Staff Working Paper ERSD-2011-20 **Date: December 2011**

World Trade Organization
Economic Research and Statistics Division

This paper appears in the WTO working paper series in the context of the WTO Essay Award Program 2011

Exporting Under Trade Policy Uncertainty: Theory and Evidence

Kyle Handley

Stanford University

Manuscript date: December 2011

EXPORTING UNDER TRADE POLICY UNCERTAINTY: THEORY AND EVIDENCE

Kyle Handley*

Stanford University

First Draft: May 2009

This Draft: December 2011

Abstract

Policy commitment and credibility are important for inducing agents to make costly, irreversible investments. Policy uncertainty can delay investment and reduce the response to policy change. I provide theoretical and novel quantitative evidence for these effects by focusing on trade policy, a ubiquitous but often overlooked source of uncertainty, when a firm's cost of export market entry is sunk. While an explicit purpose of the World Trade Organization (WTO) is to secure long term market access, little theoretical and empirical work analyzes the value of WTO institutions for reducing uncertainty for prospective exporters. Within a dynamic model of heterogeneous firms, I show that trade policy uncertainty will delay the entry of exporters into new markets and make them less responsive to applied tariff reductions. Policy instruments that reduce or eliminate uncertainty such as binding trade policy commitments at the WTO can increase entry even when applied protection is unchanged. I test the model using a disaggregated and detailed dataset of product level Australian imports in 2004 and 2006. I use the variation in tariffs and binding commitments across countries, products and time, to construct model-consistent measures of uncertainty. The estimates indicate that lower WTO commitments increase entry. Reducing trade policy uncertainty is at least as effective quantitatively as unilateral applied tariff reductions for Australia. These results illuminate and quantify an important new channel for trade creation in the world trade system.

JEL Codes: D8, D9, E6, F1, F5.

Keywords: policy uncertainty, trade, World Trade Organization, bindings

*Address: Stanford Institute for Economic Policy Research, Stanford University, 366 Galvez St, Stanford, CA 94305
Contact: handley@stanford.edu
Acknowledgements: I am grateful to Nuno Limão for many helpful discussions, suggestions and encouragement. I received helpful comments from Teresa Fort, John Haltiwanger, Russ Hillberry, Hiro Kasahara, Don MacLaren, Javier Miranda, Tim Moore, Ingmar Prucha, and John Shea as well as seminar participants at Maryland, US Census Bureau, Adelaide, Melbourne, Kansas City Federal Reserve, Oregon State, Stanford, Federal Reserve Board, Dartmouth Tuck and Michigan Ross. I thank the Australian Academy of Science for financial support and the Department of Economics at the University of Melbourne which hosted me while portions of this research were completed. This research was funded in part by NSF grant OISE-1015333. Jim Lang at Trade Data International (www.tradedata.net) provided the detailed Australian import data and useful insights.

1 Introduction

Policy commitment and credibility are extremely important for inducing economic agents to make investments, particularly when they entail large irreversible costs. Trade policy is one area where commitment and credibility are potentially very important. The need for predictability is a founding principle of the World Trade Organization[1]. Business and policy makers often cite predictable and secure policy regimes as benefits of joining preferential trade agreements.[2] Despite this, a substantial portion of global trade occurs under trade policy regimes that are not secure. For example, there was widespread fear of protectionism following the global financial crisis of 2008.[3] Yet most theoretical and empirical trade research focuses on trade policy in static, deterministic frameworks. I show theoretically and empirically that when trade policy is uncertain, conducting analysis under *de facto* certainty can be misleading and overlooks a quantitatively important channel of gains from multilateral policy commitments.

The General Agreement on Tariffs and Trade (GATT), the precursor of the WTO, was formed in 1948 to prevent a repeat of the 1930s trade wars by securing multilateral commitments to eschew protectionism. It's founding charter states, "binding against increase of low duties or of duty-free treatment shall *in principle* be recognized as a concession equivalent in value to the substantial reduction of high duties or the elimination of tariff preferences."[4] But the principle that constraints on future policy could be as valuable as applied tariff concessions has never been widely accepted or quantified; the trade off continues to be a source of controversy in multilateral negotiations (Evenett, 2007).

Even though the potential for large scale "trade wars" currently seems remote, trade policy uncertainty is pervasive in the world trade system . For example, many countries enacted discriminatory and protectionist measures in the wake of the financial crisis. Global Trade Alert has since identified nearly 700 measures that have harmed foreign commercial interests (Evenett, 2010). I discuss these and other sources of uncertainty in section 2. My primary focus is on the tariff, one of several forms of applied protection that fall under the WTO rule-based system. WTO members make enforceable commitments not to raise applied tariffs above maximum binding constraints.[5] These "bindings" are presently well above applied tariffs in some countries

[1]Under the principle "Predictability: through binding and transparency" the WTO explains that "Sometimes, promising not to raise a trade barrier can be as important as lowering one, because the promise gives businesses a clearer view of their future opportunities" http://www.wto.org/english/thewto_e/whatis_e/tif_e/fact2_e.htm (accessed October 27, 2010)

[2]Australian telecommunications provider Telstra contends that trade agreements "lock in existing levels of domestic liberalisation, preventing parties from introducing more restrictive measures in the future. This increases certainty and reduces foreign investment risk,"Telstra Corporation, Submission 31 to the Productivity Commission on Bilateral and Regional Trade Agreements, March 16, 2010, p.1

[3]To counter this perception the G-20 summit communique pledged "We will not repeat the historic mistakes of protectionism of previous eras." http://www.londonsummit.gov.uk/en/summit-aims/summit-communique/ (accessed November 9, 2010).

[4]Emphasis added. United Nations Conference on Trade and Employment, Final Act and Related Documents, Interim Commission for the International Trade Organization, April 1948, p. 31

[5]A country that violated its bindings would have to provide compensation to affected trade partners or face WTO sanctioned retaliatory tariffs.

leaving wide scope for protectionism. Over 30 percent of the tariff lines of WTO members could be increased unilaterally without providing compensation to affected trade partners (Bchir et al., 2005). Australia, for example, could raise tariffs from an average of 3.8 to 11 percent; Indonesia from 6.7 to 35.6 percent, and; the average developing country from 8 to 28 percent (Messerlin, 2008). In short, the worst case scenario if governments were to backslide into protectionism, yet not violate any WTO rules is large. A goal of my research is to understand how these constraints affect uncertainty and to quantify their value.

I consider whether and how multilateral commitments can reduce trade policy uncertainty. Dixit's (1989) seminal paper on entry and exit under uncertainty shows that when sunk market entry costs are combined with uncertainty over future conditions there may be an option value of waiting to invest. New exporters face both of these elements: evidence for large sunk cost of entry (cf. Roberts and Tybout, 1997) and, as this paper will show, uncertainty over trade policy. There is strong empirical evidence of sunk costs to export market entry, but most previous research has focused on the impact of exchange rate uncertainty with mixed findings (Roberts and Tybout, 1997; Das et al., 2007; Alessandria and Choi, 2007; Campa, 2004). Of the many sources of uncertainty faced by a prospective exporter (e.g. exchange rate or demand shocks), the trade policy toward the firm's goods poses a country and product specific risk that is difficult if not impossible to diversify.

I use a dynamic, heterogeneous firms trade model similar to Chaney (2008) in which firm productivities are known *ex-ante*. Firms must decide whether and when to begin exporting when foreign market entry costs are sunk and there is uncertainty over trade policy.[6] Both the arrival of trade policy changes and the subsequent magnitude of those changes are uncertain. Prospective entrants compare the value of beginning to export today versus waiting. On the margin, the expected value of waiting to enter until applied policy conditions improve exactly offsets the expected upside from future reductions in protection conditional on entry. The present value of the difference between exporting and waiting reflects only the potential for "bad news" and this leads firms to delay entry. Several roles emerge for policy constraints and stability on the extensive margin: first, I show that bindings reduce uncertainty by censoring the range of observable tariffs and limiting losses in the worst case scenario; second, the frequent arrival of policy changes reduces the level of firm entry; and third, firms respond more cautiously on the extensive margin when tariff changes are likely to be quickly reversed or when tariffs can reach substantially higher levels in the future.

Despite the dynamic nature of the model, I provide a closed form solution for the firm entry decision as a function of applied policy and uncertainty parameters. I derive a structural equation and measures of uncertainty from the model to test whether binding commitments reduce trade policy uncertainty. I

[6] In contrast, a firm in the standard Melitz (2003) model has initial uncertainty about its productivity which is resolved *ex-post* after paying a sunk cost of entry. A free entry condition combined with an unbounded mass of identical potential entrants drives the option value of waiting to zero.

formulate this in terms of a latent variable capturing the value of entry and estimate a linear probability model of observing trade in a disaggregated product as a proxy for firm entry. The method is novel for two reasons: first, I am able to use the observable levels of tariff bindings to *test* for the impact of uncertainty when the standard deterministic model is nested as the null hypothesis; second, the uncertainty measures can be directly controlled by policy so I can use the estimated model to quantify the relative impact of reducing applied protection versus the impact of reducing tariff uncertainty.

The empirical method requires detailed product level trade data and corresponding data on applied and bound tariffs for a single importer. I focus on Australia's "most favored nation" trade partners in the years 2004 and 2006. High quality and detailed data on products and tariffs are available during this period and, more importantly, there is wide variation across products in binding commitments. As described in Section 5.2, other aspects of Australian trade policy raise issues of uncertainty that are hardly unique to this application. I find that lower bindings, holding applied tariffs fixed, bring the entry decision forward and make firms more responsive to tariff changes on the margin. My estimates indicate that cautionary effects due to uncertainty make firms over 30 percent less responsive to tariff reductions in the average Australian tariff line. The model predicts that if Australia unilaterally reduced tariffs to free trade levels, the number of traded products would increase by 6 percent. Alternatively, if Australia both reduced tariffs to zero and bound them through WTO commitments, the combined impact of removing the motives for caution and delay would increase the number of traded products by over 12 percent. These estimates empirically quantify the value of binding tariff commitments for the first time.

In the next section, I review related literature. Section three contains a deterministic version of the model which I extend to an uncertain trade policy framework in section four. Section five discusses the empirical strategy, Australian trade policy context, data sources and the results. Section six concludes. An appendix contains further details on derivations and the data.

2 Literature Review

Policy uncertainty in general has received only limited attention in the literature. The difficulty is that most policy variations are not readily modeled by a standard stochastic process, in part because major regime changes may be large but low frequency "rare events."[7] Even if feared reversals to disastrous trade protection or threatened trade wars never materialize, the small possibility of these worst case scenario outcomes can have measurable economic effects, as Barro (2006) has recently shown for asset markets. Most work in this

[7] Hassett and Metcalf (1999) use a similar process to model the application and removal of an investment tax credit as a Poisson jump process. They find such a model is more consistent with observed firm behavior when output prices are already subject to uncertainty.

area is theoretical. Rodrik (1991), for example, develops a model of capital investment when firms believe an investment tax credit reform may be reversed in the future. If the probability of a policy reversal is high, a reform to promote investment may produce exactly the opposite outcome.[8]

A small body of work has has considered the impact of trade policy uncertainty on entry, exit and trade. Irwin (1994) analyzes the impact the GATT for western Europe in the decade following World War II. He concludes that tariff reductions under the GATT were limited, but the commitment to lock-in existing tariffs under a credible international agreement may have played an important role in post-war economic recovery and trade growth. Evenett et al. (2004) use the differences between preferential tariffs and MFN tariffs in the period before and after WTO accession to test the importance of tariff security. Results for Bulgaria and Ecuador are mixed. Francois and Martin (2004) demonstrate that tariff volatility can have negative welfare implications. They provide simulation evidence that by truncating the distribution of tariffs, WTO bindings on agricultural products within the OECD reduced the tariff volatility.

Handley and Limão (2011) develop a heterogeneous firms model of trade policy uncertainty to study Portugal's accession to the European Community in the 1980s using firm-level export data. They find that accession reduced policy uncertainty and induced firms to enter EC markets. I extend the model in Handley and Limão (2011) to assess the role of tariff bindings on export market entry. In an independent theory piece, Sala et al. (2010) also model the impact of bindings in a real options framework; they must solve the model numerically and then assess the impact of changes in tariffs and bindings for different parameterizations. In contrast, the model in this paper incorporates bindings into a general stochastic process for tariffs which is analytically solvable and, more importantly, delivers predictions which I test and quantify using disaggregated product-level data.

