMT | 5024 | 4.0% | 0.069 | 0.000 | 0.096 | 0.162 | 0.140 | 0.140 | 0.290 | 0.305 | 0.254 | 0.8% |
| Nepal | TRAINS | TRN | 5033 | 0.5% | 0.115 | 0.095 | 0.067 | 0.231 | 0.223 | 0.076 | 0.360 | 0.388 | 0.166 | 2.7% |
| New Zealand | TRAINS | CMT | 5035 | 0.0% | 0.028 | 0.000 | 0.040 | 0.090 | 0.049 | 0.101 | 0.193 | 0.177 | 0.195 | 0.3% |

| Country | Tariff Data Source | Trad Data Source | No. of Products | Share of Lines Unbound | Mean MFN Tariff | Median MFN Tariff | Std Dev, MFN Tariff | Mean Bound Tariff | Median Bound Tariff | Std Dev, Bound Tariff | Mean Uncertainty Measure | Median Uncertainty Measure | Std Dev, Uncertainty Measure | Share of Lines with MFN > Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nicaragua | TRAINS | CMT | 5052 | 0.0% | 0.053 | 0.033 | 0.062 | 0.347 | 0.336 | 0.045 | 0.683 | 0.733 | 0.082 | 0.0% |
| Niger | TRAINS | TRN | 5052 | 3.3% | 0.106 | 0.095 | 0.060 | 0.381 | 0.405 | 0.182 | 0.612 | 0.711 | 0.261 | 11.3% |
| Norway | TRAINS | CMT | 5040 | 0.0% | 0.056 | 0.000 | 0.228 | 0.113 | 0.025 | 0.323 | 0.129 | 0.053 | 0.208 | 0.5% |
| Oman | TRAINS | CMT | 5025 | 0.0% | 0.049 | 0.049 | 0.054 | 0.121 | 0.140 | 0.097 | 0.233 | 0.305 | 0.147 | 1.3% |
| Pakistan | TRAINS | CMT | 5189 | 1.3% | 0.128 | 0.095 | 0.084 | 0.457 | 0.470 | 0.150 | 0.668 | 0.777 | 0.276 | 0.0% |
| Panama | TRAINS | CMT | 5224 | 0.1% | 0.067 | 0.058 | 0.066 | 0.208 | 0.262 | 0.090 | 0.400 | 0.428 | 0.205 | 1.6% |
| Paraguay | TRAINS | CMT | 5224 | 0.0% | 0.096 | 0.095 | 0.061 | 0.290 | 0.300 | 0.040 | 0.521 | 0.550 | 0.137 | 1.2% |
| Peru | TRAINS | CMT | 5224 | 0.0% | 0.096 | 0.113 | 0.052 | 0.263 | 0.262 | 0.013 | 0.477 | 0.449 | 0.112 | 0.0% |
| Philippines | TRAINS | CMT | 5223 | 33.0% | 0.059 | 0.030 | 0.056 | 0.225 | 0.182 | 0.094 | 0.642 | 0.567 | 0.287 | 0.7% |
| Qatar | TRAINS | TRN | 5008 | 0.0% | 0.046 | 0.049 | 0.035 | 0.139 | 0.140 | 0.070 | 0.297 | 0.305 | 0.127 | 0.1% |
| Saudi Arabia | TRAINS | CMT | 4991 | 0.1% | 0.045 | 0.049 | 0.017 | 0.103 | 0.113 | 0.042 | 0.198 | 0.228 | 0.126 | 2.4% |
| Senegal | TRAINS | TRN | 5052 | 0.0% | 0.111 | 0.095 | 0.061 | 0.262 | 0.262 | 0.004 | 0.438 | 0.487 | 0.137 | 0.1% |
| Singapore | TRAINS | CMT | 5224 | 30.3% | 0.000 | 0.000 | 0.008 | 0.078 | 0.095 | 0.159 | 0.463 | 0.317 | 0.373 | 0.0% |
| South Africa | TRAINS | CMT | 5024 | 4.0% | 0.069 | 0.000 | 0.096 | 0.162 | 0.140 | 0.140 | 0.290 | 0.305 | 0.254 | 0.8% |
| Sri Lanka | TRAINS | TRN | 5051 | 62.1% | 0.097 | 0.058 | 0.090 | 0.256 | 0.281 | 0.156 | 0.774 | 1.000 | 0.327 | 6.0% |
| St. Lucia | TRAINS | CMT | 5113 | 0.4% | 0.079 | 0.049 | 0.097 | 0.471 | 0.405 | 0.143 | 0.767 | 0.802 | 0.110 | 0.2% |

| Country | Tariff Data Source | Trad Data Source | No. of Products | Share of Lines Unbound | Mean MFN Tariff | Median MFN Tariff | Std Dev, MFN Tariff | Mean Bound Tariff | Median Bound Tariff | Std Dev, Bound Tariff | Mean Uncertainty Measure | Median Uncertainty Measure | Std Dev, Uncertainty Measure | Share of Lines with MFN > Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Swaziland | TRAINS | INV | 5024 | 4.0% | 0.069 | 0.000 | 0.096 | 0.162 | 0.140 | 0.140 | 0.290 | 0.305 | 0.254 | 0.8% |
| Switzerland | TRAINS | CMT | 5051 | 0.2% | 0.071 | 0.017 | 0.163 | 0.088 | 0.022 | 0.198 | 0.043 | 0.000 | 0.147 | 4.4% |
| Taiwan, China | IDB | WTO | 5191 | 0.0% | 0.050 | 0.037 | 0.066 | 0.053 | 0.039 | 0.071 | 0.009 | 0.000 | 0.041 | 1.9% |
| Tanzania | TRAINS | CMT | 5214 | 86.7% | 0.114 | 0.095 | 0.101 | 0.788 | 0.788 | 0.000 | 0.988 | 1.000 | 0.036 | 0.0% |
| Thailand | TRAINS | CMT | 4568 | 38.0% | 0.087 | 0.049 | 0.102 | 0.221 | 0.262 | 0.089 | 0.612 | 0.574 | 0.360 | 1.4% |
| Togo | TRAINS | TRN | 5052 | 86.1% | 0.111 | 0.095 | 0.061 | 0.588 | 0.588 | 0.000 | 0.977 | 1.000 | 0.059 | 0.0% |
| Trinidad and Tobago | TRAINS | CMT | 5052 | 0.0% | 0.064 | 0.000 | 0.099 | 0.437 | 0.405 | 0.120 | 0.745 | 0.802 | 0.156 | 1.0% |
| Turkey | TRAINS | CMT | 4933 | 49.1% | 0.079 | 0.036 | 0.153 | 0.226 | 0.158 | 0.210 | 0.663 | 0.940 | 0.373 | 3.3% |
| Uganda | TRAINS | CMT | 5214 | 84.4% | 0.114 | 0.095 | 0.100 | 0.547 | 0.588 | 0.080 | 0.965 | 1.000 | 0.090 | 0.2% |
| United Arab Emirates | TRAINS | TRN | 5025 | 0.0% | 0.046 | 0.049 | 0.025 | 0.130 | 0.140 | 0.081 | 0.271 | 0.305 | 0.116 | 0.0% |
| United States | TRAINS | CMT | 4985 | 0.1% | 0.030 | 0.015 | 0.043 | 0.032 | 0.020 | 0.044 | 0.007 | 0.000 | 0.044 | 6.8% |
| Uruguay | TRAINS | CMT | 5224 | 0.0% | 0.099 | 0.100 | 0.063 | 0.273 | 0.300 | 0.052 | 0.481 | 0.478 | 0.146 | 0.0% |
| Zimbabwe | TRAINS | TRN | 5022 | 78.3% | 0.145 | 0.095 | 0.131 | 0.620 | 0.916 | 0.392 | 0.932 | 1.000 | 0.221 | 13.6% |

## A.3 Number of Exporters Receiving Preferences from each Importer

The table below presents the number of exporters receiving preferences from each importer, where preferences are considered granted when at least x% of HS6 lines exhibit preferential tariffs for that exporter, for Year 2007, x = 10, 25, 50. Number of preferential partners only reported for importers included in the sample.

| Cutoff Share of Products with Preferential Tariffs = | 10 | 25 | 50 |
|---|---|---|---|
| Albania | 5 | 5 | 5 |
| Antigua and Barbuda | 0 | 0 | 0 |
| Argentina | 11 | 11 | 11 |
| Australia | 179 | 73 | 73 |
| Bahrain | 22 | 22 | 22 |
| Barbados | 18 | 16 | 16 |
| Belize | 14 | 14 | 14 |
| Benin | 7 | 0 | 0 |
| Bolivia | 11 | 11 | 11 |
| Botswana | 17 | 13 | 4 |
| Brazil | 11 | 11 | 11 |
| Burkina Faso | 7 | 0 | 0 |
| Burundi | 15 | 15 | 15 |
| Cameroon | 5 | 5 | 5 |
| Canada | 180 | 180 | 54 |
| Central African Republic | 5 | 5 | 5 |
| Chad | 5 | 5 | 5 |

| Cutoff Share of Products with Preferential Tariffs = | 10 | 25 | 50 |
|---|---|---|---|
| Chile | 50 | 50 | 49 |
| China | 16 | 11 | 9 |
| Colombia | 26 | 11 | 11 |
| Congo, Rep. | 5 | 5 | 5 |
| Costa Rica | 4 | 4 | 4 |
| Cote d'Ivoire | 7 | 0 | 0 |
| Croatia | 34 | 34 | 2 |
| Dominica | 14 | 14 | 14 |
| Dominican Republic | 21 | 21 | 0 |
| Ecuador | 11 | 11 | 11 |
| El Salvador | 4 | 4 | 4 |
| European Union | 189 | 189 | 189 |
| Fiji | 0 | 0 | 0 |
| Gabon | 5 | 5 | 5 |
| Georgia | 0 | 0 | 0 |
| Ghana | 14 | 0 | 0 |
| Guatemala | 4 | 4 | 4 |
| Guinea-Bissau | 7 | 0 | 0 |
| Guyana | 0 | 0 | 0 |
| Honduras | 4 | 4 | 4 |
| Hong Kong, China | 0 | 0 | 0 |
| Iceland | 80 | 1 | 0 |
| India | 0 | 0 | 0 |
| Indonesia | 11 | 11 | 9 |

| Cutoff Share of Products with Preferential Tariffs = | 10 | 25 | 50 |
|---|---|---|---|
| Israel | 36 | 35 | 0 |
| Japan | 158 | 158 | 53 |
| Jordan | 21 | 21 | 21 |
| Kenya | 16 | 16 | 16 |
| Korea, Rep. | 19 | 15 | 15 |
| Kuwait | 21 | 21 | 21 |
| Kyrgyz Republic | 60 | 60 | 60 |
| Lesotho | 17 | 13 | 4 |
| Macao | 0 | 0 | 0 |
| Macedonia, FYR | 5 | 5 | 5 |
| Madagascar | 25 | 25 | 25 |
| Malaysia | 10 | 10 | 0 |
| Mali | 7 | 0 | 0 |
| Mauritius | 25 | 0 | 0 |
| Mexico | 28 | 13 | 6 |
| Moldova | 0 | 0 | 0 |
| Mongolia | 0 | 0 | 0 |
| Morocco | 56 | 55 | 55 |
| Mozambique | 13 | 13 | 0 |
| Namibia | 17 | 13 | 4 |
| Nepal | 6 | 6 | 0 |
| New Zealand | 146 | 146 | 0 |
| Nicaragua | 4 | 4 | 4 |
| Niger | 7 | 0 | 0 |

| Cutoff Share of Products with Preferential Tariffs = | 10 | 25 | 50 |
|---|---|---|---|
| Norway | 50 | 0 | 0 |
| Oman | 21 | 21 | 21 |
| Pakistan | 7 | 6 | 1 |
| Panama | 4 | 3 | 3 |
| Paraguay | 11 | 11 | 11 |
| Peru | 9 | 9 | 9 |
| Philippines | 10 | 10 | 9 |
| Qatar | 21 | 21 | 21 |
| Saudi Arabia | 21 | 21 | 21 |
| Senegal | 7 | 0 | 0 |
| Singapore | 0 | 0 | 0 |
| South Africa | 45 | 41 | 4 |
| Sri Lanka | 6 | 6 | 6 |
| St. Lucia | 14 | 14 | 14 |
| Swaziland | 17 | 13 | 4 |
| Switzerland | 194 | 193 | 193 |
| Taiwan, China | 0 | 0 | 0 |
| Tanzania | 15 | 15 | 15 |
| Thailand | 0 | 0 | 0 |
| Togo | 7 | 0 | 0 |
| Trinidad and Tobago | 15 | 15 | 0 |
| Turkey | 209 | 209 | 209 |
| Uganda | 16 | 16 | 16 |
| United Arab Emirates | 21 | 21 | 21 |

| Cutoff Share of Products with Preferential Tariffs = | 10 | 25 | 50 |
|---|---|---|---|
| United States | 154 | 154 | 77 |
| Uruguay | 11 | 11 | 11 |
| Zimbabwe | 16 | 16 | 15 |

## A.4 Quantification by Importer

This table presents the predicted percent increase in number of products products exported by a given exporter resulting from the given policy change in the quantification exercise.

Table A.3: Quantification by Importer

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Albania | 26.4 | 19.9 | -4.25 | 5.19 | 10.3 | 9.31 | 96 | 0 | 1 |
| Antigua and Bar- buda | -56.9 | 26.4 | -90.2 | 33.1 | -164 | 61.3 | 85 | 1 | 1 |
| Argentina | 62.5 | 46.3 | -1.27 | 0.639 | 60.7 | 45.6 | 99 | 0 | 1 |
| Australia | 11.9 | 8.23 | 6.34 | 3.43 | 20.9 | 12.7 | 106 | 1 | 1 |
| Bahrain | -4.45 | 2.67 | 103 | 52.3 | 106 | 53.5 | 70 | 1 | 0 |
| Barbados | -40.6 | 42.4 | -309 | 135 | -396 | 169 | 97 | 1 | 1 |
| Belize | -23.6 | 12.8 | 81.7 | 30.6 | 68 | 28.1 | 67 | 0 | 0 |
| Benin | -64 | 38.6 | 71.6 | 43.7 | 19.5 | 42.9 | 70 | 1 | 1 |
| Bolivia | -94.9 | 43.4 | -234 | 91.2 | -364 | 143 | 83 | 0 | 1 |
| Botswana | 22.5 | 18.8 | -22.2 | 9.15 | -12.1 | 12.7 | 39 | 1 | 0 |
| Brazil | 78.7 | 44.5 | 35.1 | 16.9 | 132 | 68.8 | 125 | 1 | 1 |
| Burkina Faso | -9.61 | 5.72 | 44.6 | 38.3 | 38.1 | 34.4 | 56 | 1 | 0 |
| Burundi | -15.2 | 9.13 | 69.4 | 27 | 54.8 | 22.5 | 58 | 1 | 0 |
| Cameroon | 16.2 | 9.84 | -192 | 84.7 | -178 | 80.1 | 99 | 0 | 1 |
| Canada | 42.1 | 25 | 0.952 | 0.258 | 45.4 | 26.5 | 35 | 0 | 1 |

| | Reduce all MFN Tariffs to Zero | | Reduce all Bound Tariffs to MFN Rate | | Reduce MFN and Bound to Zero | | No. Exporters | Significant Point Estimate (5% level) | |
|---|---|---|---|---|---|---|---|---|---|
| Importer | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | | U | log_tau |
| Central African Republic | 26.4 | 10.6 | -35.7 | 16.6 | -17.8 | 14.5 | 45 | 0 | 0 |
| Chad | 24.4 | 13.6 | -58 | 24 | -34.5 | 16.1 | 40 | 0 | 0 |
| Chile | 3290 | 1500 | 334 | 152 | 3700 | 1680 | 59 | 0 | 1 |
| China | 123 | 54.8 | -3.39 | 4.2 | 42.5 | 22.1 | 131 | 1 | 1 |
| Colombia | 45.3 | 43.4 | -117 | 62.5 | -111 | 59.1 | 116 | 1 | 0 |
| Congo, Rep. | 8.46 | 3.69 | -9.26 | 3.8 | -1.55 | 3.24 | 54 | 0 | 0 |
| Costa Rica | 59.7 | 48.4 | 40.3 | 17.9 | 105 | 61.1 | 103 | 1 | 1 |
| Cote d'Ivoire | -14.6 | 8.46 | 39.6 | 24.5 | 27.1 | 19.6 | 102 | 1 | 0 |
| Croatia | 34.6 | 27.2 | 5.49 | 6.99 | 73.5 | 54.6 | 103 | 1 | 1 |
| Dominica | -33.3 | 20.3 | 72.6 | 26.2 | 46.2 | 19.2 | 58 | 0 | 1 |
| Dominican Republic | 12.6 | 14.1 | 98.4 | 57 | 136 | 89.1 | 101 | 1 | 1 |

