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ABSTRACT

Policy Uncertainty, Trade and Welfare: Theory and Evidence for China and the U.S.*

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 TPU 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 it can explain between 22-30% of Chinese exports to the US after WTO accession. 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.

JEL Classification: D8, D92, F1, F13, F14, F5 and O24
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1 Introduction

One of the most important economic developments of the last 20 years is China's integration into 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) and 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.

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 finally implement 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: after the Tiananmen square protests there was pressure to revoke MFN status with Congress voting on such a bill every year in the 1990s and the House passing it three times. Had MFN status been revoked the U.S. would have reverted to Smoot-Hawley tariff levels and a trade war would likely have ensued. 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.[2]

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 had "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. to abandon trade status reviews: "The question of MFN has long stymied the development of Sino-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 has risen driven by internal reforms (many in the 1990s) with a subset of these being targeted to exports, e.g. improved access to foreign technology & inputs (Hsieh and Klenow, 2009) and relaxed FDI rules (Bloningen and Ma, 2010).

[2] 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.

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".[3]

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 Tyco Toys CEO said "We view the imposition of conditions upon the renewal of MFN as virtually synonymous with outright revocation. Conditionality means uncertainty."[4] Reports prepared for Congress discussed the higher prices that consumers would face following revocation given the incidence of higher tariff rates (Pregelj, 2001).

The first question we address 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 about the potential impacts of other sources of policy uncertainty, such as U.S. threats to impose tariffs against "currency manipulators" or revoke 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 can promote trade through a channel that is largely missing from the empirical and theoretical debate, barring recent exceptions discussed below.[5]

The second question we address is what are the aggregate price and welfare effects of TPU. 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. 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 TPU. We will focus on consumer gains that arise from lower prices due to firm entry and technology upgrading investments.

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, firms may have an option value of waiting and thus 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

[3] 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. After WTO accession, 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." (in "China-US trade volume increases 32 times in 23 years - Xinhua reports" BBC Summary of World Broadcasts, 2/18/2002.)

[4] "China Most-Favored-Nation Status," Hearing before the Committee on Finance, U.S. Senate, June 6, 1996, p. 97.

[5] 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)

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 measurement and quantification of its causal effects is difficult (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 and use it 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). Second, we allow for TPU in a two country general equilibrium context where export entry and upgrading affect the importer's price index.

By allowing for upgrading, the extended model 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. This additional intensive margin effect is important 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 (cf. Amiti and Freund, 2008, and Manova and Zhang, 2009). Moreover, in other countries there is evidence 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. This could account for the evidence of substantial firm-level TFP growth increases in China since 2001 (Brandt et al, 2012).[6]

The general equilibrium price effects are 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. This price effect of reforms that lower TPU is central in generating welfare gains 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

[6]While our current data does not allow us to *test* the firm-level channel directly, we will show how it operates and that it is taken into account in the estimation.

uncertainty measure can be calculated by using observable MFN and threat tariffs (so called column 2 tariffs). We then provide evidence that Chinese export growth in 2000-2005 was higher in those industries with higher initial TPU. 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 certain model parameters that we use to calculate the implied general equilibrium price effects. In our baseline we find that uncertainty reduction lead to as much as a 32 log point increase in Chinese exports to the U.S., which translates into an *applied* tariff equivalent of up to 8.5 percentage points. Using a semi-parametric approach we fail to reject the non-linear form of the model-consistent TPU measure, but we do reject the 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, particularly when making quantitative predictions. Our preferred quantification allows for non-linear effects of TPU present in the model; doing so is quantitatively important and generates a more conservative estimate (22 log points instead of 32), which translates into a change in exports of $55 billion dollars in 2005 due to TPU.

We use the model and our estimates to compute the counterfactual increase in the price index if China had lost its MFN status and faced column 2 tariffs and find it is about 3.3% percent. This translates into a similarly valued reduction in real income for consumers that spend most income on differentiated goods. We decompose the potential welfare cost of TPU into two effects, one which we estimate and refer to as a *within state* effect. This welfare cost effect of higher uncertainty captures the increase in prices due to depressed entry and upgrading even when applied trade policy has not changed. It is as high as 0.8 percent of U.S. welfare. This is of comparable magnitude to welfare gains from different sources in deterministic trade models. For example, 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.

The model also permits us to estimate that the TPU reduction increased Chinese varieties exported to the U.S. by 44 log points. The effect of TPU on entry is larger than on exports as predicted by the model. 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 contribute to the literature on trade agreements more broadly. The influential economic theory of the GATT/WTO proposed by Bagwell and Staiger (1999) argues that this agreement internalizes the terms-of-trade effects imposed by tariffs. There is now evidence that countries possess market power and explore it when they are not in an agreement but less so after an agreement (Broda et al, 2008; Bagwell and Staiger, 2011; Ludema and Mayda, Forthcoming). Moreover, the welfare cost of trade wars that would likely occur without such agreements are potentially large—about 3.5% for the U.S. (Ossa, 2013). But this theory and evidence on the WTO has largely ignored TPU. Recent work by Handley (2012) shows that reducing WTO 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 agreements in a standard general equilibrium model and derive a sufficient statistic for evaluating their aggregate welfare gains. We contribute to this literature by providing both theoretical and empirical evidence for welfare gains from reducing TPU through trade agreements in a dynamic setting with heterogenous firms.

We also contribute to the growing literature assessing the reduced form impact of Chinese exports on wages and employment in the European Union (cf. Bloom et al., 2012) and the U.S. (cf. Pierce and Schott, 2012). The latter study appeals to the theoretical TPU mechanism in HL to use U.S. column 2 tariffs as a reduced form determinant of the impact of Chinese exports 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 a reduced form impact of column 2 tariffs on US outcomes may be justified.[7] Two important differences relative to the recent work on the impact of China's export boom on labor markets is that our focus is on the trade and consumer welfare effects and our structural approach allows us to perform counterfactual exercises. For example, we provide a decomposition of the uncertainty effect and find that a substantial fraction is explained by a mean preserving tariff risk reduction, and the rest is due to locking in tariffs below the mean. More interestingly perhaps, we quantify the *uncertainty* impact of proposed legislation that *threatens* to impose tariffs of almost 30% on "currency manipulators". We find that implementing such legislation in 2012 would have had similar trade effects to removing China's permanent MFN status and a higher welfare cost to U.S. consumers.

The paper is structured as follows. The following section presents the theory. 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 on derivations, data and estimation.

2 Theory

We first present the 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

[7] The general equilibrium price index effects turn out to be important empirically since we find them to attenuate the impact of TPU. We also find that the TPU effects are lower when we allow for the non-linear, model consistent measure of uncertainty, and that this measure provides a better fit to the trade data.

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.

2.1 Demand, Supply and Pricing

The utility function, $Q^{\mu}q_0^{1-\mu}$, is identical across consumers and countries. It is defined over the numeraire good, 0, which is homogenous, freely traded with 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 of available goods, Ω, with an elasticity of substitution, $\sigma = 1/(1-\rho) > 1$. Total expenditure on 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 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.[8] 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 section 2.3. In a deterministic setting the firm 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

[8] 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 $Q = \left[\sum_V \int_{v\in\Omega_V} q_v^{\rho} dv\right]^{1/\rho}$ and similarly for the price index.