Many industrialized countries grant one-way preferential market access to developing country exporters. Because these preferences are frequently altered or withdrawn on a country-specific basis, they create additional uncertainty for the intended recipients. The resulting instability is an oft-cited reason these programs may have been ineffective (Panagariya, 2006).[9] The desire to secure preferential tariffs was a motivating factor for Columbia and Peru to sign agreements with the U.S. (USITC, 2008) and for Singapore, Chile and Thailand to do the same with Australia (Pomfret et. al, 2010). Even the time period between beginning negotiations and actually implementing agreements is fraught with uncertainty. Worse yet, when negotiators sign a PTA in good faith, their national legislatures may leave trade policy in limbo by failing to ratify the

[8] Johnson et al. (1997) show that reform credibility is essential to inducing firms to switch to costly but more productive technology. Empirically, Aizenman and Marion (1993) show that high volatility of monetary and fiscal aggregates has negative effects on investment and growth in cross-country regressions.

[9] For example, the United States has allowed its Generalized System of Preferences (GSP) program to expire 7 times for periods lasting 2-14 months between 1993-2008. China was subject to annual and contentious votes on renewal of it's most favored nation (MFN) status in the U.S. Congress until joining the WTO in late 2001. Bolivia was ejected from the Andean Trade Preferences and Drug Eradication Act in 2008 for a lack of cooperation in drug interdiction efforts.

treaty.[10] I encompass these aspects of unilateral preferences and their potential resolution through PTAs in my theoretical model.

More broadly, this research is related to the ongoing empirical debate regarding the value of multilateral and bilateral agreements. Rose (2004), for example, questions whether there are any tangible benefits to WTO membership. Subramanian and Mattoo (2008) contend that there is little need to conclude a multilateral round of new commitments because the proliferation of PTAs has locked in low applied tariff rates. But the aggregate evidence on trade growth following PTAs is also mixed. Some studies have found PTAs increase trade by nearly 100% or more over the long run (Baier and Bergstrand, 2007; Magee 2003). In other cases, trade growth is small or even negative. The effects vary by agreement, region and time period (Frankel, 1997; Baier, Bergstrand and Vidal, 2007). Much less is known about the mechanism behind this growth because most empirical work does not examine the details of PTA policy change (Hillberry, 2009). For example, Kehoe (2005) shows how applied general equilibrium models grossly under-predicted trade growth following NAFTA on an *ex-ante* basis. Ruhl (2008) provides a related explanation to the mechanism in this paper. If PTAs are large permanent reductions in trade frictions, then expected profits in all future states of the world are higher. This induces entry and increases trade flows on average.

Other explanations for large increases in trade following trade liberalizations include competitive reallocation and productivity enhancing investment following trade liberalization (Constantini and Melitz, 2008; Chaney, 2005; Trefler, 2004) and vertical specialization where goods cross multiple borders in stages of production (Yi, 2003; Hummels, Ishii and Yi, 2001). Both channels leave room for trade policy uncertainty to play a complementary role. Reallocation from entry, exit and investment and the choice to vertically fragment production are firm decisions made under uncertainty about trade policy. Reductions in uncertainty over the joint distribution of tariffs across multiple borders could amplify the effects of reallocation or vertical specialization on trade flows.

Recent research has examined the effects of time-varying aggregate uncertainty on firm investment. Bloom et al. (2007) examine investment at a panel of UK firms. They measure aggregate uncertainty using the volatility of the stock market. Bloom (2007) discusses the effect of uncertainty on R&D spending. A central finding of this research is that uncertainty diminishes planned investment in two ways. The first is a "delay effect" whereby firms put off investments in response to increasing uncertainty. The second is a "cautionary effect" that leads firms to reduce the responsiveness of planned investment to positive demand shocks under uncertainty. These measures and concepts of uncertainty differ from trade policy uncertainty in important ways. Policy processes are distinct from the standard stochastic processes often posited for other macroeconomic variables. The actual degree of aggregate uncertainty is not observed. This requires proxy

[10] The Korea-US and Columbia-US PTAs have been awaiting ratification since November 22, 2006 and June 30, 2007.

measures of uncertainty such as stock market volatility and firm growth rate dispersion. Unlike trade policy uncertainty, there is also little to no measurable variation in aggregate uncertainty across firms or products to study and exploit empirically. Nevertheless, I do adopt the same "caution" and "delay" terminology since the underlying mechanism driving these effects is related.

3 Deterministic Model

The basic setup is similar to Chaney (2008) and Helpman et al. (2008), but extended to a deterministic multi-period framework. The world has J exporting countries indexed by j. Each country has L_j consumers that inelastically supply labor to the market. I consider a single importer, but the model can be extended to a multi-country world. Goods shipped to the importing country are subject to tariffs which may vary by export country of origin and industry. The focus of the model is the effect on trade and market entry patterns of different trade policy regimes. In the following section, I extend this analysis to a stochastic tariff process and compare the results to the deterministic outcomes in order to draw out the role of policy uncertainty for trade.

3.1 Preferences

Utility in the importing country is a Cobb-Douglas function over a homogeneous traditional good traded on world markets at zero cost and a continuum of differentiated varieties indexed by v:

$$U = q_0^{1-\mu} \left(\int_{v \in \Omega} q(v)^{\alpha} dv \right)^{\mu/\alpha}, \quad \alpha = \frac{\sigma - 1}{\sigma} \tag{1}$$

where $\sigma > 1$ is the elasticity of substitution between varieties. The total set of varieties available Ω is the union of all domestically produced varieties and those that are imported from abroad with an expenditure share of $\mu \in (0, 1)$. Utility is maximized subject to the budget constraint on total income Y:

$$p_0 q_0 + \int_{v \in \Omega} p(v) q(v) dv = Y. \tag{2}$$

This yields the usual demand function for any particular variety v:

$$q(v) = \mu Y \frac{p(v)^{-\sigma}}{P^{1-\sigma}} \tag{3}$$

The price $p(v)$ is the delivered consumer price in the importing country. The price index is

$$P = \left[\int_{v \in \Omega} (p(v))^{1-\sigma} dv \right]^{1/(1-\sigma)} \tag{4}$$

In each exporting country j, some product varieties are only consumed domestically, but a fraction are exported overseas. Varieties are differentiated by the producing firm and country of origin. The set of foreign varieties available in the importing country is endogenous and derived below.

3.2 Production and Tariff Barriers

The homogeneous good is freely traded and produced under CRS such that one unit of the good is produced for $1/w_j$ units of labor in country j. I take the homogeneous good as numeraire and normalize its price to unity, $p_0 = 1$. Labor market clearing implies that the wage for country j is w_j. The differentiated goods are subject to trade costs. These take the form of ad-valorem tariffs that may vary by exporter j. I let $\tau_j \geq 1$ equal one plus the ad-valorem tariff for goods shipped from country j. Tariffs are paid at the border by consumers on the factory price. If an exporter of variety v charges price $p_j(v)$ at home, the final consumer abroad pays $p(v) = \tau_j p_j(v)$. There are no tariffs on domestic sales for firms in the importing country (i.e. $\tau = 1$).

A firm producing variety v in exporter j is identified by its unit labor requirement $c_j(v)$. The total variable costs to produce q units of a differentiated product are $w_j c_j(v) q_j(v)$. Operating profits from exporting for a firm with unit labor costs c_j are

$$\pi_j(p) = p_j(v) q_j(\tau_j p_j(v)) - w_j c_j q_j(\tau_j p_j(v)) \tag{5}$$

In this setup, the exporter takes account of the fact that import tariffs will reduce demand and scale down revenues. Profit maximization by monopolistically competitive firms yields the standard markup rule over marginal cost. The consumer price on a good shipped from country j is

$$p_j = \frac{w_j \tau_j c_j}{\alpha} \tag{6}$$

Combining the formulas for the markup rule, consumer demand and variable costs, the per period operating profits of exporting from country j can be expressed compactly as

$$\pi_j(v) = A_j \tau_j^{-\sigma} c_j(v)^{1-\sigma} \tag{7}$$

$$\text{where } A_j = (1-\alpha)\mu Y \left[\frac{w_j}{P\alpha} \right]^{1-\sigma}.$$

The quantity A_j summarizes exporter cost and importer demand conditions.

I index variation in aggregate productivity across exporting countries by $1/M_j$. I then assume there is a distribution of firms, $G(c)$, which summarizes the heterogeneity in unit costs within each country and is bounded below at c^L. The lowest unit cost firm in country j, c_j^L has a productivity of $\frac{1}{M_j c^L}$.

3.3 Entry, Exit and Sunk Costs

There is a fixed cost of market entry K_e paid by a firm to begin exporting. Entry costs cover the expenses of setting up a distribution network, on-site visits or agency costs, marketing, tailoring products to local markets and complying with safety regulations. There are no fixed entry or per period maintenance costs in a firm's domestic market. Since operating profits are always positive, albeit potentially quite small, every firm sells in its home market. A subset of firms pay the entry cost and begin exporting if their unit costs are below a threshold cutoff level. Following Melitz (2003), exit is induced by an exogenous death shock δ. A firm that is hit by the death shock exits immediately without recouping its sunk costs.

In a deterministic environment, where $\pi_j(t) = \pi_j$ in the foreseeable future, the firm will enter an export market if the net present discounted value of entry is positive. The value of entry today is

$$V^D = \sum_{t=0}^{\infty} \beta^t \pi_j - K_e \tag{8}$$

$$= \frac{\pi_j}{1-\beta} - K_e \tag{9}$$

where superscript D denotes "deterministic" tariffs. The discount factor combines the true discount rate ρ and the death shock such that $\beta = (1-\delta)/(1+\rho)$. Free entry implies that in equilibrium $V^D = 0$ for the marginal entrant. Imposing this condition yields a multi-period zero cutoff profit threshold for unit labor costs c_j^D

$$c_j^D = \left[\frac{A_j \tau_j^{-\sigma}}{(1-\beta)K_e} \right]^{1/(\sigma-1)} \tag{10}$$

All firms with unit costs below c_j^D will pay the entry cost and begin exporting. It is straightforward to derive that the elasticity of c_j^D to a once-and-for-all change in τ is $\frac{\sigma}{\sigma-1}$.[11]

[11] This is higher than the usual elasticity of unity because tariffs are paid at the border, rather than as part of the firm's variable trade cost technology.

4 Stochastic Setup

4.1 A framework for trade policy uncertainty

In practice, the level of future tariffs is uncertain. Many factors can affect the formation of trade policy over time. I take shocks to trade policy as given and do not explicitly model their source. Tariffs are a random variable with two sources of variation: uncertainty over the timing of policy changes, and uncertainty over the magnitude of those changes when they arrive. Even though the outcome of policy changes is unknown *ex-ante*, firms can form expectations over the likely tariff outcomes.

To model tariff uncertainty, I assume shocks to the path of tariffs arrive with probability γ per unit of time.[12] When a shock arrives, a policy maker sets a new tariff τ'. Firms know the value of γ and can assign probability measures to different tariff outcomes. The space of potential tariff outcomes and their likelihood are summarized by the distribution function $H(\tau')$ with support $[1, \tau_{max}]$. The support allows the possibility of free trade ($\tau = 1$) or a theoretical maximum tariff τ_{max}. Conceptually, letting $\tau_{max} \to \infty$ admits the possibility of total autarky.

Given τ_t, the arrival rate of shocks and the policy distribution, the conditional expected value and variance of the tariff next period are

$$E_t(\tau_{t+1}) = (1-\gamma)\tau_t + \gamma E(\tau') \tag{11}$$

$$\text{Var}_t(\tau_{t+1}) = \gamma(1-\gamma)[\tau_t - E[\tau']]^2 + \gamma \text{Var}[\tau']. \tag{12}$$

The quantity $E(\tau')$ is the unconditional expected tariff drawn from $H(\tau')$, given that a policy shock occurs. The expected tariff in the next period depends only on the level of the tariff today and the stochastic process for tariff changes. The long run autocorrelation of the tariff is $1-\gamma$. A stable trade policy regime will have a low value of γ and as a result will display high persistence in tariffs. Even with persistence, this structure allows for the possibility of large shocks if $H(\tau')$ has thick tails. In contrast, frequent policy changes (high γ) do not necessarily generate high uncertainty if $H(\tau')$ has small dispersion.

