Policy Uncertainty, Trade and Welfare: Theory and Evidence for China*

Kyle Handley
University of Michigan
handleyk@umich.edu

Nuno Limão
University of Maryland,
NBER, CEPR
Limao@umd.edu

June 20, 2013

ABSTRACT: We assess the impact of U.S. trade policy uncertainty (TPU) toward China in a tractable general equilibrium framework with heterogeneous firms. We show that increased policy uncertainty reduces investment in export entry and technology upgrading, which in turn reduces trade flows and real income for consumers. We apply the model to analyze China's export boom around its WTO accession and argue that in the case of the U.S. the most important policy effect was a reduction in TPU: granting permanent normal trade relationship status and thus ending the annual threat to revert to Smoot-Hawley tariff levels. We construct a theory-consistent measure of TPU and estimate that its elimination upon WTO accession can explain up to 1/3 of the observed Chinese export growth to the U.S. in 2000-2005—the equivalent of an *applied* tariff reduction of up to 8.5 percentage points. We also estimate a welfare gain of removing this TPU for U.S. consumers and find it is of similar magnitude to the U.S. gain from new imported varieties in 1990-2001.

*We thank Helia Costa, Lauren Deason, Rafael Dix-Carneiro, Giselle Rua and participants at the WAITS conference, Lisbon meeting on Institutions and Political Economy and University of Michigan for useful comments. Jeronimo Carballo provided excellent research assistance.

1 Introduction

One of the most important economic developments in the last 20 years is China's integration in the global trading system. The share of world imports from China rose from about 2% to 11% between 1990-2010. The share of U.S. imports from China in that period rose even faster: from 3% to 19%. More importantly, the U.S. share grew 1 percentage point per year on average in 2001-2010—twice the rate in 1990-2000. Recent evidence indicates that this export boom had large impacts—contributing to declines in U.S. prices (cf. Auer and Fischer, 2010), lower manufacturing employment and local wages (cf. Autor et al., Forthcoming). Some authors note the inflection year of the export growth to the U.S. coincides with China's WTO membership (December 2001) and argue that the accession may have reduced trade costs faced by Chinese exporters.[1] This argument is somewhat puzzling given that U.S. *applied* trade barriers toward China remained largely unchanged at the time of accession.[2]

We provide theoretical and empirical evidence that China's WTO accession did significantly contribute to its export boom to the U.S. by reducing the policy uncertainty faced by Chinese exporters. We also examine the impact this had on aggregate prices and welfare of U.S. consumers. China's WTO accession led the U.S. to enact the *permanent* most favored nation (MFN) status in 2002, which ended the annual *threat* to impose high tariffs on Chinese goods. Although China never lost its MFN status after it was granted in 1980, it came close to it: after the Tiananmen square protests there was pressure to revoke the MFN status with Congress voting on such a bill every year in the 1990s and the House passing it three times. Had the status been revoked the U.S. would have reverted to Smoot Hawley tariff levels and a trade war would likely ensue. In 2000 for example, the average U.S. MFN tariff was 4% but if China had lost its MFN status it would have faced an average tariff of 35% with about one fifth of product tariff lines going up to at least 50%. Figure 1 illustrates that products with higher threat tariffs relative to MFN prior to WTO accession had stronger export growth to the U.S. after accession by employing both a linear and a non-parametric fit.[3]

The potential impact of this policy uncertainty and the channel through which it affected trade was understood by policy makers and firms. For example, after President Clinton delinked the MFN status from China's domestic practices in 1994 the Hong Kong Secretary for Trade and Industry celebrated the U.S. decision stating that "It exceeds our expectations and businessmen and entrepreneurs can put their hearts at ease. This has removed a major issue of uncertainty and we can now go ahead with business plans in the normal way" and that the impact of renewal on investment and re-exports "(...) can only be evaluated retrospectively. But it will remove the threat of potential losses that would have arisen as a result of revocation." But the uncertainty remained; in 1997 the Chinese Foreign Trade Minister urged the U.S.

[1] Autor et al., Forthcoming, make this point and also cite other motives for this export growth. China's share of world income been rising driven by internal reforms (many in the 1990s) with a subset of these being directly targeted towards the export sector, e.g. improved access to foreign technology & inputs (Hsieh and Klenow, 2009) and relaxed FDI rules (Bloningen and Ma, 2010).

[2] The main change in US trade barriers was the lifting of the textile quotas but this only fully implemented in 2005.

[3] The non-parametric fit suggests that the relationship is not log linear, which is something we investigate in the model and test in the empirical section where we provide details about the data and estimation

to abandon trade status reviews: "The question of MFN has long stymied the development of Sino-U.S. economic ties and trade (...) [It] has created a feeling of instability among the business communities of the two countries and has not been conducive to bilateral trade development". In 2002, after WTO accession, an official at the same Ministry pointed out that by establishing "the permanent normal trade relationship with China, [the U.S.] eliminated the major long-standing obstacle to the improvement of Sino-U.S. (...) economic relations and trade."[4]

The effects of policy uncertainty on U.S. businesses activity and consumer welfare were also recognized. A coalition of businesses in the toy, apparel, footwear and electronics industries as well as exporters that feared retaliation lobbied Congress to make MFN permanent (Zeng, 2003). The CEO of Tyco Toys said "We view the imposition of conditions upon the renewal of MFN as virtually synonymous with outright revocation. Conditionality means uncertainty. We cannot plan and run our businesses if we are wondering whether our most important source of supply is about to disappear." Likewise, the American Association of Exporters and Importers wrote: "Any annual review process introduces uncertainty, weakening the ability of U.S. traders and investors to make long run plans, and saddles U.S./China trade and investment with a risk factor cost not faced by our international competitors."[5] Reports prepared for Congress discussed the higher prices that consumers would face following revocation given the incidence of higher tariff rates (Pregelj, 2001).[6]

Our first question is: how do we identify and quantify the impact of U.S. trade policy uncertainty (TPU) on China's export boom? The answer has implications beyond this particular important event. It can inform us of the potential impacts of other sources of policy uncertainty, such as U.S. threats to impose tariffs against "currency manipulators" or not renew unilateral preferences to developing countries. More broadly, our results are relevant for understanding whether trade agreements promote trade. This is a central goal of the World Trade Organization (WTO), but its success is questioned by some (Rose, 2004) and supported by others (cf. Subramanian and Wei, 2007). By quantifying the role of trade agreements in reducing policy uncertainty, our work highlights how the WTO promotes trade through a channel that is largely missing from the empirical and theoretical debate, barring recent exceptions discussed below.[7]

This leads to our second question: what are the aggregate price and welfare effects of trade policy uncertainty? The initial impetus for this question is the doubling of Chinese import penetration in the U.S. between 2000-2005, which may have depressed aggregate prices and thus improved U.S. consumer welfare. The broader motivation is to contribute to the long standing question of the aggregate gains from trade.

[4]The news sources are respectively: "HK business leaders laud US decision" South China Morning Post, 5/28/94, Business section; "Minister urges USA to abandon trade status reviews" Xinhua news agency, 10/5/97, FE/D3044/G and "China-US trade volume increases 32 times in 23 years - Xinhua reports" BBC Summary of World Broadcasts, 2/18/2002.

[5]Both quotes appear on p.97 and p. 122 in "China Most-Favored-Nation Status," Hearing before the Committee on Finance, U.S. Senate, June 6, 1996.

[6]A global general equilibrium study by Arce and Taylor (1997) estimated that if MFN were revoked, U.S. imports from China would decline by $11 billion and real income by up to $1.8 billon.

[7]The WTO site for example states that "Just as important as freer trade – perhaps more important – are other principles of the WTO system. For example: non-discrimination, and making sure the conditions for trade are stable, predictable and transparent." (www.wto.org)

Recent work by Arkolakis et al. (2012) has focused on the gains from removing applied trade barriers. Our framework highlights and quantifies an additional source of welfare gains from trade reform: the removal of policy uncertainty. We will focus on consumer gains that arise from lower prices due to firm entry and technology upgrading investments, as discussed below.

Our theoretical approach captures the concerns of policy makers and business leaders over future policy by focusing on the interaction between uncertainty and irreversible investment decisions. When the cost of investment is sunk, this can create an option value of waiting that leads firms to delay investment until uncertainty is resolved or business conditions improve. The basic theoretical mechanism for this interaction is well understood (cf. Bernanke, 1983; Dixit, 1991) and there is some evidence that economic uncertainty, as proxied by stock market volatility, leads firms to delay investments (Bloom et al., 2007). In the international trade context, there is evidence of sunk costs to export market entry (cf. Roberts and Tybout, 1997) but most empirical research on uncertainty's impact on export dynamics has focused on exchange rate uncertainty and found small or negligible impacts (IMF, 2010). Only a small body of research addresses the theoretical and empirical implications of economic policy uncertainty, in part because it is difficult to measure it and quantify its causal effects (Rodrik, 1991). In recent work, Baker et al. (2012) construct a news-based index of policy uncertainty and find it is useful in predicting declines in output and employment in VARs. Our focus and approach are considerably different since we use applied policy and counter-factual policy measures, both of which are observable, to directly estimate the effect of policy uncertainty on economic activity in a structural framework.

In section 2 we develop a tractable dynamic heterogeneous firms' model that we use to derive and then estimate the impacts of current and future trade policy on firms and consumers. In doing so we extend the partial equilibrium framework from Handley and Limão, 2012 (HL) in two important ways. First, we allow firms to not only make sunk cost investments to enter foreign markets (as in HL) *but also* to upgrade their technology (to one with lower marginal cost). The model then predicts that reductions in TPU will generate new exports via both the extensive margin (as new firms invest to enter) *and* the intensive one: via endogenous technology upgrading by incumbent exporters. Allowing for upgrading is important for three reasons. First, entry may be insufficient to account for the large effects that TPU reductions can have since new entrants are typically small and the contribution of intensive margin growth of surviving firms to total export growth is especially important for China.[8] Second, there is evidence for other countries that *applied* tariff changes can trigger within firm productivity increases (cf. Trefler, 2004, Lileeva and Trefler 2010) so it is plausible that the same may happen due to reductions in TPU. Third, there is evidence of substantial firm-level TFP growth increases in China since 2001.[9]

[8] Manova and Zhang (2009) find that from 2003-2005, the share of export growth was 30% from entry, 42% from expansion at surviving firm-product-destinations, and 28% from surviving firm expansion into new products and destinations.

[9] We are not aware of any direct evidence of the impact of foreign tariffs on Chinese productivity but Brandt et al (2012) find that firm-level TFP growth in manufacturing between 2001-2007 is about three times higher than prior to WTO accession, 1998-2001. Moreover, the TFP growth in the WTO period is higher for larger firms, which is consistent with our model's prediction that those are the most likely to upgrade.

The second theoretical contribution is to examine TPU in a two-country general equilibrium context. In particular, we allow for export entry and upgrading to affect the importers's price index. This is motivated both by the sizeable increase in Chinese import penetration and our objective of examining its welfare impacts. We show that the general equilibrium price effects dampen the direct effect of TPU on entry and upgrading but do not eliminate it. Briefly, a TPU reduction generates an incentive to enter and upgrade but this then leads to a reduction in the price index (due to love of variety and lower costs respectively), which dampens the initial incentive. This price reduction is central in generating welfare gains from reforms that lower TPU in our model.

The model allows us to aggregate firm decisions to generate a tractable TPU-augmented gravity equation at the industry level. The model consistent TPU measure captures the proportion of profits lost that Chinese exporters expected before WTO accession if China ever lost its MFN status. Importantly, this pre-WTO uncertainty measure can be calculated by using observable MFN and column 2 tariffs. We then provide evidence that Chinese export growth in 2000-2005 was higher in those industries with higher initial uncertainty measure. Our identification approach is robust to industry specific unobserved heterogeneity, sector specific growth trends and addresses potential non-linear effects via non-linear and semi-parametric estimation. We also control for a variety of changes in applied trade barriers, including tariffs and non-tariff barriers and transport costs.

We combine the policy and trade cost data with HS-6 export flows to estimate the model's parameters and calculate the implied general equilibrium price effects. We find the uncertainty reduction lead to as much as a 32 log point increase in Chinese exports to the U.S. in 2000-2005. The uncertainty reduction explains up to 1/3 of the observed export growth in that period and translates into an *applied* tariff equivalent of up to 8.5 percentage points. Moreover, we provide a decomposition of the uncertainty effect and find that about 40% of it can be explained by a mean preserving tariff risk reduction, and the rest is due to locking in the applied MFN tariff below the long-run mean. Using a semi-parametric approach we fail to reject the non-linear form of the TPU measure generated by the model, but we do reject the model fit that uses a linear measure of column 2 tariffs. These tests suggest that we should not rely on linear measures of column 2 tariffs but rather our theory consistent measure of TPU, particularly when making quantitative predictions.

We also compute the counterfactual increase in the price index if China had lost its MFN status and find it is about 2% percent, which translates into a similarly valued reduction in real income for consumers that spend most income on differentiated goods. This places an upper bound on the potential cost of TPU in this model. We also show that the potential welfare cost of TPU for consumers can be decomposed into two effects and we can estimate one of them, which we refer to as a *within state* effect. This effect captures how uncertainty increases the price index due to lower entry and upgrading even when the policy state has not yet changed and we find it was as high as 0.8 percent of welfare. By comparison, Broda and Weinstein (2006) estimate that the U.S. welfare gain from new varieties imported from all its partners is about 0.8 percent in the period of 1990-2001. Costinot and Rodríguez-Clare (Forthcoming) calculate that a worldwide tariff war would lower North American welfare by 0.7 percent. These welfare effects from deterministic trade models suggest that the estimated welfare impact of TPU is not negligible.

The structure of the model also permits us to estimate that the TPU reduction lead to a significant growth in Chinese varieties exported to the U.S. We also find supporting evidence for this entry channel by exploring additional data, namely changes in the number of traded HS-10 varieties within each industry. We find that the impact of uncertainty on variety growth using this data is 64 log points, which is equivalent to the impact of a 17 percentage point reduction in applied tariffs. The effect of TPU on entry is larger than on exports as predicted by the model.

As noted above we contribute to the recent literature on TPU by extending the partial equilibrium approach in HL to a setting with price effects and technology upgrading. Handley (2012) shows that reducing binding tariff commitments, a measure of the worst case tariffs, would increase entry of foreign products in Australia. Limão and Maggi (2013) endogenize policy uncertainty and provide conditions such that there is an uncertainty reducing motive for trade agreements in a standard general equilibrium model and derive a sufficient statistic for evaluating their welfare gains. By modelling and estimating the impact of TPU and providing evidence of its general equilibrium impacts we also contribute to the large and growing literature on the impact of Chinese import competition on wages and employment in the European Union (cf. Bloom et al, 2012) and the U.S. (cf. Pierce and Schott, 2012).[10]

The paper is structured as follows. The following section presents the theory, starting with partial equilibrium firm decisions to export and upgrade technology and then extending this to incorporate general equilibrium effects. Section 3 describes the empirical approach and data and provides the estimates and quantification. We summarize the main results and implications in section 4. The theory and data appendices contain details related to the derivations, data and estimation.

2 Theory

We first present the basic building blocks of the partial equilibrium version of the model and use it to analyze firm export entry and technology upgrading decisions. In section 2.4 we provide the remaining elements required for the general equilibrium model, which we use to re-examine the entry and upgrading decisions and to derive new results on the price index and consumer welfare. The notation is defined in the text but we also provide a reference table in the last page.

[10] The latter study appeals to the theoretical TPU mechanism in Handley and Limão (2012) to use U.S. column 2 tariffs as a reduced form determinant of the impact of Chinese imports on U.S. manufacturing employment. However, in HL there is no aggregate impact of TPU on the importer (the European Community) because the exporter is assumed to be small (Portugal). In contrast, the model and evidence in our current paper does include an impact of TPU on the importer via the price index and thus a channel via which the reduced form approach of Pierce and Schott (2012) can be justified.

2.1 Demand, Supply and Pricing

The utility function, $Q^{\mu} q_0^{1-\mu}$, is identical across consumers in all countries. It is defined over the numeraire good, 0, which is homogenous and freely traded and has expenditure share $1-\mu$, and a subutility index, $Q = \left[\int_{v\in\Omega} q_v^{\rho} dv\right]^{1/\rho}$. In this CES aggregator there is a continuum of differentiated varieties, v, from the set Ω of available goods with an elasticity of substitution, $\sigma = 1/(1-\rho) > 1$. Total expenditure on the differentiated goods in a country is denoted by E and consumers face prices p_v so the aggregate demand for each variety is standard and given by

$$q_v = \frac{E}{P}\left(\frac{p_v}{P}\right)^{-\sigma} \tag{1}$$

where $P = \left[\int_{v\in\Omega} (p_v)^{1-\sigma} dv\right]^{1/(1-\sigma)}$ is the country's price index for the differentiated goods. While income, the price index and individual prices are specific to an importer country we dispense with importer subscripts below. The consumer price for each variety, p_v, includes any existing trade costs. In the theory we focus on advalorem import tariffs, which are generally product or industry specific, so we denote the tariff factor that an importer sets on the group of varieties V by $\tau_V \geq 1$, so free trade is represented by $\tau_V = 1$. We will refer to different V as industries.[11] Therefore, producers of any variety v of product V receive p_v/τ_V.

We first determine the optimal price and operating profits for each monopolistically competitive firm conditional on supplying a market. For firms with a given technology, the marginal production cost parameter, c_v, is constant and heterogenous across firms. Given a wage, w_e, in the exporting country e, the firms' production marginal cost is then $w_e c_v$. Firms must also incur an advalorem export cost, which for now we assume is industry specific and denoted by d_V. This cost can include transport charges *and* other costs associated with producing and supplying goods for a foreign market as we discuss in detail in section 2.3. In a deterministic setting the firm simply chooses prices (or quantities) to maximize operating profits in each period to each export market, $\pi_v = (p_v/\tau_V - w_e c_v d_V)\, q_v$, leading to the standard mark-up rule over cost, $\tilde{p}_v = w_e c_v d_V/\rho$. The consumer faces this price augmented by any import tariff on that product: $p_v = (w_e c_v d_V/\rho)\, \tau_V$.

Firms make all *production* and *pricing* decisions after the policy and thus demand is known, so only their entry and upgrading investment decisions are made under uncertainty. Substituting the demand function and markup rule into the definition of operating profits we obtain

$$\pi_v = (\tau_V)^{-\sigma} c_v^{1-\sigma} d_V^{1-\sigma} A \tag{2}$$

where $A \equiv (1-\rho)\, E\, (w_e/P\rho)^{1-\sigma}$, summarizes aggregate conditions, e.g. domestic wage, w_e, and demand in a foreign market, which the firms take as given. In section 2.4 we place additional structure on the model and examine how uncertainty can affect A. In particular we will be interested in the effects via the price index, P. To isolate this we pin down the wage by assuming the homogenous good is always produced in each

[11] To map this directly to the subutility index for differentiated goods we can simply partition Ω into V sets and require identical elasticity of substitution across and within them to obtain $Q = \left[\sum_V \int_{v\in\Omega_V} q_v^{\rho} dv\right]^{1/\rho}$.

country and uses only labor so the wage is simply the marginal product in that sector, which we normalize to unity. Moreover, consumers of the differentiated good are workers who will have no other source of income and thus expenditure on the differentiated sector is E is simply a fraction μ of the constant labor income.[12]

2.2 Policy Uncertainty and Firm Entry

Our focus is on firm decisions related to the export market. Thus, we take the mass of domestic differentiated good firms as given.[13] First, we consider the decision of a domestic producer to enter an export market. In the following section we include the possibility of investments in technology upgrading. In order to enter a new market a firm must incur a sunk cost, K_V.[14] A firm with production cost parameter c_v obtains operating profits from exporting equal to $\pi(a_{sV}, c_v) = a_{sV} c_v^{1-\sigma}$ where $a_{sV} \equiv A{\tau_{sV}}^{-\sigma} d_V^{1-\sigma}$ represents the conditions each firm in an industry V faces in the export destination under state s. Export costs unrelated to tariff policy do not depend on the tariff state. Also, since A captures aggregate conditions it has no industry subscript. We *initially* examine the decision of entry by firms in a "small" industry (e.g. a given HS-6 category, of which there are more than 5000) or in a set of industries that are "small". By this we mean that changes to policy in that industry V (or set of industries) has a negligible impact on the aggregate variables and so on A. In section 2.4 we consider the effects of policy shocks that affect a large enough set of firms such that their export decisions affect aggregate conditions. In the absence of aggregate effects, a firm in an industry V is also not affected by policy in other (small) industries. This allows us to consider the impact of policy changes industry by industry and to identify s for a given industry with the policy state for that industry.

Below we omit the industry subscript V to simplify the notation. There is a continuum of firms in each industry and they differ only according to their cost. Therefore all firms with cost at or below a threshold, c_s, will enter the export market in state s. We determine that threshold first in the absence of uncertainty, as a benchmark, and then when there is uncertainty about the future state of market conditions, a_s.

If market conditions are at state s and are not expected to change then the deterministic cutoff for entering a new export market, c_s^D, is defined by

$$\pi\left(a_s, c_s^D\right)/\left(1-\beta\right) = K \Leftrightarrow c_s^D = \left[\frac{a_s}{\left(1-\beta\right)K}\right]^{\frac{1}{\sigma-1}} \text{ for each } s \tag{3}$$

where operating profits are discounted by β, the probability that the firm will survive (there is no pure time discounting).[15]

[12] As we will discuss in section 2.4, this requires that workers do not receive any policy revenue rebates or profits, which will go to entrepreneurs that own blueprints for each variety.

[13] A simple way to rationalize this is the existence of a mass N of entrepreneurs that is constant each period. Each has one unit of specific capital (a blueprint for a variety with a production technology with marginal cost c_v). If there are no entry costs into the domestic market then there are always N varieties in the domestic market.

[14] There is evidence that these can be large. We do not take a strong stand on this, other than to assume that there are some fixed costs to export and that they are at least partially irreversible. We will return to this point later.

[15] Given the absence of fixed costs of exporting per period, the firm will continue to export until it is exogenously hit by a

When there is uncertainty about future conditions the firm will have to decide whether to invest today to enter the market or wait until conditions improve. At s a firm will be just indifferent if it has cost c_s^U , which is implicitly defined by the equality of the expected value of exporting, Π_e, given the current state net of the sunk cost and the expected value of waiting, Π_w.

$$\Pi_e(a_s, c_s^U) - K = \Pi_w(a_s, c_s^U) \text{ for each } s \tag{4}$$

Any firm in this industry with $c \leq c_s^U$ will export.[16]

To determine the value functions and find the cutoffs we model the policy as a Markov process. It is represented by a transition matrix M, where a general entry $t_{ss'}$ denotes the transition probability from state s to s'. To maintain tractability and provide sharper results we impose some structure on this process that captures key features of the empirical application we subsequently explore: the U.S. policy towards China. Namely, starting in 1980 China was granted temporary MFN status by the U.S., which we denote by $s = m$. Thus, until 2001 a Chinese exporter in an industry V faced a tariff τ_{mV} but believed that the MFN status could be revoked in which case the U.S. would transition to a state $s = 2$ where it charged the much higher column 2 tariff, $\tau_{2V} > \tau_{mV}$. We denote the probability of this transition by t_{m2}. During the last part of that period, late 1990's and until 2001, China was negotiating entry into the WTO. We model this via a probability, t_{m0}, of transition from the temporary MFN status to entry into the WTO, which we denote $s = 0$. The latter state is characterized by a tariff $\tau_0 \leq \tau_m$ and a probability of column 2 that is lower than before ($t_{02} \leq t_{m2}$) or maybe even negligible ($t_{02} \to 0$). It is also reasonable to assume that if China faced column 2 tariffs then it would be less likely to transition to the WTO state directly than would be the case if it were in a negotiation/MFN stage, i.e. $t_{20} \leq t_{m0}$, and in fact it would be extremely unlikely to go *directly* to that state from column 2 (so $t_{20} \to 0$).

In sum, we think that a reasonable characterization for this policy process requires:

1. 3 possible policy states: $s = 2, m, 0$, associated with column 2, temporary MFN and WTO policies where $\tau_{2V} > \tau_{mV} \geq \tau_{0V}$ for each V.

2. The transition to either extreme state to be more likely if it occurs from the MFN state than from the other extreme, i.e. $t_{m2} \geq t_{02}$ and $t_{m0} \geq t_{20}$.

In order to simplify the analysis we take the extreme case where $t_{02} = t_{20} = 0$. The period profit ordering across states for any exporting firm in a given industry V is therefore $\pi_{2V} < \pi_{mV} \leq \pi_{0V}$. Then the *expected*

death shock.

[16] Note that if conditions were better in the past, i.e. if $c_{st}^U < \min_{T<t}\{c_{sT}^U\}$, then there are some firms that previously entered and have costs above the current cutoff. These legacy firms will still be in the market unless they have already been hit by an exogenous death shock. For now this has no consequence for our determination of c_s^U because changes in the number of firms in the market in any given (small) industry has no effect on aggregate conditions. But this will play a role when we consider general equilibrium effects.

value of exporting, denoted by Π_e, can be written as

$$\Pi_e(a_s, c) = \pi(a_s, c) + \beta \textstyle\sum_{s'} t_{ss'} \Pi_e(a_{s'}, c) \quad \text{each } s \tag{5}$$

The key point to note is that if a firm is exporting at s and the policy persists into the next period then it faces the exact same policy *and* aggregate conditions (which we will show is not necessarily the case when we allow for general equilibrium effects). The expected value of exporting next period will equal the current value. For any given firm we have a linear system of three equations (one for each state) that can be solved for each $\Pi_e(a_s, c)$. Recalling our simplification that $t_{02} = t_{20} = 0$ it is simple to solve for $s \neq m$

$$\Pi_e(a_s, c) = \frac{\pi(a_s, c) + \beta t_{sm} \Pi_e(a_m, c)}{1 - \beta t_{ss}} \quad \text{each } s \neq m \tag{6}$$

Using (5), (6) and simplifying we obtain the following for $s = m$

$$\Pi_e(a_m, c) = \frac{\pi(a_m, c)}{1 - \beta t_m} + \frac{\beta}{1 - \beta t_m} \textstyle\sum_{s \neq m} t_{ms} \frac{\pi(a_s, c)}{1 - \beta t_{ss}} \tag{7}$$

where $t_m \equiv t_{mm} + \beta \left[t_{m0} \frac{t_{0m}}{1-\beta t_{00}} + t_{m2} \frac{t_{2m}}{1-\beta t_{22}} \right]$ reflects the probability that given a current state $s = m$ this state will be revisited the following period, t_{mm}, or in future periods if the firm survives (with probability β) and the policy goes to a different state, e.g. column 2 (with probability t_{m2}) and then returns to m (with probability $\frac{t_{2m}}{1-\beta t_{22}}$).

If $s = 0$ then conditions can't improve further so the *expected* value of waiting is zero for any firm with cost at or above the entry cutoff in this state, which is thus implicitly given by

$$\frac{\pi(a_0, c_0^U) + \beta t_{0m} \Pi_e(a_m, c_0^U)}{1 - \beta t_{00}} = K$$

Any firm with $c > c_0^U$ will not enter at $s = 0$. Moreover, as we would expect and will confirm, the cost cutoff under the agreement is the highest and the one under column 2 the lowest, i.e. $c_0^U > c_m^U > c_2^U$. So any firm with $c > c_0^U$ will also not enter in any other (worse) state. Note also that in the limit, if the agreement almost eliminates the possibility of returning to temporary MFN status (e.g. if exit from WTO is not expected) then $t_{0m} \to 0$ and $c_0^U = c_0^D = [a_0/(1-\beta)K]^{1/(\sigma-1)}$.

We now find the values of waiting evaluated at the cutoff for each of the other two states. The expected value of waiting for a firm at the worst state is

$$\Pi_w(a_2, c) = 0 + \beta \left[t_{22} \Pi_w(a_2, c) + t_{2m} \left[\Pi_e(a_m, c) - K \right] \right] \quad \text{if } c \in [c_2^U, c_m^U] \tag{8}$$

If it does not enter today it obtains zero profits and if it survives and nothing changes (which occurs with probability t_{22}) then it has the same expected value of waiting. Otherwise it faces a lower tariff, with probability t_{2m}, then it enters, provided that its cost is sufficiently low, i.e. $c \in [c_2^U, c_m^U]$. We do not consider transitions to state 0 since we assume $t_{20} = 0$. We solve this expected value of waiting and replace in (4), which yields the cutoff for entry at column 2

$$\frac{\pi(a_2, c) + \beta t_{2m}\Pi_e(a_m, c_2^U)}{1 - \beta t_{22}} - K = \frac{\beta t_{2m}\left[\Pi_e(a_m, c_2^U) - K\right]}{1 - \beta t_{22}} \Leftrightarrow \frac{\pi(a_2, c_2^U)}{1 - \beta} = K \tag{9}$$

where we used $t_{2m} = 1 - t_{22}$. We see the cutoff is implicitly given by the equality of K and the present discounted value of profits *as if* the firm always expected to face a_2, therefore $c_2^U = c_2^D$. While firms are aware that conditions may improve that does not lead them to be more willing to enter than if conditions did not improve because they can simply wait and enter when conditions do change.

Finally, the value of waiting at $s = m$ is

$$\Pi_w(a_m, c) = 0 + \beta\left[t_{mm}\Pi_w(a_m, c) + t_{m2}\Pi_w(a_2, c) + t_{m0}\left[\Pi_e(a_0, c) - K\right]\right] \text{ if } c \in [c_m^U, c_0^U] \tag{10}$$

A firm that decides to wait and not enter at MFN returns to the same situation if conditions do not change, $\Pi_w(a_m, c)$. If conditions worsen, it will continue to wait but at a higher tariff, $\Pi_w(a_2, c)$. Otherwise, if conditions improve and its cost is at or below the threshold at that point then it will enter.

We can provide a simple interpretation of the value of waiting by simplifying (10) using (8) and (6) evaluated at the threshold for entry at MFN along with (4) (see appendix A.1 for derivation)

$$\Pi_w(a_m, c_m^U) = \frac{\beta t_{m0}}{1 - \beta\left(t_{mm} + t_{m2}\frac{\beta t_{2m}}{1 - \beta t_{22}}\right)}\left[\frac{\pi(a_0, c_m^U) + \beta t_{0m}\Pi_e(a_m, c_m^U)}{1 - \beta t_{00}} - K\right] \tag{11}$$

If the firm survives there is some probability that in the following period or a subsequent one the firm will transition from MFN to $s = 0$, pay the sunk cost and obtain the expected value of exporting.