| Importer | Reduce all MFN Tariffs to Zero | | Reduce all Bound Tariffs to MFN Rate | | Reduce MFN and Bound to Zero | | No. Exporters | Significant Point Estimate (5% level) | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | | U | log_tau |
| Ecuador | 72.3 | 91.7 | 42.3 | 28.6 | 152 | 158 | 87 | 1 | 1 |
| El Salvador | 42.4 | 42 | 49.2 | 22.8 | 98.3 | 60 | 84 | 1 | 1 |
| European Union | 13.7 | 6.01 | -0.541 | 0.0769 | 9.58 | 4.41 | 14 | 1 | 1 |
| Fiji | -15 | 10.9 | 126 | 105 | 120 | 99.9 | 86 | 1 | 0 |
| Gabon | -46.8 | 23.1 | 37 | 26.7 | 17.5 | 21.7 | 83 | 1 | 0 |
| Georgia | 7.86 | 14.8 | 10.2 | 6.27 | 19.1 | 17.6 | 82 | 1 | 1 |
| Ghana | 52.4 | 33.3 | -219 | 84.7 | -169 | 63.4 | 117 | 1 | 1 |
| Guatemala | 43.1 | 30.2 | 32 | 10.8 | 78.5 | 36.3 | 91 | 1 | 1 |
| Guinea-Bissau | -71 | 38.4 | -457 | 205 | -603 | 256 | 37 | 0 | 0 |
| Guyana | -46.1 | 31.3 | -162 | 63.9 | -230 | 97.5 | 76 | 1 | 1 |
| Honduras | 39.8 | 25.9 | 90.1 | 40.3 | 150 | 56.4 | 104 | 1 | 1 |
| Hong Kong, China | 0 | 0 | 17.7 | 11.4 | 0 | 0 | 136 | 1 | |
| Iceland | -2.45 | 2.09 | -0.691 | 0.481 | -3.43 | 2.43 | 71 | 0 | 0 |
| India | 1.31 | 2.67 | 30.8 | 13.2 | 38.8 | 16.3 | 145 | 1 | 1 |

| | Reduce all MFN Tariffs to Zero | | Reduce all Bound Tariffs to MFN Rate | | Reduce MFN and Bound to Zero | | No. Exporters | Significant Point Estimate (5% level) | |
|---|---|---|---|---|---|---|---|---|---|
| Importer | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | | U | log_tau |
| Indonesia | 31.7 | 26 | 30.9 | 13.7 | 66.9 | 40.4 | 59 | 1 | 1 |
| Israel | 13.2 | 19.5 | 4.71 | 4.02 | 18.4 | 22.9 | 88 | 0 | 1 |
| Japan | 7.66 | 5.21 | -0.204 | 0.295 | 5.68 | 3.86 | 44 | 1 | 1 |
| Jordan | 61.5 | 81.7 | 5.42 | 4.58 | 77.4 | 94.7 | 63 | 0 | 1 |
| Kenya | 18.6 | 12.3 | 38.8 | 15.2 | 57.7 | 22.7 | 102 | 0 | 1 |
| Korea, Rep. | 3.13 | 2.39 | 2.6 | 1.75 | 7.74 | 5.62 | 132 | 1 | 1 |
| Kuwait | 148 | 78.1 | -40300 | 18300 | -40700 | 18400 | 57 | 0 | 0 |
| Kyrgyz Republic | 41 | 51.6 | 8.65 | 10.5 | 58.3 | 63.8 | 78 | 1 | 1 |
| Lesotho | 22 | 24.7 | 408 | 169 | 456 | 207 | 31 | 0 | 1 |
| Macao | 0 | 0 | 49.8 | 40.1 | 0 | 0 | 97 | 1 | |
| Macedonia, FYR | -48.8 | 45.7 | 0.252 | 0.496 | 7.55 | 6.7 | 78 | 1 | 0 |
| Madagascar | 41.2 | 27 | 23.3 | 14.6 | 66.1 | 39.4 | 91 | 1 | 1 |
| Malaysia | 11.7 | 8.8 | 18.1 | 10.3 | 35.6 | 18.2 | 131 | 1 | 1 |
| Mali | -55.7 | 34.2 | 52.9 | 33.7 | 4.11 | 33.3 | 96 | 1 | 1 |
| Mauritius | 19.6 | 29 | 110 | 46.1 | 130 | 62.5 | 105 | 1 | 1 |

| | Reduce all MFN Tariffs to Zero | | Reduce all Bound Tariffs to MFN Rate | | Reduce MFN and Bound to Zero | | No. Exporters | Significant Point Estimate (5% level) | |
|---|---|---|---|---|---|---|---|---|---|
| Importer | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | | U | log_tau |
| Mexico | 71.9 | 41.4 | -42.4 | 23.2 | 8.07 | 37.7 | 104 | 1 | 1 |
| Moldova | 21.2 | 17.1 | 11.3 | 18.3 | 57.5 | 37.7 | 96 | 1 | 1 |
| Mongolia | -544 | 235 | 46.1 | 25.6 | -485 | 210 | 71 | 1 | 1 |
| Morocco | 17.9 | 19.5 | 53.2 | 32.5 | 103 | 69.3 | 82 | 1 | 1 |
| Mozambique | 36.9 | 40 | 10.5 | 6.75 | 47.5 | 46.2 | 102 | 0 | 1 |
| Namibia | 35.7 | 35 | -61.8 | 93.1 | -50.4 | 92.1 | 74 | 1 | 0 |
| Nepal | -49.1 | 56.8 | 116 | 51.1 | 158 | 66.3 | 68 | 1 | 1 |
| New Zealand | 42.8 | 29.8 | 18.3 | 8.93 | 66.8 | 41.3 | 45 | 1 | 1 |
| Nicaragua | 39.8 | 40.6 | 0.401 | 0.186 | 40.2 | 40.8 | 91 | 0 | 1 |
| Niger | -63 | 28.8 | 22.6 | 9.18 | -34.1 | 24.3 | 74 | 1 | 1 |
| Norway | 9.59 | 13.3 | 7.71 | 6.88 | 21.7 | 20.6 | 98 | 1 | 0 |
| Oman | -27.5 | 15.2 | 56.8 | 41.4 | 60.8 | 42.7 | 77 | 1 | 1 |
| Pakistan | -24.7 | 44.8 | 267 | 140 | 284 | 148 | 127 | 1 | 1 |
| Panama | 13.9 | 8.86 | 58 | 27.6 | 96.5 | 42.3 | 72 | 1 | 1 |
| Paraguay | 100 | 80.4 | 85.4 | 38.1 | 217 | 128 | 74 | 1 | 1 |
| Peru | 3.82 | 11.2 | -301 | 164 | -403 | 201 | 107 | 1 | 1 |
| Philippines | 6.18 | 4.75 | 27 | 12.6 | 36.1 | 17.7 | 102 | 1 | 1 |
| Qatar | 137 | 90.9 | -75.1 | 40.3 | 37.2 | 65.4 | 89 | 1 | 1 |

| Importer | Reduce all MFN Tariffs to Zero | | Reduce all Bound Tariffs to MFN Rate | | Reduce MFN and Bound to Zero | | No. Exporters | Significant Point Estimate (5% level) | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | | U | log_tau |
| Saudi Arabia | 60.1 | 32.4 | 48.3 | 25.3 | 144 | 71.1 | 123 | 1 | 1 |
| Senegal | -11.3 | 11.2 | 193 | 77.3 | 286 | 105 | 95 | 1 | 1 |
| Singapore | 0 | 0 | 31.4 | 12.5 | 0 | 0 | 97 | 1 | |
| South Africa | 45.3 | 46.7 | -22.4 | 18.2 | 7.94 | 35.3 | 106 | 1 | 1 |
| Sri Lanka | 15 | 9.37 | 6.89 | 3.31 | 22.2 | 11.4 | 96 | 0 | 1 |
| St. Lucia | 5.52 | 19 | -168 | 74 | -190 | 91.8 | 67 | 1 | 1 |
| Swaziland | 13.5 | 11.2 | -35.4 | 20.1 | -34.5 | 20.2 | 42 | 1 | 0 |
| Taiwan, China | 45.9 | 61.7 | -1.07 | 1.22 | 19.5 | 29 | 146 | 1 | 1 |
| Tanzania | -1.72 | 1.41 | 197 | 87 | 195 | 86.3 | 99 | 0 | 0 |
| Thailand | 16.3 | 10.8 | 25.4 | 12.7 | 47.7 | 21.5 | 136 | 1 | 1 |
| Togo | -98.9 | 64 | 647 | 356 | 554 | 300 | 79 | 1 | 1 |
| Trinidad and Tobago | 23.4 | 20.3 | 32.7 | 12.1 | 59.2 | 30.1 | 98 | 0 | 1 |

| | Reduce all MFN Tariffs to Zero | | Reduce all Bound Tariffs to MFN Rate | | Reduce MFN and Bound to Zero | | No. Ex-porters | Significant Point Estimate (5% level) | |
|---|---|---|---|---|---|---|---|---|---|
| Importer | Mean | Std. Dev | Mean | Std. Dev | Mean | Std. Dev | | U | log_tau |
| Turkey | 9.02 | 6.34 | 26.8 | 12.4 | 37.2 | 18.5 | 11 | 1 | 1 |
| Uganda | -1.53 | 3.09 | 112 | 61 | 112 | 60.6 | 95 | 1 | 0 |
| United Arab Emirates | 72.7 | 47.1 | -47.5 | 26.5 | 7.62 | 22.7 | 118 | 1 | 1 |
| United States | 2.48 | 1.48 | 0.441 | 0.23 | 9.55 | 5.04 | 35 | 1 | 1 |
| Uruguay | 58.7 | 37.7 | 43.8 | 30.7 | 120 | 71.8 | 94 | 1 | 1 |
| Zimbabwe | -19.8 | 14.7 | 38.9 | 27 | 19.8 | 21.9 | 78 | 1 | 1 |

## A.5 Alternative Data Treatments

In evaluating the results presented above in Section 2.7, I identify a prediction each for $x = \tau, U$ in each the pooled ($P$) and by-importer ($I$) regressions that I expect to hold ex-ante:

$Px$: For the pooled regression, I expect the point estimate $\hat{b}_x$ to be negative and significant (at the 5% level).

$Ix$: For the by-importer regressions, I expect that the percentage of exporters for which $\hat{b}_x$ is negative and significant > The percentage of importers for which $\hat{b}_x$ is positive and significant.

Predictions $Px$ (for $x = \tau, U$) simply assert that the observed signs of the point estimates on the coefficients of the applied tariff level and the uncertainty measure are those that would be expected based on the theoretic model presented above. Predictions $Ix$ (for $x = \tau, U$) then apply this theoretical prediction to the by-importer regressions by stating that we should be more likely to see a negative significant effect than a positive significant effect of both the MFN tariff level and of the uncertainty resulting from binding overhang.

Labeling each prediction according to the parameter $x = \tau, U$ and either $P$ for the pooled regression or $I$ for the by-importer regressions, we can then summarize the results presented in Sections 2.7.1 and 2.4 according to which predictions are confirmed by each specification as shown in Table A.4, where predictions that are not confirmed by the given specification are grayed out.

Recall that the baseline data treatment on which these results are based included the following assumptions: products for which the MFN exceeded the bound rate were dropped, the uncertainty measure for products with no bound rate was set to one, and the preference indicator was defined according to a 25% (of product lines with preferences) cutoff (further supplemented by the PTAs identified in the Baier Bergstrand dataset). In order to check the robustness of these results to alternative methods of dealing with MFN rates exceeding bound rates, unbound lines, and alternative preference cutoffs, I re-run both the pooled and the by-importer regressions for each possible combination along the following 3 dimensions:

- For products where the reported MFN tariff exceeds the Bound tariff, 1 of 3 possible actions is taken in defining the uncertainty measure for that product:

  - "umdrop": products for which this is the case are dropped from the analysis (as was done above)

  - "um0": $U$ is set to zero, the minimum possible value

  - "um1": $U$ is set to one, the maximum possible value

- For products with no bound tariff, 1 of 2 possible actions is taken in defining the

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Table A.4: Alternative Data Treatments

| prefcutoff | | ub1 | | ubdrop | |
|---|---|---|---|---|---|
| 25 | umdrop | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | |
| | um0 | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | |
| | um1 | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ *PU* <br> $I\tau$ $\quad$ *IU* | |
| 10 | umdrop | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | |
| | um0 | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | |
| | um1 | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ *PU* <br> $I\tau$ $\quad$ *IU* | |
| 50 | umdrop | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | |
| | um0 | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ $PU$ <br> $I\tau$ $\quad$ $IU$ | |
| | um1 | $P\tau$ $\quad$ *PU* <br> $I\tau$ $\quad$ $IU$ | | $P\tau$ $\quad$ *PU* <br> $I\tau$ $\quad$ *IU* | |

uncertainty measure for that product:

- "ub1": $U$ is set to one, the maximum possible value (as was done above)

- "ubdrop": products for which this is the case are dropped from the analysis

- The indicator for whether or not an exporter receives preferences from a given importer is defined according to a cutoff percentage of products for which a preferential tariff exists between that importer-exporter pair (as supplemented by the Baier Bergstrand dataset of PTAs):

  - "pref25": 25% cutoff (as was used above)

  - "pref10": 10% cutoff

  - "pref50": 50% cutoff

Tables analogous to Tables 2.3-2.5 exist for each of the 18 possible combinations along these 3 dimensions. In order to summarize what these tables would show, I include in Table A.4 a summary of which of the 4 predictions are confirmed by each specification/data treatment, where predictions that are not confirmed by the given specification are grayed out.

Comparing the results of these regressions based on the various versions of the data, we see that the results shown in the previous section (for the version of the data where products with MFN exceeding bound tariffs are dropped ("umdrop"), the uncertainty measure for unbound lines set to one ("ub1") and a preference indicator defined by the 25% cutoff) are largely robust to these various definitions and cutoffs, with one major exception: in several cases, fulfillment of the predictions about the sign of the uncertainty coefficient disappears in the "um1" case, that is, when products for which the MFN rate exceeds the bound rate are assigned an uncertainty measure equal to 1.

In comparing the results obtained using various cutoff levels to define the existence of preferential agreements, we see from Table A.4 that the cutoff chosen makes almost no difference in the results. Recall that the preference indicator used in determining which bilateral pairs to include in the sample is constructed using both the cutoff share of products with preferential tariffs as well as the database of PTAs constructed by Baier and Bergstrand (2007), thus, the sample of countries included in the sample may not change greatly with the cutoff chosen, as any preferential arrangements which are not picked up by the preferential tariff shares may still be in the Baier Bergstrand data.

# Appendix B

# Chapter 3 Appendix

## B.1 Proof: Constant Export Productivity Cutoffs over $H^{(n)}$ states

In this appendix, I drop sector subscript $k$ for convenience, with the understanding that the proof is valid for each sector $k$. I assume that for each $r \neq s$ either

$$\varphi_{r,s}^c(H^{(n+1)}) \leq \varphi_{r,s}^c(H^{(n)}) \quad \forall n = 0, 1, 2, \ldots \tag{B.1}$$

or

$$\varphi_{r,s}^c(H^{(n+1)}) \geq \varphi_{r,s}^c(H^{(n)}) \quad \forall n = 0, 1, 2, \ldots \tag{B.2}$$

and further assume that productivity follows some continuous distribution, that no shock is large enough to cause the constraint $NE_r(\zeta) \geq 0$ to bind, and that the economy eventually reaches its long term steady state equilibrium, $H^{det}$. I show that under these assumptions, it must be the case that in equilibrium, $\varphi_{r,s}^c(H^{(n+1)}) = \varphi_{r,s}^c(H^{(n)}) = \varphi_{r,s}^c(H^{det}) \, \forall n = 0, 1, 2, \ldots, \, \forall r, s$ (see section 3.3.4 for notation definitions). This proof relies on the equilibrium equations determining cutoff productivities $\varphi_{r,s}^c(H^{(n)})$ as well as the free entry conditions that determine the mass of new entrants into production, $NE_r(H^{(n)})$, in each

high-tariff period, and so the two subsections below derive these equations under each possible ordering of the high tariff cutoffs given in (B.2) and (B.1) and the final subsection uses these equations to prove the result.