The model permits a straightforward treatment of the impact of PTAs and bindings on the entry decision. PTA implementation affects two parameters: the probability of the tariff change γ, and the levels of current and future tariffs τ_t. If a PTA is credible, the firm's problem approaches the deterministic cutoff and this is modeled by letting $\gamma \to 0$.

Even if the PTA does not reduce γ to zero, tariff bindings can have an effect on entry by limiting the

[12] In continuous time, a similar Poisson process for the arrival of tax policy changes can be found in Rodrik (1991) and Hassett and Metcalf (1999).

magnitude of a worst case scenario tariff shock. A credible WTO binding is the maximum tariff permitted by WTO rules. The commitment to bind tariffs is a constraint on observable tariff outcomes such that the distribution of future tariffs, $H(\tau')$, is censored at the binding. By analogy to Tobit regression, censoring captures the idea that a policy maker might want to set a tariff above the binding but WTO legal constraints mean that only the binding tariff is actually observed.

I let B denote the binding level of the maximum tariff. For a binding to be effective, it must be below the maximum of the unbound tariff distribution such that $B < \tau_{max}$. Binding commitments induce a mixed discrete and continuous distribution over tariffs. A formal statement of the *bound* tariff distribution appears in the appendix. When a policy shock arrives, the new tariff is a random draw from $H(\tau')$. There is a discrete probability $H(B)$ that the tariff draw is below the binding. But with probability $1 - H(B)$, the tariff draw is above the binding and only the bound tariff rate is observed. The probabilities of extreme draws in the unbound distribution of τ are placed at the binding, thus reducing the mean and variance of tariffs.

4.2 Entry and Exit under Uncertainty

Under a stochastic tariff process, there is an option value of waiting with a structure similar to Baldwin and Krugman (1989). While the current tariff is known, future profit flows are subject to the stochastic process for tariffs. The firm's decision to enter an export market is an optimal stopping problem. Firms can be divided into exporters, state 1, and non-exporters, state 0. The value of being an exporter in the current period is V^1. A firm that is in state 1 exits only when hit by the death shock. Non-exporters hold an option value of waiting to enter in the future V^0. Non-exporters will enter a foreign market only when the value of exporting less sunk entry costs exceeds the value of waiting such that $V^1 - K_e \geq V^0$.

The decision rule for each firm is defined by the trigger tariff τ_1 that makes the firm just indifferent between entry and waiting. For each firm, identified by its unit labor requirement c, the entry trigger τ_1 implicitly solves the indifference condition

$$V^1(\tau_1) - K_e = V^0(\tau_1) \tag{13}$$

A firm will enter the export market if $\tau_t \leq \tau_1$.

Four equations define the initial problem at time t of a firm with unit labor requirement c. For clarity of exposition, I drop the country of origin subscripts. The value of exporting is

$$V^1(\tau_t) = \pi(\tau_t) + \beta[\underbrace{(1-\gamma)V^1(\tau_t)}_{\text{No Shock}} + \underbrace{\gamma EV^1(\tau')}_{\text{Shock Arrives}}]. \tag{14}$$

The quantity $V^1(\tau_t)$ is the expected present discounted value of operating profits conditional on the current tariff τ_t. With probability $1-\gamma$, the firm continues to the next period with the same value $V(\tau_t)$. With probability γ, a policy shock arrives and the tariff changes. The *ex-ante* expected value of exporting following a policy change to a new tariff τ' is

$$EV^1(\tau') = E\pi(\tau') + \beta[(1-\gamma)EV^1(\tau') + \gamma EV^1(\tau')] \tag{15}$$

In time period t, the unconditional expected value of being an exporter next period given that a policy shock arrives is $EV^1(\tau')$ in (15). This expectation is time invariant because I assume that the distribution of future tariffs $H(\tau')$ is time invariant. If a policy shock arrives in the next period or ten periods from now, the *ex-ante* expected value of the tariff draw and profits remain the same. Equation (15) can be solved explicitly for $EV^1(\tau')$ to obtain

$$EV^1(\tau') = \frac{E\pi(\tau')}{1-\beta}.$$

The resulting time invariance of $EV^1(\tau')$ does not mean that the value of exporting is time invariant. $V^1(\tau_t)$ is a function of the current tariff and firms can re-compute it on an *ex-post* basis following every tariff policy change.

The second part of the firm's problem is the value of waiting

$$V^0(\tau_t) = 0 + \beta[\underbrace{(1-\gamma)V^0(\tau_t)}_{\text{No Shock}} + \underbrace{\gamma(1-H(\tau_1))V^0(\tau_t)}_{\text{Shock Above Trigger}} + \underbrace{\gamma H(\tau_1)(EV^1(\tau_1 \mid \tau \leq \tau_1) - K_e)}_{\text{Shock Below Trigger}}] \tag{16}$$

A firm that waits receives zero profits in the current period. If no policy shocks arrive or the shock is above the entry trigger, the value of waiting remains V^0. If a policy shock arrives next period, it will be below τ_1 with probability $H(\tau_1)$. If the new tariff draw is below the entry trigger, $\tau' \leq \tau_1$, the firm will pay the sunk cost and transition to exporting. Conditional on waiting until the tariff falls below the entry trigger, the expected value of exporting is now

$$EV^1(\tau_1 \mid \tau \leq \tau_1) = E\pi(\tau' \mid \tau' < \tau_1 + \beta[(1-\gamma)EV^1(\tau_1 \mid \tau_t \leq \tau_1) + \gamma EV^1(\tau')] \tag{17}$$

This equation is structurally the same as (14), but it is evaluated *ex-ante* to obtain the expected value of exporting to a firm that delays entry until a more favorable policy shock arrives. If a firm waits to enter in the current period, it must be the case that $\tau_t > \tau_1$. Expected profits at the time of entry are greater than profits today such that $\pi(\tau_t) < E[\pi(\tau') \mid \tau' \leq \tau_1]$. Inevitably, a policy shock will eventually occur and the value of exporting after an initial delay will transition to the unconditional expected value of exporting given by (15).

The set of four equations (14),(15),(16), and (17) is a linear system in the four quantities $V^1(\tau_t)$,$EV^1(\tau')$, $V^0(\tau_t)$, and $E[V^1(\tau_1 \mid \tau \leq \tau_1)]$ and can be solved explicitly. A full derivation appears in the appendix, but the results that follow require expressions for only the current values of entry and waiting for the marginal firm. The entry margin corresponds to the firm with unit labor requirement c^U that is just indifferent to entry or waiting at time t.[13] For this marginal firm, the current tariff equals the entry trigger such that $\tau_t = \tau_1$. The corresponding value functions are

$$V^1(\tau_1) = \frac{\pi(\tau_1)(1-\beta) + \beta\gamma E[\pi(\tau')]}{[1-\beta(1-\gamma)](1-\beta)} \tag{18}$$

$$V^0(\tau_1) = \beta\gamma H(\tau_1)\frac{(1-\beta)E[\pi(\tau') \mid \tau' < \tau_1] - \beta\gamma E[\pi(\tau')] - (1-\beta)[1-\beta(1-\gamma)]K_e}{[1-\beta(1-\gamma)][1-\beta(1-\gamma H(\tau_1))]} \tag{19}$$

The expression in (13) defines a zero cutoff profit condition for the entry margin. Despite the apparent complexity of (18) and (19), a closed form expression for the cost cutoff c^U exists. I solve for the cutoff in two steps to draw out more intuition from the model. Setting the difference between V^1 and V^0 equal to entry costs K_e and simplifying terms yields

$$K_e = \left[\frac{\pi(c^U,\tau_1)}{1-\beta(1-\gamma)} + \frac{\beta\gamma E(\pi(c^U,\tau'))}{(1-\beta)[1-\beta(1-\gamma)]} + \frac{\beta\gamma H(\tau_1)[\pi(c^U,\tau_1) - E(\pi(c^U,\tau') \mid \tau' < \tau_1)]}{(1-\beta)[1-\beta(1-\gamma)]}\right] \tag{20}$$

The first term in brackets is the PDV of profits at the entry tariff where the discount factor is scaled down by the probability that no policy shock arrives. If this model were deterministic, the firm would discount by $1-\beta$ and the next two terms would disappear. The second term is the present value, following a shock, of profits at the *ex-ante* expected tariff. The third term is a negative opportunity cost of entry. It is the present value of the expected loss of entering today, given that a future policy change is below the tariff entry trigger.

In the second step, I solve (20) directly for c^U and express it in terms of an uncertainty component $\Theta(\tau_t)$

[13] Superscript U denotes the "uncertain" environment in contrast the the "deterministic" environment D.

and the deterministic cutoff c^D:

$$c^U = \Theta(\tau_t) \times c^D \tag{21}$$

$$\text{where } \Theta(\tau_t) = \left[\frac{1-\beta+\beta\gamma\Delta\left(\tau_t\right)}{1-\beta+\beta\gamma}\right]^{\frac{1}{\sigma-1}} \tag{22}$$

As shown in the appendix, $\Theta(\tau_t) \leq 1$ since $\Delta(\tau_t) \leq 1$. For a given current tariff, uncertainty over the tariff generates a lower cost cutoff than a deterministic model. The productivity premium necessary to overcome this hurdle is the ratio of c^D and c^U, or $\frac{1}{\Theta}$.

The expression for $\Delta(\tau_t)$ captures the random variation in the tariff conditional on a policy shock arrival. In the appendix, I show the following:

$$\Delta\left(\tau_t\right) = \frac{E(\tau^{-\sigma}) + H(\tau_t)[\tau_t^{-\sigma} - E(\tau^{-\sigma} \mid \tau \leq \tau_t)]}{\tau_t^{-\sigma}} \tag{23}$$

$$\Delta\left(\tau_t\right) - 1 = (1 - H(\tau_t))\left[\frac{E(\tau^{-\sigma} \mid \tau \geq \tau_t) - \tau_t^{-\sigma}}{\tau_t^{-\sigma}}\right] \leq 0$$

I interpret $\Delta\left(\tau_t\right) - 1$ as the expected proportional reduction in operating profits that occurs following a bad shock. The leading term $(1 - H(\tau_t))$ is the probability of a shock that exceeds the current tariff for the marginal firm. The term in brackets is the expected proportional loss in profits, starting from τ_t, if a bad shock arrives. The inequality is always strict except when the current tariff is at the maximum of the tariff distribution, in which case $c^D = c^U$.

Even though another policy shock could induce a new tariff that is higher or lower than the current tariff, it is only the prospect of a bad shock that affects the decision of whether to enter today. This is an example of the "bad news" principle identified in Bernanke (1983) which holds despite the convexity of profits in tariffs. When a firm enters, it weighs the expected PDV of profits from entering today against the value of waiting for a better shock in the future. Because good news in the future is offset by the opportunity cost of entry, only bad news matters when the entry investment is irreversible.

In terms of the stochastic process for tariffs, the model includes the deterministic environment as a special case. When $\gamma = 0$ exactly, the option value of waiting vanishes in equation (19). Both the stochastic value of entry in equation (18) and the zero cutoff profit threshold collapse to their deterministic counterparts. In effect, implementing a PTA can move firms toward the solution of the deterministic problem.

Lastly, since the prospect of "bad news" is a key element in a firm's entry decision, bindings play an important role by limiting losses in tariff reversals. This effect feeds through to a reduction in the firm's expected proportional reduction in profits given a reversal to higher tariffs.[14]

4.3 Implications of Uncertainty for the Entry Cutoff

Uncertainty about future trade policies delays entry at the margin relative to the deterministic model. Reducing uncertainty will lead prospective firms to bring entry forward even if applied tariffs remain unchanged. Uncertainty also makes firms on the margin more cautious. For a given tariff reduction, the elasticity of the entry cutoff to changes in tariffs is attenuated by uncertainty. These results, caution and delay, can be derived analytically and have important implications for policy. Detailed derivations appear in the appendix.

PROPOSITION 1 ***[Caution]*** *The entry cutoff c^U is less elastic with respect to tariff changes in the stochastic model relative to once-and-for-all deterministic tariff changes. Formally,*

$$\varepsilon^U(\tau_t) = \frac{\partial \log c_j^U}{\partial \log \tau_t} \quad > -\frac{\sigma}{\sigma-1} = \frac{\partial \log c_{ij}^D}{\partial \log \tau_t} = \varepsilon^D(\tau_t)$$

PROOF:(see appendix)

The expected profit loss of a bad shock is decreasing in the current tariff τ_t. As the current tariff τ_t increases, the expected reduction in profits given a reversal grows smaller. Formally, I show in the appendix that the semi-elasticity of the profit loss term $\Delta(\tau_t)$ to tariff changes is

$$\frac{\partial \Delta(\tau_t)}{\partial \ln \tau_t} = \frac{\sigma[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \geq \tau_t)]}{\tau^{-\sigma}} \geq 0$$

If $\tau_t = \tau_{max}$, $\Delta(\tau_t)$ equals one, $c^U = c^D$ and the derivative goes to zero since there is no scenario worse than the present. This implies the proportion of profits lost in a tariff reversal, $\Delta(\tau_t) - 1$, is reduced.