Plugging in the value of export in (7) and the value of waiting in (11) into the indifference condition in (4) we can solve for the cutoff c_m^U. After some simplification (in appendix section A.1) we obtain an expression for the cutoff that allows us to compare it directly to its deterministic counterpart

$$c_m^U = c_m^D U_m < c_m^D \tag{12}$$

where U_m reflects the effect of uncertainty in lowering the entry cost cutoff and is equal to

$$U_m = \left[\frac{1 - \beta}{1 - \beta\tilde{t}}\left(1 + \frac{\beta t_{m2}}{1 - \beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right]^{\frac{1}{\sigma - 1}} \tag{13}$$

The term $\tilde{t} \equiv t_{mm} + t_{m0} + t_{m2}\frac{\beta t_{2m}}{1 - \beta t_{22}}$ captures the probability that a firm enters in the future, either because it remains in MFN, moves to a better state, or moves to a worse state (t_{m2}) but eventually returns to MFN ($\frac{\beta t_{2m}}{1 - \beta t_{22}}$). In appendix A.1 we show that $U_m < 1$ whenever $\tau_2 > \tau_m$ since the latter implies a reduction in profits of moving from τ_m to the higher tariff, τ_2. If firms believe conditions could improve, $t_{m0} > 0$, but there is no probability of a column 2 tariff , $t_{m2} = 0$, then we find the cutoff reaches its deterministic level, $c_m^U = c_m^D$, because $\tilde{t} = t_{mm} + t_{m0} = 1$. The result is analogous to what we found for the worst case cutoff scenario. The potential for good news is not relevant for the marginal entrant. In terms of the estimation, it implies that we can nest the possibility that firms believed that $t_{m2} = 0$ in our estimation.

In order to ask what the cutoff would have been in a world with more policy uncertainty when $s = m$, we parameterize policy persistence by γ and let $t_{mm} = 1 - \gamma$, $t_{m2} = \gamma p_2$, and $t_{m0} = \gamma(1 - p_2)$. An increase in γ lowers policy persistence in the MFN state. This increases uncertainty of remaining in that state, making it more likely that policy will go to *either* the worst *or* best case scenario. As we show in appendix A.1, the semi-elasticity of the cutoff with respect to γ is negative for all γ, indicating that increased uncertainty generates less entry.

$$\frac{d \ln c_m^U}{d\gamma} = \frac{d \ln U_m}{d\gamma} < 0$$

We also show that

$$\frac{d \ln U_m}{d\gamma}|_{\gamma=0} = \frac{\beta p_2}{(\sigma - 1)(1 - \beta t_{22})} \left(\left(\frac{\tau_2}{\tau_m} \right)^{-\sigma} - 1 \right) < 0 \tag{14}$$

We will examine the impact of entering into the WTO as a change from state m to state 0. Therefore it is useful to note the ordering of the cutoffs we derived

$$c_2^U = c_2^D < c_m^U < c_m^D \leq c_0^D = c_0^U \tag{15}$$

We show this in detail in appendix A.1 but the ordering is reasonable: under uncertainty at the worst state, we have the lowest cost cutoff, c_2^U, so only the most efficient firms enter, under temporary MFN some additional firms enter and under a secure agreement (i.e. if no exit is anticipated) an even larger set of firms enters. The inequality $c_m^D \leq c_0^D$ is strict if $\tau_0 < \tau_m$ and the last equality assumes that the agreement state is an absorbing one ($t_{00} = 1$, so there is no uncertainty after it is entered).[17]

We now relate changes in γ to mean preserving changes in the policy, i.e. to changes in pure *risk*. If the current tariff is τ_m and an agreement eliminates uncertainty such that $\gamma = 0$ and $t_{mm} = 1$ then this corresponds to a pure policy risk reduction if τ_m is at the long-run mean.[18] In this case the entry caused by the agreement is fully explained by a risk reduction. If instead τ_m was below the mean, for example following earlier episodes of trade liberalization that were not fully credible, then an agreement that eliminates uncertainty will increase entry through both reductions in policy risk and its long run mean. We quantify the contributions of each of these components in the empirical section.

One final note on the importance of sunk costs for the results above. As long as there is some sunk cost, however small, the cutoff expressions, their ordering, and their elasticity with respect to applied policy and

[17] We can also show that $c_m^U \leq c_0^U$ even if $t_{0m} = 1$ (i.e. if a country exits the agreement after 1 period) and $\tau_0 = \tau_m$, simply because during the agreement period there is a zero probability of column 2.

[18] It is straightforward to show that in this three state process the middle one has a policy τ_m equal to the long-run mean then a decrease in γ induces a mean preserving compression of the initial conditional policy distribution, $F(\tau_{t+1}|\tau_t = \tau_m, \gamma)$.

future policy remain unchanged. We can clearly see this since c_s^U is log separable in U_s, which is independent of K.[19] If there are no sunk costs, but the firm instead faces a per-period fixed cost, then the entry problem is simpler. Each period it exports if it has cost below a cutoff given by the equality of operating profit and the period fixed cost. In this case, policy uncertainty has no impact on entry decisions, since they are made after uncertainty about the relevant payoff (today's) is resolved. Even if small shipments to specific foreign buyers may take place by incurring a small period fixed cost, we would argue that sustaining mass exporting requires large sunk cost investments. Therefore we now extend the model to show how changes in policy uncertainty can lead firms to upgrade their export technology and thus affect the intensive margin of exports.

2.3 Policy Uncertainty and Firm Technology Upgrade

The impact of trade reforms on within-firm productivity is one of general interest but has ignored the role of TPU. Therefore, we now model technology upgrade investments as a simple channel through which changes in policy uncertainty can generate new exports by incumbent firms. This upgrading channel of uncertainty may also be potentially important since new firms tend to be small so the entry channel may be insufficient to explain the magnitude of export growth from China.

For tractability we focus on firms' upgrading decisions to serve the export market. The model can be extended to also allow for upgrading technology for the domestic market. More specifically, a firm can pay a sunk cost to adopt a lower marginal export cost technology. A simple way to illustrate the main points is to focus on technology upgrades that are export market specific. We assume that if the firm has already paid the initial export entry cost, K, it can then decide to incur an additional K_z to lower its marginal export cost by a fraction $z < 1$ of the original industry baseline value, d, which we recall is the variable trade cost component that is unrelated to tariffs.[20] Its period profits can therefore be written as $\pi\left(a_s, zc_{sz}\right) = a_s\left(zc_{sz}\right)^{1-\sigma} = A\tau_s{}^{-\sigma}d^{1-\sigma}\left(zc_{sz}\right)^{1-\sigma}$. So $z^{1-\sigma}-1$ is the growth in period operating profits due to the upgrade. Thus, if policy is deterministic, a firm with export cost d will be indifferent between upgrading or not if its marginal cost of production is c_{sz}^D, which is defined by $\pi\left(a_s, zc_{sz}^D\right) - \pi\left(a_s, c_{sz}^D\right) = K_z\left(1-\beta\right)$

$$c_{sz}^D = \left[\frac{a_s\left(z^{1-\sigma}-1\right)}{K_z\left(1-\beta\right)}\right]^{\frac{1}{\sigma-1}} \tag{16}$$

Depending on the upgrade technology parameters we could have equilibria where the upgrading is done

[19] The elasticity of the number of firms with respect to policy is also independent of K under standard distributions such as Pareto, which we use later. In such cases variation in K would not provide useful variation in identifying the entry elasticity across industries for example.

[20] An interpretation of this advalorem export cost is that it represents some portion of the freight, insurance, labelling or meeting a product standard that is export specific and the firm can invest in a lower marginal cost technology to achieve these. To be more specific, we can think of different types of export entry. One alternative is for the firm to post a small advertisement or make a personal contact with a buyer at a fair and then ship some of the good directly to the buyer (so low fixed cost and high marginal cost of exporting). Another alternative is to pay a larger fixed (sunk) cost to establish a distribution network, have a marketing campaign, go through standard verification processes, etc, and then mass ship its products every period through a distributor that has lower marginal costs. Another interpretation is that a firm has a plant that produces only for exporting and it invests in production technology that is specific to that plant.

by all, none, or only a fraction of exporters. We focus on the latter case, which we find is the most interesting. This is also likely to be an empirically relevant case since it implies that only the most productive exporters upgrade, given that we assume there is a fixed cost so the most productive can spread it over more units. This also implies that the marginal entrant into exporting will not upgrade and therefore the entry cutoff, c_s^D, is still the one given by (3). Using this we can see that the upgrade cutoff is proportional to the entry cutoff, namely

$$c_{sz}^D = \phi c_s^D \tag{17}$$

where the *upgrading parameter* ϕ is given by

$$\phi \equiv \left[\left(z^{1-\sigma} - 1 \right) \frac{K}{K_z} \right]^{\frac{1}{\sigma-1}} < 1 \tag{18}$$

In sum, assuming that only a fraction of exporters upgrade then the entry cutoff is unchanged and higher than the upgrade cutoff. This is assured by the restriction that $\phi < 1$, i.e. that the marginal cost reduction is sufficiently high relative to the fixed costs. Note that ϕ is independent of the policy and therefore so is the *ratio* of cutoffs.[21] This simple extension magnifies the impact of policy since even small tariff reductions can generate large changes in exports due to upgrading from incumbent exporters. More importantly, and differently from others who examine the impact of *applied* policies on upgrading (cf. Bustos, 2011), we will now see how policy *uncertainty* can affect exports for continuing exporters via upgrading.

We now determine the cutoffs under uncertainty when upgrading is possible. We will show that when only a fraction of exporters in each state upgrade then the ratio of the upgrade to the entry cutoff is ϕ, which is the same ratio found for the deterministic case. This implies that the elasticity of the upgrade and entry cutoffs with respect to policy and its uncertainty are the same—a result we will use in the aggregation and estimation. To simplify the exposition we focus on determining the upgrade cutoffs. Given the similarities with the entry decision we will simply point out how we must modify the setup to incorporate upgrading, state the results in the text and prove them in appendix A.2.

We continue to assume that in any given state only a fraction of exporters upgrade so the marginal entrant in state s would not consider upgrading in *that* state. Moreover, if ϕ is sufficiently low then even the most productive marginal entrant would never upgrade, i.e. even a firm that is indifferent about entering under the worst policy state would never upgrade when conditions improved. For ease of exposition we focus on the latter case since it allows us to use the entry cutoffs derived in the previous section.[22]

At a given state s a firm will be just indifferent between upgrading if it has cost c_{sz}^U , which is implicitly defined by the equality of the expected value of exporting using the upgraded technology net of the sunk

[21] In the empirical work we will allow it to vary across industries.

[22] This requires $c_{0z}^U(\phi) < c_2^U$, where c_2^U is the entry cutoff under column 2 tariffs previously derived and $c_{0z}^U(\phi)$ is the upgrade cutoff under the best case (agreement) scenario that we derive below. In the appendix we provide the threshold value of ϕ below which this holds in terms of parameters. The reason why under this condition the original entry cutoffs are the relevant ones is simple: if the marginal entrants will never upgrade then their value of entry and waiting are not affected by the *possibility* of upgrading that is only done by others.

cost and the expected value of waiting while using the old technology.

$$\Pi_{ez}(a_s, zc^U_{sz}) - K_z = \Pi_{wz}(a_s, c^U_{sz}, z) \text{ for each } s \tag{19}$$

The upgrade factor z multiplies the cost in the expression of operating profits for each period after upgrading. Since z is state independent it is straightforward to show that the expected value of exporting under the new technology is given by the same general expression derived in (5), but replacing the marginal cost c with zc. This means that the value of exporting under upgrading is simply

$$\Pi_{ez}(a_s, zc_{sz}) = z^{1-\sigma}\Pi_e(a_s, c_{sz}) \text{ for each } s \tag{20}$$

The value of waiting will also reflect the upgrade possibility but now must explicitly account for the profits before upgrading. Thus we write the value of waiting with z as a separate parameter—to clarify the difference in functional form relative to the initial formulation. To illustrate the difference consider the value of waiting at the MFN state

$$\Pi_{wz}(a_m, c, z) = \pi(a_m, c) + \beta\left[t_{mm}\Pi_{wz}(a_m, c, z) + t_{m2}\Pi_{wz}(a_2, c, z) + t_{m0}\left[\Pi_{ez}(a_0, zc) - K_z\right]\right] \text{ if } c \in [c^U_{mz}, c^U_{0z}] \tag{21}$$

The key differences relative to the value of waiting for entry in (10) are that now a firm that has not upgraded makes positive export profit $\pi(a_m, c)$ today. Moreover, in the following period the firm either transitions to the same state or to column 2 tariffs, in which case it still waits and thus uses the initial technology, or transitions to the agreement state, where it will upgrade.

In the appendix we derive $\Pi_{wz}(a_2, c, z)$ and use that along with (20) in (21) to solve for $\Pi_{wz}(a_m, c, z)$. We then use this and (20) along with the indifference condition in (19) to obtain the upgrade cutoff under MFN.

$$c^U_{mz} = c^D_{mz} U_m \tag{22}$$

where c^D_{mz} is the deterministic cutoff in (16) and $U_m < 1$ is the same uncertainty factor we previously derived for entry in (13). Therefore we can write this in terms of the entry cutoff under uncertainty

$$c^U_{mz} = c^D_{mz} U_m = \phi c^D_m U_m = \phi c^U_m$$

This implies that the *elasticity* of either cutoff with respect to policy uncertainty factors in U_m is similar. Entry into the agreement now has the additional effect of leading firms with $c \in (c^U_{mz}, c^U_{0z}]$ to upgrade. Therefore, reductions in uncertainty also increase exports by existing exporters that are sufficiently productive.

We illustrate the cutoffs under uncertainty and the deterministic case in Figure 2.[23]

In the appendix we show that the relationship between the cutoffs in other states are similar, i.e. $c_{sz}^{U} = c_{sz}^{D} U_s$ for all s but, as seen before $U_2 = 1$ and, when $t_{00} \to 1$ we also have $U_0 \to 1$. So the ordering of cutoffs for upgrading across different states is the same as the ordering for entry in (15).

2.4 Policy Uncertainty and Aggregate Effects

Thus far we focused on a situation where the impact of export entry and upgrading is too small to affect domestic aggregate variables. We now relax this assumption and examine the impact of policy uncertainty on consumer welfare via the price index. We will focus the exposition on the entry decisions and at the end of the section argue that the upgrade cutoffs are proportional to the entry ones, by the constant factor ϕ, which we show in the Appendix.

2.4.1 Setup

Recent work on China's export boom focuses on its costs for the U.S.; we will instead focus on the potential benefits for consumers. More specifically, we examine the impact of reducing policy uncertainty on the price index, which requires some additional structure to tackle two new issues. First, tariff changes in industry V now have cross-industry effects through the price index. Therefore a potential exporter must form expectations not only about the tariff in its industry but also all others since these will affect the price index. Thus we must take a stand on the correlation of tariff shocks. We continue to focus on a Markov transition matrix similar to what we had before, M, but now assume that the transition applies to the full vector of tariffs, τ_s, which is common knowledge. In terms of our empirical application this implies that Chinese exporters expect that if China obtains permanent MFN (or loses it) this change will affect all of China's tariffs.

Second, we must address the transition dynamics that affect aggregate variables. More specifically, we account for the fact that after a bad shock there is exit that occurs over time and thus the price index will also adjust over time as varieties die and are not replaced if their cost is above the cutoff. The adjustment will occur even in periods where no other policy shock occurs, as long as there are some firms still above the cutoff, which are exiting. Therefore the economic conditions variable will in general have to be written as $a_{st} = (\tau_s)^{-\sigma} d^{1-\sigma} A_{st}$, which indicates the dependence on the policy state s directly via the tariff for that industry, and indirectly through the policy impacts on A_{st}.

The aggregate variable A_{st} depends on the exporting country's wage, the importer country's aggregate expenditure on differentiated goods, E_{st}, and its price index P_{st}. Recall that the numeraire is freely traded

[23] If the productivity distribution is unbounded then some firms will have upgraded in any state and so the new upgraders are exporters with intermediate productivity levels. If the distribution were bounded then it is possible that upgrading only takes place at the best state and by the most productive exporters.

and produced under a constant marginal product of labor equal to unity and the population is sufficiently large for it to always be produced in equilibrium so the wage is unity. To focus on the price effects and maintain tractability we construct the model to have constant E_{st} by making the following assumptions:

A1 There is no borrowing technology available across periods so current expenditures must equal current income each period for each individual.

A2 All individuals have similar labor endowments each period, equal to k_L. We assume there are two types of agents: entrepreneurs and workers. A fraction of individuals are entrepreneurs with constant mass N. Entrepreneurs are endowed with a blueprint for a variety, embodied in the marginal cost parameter c_v. They receive any quasi-rents from that blueprint, i.e. the profits of variety v. Any import policy revenue is rebated lump-sum to the entrepreneurs. Given this, the only source of income for the other set of individuals, the workers, is the wage.

A3 Individual utility in each period exhibits a constant expenditure share, with a fraction on the differentiated sector that is $\mu > 0$ for workers and zero for entrepreneurs.

Since A1,A2 and A3 along with the constant equilibrium wage and worker population imply E is constant in all periods we can focus on the impact of uncertainty on the price index. The preference structure in A3 is also useful in directly mapping the firm problem we previously derived to the one solved by the entrepreneur. Assuming the entrepreneurs survive each period with probability β and are income risk neutral, their decision to use K_V units of labor (or equivalently the numeraire) to start exporting depends exactly on whether the expected value of doing so net of the entry cost exceeds the value of waiting, as previously given by (4).[24]

The final simplifying assumption is that there are only 2 countries. This implies that any additional entry by exporters into a market does not affect the mass of firms from any *other* countries selling in that market since there is a fixed mass of domestic firms that always sells at home because there are no domestic fixed costs.[25]

Given these assumptions the price index is given by this function of the foreign and domestic varieties

$$P_t^{1-\sigma} = \int_{v \in \Omega_t} (p_{vt})^{1-\sigma} \, dv = \int_{v \in \Omega_{t,ch}} (\tau_{Vt} d_V c_v/\rho)^{1-\sigma} \, dv + \int_{v \in \Omega_{us}} (c_v/\rho)^{1-\sigma} \, dv$$

The domestic variety set available at any time, Ω_{us}, is constant due to the fixed mass of domestic firms and no domestic entry costs. Therefore the price index varies over time only because of the country's own import tariffs, reflected in τ_{Vt} and the current set of foreign varieties sold in the U.S. market, denoted by $\Omega_{t,ch}$. The

[24] In making the entry decision the entrepeneurs take any lump-sum tariff rebates as given. One final point is that we rule out the possibility that entrepreneurs are credit constrained by assuming that their endowment $k_L \geq \max\{K_V\}$, so they can always self-finance the sunk cost in a single period even if it exceeds that period's operating profits.

[25] In each period there is a constant mass N_V of entrepreneurs in each industry. Given no entry cost in the domestic market, there are always N_V domestic varieties in each V of the home market. An exogenous fraction $1 - \beta$ of these dies at the end of each period but it is replaced at the start of the next so the mass N_V remains unchanged.

latter set always includes foreign firms with cost below the cutoff but may also include legacy firms that entered when conditions were better in the past but would not enter today. So, whenever $c^U_{Vt} \geq \max\{c^U_{VT}\}$ for each V and all T so that entry conditions in the past were no better than today we can write the price index as a function of the vector of current tariffs and cutoffs $(\tau_t, \mathbf{c}_t)$.

$$P_t(\tau_t, \mathbf{c}_t) = \left[\sum_V N_V \int_0^{c^U_{Vt}} (\tau_{Vt} d_V c/\rho)^{1-\sigma}\, dG_V(c) + \int_{v\in\Omega_{us}} (c_v/\rho)^{1-\sigma}\, dv\right]^{\frac{1}{1-\sigma}} \tag{23}$$

where $G_V(c)$ represents the CDF of costs in industry V. In the presence of legacy firms, the price index will reflect previous cutoffs as we will subsequently discuss.[26]

Given these assumptions the only additional impact of policy uncertainty on firm decisions relative to the previous sections is due to changes in the price index.

2.4.2 Deterministic policy

The deterministic policy entry cutoff is still defined by the expression in (3). However, this is now an implicit solution since P depends on the cutoff for this and all other industries. To gain insight into this effect consider starting in some state s, which is expected to persist indefinitely so the cutoff in any given industry is c^D_s. The associated price index can be written as a function of the state's tariff and cutoff vectors, $P^D_s = P(\tau_s, \mathbf{c}^D_s)$. One important point to note is that even though the countries may be asymmetric, the structure of the model implies that each country's price index depends only on its own policy and the cutoffs that determine which foreign firms sell domestically.

The elasticity of entry with respect to tariffs now requires comparative statics on a system of equations that determine the foreign exporter entry cutoffs in each of the V industries and one equation for the domestic price index. To verify that this system has a unique equilibrium we first make use of the fact that the cutoffs are linear in the price index and in constant parameters. So any industry cutoff can be written as a linear function of some base industry cutoff, c^D_{sb}, and relative parameters, i.e. $c^D_{sV} = c^D_{sb}\kappa_{Vb}$ where $\kappa_{Vb} \equiv \left[\frac{(\tau_{sV}/\tau_{sb})^{-\sigma}}{K_V/K_b}\right]^{\frac{1}{\sigma-1}} \frac{d_V}{d_b}$. Using this we write the reduced form index as $P\left(\tau_s, c^D_{sb}, \mathbf{c}^D_{sV\neq b}\left(c^D_{sb}\kappa_{Vb}\right)\right)$, which is a positive function that is continuous and non-increasing in c^D_{sb} (since $\partial P/\partial c^D_{sV} \leq 0$ for all V , strictly so for small enough c, and $\partial c^D_{sV}/\partial c^D_{sb} = \kappa_{Vb}$ for all $V \neq b$), as illustrated in figure 3.[27] Moreover, the entry schedule for the base industry has positive slope, since $\partial c^D_{sb}/\partial P > 0$ and $c^D_{sb}|_{P\to 0} = 0$. Therefore these two schedules intersect and do so only once as shown in figure 3.

Figure 4 illustrates the impact of an unexpected reform that lowers tariffs in all industries proportionally. We denote proportional changes in a variable by $\hat{x} \equiv d\ln x$ so we are considering $\hat{\tau}_V = \hat{\tau} < 0$ for all V.

[26] The labor market clearing condition closes the model, but it only determines the allocation of labor to the numeraire sector. Since this will not affect the cutoffs and price index we do not include it here.

[27] Continuity holds provided that the distribution of firms in each industry is not bounded above so there is always at least one active exporter.

This implies that the relative cutoffs are unchanged. The entry schedule pivots down since for a given price index some firms in the base industry can now make a profit and enter. The price index schedule pivots down since for any cutoff the consumer prices are now lower. Thus it is clear that P falls. We can also show that the equilibrium operating profits and thus cutoffs for all industries increase as all the tariffs decrease proportionally. The latter result will be a useful benchmark in determining the worst case scenario for an industry when all policies change. To find the impact of a general change in tariffs (where $\hat{\tau}_V$ can vary across industries) we solve the following system

$$\hat{P} = \sum_V \left(\varepsilon_{\tau_V} \hat{\tau}_V + \varepsilon_V \hat{c}_V^D \right) \tag{24}$$

$$\hat{c}_V^D = -\frac{\sigma}{\sigma - 1} \hat{\tau}_V + \hat{P} \quad \text{each } V \tag{25}$$

where $\varepsilon_{\tau_V} \equiv \frac{\partial \ln P\left(\tau, \mathbf{c}^D\right)}{\partial \ln \tau_V}$ and $\varepsilon_V \equiv \frac{\partial \ln P\left(\tau, \mathbf{c}^D\right)}{\partial \ln c_V}$ evaluated at the original tariff values. Replacing the cutoff equation in $\hat{P}$ we obtain

$$\hat{P} = \sum_V \left(\frac{\varepsilon_{\tau_V} - \frac{\sigma}{\sigma-1} \varepsilon_V}{1 - \sum_V \varepsilon_V} \right) \hat{\tau}_V \tag{26}$$

With a specific distribution such as Pareto, we can provide closed form solutions for ε_{τ_V} and ε_V as functions of the model parameters and the share of imported differentiated goods at the initial tariff. So the expression in (26) can provide a useful measure of gains from trade liberalization to workers, who are the sole consumers of the differentiated good. Given the Cobb-Douglas utility the gain from the liberalization is simply $-\mu \hat{P}$, the proportional change in the price index weighted by the differentiated goods' share in expenditure.[28]

Even without a specific productivity distribution we can show that the radial liberalization ($\hat{\tau}_V = \hat{\tau} < 0$) increases the equilibrium cutoffs

$$\hat{c}_V^D|_{\hat{\tau}_V = \hat{\tau}} = \left(\sum_V \varepsilon_{\tau_V} - \frac{\sigma}{\sigma - 1} \right) \frac{\hat{\tau}}{1 - \sum_V \varepsilon_V} > 0$$

where the inequality is due to $\varepsilon_V \leq 0$ and $\sum_V \varepsilon_{\tau_V} < 1 \leq \frac{\sigma}{\sigma-1}$. We have $\sum_V \varepsilon_{\tau_V} \leq 1$ since the highest possible elasticity would occur if all goods (including domestic) were taxed at τ and the elasticity of P with respect to it would then be 1. One implication of this result is that all exporters will have higher profits in market where liberalization left relative tariffs unchanged.

Recall from section 2.2 that the tariff ordering in the setting we consider is $\tau_{2V} > \tau_{mV} \geq \tau_{0V}$ for all V. In the absence of general equilibrium effects this ordering implied foreign exporter profits were lowest at column 2 and highest under the agreement. The result for the cutoff above shows that the same ordering would result if (in a deterministic setting) the tariff reductions from state 2 to m and then to 0 kept τ_{bs}/τ_{Vs} unchanged across states and for all V. We can also obtain the same ordering for each firm when the tariff

[28] To verify this note that the indirect utility is $\tilde{\mu} P^{-\mu}$ where $\tilde{\mu} = w k_L \mu^{\mu} (1 - \mu)^{(1-\mu)}$ is constant since k_L is the period labor endowment and $w = 1$ in the diversified equilibrium.

change in an industry goes in the same direction as all the other industries and either (i) the changes are not too different across industries or (ii) the price index effect is not too large.[29] For exposition purposes we will assume that either because of (i) or (ii) the direct tariff effect across states dominates the indirect one in the deterministic setting, $\pi\left(a_2^D\right) \leq \pi\left(a_m^D\right) \leq \pi\left(a_0^D\right)$, which requires

$$(\tau_{2V})^{-\sigma}\left(P_2^D\right)^{\sigma-1} \leq (\tau_{mV})^{-\sigma}\left(P_m^D\right)^{\sigma-1} \leq (\tau_{0V})^{-\sigma}\left(P_0^D\right)^{\sigma-1} \quad \text{each } V \tag{27}$$

This condition could be violated by a specific industry if its tariff across states are sufficiently close but in general it seems reasonable to assume that for most industries, as own tariffs fall this effect dominates, which implies that new exporters would enter. Moreover, in the empirical section we will provide some evidence that the indirect effect is generally smaller than the direct one.[30]

2.4.3 Unexpected shocks and transition dynamics

To gain some insight into the transition dynamics (which we will require later) consider starting in a situation where the policy has always been at the worst case state, $s = 2$, and is expected to remain unchanged there so the cutoff is c_2^D. If the tariff regime changes unexpectedly to $s = m$ then each industry faces lower tariffs and, as we illustrate in figure 4, the price index falls and the cutoffs increase. Since conditions improved all firms with costs at or below those cutoffs can immediately enter, so the transition occurs in a single period.

Suppose instead that export conditions deteriorate from m to column 2. Now, firms with costs above the cutoff will continue to export (since they face no period fixed cost) until they are hit with a death shock. Therefore we have transition dynamics after conditions worsen. We can see the impact of this most simply in the case of an unanticipated shock, and later we will show how this same effect operates under ongoing policy uncertainty. Recall from previous sections that the *expression* for the cutoff at the worst case scenario under uncertainty is, in equilibrium, identical to the one under the deterministic formulation. We will see that is also the case here and thus we first derive the deterministic cutoffs in the transition period (as opposed to their steady state values already derived above). Suppose that policy is expected to be fixed and starts at $s = m$, as represented by m^D in figure 5. Now consider an unexpected shock that shifts the tariff schedule to τ_2 and ask what the cutoff is. The shock shifts both the entry and price index schedules up as shown in figure 4 so the new steady state will be at 2^{ss}, with lower cutoff and higher P, which simply reverses the experiment in figure 4.

To understand the transition we use T to denote the time period since the negative tariff shock. *If* there was no death shock then after the tariff increase all of the firms would still be exporting and the price index would simply increase due to the direct tariff effect, as indicated by $m^{D'}$ in figure 5. However, given there

[29] Using (26) and the definitions of the elasticity in the appendix we can provide specific conditions for this to hold, such as high enough trade costs.

[30] If the condition above fails for a particular industry then we would have to reorder the states in terms of profitability so that under column 2 some industries would be at their worst state and others would not, which would mainly complicate the aggregation.

is a death shock that is equally likely for all firms, the price index in the first period after the shock is higher than the value indicated by $m^{D'}$. During the transition the price index is a function of the current cutoff and the tariffs but it also reflects the initial equilibrium cutoff since some fraction of firms with costs between $\mathbf{c}_{2T}$ and $\mathbf{c}_m$ survive. Thus the current cutoff will be insufficient to pin down the price index during the transition and we will be off the steady state schedule in figure 5. As firms exit the price index in the transition, denoted P_{2T}^D, increases monotonically towards its steady state, so $P_{2T}^D \to P_2^D$.

The entry *schedule* under the transition will be the same as the one derived under the steady state. To see this note that at some time T after the shock the firm must decide between entering the export market today or waiting. If it enters today it obtains $\sum_{t=T}^{\infty} \beta^{t-T} \pi(a_{2t}, c)$ and if it waits then it obtains zero today but, if it is just indifferent between entering today or not, then in the following period it will enter and obtain a PDV of $\sum_{t=T+1}^{\infty} \beta^{t-T} \pi(a_{2t}, c)$ because *after* the shock aggregate conditions will be improving (as other firms slowly exit). Therefore the firm that after the shock is indifferent between entering at T or not is the one where the *extra* profit from entering today relative to tomorrow, $\pi(a_{2T}, c)$, is just enough to cover the extra cost paid today instead of next period $(1-\beta) K$. Equating these we obtain that after any period T the firm that is indifferent about entering when $s = 2$ must satisfy $\pi(a_{2T}, c_{2T}^D) = (1-\beta) K$. This cutoff can be related to the "steady state" cutoff c_2^D in any given industry as follows

$$c_{2T}^D = \left[\frac{a_{2T}}{(1-\beta) K} \right]^{\frac{1}{\sigma-1}} = c_2^D \left[\frac{a_{2T}}{a_2} \right]^{\frac{1}{\sigma-1}} \tag{28}$$

Note that a_{2T}/a_2 is equal to the ratio of profits at T relative to steady state under $s = 2$. It is lower than unity as long as the price index at T, P_{2T}^D, is below its steady state, P_2^D, as we argued above. Thus, due to the exogenous death, after the unexpected shock from m to $s = 2$ the cutoff falls from c_m (point m^d) to c_{2T}^D (just right of 2^{tr}) and thus "overshoots" the steady state level (2^{ss}). As firms exit the price level increases and the equilibrium cutoff moves along the new entry schedule from $c_{2T}^D \to c_2^D$.

2.4.4 Policy Uncertainty, firms, prices and welfare

We can now build on the deterministic case to analyze policy uncertainty. First, we will relate the worst (column 2) and best (WTO agreement) scenarios to the deterministic counterparts. Second, we will derive the impact of policy uncertainty under the MFN state on firm decisions, the price index and consumer welfare.