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 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.[9]

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.[10] In order to enter a foreign market a firm must incur a sunk investment cost, K_V.[11] A firm with production cost parameter c_v obtains operating profits from exporting equal to $\pi\left(a_{sV}, c_v\right) = a_{sV} c_v^{1-\sigma}$ 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. Initially we allow profits to depend on the policy state s only through the tariff factor ${\tau_{sV}}^{-\sigma}$. We can rationalize this by thinking of entering 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 examine how export decisions affect aggregate conditions in the destination market. 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

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

where operating profits are discounted by β, the probability that the firm will survive (there is no pure time discounting). Given the absence of fixed costs of exporting per period, the firm will continue to export until

[9] 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.

[10] 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.

[11] 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.

it is exogenously hit by a death shock.

With uncertainty about future policy the firm must decide whether to enter the market today 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.[12]

To solve for the cutoffs we now model the policy regime, which is characterized by a Markov transition matrix and associated tariff values. The general element of the policy state transition matrix M is $t_{ss'}$—the transition probability from state s to s'. To maintain tractability and provide sharper results we impose some structure on this transition 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 late 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 column 2 tariff, which was typically much higher so $\tau_{2V} \geq \tau_{mV}$. We denote the probability of this transition by t_{m2}. During the last part of that period, the late 1990s and through 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 ($t_{02} \leq t_{m2}$) possibly even negligible ($t_{02} \to 0$). We also 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. $t_{20} \leq t_{m0}$.

We summarize the *policy regime* as follows:

1. There are 3 possible policy states: column 2 ($s = 2$), temporary MFN ($s = m$) and WTO ($s = 0$) and $\tau_{2V} \geq \tau_{mV} \geq \tau_{0V}$ for each V.
2. Policy τ_{sV} transitions from s to s' with probability $t_{ss'}$, summarized by a matrix M
3. The transition to either extreme state is more likely if it occurs from $s = m$, i.e. $t_{m2} \geq t_{02}$ and $t_{m0} \geq t_{20}$.

We make two simplifying assumptions that are consistent with this general description of the regime. First, it is not possible to transition from column 2 to the agreement without first passing the MFN/negotiation

[12] We note that some firms above the cutoff that previously entered under better conditions will continue to exporter until hit by the exogenous death shock. We discuss these firms when we consider general equilibrium implications, but their presence is of no consequence for determining c_{st}^U given our small industry assumption.

stage and second, the WTO state is absorbing, $t_{00} = 1$.[13] Thus the policy transition matrix is

$$M = \begin{pmatrix} 0 & t_{2m} & t_{22} \\ t_{m0} & t_{mm} & t_{m2} \\ t_{00} & 0 & 0 \end{pmatrix} \tag{5}$$

The period profit ordering across states for any exporting firm is therefore $\pi_2 < \pi_m \leq \pi_0$. Then the *expected* value of exporting, denoted by Π_e, can be written as

$$\Pi_e(a_s, c) = \pi(a_s, c) + \beta \textstyle\sum_{s'} t_{ss'} \Pi_e(a_{s'}, c) \quad \text{each } s \tag{6}$$

If a firm exports in state s and the policy persists into the next period then the firm 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 be the same as the current period value. For any firm we have a linear system of three equations (one for each state) that can be solved for each $\Pi_e(a_s, c)$. It is simple to solve for $s \neq m$

$$\Pi_e(a_s, c) = \frac{\pi(a_s, c) + \beta t_{sm} \Pi_e(a_m, c)}{1 - \beta t_{ss}} \quad \text{each } s \neq m \tag{7}$$

Using (6), (7) and simplifying we obtain the following for $s = m$

$$\Pi_e(a_m, c) = \frac{\pi(a_m, c)}{1 - \beta t_m} + \frac{\beta}{1 - \beta t_m} \textstyle\sum_{s \neq m} t_{ms} \frac{\pi(a_s, c)}{1 - \beta t_{ss}} \tag{8}$$

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. $c_0^U \geq c_m^U \geq c_2^U$. So any firm with $c > c_0^U$ never enter in any other (worse) state. Note also that since we take the limit case where $t_{0m} \to 0$ we have $c_0^U = c_0^D = \left[a_0 / (1 - \beta) K\right]^{1/(\sigma-1)}$.

We now find the values of waiting evaluated at the cutoff for each of the other two states. The expected

[13] In practice the WTO does not end all TPU but the evidence we will consider suggests that it did end TPU regarding column 2 tariffs.

value of waiting for a firm at the worst state is

$$\Pi_w(a_2, c) = 0 + \beta\left[t_{22}\Pi_w(a_2, c) + t_{2m}\left[\Pi_e(a_m, c) - K\right]\right] \quad \text{if } c \in [c_2^U, c_m^U] \tag{9}$$

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 solve this expected value of waiting and replace in (4), which yields the cutoff for entry at column 2

$$\frac{\pi(a_2, c) + \beta t_{2m}\Pi_e(a_m, c_2^U)}{1 - \beta t_{22}} - K = \frac{\beta t_{2m}\left[\Pi_e(a_m, c_2^U) - K\right]}{1 - \beta t_{22}} \Leftrightarrow \frac{\pi(a_2, c_2^U)}{1 - \beta} = K \tag{10}$$

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 change for the better.

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

$$\Pi_w(a_m, c) = 0 + \beta\left[t_{mm}\Pi_w(a_m, c) + t_{m2}\Pi_w(a_2, c) + t_{m0}\left[\Pi_e(a_0, c) - K\right]\right] \text{ if } \; c \in [c_m^U, c_0^U] \tag{11}$$

A firm that decides to wait and not enter at MFN returns to the same value 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. We simplify (11) using (9) and (7) evaluated at the entry threshold for MFN where the indifference condition (4) is satisfied (see appendix A.1 for derivation)

$$\Pi_w(a_m, c_m^U) = \frac{\beta t_{m0}}{1 - \beta\left(t_{mm} + t_{m2}\frac{\beta t_{2m}}{1 - \beta t_{22}}\right)}\left[\frac{\pi(a_0, c_m^U) + \beta t_{0m}\Pi_e(a_m, c_m^U)}{1 - \beta t_{00}} - K\right] \tag{12}$$

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

Plugging in the value of exporting in (8) and the value of waiting in (12) into the indifference condition in (4) we can solve for the cutoff c_m^U. In the proof of Proposition 1 (in appendix section A.1) we obtain an expression for the cutoff that allows us to compare it directly to its deterministic counterpart

$$c_m^U = c_m^D U_m(\omega, \gamma) < c_m^D. \tag{13}$$

The partial equilibrium *uncertainty factor*, $U_m(\omega,\gamma)$, is defined as follows

$$U_m(\omega,\gamma) \equiv \left[\frac{1-\beta}{1-\beta\tilde{t}(\gamma)}\left(1+\frac{\beta t_{m2}(\gamma)}{1-\beta t_{22}}\omega\right)\right]^{\frac{1}{\sigma-1}} \tag{14}$$

where $\omega \equiv \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}$ and $\tilde{t}(\gamma) \equiv 1 - t_{m2}(\gamma) + t_{m2}(\gamma)\frac{\beta t_{2m}}{1-\beta t_{22}}$.[14] To interpret the expression and some of our results it is useful to define *MFN policy uncertainty* as the situation when there is some probability of exiting the MFN state, i.e. when $\gamma \equiv 1 - t_{mm} > 0$. We then say there is an *increase in MFN policy uncertainty* when γ increases such that a policy is more likely but the odds of either the worst or best case scenario remain the same. Formally, this implies $\frac{t_{m2}(\gamma)}{t_{m0}(\gamma)} = \frac{\gamma t_2}{\gamma(1-t_2)}$ where t_2 is the probability of $s = 2$ conditional on exiting MFN. The uncertainty factor is increasing in profits under the worst case scenario relative to MFN, $\omega \leq 1$. For the subsequent results it is also useful to highlight the possibility of tariff increases starting at a given state and since we rule these out after the agreement we have that *tariff increases are possible if* $\tau_2 > \tau_m$ and $t_{m2}(\gamma) > 0$.