**Export Productivity Cutoffs in High Tariff States**

For a firm of productivity level $\varphi$ in region $r$, I let $V_{\varphi,r,s}(\zeta)$ be the present discounted value of selling in market $s$ in state $\zeta$, taking into account current and expected future profit flows from exporting from $r$ to $s$ (or selling domestically for $r = s$). In a given state $\zeta$, region $r$ firms who have entered into production in some previous period will choose to incur the sunk cost to export to region $s$, $f_{r,s}^{exp}$, and begin exporting to $s$ if the value of exporting exceeds the value of waiting to begin exporting to $s$ by at least the amount of this sunk cost. That is, in state $\zeta$ a country $r$ firm with productivity $\varphi$ will enter export market $s$ if

$$V_{\varphi,r,s}(\zeta) - V_{\varphi,r,s}^{wait}(\zeta) \geq w_r f_{r,s}^{exp}$$

The value of being a region $r$ producer selling in region $s$ in each state for a productivity $\varphi$ firm in state $H^{(n)}$ is then:

$$
\begin{aligned}
V_{\varphi,r,s}(H^{(n)}) &= \varphi^{\sigma-1} A_{r,s}(H^{(n)}) + (1-\delta) V_{\varphi,r,s}(H^{(n+1)}) \\
\Rightarrow V_{\varphi,r,s}(H^{(n)}) &= \varphi^{\sigma-1} \sum_{i=n}^{\infty} (1-\delta)^{i-n} A_{r,s}(H^{(i)})
\end{aligned}
\tag{B.3}
$$

while the value of waiting to enter a given export market is:

$$V_{\varphi,r,s}^{wait}(H^{(n)}) = (1-\delta) \max \left[ \left( V_{\varphi,r,s}(H^{(n+1)}) - w_r f_{r,s}^{exp} \right), V_{\varphi,r,s}^{wait}(H^{(n+1)}) \right]$$

Expression (B.3) gives the present discounted value of exporting from $r$ to $s$ for a productivity $\varphi$ firm regardless of the ordering of the cutoffs over time, as once a firm pays the fixed cost and enters a given export market he will continue to sell in that market until hit by the exogenous death shock. The value of waiting to begin exporting in state $H^{(n)}$, $V_{\varphi,r,s}^{wait}(H^{(n)})$, however can be simplified further and will depend on the ordering of the cutoffs $\varphi_{r,s}^{c}(H^{(n)})$ over time:

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**Cutoffs Ranked According to (B.1)**   In the case where $\varphi_{r,s}^c(H^{(n+1)}) \leq \varphi_{r,s}^c(H^{(n)})$, for firms below the cutoff productivity in state $H^{(n)}$, there may be a positive value of waiting to enter in a later period when the cutoff is lower. For the marginal firm who is just indifferent between entering and waiting in state $H^{(n)}$ in this case, we can be sure he will choose to enter in state $H^{(n+1)}$ and so the value of waiting for $\varphi = \varphi_{r,s}^c(H^{(n)})$ in this case is

$$
\begin{aligned}
V_{\varphi_{r,s}^c(H^{(n)}),r,s}^{wait}(H^{(n)}) &= (1-\delta)\left[ V_{\varphi_{r,s}^c,r,s}(H^{(n+1)} - w_r f_{r,s}^{exp}) \right] \\
\Rightarrow V_{\varphi_{r,s}^c(H^{(n)}),r,s}^{wait}(H^{(n)}) &= \varphi_{r,s}^c(H^{(n)})^{\sigma-1} \sum_{i=n+1}^{\infty} (1-\delta)^{i-n} A_{r,s}(H^{(i)}) - (1-\delta)w_r f_{r,s}^{exp}
\end{aligned}
$$

For a firm with productivity $\varphi = \varphi_{r,s}^c(H^{(n)})$, we have

$$
\left( V_{\varphi,r,s}(H^{(n)}) - V_{\varphi,r,s}^{wait}(H^{(n)}) \right) = \left( \varphi_{r,s}^c(H^{(n)}) \right)^{\sigma-1} A_{r,s}(H^{(n)}) + (1-\delta)\left( w_r f_{r,s}^{exp} \right)
$$

And so for this marginal firm who is just indifferent between selling only in the domestic market and entering the export market in state $H^{(n)}$, it must be that[1]

$$
\begin{aligned}
w_r f_{r,s}^{exp} &= \left( \varphi_{r,s}^c(H^{(n)}) \right)^{\sigma-1} A_{r,s}(H^{(n)}) + (1-\delta)\left( w_r f_{r,s}^{exp} \right) \\
\Rightarrow \left( \varphi_{r,s}^c(H^{(n)}) \right)^{\sigma-1} &= \frac{\delta w_r f_{r,s}^{exp}}{A_{r,s}(H^{(n)})}, r \neq s
\end{aligned}
\tag{B.4}
$$

**Cutoffs Ranked According to (B.2)**   If $\varphi_{r,s}^c(H^{(n+1)}) \geq \varphi_{r,s}^c(H^{(n)})$, that is, if the cutoff productivity to export from $r$ to $s$ is increasing over time after the arrival of the high tariff shock, it will be the case that for $\varphi \leq \varphi_{r,s}^c(H^{(n)})$, $V_{\varphi,r,s}^{wait}(H^{(n)}) = 0$ since for firms below the $H^{(n)}$ state productivity cutoff, export conditions from $r$ to $s$ will only continue to worsen over time and they will never enter that export market.

In this case, for a firm with productivity $\varphi = \varphi_{r,s}^c(H^{(n)})$, we have

$$
\left( V_{\varphi,r,s}(H^{(n)}) - V_{\varphi,r,s}^{wait}(H^{(n)}) \right) = \varphi_{r,s}^c(H^{(n)})^{\sigma-1} \sum_{i=n}^{\infty} (1-\delta)^{i-n} A_{r,s}(H^{(i)})
$$

And so for this marginal firm who is just indifferent between selling only in the domestic

---

[1] I assume throughout the paper that fixed exporting costs are sufficiently high that this cutoff never falls below the minimum possible productivity draw, $b$.

market and entering the export market in state $H^{(n)}$, it must be that

$$
\begin{aligned}
w_r f_{r,s}^{exp} &= \varphi_{r,s}^c (H^{(n)})^{\sigma-1} \sum_{i=n}^{\infty} (1-\delta)^{i-n} A_{r,s}(H^{(i)}) \\
\Rightarrow \left( \varphi_{r,s}^c (H^{(n)}) \right)^{\sigma-1} &= \frac{w_r f_{r,s}^{exp}}{\sum_{i=n}^{\infty} (1-\delta)^{i-n} A_{r,s}(H^{(i)})}, \ r \neq s
\end{aligned} \tag{B.5}
$$

## Free Entry Condition in High Tariff States

Under the assumption of free entry, a prospective firm will chose to pay the sunk cost, $f_r^{sunk}$, and enter into production in state $\zeta$ if and only if $V_r^{entry}(\zeta) - w_r f_r^{sunk} \geq V_r^{wait\,to\,enter}(\zeta)$ where $V_r^{entry}(\zeta)$ is the value of entering into production in state $\zeta$ and $V_r^{wait\,to\,enter}(\zeta)$ is the value of not entering, but retaining the option of entering in some future period.[2]

For a given state $\zeta$, the value of entering into production for a firm who draws productivity $\varphi$ will be:

$$
\begin{aligned}
V_{\varphi,r}^{entry}(\zeta) &= V_{\varphi,r,r}(\zeta) \\
&\quad + (1-\delta) E_{\zeta'|\zeta} \left[ \sum_{s \neq r} 1(\varphi \geq \varphi_{r,s}^c(\zeta')) \left( V_{\varphi,r,s}(\zeta') - w_r f_{r,s}^{exp} \right) + 1(\varphi < \varphi_{r,s}^c(\zeta')) V_{\varphi,r,s}^{wait}(\zeta') \right]
\end{aligned}
$$

Thus, the expected (over $\varphi$) value of entry in state $H^{(n)}$ is given by:

$$
\begin{aligned}
V_r^{entry}(H^{(n)}) &= \int_b^{\infty} V_{\varphi,r,r}(H^{(n)}) dF(\varphi) \\
&\quad + (1-\delta) \left[ \sum_{s \neq r} \int_{\varphi_{r,s}^c(H^{(n+1)})}^{\infty} \left( V_{\varphi,r,s}(H^{(n+1)}) - w_r f_{r,s}^{exp} \right) dF(\varphi) \right. \\
&\quad \left. + \int_b^{\varphi_{r,s}^c(H^{(n+1)})} V_{\varphi,r,s}^{wait}(H^{(n+1)}) dF(\varphi) \right]
\end{aligned}
$$

I assume that the "death shock" applies equally to current and potential firms so that the same discount factor is used by all when discounting future periods. Then, the value of

---

[2]Note that $V_r^{wait\,to\,enter}$ indexed by one country denotes the value of waiting to enter into production while $V_{r,s}^{wait}$ indexed by two countries denotes the value of waiting to begin exporting to region $s$. These are two distinct values.

waiting to enter into production in a given state will be given by

$$V_r^{wait\,to\,enter}(H^{(n)}) = 0 + (1-\delta)\max\left[\left(V_r^{entry}(H^{(n+1)}) - w_r f_r^{sunk}\right), V_r^{wait\,to\,enter}((H^{(n+1)}))\right]$$
$$= (1-\delta)\left[V_r^{wait\,to\,enter}(H^{(n+1)})\right]$$

where the final equality follows from the fact that in equilibrium, free entry implies that

$V_r^{entry}(\zeta) - w_r f_r^{sunk} \leq V_r^{wait\,to\,enter}(\zeta)\,\forall\zeta$ (with strict inequality only in the case when the

constraint $NE_r(\zeta) \geq 0$ is binding). I make the explicit assumption that the condition

$NE_r(\zeta) \geq 0$ is never binding, so that in any state, in equilibrium we have that $V_r^{entry}(\zeta) -$

$w_r f_r^{sunk} = V_r^{wait\,to\,enter}(\zeta)$.

Letting $DEC_{r,s}$ be a binary indicator equal to 1 when the export cutoffs from $r$ to $s$ are

ranked according to (B.1) (that is, decreasing over time), and zero otherwise, I can write

the value of entry into production as:

$$V_r^{entry}(H^{(n)}) = \int_b^\infty V_{\varphi,r,r}(H^{(n)})dF(\varphi)$$
$$+ (1-\delta)\left[\sum_{s\neq r}\int_{\varphi_{r,s}^c(H^{(n+1)})}^\infty \left(V_{\varphi,r,s}(H^{(n+1)}) - w_r f_{r,s}^{exp}\right)dF(\varphi)\right.$$
$$\left. + \int_b^{\varphi_{r,s}^c(H^{(n+1)})} V_{\varphi,r,s}^{wait}(H^{(n+1)})dF(\varphi)\right]$$
$$= \int_b^\infty V_{\varphi,r,r}(H^{(n)})dF(\varphi)$$
$$+ (1-\delta)\left[\sum_{s\neq r}\int_{\varphi_{r,s}^c(H^{(n+1)})}^\infty \left(V_{\varphi,r,s}(H^{(n+1)}) - w_r f_{r,s}^{exp}\right)dF(\varphi) + DEC_{r,s}\right.$$
$$\left. * \sum_{i=n+1}^\infty (1-\delta)^{i-n}\int_{\varphi_{r,s}^c(H^{(i+1)})}^{\varphi_{r,s}^c(H^{(i)})} \left(V_{\varphi,r,s}(H^{(i+1)}) - w_r f_{r,s}^{exp}\right)dF(\varphi)\right]$$

since under the assumption that $\varphi_{r,s}^c(H^{(n+1)}) \leq \varphi_{r,s}^c(H^n)\,\forall n$, we have that the value of

waiting to export will be given by

$$V_{\varphi,r,s}^{wait}(H^{(n+1)}) = (1-\delta)^{i-n}\left(V_{\varphi,r,s}(H^{(i+1)}) - w_r f_{r,s}^{exp}\right) \text{ for } \varphi_{r,s}^c(H^{(i+1)})$$
$$\leq \varphi$$
$$\leq \varphi_{r,s}^c(H^i)$$

while in the case where $\varphi_{r,s}^c(H^{(n+1)}) > \varphi_{r,s}^c(H^n)$ (that is, $DEC_{r,s} = 0$), we have that

$\int_b^{\varphi_{r,s}^c(H^{(n+1)})} V_{\varphi,r,s}^{wait}(H^{(n+1)})dF(\varphi) = 0$.

Then, in state $H^{(n)}$, we have that $V_r^{entry}(H^{(n)}) - V_r^{wait\,to\,enter}(H^{(n)}) =$

$$= \int_b^\infty V_{\varphi,r,r}(H^{(n)})dF(\varphi) + (1-\delta)\left[\sum_{s\neq r}\int_{\varphi_{r,s}^c(H^{(n+1)})}^\infty \left(V_{\varphi,r,s}(H^{(n+1)}) - w_r f_{r,s}^{exp}\right)dF(\varphi)\right.$$

$$\left. + \int_b^{\varphi_{r,s}^c(H^{(n+1)})} \left(V_{\varphi,r,s}^{wait}(H^{(n+1)})\right)dF(\varphi)\right] - V_r^{wait\,to\,enter}(H^{(n)})$$

$$= \int_b^\infty V_{\varphi,r,r}(H^{(n)})dF(\varphi) + (1-\delta)\left[\sum_{s\neq r}\int_{\varphi_{r,s}^c(H^{(n+1)})}^\infty \left(V_{\varphi,r,s}(H^{(n+1)}) - w_r f_{r,s}^{exp}\right)dF(\varphi)\right.$$

$$+ (1-\delta)\left(\int_b^{\varphi_{r,s}^c(H^{(n+2)})}\left(V_{\varphi,r,s}^{wait}(H^{(n+2)})\right)dF(\varphi)\right.$$

$$\left.\left. + DEC_{r,s}\int_{\varphi_{r,s}^c(H^{(n+2)}}^{\varphi_{r,s}^c(H^{(n+1)})}\left(V_{\varphi,r,s}(H^{(n+2)}) - w_r f_{r,s}^{exp}\right)dF(\varphi)\right)\right]$$

$$- (1-\delta)V_r^{wait\,to\,enter}(H^{(n+1)})$$

$$= \tilde\varphi_{r,r}^{\sigma-1}(H^{(n)})A_{r,r}(H^{(n)})$$

$$+ (1-\delta)\left[\int_b^\infty V_{\varphi,r,r}(H^{(n+1)})dF(\varphi) + \sum_{s\neq r}(1-\delta)\left(\int_b^{\varphi_{r,s}^c(H^{(n+2)})}\left(V_{\varphi,r,s}^{wait}(H^{(n+2)})\right)dF(\varphi)\right.\right.$$

$$\left.\left. + DEC_{r,s}\int_{\varphi_{r,s}^c(H^{(n+2)}}^{\varphi_{r,s}^c(H^{(n+1)})}\left(V_{\varphi,r,s}(H^{(n+2)}) - w_r f_{r,s}^{exp}\right)dF(\varphi)\right)\right] + (1-\delta)\sum_{s\neq r}\left(1\right.$$

$$\left. - F(\varphi_{r,s}^c(H^{(n+1)}))\right)\left(\tilde\varphi_{r,s}^{\sigma-1}(H^{(n+1)})\sum_{i=n+1}^\infty (1-\delta)^{i-(n+1)}A_{r,s}(H^{(i)}) - w_r f_{r,s}^{exp}\right)$$

$$- (1-\delta)V_r^{wait\,to\,enter}(H^{(n+1)})$$

$$= \tilde\varphi_{r,r}^{\sigma-1}(H^{(n)})A_{r,r}(H^{(n)}) + (1-\delta)\underbrace{(V_r^{entry}(H^{(n+1)}) - V_r^{wait\,to\,enter}(H^{(n+1)})}_{=w_r f_r^{sunk}}$$

$$- (1-\delta)\sum_{s\neq r}\int_{\varphi_{r,s}^c(H^{(n+2)})}^\infty\left(V_{\varphi,r,s}(H^{(n+2)}) - w_r f_{r,s}^{exp}\right)dF(\varphi)$$

$$+ DEC_{r,s}(1-\delta)\int_{\varphi_{r,s}^c(H^{(n+2)}}^{\varphi_{r,s}^c(H^{(n+1)})}\left(V_{\varphi,r,s}(H^{(n+2)}) - w_r f_{r,s}^{exp}\right)dF(\varphi))$$

$$+ (1-\delta)\sum_{s\neq r}\left(1 - F(\varphi_{r,s}^c(H^{(n+1)}))\right)\left(\tilde\varphi_{r,s}^{\sigma-1}(H^{(n+1)})\sum_{i=n+1}^\infty (1-\delta)^{i-(n+1)}A_{r,s}(H^{(i)}) - w_r f_{r,s}^{exp}\right)$$

$$= \tilde\varphi_{r,r}^{\sigma-1}(H^{(n)})A_{r,r}(H^{(n)}) + (1-\delta)[w_r f_r^{sunk} - (1-\delta)$$

$$* \sum_{s\neq r}(DEC_{r,s}\int_{\varphi_{r,s}^c(H^{(n+1)})}^\infty\left(V_{\varphi,r,s}(H^{(n+2)}) - w_r f_{r,s}^{exp}\right)dF(\varphi)$$

$$+ (1 - DEC_{r,s})\int_{\varphi_{r,s}^c(H^{(n+2)})}^\infty\left(V_{\varphi,r,s}(H^{(n+2)}) - w_r f_{r,s}^{exp}\right)dF(\varphi))]$$

$$+(1-\delta)\sum_{s\neq r}\left(1-F(\varphi_{r,s}^c(H^{(n+1)}))\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)})\sum_{i=n+1}^{\infty}(1-\delta)^{i-(n+1)}A_{r,s}(H^{(i)})-w_r f_{r,s}^{exp}\right)$$

$$=\tilde{\varphi}_{r,r}^{\sigma-1}(H^{(n)})A_{r,r}(H^{(n)})+(1-\delta)w_r f_r^{sunk}-(1-\delta)^2\sum_{s\neq r}DEC_{r,s}\Big(1$$

$$-F(\varphi_{r,s}^c(H^{(n+1)}))\Big)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)})\sum_{i=n+2}^{\infty}(1-\delta)^{i-(n+2)}A_{r,s}(H^{(i)})-w_r f_{r,s}^{exp}\right)$$

$$-(1-\delta)^2\sum_{s\neq r}(1-DEC_{r,s}\Big(1$$

$$-F(\varphi_{r,s}^c(H^{(n+2)}))\Big)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+2)})\sum_{i=n+2}^{\infty}(1-\delta)^{i-(n+2)}A_{r,s}(H^{(i)})-w_r f_{r,s}^{exp}\right)+(1$$

$$-\delta)\sum_{s\neq r}\left(1-F(\varphi_{r,s}^c(H^{(n+1)}))\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)})\sum_{i=n+1}^{\infty}(1-\delta)^{i-(n+1)}A_{r,s}(H^{(i)})-w_r f_{r,s}^{exp}\right)$$

$$=\tilde{\varphi}_{r,r}^{\sigma-1}(H^{(n)})A_{r,r}(H^{(n)})+(1-\delta)w_r f_r^{sunk}+(1-\delta)\sum_{s\neq r}DEC_{r,s}\Big(1$$

$$-F(\varphi_{r,s}^c(H^{(n+1)}))\Big)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)}A_{r,s}(H^{(n+1)})+(1-\delta)w_r f_{r,s}^{exp}-w_r f_{r,s}^{exp}\right)+(1-\delta)\sum_{s\neq r}(1$$

$$-DEC_{r,s})\left[\left(1-F(\varphi_{r,s}^c(H^{(n+1)}))\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)})\sum_{i=n+1}^{\infty}(1-\delta)^{i-(n+1)}A_{r,s}(H^{(i)})-w_r f_{r,s}^{exp}\right)\right.$$

$$\left.-(1-\delta)\left(1-F(\varphi_{r,s}^c(H^{(n+2)}))\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+2)})\sum_{i=n+2}^{\infty}(1-\delta)^{i-(n+2)}A_{r,s}(H^{(i)})-w_r f_{r,s}^{exp}\right)\right]$$