As previously described there will be transition dynamics whenever a shock worsens conditions. Under the three state process that can only occur if the country moved to column 2 tariffs or if it first entered the agreement ($s = 0$) and then exited back to $s = m$. In order to simplify the analysis we will focus on the case where the probability of exiting the agreement state, t_{0m}, is zero and also assume that the economy starts at m. This has two implications. First, there is a single entry cutoff value per industry for two of the states, $s = 0, m$, which is time independent conditional on the state. Second, the entry cutoff for $s = 0$ is given by the deterministic expression in (3) since $t_{02} = 0$, but now it takes into account the price index effect. Therefore, the agreement equilibrium would simply be a point such as 0 in figure 6 with the entry and price index schedules derived in the previous subsections and evaluated at τ_0. Given this, we simply need to determine c_{2T}^U and c_m^U. Since the approach to determine these cutoffs is similar to that in section (2.2), we will describe the main results and provide the details in the appendix.

First, the worst case cutoff schedules under uncertainty are identical to the deterministic ones in (28). The argument is similar to the one made in the deterministic case: after T periods of moving to $s = 2$ a firm that is indifferent between entering at T or waiting will surely enter at $T + 1$ if it survives. The reason is that conditions will improve with certainty either because the tariff state improves or because the aggregate conditions improve. Thus a firm is indifferent if $\Pi_e(a_{2T}, c) - K = \Pi_w(a_{2T}, c)$, which we show in the appendix yields exactly $\pi(a_{2T}, c_{2T}^U) = (1 - \beta) K$ and therefore $c_{2T}^U = c_{2T}^D$. The functional form for the price index after T periods of switching to column 2 is similar to the one we described in the deterministic case, but the initial starting value for the cutoff is now $\mathbf{c}_m^U$, which we will show is different from the deterministic value. But conditional on this starting value, the *path* after the shock will be the one illustrated by 2^{tr} towards 2^{ss} (where the latter is never actually reached since eventually a shock will lead back to MFN).

As we noted before since we start at $s = m$ and there is no possibility of exiting the agreement, this implies that whenever at $s = m$ there is no history of better conditions and thus there are no transition dynamics due to exit of firms above the threshold (there is exit below the threshold due to death each period but it is immediately offset by entry so the price index is unchanged). Therefore we need only determine a single cutoff per industry for this state. To do so, note that the functional form for the expected value of export is the same as in the baseline (5) and that is also the case for the value of waiting, given by (10). The difference is that now the expressions for the expected values of export and waiting under $s = 2$ are different due to the transition dynamics. More specifically, we must solve for the value of exporting and waiting for the period when a shock leading to column 2 tariffs occurs, i.e. $\Pi_e(a_{2T=0}, c)$ and $\Pi_w(a_{2T=0}, c_m^U)$. After doing so we again employ the indifference condition in (4) for the MFN state to derive c_m^U and relate it to the deterministic cutoff as follows

$$c_m^U = \left[\frac{a_m}{(1-\beta) K}\right]^{\frac{1}{\sigma-1}} U_m(\tilde{\omega}) = c_m^D \frac{P_m}{P_m^D} U_m(\tilde{\omega}) \tag{29}$$

where

$$U_m(\tilde{\omega}, t_{ss'}) = \left[\frac{1-\beta}{1-\beta\tilde{t}}\left(1 + \frac{\beta t_{m2}}{1-\beta t_{22}}\tilde{\omega}\right)\right]^{\frac{1}{\sigma-1}} \tag{30}$$

This is similar to the partial equilibrium uncertainty expression in (13). The only difference is the term capturing the proportion of profits lost. That term is now $\tilde{\omega} = \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} g$, which still reflects the ratio of the PDV of profits under the worst case scenario relative to state m, but now takes into account a general equilibrium effect

$$g \equiv \frac{(1-\beta t_{22}) \sum_{t=0}^{\infty} (\beta t_{22})^t A_{2t}}{A_m} \geq 1. \tag{31}$$

This effect captures the average business conditions (other than tariffs) after a transition to column 2 tariffs relative to the conditions under MFN, A_m, and is common to all industries. In the absence of uncertainty about staying in the MFN state ($t_{mm} = 1$) we have $U_m(\tilde{\omega}) = 1$. In Appendix A.3 we show that when the direct effect dominates, as we assume, we have $\tilde{\omega} < 1$ and this implies that $U_m(\tilde{\omega}) < 1$.

The additional difference between the uncertainty and deterministic cutoff in the presence of price effects is captured by the difference in the price index due to uncertainty. This arises because c_m^D is evaluated at P_m^D but under uncertainty, the price index will generally be higher due to less entry, as we argue below. Therefore, all else equal the general equilibrium effects partially offset the direct impact of uncertainty on entry. Whenever the general equilibrium effect of the agreement on the price index is sufficiently small (i.e. P_m/P_m^D sufficiently close to 1) $U_m(\tilde{\omega})$ converges to the partial equilibrium value, which is lower than unity so $c_m^U(\tilde{\omega}) < c_m^D$.

To analyze the impact of uncertainty when the price effects are not negligible we again write $t_{mm} = 1-\gamma$ and $t_{m2} = \gamma p_2$ and $t_{m0} = \gamma(1-p_2)$ so an increase in γ lowers policy persistence in the MFN state. If we start at m and there is no uncertainty, $\gamma = 0$, then $U_m(\tilde{\omega}) \frac{P_m}{P_m^D} = 1$ and we obtain the deterministic cutoff and price index. We showed the existence and uniqueness of such an equilibrium and will thus examine the impact of uncertainty around it. The only *direct* effect of γ on the economy occurs through $U_m(\tilde{\omega})$ and so we will first derive this effect. As we can see from the definition of $U_m(\tilde{\omega})$, holding $\tilde{\omega} = \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} g$ fixed the parameter γ affects U through $\tilde{t}$ and t_{m2}. In general, those changes in γ will affect current conditions and therefore they would affect the future price path reflected in g. However, those indirect general equilibrium effects through g are multiplied by γ and so they disappear when we evaluate around $\gamma = 0$. Given this, the total impact around $\gamma = 0$ can be derived separately from the indirect effects on the cutoffs and price index and is equal to

$$\frac{d \ln U_m(\tilde{\omega}_V, t_{ss'})}{d\gamma}|_{\gamma=0} = \frac{\beta p_2}{(\sigma-1)(1-\beta t_{22})} (\tilde{\omega}_V|_{\gamma=0} - 1) \quad \text{each } V \tag{32}$$

where the g term in $\tilde{\omega}_V|_{\gamma=0}$ is evaluated at the deterministic values P_m^D and P_{2T}^D previously derived.

Using this result we can compare the deterministic cutoff and prices with those where $\gamma > 0$.[31] The price index starting at $s = m$ can be written as a function of the cutoffs, $P_m(\tau_m, \mathbf{c}_m)$. From (29) we have $c_{mV}^U(U_m(\tilde{\omega}_V), P_m, \tau_{mV})$, which is log linear in each of those arguments so that we obtain

$$\frac{d \ln c_{mV}^U}{d\gamma}|_{\gamma=0} = \frac{d \ln U_{mV}}{d\gamma}|_{\gamma=0} + \frac{d \ln P_m}{d\gamma}|_{\gamma=0} \qquad \text{each } V \tag{33}$$

$$\frac{d \ln P_m}{d\gamma}|_{\gamma=0} = \textstyle\sum_V \varepsilon_V \frac{d \ln c_{mV}^U}{d\gamma}|_{\gamma=0} \tag{34}$$

[31] In addition to comparing these values, across γ we could also examine the transition dynamics similarly to what we did for the tariff increase. The increase in uncertainty would not lead all firms above the cutoff to exit initially but would do so over time so the price index would be increasing over that path.

The first term in the cutoff expression is the direct effect of policy uncertainty on an industry, which is similar to the one without price effects but now evaluated at $\tilde{\omega}$. As we noted before this direct effect lowers the cutoff. The second term is the indirect effect through the price index, which is positive if uncertainty lowers a weighted average of the cutoffs and thus increases the price index. The relevant weight is the elasticity of the price index with respect to each industry cutoff, $\varepsilon_V \equiv \frac{\partial \ln P(\mathbf{c}_m)}{\partial \ln c_V}$ evaluated at the deterministic value. We can verify that uncertainty increases the price index by solving the system to obtain

$$\frac{d \ln P_m}{d\gamma}|_{\gamma=0} = \frac{\beta p_2}{(\sigma - 1)(1 - \beta t_{22})} \sum_V \tilde{\varepsilon}_V (\tilde{\omega}_V - 1)|_{\gamma=0} > 0 \tag{35}$$

where $\tilde{\varepsilon}_V \equiv \varepsilon_V / (1 - \sum_V \varepsilon_V)$. The inequality is due to $\varepsilon_V < 0$ (shown in appendix A.5) and $\tilde{\omega}_V < 1$ for each industry (where the latter holds whenever the direct effect dominates as required in (27)).[32] The general equilibrium effect due to reduced competition is common to all industries and partially offsets the direct effect. In our estimation, we will control for it and estimate the direct effect, which is an overestimate of the total effect of uncertainty on entry. We will then employ the estimated parameters and data to provide an estimate of the price elasticity with respect to γ that we can use to bound the general equilibrium effect of uncertainty on the cutoff and thus on trade.

We compare the outcome under uncertainty to the deterministic ones in figure 6. Point m^D represents the deterministic cutoff at τ_m and point m^U represents the higher price index and lower cutoff in the base industry due to uncertainty, as described above. If the agreement simply eliminates uncertainty then it moves the economy from m^U to m^D. If in addition to eliminating uncertainty the agreement also reduces tariffs then the new equilibrium is at point 0.

The price index effect is interesting in its own right since it is central to the welfare impact of uncertainty on consumers, as we now show. The indirect utility for workers in any given period when the state is $s = m$ is simply $\tilde{\mu} P_m^{-\mu}$ where $\tilde{\mu}$ is constant. Moreover, since consumers are income risk neutral we can represent the expected welfare for these consumers starting at the uncertain MFN state as

$$W_m = \tilde{\mu} P_m^{-\mu} + \tilde{\beta} [t_{m0} W_0 + t_{m2} W_{2m} + t_{mm} W_m]$$

where W_0 and W_{2m} are respectively the expected value of welfare under the agreement and under column 2 (after a transition from $s = m$) and $\tilde{\beta} < 1$ is the discount factor used by consumers, capturing their probability of survival. Using $t_{m2} = \gamma p_2$ and $t_{m0} = \gamma (1 - p_2)$ we can then derive the semi-elasticity of individual expected welfare with respect to γ around $\gamma = 0$ as

$$\frac{d \ln W_m}{d\gamma}|_{\gamma=0} = -\mu \frac{d \ln P_m}{d\gamma}|_{\gamma=0} - \frac{\tilde{\beta}}{1 - \tilde{\beta}} \left(\frac{W_m - (1 - p_2) W_0 - p_2 W_{2m}}{W_m} \right)|_{\gamma=0}. \tag{36}$$

The first term captures the negative impact of increased uncertainty in a state on consumer welfare in that

[32] A weaker necessary and sufficient condition for uncertainty to increase the price index is for the import weighted measure of $\tilde{\omega}_V - 1$ to be negative, as we show in the appendix.

state due to lower firm entry and the resulting higher price index, as explained above. Therefore we label the term $-\mu\frac{d\ln P_m}{d\gamma}|_{\gamma=0}$ the "*within state welfare effect*" of policy uncertainty. The second term captures the "*mean state switching welfare effect*" of policy uncertainty. If at MFN a policy shock becomes more likely then the probability of switching to either of the other states is higher and expected welfare would decrease if in the deterministic setting W_m is higher than the average in the other states, $(1-p_2)\,W_0+p_2W_{2m}$. The latter case is plausible in the setting that we will consider where the applied tariffs did not change much between the MFN and the agreement states. In appendix A.5.4 we derive expressions for both effects. In the quantification section we discuss how our estimates allow us to quantify the within state welfare effect.[33]

In sum, thus far in this section we showed that:

1. The basic approach can be extended to incorporate general equilibrium effects arising from the impact of the extensive margin.

2. We can still estimate a direct or partial effect of uncertainty in industry V on entry in that industry. But this partial effect overestimates the total effect of a reduction in uncertainty in the presence of general equilibrium effects, particularly if uncertainty is reduced for all industries simultaneously. We will employ (33) to adjust for those effects in the quantification. This will use the price elasticities, ε_V, which we show in the appendix, can be derived as a function of data and parameters to be estimated.

3. Increased policy uncertainty has a negative within state welfare effect on consumers, via higher price index due to lower foreign entry, and possibly also a negative effect from increasing the probability of switching to other states if those states generate lower welfare on average then the current one.

The final step is to allow for upgrading in this setting. In section 2.3 we showed that the upgrade cutoff was lower than the entry cutoff by a fixed technology parameter, i.e. $c_{sz}^U=\phi c_s^U$. A similar result holds when there are price effects. This can be shown by allowing for the possibility to upgrade and imposing a large enough cost to do so that the marginal *entrant* in any state does not upgrade (i.e. $c_{z0}^U<c_{2T=0}^U$). In that situation, the entry cutoff expressions are the same we derived above, e.g. (29).[34] Given this result, we can apply the approach in section 2.3 to show that the ratio of the upgrade to the entry cutoff is simply the fixed upgrade parameter, e.g. $c_{mz}^U=\phi c_m^U$, where c_m^U and ϕ are respectively given by (29) and (18). We show this explicitly in appendix A.4.

It is also possible to derive the general equilibrium effects of uncertainty under upgrading. The approach would be similar to the one we used above. The expression in (33) would still hold but the price term $\left(d\ln P_m\left(\mathbf{c}_m^U,\mathbf{c}_{mz}^U\right)/d\gamma\right)$ would now include effects from entry and upgrade. To obtain the total effect of uncertainty we now need to solve the system that includes the two types of cutoff in each industry and the

[33] We are not analyzing welfare during the transition period where γ increases but rather capturing the change in welfare that we would have in a deterministic situation against one where the economy started with some positive uncertainty. We do not need to solve explicitly for the values of W_0 and W_{2m} under uncertainty because the impact of γ on either of these is multiplied by γ evaluated at zero so their effect disappears.

[34] The entry cutoff *equilibrium* values will be different since the price index will now reflect lower prices by firms that upgrade, but as long as the ordering of profits in (27) still holds when evaluated at the new price index, the entry cutoff expressions will be unchanged. Note also that (27) implies the same ranking of profits for the firm if it upgrades its technology.

price index. In the appendix we show that increases in uncertainty will increase the price index both by reducing entry and upgrading. Moreover, since $c^U_{mz} = \phi c^U_m$, the expression for the price index semi-elasticity with respect to γ will be similar to the one derived without upgrading in (35) but the equilibrium value of $\tilde{\varepsilon}_V$ and $\tilde{\omega}_V$ will be different since it will reflect trade flows and the price level with upgrading.

2.5 Policy Uncertainty and Industry Exports

We now examine how changes in policy uncertainty translate into export growth and derive a tractable estimation equation at the industry level.

The export revenue received by a given firm in state s in an industry V is $p_{sv}q_{sv}/\tau_{sV}$. When we aggregate firm sales over the (endogenous) set of export firms at s (Ω_{sV}) we obtain the industry export value. When upgrading is possible there is a subset of firms that upgrades (Ω^z_{sV}) and has costs lower than the remaining set of firms ($\Omega_{sV} \setminus \Omega^z_{sV}$). Using the optimal price and quantity derived before and the economic conditions variable a we obtain

$$R_{sV} = a_{sV}\sigma \left[\int_{v\in\Omega^z_{sV}} (z_V c_v)^{1-\sigma} \, dv + \int_{v\in\Omega_{sV}\setminus\Omega^z_{sV}} (c_v)^{1-\sigma} \, dv \right] \tag{37}$$

For a *given* mass of firms that export and upgrade, exports can only grow if current economic conditions improve, i.e. if a_{sV} increases, which requires changes in the applied policy for example, but does *not* depend on policy uncertainty.[35] Therefore policy uncertainty affects exports only through its effect on the mass of firms that export or upgrade. For a given level of current conditions, a_{sV}, both entry and upgrading raise the terms in brackets and thus raise exports. Moreover, this mass is increasing in the fraction of foreign firms that decide to export, i.e. the fraction with costs below the entry cutoff we derived previously, c^U_{sV}. So, for given a_{sV}, reductions in uncertainty increase c^U_{sv} and thus exports.

We could employ (37) and the cutoff expressions derived to examine the first order effects of alternative variables. However, we explore the structure of the model by assuming a specific productivity distribution to obtain sharper predictions, nest a standard gravity model in our framework, and provide precise conditions under which we can identify the impact of uncertainty on exports. Since our data will apply to what we model as states $s = 0$ and m, our derivation below focuses on these. Recall that conditions can't improve beyond the agreement state so when $s = 0$ the mass of exporting firms is equal to $N_V G\left(c^U_0\right)$, the product of all producers in industry V in the export country times the fraction with costs below the cutoff (recall G is the CDF of costs). The mass of exporters under the temporary MFN state, $s = m$, is also equal to the fraction of exporters with costs below the relevant threshold, $N_V G\left(c^U_m\right)$, if policy conditions were never better, i.e. if there was never an agreement in the past, which applies to China's situation.[36] A sufficient

[35] We take the technology parameter z_V as a fixed parameter.

[36] An alternative condition is that there was an agreement but it ended in the distant past so that any firms that would have entered with costs above c^U_m would have died.

condition in the context of the model for $N_V G\left(c_m^U\right)$ to exactly capture the mass in this state is for the agreement to be an absorbing state, $t_{00} = 1$, so there is no exit from the agreement. In this case we can write exports as

$$R_{sV} = a_{sV}\sigma N_V \left[\int_0^{\phi_V c_{sV}^U} (z_V c)^{1-\sigma}\, dG_V(c) + \int_{\phi_V c_{sV}^U}^{c_{sV}^U} (c)^{1-\sigma}\, dG_V(c)\right] \quad \text{for } s = 0, m$$

where we used the relationship between the upgrade and entry cutoff previously derived.

If we also assume the productivity has a Pareto distribution that is bounded below at $1/c_V$ but unbounded above then $G_V(c) = (\frac{c}{c_V})^k$. Using this and assuming $k > \sigma - 1$ we can integrate the cost terms and simplify to obtain

$$R_{sV} = a_{sV}(c_{sV}^U)^{k-\sigma+1}\zeta_V \alpha_V \text{ for } s = 0, m$$

where the industry specific parameters reflecting distribution and upgrading factors are respectively $\alpha_V \equiv \frac{N_V \sigma}{c_V^k}\frac{k}{k-\sigma+1}$ and $\zeta_V \equiv 1 + \frac{K_z}{K}(\phi_V)^k > 1$. In order to compare to standard gravity equations we take logs, use the definition of a_{sV}, the entry cutoff expression derived for c_{sV}^U and simplify to obtain

$$\ln R_{sV} = (k - \sigma + 1)\ln U_s(\tilde{\omega}_V) - \frac{k\sigma}{\sigma - 1}\ln \tau_{sV} - k \ln d_V + \frac{k}{\sigma - 1}\ln A_s + \ln \zeta_V + \ln \tilde{\alpha}_V \qquad (38)$$

where $\tilde{\alpha}_V \equiv \alpha_V \left(\frac{1}{(1-\beta)K_V}\right)^{\frac{k-\sigma+1}{\sigma-1}}$. In the absence of policy uncertainty $U_s = 1$ and when no upgrading is possible $\zeta_V = 1$ then we have a standard gravity equation (cf. Chaney, 2008). All else equal, the elasticity of exports with respect to the upgrading technology parameter, ϕ_V, is positive and can vary across industries, as we would expect. However, exports are log separable in the upgrading factor, ζ_V, so that elasticity is independent of the state under the standard Pareto distribution.

We can also employ (38) to derive the partial elasticity of exports with respect to policy uncertainty. We obtain $\frac{\partial \ln R_{mV}}{\partial \gamma}|_{\gamma=0} = (k - \sigma + 1)\left[\frac{\beta p_2(\tilde{\omega}_V - 1)}{(\sigma-1)(1-\beta t_{22})}\right]$ where the term in square brackets is $\frac{d \ln U_m(\tilde{\omega}_V)}{d\gamma}|_{\gamma=0}$ from (32). If entry and upgrading has negligible impact on the price index then $\tilde{\omega}_V \longrightarrow \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma} < 1$ so increasing the probability of shock will reduce exports.[37]

3 Evidence

We use the model to examine the impact of U.S. policy uncertainty on China's exports. In particular we analyze how China's WTO accession, which eliminated the annual MFN renewal debate in the US, contributed to China's export boom to the U.S. We focus on the predictions for trade values, which will reflect both entry and upgrading effects and then quantify the impact of policy uncertainty on exports and welfare. In section 3.7 we also test and quantify the entry predictions of the model.

[37] In the presence of aggregate price effects we have $\tilde{\omega}_V < 1$ whenever (27) holds, as shown in the appendix, that is when the direct effect of lower tariffs in industry V on a firm's profits dominates the aggregate price effect.

3.1 Empirical Approach

In order to identify the impact of uncertainty on exports via the augmented gravity equation in (38) we must measure the uncertainty term, $U_s(\tilde{\omega}_V)$. If before the agreement, at $s = m$, there was no policy uncertainty ($\gamma = 0$) and thus no probability of the worst case scenario ($t_{m2} = p_2\gamma = 0$) then the model generates a standard gravity equation with an extra upgrading term. Using this insight as our null hypothesis, we use (32) to approximate $U_m(\tilde{\omega}_V) = \frac{\beta p_2(1-\tilde{\omega}_V)}{(\sigma-1)(1-\beta t_{22})}\gamma + u_{mV}$ where u_V is an approximation error term.[38] We can then rewrite (38) as

$$\ln R_{mV} = -\frac{k-\sigma+1}{\sigma-1}\frac{\beta t_{m2}}{1-\beta t_{22}} g\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) - \frac{k\sigma}{\sigma-1}\ln\tau_{mV} - k\ln d_V + \frac{k}{\sigma-1}\ln A_m + \ln\zeta_V + \ln\tilde{\alpha}_V + u_{mV} \tag{39}$$

where we recall that g is common across industries so it can be estimated as part of the coefficient on $\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}$. Rewriting in terms of estimable parameters we obtain

$$\ln R_{mV} = -b_\gamma\left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + b_\tau\ln\tau_{mV} + b_d\ln D_{mV} + b_m + b_V + u_{mV} \tag{40}$$

We estimate each of the b_i parameters, which are related to the structural parameters as follows. The first coefficient is $b_\gamma = \frac{k-\sigma+1}{\sigma-1}\frac{\beta t_{m2}}{1-\beta t_{22}} g \geq 0$, so it is predicted to be zero if and only if $t_{m2} = 0$. If there were negligible price effects of switching states ($g = 1$) our estimate of b_γ could be used to calculate the full impact of removing policy uncertainty but otherwise we also have to take into account the term $b_\gamma\left(1 - g^{-1}\right)$, which is captured as part of the time effect $b_m \equiv b_\gamma\left(1 - g^{-1}\right) + \frac{k}{\sigma-1}\ln A_m$. Our approach is to estimate b_γ, which will provide an upper bound on the total effect of uncertainty reduction and then in the quantification section provide an estimate of g that allows us to adjust the estimate to reflect the general equilibrium effects.

The applied tariff coefficient is $b_\tau = -\frac{k\sigma}{\sigma-1} < 0$, which reflects the first order effect of the tariff and is therefore the same deterministic elasticity as a static gravity model. The model assumes the advalorem export cost, d_V, is not state dependent and could thus be absorbed as part of the industry dummy, b_V. In the estimation however, we allow for a more general export cost, which includes an unobservable industry specific component and an observable component, D_{mV}, which can vary by industry and over time. More specifically, we assume $\ln d_{mV} = \ln\tilde{d}_V + \ln D_{mV}$ and use data on cost of insurance and freight to capture the observable component so in this case we have $b_d = -k < 0$, which is typical in heterogeneous firm trade gravity models.[39] The industry effect is then, $b_V = b_d\ln\tilde{d}_V + \ln\zeta_V + \ln\tilde{\alpha}_V$, which also reflects technology upgrading (ζ_V) as well as a combination of other industry factors in $\tilde{\alpha}_V$, namely the entry costs, productivity distribution parameter, c_V, and the mass of Chinese producers in V.

Since we cannot observe all the industry characteristics in b_V we require variation over time to identify

[38] We will also explore if the results are sensitive to this approximation via non-linear and semi-parametric estimation.

[39] Because tariffs are paid by the importer in the model rather than modeled as transport costs, our tariff elasticity does not reduce to the shape parameter k as in Chaney (2008) for example.

the impact of uncertainty. Moreover, we are interested in the impact of the *reduction* in uncertainty after the U.S. removed the threat of column 2 tariffs due to China's WTO entry. So our baseline estimates focus on a simple difference, where below $\Delta \ln x_V = \ln x_{0V} - \ln x_{mV}$.

$$\Delta \ln R_V = b_\gamma \left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + b_\tau \Delta \ln \tau_V + b_d \Delta \ln D_V + b + u_V \tag{41}$$

The impact of uncertainty on export growth reflects only the pre-agreement negative impact. This reflects our assumption that exporters do not anticipate an exit from the agreement, i.e. $t_{00} = 1$—an assumption that we subsequently examine.[40]

The estimation equation (41) embodies some additional identifying assumptions, which allow us to clearly link our baseline estimates to the theory. (1) t_{m2} is common across industries because we are interested in the probability of switching policy states or regimes and that is the most relevant case in our empirical application. (2) the Pareto shape parameter k is constant across industries, but the bound c_V can vary over V. (3) the elasticity of substitution is identical across industries. (4) the upgrade technology, sunk costs, and mass of producers can vary over industries but not over the short time period we consider. We will relax some of these in the empirical analysis and examine how sensitive the results are to them. It should be clear from this equation that we can relax assumption 4 for example. While the model assumes that the variables in b_V are time invariant, if the mass of Chinese producers (or sunk costs) did change over time, at a similar rate in all industries then this would be controlled for by the time effect. In the robustness section we will also address the possibility of industry-specific growth trends and other potential threats to identification.

3.2 Data and Policy Background

We combine trade and policy data from several sources. Trade flow data at the 6 digit level of the Harmonized System (HS-6) are obtained from 1996-2005 from the World Bank's World Integrated Trade Solution (WITS). These data are concorded by WITS over time to the 1996 version of the HS. We then combine it with policy data on the U.S. statutory MFN and Column 2 tariffs that are also obtained annually from schedules available in WITS at the 8-digit, tariff line level.[41] We obtain an advalorem measure of transport costs using import data from the NBER that includes both the customs value of import and the costs of insurance and freight required to ship goods to the U.S. Consistent with our model all advalorem tariffs and transport costs rates are converted to their iceberg form and logged. For example, a tariff of 20% takes the value $\tau = 1.2$ in our data. We will also employ the NBER data to examine product entry at the HS-10 digit level.

There are 5,113 HS-6 codes in the 1996 classification and China exported in 3,617 of these in both 2000 and 2005. The baseline analysis focuses on those codes traded in both years so that a log growth rate exists.

[40] This implies that $\ln U_0 = 0$ and the constant is $b = -\, b_\gamma \left(1 - g^{-1}\right) + \frac{k}{\sigma - 1} \Delta \ln A$ and $u_V = -u_{mV}$.

[41] Tariffs in about 94% of HS-6 tariff lines in 2005, are levied on a ad valorem basis but some are specific tariffs levied on a per unit basis. In the appendix we describe how we calculate the ad valorem equivalent (AVE) of specific duties and below we show our results are robust to their inclusion.

This selection that at least one firm exports in an HS-6 in each period is not problematic in this setting for two reasons. First, the model predicts that if there is ever a positive mass of Chinese firms in an industry then at least some will be productive enough to export. Second, and more importantly, these continuing HS6 codes account for 99.8% of all import growth from China in this period. Moreover, we will also address the selection issue directly by showing that the results are robust to using midpoint growth rates that allow us to incorporate HS-6 codes that had zero values in either year.

China's WTO accession in December 2001 changed few applied U.S. trade policy barriers relative to other exporters, e.g. changes in MFN tariffs averaged one half percent or less.[42] The ensuing export boom is thus difficult to explain with standard trade models. Our model suggests another source of growth, the accession secured China's pre-existing MFN status permanently and reduced TPU. While China was first granted MFN status by the U.S. in the 1980s, it was subject to annual renewal with severe consequences of revocation. China would have faced Smoot-Hawley tariff levels (so called column 2 tariffs) and a trade war would likely ensue. In 2000 we calculate that about one-fifth of roughly 5000 tariff lines would go up to at least 50%. For our baseline sample summarized in Table 1, we calculate that the (simple) average tariff China would face in the U.S. would rise from 4% (MFN) to 31% (column 2). Although China never lost MFN status, it came quite close: in the 1990s Congress voted every year on whether to revoke MFN and the House passed such a bill three times.

There was uncertainty about both China's accession to the WTO and its permanent normal trade relations (PNTR) with the U.S. as late as 2000. Foreign and economic relations between these countries remained tense into the late 1990s for several reasons including the accidental bombing of the Chinese embassy in Serbia by NATO in May 1999. In the summer of 2000 there was a vote in Congress to revoke China's MFN status. In October 2000 Congress passed the U.S.-China Relations Act granting PNTR but its enactment was *contingent* on China's accession to the WTO. In the meantime, a U.S. spy plane collided with a Chinese fighter jet over the South China Sea in April 2001. Protracted negotiations over China's WTO accession meant votes were held again in the summer of 2001 over whether to revoke MFN. The president was required to determine whether the terms of China's WTO accession satisfied its obligations under the Act. Otherwise the U.S. could opt-out of providing MFN status to China under Article XIII of the WTO, a right it had exercised with respect to other members of the WTO. China joined the WTO on December 11, 2001 and the U.S. effectively enacted PNTR on January 1, 2002.[43] This strongly suggests that uncertainty about column 2 tariffs remained at least until 2000 and that it was not reduced until 2002. Thus we focus on the growth between 2000-2005 but will also show that the basic effect is present for other relevant periods.

[42] The exception is textiles quotas that were fully lifted in 2005 and can be controlled for empirically.

[43] A detailed history of U.S. permanent normal trade relations policy with respect to China and other countries can be found in Pregelj (2001).

3.3 Non-parametric Evidence

In our theoretical framework the central variable to identify the effect of TPU is the proportion of profits lost conditional on a bad shock, $1-(\tau_{sV}/\tau_{hV})^{\sigma}$. We use the U.S. MFN tariff in product V for τ_{sV} and the respective column 2 tariff for the worst case scenario, τ_{hV}, and find that this potential loss was on average 52% when $\sigma=3$, which will be the baseline used unless otherwise stated.[44] The standard deviation is 20% so there is a reasonable amount of variation across industries. Importantly, there is also substantial variation in export growth, which suggests that the boom can't be explained by aggregate shocks. Average growth between 2000 and 2005 is 129 log points with a standard deviation of 167.[45]

We then divide the sample into terciles according to the uncertainty measure and recompute the statistics for the low and high terciles. Recall that U_V varies across industries only due to $(\tau_{hV}/\tau_{sV})^{-\sigma}$ so the terciles are *independent* of our linear approximation or choice of σ to compute the potential profits lost. As we see in Table 1 the average column 2 tariff was nearly 40% in high uncertainty goods, which translates into an average potential profit loss of 64% if the MFN status had been revoked. Export growth was 118 log points for low uncertainty whereas it was higher, 136, for high uncertainty industries, a mean difference that is statistically different.