Proposition 1 uses these definitions to summarize the effects of TPU on the export entry cost cutoffs in partial equilibrium, i.e. when foreign exporters have a negligible impact on the importer price index.[15]

Proposition 1 (Policy Uncertainty and Entry in Partial Equilibrium):
(a) The entry cutoff under MFN policy uncertainty, c_m^U, is proportional to its deterministic counterpart, c_m^D, by the uncertainty factor, $U_m(\omega,\gamma)$, in eq. (14).
(b) c_m^U is lower than its deterministic counterpart ($c_m^U < c_m^D$) and decreasing in MFN policy uncertainty ($d\ln c_m^U/d\gamma = d\ln U_m/d\gamma < 0$) iff tariff increases are possible, otherwise $c_m^U = c_m^D$.
(c) c_m^U is lower than the agreement cutoff ($c_m^U < c_0^U = c_0^D$) if tariff increases are possible or tariffs are lower under the agreement ($\tau_0 < \tau_m$) or both.

In appendix A.1 we provide a complete proof, here we outline the main points. Part (a) of the proposition summarizes the cutoff relationship in (13). To show that $c_m^U < c_m^D$ in part (b) we provide the necessary and sufficient conditions for the uncertainty factor to be lower than unity. If we evaluate $U_m(\omega,\gamma)$ in (14) at either $t_{m2} = 0$ *or* $\omega = 1$ we verify that it is unity and thus $c_m^U = c_m^D$, so the condition is necessary to have the possibility of tariffs above MFN for $c_m^U < c_m^D$. The intuition is analogous to the one for the worst case scenario cutoff where we showed that the potential for good news is not relevant for the marginal entrant's decision. In terms of the estimation, it implies that we can nest the possibility that firms believed that $t_{m2} = 0$ in our estimation. Evaluating (14) at $\omega < 1$ and $t_{m2}(\gamma) = \gamma t_2 > 0$ we find $U_m(\omega,\gamma) < 1$ so the condition is sufficient. While MFN policy uncertainty can lead to lower or higher tariffs, it is only the possibility of the latter that affects entry, that is if we have $\gamma > 0$ but $t_2 = 0$ (so tariff increases are not possible) then uncertainty has no impact on entry in the MFN state, but if tariff increases are possible then

[14] This captures the long run probability that a firm starting at $s = m$ will not be in $s = 2$.

[15] Proposition 1 applies the same basic insight in Handley and Limão (2012) to a policy process with state dependence even after the policy shock.

entry is reduced. This is an example of the "bad news principle" (Bernanke, 1983).

In the empirical section we will focus on the impact of entering into the WTO, which is modelled as a change from state m to state 0 within a given policy regime, so part (c) compares those cutoffs. If tariff increases are possible then $c_m^U < c_m^D$, as shown in part (b). Thus even if applied tariffs do not change with the agreement ($\tau_0 = \tau_m$) we have $c_m^U < c_m^D = c_0^D = c_0^U$, where the first equality is clear from the deterministic cutoff in (3) and the second one is due to the assumption that the agreement is an absorbing state. The agreement could also relax the cutoff if tariff increases are not possible provided it lowered the applied tariffs. In the latter case $c_m^U = c_m^D < c_0^D = c_0^U$ where the first equality is shown in (b) and the inequality is from (3). This implies it is important to control for applied tariff changes to separately identify the effect of uncertainty.

We will also test if there were significant changes in MFN policy uncertainty *before* the agreement, e.g. in years where an MFN vote was more likely. We think of this as a change in the policy regime since it changes the transition process, M. Part (b) of proposition 1 also shows that the entry cost cutoff is monotonically decreasing in γ. We show this by first noting that the semi-elasticity of c_m^U with respect to γ is equal to that of $U_m(\omega, \gamma)$ and differentiating (14). While the sign of the result is global, it will also be useful to have the semi-elasticity expression around the case with no MFN uncertainty, which is

$$\frac{d \ln U_m(\omega, \gamma)}{d\gamma}|_{\gamma=0} = \frac{\beta t_2}{(\sigma - 1)(1 - \beta t_{22})}(\omega - 1) \leq 0 \tag{15}$$

where the inequality is strict if $t_2 > 0$ and $\tau_2 > \tau_m$ such that $\omega < 1$. We will explore variation across industries in $\omega - 1$, the percent profit reduction under column 2 relative to MFN, to identify the impact of policy uncertainty.

If, as we are assuming, the agreement is an absorbing state then switching to it leads to a reduction in TPU broadly defined. In the empirical section we will also quantify the impact of the agreement that can be attributed to mean preserving changes in the policy, i.e. to changes in pure *risk*. To understand the basic insight consider first starting at τ_m and examining the impact of a regime change that eliminates MFN policy uncertainty (i.e. sets $\gamma = 0$). If τ_m is at the industry's long-run mean then this corresponds to a pure policy risk reduction and so all entry is due to risk reduction.[16] However, if τ_m was below its long-run mean then the change in γ has the *additional* effect of locking in lower mean tariffs. The latter case where τ_m is below the mean is the relevant one in our empirical application and so we will calculate the counterfactual impact of an agreement that eliminated policy uncertainty *if* initial tariffs were at their long-run mean to quantify the importance of the pure risk component of WTO entry.

In addition to the ordering of the cutoffs in proposition 1 in appendix A.1 we can also show that the MFN cutoff is higher than that under column 2 if and only if $\omega < 1$. So under this condition and those in

[16] It is straightforward to show in this three state process that when state m 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, $F(\tau_{t+1}|\tau_t = \tau_m, \gamma)$.

proposition 1 we have that only the most efficient firms would enter under column 2; under temporary MFN some additional firms enter; and under a secure agreement an even larger set of firms enters. In summary, we have

$$c_2^U = c_2^D < c_m^U < c_m^D \leq c_0^D = c_0^U \tag{16}$$

One final note on the importance of sunk costs, K, for the results above. As long as $K > 0$ the cutoff expressions, their ordering, and their elasticity with respect to applied policy and future policy remain unchanged. We can clearly see this since c_s^U is log separable in U_s, which is independent of K.[17] If $K = 0$ 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 the impact of TPU on technology upgrade investments, which provides a channel for changes in TPU to change exports of incumbent firms. The technology upgrading channel is plausible in the case of China given that its firms have had both large increases in TFP growth since the WTO accession and strong export growth at the intensive margin.[18]

A simple way to illustrate the main points is to focus on technology upgrades that are export market specific. More specifically, 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 export cost component that is unrelated to tariffs.[19] Its period

[17] 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.

[18] 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. 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. We find that continuing varieties at the HS-10 digit level account for 85% of export growth from China to the US in 2000-2005.