Setting this expression equal to the sunk cost of entry we have that in equilibrium:

$$\tilde{\varphi}_{r,r}^{\sigma-1}(H^{(n)})A_{r,r}(H^{(n)})+(1-\delta)\sum_{s\neq r}(1-DEC_{r,s})\left[\left(1\right.\right.$$

$$-F(\varphi_{r,s}^c(H^{(n+1)}))\Big)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)})\sum_{i=n+1}^{\infty}(1-\delta)^{i-(n+1)}A_{r,s}(H^{(i)})-w_r f_{r,s}^{exp}\right)$$

$$-(1-\delta)\left(1-F(\varphi_{r,s}^c(H^{(n+2)}))\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+2)})\sum_{i=n+2}^{\infty}(1-\delta)^{i-(n+2)}A_{r,s}(H^{(i)})\right.$$

$$\left.\left.-w_r f_{r,s}^{exp}\right)\right]=\delta w_r f_r^{sunk}$$

$$+(1-\delta)\sum_{s\neq r}DEC_{r,s}\left(1-F(\varphi_{r,s}^c(H^{(n+1)}))\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)}A_{r,s}(H^{(n+1)})-\delta w_r f_{r,s}^{exp}\right)$$

$$(B.6)$$

**Proof that** $\varphi_{r,s}^c(H^{(n+1)})=\varphi_{r,s}^c(H^{(n)})=\varphi_{r,s}^c(H^{det})\forall n=0,1,2,\ldots$

Now, by definition, $A_{r,r}(H^{(n)})=A_{s,r}(H^{(n)})\frac{\lambda_{r,r}}{\lambda_{s,r}}\tau_{s,r}^\sigma(H^{(n)})\left(\frac{w_r}{w_s}\right)^{1-\sigma}$ for any $s$. Given this, and the fact that tariffs do not change as $n$ increases, (so that $\tau_{s,r}\equiv\tau_{s,r}(H^{(n)})\forall n$) I can write this as

$$K_{q,r}^1 \left( \left( \varphi_{q,r}^c(H^{(n)}) \right)^{1-\sigma} - (1 - DEC_{q,r})(1-\delta) \left( \varphi_{q,r}^c(H^{(n+1)}) \right)^{1-\sigma} \right) + \Theta_r^n = \delta w_r f_r^{sunk}, \forall n, \, q$$
$$\neq r$$

$$(\text{B.7})$$

where $K_{q,r}^1 = \frac{a}{a+1-\sigma} \left( b^{\sigma-1} \right) \frac{\lambda_{r,r}}{\lambda_{q,r}} \tau_{q,r}^\sigma w_r^{1-\sigma} w_q^\sigma f_{q,r}^{exp}$ is constant across $n$ and the function $\Theta_r^n$ is defined by:

$$\Theta_r^n \left( \left\{ \varphi_{r,s}^c(H^{(n+j)}) \right\}_{s \neq r, j=1,2}, \left\{ \tilde{\varphi}_{r,s}(H^{(n+j)}) \right\}_{s \neq r, j=1,2}, \left\{ A_{r,s}(H^{(n+i)}) \right\}_{s \neq r, i \geq n+1} \right)$$
$$= (1-\delta) \sum_{s \neq r} DEC_{r,s} \left( 1 - F(\varphi_{r,s}^c(H^{(n+1)})) \right) \left( \tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)}) A_{r,s}(H^{(n+1)}) - \delta w_r f_{r,s}^{exp} \right)$$
$$+ (1-\delta) \sum_{s \neq r} (1 - DEC_{r,s}) \left[ \left( 1 \right. \right.$$
$$\left. - F(\varphi_{r,s}^c(H^{(n+1)})) \right) \left( \tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+1)}) \sum_{i=n+1}^\infty (1-\delta)^{i-(n+1)} A_{r,s}(H^{(i)}) - w_r f_{r,s}^{exp} \right) - (1$$
$$\left. - \delta) \left( 1 - F(\varphi_{r,s}^c(H^{(n+2)})) \right) \left( \tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+2)}) \sum_{i=n+2}^\infty (1-\delta)^{i-(n+2)} A_{r,s}(H^{(i)}) - w_r f_{r,s}^{exp} \right) \right]$$

It follows that $\Theta_r^n$ is a continuous function of export cutoff productivities (assuming that the distribution function of productivities is continuous), average export productivities, and aggregate economic conditions in periods n+1 and later. I take as given that all endogenous variables converge to their steady state values as $n \to \infty$, and in implementing the model numerically, I make the further assumption that after $N$ periods, all endogenous variables have returned to their (high tariff) steady state value, denoted by state $H^{det}$. Given this, and the fact that for any $n$, given all endogenous variable values for periods $H^{(n+1)}$ and later, we can uniquely solve for $\varphi_{q,r}^c(H^{(N-1)})$, by plugging in these the steady state equilibrium $H^{det}$ values for each of these endogenous variables in states $N, N+1, \ldots$ Taking limits as $n \to \infty$ of (B.7), it is clear that $\varphi_{q,r}^c(H^{(N-1)}) = \varphi_{q,r}^c(H^{det}), \forall q, r, q \neq r$. This then implies that $\tilde{\varphi}_{q,r}(H^{(N-1)}) = \tilde{\varphi}_{q,r}(H^{det}), \forall q, r, q \neq r$ (from the definition of $\tilde{\varphi}_{q,r}$, see (3.9)) and $A_{q,r}(H^{(N-1)}) = A_{q,r}(H^{det})$, as implied by (B.4) and (B.5). Back substituting again to solve for $\varphi_{q,r}^c(H^{(N-2)})$ then yields $\varphi_{q,r}^c(H^{(N-2)}) = \varphi_{q,r}^c(H^{det}), \forall q, r, q \neq r$, and so on, so that for all $n = 1, 2, \ldots$, we have that $\varphi_{q,r}^c(H^{(n)}) = \varphi_{q,r}^c(H^{det}), \forall q, r, q \neq r$ and $A_{q,r}(H^{(n)}) = A_{q,r}(H^{det}), \forall q, r, q \neq r$.

In understanding the assumptions driving this result, I first note that the functional form assumed for productivity distribution plays no role in this proof, other than the requirement that the cumulative distribution function be continuous. The result follows from the fact that under free entry, the aggregate economic conditions in the domestic market adjust (via the number of firms who enter) to compensate for any changes in economic conditions or cutoffs in export markets so that the value of entering into production for the marginal firm is the same, regardless of state. Further, the aggregate economic conditions for export, $A_{r,s}$, can be pinned down from just knowing the corresponding export productivity cutoff. Then, since $A_{r,s}$ completely determines $\varphi_{r,s}^c$ and vice versa, and since each is a function of next period (and later) values, it follows that for both to eventually equal some final limiting value, they must equal this in every high tariff period.

## B.2  Derivation of Free Entry Condition

In this appendix I derive the free entry condition for each sector-country based on the equilibrium condition, $V_{k,r}^{entry}(\zeta) - w_r f_{k,r}^{sunk} = V_{k,r}^{wait\,to\,enter}(\zeta)$. In the derivations below, I drop the sector subscript $k$ for ease of notation; it is understood that all values and endogenous variables are also sector specific.

The expected (over $\varphi$) value of entry in a given state is given by:

$$
V_r^{entry}(L) = \int_b^\infty V_{\varphi,r,r}(L)dF(\varphi) + (1-\delta)\sum_{s\neq r}\left[(1-\gamma)\left(\int_{\varphi_{r,s}^c(L)}^\infty \left(V_{\varphi,s}(L) - w_r f_{r,s}^{exp}\right)dF(\varphi)\right.\right.
$$
$$
\left.+ \int_b^{\varphi_{r,s}^c(L)} V_{\varphi,r,s}^{wait}(L)dF(\varphi)\right)
$$
$$
\left.+ \gamma\left(\int_{\varphi_{r,s}^c(H)}^\infty \left(V_{\varphi,r,s}(H^{(0)}) - w_r f_{r,s}^{exp}\right)dF(\varphi) + \int_b^{\varphi_{r,s}^c(H)} V_{\varphi,r,s}^{wait}(H^{(0)})dF(\varphi)\right)\right]
$$

$$
= \frac{\tilde{\varphi}_r^{\sigma-1}A_{r,r}(L)}{\delta+\gamma-\delta\gamma} + \frac{(1-\delta)\gamma}{\delta+\gamma-\delta\gamma}\int_b^\infty V_{\varphi,r,r}(H^{(0)})dF(\varphi)
$$
$$
+ (1-\delta)\sum_{s\neq r}\left[(1-\gamma)\left(\int_{\varphi_{r,s}^c(L)}^\infty \left(V_{\varphi,s}(L) - w_r f_{r,s}^{exp}\right)dF(\varphi) + \int_b^{\varphi_{r,s}^c(L)} V_{\varphi,r,s}^{wait}(L)dF(\varphi)\right)\right.
$$
$$
\left.+ \gamma\left(\int_{\varphi_{r,s}^c(H)}^\infty \left(V_{\varphi,s}(H^{(0)}) - w_r f_{r,s}^{exp}\right)dF(\varphi) + \int_b^{\varphi_{r,s}^c(H)} V_{\varphi,r,s}^{wait}(H^{(0)})dF(\varphi)\right)\right]
$$

$$= \frac{\tilde{\varphi}_r^{\sigma-1} A_{r,r}(L)}{\delta + \gamma - \delta\gamma}$$

$$+ \frac{(1-\delta)\gamma}{\delta + \gamma - \delta\gamma} \left( V_r^{entry}(H^{(0)}) - (1-\delta)\left[ \sum_{s \neq r} \int_{\varphi_{r,s}^c(H)}^{\infty} \left( V_{\varphi,r,s}(H^{(1)}) - w_r f_{r,s}^{exp} \right) dF(\varphi) \right] \right)$$

$$+ (1-\delta) \sum_{s \neq r} \left[ (1-\gamma) \left( \int_{\varphi_{r,s}^c(L)}^{\infty} \left( V_{\varphi,r,s}(L) - w_r f_{r,s}^{exp} \right) dF(\varphi) + \int_b^{\varphi_{r,s}^c(L)} V_{\varphi,r,s}^{wait}(L) dF(\varphi) \right) \right.$$

$$\left. + \gamma \left( \int_{\varphi_{r,s}^c(H)}^{\infty} \left( V_{\varphi,r,s}(H^{(0)}) - w_r f_{r,s}^{exp} \right) dF(\varphi) + \int_b^{\varphi_{r,s}^c(H)} V_{\varphi,r,s}^{wait}(H^{(0)}) dF(\varphi) \right) \right]$$

since

$$V_r^{entry}(H^{(n)}) = \int_b^{\infty} V_{\varphi,r,r}(H^{(n)}) dF(\varphi)$$

$$+ (1-\delta) \left[ \sum_{s \neq r} \int_{\varphi_{r,s}^c(H^{(n+1)})}^{\infty} \left( V_{\varphi,r,s}(H^{(n+1)}) - w_r f_{r,s}^{exp} \right) dF(\varphi) \right.$$

$$\left. + \int_b^{\varphi_{r,s}^c(H^{(n+1)})} V_{\varphi,r,s}^{wait}(H^{(n+1)}) dF(\varphi) \right]$$

$$= \int_b^{\infty} V_{\varphi,r,r}(H^{(n)}) dF(\varphi) + (1-\delta) \left[ \sum_{s \neq r} \int_{\varphi_{r,s}^c(H^{(n+1)})}^{\infty} \left( V_{\varphi,r,s}(H^{(n+1)}) - w_r f_{r,s}^{exp} \right) dF(\varphi) \right]$$

which follows from the fact that $\varphi_{r,s}^c(H^{(n+1)}) = \varphi_{r,s}^c(H) \, \forall n$, and so we have that the value of waiting to export for $\varphi < \varphi_{r,s}^c(H^{(n+1)})$ is zero.

I assume that the "death shock" applies equally to current and potential firms so that the same discount factor is used by all when discounting future periods. Then, the value of waiting to enter into production in a given state will be given by

$$V_r^{wait\,to\,enter}(\zeta) = 0 + (1-\delta) E_{\zeta'|\zeta} \max \left[ \left( V_r^{entry}(\zeta') - w_r f_r^{sunk} \right), V_r^{wait\,to\,enter}(\zeta') \right]$$

$$= (1-\delta) E_{\zeta'|\zeta} \left[ V_{r,t}^{wait\,to\,enter}(\zeta') \right]$$

where the final equality follows from the fact that in equilibrium, free entry implies that $V_r^{entry}(\zeta) - w_r f_r^{sunk} \leq V_r^{wait}(\zeta) \, \forall \zeta$ (with strict inequality only in the case when the constraint $NE_r(\zeta) \geq 0$ is binding).[3] So,

$$V_r^{wait\,to\,enter}(L) = (1-\delta) \left( (1-\gamma) V_r^{wait\,to\,enter}(L) + \gamma V_r^{wait}(H^{(0)}) \right)$$

$$\Rightarrow V_r^{wait\,to\,enter}(L) = \frac{\gamma(1-\delta)}{(\delta + \gamma - \delta\gamma)} V_r^{wait\,to\,enter}(H^{(0)})$$

---

[3]Note that $V_r^{wait\,to\,enter}$ indexed by one country denotes the value of waiting to enter into production while $V_{r,s}^{Wait}$ indexed by two countries denotes the value of waiting to begin exporting to region $s$. These are two distinct values.

and

$$V_r^{wait\,to\,enter}(H^{(n)}) = (1-\delta)V_r^{wait\,to\,enter}(H^{(n+1)}), \ n$$
$$= 0,1,2,\ldots$$