Figure 1 provides additional non-parametric evidence of this relationship by estimating a local linear regression (lowess) of export growth on $\ln(\tau_{hV}/\tau_{sV})$. We confirm the higher growth in goods with higher uncertainty pre-WTO obtained in the mean test and find a non-negative relationship over the full range of the uncertainty measure. Since the lowess procedure downweights outliers the graph also indicates that the positive relationship is not driven by them.

While we focus on Chinese *export* growth, in section 3.7 we also examine the predictions for variety growth. Given our current data we can only examine entry indirectly by considering the growth in the number of HS-10 goods traded in any given HS-6 as a proxy for variety growth. The proportion of high uncertainty HS-6 codes that experienced variety growth was 82% whereas that occurred for only 66% of HS-6 codes with low uncertainty, a difference that is statistically significant according to a 2-sample proportions test.

3.4 Estimates: Policy Uncertainty and Exports

We begin by estimating the baseline model and testing some of its predictions. We then show these results are robust to weaker identifying assumptions, outliers and alternative measures of protection. We also provide

[44] We do not use the U.S. bound tariff commitments to compute the uncertainty measure for two reasons. First, bound tariff commitments only apply to WTO members so if China's MFN status was revoked prior to WTO accession the U.S. would revert to column 2 tariffs. Second, after accession Chinese exporters could consider the uncertainty induced by the possibility of moving from MFN to the bound tariffs but those two are identical for the modal tariff line.

[45] Much of the growth in the overall sample was concentrated in machinery, textiles, furniture, and metals sectors as also noted by Berger and Martin (2013).

evidence for the functional form of the uncertainty measure implied by the model.

Baseline

We first use OLS to estimate the model on the baseline sample described above using equation (41). The results in Table 2 are consistent with the structural interpretation of the parameters. In column 1 we see that the coefficient on pre-WTO accession uncertainty, b_γ, is positive and significant. The coefficients on tariffs and transport costs are negative and significant. The estimation equation contains an over identifying restriction $b_\tau = \frac{\sigma}{\sigma-1} b_d$, which we are unable to reject. We therefore re-estimate the model in column 2 with this restriction, which increases the precision of the model across all coefficients. In the robustness checks that follow, we report both unconstrained and constrained regression whenever possible.

The baseline uses $\sigma = 3$ since this is the median value from the estimates of Broda and Weinsten (2006) for the US. But in Table A2 we construct the uncertainty variable using alternative $\sigma = 2, 4$ and find similar results.

Sector level growth trends

The estimating equation in (41) assumes that the industry effect b_V captured variables such as sunk costs and the mass of foreign producers in an industry. The model assumes these parameters are time invariant, but we now address the possibility that they vary over time. If there was unexpected growth in any industry variable that was common to all industries then the baseline estimate controls for it through the constant term, b. We can also allow that *growth* to be common to sectors (groups of industries) by including a full set of 21 sector dummies in the *difference* equation (41). Obviously, either scenario admits an IID industry specific term, which is included in the error.

We report the results that control for sector specific growth *trends* in columns 3 and 4 of Table 2. The pattern of coefficients is similar to the baseline and the coefficient on uncertainty remains positive and significant. The coefficients on tariffs and transport costs are significant in the constrained regressions.

One reason for the increase in precision in the constrained regressions is that most applied tariff changes are very small during our sample period, and there may be a few influential observations. In Table A3 we address this possibility using a robust regression method and find results that are qualitatively similar to Table 2 but the tariff change coefficient is now significant in the restricted and unrestricted versions with or without growth trends.

3.5 Robustness

Additional measures of protection and sample selection

The regressions in columns 3 and 4 of Table 2 already control for unobserved, sector level trade barriers that might impact the growth of exports from China. Nevertheless, there are barriers other than tariffs that can vary at the industry (HS6) level as well—anti-dumping duties, countervailing duties and China-specific special safeguards. We create binary indicators for whether a product has any of these temporary trade barriers (TTBs) in a given year using the database from Bown (2012). Following China's accession to the WTO it also became eligible to benefit from the phase-out of quotas in textiles that had been agreed by WTO members prior to China's accession under the Multi-Fiber Agreement (MFA), this was fully implemented by 2005. We have indicators that map to HS-6 categories where such quotas were lifted.[46]

In Table 3, we examine whether controlling for changes in TTBs or MFA quotas affects our results. For comparison, we reproduce the baseline results in column 1. In column 2 we include a regressor for the change in the binary indicator for both MFA quotas and TTBs and find them to have the expected negative sign. Importantly, their inclusion does not affect the other coefficients and this is also the case when we control for section effects (column 3).[47]

Anti-dumping and other TTBs may respond to import surges from China. To the extent that these surges are more likely in some sectors, our sector effects in column 3 already control for this potential endogeneity.[48] To address the possibility that this reverse causality could also occur within sectors, we instrument the change in TTB with its *level* binary indicator in early years—1997 and 1998. When we do so in column 4 we find that the coefficient for uncertainty remains virtually unchanged relative to the OLS version in column 3 of that table or without the TTB variable (column 3 Table 2).[49] We also find that the constrained version ($b_\tau = \frac{\sigma}{\sigma-1} b_d$) yields very similar coefficients for the uncertainty, tariff and transport variables if we include the TTB and MFA (column 5 Table 3) or not (column 4 Table 2).

We also examine whether our results are robust to adding the ad-valorem equivalent (AVE) of any specific tariffs. Including the AVE tariffs increases our sample size to 3,599 so it also allow us to address if there is any potential sample selection issue in the baseline sample that excluded HS-6 codes that contained only specific tariffs. We use AVEs to compute both the change in applied tariffs and uncertainty and in Table A4 we find that the latter is positive and significant across all the specifications analogous to the baseline Table 2. As may be expected, including AVE tariffs introduces noise and measurement error into the computation of tariff changes. This error biases the coefficient on tariffs toward zero and so in the subsequent robustness and quantification we focus on results for industries in our baseline sample with statutory ad-valorem tariffs, which covers about 98% of the total export growth of Chinese exports to the U.S. in 2000-2005.

In Table A6 we expand our sample to include HS-6 codes that transition from traded to non-traded status (and vice versa) between 2000 and 2005. Because we cannot compute log changes of these transitions, we accommodate them using a mid-point growth rate as our dependent variable in estimation equation (41)

[46] Additional details on the TTB and MFA indicators appear in the data appendix.

[47] Below we also provide evidence that the baseline results in 2000-2005 are similar to those in 2000-2004, which was a period when the quotas were mostly still in place.

[48] The MFA dates back to the 1980s and its phaseout was implemented with the Uruguay Round in 1996 before China was a member of the GATT/WTO. As such, it is plausibly exogenous as a barrier to China's imports.

[49] The two instruments pass a Sargan over-identifying restriction test and we also fail to reject the exogeneity of the TTB variable using a Durbin-Wu-Hausman test. The instruments have significant explanatory power in the first stage, with the relevant F-statistic above 10.

given by $(R_{0V} - R_{mV})/(R_{0V} + R_{mV})/2$, which is equivalent to log change in exports up to a second order approximation around $(R_{0V} + R_{mV})/2$. When we re-run the specifications in Table 2 using this alternative dependent variable we continue to find a positive and significant coefficient for the uncertainty measure. The magnitude of the coefficients is not directly comparable with the baseline results because of the rescaling of the dependent variable.

Pre-accession trends and time-varying uncertainty coefficients

If prior to accession certain HS-6 industries were growing faster and they continued to do so after accession then this could generate a bias. If the fastest growers happened to be the ones with highest profit loss measure then our baseline would tend to be upwards biased and vice versa. We examine this possibility by running our baseline estimation on pre-accession export growth and in Table A5 column 3 we find no significant effect of the initial uncertainty measure. This falsification test also indicates that the coefficient on uncertainty did not change in this pre-accession period.[50]

We can provide some additional evidence that pre-accessoin trends are not driving the baseline findings. If an industry variable is growing at the same rate in the pre and post accession period then we can remove it by taking the difference of the post-accession growth (2005-2000) and the growth in a pre-accession period. In the appendix we provide the econometric details on how this is implemented. The first column of Table A5 shows the baseline results are robust to this difference-of-differences specification.

The results above focus on specific years and a balanced panel. We now explore the full panel and examine if the uncertainty coefficient changed over time in the way predicted by the model. To do this we consider a generalized version of (40) that allows the uncertainty coefficient to vary by year, subscript t, and includes time *by* section effects, b_{ts}, in addition to HS6-effects b_V.

$$\ln R_{tV} = -b_{\gamma t}\left(1 - \left(\frac{\tau_{2V}}{\tau_{TV}}\right)^{-\sigma}\right) + b_\tau \ln \tau_{tV} + b_d \ln D_{tV} + b_{ts} + b_V + u_{tV} \quad ; t = 1996 - 2006$$

We estimate two versions of this equation. First, recall that there is almost no variation over 2000-2005 in the uncertainty variable so in the baseline we focused in the change in coefficient. To compare the panel results with the baseline we initially use the same uncertainty measure interacted by year so that $T = 2000$ in the uncertainty measure above. In this case we can not identify $b_{\gamma t}$ for each year since the uncertainty regressor only varies within industry. Instead, we estimate the change over time relative to a base year, namely $b_{\gamma t} - b_{2000}$. These estimates are presented in Figure 7 and show that the impact of the uncertainty variable in 1996-2001 is identical to 2000, which is what the model would predict since PNTR was only enacted in 2002. The effect is uniformly positive and significantly higher following WTO accession in 2002 and all subsequent years. Therefore, the change in the impact of uncertainty matches China's accession and PNTR status with the U.S. We also note the magnitude of the 2005 estimate is comparable to what we

[50]The pre-accession period we consider is 1999-1996 to avoid another potential change in trade regime: the implementation of the Uruguay Round in 1995.

found in the baseline.

We then explore variation in the uncertainty measure in the period 1996-2000 when there were changes in the applied tariffs as the Uruguay Round was implemented. Thus we can identify pre- and post-accession effects. We construct the uncertainty measure for each industry year, allowing $T = t$, restricting the coefficient such that $b_{\gamma t} = b_{\gamma pre}$ for $t = 1996 - 2001$ and $b_{\gamma t} = b_{\gamma post}$ for $t = 2002 - 2006$. The model predicts that $b_{\gamma pre} > 0$, $b_{\gamma pre} > b_{\gamma post}$ and $b_{\gamma post} \geq 0$, that latter with strict equality if the agreement eliminated this source of uncertainty. In the second column of Table A8 we find evidence that supports all three hypothesis: uncertainty lowered exports in 1996-2001, it had a significantly smaller impact in the post period, and that post effect is not significantly different from zero.

Outliers, approximation, elasticity and functional form

To determine if the results are robust to the presence of influential outliers we do the following. First, in Table A3 we employ a robust regression estimation that places less weight on outliers and find results that are qualitatively similar to Table 2. Second, we use a median regression and also find results that are similar to the baseline in terms of sign and all variables are significant at the 1% level (available on request). Third, transport cost can be measured with error and so we analyze if the results are robust to trimming extreme values.[51] In Table A7 column 1 we find results similar to the analogous specification that uses the full sample (column 2 Table 2) in terms of sign and significance. The same is true when we include section effects (column 3). In both cases the effect of the transport cost variable is stronger possibly indicating that the extreme values reflected measurement error.

Our estimation thus far relied on a linear approximation to the uncertainty term and imposed particular values for σ, which allowed for linear estimation. We now ask if there is evidence supporting this approach. We do so in two complementary ways. First, we employ non-linear least squares (NLLS) and explore the structure of the theoretical model to compare the resulting coefficients with the ones previously obtained. Second, we use a semi-parametric approach that does not place much theoretical structure on the estimation and compare the fit with our linear approach. For either approach it is useful to re-write the uncertainty term in the estimation equation as a function, $f\left(\tilde{U}_V\right)$, so the general form of the estimation equation is

$$\Delta \ln R_V = f\left(\tilde{U}_V\right) + b_\tau \Delta \ln \tau_V + b_d \Delta \ln D_V + b + u_V \qquad (42)$$

The model's structure implies a specific functional form for $f\left(\tilde{U}_V\right)$, which we employ to estimate the

[51] More specifically, we drop observations that lie outside the interquartile range by more than three times the value of that range, which is about 5% of the baseline sample.

following equation using NLLS:[52]

$$\Delta \ln R_V = -\frac{b_d - \sigma + 1}{\sigma - 1} \ln \left(1 + \tilde{b}_\gamma \left(\frac{\tau_2}{\tau_m} \right)^{-\sigma} \right) + \frac{b_d}{\sigma - 1} \Delta \ln \tau_V + b_d \Delta \ln D_V + \tilde{b} + u_V \tag{43}$$

where $\tilde{b}_\gamma \equiv \frac{\beta t_{m2}}{1-\beta t_{22}} g$ and $\tilde{b} \equiv b - \frac{k-\sigma+1}{\sigma-1} \ln \frac{1-\beta}{1-\beta \bar{t}}$. In order to help identify the parameters of interest we explore the theoretical constraints $b_d = k = b_\tau \frac{\sigma-1}{\sigma}$.[53] If the linear approximation is reasonable then we should find the following when we compare the linear constrained estimates with the NLLS estimation at $\sigma = 3$. First, we confirm the coefficients for the tariff and transport cost regressor are similar by comparing columns 1 and 2 or 3 and 4 of Table A7.[54] Second, we use the delta method to construct an estimate for the uncertainty parameter estimated under OLS, $b_\gamma = \frac{b_d - \sigma + 1}{\sigma - 1} \tilde{b}_\gamma$. We find that the estimated b_γ implied by NLLS is positive and significant. The point estimate with section effects, for example, is 0.67, which is within one standard error of its OLS counterpart. We also test if $\sigma = 3$ by running NLLS on the unrestricted version of (43). The last row of Table A7 shows that we are unable to reject this restriction.

Standard trade models with a gravity structure yield an estimation equation that is a special case of (42) with $f = 0$. It is plausible that in other models with uncertainty, trade would depend on some log separable uncertainty function that depends on the worst case scenario relative to the current policy, $f\left(\tilde{U}_V\left(\frac{\tau_2}{\tau_m}\right)\right)$, but the exact functional form will depend on the model's assumptions. We now employ semi-parametric estimation to allow the data to identify this functional form. We then test if the resulting fit is similar to one that uses a polynomial approximation. Since in our baseline we employ a particular polynomial approximation, linear in $-\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}$, that is what we now use as the argument in $f\left(\tilde{U}_V\right)$ in (42) to estimate Robinson's (1988) double residual semi-parametric regression. Figure 8 presents the semi-parametric fit plotted against $1 - \left(\frac{\tau_2}{\tau_m}\right)^{-3}$.[55] It is clear that the partial association of the initial uncertainty measure and subsequent growth is positive. We also plot the prediction from our linear approximation (green line) and find that it lies everywhere within the 95% confidence interval of the semi-parametric fit.

When we employ $\sigma = 3$ we fail to reject the equality of fit between the baseline parametric and semi-parametric using the test in Hardle and Mammen (1993). Moreover, when we re-run the semi-parametric test using $\sigma = 1$ we do reject the equality of that fit against a first order polynomial. Therefore the data suggest that this policy ratio is relevant and its effect on export growth is non-linear and can be captured by a power function such as the one we use in the baseline. These tests suggest that we should not rely on linear measures of column 2 tariffs when making quantitative predictions about the impact of TPU.[56]

[52] The model implies that $f\left(\tilde{U}_V\right) = -(k - \sigma + 1) \ln U_t(\tilde{\omega}_V) = -\frac{k-\sigma+1}{\sigma-1}\left[\ln\left(1 + \frac{\beta t_{m2}}{1-\beta t_{22}} g \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right) + \ln \frac{1-\beta}{1-\beta \bar{t}}\right]$.

[53] Given that the NLLS estimation relies on the model structure and the variation in the transport cost variable to identify k, we minimize the potential influence of outliers by focusing on the subsample without transport cost outliers just described above.

[54] We also find that the constant is higher under NLLS as predicted since $\tilde{b} < b$.

[55] We do not place any constraints on the tariff or transport cost coefficients, include section dummies and focus on the baseline sample to compare with Table 2.

[56] We approximate the distribution of the test statistic using 1000 wild bootstrap replications. Our baseline parametric model, $\sigma = 3$, has a test statistic of 1.22, scaled to the Normal distribution, and a simulated critical value of 1.96, so we can't reject the

3.6 Counterfactuals and Quantification

We now use the estimates and model structure to quantify the effect of the policy uncertainty reduction on trade, prices and consumer welfare.

Using the parameter definitions in (40) we can provide an expression for the average "partial effect" over industries of eliminating uncertainty while holding general equilibrium price effects due to the agreement fixed as follows

$$\mathbb{E}\left(\ln R_{0V} - \ln R_{mV}\right)|_{\tau,D,P} = b_{\gamma}\mathbb{E}\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) \leq b_{\gamma}\mathbb{E}\left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) \quad (44)$$

The middle expression still reflects a general equilibrium effect, $g \geq 1$, due to the possibility of a worst case scenario present *before* the agreement. Therefore the expression on the RHS of the inequality is an upper bound for this partial effect. To obtain this upper bound we simply take the product of the estimated coefficient and the sample mean of the uncertainty variable. We employ the estimate in column 4 of Table 2, $\hat{b}_{\gamma} = 0.7$, and find that over the 5 year period, the uncertainty removal lead to export growth of up to 37 log points, as shown in the top left of Table 4.

To determine how close the upper bound is to the real effect recall that $g \in [1, \left(P_2^D/P_m^D\right)^{\sigma-1}]$. From (44) we can see that even if $b_{\gamma} \neq 0$, as estimated, the average effect could still be zero if $g^{-1} = \mathbb{E}\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}$. But this would require the price index in the worst case scenario to be 1.45 times higher than under MFN. This is an implausibly large impact of column 2 tariffs even if fully and irreversibly implemented given the import penetration of China, which was about 0.02 in 2000 and 0.04 in 2005. Therefore any reasonable estimates of g will not overturn the sign of the estimated uncertainty effect, the question is whether the magnitude is very different from the upper bound of 37 log points.[57]

In appendix A.5.1 we show how to use the model to approximate P_2^D/P_m^D, in a way that can be combined with data and our estimates to derive an upper bound for g. The approximation of the ratio of price indices is a weighted average of tariff changes multiplied by an aggregate coefficient that depends on the parameters k and σ and the aggregate import penetration of China.[58] Doing so yields a price index increase of about 1.77 log points and implies an upper bound for $g = 1.04$. Using this value to evaluate the middle expression in (44) we obtain what we call the partial effect in column 2 of Table 4, which is 34 log points.

equality at the 10% level. When we employ $\sigma = 1$ in the semi-parametric estimation we reject the equality of fit between this and a first order polynomial approximation (which is equivalent to using a linear approximation with $-(\tau_m/\tau_2)$ as a regressor. The test statistic is 2.32 and the critical value is 1.96.

[57] To see this note that in our baseline we would require $g^{-1} = \mathbb{E}\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-3} = 0.47$ and therefore $\left(\frac{P_2^D}{P_m^D}\right)^{\sigma-1}$ to be at least 2.09. The import penetration figures are from Autor et al (Forthcoming). Auer and Fischer (2010) estimate that a 1 percentage point increase in import penetration would lower the US PPI by 2.35% so even if China went from the post agreement penetration to no trade with the US the impact on the PPI would be at most 4×2.35%.

[58] We use $\sigma = 3$ and $k = 2.6$ (the value implied by the transport cost coefficient in column 4 of Table 2). Since the approximation is around the deterministic policy scenario we employ the post-agreement import levels to weight up the tariff changes from post agreement to the column 2 levels (but obtain similar results if we used the pre agreement weights) and use the import penetration level in 2005 (which is twice as high as before).

Next we calculate the average total effect, which also includes the price impact generated by changing uncertainty alone.[59]

$$\mathbb{E}\left(\ln R_{0V} - \ln R_{mV}\right)|_{\tau,D} = b_{\gamma}\mathbb{E}\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + k\left(\ln P_0/P_m\right)|_{\tau,D}$$

In Appendix A.5.1 we show how the model allows us to use the data and estimated parameters to calculate the growth in the price index due to eliminating uncertainty: $\ln P_0/P_m \approx -\gamma\frac{d\ln P_m}{d\gamma}|_{\gamma=0}$. This growth is about -0.8 log points so $k\left(\ln P_0/P_m\right)|_{\tau,D}$ is -2 log points, which we add to the partial effect to obtain the average total effect in the last column of Table 4: 32 log points.

Another way to quantify the importance of uncertainty on trade is to ask what its transport cost equivalent is, i.e. how large a change in average transport cost is required to generate the change in trade caused by the uncertainty change. We obtain this for the partial effect in column 2 of Table 4 by dividing the impact of uncertainty calculated above by the transport cost elasticity, which implies a transport cost equivalent of 13 percentage points. We can also calculate the applied tariff advalorem equivalent, which is 9 percentage points, as we report in Table 4.[60]

We also quantify how much of the change in exports can be accounted for by the uncertainty removal. Denoting the export level predicted by removing uncertainty alone by $\hat{R}$ we calculate the ratio of the predicted change to the observed, $(\hat{R} - R_{00})/(R_{05} - R_{00})$. In column 2 of Table 4 we use $\hat{R} = \sum_V R_{00V}\exp\left(\hat{b}_{\gamma}\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)\right)$ and find that uncertainty accounted for 34% of the observed import growth. In the third column we find that including the price effect reduces the share to 32%.[61]

We now examine the impact of uncertainty on consumer welfare. In particular we ask: what are the bounds on the percent change in expected consumer welfare from raising policy uncertainty to its pre-agreement level? Recall that in (36) we decomposed the impact of uncertainty into a "*within state welfare effect*", which when multiplied by γ yields $-\mu\gamma\frac{d\ln P_m}{d\gamma}|_{\gamma=0}{=}{-}0.8\mu$ percent, and a "*mean state switching welfare effect*". The latter reflects the higher probability that tariffs will transition to a new state and would require information we do not have (namely on transition probabilities in other states and the consumer discount factor, $\tilde{\beta}$). However, since applied tariffs under the MFN and post agreement state were very similar the mean state switching effect would further decrease welfare.[62]

[59] We obtain this by adding the price effect subsumed in the A term in (39) to the partial effect represented by the middle expression in (44).

[60] Note that the calculation of the applied tariff equivalent applies exactly only after the agreement when uncertainty is eliminated and so it should be interpreted as the increase in the applied tariff required after such an agreement to eliminate the export growth caused by uncertainty reduction. The transport cost equivalent is not subject to this issue because it does not enter the uncertainty variable. The advalorem equivalents are very similar for the average partial and total effect of tariffs (and transport costs) because similarly to the uncertainty variable these variables also have price index effects, which we take into account in calculating the advalorem equivalent.

[61] For the third column we use $\hat{R} = \Sigma_V R_{00V}\exp\left(\hat{b}_{\gamma}\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + k\left(\ln P_0/P_m\right)|_{\tau,D}\right)$.

[62] As we show in appendix A.5.3 the reason why we can approximate this welfare effect without the technology parameters is that they are reflected in the export level that we use to weight up the change in the cutoffs that generate the price index change.

To place the welfare effect in context, consider a consumer that spends all income on differentiated products ($\mu = 1$). In this case increasing uncertainty back to the pre agreement level would reduce expected welfare by at least 0.8 percent (the within state effect) and at most by about 1.8 percent—the full change in the price index in the deterministic vs. column 2 state. By comparison, Broda and Weinstein (2006) estimate that the real income gain from new imported varieties in the U.S. between 1990-2001 was 0.8 percent.[63] Costinot and Rodríguez-Clare (Forthcoming) calculate that a worldwide tariff war (uniform tariffs of 40%) would lower North American welfare by 0.7 percent in a static model with heterogenous firms, monopolistic competition and multiple sectors.[64]

In sum, the quantification indicates that the reduced policy uncertainty accounted for a large share of the increased exports in 2000-2005, nearly a third. Even the specifications that generate more conservative estimates (e.g. column 4 of Table A3) can account for about a quarter of that change.

Nonlinear quantification and risk decomposition

The quantification we used thus far employed the baseline estimates that relied on a linear approximation of the uncertainty term, U. We can also examine the predicted effect of uncertainty using the non-linear estimates in Table A7, which did not require any approximation to the uncertainty term. The equivalent of the partial effect in (44) is given by

$$\begin{aligned}\mathbb{E}\left(\ln R_{0V} - \ln R_{mV}\right)|_{\tau,D,P} &= -\left(k - \sigma + 1\right)\mathbb{E}\left[\ln U_m\left(\tilde{\omega}_V\right)\right] \\ &= -\frac{b_d - \sigma + 1}{\sigma - 1}\mathbb{E}\left[\ln \frac{1 + \tilde{b}_\gamma\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}}{1 + \tilde{b}_\gamma / g}\right] \qquad (45)\end{aligned}$$

where the first line assumes, consistent with evidence, that uncertainty is insignificant after the agreement ($\ln U_0(\tilde{\omega}_V) = 0$). The second line uses the definitions of the parameters estimated in the NLLS: $\tilde{b}_\gamma = \frac{\beta t_{m2}}{1-\beta t_{22}} g$ and $b_d = k$. [65] In the first row of Table 5 we provide the results, which yield a partial effect of 26 log points. We can also calculate the full general equilibrium effect and find it is 22 log points and accounts for 21% of observed export growth. The smaller point estimate here relative to its counterpart in the baseline estimates (column 2 of Table 4) reflects both the nonlinearity of the impact of the uncertainty variable and the slightly higher elasticity of exports to trade costs (which generates a stronger role for the price index change on exports). However, the price index effect caused by the uncertainty change is identical when we use the baseline or these estimates, -0.8, and thus so is the welfare impact.

[63] As is standard in most trade models neither of these quantifications takes into account services. However, the model and calculations do take into account the large fraction of non-traded goods since many of the differentiated goods are produced by firms that are not productive enough to export. This is reflected in the low values of import penetration from China, which captures imports/US consumption.

[64] Our model differs on some important dimensions: e.g. uncertainty, sunk costs, an outside good and no free entry in the domestic market. Clearly, the specification of the model affects the welfare calculation, e.g. Ossa (2011) calculates a welfare cost of 3.5% for the US if all countries move from equilibrium cooperative tariffs to a Nash tariff war in a deterministic tariff setting with homogenous firms.

[65] In Table A7 column 2 we found $b_d = 4.4$ and $b_\gamma = 0.82 = \frac{b_d - \sigma + 1}{\sigma - 1}\tilde{b}_\gamma$, so $\tilde{b}_\gamma = 0.69$ from which we re-calculate g=1.07.

We further use these estimates to determine which fraction of the export growth due to the agreement is attributable to a mean preserving tariff risk reduction. To do so we first decompose the impact of an agreement that permanently changes tariffs from τ_m to τ_0 into two components:

$$\ln \frac{R_{0V}(\tau_0)}{R_{mV}(\tau_m)} = \underbrace{\ln \frac{R_{0V}(\tau_m)}{R_{mV}(\tau_m)}}_{\text{Credibility}} + \ln \frac{R_{0V}(\tau_0)}{R_{0V}(\tau_m)} \tag{46}$$

where the RHS follows by addition and subtraction of $\ln R_{0V}(\tau_m)$, the counterfactual export value if applied tariffs under the agreement were τ_m instead of τ_0. This permits us to interpret the first term as a *credibility effect* of the agreement: the export growth from making pre-agreement tariffs permanent. The second term captures the effect of any applied tariff reductions that occur after WTO entry when uncertainty has been reduced. In this application $\tau_0 \approx \tau_m$ so the second term is small—less than 2 log points on average. We can decompose the credibility effect as follows

$$\ln \frac{R_{0V}(\tau_m)}{R_{mV}(\tau_m)} = \ln \frac{R_{0V}(\bar{\tau})}{R_{mV}(\bar{\tau})} + \left[\ln \frac{R_{0V}(\tau_m)}{R_{0V}(\bar{\tau})} - \ln \frac{R_{mV}(\tau_m)}{R_{mV}(\bar{\tau})}\right] \tag{47}$$

where $\bar{\tau}$ is the vector representing the long-run mean of the tariff in each industry. So the first term is the growth in exports due to credibly setting tariffs permanently at their long-run mean, i.e. a mean preserving compression in tariffs. If the initial tariff τ_m was at the long-run mean then all of the credibility effect would be accounted for by the risk reduction. However, if the initial tariffs are below the long-run mean then the agreement will have an additional effect of locking in lower mean tariffs. The latter effect is captured by the term in brackets and is positive because permanent reductions in tariffs relative to the mean—the first term—have larger effect on exports than temporary ones—the second term.

We quantify the risk reduction term, $\ln \frac{R_{0V}(\bar{\tau})}{R_{mV}(\bar{\tau})}$, by using the partial effect expression in (45) evaluated at the mean tariff for each industry,$\bar{\tau}_V$. In order to compute the mean tariff we require two additional assumptions. First, the column 2 state is absorbing ($t_{22} = 1$) so starting at τ_{mV} the long-run mean is $\bar{\tau}_V = \frac{t_{m0}}{t_{m0}+t_{m2}}\tau_{0V} + \frac{t_{m2}}{t_{m0}+t_{m2}}\tau_{2V}$, reflecting the probability of going into an agreement relative to a trade war *conditional* on abandoning the temporary MFN policy. Second, to compute $\bar{\tau}_V$ we must consider alternative odds of the agreement relative to trade war state. In our baseline we consider $t_{m0}/t_{m2} = 2$, which yields $\bar{\tau}_V$ ranging from 1 to 2.04 with an average of 1.15 and implies an average export growth of 10 log points due to tariff risk reduction. Recalling that the average partial effect was about 26 log points (Table A9), we see that the risk reduction component is almost 40 percent of that value.[66]

[66] For alternative odds of entering the WTO vs. a trade war of 3:1 and 1:1, we find the total growth from risk reduction is between 7 and 15 log points.

3.7 Additional Results: policy uncertainty and entry

We now examine the effect of policy uncertainty on entry. We first explore the structure of the model and estimates from the export equation to quantify the role of entry and then ask if there is corroborating evidence from estimates that use detailed product level data.