[19] 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.

profits can therefore be written as $\pi(a_s, zc_{sz}) = a_s (zc_{sz})^{1-\sigma} = A\tau_s{}^{-\sigma} d^{1-\sigma} (zc_{sz})^{1-\sigma}$. 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^D_{sz}, which is defined by $\pi\left(a_s, zc^D_{sz}\right) - \pi\left(a_s, c^D_{sz}\right) = K_z (1-\beta)$

$$c^D_{sz} = \left[\frac{a_s \left(z^{1-\sigma} - 1\right)}{K_z (1-\beta)}\right]^{\frac{1}{\sigma-1}} \tag{17}$$

Depending on the upgrade technology parameters we could have equilibria where the upgrading is done by all, none, or only a fraction of exporters. We focus on the latter case, which we find is the most interesting. This implies that the marginal entrant into exporting will not upgrade and therefore the entry cutoff, c^D_s, is still the one given by (3). Using this we can see that the upgrade cutoff is proportional to the entry cutoff by an *upgrading parameter* ϕ. Thus we have

$$c^D_{sz} = \phi c^D_s \tag{18}$$

$$\phi \equiv \left[\left(z^{1-\sigma} - 1\right) \frac{K}{K_z}\right]^{\frac{1}{\sigma-1}} < 1 \tag{19}$$

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. 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. We will thus say that *the upgrading parameter is sufficiently low* if $\phi < \bar{\phi}$ and $\bar{\phi}$ is defined by $c_{0z}^{U}\left(\bar{\phi}\right) = c_{2}^{U}$ where c_{2}^{U} is the entry cutoff under column 2 tariffs previously derived and $c_{0z}^{U}\left(\phi\right)$ is the upgrade cutoff under the agreement scenario that we derive below.[20]

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

$$\Pi_{ez}(a_s, zc_{sz}^{U}) - K_z = \Pi_{wz}(a_s, c_{sz}^{U}, z) \text{ for each } s \tag{20}$$

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 (6), but replacing the marginal cost c with zc. This means that the value of exporting under upgrading is simply

$$\Pi_{ez}(a_s, zc_{sz}) = z^{1-\sigma}\Pi_{e}(a_s, c_{sz}) \text{ for each } s \tag{21}$$

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

$$\Pi_{wz}(a_m, c, z) = \pi(a_m, c) + \beta\left[t_{mm}\Pi_{wz}(a_m, c, z) + t_{m2}\Pi_{wz}(a_2, c, z) + t_{m0}\left[\Pi_{ez}(a_0, zc) - K_z\right]\right] \text{ if } c \in [c_{mz}^{U}, c_{0z}^{U}] \tag{22}$$

The key differences relative to the value of waiting for entry in (11) are that now a firm that has not upgraded makes positive export profit 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 (21) in (22) to solve for $\Pi_{wz}(a_m, c, z)$. We then use this and (21) along with the indifference condition in (20) to obtain the upgrade cutoff under MFN. The following Proposition characterizes the impact of TPU on entry and upgrading in partial equilibrium.

Proposition 2 (Policy Uncertainty, Entry and Technology Upgrading in Partial Equilibrium): *When firms can pay a sunk cost to upgrade their export technology and the upgrading parameter is sufficiently low ($\phi < \bar{\phi} \leq 1$)*

(a) the entry cutoff are given by Proposition 1;

(b) the upgrading cutoff is proportional to the entry cutoff: $c_{sz}^{U}/c_{s}^{U} = \phi$ for all s;

[20] In the appendix we provide the threshold value of ϕ below which this holds in terms of parameters.

(c) c^U_{mz} is lower than its deterministic counterpart by the uncertainty factor in eq. (14): $c^U_{mz} = U_m c^D_{mz} < c^D_{mz}$; and decreasing in MFN policy uncertainty: $d \ln c^U_{mz}/d\gamma = d \ln U_m/d\gamma < 0$ iff tariff increases are possible;
(d) c^U_{mz} is lower than the agreement cutoff ($c^U_{mz} < c^U_{0z} = c^D_{0z}$) if tariff increases are possible or tariffs are lower under the agreement ($\tau_0 < \tau_m$) or both.

Part (a) holds because if $\phi < \bar{\phi}$ then upgrading does not lower marginal costs by enough for the marginal entrants to ever upgrade. Thus their value of entry and waiting are not affected by the *possibility* of upgrading that is only done by others and so the entry cutoffs and their properties are still given by Proposition 1.

The proportionality of the upgrade to the entry cutoffs in part (b) is analogous to the one we found under the deterministic case. Since the upgrading parameter is independent of policy values the result holds for all policy states. Moreover, parts (a) and (b) then imply that the upgrade cutoff "inherits" all the properties of the entry cutoffs with respect to TPU. Namely, the upgrade cutoff under uncertainty is proportional to the deterministic cutoff in (17) by the same uncertainty factor in (14). This also implies that the *elasticity* of either cutoff with respect to policy uncertainty factors is similar.

Finally, part (d) notes that entry into the agreement 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.[21]

In the appendix we show that the relationship between the cutoffs in other states are similar, i.e. $c^U_{sz} = c^D_{sz} U_s$ for all s so the ordering of cutoffs for upgrading across different states is the same as the ordering for entry in (16).

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 TPU on consumer welfare via the price index. The exposition focuses on the entry decisions and at the end of the section we 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 focus on the potential benefits to consumers of lower prices from reducing policy uncertainty. This requires some additional structure to

[21] 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.

tackle two new issues. First, tariff changes in any one industry has cross-industry effects through the price index. Second, we must address transition dynamics in aggregate state variables.

A potential exporter must form expectations about its own and other cross-industry tariffs affecting the price index. We continue to employ the same transition matrix, M, but now assume that it 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.

Transition dynamics in aggregate variables arise directly due to changes in policy and indirectly through the evolution of the price index. Specifically, we account for the fact that after a bad shock, firms above the cutoff threshold will exit over time. This leads to both contemporaneous adjustment and longer run transition dynamics in the price index. Therefore, the economic conditions variable will be time and state dependent, $a_{st} = (\tau_s)^{-\sigma} d^{1-\sigma} A_{st}$. The aggregate variable A_{st} depends on the exporting country's wage, the importer's expenditure on differentiated goods, E_{st}, and its price index P_{st}. Recall that the numeraire is freely traded and produced under a constant marginal product of labor equal to unity and the population is sufficiently large for the numeraire to be produced in equilibrium, so the wage is unity. To close the model in a tractable way we make the following simplifying assumptions:

- A1 There is no borrowing technology available across periods so current expenditures must equal current income each period for each individual.
- A2 All agents have labor endowments of k_L each period. We assume there are two types of agents: entrepreneurs and workers. A fraction of agents 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 workers is the wage.
- A3 The constant expenditure share of per period utility on differentiated goods is $\mu > 0$ for workers and zero for entrepreneurs.

We highlight two implications of this structure. First, assumptions A1-A3, the constant equilibrium wage and worker population imply that expenditure on differentiated goods in any given period is constant, which allows us to focus on the impact of uncertainty on prices. Second, the preference structure in A3 maps 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).[22]

[22] In making the entry decision the entrepeneurs take any lump-sum tariff rebates as given. Also, 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.