By log differentiating the expression for c_j^U from equation (21), I derive the elasticity as

$$\begin{aligned} \varepsilon^U(\tau_t) &= \frac{d \ln c_t^D}{d \ln \tau_t} + \frac{d \ln \Theta_t}{d \ln \tau_t} \\ &= -\frac{\sigma}{\sigma-1}\left[1 - \left(\frac{\beta\gamma}{(1-\beta+\beta\gamma\Delta)}\left(\frac{[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \geq \tau_t)]}{\tau_t^{-\sigma}}\right)\right)\right] \end{aligned}$$

The term in brackets is less than or equal to one.

In absolute magnitudes $\mid \varepsilon^U(\tau_t) \mid < \mid \varepsilon^D(\tau_t) \mid$ and the responsiveness of the entry margin is reduced under uncertainty. The two exceptions (limiting cases) are when $\gamma = 0$ (i.e. tariffs are deterministic) or when τ_t is

[14] A binding augmented version of the profit loss term $\Delta(\tau_t, B)$ is derived in the appendix.

already at the maximum of the tariff distribution. In either case, the elasticity of the cutoff under uncertainty evaluated at the tariff maximum equals the elasticity at the deterministic cutoff.

Trade policy uncertainty also generates first order reductions in the entry margin. These are summarized in the following proposition.

PROPOSITION 2 ***[Delay]*** *Higher bindings or higher arrival rates of policy shocks reduce the entry cutoff, c^U, by delaying investment in market entry. In elasticity terms:*

(a) Arrival Rates

$$\varepsilon(\gamma) = \frac{d\ln c_t^U}{d\ln\gamma} = \frac{d\ln\Theta_t}{d\ln\gamma} = \frac{\beta\gamma}{\sigma-1}\left[\frac{1-\beta}{(1-\beta(1-\gamma))\left((1-\beta\left(1-\gamma\Delta\right)\right)}\right](\Delta-1) < 0$$

(b) Bindings

$$\varepsilon(B) = \frac{d\ln c_t^U}{d\ln B} = \frac{d\ln\Theta_t}{d\ln B} = -\frac{\sigma}{\sigma-1}\left(\frac{\beta\gamma}{(1-\beta+\beta\gamma\Delta)}\left(\frac{(1-H(B))B^{-\sigma}}{\tau_t^{-\sigma}}\right)\right) < 0$$

PROOF:(see appendix)

This proposition isolates the effects of policy shock timing and magnitudes into two components. First, increases in the arrival rate of policy shocks reduce entry. In the deterministic limit $\varepsilon(\gamma) = 0$ and this delay effect vanishes. The effect is independent of the form of the tariff distribution $H(\tau')$. Future tariffs could have a lower expected value than current tariffs and some firms would still delay entry. This follows from the option value of waiting. If a more favorable tariff regime is on the horizon, delaying entry may be optimal. Similarly, when current tariffs are low and expected tariffs are high, firms on the margin will wait to enter. Second, binding reductions can increase entry, even if they do not constrain the current applied tariff, by mitigating the worst case scenario and bringing entry forward. In an environment where policy shocks cannot be eliminated, lower bindings can raise trade even if the binding is above the current period applied tariff. On the extensive margin, binding reductions could be just as effective as applied tariff reductions for increasing trade.

4.4 Testable Predictions

These propositions provide theoretical grounding for the empirical application that follows. Trade policy uncertainty reduces the number of firms exporting and the responsiveness of the extensive margin to policy shocks. Lower binding tariff commitments increase entry, even if the current binding is above the applied tariff. The figurative "insurance" against backsliding through binding commitments could be empirically relevant if prospective entrants place some probability weight on the possibility of large scale tariff reversals. In theory, further reductions in binding commitments through WTO negotiations would be meaningful. This is a testable implication of the model.

The derived elasticities for tariffs and bindings can be applied to the policy controversy over the value of non-binding, bound tariff commitments. Consider a current tariff τ_0 that is below its binding B_0. Suppose the current tariff and binding are changed by $d\ln\tau$ and $d\ln B$, respectively. The comparative static for a change in the entry cutoff $d\ln c^U$ is computed as follows

$$d\ln c^D = \varepsilon^U(\tau_0)d\ln\tau + \varepsilon(B_0)d\ln B \tag{24}$$

$$= \varepsilon^D(\tau_0)d\ln\tau - \varepsilon(B_0)\times(d\ln B - d\ln\tau) + r_0 \times d\ln\tau \tag{25}$$

$$\text{where } r_0 = \frac{\sigma}{\sigma-1}\left(\frac{\beta\gamma}{(1-\beta+\beta\gamma\Delta)}\left(\frac{(H(B_0)-H(\tau_0))E[\tau^{-\sigma}\mid\tau\in(\tau_0,B_0)]}{\tau_0^{-\sigma}}\right)\right).$$

The first term is the deterministic elasticity. The second term captures relationship between simultaneous binding and tariff changes. If the binding is unchanged, say in a unilateral tariff reduction, then the impact on the entry cutoff is reduced. However if both the binding and tariff change by the same amount then $d\ln B - d\ln\tau = 0$ and the second term drops out. The third term is the residual uncertainty about tariff outcomes in the policy space between the τ_0 and the binding B_0. Residual uncertainty will reduce the elasticity of the cutoff if the gap between B_0 and τ_0 is large and the probability mass in that range of the tariff distribution is high.

This comparative static result is summarized in the following corollary to propositions 1 and 2.

COROLLARY 1 ***[Bound tariff changes]*** *Tariff changes accompanied by equal or greater changes in binding commitments will generate more new entry than unbound, unilateral tariff changes.*

When tariffs are reduced unilaterally, without constraining future policy makers through binding, the impact on the entry cutoff is mitigated. I confirm the broader implications of this prediction in the quantification exercise.

5 Empirical Evidence

To help understand basis for my estimation method, I provide a brief overview of my data with additional details in section 5.3 and the appendix. I have annual import data at the 10-digit level of detail for Australia from 2002-2006. There are over 8,300 products that are potentially tradable and these are matched to country-product specific tariff lines. These product classifications are extremely detailed. For instance, Australian customs tracks 67 different varieties of tubes and pipes. If I break the data down to its nuts and bolts, literally, I find there are ten different varieties of bolts which can be fastened with two types of nuts.

These data encompass the entire population of potential importers whether a good is traded or not. Because I know there is heterogeneity at the industry level, I adapt the model to account for this. There are 1243 industries at the 4-digit Heading level of the Harmonized System for product classifications. I then estimate the model on a pooled cross-section in 2004 and 2006.

The broader empirical strategy is to use measures of uncertainty derived from the model to test if exporters place positive weight on the probability of a reversal to binding tariff levels. The approach exploits the cross section variation in tariffs and bindings to model the probability that a product is traded. I use the data to address whether uncertainty over reversals to binding tariff levels affects the long-run pattern of entry across industries.

5.1 Estimation Method

I estimate the model on disaggregated product data. Trade is observed at the product level if the unit cost of the most productive firm in country j is below the cutoff for a particular variety, i.e. $c_j^L < c_{tjv}^U$. Data on firms from a multitude of potential import partners are not available. A reasonable proxy for firm entry is whether a disaggregated product is traded.[15]

The unit cost of the marginal firm c_{tjv} from country j in product variety v is not observed, but it must equal the cutoff threshold $c_{tjv} = c_{tj}^U$. It turns out the ratio of the cutoff for the marginal firm in product v to that of the most productive firm in the industry c_j^L can be defined in terms of observables as a latent variable.[16] If the expected PDV of entering today is greater than or equal to the fixed cost of entry, I observe the decision of at least one firm to enter when a product is traded. I define a latent variable Z_{tjv} for the $v-th$ product variety from country j in as

$$Z_{tjv} = \left(\frac{c_{tj}^U}{c_j^L}\right)^{\sigma-1} = \frac{\Theta_t^{\sigma-1}\tau_{tjv}^{-\sigma}A_{tj}(c_{jI}^L)^{1-\sigma}}{(1-\beta)K_{tjv}} \equiv \frac{\text{PDV Operating Profits}}{\text{Entry Cost}}$$

where the second equality follows from substitution of equations (21) and (10) for c_{tj}^U. This quantity is the ratio of the PDV of operating profits for the most productive firm in an industry to sunk entry costs. If $Z_{jv} \geq 1$ for at least one exporter, then trade is observed in that product variety. Otherwise, no trade is

[15] The evidence of firm level entry following trade liberalizations from detailed firm studies such as Eaton et al. (2007) is confirmed in disaggregated product level studies such as Kehoe and Ruhl (2009) and Debaere and Mostashari (2010). Even if firm data were available, it would be difficult to identify the set of potential exporters and estimate entry probabilities at the tariff line level for the universe of all firms. A method for evaluation of trade policy reforms under uncertainty with more widely available product data is a contribution of this paper.

[16] A similar cross-country latent variable formulation is used in Helpman et al. (2008).

observed.

I assume that sunk export costs are common within each industry group such that $K_e = K_I$. Taking logs and substituting for Θ using equation (22) yields

$$z_{tjv} \propto -\sigma \ln \tau_{tjv} + \underbrace{\ln \left[\frac{1-\beta+\beta\gamma\Delta}{1-\beta+\beta\gamma} \right]}_{=\ln \Theta_{tjv}^{\sigma-1}} + d_{tj} + d_{tI} + \varepsilon_{tjv} \tag{26}$$

where $\varepsilon_{tjv} \sim N(0, \sigma_\varepsilon^2)$ is i.i.d measurement error. The exporter-year effect $d_{tj} = (1-\sigma)\ln(M_j + (1-\sigma)\ln w_j$ encompasses unobserved heterogeneity in aggregate productivity and wages. The industry-year effect $d_{tI} = k_{jI} + \ln \mu_I + y_t + (1-\sigma)\ln w_j + (\sigma-1)p_{tI}$ combines unobserved heterogeneity in entry costs and demand conditions from the price index and aggregate expenditure. Trade is observed when $z_{tjv} = \ln(Z_{tjv})$ is positive.

This specification differs from a deterministic model due to the bracketed term, which is non-linear in the parameters of interest. In the deterministic limit where $\gamma = 0$ the bracketed uncertainty term drops out entirely. Since I ultimately test for presence of uncertainty, I take $\gamma = 0$ as a testable null hypothesis and linearize around this point. The first-order Taylor approximation to $\Theta_{tjv}^{\sigma-1}$ around $\gamma = 0$ is

$$U_{tjv} = \Theta_{tjv}^{\sigma-1}|_{\gamma=0} = \frac{\beta\gamma}{1-\beta}(\Delta(\tau_{tjv}) - 1). \tag{27}$$

The linearized uncertainty term parsimoniously represents the two components of the uncertainty process: the magnitude of the expected proportional loss in profits given a policy shock arrives is captured by $\Delta(\tau_{tjv}) - 1$; the arrival rate of trade policy shocks appears linearly in γ. Estimation requires measures of the profit losses that could occur in a reversal.

A strength of the analytical simplicity of this model and the focus on trade policy is that measures of the expected profit loss can be constructed from tariff data. I discretize the expected loss for a reversal to the binding tariff with probability $p_B = 1 - H(\tau_{tv,MFN})$. The discrete decomposition is

$$\begin{aligned} \Delta(\tau_{tjv}) - 1 &= (1 - H(\tau_{tjv}))\frac{E(\tau_{tjv}^{-\sigma} \mid \tau > \tau_{tjv}) - \tau_{tjv}^{-\sigma}}{\tau_{tjv}^{-\sigma}} \\ &= -p_B \frac{\tau_{tv,MFN}^{-\sigma} - B_{tv}^{-\sigma}}{\tau_{tjv}^{-\sigma}} \qquad = -p_B U_{tjv}^B \end{aligned} \tag{28}$$

The uncertainty measure is bounded below at zero and bounded above at 1 for a reversal to total autarky. For any partner and tariff line where the bound tariff is above the applied tariff, the "binding uncertainty" measure U_{tjv}^B is positive. For example, "Windscreens of toughened (tempered) safety glass of a kind used as components in passenger motor vehicles" had a tariff of 5% at the MFN rate and 10% at the bound rate in 2004. These correspond to a profit loss of 17% for binding uncertainty (U^B) when $\sigma = 4$.