The model predicts that the number of Chinese varieties exported to the U.S. at time t in industry V, denoted by n_{tV}, is at least $G(c_{tV}^U)N_V$ —the fraction $G(\cdot)$ of all available Chinese varieties N_V that have costs below the entry threshold. Moreover, recall that when the current policy conditions are no worse than in the past, e.g. when $s = 0$ or m at time t, then $n_{tV} = G(c_{tV}^U)N_V$. We can then use the Pareto assumption and the derived cutoff, c_{tV}^U, to provide a general expression for the number of varieties before or after the agreement. Doing so and then taking the difference between one period before and after WTO accession, as done for the export equation, we obtain

$$\Delta \ln n_{tV} = -k \ln U_{tV} - \frac{k\sigma}{\sigma - 1} \Delta \ln \tau_V - k\Delta \ln d_V + \frac{k}{\sigma - 1} \Delta \ln A + u_V \tag{48}$$

The following points are relevant. First, the elasticity of entry with respect to tariffs is the same as in the export equation and that is also the case for export costs. Second, the elasticity of entry with respect to U is now higher by a factor $k/(k - \sigma + 1)$ since U does not affect the intensive margin directly unless firms upgrade.

We use these relationships between coefficients to derive the entry counterparts of the upper bound, partial and GE effects in the export quantification. For the partial effect for example, we calculate

$$\begin{aligned} \mathbb{E}(\ln n_{0V} - \ln n_{mV})|_{\tau,D,P} &= -k\mathbb{E}(\ln U_m(\tilde{\omega}_V)) \\ &= \frac{k}{k - \sigma + 1} \mathbb{E}(\ln R_{0V} - \ln R_{mV})|_{\tau,D,P} \end{aligned} \tag{49}$$

Since we are exploring the model structure very closely for this exercise we focus on the NLLS estimates for the export equation that are closer to the theoretical model (column 2 Table A7). The estimates in the second row of Table 5 show that reducing uncertainty increased Chinese exported varieties by 48 log points if we ignore the price index effect and 44 when we do take it into account. These results also apply to the growth of firms that upgrade in 2000-2005 since the model predicts that their cutoff is proportional to the entry cutoff up to a constant factor.

We also ask if there is additional evidence for the entry predictions by exploring the product data at a more disaggregated level than the HS-6. More specifically, we examine the growth in the number of traded products within each industry as a proxy for new varieties exported. With access to firm level data one could construct a variety measure as a firm by HS-10 product. In the appendix, we show that without such data we can still provide an estimate of the effect of uncertainty on variety entry if the mapping from the number of HS-10 categories to varieties is similar across industries.

Given the data limitations, our goals are simply to examine whether there is corroborating evidence for the entry uncertainty channel identified in our trade flow regressions and if so quantify its importance.[67] As shown in the appendix, if we use the growth in the product count as a proxy for variety entry we can identify the coefficients in (48) up to a factor, $\nu' \in [0,1]$. The identifying condition is that this factor is similar across industries, which allows us to estimate the following equation

$$\Delta \ln (pcount_V) = b^e_\gamma \left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + b^e_\tau \Delta \ln \tau_V + b^e_d \Delta \ln D_V + b^e + e_V \tag{50}$$

when we again approximate the uncertainty term around $\gamma = 0$, as in the baseline export results.

In Table 6, we report the results of the specifications analogous to the baseline Table 2 but now focusing on variety growth. The first column shows the baseline specification and we find that all three variables have the predicted sign and are statistically significant. In column 3 we control for section effects and find similar results. In both cases we test and fail to reject that $b^e_\tau / b^e_d = \sigma / (\sigma - 1)$ and impose this constraint in columns 2 and 4. We can see that the point estimates of the tariff and transport cost elasticity are lower than their respective values in the export equation (Table 2 column 4), which is consistent with the fact that the parameters here are scaled by $\nu' \in [0,1]$.

In order to quantify the impact of uncertainty on entry we can perform similar exercises to the ones using the export estimates. Therefore, Table 7 is the analog of Table 4 for variety growth. First, recall that the tariff advalorem equivalent of removing uncertainty can be obtained as the average change in tariffs that would deliver the same expected growth in exported varieties as the uncertainty removal. As the model predicts, the impact of uncertainty relative to tariffs is higher for entry (0.17) than for trade flows (0.088). Similarly we can calculate the transport cost advalorem equivalent, which is 0.25, and verify that it is higher than for trade flows (0.13).

We compute a general equilibrium impact of uncertainty on entry of 0.64, which is higher than the structural, nonlinear estimate above.[68] To place these entry quantifications in context we note that the *total* growth in the number of Chinese exporting firms to the world over this period was 0.83 (Ma et al., 2013). So if the *average* growth of varieties to the U.S. is not too far from that total growth, then policy uncertainty removal would have accounted for a substantial part of that increase.

[67] While in the theoretical model we identify a variety with a unique firm by assuming an entrepreneur is endowed with a single blueprint we can allow each to be endowed with multiple variety blueprints. If the export entry and upgrade costs are independent across the number of varieties a firm produces then our results would hold in this setting.

[68] For details of this calculation see the appendix.

4 Conclusion

We assess the impact of U.S. trade policy uncertainty toward China in a tractable general equilibrium framework with heterogeneous firms. We show that increased policy uncertainty reduces investment in export entry and technology upgrading, which in turn reduces trade flows and real income for consumers. We apply the model to the period surrounding China's accession to the WTO. China's WTO membership lead the U.S. to grant it permanent most-favored-nation tariff treatment, ending the annual threat to revoke MFN and subject Chinese imports to Smoot-Hawley tariffs. While much work has focused on the costs of Chinese import penetration to employment and wages, we focus on the potential for gains from reducing trade policy uncertainty.

We derive observable, theory-consistent measures of policy uncertainty and estimate its effect on trade flows, prices and welfare. Had MFN status been revoked, Chinese exporters would have faced an average profit loss of over 50%. We find that the removal of this threat upon WTO accession can account for up to one third of the increase in Chinese exports to the U.S. in 2000-2005. About 40% of the growth can be attributed to a mean preserving tariff risk reduction and the remaining is due to locking in the applied MFN tariff below the long-run mean. The welfare cost of this uncertainty was at least 0.8 percent of consumer real income (if most of their income was spent on differentiated goods). We therefore also quantify a new source of gains from trade agreements, even if applied tariff changes are small.

Our findings have implications beyond this particular important event. They suggest that U.S. threats to impose tariffs against "currency manipulators" or not renew unilateral preferences to developing countries are currently reducing imports and consumer welfare. More broadly, our results provide evidence that one of the important channels through which the WTO can increase trade and welfare is by reducing trade policy uncertainty and thereby increasing export entry and technology upgrading.

References

Arce, H. and Taylor, C. (1997), The effects of changing U.S. MFN status for China, *Review of World Economics (Weltwirtschaftliches Archiv)*, 133(4):737-753.

Arkolakis, C., Costinot, A. and Rodriguez-Clare, A. (2012). New Trade Models, Same Old Gains?, *American Economic Review*, 102(1):94-130.

Auer, R. A. and Fischer, A, M. (2010). The effect of low-wage import competition on U.S. inflationary pressure, *Journal of Monetary Economics*, 57(4):491-503.

Autor, D., Dorn, D. and Hanson, G. (Forthcoming). The China Syndrome: Local Labor Market Effects of Import Competition in the United States. *American Economic Review*.

Baker, S., Bloom, N. and Davis, S. (2012). Has Economic Policy Uncertainty Hampered the Recovery?, Working Papers 2012-003, Becker Friedman Institute for Research In Economics.

Berger, B. and Martin, R. (2013) The growth of Chinese exports: an examination of the detailed trade data,*China and the World Economy*, 21(1):64-90.

Bernanke, B. S. (1983). Irreversibility, Uncertainty, and Cyclical Investment. *The Quarterly Journal of Economics*, 98(1):85-106.

Blonigen, B. A. and Ma, A. C. (2010). Please Pass the Catch-Up: The Relative Performance of Chinese and Foreign Firms in Chinese Export, in Feenstra, R. C. and Wei, S.-J. editors, *China's Growing Role in World Trade*, NBER Books, National Bureau of Economic Research, Inc, p. 475-509.

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

Bown, Chad P. (2012). Temporary Trade Barriers Database, *The World Bank,* available at http://econ.worldbank.org/ttbd/

Brambilla, I, Khandelwal, A., and Schott, P. (2010) China's Experience under the Multi-Fiber Arrangement (MFA) and the Agreement on Textiles and Clothing (ATC), NBER Chapters, *China's Growing Role in World Trade*, p. 345-387. National Bureau of Economic Research, Inc.

Brandt, L., Van Biesebroeck, J. and Yifan Zhang.(2012) Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing, *Journal of Development Economics*, 97: 339–351.

Broda, C. and Weinstein, D. (2006). Globalization and the gains from variety. *The Quarterly Journal of Economics*, 121(2):541-585.

Bustos, P. (2011). Trade liberalization, exports, and technology upgrading: evidence on the impact of MERCOSUR on argentinian firms. *American Economic Review*, 101(1):304-40.

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

Costinot, A. and Andrés Rodríguez-Clare. (Forthcoming). Trade Theory with Numbers: Quantifying the Consequences of Globalization. *Handbook of International Economics*, Vol. 4, eds. Gopinah, Helpman and Rogoff.

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

Handley, K. and Limão, N. (2012). Trade and Investment under Policy Uncertainty: Theory and Firm Evidence. NBER Working Papers 17790.

Handley, K. (2012). Exporting under Trade Policy Uncertainty: Theory and Evidence, Working Paper, University of Michigan. http://webuser.bus.umich.edu/handleyk/eutpu.pdf

Hardle, W. and E. Mammen. (1993). Comparing Nonparametric Versus Parametric Regression Fits. *Annals of Statistics*, 21(4): 1926-1947.

Hsieh, C.-T. and Klenow, P. J. (2009). Misallocation and Manufacturing TFP in China and India, *The Quarterly Journal of Economics*, 124(4):1403-48.

International Monetary Fund (2010). World Economic Outlook. Chapter 4.

Lileeva, A. and Trefler, D. (2010). Improved Access to Foreign Markets Raises Plant-Level Productivity... for Some Plants, *The Quarterly Journal of Economics*, 125(3):1051-1099.

Limão, N. and G. Maggi. (2012). Uncertainty and Trade Agreements. NBER Working Papers 18703.

Manova, K. and Zhang, Z. (2009) China's Exporters and Importers: Firms, Products and Trade Partners, NBER Working Papers 15249.

Ossa, R. (2011). Trade Wars and Trade Talks with Data. NBER Working Papers 17347.

Pierce, J.R. and Schott, P. K. (2012). The Surprisingly Swift Decline of U.S. Manufacturing Employment, NBER Working Papers 18655.

Pregelj, V. (2001) Most-Favored-Nation Status of the People's Republic of China. *CRS Report for Congress.*

Roberts, M. J. And Tybout, J. (1997). The Decision To Export In Colombia: An Empirical Model Of Entry With Sunk Costs *American Economic Review*, 87(4):545-64

Robinson, P. M. (1988). Root-N-Consistent Semiparametric Regression. *Econometrica*, 56(4): 931-954.

Rodrik, D. (1991). Policy Uncertainty And Private Investment In Developing Countries. *Journal of Development Economics*, 36(2):229-242.

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

Subramanian, A, and SJ Wei. 2007. The WTO promotes trade, strongly but unevenly. *Journal of International Economics* 72(1):151-175.

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

Zeng, K. (2003). *Trade Threats, Trade Wars: Bargaining, Retaliation, and American Coercive Diplomacy*, University of Michigan Press.

A Theory Appendix

A.1 Entry threshold

In this appendix we provide the details for deriving the entry thresholds presented in section 2.2.

Derivation of expected value of exporting (MFN), eq. (7)

$$\Pi_e(a_m,c)\,(1-\beta t_{mm}) = \pi(a_m,c) + \beta\left[t_{m0}\Pi_e(a_0,c) + t_{m2}\Pi_e(a_2,c)\right]$$
$$\Pi_e(a_m,c)\,(1-\beta t_{mm}) = \pi(a_m,c) + \beta\left[t_{m0}\frac{\pi(a_0,c)+\beta t_{0m}\Pi_e(a_m,c)}{1-\beta t_{00}} + t_{m2}\frac{\pi(a_2,c)+\beta t_{2m}\Pi_e(a_m,c)}{1-\beta t_{22}}\right]$$

$$\Pi_e(a_m,c) = \frac{\pi(a_m,c)}{1-\beta t_m} + \frac{\beta}{1-\beta t_m}\textstyle\sum_{s\neq m} t_{ms}\frac{\pi(a_s,c)}{1-\beta t_{ss}} \tag{51}$$

Derivation of expected value of waiting (MFN), eq. (11)

To obtain (11) we simplify (10) using (8) and (6) evaluated at the threshold for entry at MFN along with (4), i.e. $\Pi_e(a_m,c_m^U)-K=\Pi_w(a_m,c_m^U)$

$$\Pi_w(a_m,c_m^U) = \frac{\beta}{1-\beta t_{mm}}\left[t_{m2}\frac{\beta t_{2m}\left[\Pi_e(a_m,c_m^U)-K\right]}{1-\beta t_{22}} + t_{m0}\left[\frac{\pi(a_0,c_m^U)+\beta t_{0m}\Pi_e(a_m,c_m^U)}{1-\beta t_{00}} - K\right]\right]$$
$$\Pi_w(a_m,c_m^U) = \frac{\beta t_{m0}}{1-\beta\left(t_{mm}+t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}}\right)}\left[\frac{\pi(a_0,c_m^U)+\beta t_{0m}\Pi_e(a_m,c_m^U)}{1-\beta t_{00}} - K\right]$$

Derivation of cutoff at MFN

Using the value of export in (7) and the value of waiting in (11), we can use the indifference condition in (4) to solve for the cutoff c_m^U. Below we simplify notation using $\tilde{t}-t_{m0}\equiv t_{mm}+t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}}$ and $\Pi\equiv\Pi_e(a_m,c_m^U)$

$$\Pi - K = \frac{\beta t_{m0}}{\left(1-\beta\left(\tilde{t}-t_{m0}\right)\right)}\left[\frac{\pi(a_0,c_m^U)+\beta t_{0m}\Pi}{1-\beta t_{00}} - K\right] \tag{52}$$
$$\left(1-\beta\left(\left(\tilde{t}-t_{m0}\right)+\frac{t_{m0}\beta t_{0m}}{1-\beta t_{00}}\right)\right)\Pi = \frac{\beta t_{m0}\pi(a_0,c_m^U)}{1-\beta t_{00}} + K\left(1-\beta\tilde{t}\right)$$

noting that the LHS is simply $(1-\beta t_m)\,\Pi$ since $t_m\equiv t_{mm}+\beta\left[t_{m0}\frac{t_{0m}}{1-\beta t_{00}}+t_{m2}\frac{t_{2m}}{1-\beta t_{22}}\right] = \left(\tilde{t}-t_{m0}\right)+\frac{t_{m0}\beta t_{0m}}{1-\beta t_{00}}$ we can replace it with the value in (51) to obtain

$$\pi(a_m,c_m^U) + \beta\textstyle\sum_{s\neq m} t_{ms}\frac{\pi(a_s,c_m^U)}{1-\beta t_{ss}} = \frac{\beta t_{m0}\pi(a_0,c_m^U)}{1-\beta t_{00}} + K\left(1-\beta\tilde{t}\right)$$
$$\pi(a_m,c_m^U) + \beta t_{m2}\frac{\pi(a_2,c_m^U)}{1-\beta t_{22}} = K\left(1-\beta\tilde{t}\right)$$

Using the profit function in (2) to write as a function of cost we can then simplify to obtain

$$\left(c_m^U\right)^{\sigma-1} = \frac{1}{K\left(1-\beta\tilde{t}\right)}\left[a_m + \beta t_{m2}\frac{a_2}{1-\beta t_{22}}\right]$$
$$c_m^U = \underbrace{\left[\frac{a_m}{K\left(1-\beta\right)}\right]^{\frac{1}{\sigma-1}}}_{c_m^D}\underbrace{\left[\frac{1-\beta}{1-\beta\tilde{t}}\left(1+\frac{\beta t_{m2}}{\left(1-\beta t_{22}\right)}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right]^{\frac{1}{\sigma-1}}}_{U_m}$$

Proof for $\frac{d\ln c_m^U}{d\gamma} < 0$

$$\begin{aligned}
\frac{d\ln c_m^U}{d\gamma} &= \frac{1}{\sigma-1}\frac{d}{d\gamma}\left[\ln\frac{1-\beta}{1-\beta\tilde{t}}\left(1+\frac{\beta\gamma p_2}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right] \\
&= \frac{1}{\sigma-1}\left(-\frac{d\ln\left(1-\beta\tilde{t}\right)}{d\tilde{t}}\frac{d\tilde{t}}{d\gamma}+\frac{d}{d\gamma}\ln\left(1+\frac{\beta\gamma p_2}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right) \\
&= \frac{1}{\sigma-1}\frac{\beta p_2}{1-\beta t_{22}}\left(-\left(\frac{1-\beta}{1-\beta\tilde{t}}\right)+\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}/\left(1+\frac{\beta\gamma p_2}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right)
\end{aligned}$$

where the third line uses $\tilde{t} \equiv t_{mm} + t_{m0} + t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}} = 1-\gamma+\gamma\left(1-p_2\right)+\gamma p_2\frac{\beta t_{2m}}{1-\beta t_{22}}$ and simplifies.

Around $\gamma = 0$ we have $\frac{d\ln c_m^U}{d\gamma}|_{\gamma=0} = \frac{1}{\sigma-1}\frac{\beta p_2}{1-\beta t_{22}}\left(\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}-1\right) < 0$. The inequality holds for all γ

$$\begin{aligned}
\frac{d\ln c_m^U}{d\gamma} &< 0 \\
\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} &< \left(1+\frac{\beta\gamma p_2}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\left(\frac{1-\beta}{1-\beta\tilde{t}}\right) \\
\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\left(1-\frac{\beta\gamma p_2}{\left(1-\beta t_{22}\right)}\left(\frac{1-\beta}{1-\beta\tilde{t}}\right)\right) &< \left(\frac{1-\beta}{1-\beta\tilde{t}}\right) \qquad (53) \\
\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\left[\left(1-\beta t_{22}\right)\left(1-\beta\tilde{t}\right)-\beta t_{m2}\left(1-\beta\right)\right] &< \left(1-\beta\right)\left(1-\beta t_{22}\right)
\end{aligned}$$

This holds because $\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} < 1$ and the term in brackets on the LHS simplifies to the term on the RHS, $(1-\beta)(1-\beta t_{22})$, after we use the definition for $\tilde{t}$ as well as $t_{2m} = 1 - t_{22}$.

Ordering of cutoffs:

We now prove $c_m^U = c_m^D U_m < c_m^D$, i.e. $U_m < 1$ if $t_{m2} > 0$ and $\frac{\tau_2}{\tau_m} > 1$

More generally we show the following ordering of cutoffs

$$c_2^U = c_2^D < c_m^U < c_m^D \le c_0^U = c_0^D$$

where the last equality is true if $t_{0m} = 0$

1. $c_m^D \le c_0^U = c_0^D$ is obvious given that tariffs are lower (or no higher) under $s = 0$ than $s = m$
2. $c_m^U < c_m^D$ if $t_{m2} > 0$ and $\frac{\tau_2}{\tau_m} > 1$ $(U_m < 1)$

$$c_m^U = c_m^D U_m < c_m^D$$

$$U_m = \left[\frac{1-\beta}{1-\beta\tilde{t}}\left(1+\frac{\beta t_{m2}}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right]^{\frac{1}{\sigma-1}} < 1 \tag{54}$$

$$\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\left[(1-\beta)\frac{\beta t_{m2}}{1-\beta t_{22}}\right] < 1-\beta\tilde{t}-(1-\beta)$$

This inequality holds because $\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} < 1$ and the term in brackets on the LHS simplifies to the term on the RHS after we use the definition for $\tilde{t}$ as well as $t_{2m} = 1 - t_{22}$.

3. $c_2^U = c_2^D < c_m^U$

$$c_2^U = c_2^D = \left[\frac{a_2}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}} < c_m^D\left[\frac{(1-\beta)(1-\beta t_{22})+(1-\beta)\beta t_{m2}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}}{\left(1-\beta\tilde{t}\right)(1-\beta t_{22})}\right]^{\frac{1}{\sigma-1}}$$

$$\left[\frac{a_2}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}} < \left[\frac{a_m}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}}\left[\left(1+\frac{\beta t_{m2}}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\frac{1-\beta}{1-\beta\tilde{t}}\right]^{\frac{1}{\sigma-1}}$$

$$\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} < \left(1+\frac{\beta t_{m2}}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\frac{1-\beta}{1-\beta\tilde{t}}$$

This is the same inequality as in (53) that we showed to hold when proving $\frac{d\ln c_m^U}{d\gamma} < 0$.

A.2 Technological upgrade threshold

In this appendix we provide the details for deriving the upgrade thresholds presented in section 2.3.

Derivation of $\Pi_{wz}(a_s, c, z)$.

For $s = 0$ if it is not optimal to upgrade then the firm obtains $\pi(a_0, c)$ today and for all future periods since conditions can't improve, therefore it is equal to the expected value of exporting at the original technology

$$\Pi_{wz}(a_0, c, z) = \Pi_e(a_0, c) \tag{55}$$

for the remaining states we have $\Pi_{wz}(a_m, c, z)$, given by (21) in the text and for $s = 2$ we have the following for $c \in [c_{2z}^U, c_{mz}^U]$

$$\Pi_{wz}(a_2, c, z) = \pi(a_2, c) + \beta\left[t_{22}\Pi_{wz}(a_2, c, z) + t_{2m}\left[\Pi_{ez}(a_m, zc) - K_z\right]\right] \tag{56}$$

$$\Pi_{wz}(a_2, c, z)(1-\beta t_{22}) = \pi(a_2, c) + \beta t_{2m}\left[\Pi_{ez}(a_m, zc) - K_z\right]$$

Reduced form of $\Pi_{wz}(a_m, c, z)$

Using (21), (56) and (20) we obtain

$$\Pi_{wz}(a_m, c_{mz}^U, z)(1-\beta t_{mm}) = \pi(a_m, c_{mz}^U) + \beta\left[\frac{t_{m2}}{1-\beta t_{22}}\left[\pi(a_2, c_{mz}^U) + \beta t_{2m}\left[\Pi_{ez}(a_m, zc_{mz}^U) - K_z\right]\right] + t_{m0}\left[z^{1-\sigma}\Pi_e(a_0, c_{mz}^U) - K_z\right]\right]$$

$$\Pi_{wz}(a_m, c_{mz}^U, z)\left(1-\beta\hat{t}\right) = \pi(a_m, c_{mz}^U) + \beta\left[\frac{t_{m2}}{1-\beta t_{22}}\pi(a_2, c_{mz}^U) + t_{m0}\left[z^{1-\sigma}\frac{\pi(a_0, c) + \beta t_{0m}\Pi_e(a_m, c)}{1-\beta t_{00}} - K_z\right]\right]$$

where $\hat{t} \equiv t_{mm} + \beta t_{m2} \frac{t_{2m}}{1-\beta t_{22}}$.

MFN cutoff derivation (c^U_{mz})

$$
\begin{aligned}
z^{1-\sigma}\Pi_e(a_m, c^U_{mz}) - K_z &= \Pi_{wz}(a_m, c^U_{mz}, z) \\
\left[z^{1-\sigma}\Pi_e(a_m, c^U_{mz}) - K_z\right]\left(1-\beta\hat{t}\right) &= \pi(a_m, c^U_{mz}) + \beta\left[\frac{t_{m2}\pi(a_2, c^U_{mz})}{1-\beta t_{22}} + t_{m0}\left[z^{1-\sigma}\frac{\pi(a_0, c^U_{mz}) + \beta t_{0m}\Pi_e(a_m, c^U_{mz})}{1-\beta t_{00}} - K_z\right]\right]
\end{aligned}
$$

$$
z^{1-\sigma}\Pi_e(a_m, c^U_{mz})\left(1-\beta t_m\right) = \pi(a_m, c^U_{mz}) + \beta\left[\frac{t_{m2}}{1-\beta t_{22}}\pi(a_2, c^U_{mz}) + \frac{t_{m0}z^{1-\sigma}\pi(a_0, c^U_{mz})}{1-\beta t_{00}}\right] - \left(\beta t_{m0} - \left(1-\beta\hat{t}\right)\right)K_z
$$

$$
\begin{aligned}
z^{1-\sigma}\left(\pi(a_m, c^U_{mz}) + \beta\textstyle\sum_{s\neq m} t_{ms}\dfrac{\pi(a_s, c^U_{mz})}{1-\beta t_{ss}}\right) &= \pi(a_m, c^U_{mz}) + \beta\left[\frac{t_{m2}}{1-\beta t_{22}}\pi(a_2, c^U_{mz}) + \frac{t_{m0}z^{1-\sigma}\pi(a_0, c^U_{mz})}{1-\beta t_{00}}\right] + \left(1-\beta\tilde{t}\right)K_z \\
\left(z^{1-\sigma}-1\right)\left(\pi(a_m, c^U_{mz}) + \beta t_{m2}\frac{\pi(a_2, c^U_{mz})}{1-\beta t_{22}}\right) &= \left(1-\beta\tilde{t}\right)K_z
\end{aligned}
$$

where 4th line uses $t_m \equiv t_{mm} + \beta\left[t_{m0}\frac{t_{0m}}{1-\beta t_{00}} + t_{m2}\frac{t_{2m}}{1-\beta t_{22}}\right]$ from (7) and $\tilde{t} \equiv t_{mm} + t_{m0} + t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}}$.

To solve for the cutoff we use ((2)), factor out c and re-arrange to obtain

$$
\begin{aligned}
c^U_{mz} &= \left[\frac{a_m\left(z^{1-\sigma}-1\right)}{\left(1-\beta\tilde{t}\right)K_z}\left(1 + \frac{\beta t_{m2}}{1-\beta t_{22}}\frac{a_2}{a_m}\right)\right]^{\frac{1}{\sigma-1}} \\
c^U_{mz} &= \left[\frac{1-\beta}{1-\beta\tilde{t}}\left(1 + \frac{\beta t_{m2}}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right]^{\frac{1}{\sigma-1}} c^D_{mz} \\
c^U_{mz} &= U_m c^D_{mz}
\end{aligned}
$$

Worst case upgrade cutoff (c^U_{2z})

Using the cutoff in (19) and evaluating at the equilibrium value of exporting for the marginal upgrader at $s = 2$ (20) and value of waiting in (56) we obtain

$$
\begin{aligned}
z^{1-\sigma}\Pi_e(a_2, c^U_{2z}) - K_z &= \Pi_{wz}(a_2, c^U_{2z}, z) \\
\left[z^{1-\sigma}\left(\frac{\pi(a_2, c^U_{2z}) + \beta t_{2m}\Pi_e(a_m, c^U_{2z})}{1-\beta t_{22}}\right) - K_z\right]\left(1-\beta t_{22}\right) &= \pi(a_2, c^U_{2z}) + \beta t_{2m}\left[z^{1-\sigma}\Pi_e(a_m, c^U_{2z}) - K_z\right] \\
z^{1-\sigma}\pi(a_2, c^U_{2z}) &= \pi(a_2, c^U_{2z}) - \left(\beta t_{2m} - \left(1-\beta t_{22}\right)\right)K_z \\
c^U_{2z} &= \left[\frac{a_2\left(z^{1-\sigma}-1\right)}{\left(1-\beta\right)K_z}\right]^{\frac{1}{\sigma-1}} = c^D_{2z}
\end{aligned}
$$

where the second line uses (6) and the third one uses $t_{2m} + t_{22} = 1$.

Agreement cutoff (c^U_{0z})

Using the cutoff condition (19), as well as (20) and (55) we obtain

$$z^{1-\sigma}\Pi_e(a_0, c^U_{0z}) - K_z = \Pi_e(a_0, c)$$

$$\left(z^{1-\sigma}-1\right)\left[\pi(a_0, c^U_{0z}) + \beta t_{0m}\left(\frac{\pi(a_m, c^U_{0z})}{1-\beta t_m} + \frac{\beta}{1-\beta t_m}t_{m0}\frac{\pi(a_0, c^U_{0z})}{1-\beta t_{00}} + \frac{\beta}{1-\beta t_m}t_{m2}\frac{\pi(a_2, c^U_{0z})}{1-\beta t_{22}}\right)\right] = K_z\left(1-\beta t_{00}\right)$$

where the second line uses (6) and (7). We can factor out the cost and solve the general expression above in the same way we did for the entry cutoff to obtain

$$c^U_{0z} = U_0 c^D_{0z} \tag{57}$$

where U_0 is given by

$$U_0 = \left[\frac{1-\beta}{1-\beta t_{00}}\left(1 + \frac{\beta t_{0m}}{1-\beta t_m}\left(\beta t_{m0} + \left(\frac{\tau_m}{\tau_0}\right)^{-\sigma}\left(1 + \frac{\beta t_{m2}}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right)\right)\right]^{\frac{1}{\sigma-1}} \tag{58}$$

If no exit from the agreement is expected ($t_{00} = 1 = 1 - t_{0m}$) then $U_0 = 1$ as we note in the text and so

$$c^U_{0z}|_{t_{00}=1} = \left[\frac{a_0\left(z^{1-\sigma}-1\right)}{\left(1-\beta\right)K_z}\right]^{\frac{1}{\sigma-1}} = c^D_{0z}$$

Sufficient condition for $c^U_{0z}(\phi) < c^U_2$

As we note in the text this will ensure that the marginal entrant into exporting in any state will never upgrade in any state so the entry cutoffs derived in section 2.2 are unaffected by the possibility of upgrading. To obtain the condition for ϕ such that $c^U_{0z} < c^U_2$ we use the cutoffs previously derived to obtain

$$U_0\left[\frac{a_0\left(z^{1-\sigma}-1\right)}{\left(1-\beta\right)K_z}\right]^{\frac{1}{\sigma-1}} < \left[\frac{a_2}{\left(1-\beta\right)K}\right]^{\frac{1}{\sigma-1}}$$

$$\phi < \left[\frac{a_2}{a_0}\right]^{\frac{1}{\sigma-1}}/U_0 = \left[\frac{\tau_2}{\tau_0}\right]^{\frac{-\sigma}{\sigma-1}}/U_0$$

So if the agreement is absorbing (so $U_0 = 1$) the condition is simply that the upgrading parameter ϕ is sufficiently small or $\left(z^{1-\sigma}-1\right)\frac{K}{K_z} < \left(\frac{\tau_2}{\tau_0}\right)^{-\sigma}$.

A.3 Entry threshold (general equilibrium)

Deriving $c^U_{2T} = c^D_{2T}$

Under $s = 2$ a firm that is indifferent between entering at T or waiting will enter in $T+1$ if it survives either because the tariff state improves or because the aggregate conditions improve. Thus for all $T \geq 0$ the value of waiting and exporting are respectively

$$\Pi_w(a_{2T}, c^U_{2T}) = 0 + \beta\left[t_{22}\Pi_e(a_{2T+1}, c^U_{2T}) + t_{2m}\Pi_e(a_m, c^U_{2T}) - K\right] \tag{59}$$

$$\Pi_e(a_{2T}, c) = \pi(a_{2T}, c) + \beta\left[t_{22}\Pi_e(a_{2T+1}, c) + t_{2m}\Pi_e(a_m, c)\right] \tag{60}$$

Thus a firm is indifferent between the two when $\Pi_e(a_{2T}, c^U_{2T}) - K = \Pi_w(a_{2T}, c^U_{2T})$, which yields $\pi(a_{2T}, c) = (1-\beta)K$ and therefore $c^U_{2T} = c^D_{2T}$.