Finally, we restrict our attention to a 2-country model so entry into a foreign market does not affect the mass of firms from any *other* countries selling in that market.[23] We can then write the price index as follows

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

The measure of domestic varieties 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 there, denoted by $\Omega_{t,ch}$. The 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. Whenever economic conditions today are at least as good as the past, $c_{Vt}^U \geq \max\{c_{V,t-T}^U\}_{T=0}^{\infty}$ for each V, we can write the price index as a function of the vector of current tariffs and cutoffs $(\tau_t, \mathbf{c}_t)$.

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

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.

Given these assumptions we now define the equilibrium. The only additional impact of policy uncertainty on firm decisions relative to the previous sections is due to changes in the price index. The exogenous policy state $s \in \{0, m, 2\}$ and corresponding tariff variable τ_s evolves according the process described by the policy regime previously described. Consumers maximize utility and firms (entrepreneurs) maximize profits as described above. An equilibrium at period t is then fully described by the set endogenous vector of industry entry cutoffs, $\mathbf{c}_t$, the price index, P_t, and the measure of foreign varieties available, $\Omega_{t,ch}$, such that labor and goods markets clear and trade is balanced.[24] In what follows, we characterize the equilibrium values of the main variables of interest, $\mathbf{c}_t$ and P_t.

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 all industry cutoffs. 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_s^D. The associated price index can be written as a function of the state's tariff and cutoff vectors, $P_s^D = P\left(\tau_s, \mathbf{c}_s^D\right)$. 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

[23] Recall that there is a fixed mass, N_V , of domestic firms that always sells at home because there are no domestic fixed costs. 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.

[24] 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.

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 P and in constant parameters. So any industry cutoff can be written as a linear function of some base industry cutoff, c_{sb}^{D}, and relative parameters, i.e. $c_{sV}^{D} = c_{sb}^{D}\kappa_{Vb}$ 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

$$P\left(\tau_s, c_{sb}^{D}, \mathbf{c}_{sV\neq b}^{D}\left(c_{sb}^{D}\kappa_{Vb}\right)\right) \tag{24}$$

which is a positive function that is continuous and non-increasing in c_{sb}^{D}—as illustrated by the price schedule in figure 3.[25] The entry schedule for the base industry has positive slope, since $\partial c_{sb}^{D}/\partial P > 0$ and $c_{sb}^{D}|_{P\to 0} = 0$. Therefore these two schedules intersect at an equilibrium and do so only once, as shown in figure 3.

Consider now an unexpected permanent reduction in tariffs. Denoting proportional changes by $\hat{x} \equiv d\ln x$, figure 4 depicts a radial liberalization where $\hat{\tau}_V = \hat{\tau} < 0$ for all V so relative cutoffs are unchanged. The initial equilibrium is at point I and at any given value of the price index this increases profits enough for some firms in the base industry to enter. So the entry cutoff is higher and if we rule out price index effects, as in proposition 1, the new cutoff would be at point PE. However, the price index schedule will also pivot down since for any cutoff the consumer prices are lower following the liberalization so the new equilibrium is at point *GE*. The price index clearly falls and thus we have less entry than under the partial equilibrium case but more than under high tariffs, as we show below.

To find the impact of a general change in tariffs (where $\hat{\tau}_V$ can vary across industries) we solve the following system

$$\hat{P} = \textstyle\sum_V \left(\varepsilon_{\tau_V}\hat{\tau}_V + \varepsilon_V \hat{c}_V^{D}\right) \tag{25}$$

$$\hat{c}_V^{D} = -\frac{\sigma}{\sigma-1}\hat{\tau}_V + \hat{P} \quad \text{for each } V \tag{26}$$

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

$$\hat{P} = \textstyle\sum_V \left(\frac{\varepsilon_{\tau_V} - \frac{\sigma}{\sigma-1}\varepsilon_V}{1-\sum_V \varepsilon_V}\right)\hat{\tau}_V \tag{27}$$

We can then use this to verify that the radial liberalization ($\hat{\tau}_V = \hat{\tau} < 0$) increases cutoffs in all industries

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

[25] It can be shown that $\partial P/\partial c_{sV}^{D} \leq 0$ for all V , strictly so for small enough c, and $\partial c_{sV}^{D}/\partial c_{sb}^{D} = \kappa_{Vb}$ for all $V \neq b$. Continuity holds provided that the distribution of firms in each industry is not bounded above so there is always at least one active exporter.

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 partial 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 markets where liberalization leaves relative tariffs unchanged.

With a specific productivity 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 (27) can be used to measure gains from trade liberalization to workers, who are the sole consumers of the differentiated good. Given the utility function we use 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.[26]

Recall from section 2.2 that the tariff ordering in the setting we consider is $\tau_{2V} \geq \tau_{mV} \geq \tau_{0V}$ 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 also obtain the same ordering for each firm when the tariff 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.[27] For exposition purposes we will assume that either because of (i) or (ii) in the deterministic setting the *direct effect of worst case tariffs dominates* if the operating profit in the deterministic equilibrium is lower under column 2 tariffs than under MFN tariffs for all industries, $\pi\left(a_2^D\right) \leq \pi\left(a_m^D\right)$, which requires

$$(\tau_{2V})^{-\sigma}\left(P_2^D\right)^{\sigma-1} \leq (\tau_{mV})^{-\sigma}\left(P_m^D\right)^{\sigma-1} \quad \text{all } V \tag{28}$$

This amounts to requiring the direct tariff effect on the operating profit dominates the indirect effect via the price index. This condition could be violated by a specific industry if its column 2 tariff is very close to the MFN 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.[28] A somewhat more stringent condition is that the *direct effect of tariffs dominates*, which extends the condition above to include an additional inequality between the MFN and agreement profits: $\pi\left(a_2^D\right) \leq \pi\left(a_m^D\right) \leq \pi\left(a_0^D\right)$. It is clear from (26) that this last condition is necessary and sufficient for $\hat{c}_V^D \geq 0$.

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

[27] Using (27) and the definitions of the elasticity in the appendix we can provide specific conditions for this to hold, such as high enough export costs, d.

[28] 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.

2.4.3 Unanticipated shocks and transition dynamics

To gain some insight into the transition dynamics (which we will later use) consider a situation where initially the policy is at the worst case state and expected to remain unchanged. What is the adjustment path when there is an unanticipated permanent decrease in all tariffs? If the proportional decrease is similar across industries then we can again illustrate this in figure 4: the economy moves immediately from the initial equilibrium, point I, to the new one, point GE. There are no transition dynamics because firms can immediately enter in response to the improved conditions. There are also no transition dynamics if tariffs fall by different proportions provided that the direct effect of worst case tariffs dominates.

Consider now an unanticipated permanent *increase* in tariffs. Under a radial tariff increase the steady state values are those already described in figure 4 and reproduced in figure 5 where the initial equilibrium is labelled m^D and the final equilibrium is at point 2^D. However, unlike the liberalization case, now there are transition dynamics. The motive for the asymmetry in the adjustment path is that after a tariff increase 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.

The adjustment path involves a jump from m^D to a point on the entry schedule between 2^{TR} and 2^D followed by an adjustment over time to 2^D. To understand this note that the price index initially jumps due to the direct effect of higher tariffs. *If* there was no death shock then after the tariff increase, the equilibrium would have permanently higher prices at P^{TR} and all of the firms would still be exporting. With the exogenous death shock the least productive firms do not re-enter after being hit by that shock so the initial price is higher than P^{TR} so we must jump to a point above 2^{TR}. Each period after the initial jump firms are dying and the least productive with $c > c_2^D$ do not re-enter and thus there is a monotonic increase in the price index towards its steady state, P_2^D.