Substituting the uncertainty measure into equation (26) yields

$$z_{tjv} = -\sigma \ln \tau_{tjv} - p_B \gamma \frac{\beta}{1-\beta} U^B_{tjv} + d_{tj} + d_{tI} + \varepsilon_{tjv} \tag{29}$$

In moving from theory to data, several identifying assumption are necessary. First, I assume a common elasticity of substitution σ across industries. Second, exporters within an industry form the same expectations, using the same tariff distribution, about future policies. This is necessary to identify the probability of reversals, conditional on the current trade policy. The assumption is consistent with a rational expectations environment where there are no arbitrage opportunities.

Let T_{tjv} be a binary indicator defined as $T_{tjv} = \mathbf{1}[z_{tjv} > 0]$. I model the probability that a product is traded as $p^{(T=1)}_{tjv} = \Pr.(T_{tjv} = 1 \mid Xb) = F(Xb)$ where $F(\cdot)$ is a CDF. The estimating equation using the first-order approximation is

$$p^{(T=1)}_{tjv} = F[b_\tau \ln \tau_{tjv} + b_B U^B_{tjv} + d_{tj} + d_{tI}]. \tag{30}$$

Given the assumed normality of the errors, I could estimate a Probit model. However, there are over 2000 industry-year fixed effects in the empirical application. Estimates of these incidental parameters are potentially inconsistent, leading to bias in the parameters of interest. I assume instead that $F(\cdot)$ is linear and estimate a linear probability model (LPM) using OLS.[17]

A set of exporter-year fixed effects d_{jI} and industry-year effects d_{tI}, control for unobserved variables: differences in aggregate technology, fixed costs of entry, home country wages, w_j, terms of trade shocks, the industry price index, expenditure share and aggregate demand. The parameters are scaled into the marginal effects on the probability a product is traded, but they can still be interpreted in the context of the model. The elasticity of product sales to applied tariffs is negative and estimated by the parameter $b_\tau = -\sigma$ up to a scale factor. The negative impact of uncertainty is estimated up to scale by the parameter $b_B = \frac{\beta}{1-\beta}\gamma \cdot p_B$ where the term in discount factors is a positive constant. These coefficients are proportional to the probability weight placed on reversals to the binding, given by $\gamma \cdot p_B$. Negative coefficients indicate exporters in the average tariff line place some weight on bad news when making entry decisions.

The above first-order approximation used to compute the uncertainty terms decouples the elasticity on

[17] As a practical matter, I have also found that while computing marginal effects is computationally feasible it is extremely memory intensive and time consuming for this model. OLS does not restrict predicted probabilities to the range $(0, 1)$ and raises heteroskedasticity issues. I have verified in unreported results that signs and significance patterns are unchanged in probit fixed effect and conditional logit specifications.

applied tariffs from the uncertainty measures. In order to measure and test the cautionary effects derived in Proposition 1 and elaborated in the Corollary, I need to account for the fact that the uncertainty measure is function of tariff and binding levels. The elasticity of entry to tariff and binding changes is computed by log differentiation of the uncertainty measure. In terms of the model, the estimated elasticity of product entry to tariff reductions, $\varepsilon(\tau)$ is the sum of the direct effect to current profits, the first term in (30), and the change to future profits if a reversal occurs, the second term in (30):

$$\begin{aligned} e(\tau) &= b_\tau + b_B \frac{\partial U^B_{tjv}}{\partial \tau} \tau_{tjv} \\ &= b_\tau - b_B \sigma \times \frac{B^{-\sigma}_{tv}}{\tau^{-\sigma}_{tjv}} \\ &= -\sigma \underbrace{\left[1 - \gamma p_b \frac{\beta}{1-\beta} \frac{B^{-\sigma}_{tv}}{\tau^{-\sigma}_{tjv}} \right]}_{\text{Cautionary Effect}} . \end{aligned} \tag{31}$$

This is simply the first order approximation to the cautionary effect derived in Proposition 1. In this first order approximation it not assured that the term in brackets is less than one, as in the theoretical model, since $\frac{\beta}{1-\beta} > 1$ whenever $\beta > 0.5$. Nevertheless, the estimates in the econometric model below will satisfy this restriction. The elasticity of entry to applied tariff changes will depend on the probability of reversals, $\gamma \cdot p_B$, and their magnitudes $B^{-\sigma}/\tau^{-\sigma}$.

Proposition 2 shows that the elasticity of entry is reduced by increases in bindings. I can also use the empirical model structure to obtain the elasticity of entry to changes in binding levels following the same computation as above:

$$\begin{aligned} e(B) &= b_B \frac{\partial U^B_{tjv}}{\partial B} B_{tjv} \\ &= -b_B \sigma \times \frac{B^{-\sigma}_{tv}}{\tau^{-\sigma}_{tjv}} \\ &= -\sigma \gamma p_b \frac{\beta}{1-\beta} \frac{B^{-\sigma}_{tv}}{\tau^{-\sigma}_{tjv}} < 0. \end{aligned} \tag{32}$$

The elasticity of entry to binding changes and the cautionary effect from above are symmetric. If bindings are reduced by the same percentage as applied tariffs, the cautionary effect is exactly offset "as if" tariffs were deterministic. This result follows from the Corollary to Propositions 1 and 2.

5.2 The Application to Trade Policy in Australia

I focus on Australia, a country with a confluence of high quality data and policy variation relevant to uncertainty. In recent history, Australia maintained fairly high applied trade barriers. Unilateral liberalization means there are now large gaps between applied protection and binding commitments. Like many developed countries, it has recently implemented a series of PTAs. Several of the agreements were with developing countries that already had preferential, but discretionary, market access. These factors encompass several of the sources of trade policy uncertainty reviewed in the introduction. Theoretically grounded empirical estimates of the role of policy uncertainty and the interaction of various trade policy instruments for Australia should have validity in a host of outside applications and forthcoming policy negotiations.

While Australia has low applied tariffs at present, this has not been the case historically. Lloyd's (2008) careful construction of a 100 year time series for Australian tariffs shows that some sectors were highly protected as recently as the early 1990s. There was a legacy of protection for non-competitive industries and political interference in the tariff making process during the pre- and post-war period (Glezer, 1982). Gradual and, more importantly, *unilateral* liberalization began in the late 1980s and continued into the 1990s.[18] Even in sectors with low applied tariffs, a prospective exporter in the years 2002-2006 could look back little more than a decade to justify fear of a high tariff regime.

Since higher historical tariffs were the starting point for concessions in the Uruguay Round (1986-1994) of multilateral negotiations (see Corden, 1996), Australia's binding commitments today are high and dispersed.[19] Although applied tariffs are at or near zero in many products, the maximum bound rates range from zero to 55 percent. This variation in the binding gap between applied and bound rates is exploited empirically. Importantly, Australia removed most quotas and other quantitative import restrictions in a process known as "tariffication" as part of its Uruguay Round concessions (Snape et al. 1998). Measurement of trade barriers is now mostly homogeneous across products.

Australia's own Productivity Commission recently cited the prevention of "backsliding" on liberalization as a potential benefit of preferential trade agreements. In their comprehensive review of Australia's trade agreements, the Commission notes that

> *. . . even where agreements do not result in a reduction in existing barriers, they can be used to lock in current policies, restricting countries from increasing barriers in the future* (Productivity Commission, 2010, p. 6.21)

[18]Coincidentally, journalist Paul Kelly titled his exhaustive book documenting the economic and political upheaval of these reforms "The End of Certainty."

[19]Policy makers in Australia had adopted a so-called "midway" position in multilateral negotiations. Australia maintained it was neither a developing nor a fully industrialized country and required the flexibility to impose tariffs to protect infant industries with cost disadvantages (Snape et al. 1998).

As a case in point, if Australia were to revert all tariffs to their bindings this would substantially shift the tariff profile. In 2004, only 24% of Australia's MFN tariffs are equal to the binding tariff commitment. The magnitude of changes in a reversal to bindings can be large. As the histogram in Figure 1 shows, nearly 73% of MFN tariffs could increase, some by up to 35% in the worst case scenario. Were such reversals to occur, an exporter in the average tariff line could see his profits reduced by 19% each year. As Figure 2 shows, the profit losses extend to nearly all product lines. A full reversal to bindings would shift the distribution of profits down substantially relative to the level at applied tariffs in 2004.[20]

5.3 Data Implementation and Sample

A complete description of the data sources appears in the appendix. I focus here on construction of the regression samples, tariffs and uncertainty measures.

The tariff line measure of the ad valorem applied tariff (i.e. 1+ tariff rate) is the MFN rate offered to all WTO members. A large number of developing country exporters are eligible for preferences under one or more programs in addition to the MFN tariff. Utilization of these preferential tariffs is not 100% and requires additional documentation and compliance costs (Pomfret et al., 2010). I exclude all countries from the sample that are eligible for unilateral preferences such as the Generalized System of Preferences even though not all tariff lines are covered under these regimes. Since my objective is to estimate the impact of reversals to binding tariffs for WTO members, I excluded all trade partners that have bilateral PTAs. Evidence from Handley and Limão (2011) suggests these PTAs may offer increased security of preferential tariffs and would contaminate my results. This restriction excludes New Zealand in 2004 and 2006 and Thailand, Singapore and the United States in 2006.

The uncertainty measures of the expected loss from reversals to the binding (U_B) are constructed using the theoretical structure above. Using data on MFN applied tariffs and bindings, I construct the uncertainty measures in equation (28) for parameterizations of the elasticity of substitution ($\sigma \in \{3, 4, 5\}$). I assume $\sigma = 4$ in my baseline estimates, but show these are robust to the choice of σ.[21]

I define an industry by the HS4 Heading of a product variety, resulting in 1243 industries. All final specifications include exporter-year and industry-year fixed effects which control for several sources of heterogeneity in the estimating equation (30). The critical factor to absorb in this application are the relative productivity differences between exporters in each industry. However, because many countries trade no products within an HS4 defined industry, they are perfectly predicted by these fixed effects and are dropped from the regression sample.

[20] I compute the percentage profit reductions from the uncertainty measures derived in the preceding empirical section. See appendix for further details.

[21] Bernard et al. (2003) estimate that $\sigma = 3.8$ using U.S. firm level trade data.

The final samples contains 600,818 exporter-product observations for the years 2004 and 2006. Table 1 reports summary statistics. Within the sample, the average applied tariffs are low at approximately 4.5 and 3.8 log percentage points in 2004 and 2006. The average potential loss is over 19% for binding uncertainty *per annum*.

5.4 Product Regressions – Baseline

The baseline linear probability estimates appear in Table 2. Estimated coefficients from the baseline model appear in column 2. They conform precisely to the predictions from theory. The coefficients on the applied tariff and uncertainty measures are negative and significant.[22] For comparison, I run a naive model containing only tariffs and fixed effects as regressors in column 1. Since tariffs are positively correlated with the uncertainty measure, omitting uncertainty imparts a downward bias to the tariff coefficient in column 1. To compare the impact of reducing bindings versus unilaterally reducing applied tariffs, I turn to the lower panel of Table 2. Caution and delay effects are large and evident after I compute the elasticities at the mean of the uncertainty measure using expressions (31) and (32). The elasticity of entry to tariff reductions is reduced from 28 percent to 18.5 percent, a reduction of nearly one third due to the cautionary effect. When uncertainty is present, the responsiveness of entry to tariff reductions is substantially mitigated by caution. Delay effects are also important. The elasticity of the probability of being traded increases by 9 percent for every 1 percent decrease in bindings. In sum, for every 1 percentage point reduction in *applied* tariffs the same effect can achieved by a 2 percentage point reduction in binding commitments not to raise tariffs in the future.