Deriving c^U_{mT}

The functional form for the expected value of export at $s = m$ is the same as in the baseline (5) and that is also the case for the value of waiting, given by (10). But they are different from the baseline under $s = 2$ due to transition dynamics. More specifically, we require

$$\begin{aligned}\Pi_e(a_{2T=0}, c) &= \pi(a_{2T=0}, c) + \beta\left[t_{22}\Pi_e(a_{2T=1}, c) + t_{2m}\Pi_e(a_m, c)\right] \\ &= \textstyle\sum_{t=0}^{\infty}\left(\beta t_{22}\right)^t \pi(a_{2t}, c) + \frac{\beta t_{2m}}{1-\beta t_{22}}\Pi_e(a_m, c)\end{aligned}$$

where the second line uses the fact that (60) holds for all T and solves it forward.

For the value of waiting we use the fact that a firm that is indifferent between entering at MFN will never want to enter under column 2, independently of how long ago the shock occurred to obtain

$$\begin{aligned}\Pi_w(a_{2T=0}, c_m^U) &= 0 + \beta\left[t_{22}\Pi_w(a_{2T=1}, c_m^U) + t_{2m}\Pi_w(a_m, c_m^U)\right] \\ &= \frac{\beta t_{2m}}{1-\beta t_{22}}\Pi_w(a_m, c_m^U)\end{aligned}$$

Replacing $\Pi_e(a_{2T=0}, c)$ in (5) and $\Pi_w(a_{2T=0}, c_m^U)$ in (10) we obtain respectively

$$\Pi_e(a_m, c) = \pi(a_m, c) + \beta\left[t_{m0}\Pi_e(a_0, c) + t_{mm}\Pi_e(a_m, c) + t_{m2}\textstyle\sum_{t=0}^{\infty}\left(\beta t_{22}\right)^t \pi(a_{2t}, c) + \frac{\beta t_{2m}}{1-\beta t_{22}}\Pi_e(a_m, c)\right]$$

$$\Pi_e(a_m, c) = \frac{1}{1-\beta\left(\tilde{t} - t_{m0}\right)}\left\{\pi(a_m, c) + \beta\left[t_{m0}\Pi_e(a_0, c) + t_{m2}\textstyle\sum_{t=0}^{\infty}\left(\beta t_{22}\right)^t \pi(a_{2t}, c)\right]\right\} \tag{61}$$

$$\begin{aligned}\Pi_w(a_m, c_m^U) &= \beta\left[t_{m0}\left[\Pi_e(a_0, c_m^U) - K\right] + t_{mm}\Pi_w(a_m, c_m^U) + t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}}\Pi_w(a_m, c_m^U)\right] \\ &= \frac{\beta t_{m0}}{1-\beta\left(\tilde{t} - t_{m0}\right)}\left[\Pi_e(a_0, c_m^U) - K\right]\end{aligned}$$

where $\tilde{t} \equiv t_{m0} + t_{mm} + t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}}$

Using the indifference condition and (61), simplifying and solving for c_m^U we have

$$\begin{aligned}\Pi_e(a_m, c_m^U) - K &= \Pi_w(a_m, c_m^U) \\ \pi(a_m, c) + \beta\left[t_{m0}\Pi_e(a_0, c) + t_{m2}\textstyle\sum_{t=0}^{\infty}\left(\beta t_{22}\right)^t \pi(a_{2t}, c)\right] - K\left(1-\beta\left(\tilde{t} - t_{m0}\right)\right) &= \left[t_{m0}\left[\Pi_e(a_0, c_m^U) - K\right]\right] \\ \pi(a_m, c) + \beta\left[t_{m2}\textstyle\sum_{t=0}^{\infty}\left(\beta t_{22}\right)^t \pi(a_{2t}, c)\right] &= \left(1-\beta\tilde{t}\right)K \\ a_m\left[1 + \beta t_{m2}\frac{\sum_{t=0}^{\infty}\left(\beta t_{22}\right)^t a_{2t}}{a_m}\right]c^{1-\sigma} &= \left(1-\beta\tilde{t}\right)K \\ \frac{a_m}{(1-\beta)K}\frac{(1-\beta)}{\left(1-\beta\tilde{t}\right)}\left[1 + \frac{\beta t_{m2}}{1-\beta}\frac{\sum_{t=0}^{\infty}\left(\beta t_{22}\right)^t a_{2t}}{\sum_{t=0}^{\infty}\beta^t a_m}\right] &= c^{\sigma-1} \\ \left[\frac{a_m^D}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}}\left[\frac{a_m}{a_m^D}\right]^{\frac{1}{\sigma-1}} U_m\left(\tilde{\omega}\right) &= c_m^U \\ c_m^U &= c_m^D\frac{P_m}{P_m^D}U_m\left(\tilde{\omega}\right)\end{aligned}$$

where

$$U_m\left(\tilde{\omega}\right) = \left[\frac{1-\beta}{1-\beta\tilde{t}}\left(1 + \frac{\beta t_{m2}}{1-\beta t_{22}}\tilde{\omega}\right)\right]^{\frac{1}{\sigma-1}}$$

This expression is similar to the one we derived in the absence of GE effects in (13). But the proportion of profits lost term is now $\tilde{\omega} = \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} \frac{(1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t A_{2t}}{A_m}$.

$U_m(\tilde{\omega}) < 1$ if $\tilde{\omega} < 1$

$$\left[\frac{1-\beta}{1-\beta\tilde{t}}\left(1+\frac{\beta t_{m2}}{1-\beta t_{22}}\tilde{\omega}\right)\right]^{\frac{1}{\sigma-1}} < 1 \Leftrightarrow \tilde{\omega}\left[(1-\beta)\frac{\beta t_{m2}}{1-\beta t_{22}}\right] < 1-\beta\tilde{t}-(1-\beta) \tag{62}$$

This inequality holds if $\tilde{\omega} < 1$ since the term in brackets on the LHS simplifies to the term on the RHS after we use the definition for $\tilde{t}$ as well as $t_{2m} = 1 - t_{22}$.

$\tilde{\omega} < 1$ when direct effect dominates (27).

$$\tilde{\omega} \equiv \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} \frac{(1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t A_{2t}}{A_m} < 1 \Longleftrightarrow (1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t \pi_{2t} < \pi_m$$

The equivalence is due to the profit definition. The inequality holds since $\pi_{2t} \leq \pi_2$ for all t (lower profits under transition than steady state) and $(1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t \pi_2 = \pi_2 < \pi_m$ where the inequality holds whenever the direct effect dominates (given by condition in 27).

A.4 Technological upgrade threshold (general equilibrium)

Assume $c_{z0}^U < c_{2T=0}^U$ s.t. only the most productive will ever upgrade.

The price index now reflects upgrading and thus the equilibrium value of entry cutoffs change but their functional form does not. We continue to assume the profit ranking condition in (27) still holds, which requires only that we evaluate it using the price index that now reflects upgrading.

1. $c_{z2T}^U = \phi c_{2T}^U$.

Under $s = 2$ a firm that is indifferent between upgrading at T or waiting will upgrade the following period if it survives either because the tariff state improves or because the aggregate conditions improve. Thus for all $T \geq 0$ the value of waiting and upgrading are respectively

$$\Pi_{wz}(a_{2T}, c_{z2T}^U, z) = \pi(a_{2T}, c) + \beta z^{1-\sigma}\left[t_{22}\Pi_e(a_{2T+1}, c_{z2T}^U) + t_{2m}\Pi_e(a_m, c_{z2T}^U) - K_z/z^{1-\sigma}\right] \tag{63}$$

$$z^{1-\sigma}\Pi_e(a_{2T}, c) = z^{1-\sigma}\pi(a_{2T}, c) + \beta z^{1-\sigma}\left[t_{22}\Pi_e(a_{2T+1}, c) + t_{2m}\Pi_e(a_m, c)\right] \tag{64}$$

Thus a firm is indifferent between the two when $z^{1-\sigma}\Pi_e(a_{2T}, c_{z2T}^U) - K_z = \Pi_{wz}(a_{2T}, c_{z2T}^U, z)$, which yields $\left(z^{1-\sigma}-1\right)\pi(a_{2T}, c_{z2T}^U) = (1-\beta)K_z$. Recall that the entry cutoff is implicitly defined by $\pi(a_{2T}, c_{2T}^U) = (1-\beta)K$ and therefore $c_{z2T}^U = \phi c_{2T}^U$ where ϕ is given by (18).

2. $c_{0z}^U = c_{0z}^D = \phi c_0^D$ **when** $t_{00} = 1$**.**

If the agreement is an absorbing state then c_{0z}^U is equal to the deterministic cutoff implicitly given by (16) when evaluated at the price index consistent with it.

3. $c_{mz}^U = \phi c_m^U$

The cutoff under uncertainty when $s = m$ is c_{mz}^U and defined by the indifference condition

$$z^{1-\sigma}\Pi_e(a_m, c_{zm}^U) - K_z = \Pi_{wz}(a_m, c_{zm}^U, z)$$

where $\Pi_e(a_m, c_{zm}^U)$ is given by (61), evaluated at the new equilibrium cutoff.

For the value of waiting we first use the fact that a firm that is indifferent between upgrading at MFN it will never want to upgrade under column 2 to obtain

$$\begin{aligned}\Pi_{wz}(a_{2T=0}, c^U_{zm}, z) &= \pi(a_{2T=0}, c^U_{zm}) + \beta\left[t_{22}\Pi_{wz}(a_{2T=1}, c^U_{zm}, z) + t_{2m}\Pi_{wz}(a_m, c^U_{zm}, z)\right] \\ &= \sum_{t=0}^{\infty}(\beta t_{22})^t \pi(a_{2t}, , c^U_{zm}) + \frac{\beta t_{2m}}{1-\beta t_{22}}\Pi_{wz}(a_m, c^U_{zm}, z)\end{aligned}$$

which we replace in the value of waiting at MFN

$$\begin{aligned}\Pi_{wz}(a_m, c^U_{zm}, z) &= \pi(a_m, c) + \beta\left[t_{m0}\left[z^{1-\sigma}\Pi_e(a_0, c^U_{zm}) - K_z\right] + t_{mm}\Pi_{wz}(a_m, c^U_{zm}, z) + t_{m2}\Pi_{wz}(a_{2T=0}, c^U_{zm}, z)\right] \\ &= \pi(a_m, c) + \beta\left[\begin{array}{c} t_{m0}\left[z^{1-\sigma}\Pi_e(a_0, c^U_{zm}) - K_z\right] + \left(t_{mm} + t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}}\right)\Pi_{wz}(a_m, c^U_{zm}, z) \\ + t_{m2}\sum_{t=0}^{\infty}(\beta t_{22})^t \pi(a_{2t}, c^U_{zm}) \end{array}\right] \\ &= \left[\pi(a_m, c) + \beta t_{m0}\left(z^{1-\sigma}\Pi_e(a_0, c^U_{zm}) - K_z\right) + \beta t_{m2}\sum_{t=0}^{\infty}(\beta t_{22})^t \pi(a_{2t}, c^U_{zm})\right] / \left(1-\beta\left(\tilde{t}-t_{m0}\right)\right)\end{aligned}$$

Using the indifference condition and (61), simplifying and solving for c^U_{mz} we have

$$\begin{aligned}z^{1-\sigma}&\{\pi(a_m, c) + \beta\left[t_{m0}\Pi_e(a_0, c) + t_{m2}\sum_{t=0}^{\infty}(\beta t_{22})^t \pi(a_{2t}, c)\right]\} - K_z\left(1-\beta\left(\tilde{t}-t_{m0}\right)\right) \\ &= \pi(a_m, c) + \beta t_{m0}\left(z^{1-\sigma}\Pi_e(a_0, c^U_{zm}) - K_z\right) + \beta t_{m2}\sum_{t=0}^{\infty}(\beta t_{22})^t \pi(a_{2t}, c^U_{zm})\end{aligned}$$

$$\begin{aligned}\left(z^{1-\sigma}-1\right)\left(\pi(a_m, c) + \beta t_{m2}\sum_{t=0}^{\infty}(\beta t_{22})^t \pi(a_{2t}, c)\right) &= \left(1-\beta\tilde{t}\right)K_z \\ a_m\left(z^{1-\sigma}-1\right)\left[1 + \beta t_{m2}\frac{\sum_{t=0}^{\infty}(\beta t_{22})^t a_{2t}}{a_m}\right]c^{1-\sigma} &= \left(1-\beta\tilde{t}\right)K_z \\ \frac{a_m\left(z^{1-\sigma}-1\right)}{(1-\beta)K_z}\frac{(1-\beta)}{\left(1-\beta\tilde{t}\right)}\left[1 + \frac{\beta t_{m2}}{1-\beta}\frac{\sum_{t=0}^{\infty}(\beta t_{22})^t a_{2t}}{\sum_{t=0}^{\infty}\beta^t a_m}\right] &= c^{\sigma-1} \\ c^U_{mz} &= \phi c^D_m \frac{P_m}{P^D_m} U_m(\tilde{\omega}) \\ c^U_{mz} &= \phi c^U_m(\tilde{\omega})\end{aligned}$$

where $U_m(\tilde{\omega})$ is the same expression we found for (30). So $\tilde{\omega} = \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\frac{(1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t A_{2t}}{A_m} < 1$ when direct effect dominates (27), as shown in the previous section of the Appendix.

A.5 Comparative statics (general equilibrium)

A.5.1 Effect of trade costs on firm entry and price index

Here we derive the impact of tariffs and transport costs on the price index and firm entry. These are used in the quantification section to provide an upper bound for the term g and to calculate the price effect of tariffs and transport cost to include in the GE advalorem equivalent of uncertainty calculation.

Recall that $g \equiv \frac{(1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t A_{2t}}{A_m} \leq \left(\frac{P^D_2}{P^D_m}\right)^{\sigma-1}$ so $g \leq \exp\left((\sigma-1)\ln\frac{P^D_2}{P^D_m}\right)$. So we first provide a linear approximation to the growth in the deterministic price index due to the change in tariffs from MFN to column 2. We do so in the absence of upgrading and then argue that the expression is similar with upgrading (when written as a function of export shares, which will reflect any upgrading). This is shown in section A.5.3 when deriving the elasticities of P wrt cutoffs. A similar argument to the one in that section can be applied here.

Recall that we have an implicit solution to the system of $V+1$ equations $P\left(\mathbf{c}^D,\tau\right)$ and $c_V\left(P^D,\tau_V\right)$ for each V so the total change due to the tariff can be found as follows

$$\begin{aligned} d\ln P\left(\mathbf{c}^D,\tau\right) &= \sum_V \frac{\partial \ln P\left(\mathbf{c}^D,\tau\right)}{\partial \ln c_V^D} d\ln c_V^D + \sum_V \frac{\partial \ln P\left(\mathbf{c}^D,\tau\right)}{\partial \ln \tau_V} d\ln \tau_V \\ &= \frac{k-\sigma+1}{(1-\sigma)} I \sum_V \frac{\tau_V R_V}{\sum_V \tau_V R_V} d\ln c_V^D + I \sum_V \frac{\tau_V R_V}{\sum_V \tau_V R_V} d\ln \tau_V \end{aligned}$$

where $I \equiv \sum_V \tau_V R_V / E$. Below we derive the two partial elasticities used in the second line as follows. Denote Ω_{VC} as the set of varieties in industry V produced by firms in country $C = ch(ina), o(ther)$ so $\Omega = \cup_{VC}\Omega_{VC}$ and the price index, P can then be written as

$$P^{1-\sigma} = \int_{v\in\Omega} (p_v)^{1-\sigma} dv = \sum_{V,ch} \int_{v\in\Omega_{V,ch}} (p_v)^{1-\sigma} dv + \sum_{V,C\neq ch} \int_{v\in\Omega_{VC}} (p_v)^{1-\sigma} dv$$

Using the equilibrium price paid by consumers of imported goods, $p_v = (w_e \tau_V d_V c_v/\rho)$, and the Pareto distribution we then obtain $\frac{\partial \ln P\left(\mathbf{c}_V^D(\tau),\tau\right)}{\partial \ln c_V^D(\tau)}$ as follows

$$\begin{aligned} \frac{\partial \ln P\left(c^D(\tau),\tau\right)}{\partial \ln c_V^D} &= \frac{1}{1-\sigma}\partial \ln\left[\sum_{V,ch} \frac{N_V}{c_V^k} \int_0^{c_V^D} \left((w_e d_V/\rho)\,\tau_V\right)^{1-\sigma} k\,(c)^{k-\sigma} dc + \sum_{V,C\neq china} \int_{v\in\Omega_{VC}} (p_v)^{1-\sigma} dv\right] / \partial \ln c_V^D \\ &= \frac{1}{1-\sigma}\frac{c_V^D}{P^{1-\sigma}}\partial\left[\sum_{V,ch} \frac{N_V}{c_V^k} \int_0^{c_V^D} \left((w_e d_V/\rho)\,\tau_V\right)^{1-\sigma} k\,(c)^{k-\sigma} dc\right] / \partial c_V^D \\ &= \frac{1}{1-\sigma}\frac{c_V^D}{P^{1-\sigma}}\left[\left((w_e d_V/\rho)\,\tau_V\right)^{1-\sigma} \frac{N_V}{c_V^k} k\left(c_V^D\right)^{k-\sigma}\right] \\ &= \frac{k-\sigma+1}{1-\sigma}\frac{\tau_V R_V}{E} \end{aligned}$$

where the last line follows after using $a = E\,(1-\rho)\,(w_e d/P\rho)^{1-\sigma}\,\tau_{sV}{}^{-\sigma}$ and $R_{tV} = a_{tV}\sigma N_V \int_0^{c_1^D} (c)^{1-\sigma} dG(c)$.

The partial tariff elasticity, $\frac{\partial \ln P\left(\mathbf{c}^D,\tau\right)}{\partial \ln \tau_V}|_{\tau_m}$, is obtained as follows

$$\begin{aligned} \frac{\partial \ln P\left(c^D,\tau\right)}{\partial \ln \tau_V} &= \frac{1}{1-\sigma}\partial \ln\left[\sum_{V,ch} N_V \int_0^{c_1^D} \left((w_e d_V c/\rho)\,\tau_V\right)^{1-\sigma} dG(c) + \sum_{V,C\neq china} \int_{v\in\Omega_{VC}} (p_v)^{1-\sigma} dv\right] / \partial \ln \tau_V \\ &= \frac{1}{1-\sigma}\frac{\tau_{mV}}{P_m^{1-\sigma}}\partial\left[\sum_{V,ch} N_V \int_0^{c_1^D} \left((w_e d_V c/\rho)\,\tau_V\right)^{1-\sigma} dG(c)\right] / \partial \tau_{mV} \\ &= \frac{1}{P_m^{1-\sigma}} N_V \int_0^{c_1^D} \left((w_e d_V c/\rho)\,\tau_V\right)^{1-\sigma} dG(c) \\ &= \frac{\tau_V R_V}{E} \end{aligned}$$

where the last line follows after using $a = E\,(1-\rho)\,(w_e d/P\rho)^{1-\sigma}\,\tau_{sV}{}^{-\sigma}$ and $R_{tV} = a_{tV}\sigma N_V \int_0^{c_1^D} (c)^{1-\sigma} dG(c)$.

Weighted effect of tariff on cutoff

$$d\ln c_V\left(P^D,\tau_V\right)=\frac{\partial\ln c_V\left(P^D,\tau_V\right)}{\partial\ln\tau_V}d\ln\tau_V+\frac{\partial\ln c_V\left(P^D,\tau_V\right)}{\partial\ln P^D}d\ln P$$
$$I{\sum}_V\frac{\tau_V R_V}{\Sigma_V\tau_V R_V}d\ln c_V\left(P^D,\tau_V\right)=\frac{-\sigma}{\sigma-1}I{\sum}_V\frac{\tau_V R_V}{\Sigma_V\tau_V R_V}d\ln\tau_V+Id\ln P$$

Impact of tariffs on P

Replacing the cutoff effect above in the price expression and simplifying

$$d\ln P\left(\mathbf{c}^D,\tau\right)=\frac{k-\sigma+1}{(1-\sigma)}\left(\frac{-\sigma}{\sigma-1}I{\sum}_V\frac{\tau_V R_V}{\Sigma_V\tau_V R_V}d\ln\tau_V+Id\ln P\right)+I{\sum}_V\frac{\tau_V R_V}{\Sigma_V\tau_V R_V}d\ln\tau_V$$
$$d\ln P\left(\mathbf{c}^D,\tau\right)\left[1-I\frac{k-\sigma+1}{(1-\sigma)}\right]=\frac{k-\sigma+1}{(1-\sigma)}\left(\frac{-\sigma}{\sigma-1}I{\sum}_V\frac{\tau_V R_V}{\Sigma_V\tau_V R_V}d\ln\tau_V\right)+I{\sum}_V\frac{\tau_V R_V}{\Sigma_V\tau_V R_V}d\ln\tau_V$$
$$d\ln P\left(\mathbf{c}^D,\tau\right)=\left[\left(\frac{-\sigma}{\sigma-1}\right)\frac{k-\sigma+1}{(1-\sigma)}+1\right]\frac{I}{1-I\frac{k-\sigma+1}{(1-\sigma)}}{\sum}_V\frac{\tau_{mV}R_{mV}}{\sum_V\tau_{mV}R_{mV}}d\ln\tau_V$$

If we evaluated the change starting at the MFN values and increasing to column 2 we obtain

$$d\ln P\left(\mathbf{c}^D\left(\tau\right),\tau\right)|_{\tau_m}=\left[\frac{\frac{\sigma}{\sigma-1}\left(k-\sigma+1\right)+\sigma-1}{\left(k-\sigma+1\right)I+\sigma-1}\right]I{\sum}_V\frac{\tau_{mV}R_{mV}}{\sum_V\tau_{mV}R_{mV}}\ln\frac{\tau_{2V}}{\tau_{mV}}$$

Impact of transport cost on P

This can be similarly found if we note that $\frac{\partial\ln P\left(c^D,\tau\right)}{\partial\ln\tau_V}=\frac{\partial\ln P\left(c^D,\tau\right)}{\partial\ln d_V}$ and $d\ln c_V\left(P^D,d_V\right)|_\tau=-d\ln d_V+d\ln P$, so

$$d\ln P\left(\mathbf{c}^D,\tau,\mathbf{d}\right)=\frac{k-\sigma+1}{(1-\sigma)}\left(-I{\sum}_V\frac{\tau_V R_V}{\sum_V\tau_V R_V}d\ln d_V+Id\ln P\right)+I{\sum}_V\frac{\tau_V R_V}{\sum_V\tau_V R_V}d\ln d_V$$
$$d\ln P\left(\mathbf{c}^D,\tau,\mathbf{d}\right)\left[1-I\frac{k-\sigma+1}{(1-\sigma)}\right]=\left(I{\sum}_V\frac{\tau_V R_V}{\sum_V\tau_V R_V}d\ln d_V\right)\frac{k}{\sigma-1}$$
$$d\ln P\left(\mathbf{c}^D,\tau,\mathbf{d}\right)=\left[\frac{k}{\left(k-\sigma+1\right)I+\left(\sigma-1\right)}\right]I{\sum}_V\frac{\tau_V R_V}{\sum_V\tau_V R_V}d\ln d_V$$

A.5.2 Effect of policy uncertainty on firm entry and price index

In equation (35) we provide the semi-elasticity of the price index wrt γ as a function of $\varepsilon_V\equiv\partial\ln P\left(\mathbf{c}\right)/\partial\ln c_V^U$. We now show that this is similar to the deterministic elasticity derived in the last section and then use it to to obtain the relationship between the price index and γ in terms of deep parameters and data. We first do so in the absence of upgrading and then show that the expression is similar with upgrading (when written as a function of export shares, which will reflect any upgrading). We also use the expression to evaluate the general equilibrium impact of changes in uncertainty on entry.

Denote Ω_{VC} as the set of varieties in industry V produced by firms in country $C=ch(ina),o(ther)$ so $\Omega=\cup_{VC}\Omega_{VC}$ and the price index, P can then be written as

$$P^{1-\sigma}=\int_{v\in\Omega}\left(p_v\right)^{1-\sigma}dv={\sum}_{V,ch}\int_{v\in\Omega_{V,ch}}\left(p_v\right)^{1-\sigma}dv+{\sum}_{V,C\neq ch}\int_{v\in\Omega_{VC}}\left(p_v\right)^{1-\sigma}dv$$

Using the equilibrium price paid by consumers of imported goods, $p_v=\left(w_e\tau_V d_V c_v/\rho\right)$, and the Pareto distribution we then obtain ε_V as follows

$$\begin{aligned}\frac{\partial \ln P(\mathbf{c})}{\partial \ln c_V^U} &= (1-\sigma)^{-1}\partial \ln\left[\sum\nolimits_{V,ch}\frac{N_V}{c_V^k}\int_0^{c_V^U}(w_e\tau_V d_V/\rho)^{1-\sigma}k(c)^{k-\sigma}\,dc+\sum\nolimits_{V,C\neq ch}\int_{v\in\Omega_{VC}}(p_v)^{1-\sigma}\,dv\right]/\partial\ln c_V^U\\ &= (1-\sigma)^{-1}\frac{c_V^U}{P^{1-\sigma}}\partial\left[\sum\nolimits_{V,ch}\frac{N_V}{c_V^k}\int_0^{c_V^U}(w_e\tau_V d_V/\rho)^{1-\sigma}k(c)^{k-\sigma}\,dc\right]/\partial c_V^U\\ &= (1-\sigma)^{-1}\frac{c_V^U}{P^{1-\sigma}}\left[(w_e\tau_V d_V/\rho)^{1-\sigma}\frac{N_V}{c_V^k}k\left(c_V^U\right)^{k-\sigma}\right]\\ &= (1-\sigma)^{-1}\left[\tau_V k\left(d_V w_e/(P\rho)\right)^{1-\sigma}\tau_V^{-\sigma}\frac{N_V}{c_V^k}\left(c_V^U\right)^{k-\sigma+1}\right]\end{aligned}$$

where we can then use the equilibrium expression for exports below to obtain

$$\varepsilon_V \equiv \frac{\partial \ln P(\mathbf{c})}{\partial \ln c_V^U} = -\frac{k-\sigma+1}{\sigma-1}\frac{\tau_V R_V}{E} \tag{65}$$

$$\begin{aligned}R_V &= \tau^{-\sigma}d_V^{1-\sigma}(c_V^U)^{k-\sigma+1}\frac{N_V}{c_V^k}\frac{k}{k-\sigma+1}(w_e/P\rho)^{1-\sigma}E\\ (k-\sigma+1)\frac{R_V}{E} &= k\left(w_e/P\rho d_V\right)^{1-\sigma}\tau^{-\sigma}\frac{N_V}{c_V^k}(c_V^U)^{k-\sigma+1}\end{aligned}$$

Semi-elasticity of P wrt γ

Using the expression for ε_V derived above in (35) and noting that $\tilde{\varepsilon}_V \equiv \frac{\varepsilon_V}{(1-\Sigma_V\varepsilon_V)}$ we obtain

$$\begin{aligned}\left.\frac{d\ln P_m(\mathbf{c}_m)}{d\gamma}\right|_{\gamma=0} &= \frac{\beta p_2}{(\sigma-1)(1-\beta t_{22})}\sum\nolimits_V\tilde{\varepsilon}_{mV}(\tilde{\omega}_V-1)\\ &= \frac{\beta p_2}{(\sigma-1)(1-\beta t_{22})}\sum\nolimits_V\frac{\frac{k-\sigma+1}{(1-\sigma)}\frac{\tau_{mV}R_{mV}}{E}}{1-\frac{k-\sigma+1}{(1-\sigma)}\frac{\sum_V\tau_{mV}R_{mV}}{E}}(\tilde{\omega}_{mV}-1)\\ &= \frac{\beta p_2}{(\sigma-1)(1-\beta t_{22})}\frac{(k-\sigma+1)I_m}{(k-\sigma+1)I_m+\sigma-1}\Sigma_V r_{mV}(1-\tilde{\omega}_{mV})\end{aligned}$$

where $I_m \equiv \frac{\Sigma_V\tau_{mV}R_{mV}}{E}$ and the tariff inclusive import weights evaluated under the MFN state are defined as $r_{mV} \equiv \frac{\tau_{mV}R_{mV}}{\Sigma_V\tau_{mV}R_{mV}}$. Thus a necessary and sufficient condition for $\left.\frac{d\ln P_m(\mathbf{c}_m)}{d\gamma}\right|_{\gamma=0} > 0$ is $\sum_V r_{mV}(1-\tilde{\omega}_V)|_{\gamma=0} > 0$.