We need only show that the entry *schedule* in the adjustment period is the same as the steady state schedule at τ_2. At some time T during the transition a firm that was hit by a death shock must decide between re-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 the two then in the following period it will enter for sure 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 (since P increases as firms 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 transition period T the firm that is indifferent about entering when $s = 2$ must satisfy $\pi(a_{2T}, c_{2T}^D) = (1-\beta) K$. Therefore the entry *schedule* as a function of P_{2T} is the same as the one derived for the steady state. The *equilibrium* cutoff in transition, c_{2T}^D, can be related to the "steady state" cutoff c_2^D in any given industry as follows

$$c_{2T}^D = \left[\frac{a_{2T}}{(1-\beta)\,K}\right]^{\frac{1}{\sigma-1}} = c_2^D \left[\frac{a_{2T}}{a_2}\right]^{\frac{1}{\sigma-1}} \tag{29}$$

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. In sum, after a negative shock there is sluggish exit and so conditions for potential entrants are worse in transition than in steady state and when we consider policy uncertainty we need to take this into account to compute the value functions.

2.4.4 Policy uncertainty, entry, upgrading, prices and welfare

We now build on the deterministic case to analyze TPU. First, we relate the column 2 and WTO scenarios to their deterministic counterparts. Second, we derive the impact of TPU under the MFN state on firm decisions, the price index and consumer welfare.

Entry and Prices

As described in the previous section there are transition dynamics whenever a shock worsens conditions due to exogenous exit, which affects the price index. When the direct effect of tariffs on profits dominates the price index effect then a switch to column 2 worsens conditions for the firm so the cutoffs we determine in this state, c_{2T}^U, will be time dependent. But at the MFN state there is no history of better conditions thus we need only determine one cutoff per industry in this state.[29] Similarly, there is a single cutoff per industry under the WTO. In sum, below we determine c_0^U, c_m^U and c_{2T}^U; since the *approach* is similar to section (2.2) we will describe the main results and provide the details in the appendix.

The entry cutoff under the WTO is given by the deterministic expression in (3), but now it takes into account the price index effect in (23); with each of these expressions evaluated at τ_0.

The worst case entry *schedule* is the one derived in (29). The argument is similar to the one made in the deterministic case after an unexpected shock: 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 (back to MFN) or because the aggregate conditions improve (as other firms exit). 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 $c_{2T}^U = c_{2T}^D$. So the transition dynamics will be similar to what we derived under the unexpected permanent tariff increase: a jump in the price index followed by exit and an increasing price index (and falling cutoff). The main difference is that

[29] The reason why there is no history of better conditions at $s=m$ is that the only other state that would yield such conditions is the agreement, from which there is no exit.

under uncertainty we start at a different equilibrium, which in the radial case would be at point m^U in figure 5, as we argue below.

As in the deterministic economy, whenever there is no history of better conditions at state $s = m$, the economy reaches a steady state immediately with no transition dynamics.[30] We can determine a single cutoff for each industry in general equilibrium at the MFN state, but to do so we must account for the transition dynamics in the values of exporting and waiting under $s = 2$. At the MFN state, the functional forms for the expected values of exporting (6) and waiting (11) are unchanged, but we must solve for the expected 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 employ the indifference condition in (4) for the MFN state to derive c_m^U and relate it to the deterministic cutoff via the uncertainty factor as follows

$$c_m^U = \left[\frac{a_m}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}} U_m(\tilde{\omega}, \gamma) = c_m^D U_m(\tilde{\omega}, \gamma) \frac{P_m}{P_m^D} \tag{30}$$

$$U_m(\tilde{\omega}, \gamma) \equiv \left[\frac{1-\beta}{1-\beta\tilde{t}(\gamma)}\left(1 + \frac{\beta t_{m2}(\gamma)}{1-\beta t_{22}}\tilde{\omega}\right)\right]^{\frac{1}{\sigma-1}} \tag{31}$$

The last expression has one key difference relative to the partial equilibrium uncertainty factor in (14): the term $\tilde{\omega} = \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} g$. This term still reflects the ratio of the PDV of profits under the worst case scenario relative to state m but it now takes into account a *general equilibrium effect* given by

$$g \equiv \frac{(1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t A_{2t}}{A_m} \geq 1. \tag{32}$$

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 MFN policy uncertainty ($t_{mm} = 1$) we have $U_m(\tilde{\omega}, \gamma) = 1$. In Appendix A.3 we show that when the direct effect dominates, as we assume, we have $\tilde{\omega} < 1$ and this implies that $U_m(\tilde{\omega}, \gamma) < 1$.

The additional difference between the uncertainty and deterministic cutoff is 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, as we also saw in the deterministic case. Whenever the policy changes have negligible general equilibrium effects (i.e. P_m/P_m^D and P_m/P_{2t} close to 1) then $c_m^U = c_m^D U_m(\omega, \gamma)$ so when the price effects are negligible we have $c_m^U(\omega) < c_m^D$ under the conditions given in Proposition 1.

Proposition 3 establishes the relationship between the cutoffs when price effects are *not* negligible.

[30] There is exit below the threshold due to death each period but it is immediately offset by entry so the price index and other aggregate quantities are unchanged.

Proposition 3 (Policy Uncertainty and Entry in General Equilibrium):
(a) The entry cutoff under MFN policy uncertainty is $c_m^U = c_m^D U_m(\tilde{\omega}_V, \gamma) \frac{P_m}{P_m^D}$ *where* $U_m(\tilde{\omega}_V, \gamma)$ *is in eq. (31).*
(b) If tariff increases are possible and the direct effect of worst case tariffs dominates then eliminating MFN uncertainty ($\gamma = 0$) *increases entry and decreases the price index at MFN:* $c_{mV}^U \leq c_{mV}^D$ *for all V (at least one strict) and* $P_m > P_m^D$;
(c) If tariff increases are possible and the direct effect of tariffs dominates then the agreement increases entry and decreases the price index: $c_{mV}^U \leq c_{0V}^U = c_{0V}^D$ *for all V (at least one strict) and* $P_m > P_0 = P_0^D$.

Proposition 3 is the general equilibrium equivalent of Proposition 1. The central difference is that we now allow tariffs to affect the importer price index. This is reflected in part (a) in two ways. First, the uncertainty cutoff $U_m(\tilde{\omega}, \gamma)$ is evaluated at $\tilde{\omega} = \omega g \geq \omega$ so there is a smaller effect of TPU on entry than in partial equilibrium because if higher tariffs do arrive there will be exit and the price index will be higher. Second, and for a similar reason, the price index in the MFN state is higher under uncertainty, which leads to relatively more entry than in the absence of general equilibrium effects.