It is possible that other types of protection are driving these results. In all regressions, I include a binary indicator for a positive MFN tariff at the tariff line level. Australia's current tariff profile tends to have zero tariffs in products that are not produced domestically or less frequently imported. Where there is both domestic production and import competition, positive tariffs are levied. Failure to control for this confounds the effect of tariff protection on exporting with policymakers' motive to protect import-competing sectors. Some lines are subject to non-tariff barriers (NTBs) and these forms of protection could bias my results if Australia substitutes NTB protection for applied protection near the binding. I use the ad-valorem equivalent NTB measures from Kee et al. (2009) to construct additional controls. Because these measures have no time variation, I interact them with a year indicator. These NTBs slightly reduce the probability a product is traded, but they are not significant in column 3. A small fraction of tariff lines levy some mixture of specific and ad-valorem tariffs; I include tariff line indicators for these "complex" tariffs in column 4 of

[22]Bindings are set at the 6 digit sub-heading level of the Harmonized System and do not change through time during the sample. I have verified in unreported results that the results are robust to clustering standard errors at the 6 digit level.

Table 2 interacted with year indicators. The added variable is significant with a positive sign but does not change the main results.

5.5 Quantification

I quantify the effects of applied tariff reductions relative to uncertainty reductions by using the econometric model to predict the number of new products under different regimes.[23] In this exercise, I take the sum of predicted probabilities generated by the model for each exporter in terms of changes to applied tariffs and bindings. The exporter-year and industry-year effects absorb a large share of total variation in the pattern of traded goods. This is not surprising given the well-known, traditional roles of technology driven comparative advantage, distance, transport costs and endowment differences in predicting the pattern of trade. Nevertheless, most of these factors cannot be directly influenced by trade policy, even over the long run. I focus on comparing the relative impacts of alternative trade policy instruments. I will show however, that in some scenarios the aggregate impact of trade policy uncertainty is substantial.

I use the estimates to run policy experiments which compare the scope for new product creation given the margins of policy adjustment available to Australia in 2004 and 2006. I focus on three channels: setting all applied tariffs to zero, reducing bindings to zero, or both together. The predicted values of product creation for 2004 and 2006 appear in Table 3. For 2004, the model predicts a 6.54% increase in products, or 2630 new products, if Australia were to set all its remaining MFN tariffs to zero on a unilateral basis. Relative to the deterministic environment, the caution effect reduces the number of new products created by 1069 products. The delay effect is of similar magnitude in terms of products. If Australia reduced all bindings to the current applied tariffs, eliminating the risk of future "bad news", the number of traded products would increase by 2.9 percent, or 1167 products, in 2004. The remarkable aspect of this effect is that not a single *applied* policy measure would need to change. Merely the commitment never to raise tariffs above 2004 or 2006 levels would generate a 3 percent increase in traded products with MFN partners. The greatest increase in traded products is achieved by reducing tariffs to free trade levels and binding them through the WTO. Eliminating the motives for both caution and delay while reducing tariffs would increase the number of traded products by over 12 percent in 2004 or 2006.

A caveat is that these predictions ignore general equilibrium effects. It is possible that if all trade partners uniformly faced less uncertainty, the level of product creation would be attenuated by increased competition. This suggests a need for future work on theoretical and empirical effects of policy uncertainty in general equilibrium. While some predicted effects appear to be quite large, it is possible these product measures actually understate the true level of entry by firms. There is undoubtedly within product firm

[23] A similar quantification exercise is used by Debaere and Mostashari (2010) in a different context.

entry. If a product is already traded or becomes traded due to the policy change, multiple firm entry can only be counted once. But whether the estimates over- or understate the true impact is less relevant when evaluating the relative efficacy of reducing unilateral applied tariffs versus reducing uncertainty. As long the predictions are not systematically skewed toward applied protection or uncertainty, the relative contribution of uncertainty reductions are at least as effective as tariff reductions.

5.6 Robustness

5.6.1 Parameterization of Uncertainty Measures

The uncertainty measure requires a parametric assumption about the elasticity of substitution given by σ. The strength of using the model based measure is that it has a clear interpretation in going from the model to the regression specifications. Results could be sensitive to the assumption that the elasticity of substitution is $\sigma = 4$ when constructing the measures. Table 4 reports the results across values of σ with the baseline specification included for easy comparison in column 2. Signs and significance are largely unchanged. Moving from high to low values of σ tends to increase the magnitude of estimated coefficients on the uncertainty measures.

5.6.2 Reduced-Form Specification

The model also makes reduced-form predictions about the elasticity of entry to bindings that can be used to avoid parameterization of the uncertainty measures. I regress the traded product indicator on logs of applied tariffs, bindings and their interaction. Results with log levels of tariffs and bindings appear in Table 5. The elasticity of entry to the binding is negative and significant. To capture the caution effect, I include an interaction term for tariffs and bindings in column 2. The positive and significant coefficient on the interaction indicates that caution is present in the reduced form specification as well.

6 Conclusion

Trade policy is inherently uncertain. I account for this in a tractable model that delivers clear theoretical predictions for export market entry patterns along with an estimation strategy. Evidence from Australia suggests that prospective exporters place weight on the possibility of trade policy reversals. This leads to delay of the entry decision and less responsiveness on the entry margin. I find that multilateral policy commitments at the WTO help to reduce this uncertainty and increase product entry. Within the space of trade policy tools available, policy commitments could generate nearly as much product entry as unilateral tariff reductions. These results are important for quantifying the value and modeling the impact of tariff binding commitments at the World Trade Organization. The evidence of greater product entry in tariff lines with lower bindings, a key policy instrument for guaranteeing predictable market access, indicates that these commitments are valuable to exporters.

Several theoretical extensions to the model would be useful in broader contexts. The first is to extend the model to a general equilibrium framework. As mentioned in the quantification exercise, the uncertainty reducing benefits of policy commitment may diminish if all trade partners have more secure market access. But if such effects are present, then the benefit of multilateral over regional liberalization may be even greater.

Extending and verifying these results to a broader group of countries and applications outside of international trade is important. Fortunately the methodology developed here, by using product data and model-based uncertainty measures, can be applied more broadly within international trade applications and to other forms of policy uncertainty. An important extension is the impact of trade policy uncertainty on foreign direct investment where sunk costs of opening a production facility are even higher. Trade policy uncertainty takes many other forms in the world trade system. Modeling and testing the risk of non-renewal in preferential tariff programs, temporary trade bans, economic sanctions and the risk of anti-dumping measures are all subjects for future work.

References

Aizenman, J. and Marion, N. P. (1993). Policy Uncertainty, Persistence and Growth. *Review of International Economics*, 1(2):145–63.

Alessandria, G. and Choi, H. (2007). Do Sunk Costs of Exporting Matter for Net Export Dynamics? *The Quarterly Journal of Economics*, 122(1):289–336.

Baier, S. L. and Bergstrand, J. H. (2007). Do free trade agreements actually increase members' international trade? *Journal of International Economics*, 71(1):72–95.

Baier, S. L., Bergstrand, J. H., and Vidal, E. (2007). Free Trade Agreements In the Americas: Are the Trade Effects Larger than Anticipated? *The World Economy*, 30(9):1347–1377.

Baldwin, R. and Krugman, P. (1989). Persistent trade effects of large exchange rate shocks. *The Quarterly Journal of Economics*, 104(4):635–54.

Bchir, H., Jean, S., and Laborde, D. (2005). Binding overhang and tariff-cutting formulas. Working Papers 2005-18, CEPII research center.

Bernanke, B. S. (1983). Irreversibility, uncertainty, and cyclical investment. *The Quarterly Journal of Economics*, 98(1):85–106.

Bernard, A. B., Eaton, J., Jensen, J. B., and Kortum, S. (2003). Plants and productivity in international trade. *American Economic Review*, 93(4):1268–1290.

Bloom, N. (2007). Uncertainty and the Dynamics of R&D. *American Economic Review*, 97(2):250–255.

Bloom, N., Bond, S., and Reenen, J. V. (2007). Uncertainty and investment dynamics. *Review of Economic Studies*, 74(2):391–415.

Campa, J. M. (2004). Exchange rates and trade: How important is hysteresis in trade? *European Economic Review*, 48(3):527–548.

Chaney, T. (2005). Productivity overshooting: The dynamic impact of trade opening with heterogeneous firms. mimeo, University of Chicago.

Chaney, T. (2008). Distorted Gravity: The Intensive and Extensive Margins of International Trade. *American Economic Review*, 98(4):1707–21.

Constantini, J. and Melitz, M. (2008). The dynamics of firm-level adjustment to trade liberalization. In Helpman, E., Marin, D., and Verdier, T., editors, *The Organization of Firms in a Global Economy*, chapter 4, pages 107–141. Harvard University Press.

Cooper, W. H. (2005). The U.S.-Australia Free Trade Agreement: Provisions and Implications. CRS Report for Congress, Congressional Research Service.

Corden, W. M. (1996). Protection and liberalisation in Australia and abroad. *Australian Economic Review*, 114:141–154.

Das, S., Roberts, M. J., and Tybout, J. R. (2007). Market entry costs, producer heterogeneity, and export dynamics. *Econometrica*, 75(3):837–873.

Debaere, P. and Mostashari, S. (2010). Do tariffs matter for the extensive margin of international trade? An empirical analysis. *Journal of International Economics*, 81(2):163–169.

Dixit, A. K. (1989). Entry and exit decisions under uncertainty. *Journal of Political Economy*, 97(3):620–38.

Eaton, J., Eslava, M., Kugler, M., and Tybout, J. (2007). Export Dynamics in Colombia: Firm-Level Evidence. NBER Working Papers 13531, National Bureau of Economic Research, Inc.

Evenett, S. (2007). Reciprocity and the Doha Round Impasse: Lessons for the Near Term and After. Policy Insight 11, Center for Economic Policy Research.

Evenett, S., Gage, J., and Kennett, M. (2004). WTO Membership and Market Access: Evidence from the Accessions of Bulgaria and Ecuador. Staff report, Universitat St. Gallen.

Evenett, S. J. (2010). Global Developments Since the G20 Summit in Toronto, June 2010. In Evenett, S. J., editor, *Tensions Contained... For Now: The 8th GTA Report*, chapter 2, pages 19–32. London.

Francois, J. F. and Martin, W. (2004). Commercial policy variability, bindings, and market access. *European Economic Review*, 48(3):665–679.

Frankel, J. A. (1997). *Regional Trading Blocs*. Institute for International Economics, Washington, DC.

Glezer, L. (1982). *Tariff Politics: Australian Policy-Making 1960-1980*. Melbourne University Press, Carlton, Victoria.

Greene, W. (2002). The Behavior of the Fixed Effects Estimator in Nonlinear Models. Working Papers 02-05, New York University, Leonard N. Stern School of Business, Department of Economics.

Handley, K. and Limao, N. (2011). Trade and Investment under Policy Uncertainty: Theory and Firm Evidence. Working paper, University of Maryland.

Hassett, K. A. and Metcalf, G. E. (1999). Investment with Uncertain Tax Policy: Does Random Tax Policy Discourage Investment? *Economic Journal*, 109(457):372–93.

Helpman, E., Melitz, M., and Rubinstein, Y. (2008). Estimating trade flows: Trading partners and trading volumes. *The Quarterly Journal of Economics*, 123(2):441–487.

Hillberry, R. (2009). Review of international experience: ex-post studies of other PTAs and implications for PTA design. In Jayasuriya, S., MacLaren, D., and Magee, G., editors, *Negotiating a Preferential Trading Agreements: Issues, constraints and Practical Options*, chapter 2, pages 12–34. Edward Elgar, Northhampton, MA.

Hummels, D., Ishii, J., and Yi, K.-M. (2001). The nature and growth of vertical specialization in world trade. *Journal of International Economics*, 54(1):75–96.

Irwin, D. A. (1994). The GATT's Contribution to Economic Recovery in Post-War Western Europe. NBER Working Papers 4944, National Bureau of Economic Research, Inc.

Johnson, S., Kouvelis, P., and Sinha, V. (1997). On reform intensity under uncertainty. *Journal of Comparative Economics*, 25(3):297–321.

Kee, H. L., Nicita, A., and Olarreaga, M. (2009). Estimating Trade Restrictiveness Indices. *Economic Journal*, 119(534):172–199.

Kehoe, T. J. (2005). An evaluation of the performance of applied general equilibrium models of the impact of NAFTA. In Kehoe, T. J., Srinivasan, T. N., and Whalley, J., editors, *Frontiers in Applied General Equilibrium Modeling*, chapter 13, pages 341–377. Cambridge University Press, Cambridge, UK.

Kehoe, T. J. and Ruhl, K. J. (2009). How important is the new goods margin in international trade? Staff Report 324, Federal Reserve Bank of Minneapolis.