Semi-elasticity of entry wrt γ

$$\begin{aligned}\sum\nolimits_V r_{mV}\frac{d\ln c_{mV}^U}{d\gamma}|_{\gamma=0} &= \sum\nolimits_V r_{mV}\left.\left[\frac{d\ln U_m(\tilde{\omega}_V)}{d\gamma}+\frac{d\ln P_m(\mathbf{c}_m)}{d\gamma}\right]\right|_{\gamma=0}\\ &= \sum\nolimits_V r_{mV}\frac{\beta p_2}{(\sigma-1)(1-\beta t_{22})}(\tilde{\omega}_V-1)+\frac{\beta p_2}{(\sigma-1)(1-\beta t_{22})}\frac{(k-\sigma+1)I}{(k-\sigma+1)I+\sigma-1}\sum\nolimits_V r_{mV}(1-\tilde{\omega}_V)\\ &= \left(1-\frac{(k-\sigma+1)I_m}{(k-\sigma+1)I_m+\sigma-1}\right)\frac{\beta p_2}{(\sigma-1)(1-\beta t_{22})}\sum\nolimits_V r_{mV}(\tilde{\omega}_V-1)\end{aligned}$$

A.5.3 Effect of policy uncertainty on upgrading and price index

Similarly to the derivation without upgrading we split the price index into the subcomponents depending on the country of origin and industry (1st line below). In the second line we further divide the foreign varieties in to the endogenous set of firms that upgrades ($\Omega^z_{V,ch}$), since they will have lower equilibrium prices and the remaining set of firms ($\Omega_{V,ch} \setminus \Omega^z_{V,ch}$).

$$
\begin{aligned}
P^{1-\sigma} &= \int_{v\in\Omega} (p_v)^{1-\sigma}\, dv = \textstyle\sum_{V,ch} \displaystyle\int_{v\in\Omega_{V,ch}} (p_v)^{1-\sigma}\, dv + \textstyle\sum_{V,C\neq ch} \displaystyle\int_{v\in\Omega_{VC}} (p_v)^{1-\sigma}\, dv \\
&= \textstyle\sum_{V,ch} \left[\displaystyle\int_{v\in\Omega^z_{V,ch}} (p_v)^{1-\sigma}\, dv + \int_{v\in\Omega_{V,ch}\setminus\Omega^z_{V,ch}} (p_v)^{1-\sigma}\, dv\right] + \textstyle\sum_{V,C\neq ch} \displaystyle\int_{v\in\Omega_{VC}} (p_v)^{1-\sigma}\, dv
\end{aligned}
$$

Using the equilibrium price, $p_v = (w_e \tau_V d_V c_v/\rho)$ for the non-upgraders and $z\,(w_e \tau_V d_V c_v/\rho)$ for the upgraders, as well as the Pareto distribution we obtain ε_V at a state such as the MFN one where the cutoffs are $c^U_{mz} = \phi c^U_m$ (we omit the state subscript below and the V subscripts for the technological parameters for notational simplicity)

$$
\begin{aligned}
\left.\frac{\partial \ln P(\mathbf{c})}{\partial \ln c^U_V}\right|_{\mathbf{c}_C} &= (1-\sigma)^{-1}\frac{c^U_V}{P^{1-\sigma}}\partial\left[\frac{N_V}{c^k_V}\left\{\int_0^{\phi c^U_V} (z w_e \tau_V d_V/\rho)^{1-\sigma} k\,(c)^{k-\sigma}\, dc + \int_{\phi c^U_V}^{c^U_V} (w_e \tau_V d_V/\rho)^{1-\sigma} k\,(c)^{k-\sigma}\, dc\right\}\right]/\partial c^U_V \\
&= (1-\sigma)^{-1}\frac{c^U_V}{P^{1-\sigma}}\partial\left[\frac{N_V}{c^k_V}(w_e \tau_V d_V/\rho)^{1-\sigma} k\left\{z^{1-\sigma}\int_0^{\phi c^U_V} (c)^{k-\sigma}\, dc + \int_{\phi c^U_V}^{c^U_V} (c)^{k-\sigma}\, dc\right\}\right]/\partial c^U_V \\
&= (1-\sigma)^{-1}\frac{1}{P^{1-\sigma}}\left[\frac{N_V}{c^k_V}(w_e \tau_V d_V/\rho)^{1-\sigma} k\left\{z^{1-\sigma}\left(\phi c^U_V\right)^{k-\sigma+1} + \left(c^U_V\right)^{k-\sigma+1} - \left(\phi c^U_V\right)^{k-\sigma+1}\right\}\right] \\
&= \left[(1-\sigma)^{-1}\tau_V k\left(d_{V w_e}/(P\rho)\right)^{1-\sigma}\tau_V^{-\sigma}\frac{N_V}{c^k_V}\left(c^U_V\right)^{k-\sigma+1}\right]\zeta_V
\end{aligned}
$$

where $\zeta_V = 1 + (\phi_V)^{1-\sigma+k}\left(z_V^{1-\sigma} - 1\right)$ and the expression in [] is the same we derived for $\varepsilon_V|_{\zeta_V=1}$, i.e. without upgrading so $\varepsilon_V = \varepsilon_V|_{\zeta_V=1}\zeta_V$. This implies that the price elasticity wrt each cutoff is higher under upgrading. Since we also have that exports with upgrading can be written similarly: $R_V = R_V|_{\zeta_V=1}\zeta_V$ we obtain the same general expression for the elasticity when written in terms of the export value

$$
\varepsilon_V \equiv \partial \ln P(\mathbf{c})/\partial \ln c^U_V|_{\mathbf{c}_C} = -\frac{k-\sigma+1}{\sigma-1}\frac{\tau_V R_V}{E}
$$

Semi-elasticity of P wrt γ under upgrading

P depends on γ only via c^U so $d\ln P/d\gamma$ is the same as derived without upgrading but now ε_V reflects any upgrading that took place, as embodied in R_V, that is we still obtain

$$
\left.\frac{d\ln P_m(\mathbf{c}_m)}{d\gamma}\right|_{\gamma=0} = \frac{\beta p_2}{(\sigma-1)(1-\beta t_{22})}\frac{(k-\sigma+1)I_m}{(k-\sigma+1)I_m + \sigma - 1}\textstyle\sum_V r_{mV}\left(1-\tilde{\omega}_{mV}\right)
$$

where $I_m \equiv \frac{\sum_V \tau_{mV}R_{mV}}{E}$ and the tariff inclusive import weights evaluated under the MFN state are defined as $r_{mV} \equiv \frac{\tau_{mV}R_{mV}}{\Sigma_V \tau_{mV}R_{mV}}$.

Semi-elasticity of entry and upgrading wrt γ

We also obtain a similar expression in terms of export revenues as in the absence of upgrading for the weighted semi-elasticity of entry with respect to uncertainty

$$\sum_V r_{mV} \left.\frac{d\ln c^U_{mV}}{d\gamma}\right|_{\gamma=0} = \left(1 - \frac{(k-\sigma+1)\, I_m}{(k-\sigma+1)\, I_m + \sigma - 1}\right) \frac{\beta p_2}{(\sigma-1)\,(1-\beta t_{22})} \sum_V r_{mV} \left(\tilde{\omega}_V - 1\right)$$

which also applies to the upgrading cutoff since $c^U_{mz} = \phi c^U_m$.

A.5.4 Effect of policy uncertainty on consumer welfare

Workers have direct utility $Q^\mu q_0^{1-\mu}$ where Q is the CES aggregator over all varieties and $\mu \in (0,1]$. Therefore, since q_0 is the numeraire, the period indirect utility when $s = m$ is $\tilde{\mu} P_m^{-\mu}$ where $\tilde{\mu} = w_e k \mu^\mu (1-\mu)^{(1-\mu)}$ is constant since k is the period labor endowment and the wage of the exporter $w_e = 1$ in the diversified equilibrium. Using $t_{m2} = \gamma p_2$ and $t_{m0} = \gamma(1-p_2)$ we write the expected welfare for a worker starting at $s = m$ as

$$\begin{aligned} W_m &= \tilde{\mu} P_m^{-\mu} + \tilde{\beta}\left[\gamma(1-p_2)\, W_0 + \gamma p_2 W_{2m} + (1-\gamma)\, W_m\right] \\ &= \frac{\tilde{\mu} P_m^{-\mu}}{1-\tilde{\beta}(1-\gamma)} + \frac{\tilde{\beta}\gamma}{1-\tilde{\beta}(1-\gamma)}\left[(1-p_2)\, W_0 + p_2 W_{2m}\right] \end{aligned}$$

where W_0 and W_{2m} are the expected welfare values after switching to $s = 0, 2$ respectively.

We obtain the growth in welfare due to a change in γ around $\gamma = 0$ in eq.(36) as follows

$$\begin{aligned} \left.\frac{d\ln W_m}{d\gamma}\right|_{\gamma=0} &= \left(\frac{1}{W_m}\tilde{\mu}\frac{-\mu P_m^{-\mu-1}\frac{dP_m}{d\gamma}\left(1-\tilde{\beta}\right) - P_m^{-\mu}\tilde{\beta}}{\left(1-\tilde{\beta}\right)^2} + \frac{1}{W_m}\frac{\tilde{\beta}}{1-\tilde{\beta}}\left[(1-p_2)\, W_0 + p_2 W_{2m}\right]\right)|_{\gamma=0} \\ &= \left(\frac{\tilde{\mu}\left(P_m^D\right)^{-\mu}}{1-\tilde{\beta}}\right)^{-1}\left(\tilde{\mu}\frac{-\mu\left(P_m^D\right)^{-\mu-1}\frac{dP_m}{d\gamma}|_{\gamma=0}\left(1-\tilde{\beta}\right) - \left(P_m^D\right)^{-\mu}\tilde{\beta}}{\left(1-\tilde{\beta}\right)^2} + \frac{\tilde{\beta}}{1-\tilde{\beta}}\left[(1-p_2)\, W_0 + p_2 W_{2m}\right]|_{\gamma=0}\right) \\ &= -\mu\frac{d\ln P_m}{d\gamma}|_{\gamma=0} - \frac{\tilde{\beta}}{1-\tilde{\beta}}\left(\frac{W_m - (1-p_2)\, W_0 - p_2 W_{2m}}{W_m}\right)|_{\gamma=0} \end{aligned}$$

where the impact of γ on W_0 and W_2 disappears because it is multiplied by γ so it will be zero around $\gamma = 0$.

Within state welfare effect of policy uncertainty $-\mu\frac{d\ln P_m}{d\gamma}|_{\gamma=0}$: See Appendix section A.5.2.

Mean state switching welfare effect of policy uncertainty

To derive this note that the deterministic expected welfare is $W_s|_{\gamma=0} = \tilde{\mu}\left(P_s^D\right)^{-\mu} / (1-\beta)$ if $s = 0, m$. After T periods of transition from $s = m$ to $s = 2$ we have

$$W_{2t}|_{\gamma=0} = \tilde{\mu}\left(P_{2t}^D\right)^{-\mu} + \tilde{\beta}\left(t_{22} W_{2t+1} + (1-t_{22})\, W_m|_{\gamma=0}\right) \quad t = \{0, 1, ..., \infty\}$$

It is straightforward to solve this for the first period after transition to obtain $W_{2m} = W_{20}$ as

$$W_{2m}|_{\gamma=0} = \tilde{\mu}\sum_{t=0}^{\infty}\left(\tilde{\beta}t_{22}\right)^t\left(P_{2t}^D\right)^{-\mu} + \frac{1-t_{22}}{1-\tilde{\beta}t_{22}}\tilde{\beta}W_m|_{\gamma=0} \tag{66}$$

Using this and the deterministic values for W_s,at $s = 0, m$ we obtain the mean state switching effect in terms of model parameters and relative price indices. Our approach does not allow us to identify p_2 or t_{22}

so we are unable to provide an approximation for this term.

$$\frac{\tilde{\beta}}{1-\tilde{\beta}}\left(\frac{W_m-(1-p_2)\,W_0-p_2W_{2m}}{W_m}\right)\Big|_{\gamma=0}=\frac{\tilde{\beta}}{1-\tilde{\beta}}\left(1-(1-p_2)\left(\frac{P_0^D}{P_m^D}\right)^{-\mu}-p_2\frac{W_{2m}}{W_m}|_{\gamma=0}\right)$$
$$=\frac{\tilde{\beta}}{1-\tilde{\beta}}\left(\begin{array}{c}1-(1-p_2)\left(\frac{P_0^D}{P_m^D}\right)^{-\mu}\\ -p_2\left(\left(1-\tilde{\beta}\right)\sum_{t=0}^{\infty}\left(\tilde{\beta}t_{22}\right)^t\left(\frac{P_{2t}^D}{P_m^D}\right)^{-\mu}+\frac{1-t_{22}}{1-\tilde{\beta}t_{22}}\tilde{\beta}\right)\end{array}\right)$$

B Data and Estimation Appendix

B.1 Data sources and definitions

Change in Ad valorem Tariffs $\Delta\tau_{mV}$ Log change in 1 plus the statutory ad-valorem MFN tariff rate aggregated to the HS6 level between 2005 and 2000. Source: TRAINS via WITS download.

Change in AVE Tariffs $\Delta\tau_{mV}$ Log change in 1 plus the advalorem equivalent (AVE) of the MFN tariff rate at the HS6 level between 2005 and 2000. For specific tariffs, the AVE is given by the ratio of unit duty to the average 1996 import unit value. Source: TRAINS for tariff rates and COMTRADE for unit values, via WITS download.

Column 2 Tariff τ_{2V} Log of the 1 plus the column 2 (Smoot-Hawley) tariff rate at the HS6 level. For specific tariffs, base year unit values from 1996 used for all years to compute the AVE tariff. Source: TRAINS for tariff rates and COMTRADE for unit values, via WITS download.

Pre-WTO Uncertainty Measure of uncertainty from the model $1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}$ computed using year 2000 column 2 and MFN tariff rates for ad-valorem and AVE tariff rates respectively.

Change in Transport Costs ΔD_V Log change in the ratio of trade values inclusive of costs, insurance and freight (CIF) to free on board value (FOB). Source: CIF/FOB ratios constructed at HS6 level using disaggregated data from Center for International Data (http://cid.econ.ucdavis.edu/)

Change in TTBs Indicators for temporary trade barriers in-force including anti-dumping duties, countervailing duties, special safeguards, and China-specific special safeguards. Data are aggregated up to HS6 level. Source: World Bank Temporary Trade Barriers Database (Bown, 2012)

Change in MFA Indicators for in-force Multi-Fiber Agreement on Textiles and Clothing (MFA/ATC) quotas aggregated to the HS6 level and concorded through time. Source: Brambilla et al. (2010) available at http://faculty.som.yale.edu/peterschott/sub_international.htm

Change in No. of HS-10 Traded Products Change in log count of traded HS10 products within each HS6 industry from 2000 to 2005. Source: disaggregated data from Center for International Data (http://cid.econ.ucdavis.edu/)

B.2 Double difference specification

If there is a growth rate trend in the number of firms in an industry that is industry specific, $\Delta(\ln N_V) = \theta_V$, and θ_V is correlated with our policy or trade cost variables, then identification is still possible via a difference-of-differences approach. We illustrate this using the mass of firms but the variables in a_V could also be allowed to have industry specific time trends. This yields the following long difference

$$\Delta_{m0}\ln R_V = b_\gamma\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + b_\tau\Delta\ln\tau_V + b_d\Delta\ln D_V + b + \theta_V + u_V$$

where Δ_{m0} is subscripted to denote the difference over a transition from m to 0.

Now consider taking the difference between two years that remain in state m. For example, if the difference above uses 2000 (m) and 2005 (0) and we will now use the difference between 1999(m) and 1996(m) and denote it by Δ_{mm}

$$\Delta_{mm}\ln R_V = -\Delta_{mm}b'_\gamma\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + b_\tau\Delta_{mm}\ln\tau_V + b_d\Delta_{mm}\ln D_V + b' + \theta_V + u'_V. \qquad (67)$$

Since both our uncertainty measure and the estimated parameters on the uncertainty measure could change over time, we denote the parameter on uncertainty by b'_γ and note that there are two components to the change in the first term

$$-\Delta_{mm}b'_{\gamma}\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)=-b'_{m}\Delta_{mm}\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)-\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)\Delta_{mm}b'_{m}$$

The second term is evaluated at final period tariffs, which are very close to 2000 levels. Because τ_{2V} is fixed during this period and any variation in $\left(\frac{\tau_{2V}}{\tau_{mV}}\right)$ is due to small changes in τ_{mV}, already controlled by $\Delta_{mm}\ln\tau_{V}$, we take $\Delta_{mm}\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)\approx 0$ to obtain

$$\begin{aligned}-\Delta_{mm}b'_{\gamma}\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)&\approx-\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)\Delta_{mm}b'_{\gamma}\\&=-\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)\frac{k-\sigma+1}{\sigma-1}\frac{\beta t_{m2}}{1-\beta}\Delta_{mm}g'_{m}=-\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)\frac{b_{\gamma}}{g_{m}}\Delta_{mm}g'_{m}.\end{aligned}$$

We then take the double difference, normalizing each differenced RHS variable by the length of the time period to obtain magnitudes comparable to our first differenced results

$$\frac{\Delta_{m0}\ln R_{V}}{5}-\frac{\Delta_{mm}\ln R_{V}}{3}=b_{\gamma}\left(1+\frac{\Delta_{mm}g'_{m}}{g_{m}}\right)\frac{\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)}{5}+b_{\tau}\left(\frac{\Delta_{m0}\ln\tau_{V}}{5}-\frac{\Delta_{mm}\ln\tau_{V}}{3}\right)\tag{68}$$

$$+b_{d}\left(\frac{\Delta_{m0}\ln D_{V}}{5}-\frac{\Delta_{mm}\ln D_{V}}{3}\right)+b-b'+u_{V}-u'_{V}\tag{69}$$

The coefficients from estimating the double difference equation (68) have the same interpretation as our baseline regression. The sample size drops since we can only use HS6 industries traded in 2005, 2000, 1999, and 1996. Further, the double differenced variables are somewhat noisy so we employ a robust regression routine that downweights outliers more than 7 times the median absolute deviation from the median residuals, iterating until convergence.

B.3 Entry specification and quantification

Specification

The change in the number of exported varieties is unobserved to us and so we treat it as a latent variable and model how it maps to observable changes in exported products. We assume there is a function continuous, increasing, differentiable function $\nu(\cdot)$ that maps varieties to product counts: $\ln(pcount_{tV})=\nu(\ln n_{tV})$. If there was only one firm in an HS-6 industry and it produced a single variety then we would observe one traded product (an HS-10 category) in an industry. We cannot observe more traded products than the maximum number tracked by customs in each industry, i.e. the total number of HS-10 categories in an HS-6. So clearly we have a lower bound $\nu(\ln n_{tV}=0)=0$ and an upper bound $\ln(pcount^{\max}_{tV})=\nu(\ln n_{hV})$ for all $\ln n_{tV}$ at least as high as n_{hV}—the (unobserved) threshold where all HS-10 product categories in an HS-6 industry have positive values. If we assume product counts and varieties are continuous, then $\nu'\geq 0$ for $n_{V}\in(0,n_{hV})$ and zero otherwise. The weak inequality accounts for the possibility that different firms export within the same HS-10 category so there is true increase in variety that is not reflected in new HS-10 categories traded. We log linearize the equation of product counts around $\ln n_{t-1V}$. Then the change in products between t and and $t-1$ is $\Delta\ln(pcount_{tV})\approx\nu'(\ln n_{t-1V})\Delta\ln n_{tV}$. Therefore, if we use the growth in the product count as a proxy for variety entry we can identify the coefficients in (48) up to a factor, ν', if that factor is similar across industries. This implies

$$\Delta\ln(pcount_{V})=b^{e}_{\gamma}\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)+b^{e}_{\tau}\Delta\ln\tau_{V}+b^{e}_{d}\Delta\ln D_{V}+b^{e}+e_{V}\tag{70}$$

The estimation coefficients obtained from a linear regression rescale the parameters in (48) by ν'. So the predictions are $b^e_\gamma = \frac{k}{\sigma-1}\frac{\beta t_{m2}}{1-\beta t_{22}} g\nu' \geq 0$, $b^e_\tau = \frac{-\sigma k}{\sigma-1}\nu' \leq 0$ and $b^e_d = -k\nu' \leq 0$ and the constant $b^e = -b^e_\gamma\left(1-g^{-1}\right) + \nu'\frac{k}{\sigma-1}\Delta \ln A$. The weak inequalities capture the possibility that $\nu' = 0$.

In going from this specification to the data, we account for the maximum number of *tradable* products within each HS6. We use this information to impose sample restrictions on the regression consistent with our specification of the $\nu()$ function. We drop observations if an industry already trades the maximum number of products available at the beginning and end of the sample – a "max-to-max" transition where $\nu' = 0$– as well as industries that are non-traded throughout the sample – "zero-to-zero" transitions. This means we have a symmetric sample restriction at the upper and lower bounds suggested by our mapping ν. In estimating the log changes specification we must focus only on the industries with some traded product in both periods, which is what we also did in the baseline trade flow regression. The estimates are in Table 7.

Quantification

To compute the average change in tariffs that would deliver the same expected growth in exported varieties as the uncertainty removal by rearranging $\mathbb{E}\left(\Delta \ln \tau_V\right)\frac{\partial \ln n_V}{\partial \ln \tau_V} = \mathbb{E}\left(\Delta \ln n_V\right)|_{\tau,d,P}$ in terms of estimated parameters and data:

$$\mathbb{E}\left(\Delta \ln \tau_V\right) = E_V\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)\frac{k}{\sigma-1}\frac{\beta t_{m2}}{1-\beta t_{22}} g\left(\frac{-\sigma k}{\sigma-1}\right)^{-1} = E_V\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) b^e_\gamma / b^e_\tau$$

To compute the impact of uncertainty we first obtain an estimate of ν' using the cross equation restriction implied by the model $\nu' = b^e_d/b_d = 0.49/2.6 = 0.19$, where b_d is obtained from the baseline export equation used for quantification (column 4, Table 2). We compute the general equilibrium impact of uncertainty on entry as $\frac{b^e_\gamma}{\nu'}\mathbb{E}\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + k\left(\ln P_0/P_m\right)|_{\tau,D}$.

Table 1
Summary statistics by pre-WTO policy uncertainty

	Uncertainty		
	Low	**High**	**Total**
Chinese export growth to US (Δln, 2005-2000)	1.18	1.36***	1.29
	[1.788]	[1.603]	[1.672]
MFN tariff (ln), 2000	0.028	0.044	0.039
	[0.036]	[0.048]	[0.045]
Column 2 tariff (ln), 2000	0.158	0.393	0.311
	[0.096]	[0.116]	[0.156]
Potential profit loss in worst case (pre WTO)	0.303	0.636	0.52
	[0.175]	[0.086]	[0.202]
Change in MFN tariff (Δln)	-0.002	-0.004	-0.003
	[0.007]	[0.010]	[0.009]
Change in transport costs (Δln)	-0.01	-0.002	-0.005
	[0.100]	[0.079]	[0.087]
Observations	1080	1080	3242

Notes:
Means with standard deviations in brackets.
Low and High refer to the bottom and top tercile of each variable. Total includes the full sample used in baseline Table 2.
*** Difference of means between High and Low export growth significant at 1% level

Table 2
Export Growth from China (2000-2005)

	1	2	3	4
Uncertainty Pre-WTO	0.682***	0.731***	0.687***	0.703***
[+]	[0.158]	[0.154]	[0.186]	[0.185]
Change in Tariff (Δln)	-9.702**	-3.969***	-6.608	-3.894***
[-]	[4.473]	[0.702]	[5.057]	[0.704]
Change in Transport Costs (Δln)	-2.556***	-2.646***	-2.562***	-2.596***
[-]	[0.474]	[0.468]	[0.474]	[0.469]
Constant	0.895***	0.887***		
	[0.0881]	[0.0877]		
Observations	3,242	3,242	3,242	3,242
R-squared	0.03	.	0.05	.
Section FE	no	no	yes	yes
Restriction p-value (F-test)	0.195	1	0.588	1

Notes:

Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. Predicted sign of coefficient in brackets under variable.

Uncertainty measure uses U.S. MFN and Column 2 Tariffs to construct profit loss measure at σ=3

All specifications employ OLS and 2 and 4 impose theoretical constraint on tariffs and transport cost coefficients: $b_\tau=b_d(\sigma/(\sigma-1))$.

Table 3
Export Growth from China (2000-2005): Robustness to NTBs

	1	2	3	4	5
Specification:	Baseline	+MFA/TTB	+Section FE	IV (TTB)	Constrained
Uncertainty Pre-WTO	0.682***	0.624***	0.688***	0.694***	0.709***
[+]	[0.158]	[0.156]	[0.186]	[0.185]	[0.184]
Change in Tariff (Δln)	-9.702**	-8.791*	-7.47	-7.61	-3.948***
[-]	[4.473]	[4.546]	[5.057]	[5.046]	[0.700]
Change in Transport cost (Δln)	-2.556***	-2.548***	-2.588***	-2.596***	-2.632***
[-]	[0.474]	[0.470]	[0.471]	[0.469]	[0.466]
Change in MFA quota status		-0.171*	-0.311**	-0.311**	-0.303**
		[0.100]	[0.136]	[0.136]	[0.135]
Change in TTB status		-0.831**	-0.913***	-1.303	-0.908***
		[0.332]	[0.339]	[0.902]	[0.338]
Constant	0.895***	0.912***			
	[0.0881]	[0.0874]			
Observations	3,242	3,242	3,242	3,242	3,242
R-squared	0.028	0.033	0.054		
Section FE	no	no	yes	yes	yes
F-stat, 1st Stage				10.2	
Over-ID restriction (p-value)				0.566	
Restriction p-value (F-test)	0.195	0.281	0.482	0.466	1

Notes:
Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. Predicted sign of coefficient in brackets under variable.
Specifications 1-3 employ OLS and 5 impose theoretical constraint on tariffs and transport cost coefficients: $b\tau=bd(\sigma/(\sigma-1))$.
Specification 4 employs IV. Excluded instruments for Change in TTB are TTB indicators for 1998 and 1997.
Uncertainty measure uses U.S. MFN and Column 2 Tariffs to construct profit loss measure at $\sigma=3$

Table 4
Contribution of Policy Uncertainty to Export Growth (2000-2005)

	Upper bound	Partial	GE
Average export growth from lower uncertainty (Δln)	0.37	0.34	0.32
Share of export growth predicted by uncertainty reduction[1]	0.36	0.34	0.32
Ad Valorem transport cost equivalent of uncertainty (Δ ln)	0.14	0.13	0.13
Ad Valorem tariff equivalent of uncertainty (Δln)	0.094	0.088	0.086

Notes:
Quantification uses estimates with section fixed effects and constraint on transport costs and tariffs from column 4 of Table 2
The upper bound column assumes no price index effects, which are incorporated in the partial and general equilibrium (GE)
(1) Fraction of total observed growth accounted for by uncertainty.

Table 5
Contribution of Policy Uncertainty to Export and Variety Growth (2000-2005): NLLS estimates

	Upper bound	Partial	GE
Average **export** growth from lower uncertainty (Δln)	0.29	0.26	0.22
Average **variety** growth from lower uncertainty (Δln)	0.53	0.48	0.44

Notes:
Employs NLLS estimates (column 2 Table A7). The upper bound column assumes no price index effects, which are incorporated in the partial and general equilibrium (GE) columns, which are calculated as described in the text.

Table 6
Variety Growth from China (2000-2005)

	1	2	3	4
Uncertainty Pre-WTO	0.253***	0.280***	0.240***	0.256***
[+]	[0.0731]	[0.0711]	[0.0890]	[0.0885]
Change in Tariff (Δln)	-2.680**	-0.729***	-2.263*	-0.733***
[-]	[1.291]	[0.245]	[1.346]	[0.240]
Change in Transport cost (Δln)	-0.440***	-0.486***	-0.461***	-0.489***
[-]	[0.165]	[0.163]	[0.162]	[0.160]
Observations	1,227	1,227	1,227	1,227
R-squared	0.024	.	0.061	.
Section FE	no	no	yes	yes
Restriction p-value (F-test)	0.12	1	0.246	1

Notes:

Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. Predicted sign of coefficient in brackets under variable.

All specifications employ OLS and 2 and 4 impose theoretical constraint on tariffs and transport cost coefficients: bτ=bd(σ/(σ-1)). Constant included but not reported.

The variety growth used as a dependent variable is measured by the ln change in the number of HS-10 products in a given each HS6.

Sample: All regressions drop max-to-max transitions - observations at the maximum number of tradable HS-10 varieties at

Table 7
Contribution of Policy Uncertainty to Variety Growth (2000-2005)

	Upper bound	Partial	GE
Average entry from lower uncertainty (Δln)	0.71	0.66	0.64
Ad Valorem transport cost equivalent of uncertainty (Δln)	0.27	0.25	0.26
Ad Valorem tariff equivalent of uncertainty (Δln)	0.18	0.17	0.17

Notes:
Quantification uses estimates with section fixed effects and constraint on transport costs and tariffs from column 4 of Table 6. The upper bound column assumes no price index effects, which are incorporated in the partial and general equilibrium (GE) columns, as described in the text.

Table A1
Summary Statistics Across Regression Specifications

Table:	1-4, A2-3	A4	5,6
Chinese export growth to US (Δln, 2005-2000)	1.29	1.25	n/a
	[1.672]	[1.678]	
Uncertainty Pre-WTO (2000)	0.52	0.52	0.52
	[0.202]	[0.226]	[0.193]
Change in Tariff (Δln)	-0.003	-0.006	-0.005
	[0.00884]	[0.0213]	[0.0114]
Change in Transport Costs (Δln)	-0.005	-0.0055	-0.007
	[0.0870]	[0.0881]	[0.0861]
Change in MFA quota status (binary)	-0.129	-0.119	n/a
	[0.335]	[0.324]	
Change in TTB status (binary)	0.00802	0.0075	n/a
	[0.124]	[0.123]	
Product growth	n/a	n/a	0.352
			[0.463]
Observations	3,242	3,599	1,227
Fraction of total export growth	0.976	0.998	0.262

Notes:
Mean and [standard deviation] for variables. See referenced table and text for detailed information about sample and variable definitions. "n/a": not applicable since variable not used in the corresponding table.

Table A2

Export Growth from China (2000-2005): robustness across elasticity of substitution

	1	2	3	4
		σ=2		
Uncertainty Pre-WTO (σ=2)	0.791***	0.839***	0.799***	0.810***
[+]	[0.192]	[0.188]	[0.227]	[0.224]
Change in Tariff (Δln)	-9.741**	-5.288***	-6.707	-5.170***
[-]	[4.479]	[0.927]	[5.057]	[0.932]
Change in Transport Costs (Δln)	-2.552***	-2.644***	-2.559***	-2.585***
[-]	[0.474]	[0.464]	[0.475]	[0.466]
constant	0.934***	0.928***		
	[0.0829]	[0.0826]		
Observations	3,242	3,242	3,242	3,242
R-squared	0.027		0.05	
Restriction p-value (F-test)	0.311	1	0.758	1

	1	2	3	4
		σ=4		
Uncertainty Pre-WTO (σ=4)	0.640***	0.686***	0.642***	0.659***
[+]	[0.142]	[0.139]	[0.169]	[0.167]
Change in Tariff (Δln)	-9.702**	-3.527***	-6.538	-3.464***
[-]	[4.466]	[0.625]	[5.057]	[0.627]
Change in Transport Costs (Δln)	-2.558***	-2.645***	-2.564***	-2.598***
[-]	[0.474]	[0.469]	[0.474]	[0.470]
	0.858***	0.849***		
	[0.0927]	[0.0923]		
Observations	3,242	3,242	3,242	3,242
R-squared	0.028		0.05	
Restriction p-value (F-test)	0.163	1	0.541	1

Notes:

Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. Predicted sign of coefficient in brackets under variable.

Uncertainty measure uses U.S. MFN and Column 2 Tariffs to construct profit loss measure at σ indicated in each panel

All specifications employ OLS and 2 and 4 impose theoretical constraint on tariffs and transport cost coefficients: bτ=bd(σ/(σ-1)).

Table A3
Export Growth from China (2000-2005): Robustness to outliers

	1	2	3	4
Uncertainty Pre-WTO	0.499***	0.559***	0.514***	0.546***
[+]	[0.123]	[0.121]	[0.147]	[0.146]
Change in Tariff (Δln)	-11.27***	-4.035***	-9.741***	-4.089***
[-]	[2.813]	[0.417]	[3.083]	[0.4155]
Change in Transport Costs (Δln)	-2.541***	-2.690***	-2.631***	-2.726***
[-]	[0.281]	[0.278]	[0.279]	[0.277]
Constant	0.866***	0.855***		
	[0.0676]	[0.0677]		
Observations	3,242	3,242	3,242	3,242
R-squared	0.04		0.06	
Section Fixed effects	no	no	yes	yes

Notes:

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. Predicted sign of coefficient in brackets under variable.

Robust regression downweights outliers more than 7 times the median absolute deviation from the median residual. It iterates first over Huber weights until convergence and then and Bi-weights.

Specifications 2 and 4 impose theoretical constraint on tariffs and transport cost coefficients: $b\tau = bd(\sigma/(\sigma-1))$.