Part (b) provides a sufficient condition for uncertainty to lower the cutoff and thus entry in the MFN state. Recall from Proposition 1 that the possibility of tariff increases was necessary and sufficient, now to ensure that $s = 2$ is still the worst case for firms we require not just that $\tau_2 > \tau_m$ but that $\tau_2 > \tau_m \left(P_2^D / P_m^D\right)^{\frac{\sigma-1}{\sigma}}$ such that the *direct effect of worst case tariffs* in (28) dominates. To understand the role of this condition and the result in part (b) consider the case of a *radial liberalization* such that τ_{2V}/τ_{mV} is identical across V. In this case it is straightforward to show that the direct effect dominates. Moreover, in this case $U_m(\tilde{\omega}_V, \gamma)$ is the same for all V since $\tilde{\omega}_V = \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma} g$. In the deterministic analysis we showed that the cutoff for any V can be written as a linear function of a base industry cutoff and relative parameters: $c_{sV}^D = c_{sb}^D \kappa_{Vb}$ where $\kappa_{Vb} \equiv \left[\frac{(\tau_{sV}/\tau_{sb})^{-\sigma}}{K_V/K_b}\right]^{\frac{1}{\sigma-1}} \frac{d_V}{d_b}$. We can do the same under uncertainty for the cutoffs in states $s = 0, 2$ since their functional form is unchanged. Therefore we can also write the reduced form price index functions for these two states in terms of the base cutoffs and κ_{Vb}, as we did in (24). What is less obvious is that we can do the same for the MFN state. We can do so because under a radial liberalization $U_m(\tilde{\omega}_V, \gamma)$ is the same for all V so we can re-express the relative cutoffs under uncertainty as a function of κ_{Vb} and obtain the same as in the deterministic case, $c_{mV}^U / c_{mb}^U = \kappa_{Vb} = c_{mV}^D / c_{mb}^U$. Thus the price index can be written in reduced form as in (24), which depends only on c_{mb}^U, κ_{Vb} and tariffs but not on γ. This implies that a decrease in γ does not alter the price index schedule if τ_{2V}/τ_{mV} is identical across V. The equilibrium under TPU must therefore lie on the deterministic price schedule in figure 5, on a point such as m^U. To see that the deterministic equilibrium must entail higher entry and lower P consider starting at m^U and setting $\gamma = 0$. In this case $U = 1$ and so at the original price index level the cutoff must increase, given the relative cutoffs are unchanged that must occur for all industries so the price index moves down along the original schedule.

The empirical analysis explores variation in tariffs across industries. Therefore in the appendix we show that part (b) of Proposition 3 also holds without a radial liberalization provided the direct effect of worst case tariffs dominates. This condition ensures the cost cutoffs move in the same direction in all industries and thus the price index falls. Part (c) compares the MFN outcome with the agreement. If the tariffs under MFN and the agreement are the same then we can simply use the result in part (b). If they are lower under the agreement we have additional entry and a lower price provided again that the direct effect of tariff reductions dominates the effect from a lower price index.

Consumer welfare

We now derive expressions for the welfare gains to consumers of changes TPU. To obtain expressions that we can quantify empirically we derive these effects *around* the deterministic equilibrium, which we showed exists and is unique and a special case of the more general model when $\gamma = 0$. For given values of $\tilde{\omega}$ the only *direct* impact of γ occurs through $U_m(\tilde{\omega}, \gamma)$ via changes in the transition probability terms $\tilde{t}$ and t_{m2}.[31] Therefore the total impact of changing the policy regime on the uncertainty factor around $\gamma = 0$ is

$$\frac{d \ln U_m(\tilde{\omega}_V, \gamma)}{d\gamma}|_{\gamma=0} = \frac{\beta t_2}{(\sigma - 1)(1 - \beta t_{22})} (\tilde{\omega}_V|_{\gamma=0} - 1) \quad \text{each } V \tag{33}$$

where $\tilde{\omega}_V|_{\gamma=0}$ implies that g is evaluated at the deterministic values of P_m^D and P_{2T}^D previously derived. This effect on U will then affect the cutoffs, which will in turn impact the price index and welfare. The price index in the MFN state under uncertainty can be written as a function of the tariffs and cutoffs in that state, $P_m(\tau_m, \mathbf{c}_m)$. From (30) we have $c_{mV}^U(U_m, P_m, \tau_{mV})$, which is log linear in each of these arguments so the impact of changing γ is found by replacing (33) in the following system and solving it:

$$\frac{d \ln c_{mV}^U}{d\gamma}|_{\gamma=0} = \frac{d \ln U_{mV}}{d\gamma}|_{\gamma=0} + \frac{d \ln P_m}{d\gamma}|_{\gamma=0} \qquad \text{each } V \tag{34}$$

$$\frac{d \ln P_m}{d\gamma}|_{\gamma=0} = \textstyle\sum_V \varepsilon_V \frac{d \ln c_{mV}^U}{d\gamma}|_{\gamma=0} \tag{35}$$

The first term in the cutoff expression is the direct effect of TPU on each 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 *price index elasticity with respect to export entry cost cutoffs*, $\varepsilon_V \equiv \frac{\partial \ln P(\mathbf{c}_m)}{\partial \ln c_{mV}}|_{\gamma=0}$. We can verify that uncertainty increases the price index by solving the system to obtain

$$\frac{d \ln P_m}{d\gamma}|_{\gamma=0} = \frac{\beta t_2}{(\sigma - 1)(1 - \beta t_{22})} \textstyle\sum_V \tilde{\varepsilon}_V (\tilde{\omega}_V - 1)|_{\gamma=0} > 0 \tag{36}$$

[31] Changes in γ affect current conditions and therefore the future price path reflected in $\tilde{\omega}$. However, the latter are indirect general equilibrium effects and are multiplied by γ and so they are negligible when evaluating around $\gamma = 0$.

where $\tilde{\varepsilon}_V \equiv \varepsilon_V / (1 - \sum_V \varepsilon_V) < 0$ since $\varepsilon_V < 0$ due to love of variety. MFN policy uncertainty will then increase the price index if $\tilde{\omega}_V < 1$ for all V, which we show in Proposition 3 holds whenever the direct effect of worst case tariffs dominates.[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 index elasticity with respect to γ using (36) to bound the general equilibrium effect of TPU on the cutoff and trade.[33]

Proposition 4 summarizes the impact of TPU on the price index and consumer welfare.

Proposition 4 (Policy Uncertainty, Prices and Consumer Welfare in General Equilibrium): *If tariff increases are possible and the direct effect of worst case tariffs dominates then*
(a) an increase in MFN policy uncertainty increases the importer's price index in the MFN state by $\frac{d \ln P_m}{d\gamma}|_{\gamma=0}$ *given by (36) and lowers consumer welfare in that state by* $-\mu \frac{d \ln P_m}{d\gamma}|_{\gamma=0}$.
(b) consumer expected welfare is higher under an agreement that eliminates uncertainty even if tariffs remain at MFN levels.

As we argued above the price effect is positive and therefore $-\mu \frac{d \ln P_m}{d\gamma}|_{\gamma=0} < 0$ and we need only show it represents a welfare effect in the MFN state. To see this recall that the consumers of differentiated goods have period indirect utility equal to $\tilde{\mu} P_m^{-\mu}$ where $\tilde{\mu}$ is constant so the growth in the period utility due to a change in γ is $-\mu \frac{d \ln P_m}{d\gamma}$. In the appendix we also show that this corresponds to one of the two impacts of γ on *expected* welfare for consumers, which is given by

$$W_m = \tilde{\mu} P_m^{-\mu} + \tilde{\beta} \left[\gamma (1 - t_2) W_0 + \gamma t_2 W_{2m} + (1 - \gamma) W_m \right] \tag{37}$$

where W_0 and W_{2m} are the expected welfare values after switching to $s = 0, 2$ respectively. Solving for W_m we obtain the following expression for consumer welfare growth due to a change in γ

$$\frac{d \ln W_m}{d\gamma}|_{\gamma=0} = -\mu \frac{d \ln P_m}{d\gamma}|_{\gamma=0} - \frac{\tilde{\beta}}{1 - \tilde{\beta}} \left(\frac{W_m - (1 - t_2) W_0 - t_2 W_{2m}}{W_m} \right) |_{\gamma=0}. \tag{38}$$

The first term captures the negative impact of increased uncertainty on consumer welfare in the current state due to lower firm entry and the resulting higher price index, as encompassed in part (a) and 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,

[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.
[33] The expression in (36) holds for general distributions of productivity; in the appendix we show what it implies under the standard Pareto distribution that we employ in the estimation.