Lippoldt, D. C. (2006). The Australian Preferential Tariff Regime. OECD Trade Policy Working Papers 33, OECD, Trade Directorate.

Lloyd, P. (2008). 100 Years of Tariff Protection in Australia. *Australian Economic History Review*, 48(2):99–145.

Magee, C. S. (2003). Endogenous Preferential Trade Agreements: An Empirical Analysis. *The B.E. Journal of Economic Analysis and Policy*, 2(1):15.

Mattoo, A. and Subramanian, A. (2008). Multilateralism beyond Doha. Peterson Institute Working Paper Series WP08-8, Peterson Institute for International Economics.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6):1695–1725.

Messerlin, P. A. (2008). Walking a Tightrope: World Trade in Manufacturing and the Benefits of Binding. Policy brief, German Marshall Fund of the United States.

Panagariya, A. (2006). Aid through Trade: An Effective option? In Birdsall, N., Vaishnav, M., and Ayres, R. L., editors, *Short of the Goal: U.S. Policy and Poorly Performing States*, chapter 10, pages 309–333. Brookings Institution Press, Baltimore, MD.

Pierce, J. R. and Schott, P. K. (2009). A concordance between ten-digit u.s. harmonized system codes and sic/naics product classes and industries. NBER Working Papers 15548, National Bureau of Economic Research, Inc.

Pomfret, R., Kaufmann, U., and Findlay, C. (2010). Are Preferential Tariffs Utilized? Evidence from Australian Imports, 2000-9. Working paper, School of Economics, University of Adelaide.

Productivity Commission (2010). Bilateral and Regional Trade Agreements. Draft research report, Australian Government: Productivity Commission.

Roberts, M. J. and Tybout, J. R. (1997). The decision to export in colombia: An empirical model of entry with sunk costs. *American Economic Review*, 87(4):545–64.

Rodrik, D. (1991). Policy uncertainty and private investment in developing countries. *Journal of Development Economics*, 36(2):229–242.

Rose, A. K. (2004). Do We Really Know That the WTO Increases Trade? *American Economic Review*, 94(1):98–114.

Ruhl, K. J. (2008). The International Elasticity Puzzle. Working paper, NYU Stern.

Sala, D., Schrder, P. J. H., and Yalcin, E. (2010). Market Access Through Bound Tariffs. *Scottish Journal of Political Economy*, 57(s1):272–289.

Snape, R., Gropp, L., and Luttrell, T. (1998). *Australian Trade Policy 1965-1997: a documentary history.* Allen and Unwin, St. Leonards, NSW.

Trefler, D. (2004). The Long and Short of the Canada-U. S. Free Trade Agreement. *American Economic Review*, 94(4):870–895.

U.S. International Trade Commission (2008). Andean Trade Preference Act: Impact on U.S. Industries and Consumers and on Drug Crop Eradication and Crop Substitution, 2007. Technical Report Publication 4037, United States International Trade Commission.

Yi, K.-M. (2003). Can vertical specialization explain the growth of world trade? *Journal of Political Economy*, 111(1):52–102.

A Appendix

A.1 Value functions and stochastic cutoff condition

Deriving the full set of value functions is a basic application of linear algebra. The solutions to the set of equations is

$$
\begin{aligned}
V^1(\tau_t) &= \frac{\pi(\tau_t)[1-\beta(1-\gamma E[\pi(\tau')])]}{[1-\beta(1-\gamma)](1-\beta)} \\
EV^1(\tau') &= \frac{E[\pi(\tau')]}{1-\beta} \\
V^0(\tau_t) &= \beta\gamma H(\tau_1)\frac{(1-\beta)E[\pi(\tau') \mid \tau' < \tau_1] - \beta\gamma E[\pi(\tau')] - (1-\beta)[1-\beta(1-\gamma)]K_e}{[1-\beta(1-\gamma)][1-\beta(1-\gamma H(\tau_1))]} \\
EV^1(\tau_1 \mid \tau < \tau_1) &= \frac{\beta\gamma E[\pi(\tau')] - E[\pi(\tau') \mid \tau' < \tau_1](1-\beta)}{(1-\beta+\beta\gamma)(1-\beta)}
\end{aligned}
$$

A.2 CDF of bound tariff distribution

The observed tariff in the bound regime τ_B is censored at the binding rate of B.

$$
\tau_B = \begin{cases} \tau & \text{if } \tau \leq B \\ B & \text{if } \tau > B. \end{cases}
$$

The CDF of τ_B is $H_{\tau_B}(\tau_B) = pH_1(\tau) + (1-p)H_2(\tau)$. Where $p = H_{\tau_B}(B)$ and

$$
H_1(\tau) = \begin{cases} \frac{H(\tau)}{H(B)} & \text{if } \tau \leq B \\ 0 & \text{if } \tau > B, \end{cases} \quad \text{and } H_2(\tau) = \begin{cases} 1 & \text{if } \tau \leq B \\ 0 & \text{if } \tau > B. \end{cases}
$$

A.3 Profit Loss Term $\Delta(\tau_t)$

A.3.1 $\Delta(\tau_t) \leq 1$

I denote the maximum tariff by τ_{max}.

$$
\begin{aligned}
\Delta(\tau_t) &= \left[E(\tau^{-\sigma}) + H(\tau_t)[\tau_t^{-\sigma} - E(\tau^{-\sigma} \mid \tau \leq \tau_t)]\right] / \tau_t^{-\sigma} \\
&= \left[\int_1^{\tau_{max}} \tau^{-\sigma} dH(\tau) + H(\tau_t)\tau_t^{-\sigma} - \int_1^{\tau_t} \tau^{-\sigma} dH(\tau)\right] / \tau_t^{-\sigma} \\
&= \left[\int_{\tau_t}^{\tau_{max}} \tau^{-\sigma} dH(\tau) + H(\tau_t)\tau_t^{-\sigma}\right] / \tau_t^{-\sigma} \\
&= \left[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \geq \tau_t) + H(\tau_t)\tau_t^{-\sigma}\right] / \tau_t^{-\sigma}
\end{aligned}
$$

Then to show that $\Delta(\tau_t) \leq 1$, I take the difference D of the numerator and denominator in the final line above

$$
\begin{aligned}
D &= \left[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \geq \tau_t) + H(\tau_t)\tau_t^{-\sigma}\right] - \tau_t^{-\sigma} \\
&= (1-H(\tau_t))[E(\tau^{-\sigma} \mid \tau \geq \tau_t) - \tau_t^{-\sigma}] \\
&\leq 0
\end{aligned}
$$

The inequality follows because $\tau_t^{-\sigma}$ is always greater than $E(\tau^{-\sigma} \mid \tau > \tau_t)$. When the current tariff is at the maximum of the support of $H(\tau)$ such that $\tau_t = \tau_{max}$, then the difference in brackets and the term $(1 - H(\tau_t))$ are both zero.

A.3.2 Derivation of $\Delta(\tau_t, B)$ when tariffs are bound.

$$\begin{aligned}
\Delta(\tau_t) &= \left[E(\tau^{-\sigma}) + H(\tau_t)[\tau_t^{-\sigma} - E(\tau^{-\sigma} \mid \tau \le \tau_t)]\right]/\tau_t^{-\sigma} \\
&= \left[(1-H(B))B^{-\sigma} + \int_1^B \tau^{-\sigma} dH(\tau) + H(\tau_t)\tau_t^{-\sigma} - \int_1^{\tau_t} \tau^{-\sigma} dH(\tau)\right]/\tau_t^{-\sigma} \\
&= \left[(1-H(B))B^{-\sigma} + \int_{\tau_t}^B \tau^{-\sigma} dH(\tau) + H(\tau_t)\tau_t^{-\sigma}\right]/\tau_t^{-\sigma} \\
&= \frac{(1-H(B))B^{-\sigma} + [H(B)-H(\tau_t)]E(\tau^{-\sigma} \mid \tau_t < \tau < B) + H(\tau_t)\tau_t^{-\sigma}}{\tau_t^{-\sigma}} \qquad (33)
\end{aligned}$$

A.4 Proofs of Propositions 1 and 2

PROPOSITION 1 ***[Caution]*** *The entry cutoff c^U is less elastic with respect to tariff changes in the stochastic model relative to once-and-for-all deterministic tariff changes. Formally,*

$$\varepsilon^U(\tau_t) = \frac{\partial \log c_j^U}{\partial \log \tau_t} > -\frac{\sigma}{\sigma-1} = \frac{\partial \log c_{ij}^D}{\partial \log \tau_t} = \varepsilon^D(\tau_t)$$

PROOF:

As described in the main text, the proof consists of two parts. First, I show that the expected profit loss of a bad shock is decreasing in the current tariff τ_t. Second, I show the stochastic elasticity is proportionally less than the deterministic elasticity.

(1) $\frac{\partial \Delta(\tau_t)}{\partial \tau_t} \ge 0$ implies the proportion of profits lost in a tariff reversal, $\Delta(\tau_t) - 1$, is reduced as tariffs increase.

$$\begin{aligned}
\frac{\partial \Delta(\tau_t)}{\partial \tau_t} &= \tau_t[-\tau_t^{-\sigma}h(\tau_t) + h(\tau_t)\tau_t^{-\sigma} - \sigma H(\tau_t)\tau_t^{-\sigma-1}]/\tau_t^{-\sigma} + \tau_t[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \ge \tau_t) + H(\tau_t)\tau_t^{-\sigma}](\sigma\tau^{\sigma-1}) \\
&= \tau_t[-\sigma H(\tau_t)\tau_t^{-1}] + \sigma\tau^{\sigma}[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \ge \tau_t) + H(\tau_t)\tau_t^{-\sigma}] \\
&= \sigma\tau^{\sigma}[-H(\tau_t)\tau_t^{-\sigma} + (1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \ge \tau_t) + H(\tau_t)\tau_t^{-\sigma}] \\
&= \sigma\tau^{\sigma-1}[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \ge \tau_t)] \\
&= \sigma[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \ge \tau_t)]/\tau^{-\sigma}
\end{aligned}$$

In semi-elasticity terms, this becomes

$$\frac{\partial \Delta(\tau_t)}{\partial \ln \tau_t} = \frac{\sigma[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \ge \tau_t)]}{\tau^{-\sigma}} \ge 0$$

(2) Using the expression for c_j^U from in equation (21), I log differentiate and derive the elasticity

$$\begin{aligned}
\varepsilon^U(\tau_t) &= \frac{d \ln c_t^D}{d \ln \tau_t} + \frac{d \ln \Theta_t}{d \ln \tau_t} \\
&= -\frac{\sigma}{\sigma-1} + \frac{1}{\sigma-1}\left(\frac{\beta\gamma}{(1-\beta+\beta\gamma\Delta)}\frac{d\Delta_t}{d \ln \tau_t}\right) \\
&= -\frac{\sigma}{\sigma-1}\left[1 - \left(\frac{\beta\gamma}{(1-\beta+\beta\gamma\Delta)}\left(\frac{[(1-H(\tau_t))E(\tau^{-\sigma} \mid \tau \ge \tau_t)]}{\tau_t^{-\sigma}}\right)\right)\right] \\
&= -\frac{\sigma}{\sigma-1} \times \phi(\tau_t) \\
&= \varepsilon^D(\tau) \times \phi(\tau_t)
\end{aligned}$$

The term in brackets, represented by $\phi(\tau_t)$, is less than or equal to one. Therefore, in absolute values $\mid \varepsilon^U(\tau_t) \mid < \mid \varepsilon^D(\tau_t) \mid$. ■

PROPOSITION 2 ***[Delay]*** *Higher bindings or higher arrival rates of policy shocks reduce the entry cutoff by delaying investment in market entry. In elasticity terms:*

(a) Arrival Rates

$$\varepsilon(\gamma) = \frac{d \ln c_t^U}{d \ln \gamma} = \frac{d \ln \Theta_t}{d \ln \gamma} = \frac{\beta\gamma}{\sigma - 1} \left[\frac{1-\beta}{(1-\beta(1-\gamma))\left((1-\beta\left(1-\gamma\Delta\right)\right)} \right] (\Delta - 1) < 0$$

(b) Bindings

$$\varepsilon(B) = \frac{d \ln c_t^U}{d \ln B} = \frac{d \ln \Theta_t}{d \ln B} = -\frac{\sigma}{\sigma-1} \left(\frac{\beta\gamma}{(1-\beta+\beta\gamma\Delta)} \left(\frac{(1-H(B))B^{-\sigma}}{\tau_t^{-\sigma}} \right) \right) < 0$$

PROOF:

(a) Log differentiating the cutoff under uncertainty with respect to γ, I obtain

$$\begin{aligned} \frac{d \ln c_t^U}{d \ln \gamma} &= \frac{d \ln \Theta_t}{d \ln \gamma} \\ &= \frac{\gamma}{\sigma-1} \left(\frac{d}{d\gamma} \ln(1-\beta\left(1-\gamma\Delta\right)) - \frac{d}{d\gamma} \ln\left(1-\beta(1-\gamma)\right) \right) \\ &= \frac{\beta\gamma}{\sigma-1} \left[\frac{1-\beta}{(1-\beta(1-\gamma))\left((1-\beta\left(1-\gamma\Delta\right)\right)} \right] (\Delta - 1) \end{aligned}$$

We thus have

$$\operatorname{sgn}\left(\frac{d \ln c_t^U}{d\gamma} \right) = \operatorname{sgn}\left(\frac{\Delta - 1}{\left((1-\beta\left(1-\gamma\Delta\right)\right)} \right) < 0$$

which is negative since $\Delta - 1 < 0$ whenever $\tau_t < \tau_{max}$.