Then, I can write the difference between the value of entering into production and waiting

to enter in state $L$ as:

$$V_r^{entry}(L) - V_r^{wait\,to\,enter}(L)$$
$$= \frac{\tilde{\varphi}_{r,r}^{\sigma-1}(L)A_{r,r}(L)}{\delta+\gamma-\delta\gamma}$$
$$+ \frac{(1-\delta)\gamma}{\delta+\gamma-\delta\gamma}\left(V_r^{entry}(H^{(0)}) - (1-\delta)\left[\sum_{s\neq r}\int_{\varphi_{r,s}^c(H)}^{\infty}\left(V_{\varphi,r,s}(H^{(1)}) - w_r f_{r,s}^{exp}\right)dF(\varphi))\right]\right)$$
$$+ (1-\delta)\sum_{s\neq r}\left[(1-\gamma)\left(\int_{\varphi_{r,s}^c(L)}^{\infty}\left(V_{\varphi,r,s}(L) - w_r f_{r,s}^{exp}\right)dF(\varphi) + \int_b^{\varphi_{r,s}^c(L)}V_{\varphi,r,s}^{wait}(L)dF(\varphi)\right)\right.$$
$$+ \gamma\left(\int_{\varphi_{r,s}^c(H)}^{\infty}\left(V_{\varphi,r,s}(H^{(0)}) - w_r f_{r,s}^{exp}\right)dF(\varphi) + \int_b^{\varphi_{r,s}^c(H)}V_{\varphi,r,s}^{wait}(H^{(0)})dF(\varphi)\right)\bigg]$$
$$- \frac{\gamma(1-\delta)}{(\delta+\gamma-\delta\gamma)}V_r^{wait\,to\,enter}(H^{(0)})$$

$$= \frac{\tilde{\varphi}_{r,r}^{\sigma-1}(L)A_{r,r}(L)}{\delta+\gamma-\delta\gamma} + \frac{\gamma(1-\delta)}{(\delta+\gamma-\delta\gamma)}\left(\underbrace{w_r f_r^{sunk}}_{=V_r^{entry}(H^{(0)})-V_r^{wait\,to\,enter}(H^{(0)})}\right.$$
$$\left. -(1-\delta)\sum_{s\neq r}\left(1-F(\varphi_{r,s}^c(H))\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H)\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right)\right) + (1$$
$$-\delta)\sum_{s\neq r}\left[(1-\gamma)\left(1-F(\varphi_{r,s}^c(L))\right)\left(\left(\frac{\tilde{\varphi}_{r,s}^{\sigma-1}(L)}{\delta+\gamma-\delta\gamma}\right)\left[A_{r,s}(L)+\gamma(1-\delta)\frac{A_{r,s}(H)}{\delta}\right] - w_r f_{r,s}^{exp}\right)\right]$$
$$+(1-\delta)\sum_{s\neq r}(1-\gamma)\frac{\gamma(1-\delta)}{\delta+\gamma-\delta\gamma}\left(F(\varphi_{r,s}^c(L))-F(\varphi_{r,s}^c(H))\right)\left(\tilde{\varphi}_{r,s}^{LH^{\sigma-1}}\frac{A_{r,s}(H)}{\delta}-w_r(H^0)f_{r,s}^{exp}\right)*1_{RankB_{r,s}}$$

$$+(1-\delta)\sum_{s\neq r}\gamma\left(1-F(\varphi_{r,s}^c(H))\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H)\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right)$$

where

$$\tilde{\varphi}_{r,s}^{LH} = \begin{cases} \varphi_{r,s}^c(L) & ,\varphi_{r,s}^c(L) = \varphi_{r,s}^c(H) \\ \left[\dfrac{\int_{\varphi_{r,s}^c(L)}^{\varphi_{r,s}^c(H)}\varphi^{\sigma-1}dF(\varphi)}{F(\varphi_{r,s}^c(H))-F(\varphi_{r,s}^c(L))}\right]^{\frac{1}{\sigma-1}} & ,\varphi_{r,s}^c(L) \neq \varphi_{r,s}^c(H) \end{cases}$$

is the average productivity level between high and low state cutoffs and $1_{RankB_{r,s}}$ is a

binary indicator equal to one when $\varphi_{r,s}^c(L) > \varphi_{r,s}^c(H)$. Then, in equilibrium, the mass of

new entrants in state $L$ is determined by:

$$\tilde{\varphi}_{r,r}^{\sigma-1}(L)A_{r,r}(L) + \gamma(1-\delta)\left(-(1-\delta)\sum_{s\neq r}\left(\frac{M_{r,s}(H^{(1)})}{N_r(H^{(1)})}\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H)\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right)\right)$$

$$+ (1-\delta)\sum_{s\neq r}\Bigg[(1$$

$$-\gamma)\left(\frac{M_{r,s}(L)}{N_r(L)}\left((\tilde{\varphi}_{r,s}^{\sigma-1}(L))\left[A_{r,s}(L) + \gamma(1-\delta)\frac{A_{r,s}(H)}{\delta}\right] - (\delta+\gamma-\delta\gamma)\,w_r f_{r,s}^{exp}\right)\right)\Bigg]$$

$$+ (1-\delta)\sum_{s\neq r}(1-\gamma)\gamma(1$$

$$-\delta)\left(F(\varphi_{r,s}^c(L) - F(\varphi_{r,s}^c(H))\left(\tilde{\varphi}_{r,s}^{LH^{\sigma-1}}\frac{A_{r,s}(H)}{\delta} - w_r(H^0)f_{r,s}^{exp}\right)*1_{RankB_{r,s}}\right.$$

$$+ \sum_{s\neq r}\gamma\,(\delta+\gamma-\delta\gamma)\left(\frac{M_{r,s}(H^{(0)})}{N_r(L) + NE_r(L)}\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H)\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right) = \delta w_r f_r^{sunk}$$

And in state $H^{(n)}$,

$$V_r^{entry}(H^{(n)}) - V_r^{wait\,to\,enter}(H^{(n)}) = \int_b^\infty V_{\varphi,r,r}(H^{(n)})dF(\varphi)$$

$$+ (1-\delta)\sum_{s\neq r}\int_{\varphi_{r,s}^c(H^{(n+1)})}^\infty \left(V_{\varphi,r,s}(H^{(n+1)})\right.$$

$$\left. - w_r f_{r,s}^{exp}\right)dF(\varphi) - V_r^{wait}(H^{(n)})$$

$$= \tilde{\varphi}_{r,r}^{\sigma-1}(H)A_{r,r}(H) + (1-\delta)\int_b^\infty V_{\varphi,r,r}(H^{(n+1)})dF(\varphi)$$

$$+ \sum_{s\neq r}\left(\frac{M_{r,s}(H^{(n+1)})}{N_r(H^{(n)}) + NE_r(H^{(n)})}\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H))\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right)$$

$$- (1-\delta)V_r^{wait}(H^{(n+1)})$$

$$= \tilde{\varphi}_{r,r}^{\sigma-1}(H)A_{r,r}(H) + (1-\delta)\left(V_{\varphi,r,r}^{entry}(H^{(n+1)})\right.$$

$$\left. - (1-\delta)\sum_{s\neq r}\left(\frac{M_{r,s}(H^{(n+2)})}{N_r(H^{(n+2)})}\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+2)})\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right)\right)$$

$$+ \sum_{s\neq r}\left(\frac{M_{r,s}(H^{(n+1)})}{N_r(H^{(n)}) + NE_r(H^{(n)})}\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H))\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right)$$

$$- (1-\delta)V_r^{wait}(H^{(n+1)})$$

$$= \tilde{\varphi}_{r,r}^{\sigma-1}(H)A_{r,r}(H)$$

$$+ (1-\delta)\left(w_r f_r^{sunk} - (1-\delta)\sum_{s\neq r}\left(\frac{M_{r,s}(H^{(n+2)})}{N_r(H^{(n+2)})}\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H^{(n+2)})\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right)\right)$$

$$+ \sum_{s\neq r}\left(\frac{M_{r,s}(H^{(n+1)})}{N_r(H^{(n)}) + NE_r(H^{(n)})}\right)\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H))\frac{A_{r,s}(H)}{\delta} - w_r f_{r,s}^{exp}\right)$$

$$= \tilde{\varphi}_{r,r}^{\sigma-1}(H)A_{r,r}(H) + (1-\delta)w_r f_r^{sunk}$$
$$+ \sum_{s \neq r} \left( \frac{M_{r,s}(H^{(n+1)})}{N_r(H^{(n)}) + NE_r(H^{(n)})} \right) \left( \tilde{\varphi}_{r,s}^{\sigma-1}(H)A_{r,s}(H) - \delta w_r f_{r,s}^{exp} \right)$$

So that the number of new entrants in state $H^{(n)}$ is determined by:

$$\tilde{\varphi}_{r,r}^{\sigma-1}(H)A_{r,r}(H) + \sum_{s \neq r} \left( \frac{M_{r,s}(H^{(n+1)})}{N_r(H^{(n)}) + NE_r(H^{(n)})} \right) \left( \tilde{\varphi}_{r,s}^{\sigma-1}(H)A_{r,s}(H) - \delta w_r f_{r,s}^{exp} \right)$$
$$= \delta w_r f_r^{sunk}$$

# B.3 Derivation of Cutoff Export Productivity in Low Tariff State

In state $\zeta$ a country $r$-sector $k$ firm with productivity $\varphi$ will enter export market $s$ if

$$V_{\varphi,k,r,s}(\zeta) - V_{\varphi,k,r,s}^{wait}(\zeta) \geq w_r f_{k,r,s}^{exp}$$

The expressions for these values as a function of the state and productivity level are as follows:

For $\varphi \leq \varphi_{k,r,s}^c(L)$ and $r \neq s$:

$$V_{\varphi,k,r,s}^{wait}(L) = \begin{cases} 0 & if \; 1_{RankB_{k,r,s}} = 0 \; or \\ & 1_{RankB_{k,r,s}} = 1 \; \text{and} \; \varphi < \varphi_{k,r,s}^c(H^{(0)}) \\ \frac{(1-\delta)\gamma}{\delta+\gamma-\delta\gamma} \left( V_{\varphi,k,r,s}(H^{(0)}) - w_r f_{k,r,s}^{exp} \right) & if \; 1_{RankB_{k,r,s}} = 1 \; \text{and} \; \varphi \geq \varphi_{k,r,s}^c(H^{(0)}) \end{cases}$$

$$V_{\varphi,k,r,s}(L) = \frac{\pi_{\varphi,k,r,s}(L) + (1-\delta)\gamma V_{\varphi,k,r,s}(H^{(0)})}{\delta + \gamma - \delta\gamma}$$

Which implies that for $\varphi \leq \varphi_{k,r,s}^c(L)$ (and $\varphi > \varphi_{k,r,s}^c(H^{(0)})$ in the case where cutoffs are ranked according to B),

$$(\delta + \gamma - \delta\gamma) \left( V_{\varphi,k,r,s}(L) - V_{\varphi,k,r,s}^{wait}(L) \right)$$
$$= \begin{cases} \pi_{\varphi,k,r,s}(L) + (1-\delta)\gamma \sum_{i=0}^{\infty} (1-\delta)^i \varphi^{\sigma-1} A_{k,r,s}(H^{(i)}) & if \; 1_{RankB_{k,r,s}} = 0 \\ \pi_{\varphi,k,r,s}(L) + (1-\delta)\gamma w_r f_{k,r,s}^{exp} & if \; 1_{RankB_{k,r,s}} = 1 \end{cases}$$

And, since for the marginal firm who is just indifferent between selling in the domestic market and entering the export market in state $L$, $V_{\varphi,k,r,s}(L) - V_{\varphi,k,r,s}^{wait}(L) = w_r f_{k,r,s}^{exp}$, we

have:

For a sector $k$ region $r$ with export cutoffs to $s$ ranked according to Ranking A (see 3.8), then:

$$(\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp} = \pi_{\varphi,k,r,s}(L) + (1-\delta)\gamma \sum_{i=0}^{\infty} (1-\delta)^i \left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1} A_{k,r,s}(H^{(i)})$$

$$\Rightarrow (\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp} = \left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1} \left[ A_{k,r,s}(L) + (1-\delta)\gamma \left( \sum_{n=0}^{\infty} (1-\delta)^n A_{k,r,s}(H^{(n)}) \right) \right]$$

$$\Rightarrow \left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1} = \frac{(\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp}}{\left[ A_{k,r,s}(L) + \gamma \left( \sum_{n=0}^{\infty} (1-\delta)^{n+1} A_{k,r,s}(H^{(n)}) \right) \right]} \qquad \text{(B.8)}$$

For a region $r$ with sector $k$ cutoffs for exporting to market $s$ ranked according to Ranking B, (see (3.8)), we have:

$$(\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp} = \pi_{\varphi,r,s}(L) + (1-\delta)\gamma w_r(H^{(0)}) f_{k,r,s}^{exp}$$

$$\Rightarrow (\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp} = \left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1} A_{k,r,s}(L) + (1-\delta)\gamma w_r(H^{(0)}) f_{k,r,s}^{exp}$$

$$\Rightarrow \left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1} = \frac{(\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp} - (1-\delta)\gamma w_r(H^{(0)}) f_{k,r,s}^{exp}}{A_{k,r,s}(L)} \qquad \text{(B.9)}$$

## B.4  Proof: Cutoffs Increasing in Probability of Tariff Hike

As shown in section 3.3.6, the cutoff productivity in sector $k$, country $r$ to choose to enter export $s$ market in state $H^{(n)}$ satisfies $\left(\varphi_{k,r,s}^c(H^{(n)})\right)^{\sigma-1} = \frac{\delta w_r f_{k,r,s}^{exp}}{A_{k,r,s}(H^{(n)})}$ and for a sector $k$ and country $r$ with $s$ cutoffs ranked according to Ranking A , that is, for which $\varphi_{k,r,s}^c(L) \leq \varphi_{k,r,s}^c(H^{det}) = \varphi_{k,r,s}^c(H^{(n)}) \,\forall n = 0, 1, \ldots$, we have that $\left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1} =$

$\frac{(\delta+\gamma-\delta\gamma)w_r f_{k,r,s}^{exp}}{A_{k,r,s}(L)+\gamma\frac{1-\delta}{\delta}A_{k,r,s}(H^{det})}$, and so

$$\frac{(\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp}}{A_{k,r,s}(L) + \gamma\frac{1-\delta}{\delta}A_{k,r,s}(H^{det})} \leq \frac{\delta w_r f_{k,r,s}^{exp}}{A_{k,r,s}(H^{det})}$$

$$\Rightarrow (\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp} A_{k,r,s}(H^{det}) \leq \delta w_r f_{k,r,s}^{exp}\left(A_{k,r,s}(L) + \gamma\frac{1-\delta}{\delta}A_{k,r,s}(H^{det})\right)$$

$$\Rightarrow A_{k,r,s}(H^{det}) \leq A_{k,r,s}(L)$$

Further, for a country with cutoffs ranked according to Ranking A, we have that

$$\frac{\partial}{\partial\gamma}\left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1} = \frac{\partial}{\partial\gamma}\left[\frac{(\delta + \gamma - \delta\gamma)\, w_r f_{k,r,s}^{exp}}{A_{k,r,s}(L) + \gamma\frac{1-\delta}{\delta}A_{k,r,s}(H^{det})}\right]$$

$$= \frac{\left(A_{k,r,s}(L) + \gamma\frac{1-\delta}{\delta}A_{k,r,s}(H^{det})\right)(1-\delta)\,w_r f_{k,r,s}^{exp} - (\delta + \gamma - \delta\gamma)\,w_r f_{k,r,s}^{exp}\frac{1-\delta}{\delta}A_{k,r,s}(H^{det})}{\left(A_{k,r,s}(L) + \gamma\frac{1-\delta}{\delta}A_{k,r,s}(H^{det})\right)^2}$$

$$= \frac{w_r f_{k,r,s}^{exp}(1-\delta)\left(A_{k,r,s}(L) - A_{k,r,s}(H^{det})\right)}{\left(A_{k,r,s}(L) + \gamma\frac{1-\delta}{\delta}A_{k,r,s}(H^{det})\right)^2} \geq 0$$

So that for a country with $\varphi_{k,r,s}^c(L) \leq \varphi_{k,r,s}^c(H^{det})$, it is also the case that the export cutoff productivity is increasing in $\gamma$, the probability that the high tariff shock will arrive in any given period.