Uncertainty measure uses U.S. MFN and Column 2 Tariffs to construct profit loss measure at $\sigma=3$

Table A4

Export Growth from China (2000-2005): Robustness to ad-valorem equivalent (AVE) tariffs

	1	2	3	4
Uncertainty Pre-WTO	0.901***	0.841***	0.838***	0.770***
[+]	[0.132]	[0.128]	[0.152]	[0.148]
Change in AVE Tariff (Δln)	-0.83	-3.398***	-0.449	-3.386***
[-]	[1.431]	[0.593]	[1.533]	[0.602]
Change in Transport Costs (Δln)	-2.491***	-2.266***	-2.488***	-2.258***
[-]	[0.431]	[0.395]	[0.434]	[0.402]
Constant	0.762***	0.778***		
	[0.0748]	[0.0739]		
Observations	3,599	3,599	3,599	3,599
R-squared	0.03		0.06	
Section Fixed Effects	no	no	yes	yes
Restriction p-value (F-test)	0.067	1	0.051	1

Notes:

Robust standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Predicted sign of coefficient in brackets under variable.

Uncertainty measure uses U.S. MFN statutory and Column 2 Tariffs to construct profit loss measure at $\sigma=3$. It uses both ad-valorem and the AVE of specific tariffs.

All specifications employ OLS and 2 and 4 impose theoretical constraint on tariffs and transport cost coefficients: $b\tau=bd(\sigma/(\sigma-1))$.

Table A5
Export growth from China: Robustness to HS-6 level and Pre-Accession Trends

	1	2	3	4
Dependent variable (ln):	Annualized Difference in Export Growth (2005-2000)/5-(1999-1996)/3		Pre-Accession Export Growth (1999-1996)	
Uncertainty Pre-WTO (2000)	0.504**	0.410*		
[+]	[0.223]	[0.225]		
Uncertainty Pre-WTO (1996)			0.0242	0.059
[~0]			[0.110]	[0.110]
Change in Tariff (Δln) [1]	-7.226***	-6.513***	-4.566***	-4.410***
[-]	[2.178]	[2.191]	[1.610]	[1.603]
Change in Transport Cost (Δln) [1]	-3.249***	-3.298***	-3.425***	-3.440***
[-]	[0.303]	[0.303]	[0.290]	[0.288]
Change in MFA quota status [1]		-0.378***		0.462***
		[0.112]		[0.162]
Change in TTB status [1]		-0.118		-0.205
		[0.218]		[0.306]
Observations	2,588	2,588	2,588	2,588
R-squared	0.047	0.052	0.055	0.058

Notes:

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. Predicted sign of coefficient in brackets under variable.

Robust regression employed to address potential effect of outliers or influential individual observations due to double differencing. The estimation routine downweights outliers more than 7 times the median absolute deviation from the median residual. It iterates first over Huber weights until convergence and then Bi-weights.

Uncertainty measure uses U.S. MFN and Column 2 Tariffs to construct profit loss measure at σ=3

(1) In columns 1 and 2 the change in tariff and transport cost variable represents double differences. In columns 3 and 4 they are single differences. Similarly for MFA and TTB variables.

Table A6

Export Growth from China (2000-2005): Robustness to (zero inclusive) mid-point growth

	1	2	3	4
Uncertainty Pre-WTO	0.452***	0.460***	0.438***	0.433***
[+]	[0.0914]	[0.0898]	[0.110]	[0.109]
Change in Tariff (ln)	-2.177	-1.128***	-0.201	-1.072***
[-]	[1.981]	[0.304]	[2.134]	[0.309]
Change in Transport Costs (ln)	-0.737***	-0.752***	-0.724***	-0.715***
[-]	[0.206]	[0.203]	[0.209]	[0.206]
constant	0.651***	0.651***		
	[0.0523]	[0.0523]		
Observations	3,766	3,766	3,766	3,766
R-squared	0.014		0.035	
Section FE	no	no	yes	yes
Restriction p-value (F-test)	0.595	1	0.682	1

Notes:

Standard errors in brackets. *** $p<0.01$, ** $p<0.05$, * $p<0.10$. Predicted sign of coefficient in brackets under variable.

Midpoint growth of export level R is given by $2*(R(t)-R(t-1))/(R(t)+R(t-1))$ for t=2005 and t-1=2000. Defined for all exported 6 digit HS codes with positive exports in either the years 2000, 2005 or both.

Uncertainty measure uses U.S. MFN and Column 2 Tariffs to construct profit loss measure at $\sigma=3$

All specifications employ OLS and 2 and 4 impose theoretical constraint on tariffs and transport cost coefficients: $b\tau=bd(\sigma/(\sigma-1))$.

Table A7

Export Growth from China: Robustness to functional form & transp. cost outliers

estimation method	OLS	NLLS	OLS	NLLS
Uncertainty (pre-WTO) [1]	0.646***	0.823***	0.542***	0.668**
[+]	[0.149]	[0.305]	[0.184]	[0.338]
Change in Tariff (ln)	-6.376***	-6.594***	-6.186***	-6.302***
[-]	[1.246]	[1.242]	[1.249]	[1.248]
Change in Transport Costs (ln)	-4.251***	-4.396***	-4.124***	-4.202***
[-]	[0.831]	[0.828]	[0.833]	[0.832]
constant	0.908***	1.579***		
	[0.0844]	[0.106]		
Observations	3,074	3,074	3,074	3,074
R-squared		0.02		0.04
Section FE	no	no	yes	yes
No. coefficients estimated	3	3	23	23
Restriction test σ=3 (p-value)	n/a	0.14	n/a	0.97

Notes

Standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.10. Predicted sign of coefficient in brackets under variable.

Sample: All specifications exclude transport cost outliers, as measured by changes in costs more than three times the interquartile range value beyond the top or bottom quartile value of the baseline sample.

All specifications impose constrain from theory: tariff/transport cost=σ/(σ-1)

1) Uncertainty measure uses U.S. MFN (τm) and Column 2 tariffs (τ2) to construct the profit loss measure. This is approximated by $1-(\tau_m/\tau_2)^{\sigma}$ under OLS. For the NLLS we do not approximate and use instead the general function $\ln(1+b^*(\tau_m/\tau_2)^{\sigma})$ where b is estimated. The estimates from NLLS are then transformed via the delta method using the model restrictions as described in the text to compute a parameter comparable to the one in the linear specification. The four specifications in the columns restrict σ=3. We test this by relaxing the restriction in two additional NLLS specifications; the results in the last line show the p-value at which we can't reject the restriction.

Table A8
Export Growth from China Panel (1996-2006)

	1	2
Tariff (ln)	-5.358***	-7.618***
[-]	[1.929]	[1.990]
Transport Costs (ln)	-2.378***	-2.384***
[-]	[0.223]	[0.225]
Uncertainty Pre-effect (1996-2001)		-1.883**
[-]		[0.926]
Uncertainty Post-effect (2002-2006)		-1.208
[~0]		[0.933]
Uncertainty (2000) - change in coefficient relative to year 2000		
1996	-0.211	
[~0]	[0.268]	
1997	0.0277	
[~0]	[0.222]	
1998	-0.204	
[~0]	[0.166]	
1999	0.0775	
[~0]	[0.188]	
2001	0.22	
[~0]	[0.192]	
2002	0.458**	
[+]	[0.182]	
2003	0.621**	
[+]	[0.299]	
2004	0.724***	
[+]	[0.216]	
2005	0.846***	
[+]	[0.247]	
2006	0.789***	
[+]	[0.291]	
Observations	37,360	37,347
R-squared	0.03	0.03
HS6 & Section by year FE	y	y
Uncertainty post-effect is zero (p-value)	n.a.	0.195
Restriction p-value (F-test)	0.382	0.046

Notes:
Robust standard errors, adjusted for clustering on HS6 and section-year, in brackets. *** p<0.01, **
Predicted sign of coefficient in brackets under variable. Uncertainty measure uses U.S. MFN and Column 2 Tariffs to construct profit loss measure at σ=3. All specifications employ OLS. In column 1, uncertainty measure is fixed at 2000 level and interacted with year indicators (omitting 2000).

Table A9

Contribution of Policy Uncertainty to Export Growth (2000-2005): Robustness to NLLS estimates

	Upper bound	Partial	GE
Average export growth from lower uncertainty (Δln)	0.29	0.26	0.22
Share of export growth predicted by uncertainty reduction[1]	0.28	0.25	0.21
Ad Valorem transport cost equivalent of uncertainty (Δln)	0.07	0.06	0.06
Ad Valorem tariff equivalent of uncertainty (Δln)	0.04	0.04	0.04

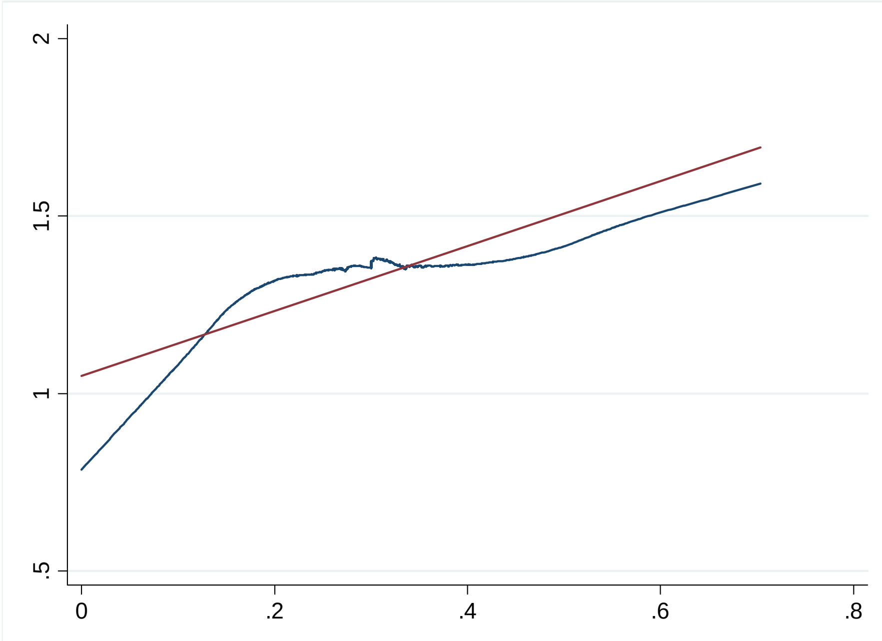
Notes:

Quantification uses estimates with section fixed effects and constraint on transport costs and tariffs from column 2 of Table A7. The upper bound column assumes no price index effects, which are incorporated in the partial and general equilibrium (GE) columns, as described in the text.

(1) Fraction of total observed growth accounted for by uncertainty.

Figure 1

China's Export Growth 2000-2005 vs. US pre-WTO tariff threat: Non-parametric and Linear fit



Notes: Linear fit from OLS regression: *export_growth*=1.05 +0.92*ln(τ_2/τ_{MFN}) where τ_2 and τ_{MFN} are the column 2 and MFN tariff factors in 2000; both coefficients are significant at the 1% level. The non-parametric fit uses a running-line least-squares smoothing (lowess).

Figure 2

Policy uncertainty impact on export entry and technology upgrade cost cutoffs

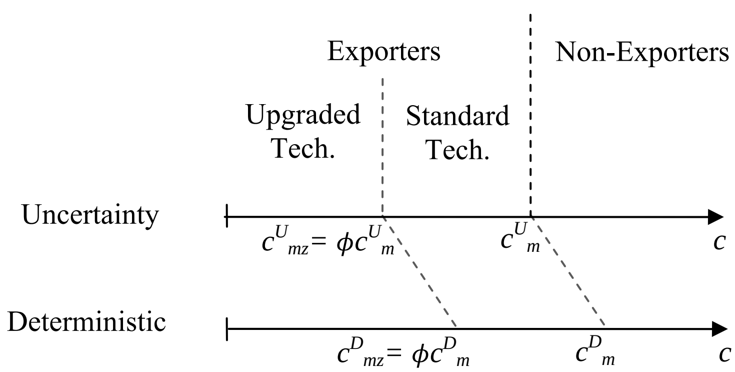
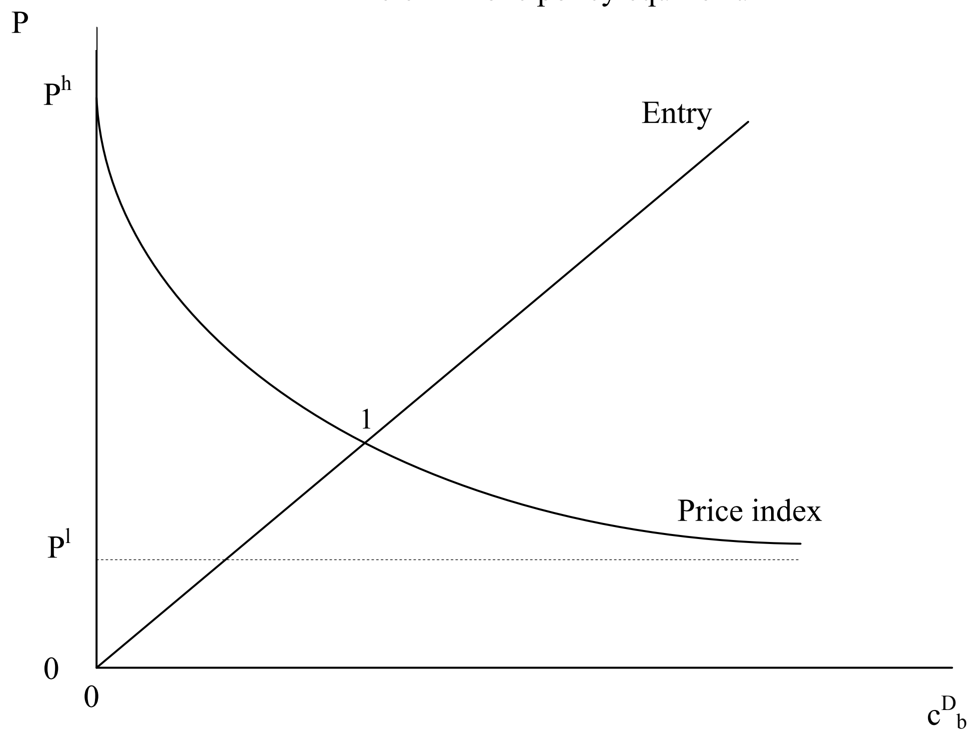
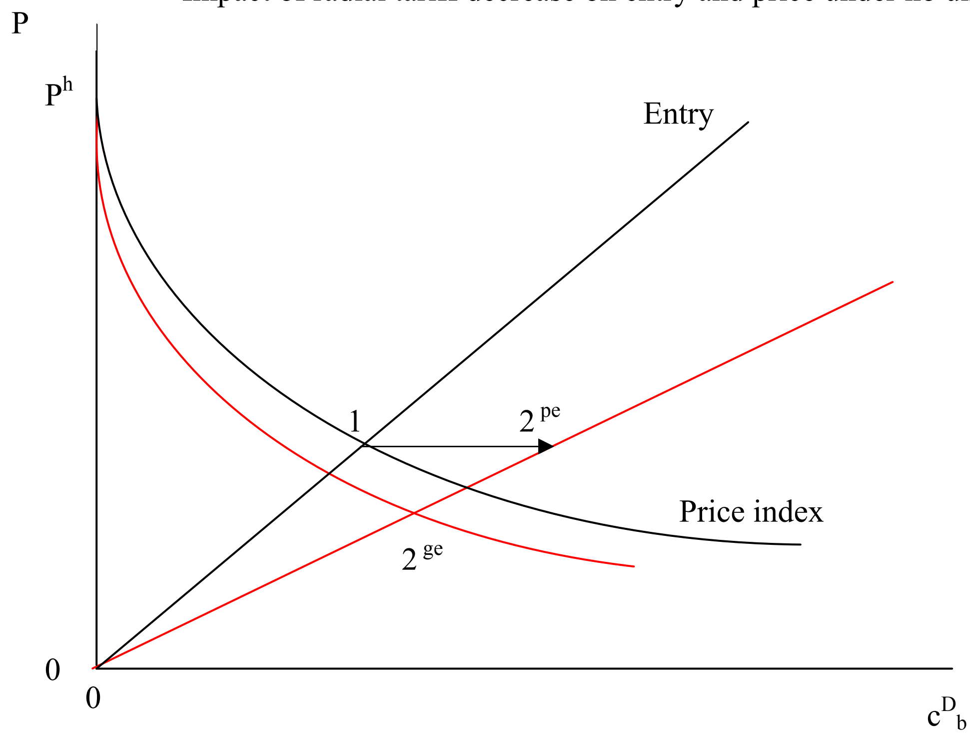


Figure 3
Deterministic policy equilibrium



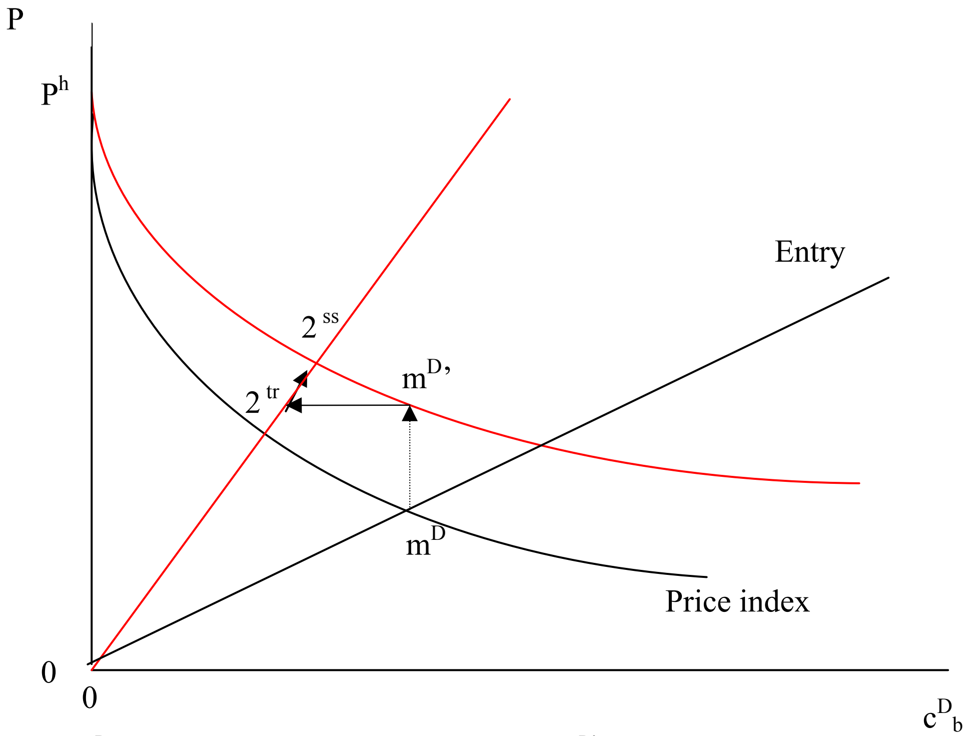
P^h: limit with no foreign varieties sold
P^l: limit with all foreign varieties sold

Figure 4
Impact of radial tariff decrease on entry and price under no uncertainty



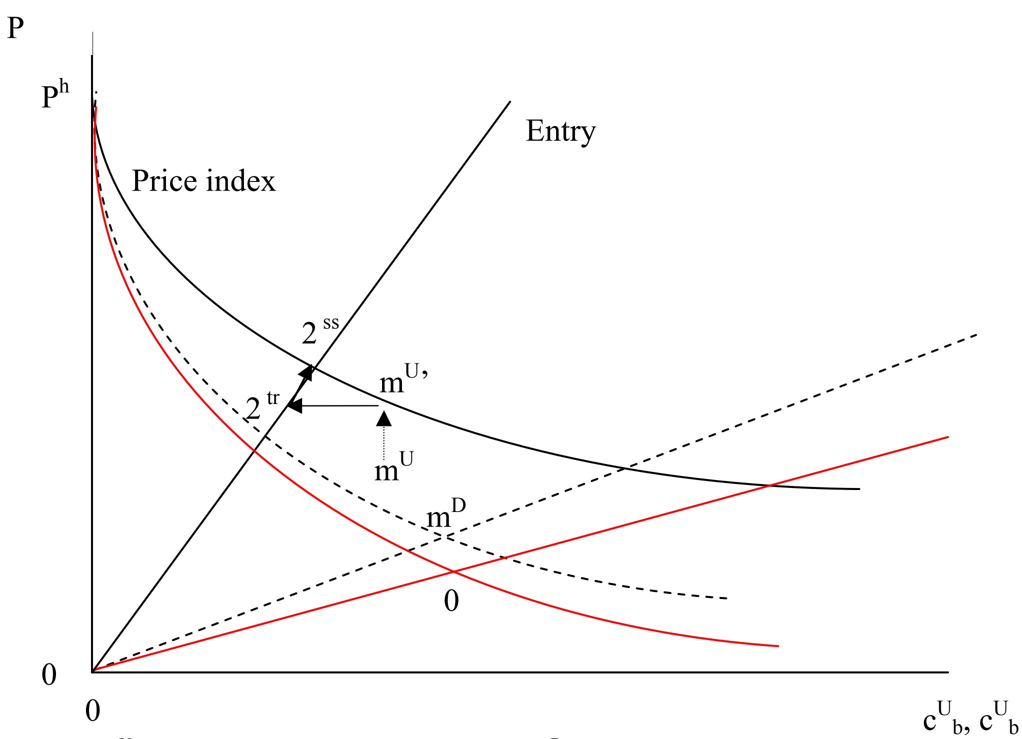
1: Initial equilibrium, 2^{pe}: Equilibrium after tariff reduction in partial equilibrium
2^{ge}: equilibrium under general equilibrium. Radial decrease: $d\ln(\tau_V)=\delta<0$ for all V.

Figure 5
Transition dynamics after unexpected (radial) tariff increase



m^D: Initial deterministic equilibrium (MFN), $m^{D'}$: Lower bound price index after shock (if no death), 2^{tr} : lower bound cutoff after shock), 2^{ss}: Steady state under column 2.

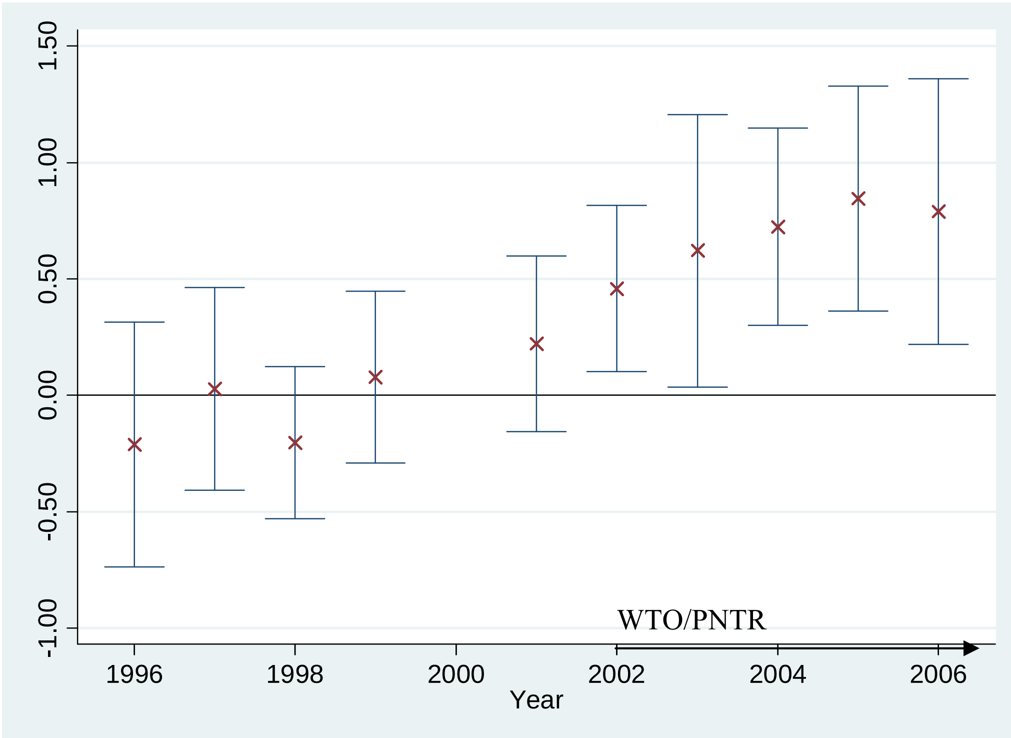
Figure 6
Comparison of equilibria under policy uncertainty



m^U: MFN equilibrium with uncertainty; m^D: Equilibrium under MFN without uncertainty;
0: equilibrium after WTO under no uncertainty (if tariffs reduced); $2^{tr} \rightarrow 2^{ss}$ transition path after switch to column 2 state under uncertainty until new shock leading to m occurs.

Figure 7

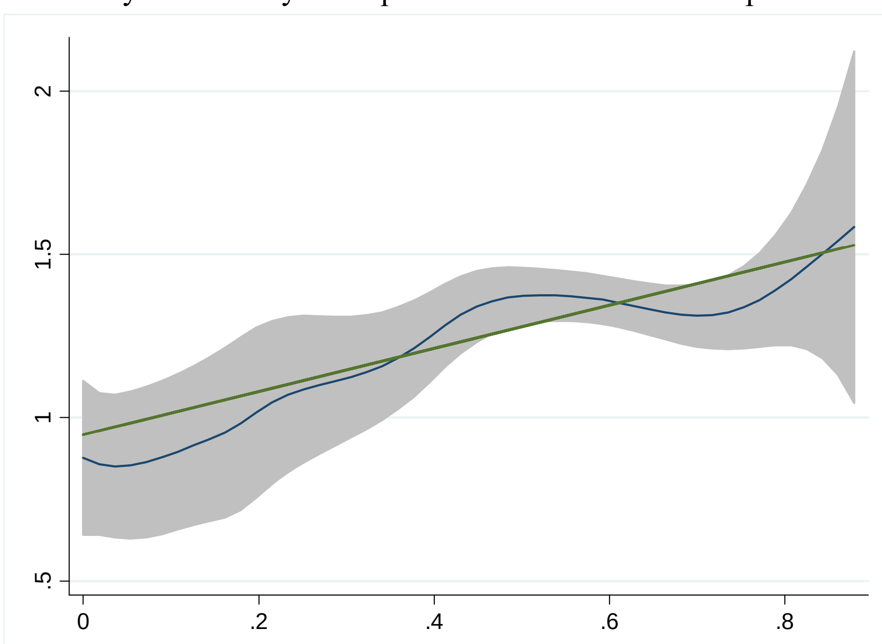
Impact of Pre-WTO tariff threat on Chinese exports relative to 2000



"x" represent point estimates for time varying coefficients on profit loss variable in 2000 and spikes represent 95% CI. Obtained from a fixed effects panel estimation of export levels at HS-6 levels in years 1996-2006, includes year, HS-6 and year*section effects.

Figure 8

(Partial) effect of Policy Uncertainty on Export Growth 2000-05: Semi-parametric and Linear fit



Notes: Both fits regress export growth on changes in transport costs, tariffs and section dummies. The linear fit uses OLS and also includes $-(\tau_2/\tau_{MFN})^{-3}$, which the semi-parametric uses as an argument of the local polynomial estimated using the Robinson (1988) semi-parametric estimator. We plot the fit against $1-(\tau_2/\tau_{MFN})^{-3}$ for ease of comparison with the uncertainty variable used in the baseline.

Notation Reference

Symbol	Description	Section
Q	CES subutility index	2.1
μ	share of income spend on differentiated goods	2.1
q_0	quantity of homogeneous good	2.1
Ω	set of available differentiated goods	2.1
σ	elasticity of substitution	2.1
E	total expenditure on differentiated goods	2.1
p_v	consumer price of variety v	2.1
P	price index for differentiated goods	2.1
τ_V	tariff for industry V	2.1
c_v	unit labor cost for producer of variety v, the inverse of productivity $(1/c_v)$	2.1
w_e	wage in exporting country e	2.1
d_V	advalorem transport cost for industry V	2.1
$\tilde{p}_v$	producer price of variety v	2.1
π_v	operating profits	2.1
A	Aggregate demand and supply conditions	2.1
K, K_z	sunk cost to start exporting or upgrading (z)	2.2
a_{sV}	demand conditions for industry V in state s	2.2
c_s^j	j cost cutoff for state s	2.2
β	probability that the firm/entrepreneur will survive	2.2
$\Pi_e, \Pi_{ez}, \Pi_w, \Pi_{wz}$	expected value function of exporting (e), waiting (w), or upgrading $(\cdot z)$	2.2
M	transition matrix	2.2
$t_{ss'}$	transition probability from state s to s' of transition matrix M	2.2
t_m	probability that given current state will be revisited, function of transition probabilities and β	2.2
$\tilde{t}$	probability that a firm enters in the future, function of transition probabilities and β	2.2
U_s	effect of uncertainty in state s on entry/upgrade cutoffs	2.2
γ	policy persistence parameter, $\gamma = 1 - t_{mm}$	2.2
z	technology upgrade factor	2.3
ϕ	upgrade parameter (equilibrium ratio of upgrade and entry cutoff)	2.3
k_L	labor endowment	2.4
N	mass of entrepreneurs	2.4
$\widehat{X}$	proportional changes in variable X	2.4
$G_V(c)$	CDF of productivity in industry V	2.4
κ_{Vb}	relative parameters of cost cutoff in industry V to base industry b	2.4
ε_i	elasticity of price index wrt to variable i.	2.4
$\tilde{\mu}$	parameters of indirect utility function $\tilde{\mu} = w_e k_L \mu^\mu (1-\mu)^{(1-\mu)}$	2.4
T	time period since the negative tariff shock	2.4
$\tilde{\omega}$	proportion of profits lost in a reversal to column 2 tariffs	2.4
g	general equilibrium adjustment factor to profits lost in reversal	2.4
$\tilde{\varepsilon}_V$	adjusted elasticity of price index wrt to c_V	2.4
W_s	consumer welfare at state s.	2.4
$\tilde{\beta}$	discount factor of consumers	2.4
R_{sV}	export level of industry V in state s	2.5

Symbol	Description	Section
k	shape parameter of the Pareto distribution for productivity $G_V(c)$	2.5
α_V,$\tilde{\alpha}_V$	industry specific distribution factor and modified factor in the export revenue	2.5
ζ_V	industry specific upgrading factor in the export revenue for industry V	2.5
u_V,e_V	approximation error terms for industry V	3.1
b_i,$\tilde{b}_i$,b_i^e	estimates of parameter i for benchmark, NLLS and product counts	3.1
D_{mV}	observable component of advalorem export cost in industry V, state m	3.1
$\tilde{d}_V$	unobservable component of advalorem export costs for industry V	3.1
$f(\tilde{U}_V)$	general functional form for effect of uncertainty term on exports for industry V	3.3
I	tariff inclusive import value relative to differentiated goods expenditure	3.4
n_V	number of Chinese varieties exported to the U.S. industry V.	3.5
v'	non-negative factor relating firm growth product count	3.5
r_{Vm}	import share of industry V in state m	E.5
ν	function mapping varieties to product counts	F.3