(b) I use the binding censored version of the profit loss term $\Delta(\tau_t, B)$ from equation (33). Log differentiating the cutoff, I obtain

$$\begin{aligned} \frac{d \ln c_t^U}{d \ln B} &= \frac{d \ln \Theta_t}{d \ln B} \\ &= \frac{1}{\sigma-1} \left(\frac{\beta\gamma}{(1-\beta+\beta\gamma\Delta)} \frac{d\Delta_{t,B}}{d \ln B} \right) \\ &= -\frac{\sigma}{\sigma-1} \left(\frac{\beta\gamma}{(1-\beta+\beta\gamma\Delta)} \left[\frac{(1-H(B))B^{-\sigma}}{\tau_t^{-\sigma}} \right) \right] \; < \; 0. \end{aligned}$$

The term is brackets is positive and the cutoff is decreasing in the binding. ■

A.5 Data Sources and Descriptions

I use trade flow and product data for all imported exporter-product pairs from 2004 and 2006. These data are at 10-digit level of disaggregation known as the Harmonized Tariff Items Statistical Codes (HTISC) by Australian Customs. The data were obtained on an annual basis from Trade Data International, an authorized re-seller of trade data from the Australian Bureau of Statistics. [24] In 2004 and 2006, there are

[24]The HTISC is equivalent to the Harmonized System in the first 6 digits, known as HS6 level. Following the HS6, the next 2 digits capture "tariff items" and are assigned for further disaggregation of tariff duties. The final 2 digits are "statistical codes" assigned to provide additional disaggregation for statistical purposes.

over 8,300 products that could be exported from any single country to Australia.[25] I account for the 153 code changes during the period from 2002 to 2006 to avoid spurious entry and exit of products.

Tariff data were extracted from the WTO's Tariff Analysis On-line system, a comprehensive database tariff concessions. The Integrated Database includes details at the 8-digit tariff line level for Australia's applied MFN tariffs; Generalized System of Preferences; and other unilateral preference programs. The Consolidated Tariff Schedules contain a record of Australia's certified binding concessions at the HS6 level (the level at which bindings are negotiated).

Table 1: Summary Statistics –Means with standard deviation in parentheses

	2004	2006	Total
Product Traded (binary)	0.133	0.117	0.125
	(0.340)	(0.321)	(0.331)
Applied Tariff(ln)	0.045	0.038	0.041
	(0.057)	(0.041)	(0.050)
Binding(ln)	0.105	0.106	0.105
	(0.098)	(0.098)	(0.098)
Binding Uncertainty	0.194	0.210	0.202
	(0.176)	(0.188)	(0.182)
Complex Tariff	0.002	0.002	0.002
	(0.042)	(0.042)	(0.042)
NTB AVE (ln)	0.043	0.043	0.043
	(0.153)	(0.154)	(0.154)
Pos. MFN Tariff	0.570	0.574	0.572
	(0.495)	(0.495)	(0.495)
Observations	298,794	302,024	600,818

mean coefficients; sd in parentheses

[25] This degree of product diversity is comparable to that found in the 10-digit U.S. import data or Combined Nomenclature of the European Union. For comparison, the level of detail in the HS6 data from the UN COMTRADE database tracks just over 5,000 products due to aggregation.

Table 2: Probability a product is traded in 2004 and 2006

Dependent Variable: Product Traded (binary)	(1)	(2)	(3)	(4)
Marginal Effects:				
Applied Tariff(ln)	-0.233***	-0.275***	-0.276***	-0.285***
	(0.026)	(0.027)	(0.027)	(0.027)
Binding Uncertainty		-0.028***	-0.029***	-0.028***
		(0.004)	(0.004)	(0.004)
Controls				
Pos. MFN Tariff(binary)	0.039***	0.039***	0.039***	0.040***
	(0.002)	(0.002)	(0.002)	(0.002)
NTB AVE(ln)–2004			-0.008	
			(0.005)	
NTB AVE(ln)–2006			-0.004	
			(0.005)	
Complex Tariff(binary)–2004				0.053***
				(0.014)
Complex Tariff(binary)–2006				0.033*
				(0.013)
Elasticities (at mean of Binding Uncertainty Measure) w. r. t.				
Applied Tariff		-0.185	-0.185	-0.196
		(0.028)	(0.028)	(0.028)
Binding		-0.090	-0.091	-0.089
		(0.013)	(0.013)	(0.013)
Cautionary Effect (p.p.)–Relative to		-32.792	-32.976	-31.331
Marginal Effect in Row 1		(5.258)	(5.244)	(5.025)
Observations	600818	600818	600818	600818
Adjusted R^2	0.299	0.299	0.299	0.299
Exporter x Year FE	YES	YES	YES	YES
Industry(HS4) x Year FE	YES	YES	YES	YES

Notes: Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

$\sigma = 4$ for uncertainty measure. See text for description of elasticity calculations.

Table 3: Quantification – cross-section policy experiments in terms of products for 2004 and 2006

Predicted New Products – Totals and Growth Rates (p.p.)	Year	
Policy Experiments	2004	2006
A. Tariff Reductions		
1. Reduce all applied tariffs to zero (Deterministic)	3699	3099
	(362)	(303)
2. Less the Caution Effect (Uncertainty)	-1069	-860
	(158)	(127)
3. Net effect of tariff reduction (A1+A2)	2630	2239
	(365)	(304)
Growth Rate (Uncertainty)	6.54	6.42
	(0.908)	(0.872)
B. Binding Reductions		
1. Reduce Bindings to Current Applied Tariff(Delay Effect)	1167	1228
	(173)	(182)
Growth Rate	2.91	3.52
	(0.431)	(0.522)
2. Reduce Bindings to Zero (Free Trade)	2237	2087
	(332)	(310)
Growth Rate	5.57	5.98
	(0.826)	(0.888)
C. Tariff and Binding Reductions		
Reduce and bind all tariffs to zero (A3+B2)	4868	4326
	(432)	(384)
Total Growth Rate	12.11	12.39
	(1.076)	(1.101)
Total Traded Products (Data)	34,905	40,194

Notes: Estimates computed from column 2 of Table 2. Totals do not add precisely due to rounding error.
Robust standard errors computed via delta method in parentheses.
Growth rates are relative to number of traded products in 2004 and 2006 (bottom row)

Table 4: Robustness across alternative elasticity of substitution parameters (σ) for uncertainty measure

Elasticity Parameter:	(1) $\sigma = 3$	(2) $\sigma = 4$	(3) $\sigma = 5$
Applied Tariff(ln)	-0.276***	-0.275***	-0.274***
	(0.027)	(0.027)	(0.027)
Binding Uncertainty	-0.035***	-0.028***	-0.024***
	(0.005)	(0.004)	(0.004)
Pos. MFN Tariff(binary)	0.039***	0.039***	0.039***
	(0.002)	(0.002)	(0.002)
Observations	600818	600818	600818
Adjusted R^2	0.299	0.299	0.299
Exporter x Year FE	YES	YES	YES
Industry(HS4) x Year FE	YES	YES	YES

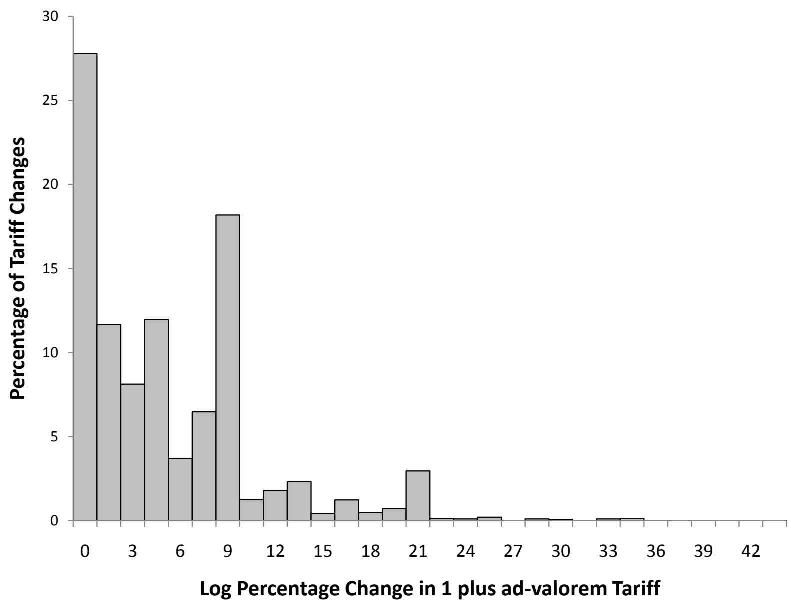
Notes: Robust standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Robustness to reduced-form estimation on log of bindings and tariffs

Dependent Variable: Product Traded (binary)	(1)	(2)
Applied Tariff(ln)	-0.207***	-0.433***
	(0.027)	(0.043)
Binding(ln)	-0.066***	-0.128***
	(0.010)	(0.013)
Tariff×Binding(ln)		0.981***
		(0.129)
Pos. MFN Tariff (binary)	0.039***	0.047***
	(0.002)	(0.002)
Observations	600818	600818
Adjusted R^2	0.299	0.299
Exporter x Year FE	YES	YES
Industry(HS4) x Year FE	YES	YES

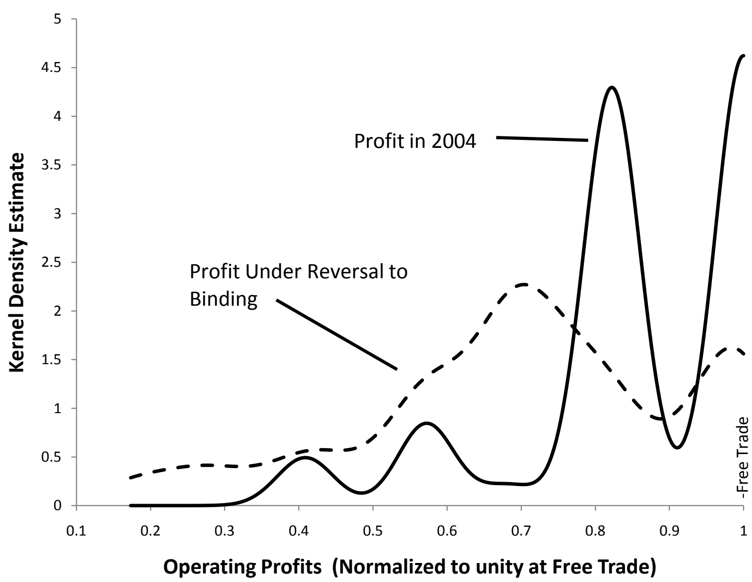
Notes: Robust standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1: Distribution of tariff changes under a binding reversal in 2004



Notes: Change in log points from the MFN tariff to the bound tariff in 2004. $100 \times \ln(B_v/\tau_v)$ where $B, \tau = (1 + \text{ad-valorem rate})$. Bin width is 1.5 log points.

Figure 2: Shift in distribution of profits under a binding reversal in 2004 at applied (MFN rate) vs bound tariff levels



Notes: Kernel densities. Profits are normalized to unity at $\tau = 1$. Higher tariffs scale down profits by $\tau^{-\sigma}$ in the model. I compute the operating profit for all product lines at the applied MFN tariff in 2004. I then compute profits in 2004 as if there had been reversal to the worst case bound tariffs.