## B.5  Summary of Equilibrium Conditions

| Variable | Associated Equation |
|---|---|
| $U_r(\varsigma)$ | $U_r(\varsigma) = q0_r(\varsigma)^{1-\sum_k \mu_k}\prod_k Q_{k,r}^{\mu_k}(\varsigma)$ |
| $Q_{k,r}(\varsigma)$ | $E_{k,r}(\varsigma) = P_{k,r}(\varsigma)Q_{k,r}(\varsigma)$ |
| $q0_r(\varsigma)$ | $q0_r(\varsigma) = \left(1 - \sum_k \mu_k\right)GDP_r(\varsigma)$ |
| $E_{k,r}(\varsigma)$ | $E_{k,r}(\varsigma) = \mu_k GDP_r(\varsigma)$ |
| $P_{k,r}(\varsigma)$ | $P_{k,r}^{1-\sigma}(\varsigma) = \lambda_{k,r,r}\left(N_{k,r}(\varsigma) + NE_{k,r}(\varsigma)\right)\left(\tilde{p}_{k,r,r}(\varsigma)\right)^{1-\sigma} +$ $\sum_{s\neq r}\lambda_{k,s,r}\left[\left(M_{k,s,r}(\varsigma)\right)\left(\tilde{p}_{k,s,r}(\varsigma)\tau_{k,s,r}(\varsigma)\right)^{1-\sigma} + Leg_{k,s,r}(\varsigma)\left(\tilde{p}_{k,s,r}^{leg}(\varsigma)\tau_{k,s,r}(\varsigma)\right)^{1-\sigma}\right]$ |
| $A_{k,r,s}(\varsigma)$ | $A_{k,r,s}(\varsigma) \equiv \frac{1}{\sigma}\left[\left(\frac{\sigma}{\sigma-1}\right)w_r\right]^{1-\sigma}\lambda_{k,r,s}Q_{k,s}(\varsigma)\left(\frac{P_{k,s}(\varsigma)}{\tau_{k,r,s}(\varsigma)}\right)^{\sigma}$ |

| Variable | Associated Equation |
|---|---|
| $\varphi_{k,r,s}^c(\zeta) \geq b$ | $\left(\varphi_{k,r,s}^c(L)\right)^{\sigma-1} \geq \dfrac{(\delta+\gamma-\delta\gamma)w_r f_{k,r,s}^{exp} - (1-\delta)\gamma w_r f_{k,r,s}^{exp} * {}^1RankB_{k,r,s}}{\left[A_{k,r,s}(L) + \gamma\left(\sum_{n=0}^{\infty}(1-\delta)^{n+1}A_{k,r,s}(H^{(n)})\right)*\left(1 - {}^1RankB_{k,r,s}\right)\right]}$ |
| | $\left(\varphi_{k,r,s}^c(H^{(n)})\right)^{\sigma-1} \geq \dfrac{\delta w_r f_{k,r,s}^{exp}}{A_{k,r,s}(H^{(n)})},\, n = 0,1,2,\ldots$ |
| $Diff_{k,r,s} \geq 0\,, r \neq s$ | $Diff_{k,r,s} \geq \left(\dfrac{b}{\varphi_{k,r,s}^c(H^{det})}\right)^a - \left(\dfrac{b}{\varphi_{k,r,s}^c(L)}\right)^a$ |
| ${}^1RankB_{k,r,s}$ | ${}^1RankB_{k,r,s} = \dfrac{Diff_{k,r,s}}{\left(\dfrac{b}{\varphi_{k,r,s}^c(H^{det})}\right)^a - \left(\dfrac{b}{\varphi_{k,r,s}^c(L)}\right)^a}$ |
| $\tilde{\varphi}_{k,r,s}^{LH}, r \neq s$ | $\left(\left(\dfrac{b}{\varphi_{k,r,s}^c(L)}\right)^a - \left(\dfrac{b}{\varphi_{k,r,s}^c(H^{det})}\right)^a\right)\left(\tilde{\varphi}_{k,r,s}^{LH}\right)^{\sigma-1} =$ $\dfrac{ab^a}{\sigma-a-1}\left(\left(\varphi_{k,r,s}^c(H^{det})\right)^{\sigma-a-1} - \left(\varphi_{k,r,s}^c(L)\right)^{\sigma-a-1}\right)$ |
| $\tilde{\varphi}_{k,r,s}(\zeta)$ | $\left(\tilde{\varphi}_{k,r,s}(\zeta)\right)^{\sigma-1} = \dfrac{a}{a+1-\sigma}\left(\left(\varphi_{k,r,s}^c(\zeta)\right)^{\sigma-1}\right)$ |
| $\tilde{\varphi}_{k,r,s}^{leg}(H^{(n)}), r \neq s, n =$ $0,1,\ldots$ | $\left(\left(\dfrac{b}{\varphi_{k,r,s}^c(L)}\right)^a - \left(\dfrac{b}{\varphi_{k,r,s}^c(H^{(n)})}\right)^a\right)\left(\tilde{\varphi}_{k,r,s}^{leg}(H^{(n)})\right)^{\sigma-1} =$ $\dfrac{ab^a}{\sigma-a-1}\left(\left(\varphi_{k,r,s}^c(H^{(n)})\right)^{\sigma-a-1} - \left(\varphi_{k,r,s}^c(L)\right)^{\sigma-a-1}\right)\, n = 0,1,2,\ldots$ |
| $M_{k,r,s}(\zeta), s \neq r$ | $M_{k,r,s}(\zeta) = N_{k,r}(\zeta)\left(\dfrac{b}{\varphi_{k,r,s}^c(\zeta)}\right)^a$ |
| $Leg_{k,r,s}(\zeta) \geq 0, s \neq r$ | $Leg_{k,r,s}(L) = 0$ |
| | $Leg_{k,r,s}(H^{(n)}) - N_{k,r}(H^{(0)})(1-\delta)^n\left(\left(\dfrac{b}{\varphi_{k,r,s}^c(L)}\right)^a - \left(\dfrac{b}{\varphi_{k,r,s}^c(H^{(n)})}\right)^a\right) \geq 0,\, n = 0,1,2,\ldots$ |
| $N_{k,r}(\zeta)$ | $N_{k,r}(L) = \dfrac{(1-\delta)}{\delta} NE_{k,r}(L)$ |
| | $N_{k,r}(H^{(0)}) = N_{k,r}(L)$ |
| | $N_{k,r}(H^{(n+1)}) = (1-\delta)\left(N_{k,r}(H^{(n)}) + NE_{k,r}(H^{(n)})\right),\, n = 0,1,\ldots$ |
| $NX_{k,r,s}(\zeta), s \neq r$ | $NX_{k,r,s}(L) = \delta M_{k,r,s}(L)$ |
| | $NX_{k,r,s}(H^{(0)}) =$ $(1-\delta)NE_{k,r}(L)\left(\dfrac{b}{\varphi_{k,r,s}^c(H^{(0)})}\right)a + N_{k,r}(H^{(0)})\left(\left(\dfrac{b}{\varphi_{k,r,s}^c(H^{(0)})}\right)^a - \left(\dfrac{b}{\varphi_{k,r,s}^c(L)}\right)^a\right)*{}^1RankB_{k,r,s}$ |
| | $NX_{k,r,s}(H^{(n)}) = (1-\delta)NE_{k,r}(H^{(n-1)})\left(\dfrac{b}{\varphi_{k,r,s}^c(H^{(n)})}\right)^a +,\, n = 1,2,3,\ldots$ |

| Variable | Associated Equation |
|---|---|
| $NE_{k,r}(\zeta)$ | $\bar\varphi_{k,r,r}^{\sigma-1}(L)A_{k,r,r}(L) + \sum_{s\neq r}\gamma\left(\delta+(1-\delta)(\gamma-1)\right)\left(\dfrac{M_{k,r,s}(H^{(0)})}{N_{k,r}(L)+NE_{k,r}(L)}\right)\left(\bar\varphi_{k,r,s}^{\sigma-1}(H)\dfrac{A_{k,r,s}(H)}{\delta}-w_r f_{k,r,s}^{exp}\right)$ <br><br> $+(1-\delta)\sum_{s\neq r}\left[(1-\gamma)\left(\dfrac{M_{k,r,s}(L)}{N_{k,r}(L)}\left(\left(\bar\varphi_{k,r,s}^{\sigma-1}(L)\right)\left[A_{k,r,s}(L)+\gamma(1-\delta)\dfrac{A_{k,r,s}(H)}{\delta}\right]-(\delta+\gamma-\delta\gamma)\,w_r f_{k,r,s}^{exp}\right)\right)\right]+$ <br><br> $+(1-\delta)\sum_{s\neq r}(1-\gamma)\gamma(1-\delta)\left(F(\varphi_{k,r,s}^c(L))-F(\varphi_{r,s}^c(H))\right)\left(\bar\varphi_{k,r,s}^{LH\,\sigma-1}\dfrac{A_{r,s}(H)}{\delta}-w_r(H^0)f_{k,r,s}^{exp}\right)*1_{RankB_{k,r,s}}$ <br><br> $=\delta w_r f_{k,r}^{sunk}$ |
| | $\bar\varphi_{k,r,r}^{\sigma-1}(H^{(n)})A_{k,r,r}(H^{(n)})+$ <br><br> $\sum_{s\neq r}\left(\dfrac{M_{k,r,s}(H^{(n+1)})}{N_{k,r}(H^{(n)})+NE_{k,r}(H^{(n)})}\right)\left(\bar\varphi_{k,r,s}^{\sigma-1}(H^{(n+1)})A_{k,r,s}(H^{(n+1)})-\delta w_r f_{k,r,s}^{exp}\right)=\delta w_r f_{k,r}^{sunk}$ |
| $\bar p_{k,r,s}^{cat}(\zeta),\, cat\in\{\cdot,leg\}$ | $\bar p_{k,r,s}^{cat}(\zeta)=\dfrac{w_r}{\bar\varphi_{k,r,s}^{cat}(\zeta)}\left(\dfrac{\sigma}{\sigma-1}\right)$ |
| $\bar q_{k,r}^{cat}(\zeta),\, cat\in\{\cdot,leg\}$ | $\bar q_{k,r,s}^{cat}(\zeta)=\lambda_{k,r,s}Q_{k,s}(\zeta)\left(\dfrac{P_{k,s}(\zeta)}{\tau_{k,r,s}(\zeta)\bar p_{k,r,s}^{cat}(\zeta)}\right)^{\sigma}$ |
| $GDP_r(\zeta)$ | $GDP_r(\zeta)\quad=\quad w_r\bar L_r+\sum_k\sum_{s\neq r}(\tau_{k,s,r}-1)\left[M_{k,s,r}(\zeta)\bar p_{k,s,r}(\zeta)\bar q_{k,s,r}(\zeta)+Leg_{k,s,r}(\zeta)\bar p_{k,s,r}^{leg}(\zeta)\bar q_{k,s,r}^{leg}(\zeta)\right]+$ <br><br> $+\sum_k\left(N_{k,r}(\zeta)+NE_{k,r}(\zeta)\right)\dfrac{\bar p_{k,r,r}(\zeta)\bar q_{k,r,r}(\zeta)}{\sigma}-\sum_k w_r f_{k,r}^{sunk}NE_r(\zeta)-\sum_k\sum_{s\neq r}w_r f_{k,r,s}^{exp}NX_{k,r,s}(\zeta)$ <br><br> $+\sum_k\sum_{s\neq r}\left[M_{k,r,s}(\zeta)\dfrac{\bar p_{k,r,s}(\zeta)\bar q_{k,r,s}(\zeta)}{\sigma}+Leg_{k,r,s}(\zeta)\dfrac{\bar p_{k,r,s}^{leg}(\zeta)\bar q_{k,r,s}^{leg}(\zeta)}{\sigma}\right]$ |

## B.6  Conjecture: Constant Cutoffs across $L$ and $H$ states in sectors with constant tariffs

In this section, I hypothesize that under the assumption of Pareto distributed productivity, for any sector $k$ with $\tau_{k,r,s}\equiv\tau_{k,r,s}(L)=\tau_{k,r,s}(H)\,\forall r\neq s$, that is, any sector for which no bilateral tariffs change with the arrival of the high tariff shock, it will be the case that $\varphi_{k,r,s}^c(L)=\varphi_{k,r,s}^c(H)$, that is, that productivity cutoffs to export in this sector do not change, despite changes in the aggregate economy that may be caused by tariff shocks in

other sectors. To simplify notation, for the remainder of this section I drop the $k$ industry subscript; it is assumed that all industry specific variables in this section are for an industry $k$ which is not directly affected by the tariff shock.

Now using fact that cutoffs $\varphi^c_{r,s}(H) \equiv \varphi^c_{r,s}(H^{(n)})$ as well as aggregate economic conditions $A_{r,s}(H) \equiv A_{r,s}(H^{(n)})$ are constant across $n$ and also assuming homogenous good produced in all countries (so that wages do not depend on the state $\zeta \in \{L, H^{(n)}\}$) and Pareto distributed productivity, the free entry condition in state $L$ implies that in equilibrium, for each $r$:

$$
\tilde{\varphi}^{\sigma-1}_{r,r}(L)A_{r,r}(L) + \gamma(1-\delta)\left( w_r f^{sunk}_r \right.
$$

$$
-\sum_{s\neq r}\left(\frac{b}{\varphi^c_{r,s}(H)}\right)^a \left(\frac{a}{a+1-\sigma}\varphi^c_{r,s}(H)^{\sigma-1}\left(\frac{1-\delta}{\delta}\right)A_{r,s}(H) - (1-\delta)w_r f^{exp}_{r,s}\right)\bigg)
$$

$$
+ (1-\delta)\sum_{s\neq r}\bigg[(1
$$

$$
-\gamma)\left(\left(\frac{b}{\varphi^c_{r,s}(L)}\right)^a\left(\left(\frac{a}{a+1-\sigma}\varphi^c_{r,s}(L)^{\sigma-1}\right)\left[A_{r,s}(L)+\gamma\frac{1-\delta}{\delta}A_{r,s}(H)\right] - (\delta+\gamma-\delta\gamma)\,w_r f^{exp}_{r,s}\right)\right)\bigg]
$$

$$
+ (1-\delta)\sum_{s\neq r}(1-\gamma)\gamma(1-\delta)\left( ab^a \left(\varphi^c_{r,s}(H)^{\sigma-a-1} - \varphi^c_{r,s}(L)^{\sigma-a-1}\right)\frac{A_{r,s}(H)}{\delta}\right.
$$

$$
\left. -\left(\left(\frac{b}{\varphi^c_{r,s}(H)}\right)^a - \left(\frac{b}{\varphi^c_{r,s}(L)}\right)^a\right)w_r f^{exp}_{r,s}\right) * 1_{RankB_{r,s}}
$$

$$
+ (\delta+\gamma-\delta\gamma)\sum_{s\neq r}\gamma(1-\delta)\left(\frac{b}{\varphi^c_{r,s}(H)}\right)^a \left(\frac{a}{a+1-\sigma}\varphi^c_{r,s}(H)^{\sigma-1}\frac{A_{r,s}(H)}{\delta} - w_r f^{exp}_{r,s}\right)
$$

$$
= (\delta+\gamma-\delta\gamma)w_r f^{sunk}_r
$$

Now, using the condition governing export productivity cutoffs, namely

$$
\varphi^c_{r,s}(L)^{\sigma-1} = \frac{\delta w_r f^{exp}_{r,s} + \gamma(1-\delta)w_r f^{exp}_{r,s} * (1 - 1_{RankB_{r,s}})}{A_{r,s}(L) + \frac{\gamma(1-\delta)}{\delta}A_{r,s}(H) * (1 - 1_{RankB_{r,s}})}
$$

and

$$
\varphi^c_{k,r,s}(H)^{\sigma-1} = \frac{\delta w_r f^{exp}_{r,s}}{A_{k,r,s}(H)}
$$

this can be written as:

$$\tilde{\varphi}_{r,r}^{\sigma-1}(L)A_{r,r}(L) + \gamma(1-\delta)^2\left(-\sum_{s\neq r}\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a\left(\frac{\sigma-1}{a+1-\sigma}w_r f_{r,s}^{exp}\right)\right) + (1-\delta)\sum_{s\neq r}\Bigg[(1$$

$$-\gamma)\left(\left(\frac{b}{\varphi_{r,s}^c(L)}\right)^a\left(\left(\frac{a}{a+1-\sigma}\varphi_{r,s}^c(L)^{\sigma-1}\right)\left[A_{r,s}(L)+\gamma\frac{1-\delta}{\delta}A_{r,s}(H)\right]-(\delta+\gamma-\delta\gamma)\,w_r f_{r,s}^{exp}\right)\right)\Bigg]$$

$$+(1-\delta)\sum_{s\neq r}(1-\gamma)\gamma(1-\delta)\left(\left(\varphi_{r,s}^c(H)^{\sigma-a-1}-\varphi_{r,s}^c(L)^{\sigma-a-1}\right)\frac{A_{r,s}(H)}{\delta}\right.$$

$$\left.-\left(\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a-\left(\frac{b}{\varphi_{r,s}^c(L)}\right)^a\right)w_r f_{r,s}^{exp}\right)$$

$$*1_{RankB_{r,s}}+(\delta+\gamma(1-\delta))\sum_{s\neq r}\gamma(1-\delta)\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a\left(\frac{\sigma-1}{a+1-\sigma}w_r f_{r,s}^{exp}\right)=\delta w_r f_r^{sunk}$$

$$\Rightarrow \tilde{\varphi}_{r,r}^{\sigma-1}(L)A_{r,r}(L)+\left[(\delta+\gamma-\delta\gamma)\gamma(1-\delta)-\gamma(1-\delta)^2\right]\sum_{s\neq r}\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a\left(\frac{\sigma-1}{a+1-\sigma}w_r f_{r,s}^{exp}\right)$$

$$+(1-\delta)\sum_{s\neq r}\left[(1-\gamma)\left(\left(\frac{b}{\varphi_{r,s}^c(L)}\right)^a\left[\frac{(\sigma-1)(\delta+\gamma-\delta\gamma)}{a+1-\sigma}w_r f_{r,s}^{exp}\right]\right)\right]*(1-1_{RankB_{r,s}})$$

$$+(1-\delta)\sum_{s\neq r}\Bigg[(1-\gamma)\left(\frac{b}{\varphi_{r,s}^c(L)}\right)^a\left(\left(\frac{a\delta}{a+1-\sigma}\right)+\frac{a\gamma(1-\delta)}{a+1-\sigma}\left(\frac{\varphi_{r,s}^c(L)}{\varphi_{r,s}^c(H)}\right)^{\sigma-1}\right.$$

$$\left.\left.-(\delta+\gamma-\delta\gamma)\right)\right]w_r f_{r,s}^{exp}$$

$$*1_{RankB_{r,s}}+(1-\delta)\sum_{s\neq r}(1-\gamma)\gamma(1-\delta)\left(\left[\frac{1}{\varphi_{r,s}^c(H)^a}-\left(\frac{\varphi_{r,s}^c(L)}{\varphi_{r,s}^c(H)}\right)^{\sigma-1}\left(\frac{1}{\varphi_{r,s}^c(L)^a}\right)\right]\right.$$

$$\left.-\left[\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a-\left(\frac{b}{\varphi_{r,s}^c(L)}\right)^a\right]\right)w_r f_{r,s}^{exp}*1_{RankB_{r,s}}$$

$$=\delta w_r f_r^{sunk}$$

$$\text{(B.10)}$$

The free entry condition in any $H$ state yields

$$\tilde{\varphi}_{r,r}^{\sigma-1}(H)A_{r,r}(H)+(1-\delta)\sum_{s\neq r}\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a\left(\tilde{\varphi}_{r,s}^{\sigma-1}(H)A_{r,s}(H)-\delta w_r f_{r,s}^{exp}\right)\quad=\quad \delta w_r f_r^{sunk}$$

$$\Rightarrow \tilde{\varphi}_{r,r}^{\sigma-1}(H)A_{r,r}(H)+(1-\delta)\sum_{s\neq r}\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a\left(\frac{a}{a+1-\sigma}\varphi_{r,s}^c(H)^{\sigma-1}A_{r,s}(H)-\delta w_r f_{r,s}^{exp}\right)\quad=\quad \delta w_r f_r^{sunk}$$

$$\Rightarrow \tilde{\varphi}_{r,r}^{\sigma-1}(H)A_{r,r}(H)+(1-\delta)\sum_{s\neq r}\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a\left(\frac{\sigma-1}{a+1-\sigma}\delta w_r f_{r,s}^{exp}\right)\quad\text{(B.11)}$$

$$=\delta w_r f_r^{sunk}$$

Subtracting the free entry condition (B.10) in state $L$ from (B.11) in state $H$, we have that for each $r$:

$$\tilde{\varphi}_{r,r}^{\sigma-1} \left[A_{r,r}(L) - A_{r,r}(H)\right] + (1-\delta) \sum_{s \neq r} \left[\Gamma_{r,s} * (1 - 1_{RankB_{r,s}}) + \Lambda_{r,s} * 1_{RankB_{r,s}}\right] = 0$$

where

$$\Gamma_{r,s} = (1-\gamma) \left(\left[\left(\frac{b}{\varphi_{r,s}^c(L)}\right)^a - \left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a\right] \left[\frac{(\sigma-1)(\delta+\gamma-\delta\gamma)}{a+1-\sigma} w_r f_{r,s}^{exp}\right]\right)$$

and

$$\Lambda_{r,s} = -(1-\gamma) \left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a \left[\frac{(\sigma-1)(\delta+\gamma-\delta\gamma)}{a+1-\sigma} w_r f_{r,s}^{exp}\right]$$
$$+ \left[(1-\gamma)\left(\frac{b}{\varphi_{r,s}^c(L)}\right)^a \left(\left(\frac{a\delta}{a+1-\sigma}\right) + \frac{a\gamma(1-\delta)}{a+1-\sigma}\left(\frac{\varphi_{r,s}^c(L)}{\varphi_{r,s}^c(H)}\right)^{\sigma-1}\right.\right.$$
$$\left.\left. -(\delta+\gamma-\delta\gamma)\right)\right] w_r f_{r,s}^{exp} + (1-\gamma)\gamma(1-\delta)\left(\left[\frac{1}{\varphi_{r,s}^c(H)^a} - \left(\frac{\varphi_{r,s}^c(L)}{\varphi_{r,s}^c(H)}\right)^{\sigma-1}\left(\frac{1}{\varphi_{r,s}^c(L)^a}\right)\right]\right.$$
$$\left. - \left[\left(\frac{b}{\varphi_{r,s}^c(H)}\right)^a - \left(\frac{b}{\varphi_{r,s}^c(L)}\right)^a\right]\right) w_r f_{r,s}^{exp}$$

Then, using the expressions for cutoff productivities and the fact that $A_{r,r}(\zeta) = A_{q,r}(\zeta)\frac{\lambda_{r,r}}{\lambda_{q,r}}\tau_{q,r}^\sigma(\zeta)\left(\frac{w_r}{w_q}\right)^{1-\sigma}$, for $q \neq r$, $1_{RankB_{q,r}} = 0$, this gives

$$\frac{a}{a+1-\sigma}\left(b^{\sigma-1}\right)\frac{\lambda_{r,r}}{\lambda_{q,r}}\tau_{q,r}^\sigma\left(\frac{w_r}{w_q}\right)^{1-\sigma}\left[A_{q,r}(L) + \frac{\gamma(1-\delta)}{\delta}A_{q,r}(H)\right.$$
$$\left. - \frac{\delta+\gamma-\delta\gamma}{\delta}A_{q,r}(H)\right] + (1-\delta)\sum_{s \neq r}\left[\Gamma_{r,s} * (1 - 1_{RankB_{r,s}}) + \Lambda_{r,s} * 1_{RankB_{r,s}}\right] = 0$$

$\Rightarrow$

$$K_{q,r}^1(\delta+\gamma-\delta\gamma)\left[\varphi_{q,r}^c(L)^{1-\sigma} - \varphi_{q,r}^c(H)^{1-\sigma}\right]$$
$$+ (1-\delta)\sum_{s \neq r}\left[\Gamma_{r,s} * (1 - 1_{RankB_{r,s}}) + \Lambda_{r,s} * 1_{RankB_{r,s}}\right] = 0$$

while for $q \neq r$, $1_{RankB_{q,r}} = 1$, this gives

$$\frac{a}{a+1-\sigma}\left(b^{\sigma-1}\right)\frac{\lambda_{r,r}}{\lambda_{q,r}}\tau_{q,r}^\sigma\left(\frac{w_r}{w_q}\right)^{1-\sigma}\left[\frac{\delta w_q f_{q,r}^{exp}}{A_{q,r}(L)} - \frac{\delta w_q f_{q,r}^{exp}}{A_{q,r}(H)}\right]$$
$$+ (1-\delta)\sum_{s \neq r}\left[\Gamma_{r,s} * (1 - 1_{RankB_{r,s}}) + \Lambda_{r,s} * 1_{RankB_{r,s}}\right] = 0$$

$\Rightarrow$

$$K_{q,r}^1\left[\varphi_{q,r}^c(L)^{1-\sigma} - \varphi_{q,r}^c(H)^{1-\sigma}\right] + (1-\delta)\sum_{s \neq r}\left[\Gamma_{r,s} * (1 - 1_{RankB_{r,s}}) + \Lambda_{r,s} * 1_{RankB_{r,s}}\right] = 0$$

So, we have that for any $q \neq r$,

$$K_{q,r}^1 \left[ \varphi_{q,r}^c(L)^{1-\sigma} - \varphi_{q,r}^c(H)^{1-\sigma} \right] \left[ 1_{RankB_{q,r}} + (\delta + \gamma - \delta\gamma) * (1 - 1_{RankB_{q,r}}) \right]$$

$$+ (1 - \delta) \sum_{s \neq r} \left[ \Gamma_{r,s} * (1 - 1_{RankB_{r,s}}) + \Lambda_{r,s} * 1_{RankB_{r,s}} \right] = 0 \quad \text{(B.12)}$$

where $K_{q,r}^1 = \frac{a}{a+1-\sigma} \left( b^{\sigma-1} \right) \frac{\lambda_{r,r}}{\lambda_{q,r}} \tau_{q,r}^\sigma w_r^{1-\sigma} w_q^\sigma f_{q,r}^{exp}$ as before, and now $\tau_{q,r}$ does not depend

on the state since we are considering an industry $k$ which is not directly affected by the tariff

shock.

Now, the free entry condition in state $H$, (B.11), can be rewritten entirely in terms of

cutoff productivities in state $H$. For $q \neq r$,

$$K_{q,r}^1 \varphi_{q,r}^c(H)^{1-\sigma} + (1 - \delta) \sum_{s \neq r} \left( \frac{b}{\varphi_{r,s}^c(H)} \right)^a \left( \frac{\sigma - 1}{a + 1 - \sigma} \delta w_r f_{r,s}^{exp} \right) = \delta w_r f_r^{sunk} \quad \text{(B.13)}$$

Equations (B.12) and (B.13) together yield $2 * C(C - 1)$ equations (where $C$ is the

number of countries) in $2 * C(C - 1)$ unknowns, $\varphi_{q,r}^c(L)$ and $\varphi_{q,r}^c(H)$ for each $q \neq r$.

Although I cannot solve for these variables explicitly in order to verify that there is a

unique solution to the system of equations, I can verify that there is a solution which

satisfies $\varphi_{q,r}^c(L) = \varphi_{q,r}^c(H) \, \forall q \neq r$: If $\varphi_{r,s}^c(H) = \varphi_{r,s}^c(L)$, then by definition $1_{RankB_{r,s}} = 0$,

and it is clear that $\Gamma_{r,s} = 0$.[4] Then, for $\varphi_{q,r}^c(H) = \varphi_{q,r}^c(L) \, \forall q \neq r$, we have that equation

(B.12) is satisfied.

---

[4]It is also true that in this case $\Lambda_{r,s} = 0$, as one would expect given that $1_{RankB_{r,s}}$ changes values from 0 to 1 exactly at when $\varphi_{r,s}^c(H) = \varphi_{r,s}^c(L)$; that is, all of the above equations continue to be valid if we define $1_{RankB_{r,s}} = \begin{cases} 0 & \text{for } \varphi_{r,s}^c(L) < \varphi_{r,s}^c(H) \\ 1 & \text{for } \varphi_{r,s}^c(L) \geq \varphi_{r,s}^c(H) \end{cases}$ rather than $1_{RankB_{r,s}} = \begin{cases} 0 & \text{for } \varphi_{r,s}^c(L) \leq \varphi_{r,s}^c(H) \\ 1 & \text{for } \varphi_{r,s}^c(L) > \varphi_{r,s}^c(H) \end{cases}$ as is done here.

# Appendix C

# Chapter 4 Appendix

## C.1 Preference Program Use: Chilean Exports to US

Figure C.1 presents the breakdown of exports to the US by preference program, here by number of HTS8 lines. Here we see that for several products it appears that Chile-US FTA preferences replace GSP preferences after 2004 (and that there is a phase-in period of a year for some of these products). It also appears that Chile-US preferences cover more products than were covered under GSP, which is indeed the case.

Figure C.2 presents the value of Chile-US exports in 2001 for each sector broken down by the preference program under which goods were imported. We see that the largest use of GSP preferences by dollar value in 2001 is in the Chemicals sector, followed by Base Metals, Wood, and Vegetable Products. For all of these sectors but Chemicals, this large GSP trade value is due to the fact that the sector trade value is large, while the share of trade for which products enter under GSP is less than 20% (for Chemicals it is over 60%) (see figure 4.2).
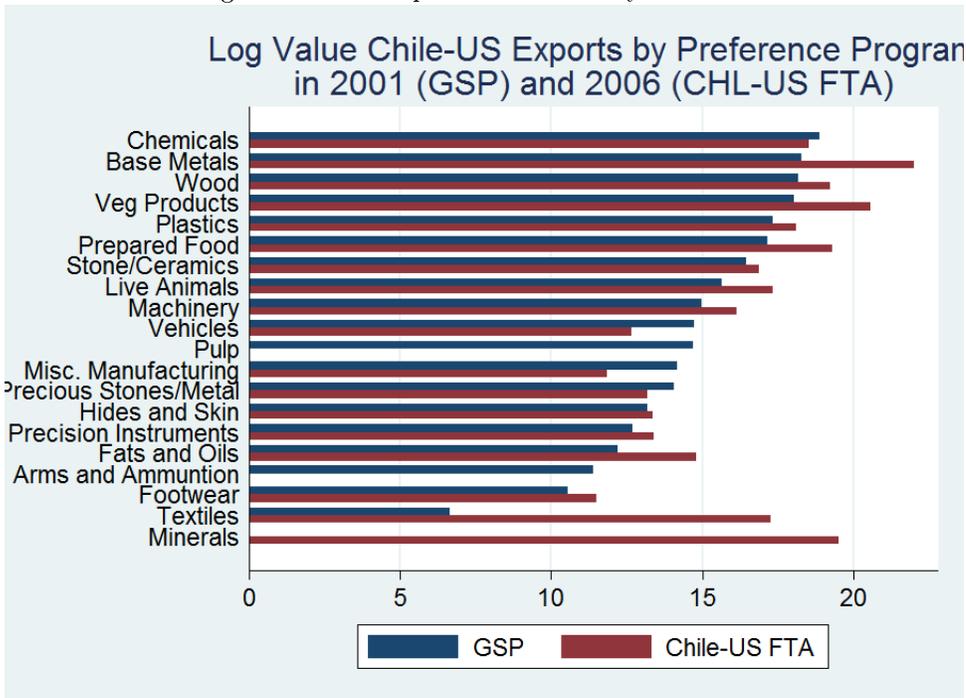
## C.2 Additional Regression Results

Table C.1 presents the results of the same difference in difference regressions run in section 4.4, now where observations are weighted by trade flow value to give more weight to large

Figure C.1: US Imports from Chile by Preference Scheme: HTS8 Count
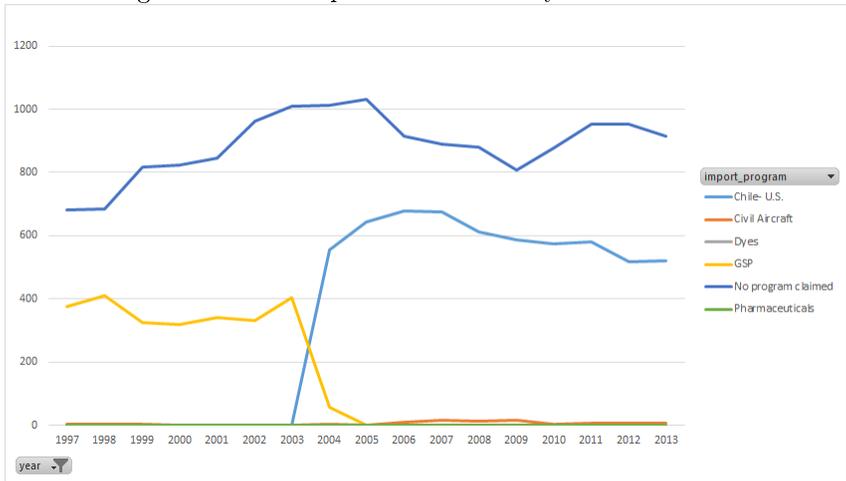


Source: US International Trade Commission.

Figure C.2: US Imports from Chile by Preference Scheme



Source: US International Trade Commission.

Table C.1: Regression Results: FTA Impact on Trade

| Dependent Var: | Change in Log Export Value | | Change in Log No. Exporters | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Year | 0.0870*** | 0.0833*** | 0.0473*** | 0.0376*** |
| | (0.00269) | (0.00278) | (0.00603) | (0.00801) |
| FTA | 0.383*** | 0.242*** | -0.00553 | 0.0208 |
| | (0.0307) | (0.0446) | (0.0379) | (0.0416) |
| FTAlag1 | | 0.129** | | -0.0732 |
| | | (0.0609) | | (0.0472) |
| FTAlag2 | | 0.113** | | 0.127*** |
| | | (0.0517) | | (0.0462) |
| Constant | -173.4*** | -166.0*** | -94.19*** | -74.90*** |
| | (5.386) | (5.567) | (12.07) | (16.02) |
| | | | | |
| Observations | 2,021 | 2,021 | 449 | 449 |
| R-squared | 0.907 | 0.908 | 0.700 | 0.706 |

Standard errors reported in parentheses; significance reported as *** $p<0.01$, ** $p<0.05$, * $p<0.1$

trading partners of Chile. We see that when weighting by trade flow value, the change in log export value does reflect a positive significant effect of having an FTA with Chile in force, and that there also appear to be positive effects of the agreement in the years leading up to its implementation. Weighting by trade value in the regressions with log number of exporters as the dependent variable now yields no significant effect of having an FTA in force when only controlling for pre and post FTA years, but does show a positive significant effect of being 2 years prior to implementation or later.

## C.3 Tariff Aggregation Method

I present here the same tariff information as presented in column 1 of Table 4.1, that is, the sector level applied tariff faced by Chilean exporters to the US, now with an additional column for each tariff aggregated using an alternative method; rather than reporting the "Effective Applied Rate" as reported by WITS, in this alternative aggregation method I take the applied tariff rate faced by Chilean exporters to the US in 2001 to be the minimum between the reported GSP preferential rate and the MFN rate at the HTS8 level. I then aggregate up to the sector level using bilateral trade weights.

Table C.2: Alternative Tariff Aggregation

| Section | SectionName | Eff. Applied Rate (Original Aggregation) | Alternative Aggregation |
|---|---|---|---|
| 1 | Live Animals | 0.3% | 3.0% |
| 2 | Veg Products | 0.8% | 0.8% |
| 3 | Fats and Oils | 0.2% | 0.2% |
| 4 | Prepared Food | 1.6% | 3.1% |
| 5 | Minerals | 0.2% | 0.3% |
| 6 | Chemicals | 0.0% | 0.1% |
| 7 | Plastics | 0.0% | 0.0% |
| 8 | Hides and Skin | 0.8% | 1.2% |
| 9 | Wood | 0.3% | 0.0% |
| 10 | Pulp | 0.0% | 0.0% |
| 11 | Textiles | 15.5% | 18.7% |
| 12 | Footwear | 8.9% | 9.1% |
| 13 | Stone/Ceramics | 0.0% | 0.0% |
| 14 | Precious Stones/Metal | 0.0% | 0.0% |
| 15 | Base Metals | 0.8% | 0.1% |
| 16 | Machinery | 0.0% | 0.0% |
| 17 | Vehicles | 0.0% | 0.1% |
| 18 | Precision Instruments | 0.0% | 0.0% |
| 19 | Arms and Ammunition | 0.0% | 0.0% |
| 20 | Misc. Manufacturing | 0.0% | 0.0% |

Source: Original aggregation- TRAINS effectively applied tariff data, including AVEs computed using UNCTAD method 1; Alternative aggregation-TRAINS tariff line level data, including AVEs computed using UNCTAD method 1.

Figure C.3: Simulated Increase in Exporters: CHL to ROW
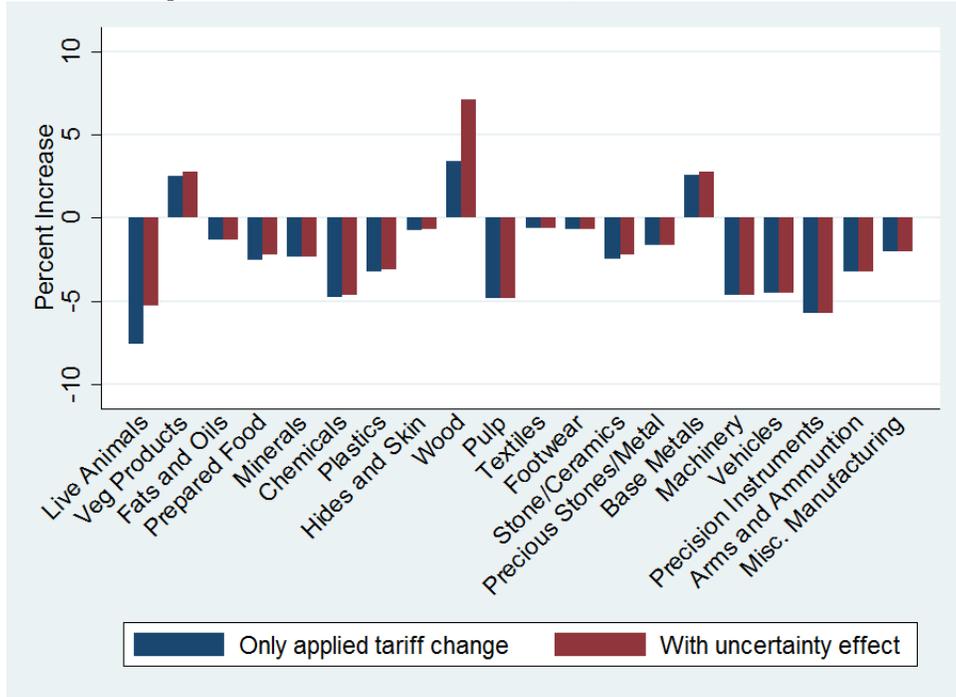


## C.4 Additional By-Sector Results for Chile

Figures C.3 and C.4 respectively now present the model simulation results (with and without the effect of the 9.98% tariff threat) on the mass of exporters from Chile to the "ROW" region and the mass of domestic producing firms in each sector in Chile. We see that the relative effect of including the tariff threat in the model is smaller when considering the impact on Chilean exports not to the US, but the Rest of the World, however the effect is still present. This increased mass of exporters to other regions is driven by a larger increase (or smaller decrease) in the mass of domestic firms producing in Chile simulated by the model that takes into account the tariff hike threat.

The figures presented thus far show model simulation results as percent changes from the non-FTA steady state equilibrium to the FTA steady state equilibrium, which does not differentiate between sectors which may be of more or less importance to the Chilean economy. Figure C.5 shows these simulation results by sector now in levels rather than percentages. The largest difference between the two models in dollar amounts occurs in the

Figure C.4: Simulated Increase in Chilean Firms
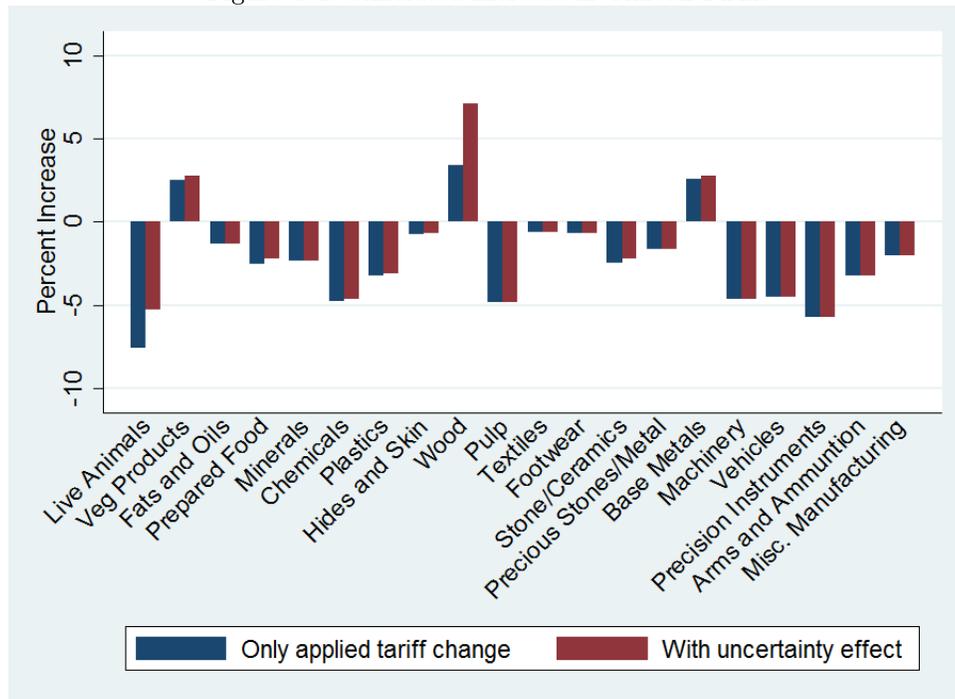
Wood and Wood Articles sector, where the model that ignores the effect of the tariff hike threat prior to the FTA predicts that trade flows from Chile to the USA will increase by 38.8 million USD, while the model that assumes initial trade flows were affected by the threat of a tariff hike (with 9.98% probability in any future period) predicts that the FTA will increase trade flows from Chile to the USA in the Wood and Wood Articles sector by 72.1 million USD. For each Wood, Chemicals, Vegetable Products, and Base Metals sectors, the simulated increase in Chile-US exports generated by the model with the tariff threat is over 8 million USD greater than in the model without this. Overall, the model without the tariff threat effect predicts that Chilean exports to the United States will increase by 5.84% as a result of the FTA, while the model with the effect of the tariff threat predicts that exports will increase by 7.05%. These are both within the range of increased trade predicted by the International Trade Commission in their report (they give a range of 6-14% increase for Chile to US exports)..

Figure C.5: Simulated Increase in Trade: CHL to USA
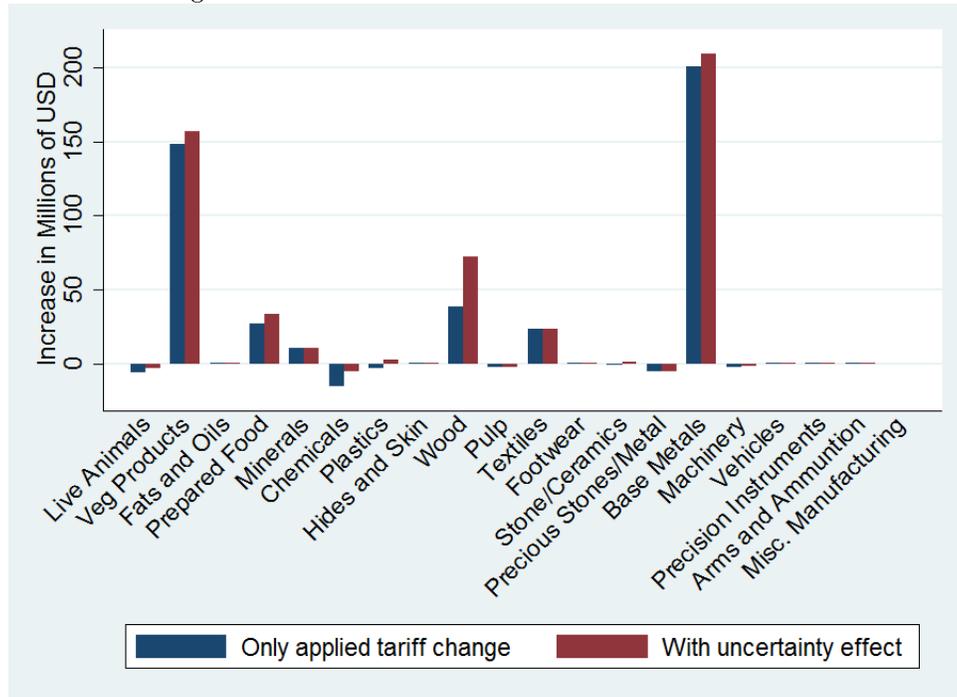


## C.5  Additional By-Sector Results for Mercosur

Figures C.6 and C.7 present the results of the two models for simulated percent increases in exports from Mercosur to Chile and the US respectively. It is clear that the additional impact of including the effects of reducing tariff uncertainty is less pronounced for Mercosur exports relative to Chilean exports, as would be expected given that any impact on Mercosur exports must come through indirect general equilibrium effects. The effect of the tariff threat elimination via the FTA on Mercosur-US trade is even smaller; for most sectors, trade from Mercosur to the US is predicted to increase by less when taking into account the effect of the tariff threat elimination, however the magnitude of these differences with the predicted increase from the model without the tariff threat is extremely small.

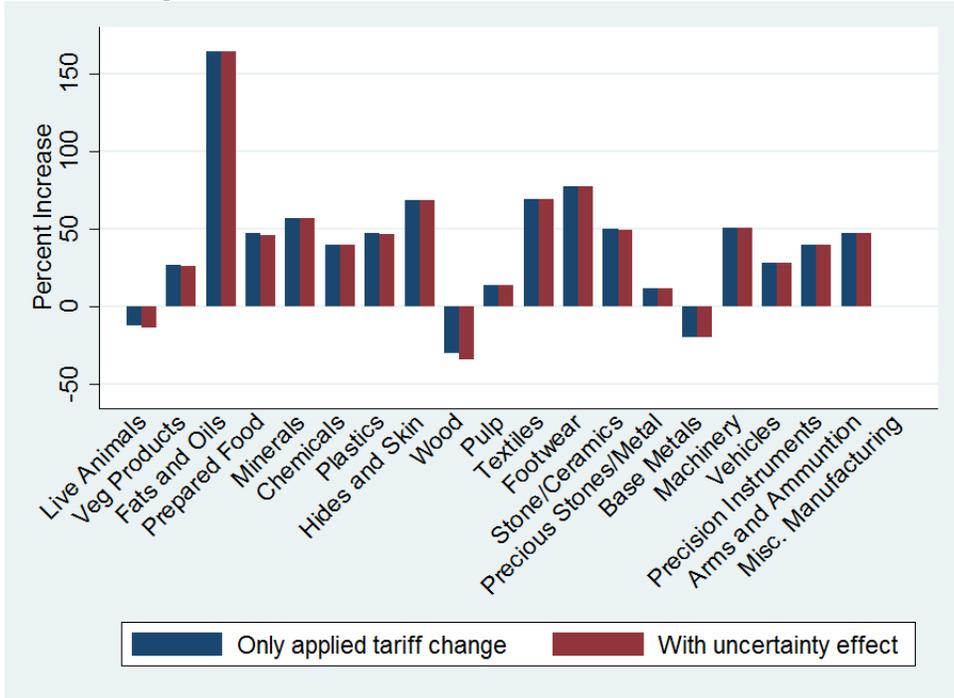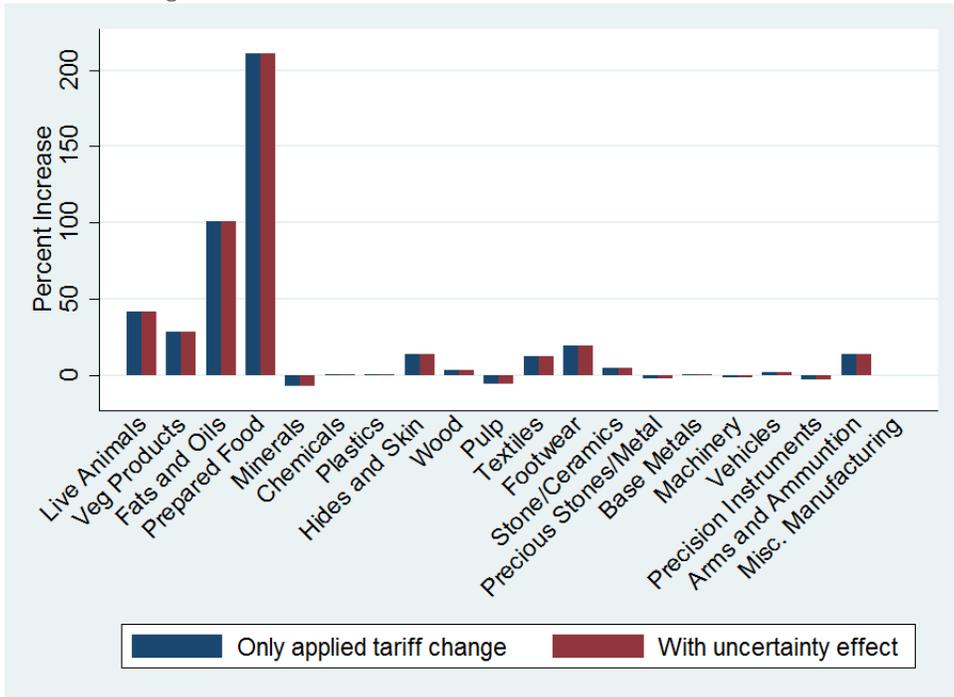Figure C.6: Simulated Increase in Trade: Mercosur to CHL



Figure C.7: Simulated Increase in Trade: Mercosur to USA

## C.6 Calibration Equations

The equations below are taken directly from the equilibrium conditions of the deterministic general equilibrium model. A variable name followed by "0" indicates that this is a baseline value (in this case, year 2011 data is used as the baseline) used to calibrate the model parameters.

$$EXP0_{k,r} = \mu_{k,r} GDP0_r$$

$$Q0_{k,r} = \frac{EXP0_{k,r}}{P0_{k,r}}$$

$$vx0_{k,r,r} = EXP0_{k,r} - \sum_{s \neq r} \tau_{k,s,r} vx0_{k,s,r}$$

$$q0_r = \mu_{0,r} GDP0_r$$

$$NE0_{k,r} = \frac{\delta}{1-\delta} N0_{k,r}$$

$$NX0_{k,r,s} = \delta M0_{k,r,s}$$

$$fe_{k,r,s} = \left( \frac{vx0_{k,r,s}}{M0_{k,r,s}} \left( \frac{a+1-\sigma}{a\sigma} \right) \right) / \delta w_r \ , r \neq s$$

where the expression above uses the fact that average firm revenue is given by $\tilde{p}_{r,s} \tilde{q}_{r,s} = \frac{vx_{r,s}}{M_{r,s}}$

$$\tilde{p}0_{k,r,s} = \frac{w_r}{\tilde{\varphi}0_{k,r,s}} \left( \frac{\sigma}{\sigma-1} \right)$$

$$\lambda_{k,r,s} = \frac{vx0_{k,r,s}}{M0_{k,r,s}} \frac{\tau_{k,r,s}^{\sigma} \tilde{p}0_{k,r,s}^{\sigma-1}}{Q0_{k,s} P0_{k,s}^{\sigma}}$$

$$\tilde{q}0_{k,r,s} = \lambda_{k,r,s} Q0_{k,s} \left( \frac{P0_{k,s}}{\tau_{k,r,s} \tilde{p}0_{k,r,s}} \right)^{\sigma}$$

$$f_{k,r}^{sunk} = \frac{1}{\delta w_r} \left[ \frac{\tilde{p}0_{k,r,r} \tilde{q}0_{k,r,r}}{\sigma} + (1-\delta) \sum_s \frac{M0_{k,r,s}}{N0_{k,r}} \left( \frac{\tilde{p}0_{k,r,s} \tilde{q}0_{k,r,s}}{\sigma} - \delta w_r fe_{k,r,s} \right) \right]$$

$$\bar{L}_r = \frac{1}{w_r} \left( GDP0_r \right.$$

$$- \left[ \sum_k \sum_{s \neq r} (\tau_{k,s,r} - 1) \left[ M0_{k,s,r} \tilde{p}0_{k,s,r} \tilde{q}0_{k,s,r} \right] + \sum_k (N0_{k.r} + NE0_{k,r}) \frac{\tilde{p}0_{k,r,r} \tilde{q}0_{k,r,r}}{\sigma} \right.$$

$$\left. + \sum_k \sum_{s \neq r} \left[ M0_{k,r,s} \frac{\tilde{p}0_{k,r,s} \tilde{q}0_{k,r,s}}{\sigma} \right] - \sum_k w_r f_{k,r}^{sunk} NE0_r - \sum_k \sum_{s \neq r} w_r f_{k,r,s}^{exp} NX0_{k,r,s} \right] \right)$$

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