$(1-t_2)\, W_0 + t_2 W_{2m}$. 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.3 we derive expressions for both effects. In the quantification section we discuss how our estimates allow us to quantify the within state welfare effect.[34]

Part (b) of proposition 4, that welfare is higher under the agreement, is a global property for all $\gamma > 0$, which we prove in the appendix. The welfare gain for consumers is again driven by price decreases, which are due to higher variety and possibly lower tariffs.

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 (34) 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.

Technology Upgrade

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. (30).[35] 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 (30) and (19). 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 (34) 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

[34] 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.

[35] 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 (28) still holds when evaluated at the new price index, the entry cutoff expressions will be unchanged. Note also that (28) implies the same ranking of profits for the firm if it upgrades its technology.

uncertainty we now need to solve the system that includes the two types of cutoff in each industry and the 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 (36) 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

$$R_{sV} = a_{sV}\sigma \left[\int_{v \in \Omega^z_{sV}} (z_V c_v)^{1-\sigma} \, dv + \int_{v \in \Omega_{sV} \setminus \Omega^z_{sV}} (c_v)^{1-\sigma} \, dv \right] \tag{39}$$

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. 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 (39) 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. The steady state mass of exporting firms in states s and m is equal to $N_V G\left(c^U_s\right)$, the product of all producers in industry V in the export country times the fraction with costs below the cutoff (since G is the CDF of costs). A sufficient condition in the context of the model for $N_V G\left(c^U_s\right)$ to exactly capture the mass of exports is for the agreement to be an absorbing state, $t_{00} = 1$, as we have assumed. Then conditions cannot improve further in state 0. Since there is no history of better conditions then temporary MFN, an assumption that applies to China's situation, it will also hold in state m.[36] 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.

We then assume that productivity has a Pareto distribution that is bounded below at $1/c_V$ but unbounded above so $G_V(c) = (\frac{c}{c_V})^k$. 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

$$\ln R_{sV} = (k - \sigma + 1) \ln U_s(\tilde{\omega}_V, \gamma) - \frac{k\sigma}{\sigma - 1} \ln \tau_{sV} - k \ln d_V + \frac{k}{\sigma - 1} \ln A_s + \ln \zeta_V + \ln \tilde{\alpha}_V \tag{40}$$

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.

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 U.S., 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.

3.1 Empirical Approach

To identify the impact of TPU on exports via the augmented gravity equation in (40) we must measure the uncertainty factor. If before the agreement, at $s = m$, there was no policy uncertainty ($\gamma = 0$) and thus no probability of the worst case scenario ($t_{m2} = \gamma t_2 = 0$) then the model generates a standard gravity

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

equation with an extra upgrading term. Using this insight as our null hypothesis, we use (33) to approximate $U_m(\tilde{\omega}_V,\gamma)=\frac{\beta t_2(1-\tilde{\omega}_V)}{(\sigma-1)(1-\beta t_{22})}\gamma+u_{mV}$ where u_V is an approximation error term.[37] We can then rewrite (40) as

$$\ln R_{mV}=-\frac{k-\sigma+1}{\sigma-1}\frac{\beta t_{m2}}{1-\beta t_{22}}g\left(g^{-1}-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)-\frac{k\sigma}{\sigma-1}\ln\tau_{mV}-k\ln d_V+\frac{k}{\sigma-1}\ln A_m+\ln\zeta_V+\ln\tilde{\alpha}_V+u_{mV} \tag{41}$$

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

$$\ln R_{mV}=-b_\gamma\left(1-\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)+b_\tau\ln\tau_{mV}+b_d\ln D_{mV}+b_m+b_V+u_{mV} \tag{42}$$

We estimate each of the b_i, which are related to the structural parameters as follows: $b_\gamma=\frac{k-\sigma+1}{\sigma-1}\frac{\beta t_{m2}}{1-\beta t_{22}}g\geq 0$, 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. We note that b_γ will capture the impact of TPU on *total* exports in an industry reflecting both entry and any technology upgrading effects.[38]

The applied tariff coefficient is $b_\tau=-\frac{k\sigma}{\sigma-1}<0$, which reflects the first order effect of the tariff . 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 the impact of uncertainty. Moreover, we are interested in the impact of the *change* 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

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

[38] This can be done through a single parameter since according to the model both the entry and upgrading cutoffs have the same elasticity with respect to TPU.

[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.

a simple difference, where below $\Delta \ln x_V = \ln x_{0V} - \ln x_{mV}$.

$$\Delta \ln R_V = b_\gamma \left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + b_\tau \Delta \ln \tau_V + b_d \Delta \ln D_V + b + u_V \tag{43}$$

The impact of uncertainty on export growth reflects only the pre-agreement level of uncertainty. 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 (43) explores 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 and (4) the upgrade technology, sunk costs, and mass of producers can vary across industries but not over the short time period we consider. We will relax some of these assumptions in the empirical analysis. For example, in the robustness section we 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 (so an advalorem tariff of 20% is converted to $\tau = 1.2$). 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. 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

[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 $u_V = -u_{mV}$. If $b_{\gamma t}$ is not zero after the agreement and we note that column 2 tariffs stayed unchanged, then we can interpret our estimate of $b_\gamma = b_{\gamma 2000} - b_{\gamma t}$ so if there is no change in probabilities the estimate will be zero but if the probability of going to column 2 and/or staying there falls then $b_\gamma > 0$.

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

then at least some will be productive enough to export. Second, and more importantly, these continuing HS6 codes account for 99.8% of all export growth from China to the U.S. 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 column 2 tariffs and a trade war would likely have ensued. For our baseline sample, which is 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) if it lost its MFN status in 2000. 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.

3.3 Non-parametric Evidence

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 τ_{hV}, and find that this potential loss was on average 52% when $\sigma = 3$, which will be the baseline used

[42] The exception is textiles quotas that were fully lifted in 2005 and can be controlled for empirically.
[43] Pregelj (2001) provides details on the U.S. MFN status relative to China.

unless otherwise stated.[44] The standard deviation of this measure 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 lowest and highest 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. It also suggests the relationship is not driven by outliers since the lowess procedure used downweights 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 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 (43). The results in Table 2 are consistent with the structural interpretation of the parameters. In column 1 we see

[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).

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 can't 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 U.S. 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 (43) 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 (43). 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* heterogeneity 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 controlling for sector growth heterogeneity.

3.5 Robustness

Additional measures of protection and sample selection

The regressions in columns 3 and 4 of Table 2 already control for changes in trade barriers other than the ones included provided that they change only at the sector level. Nevertheless, there are barriers other than tariffs that can vary at the more disaggregated industry (HS6) level as well—anti-dumping duties, countervailing duties and China-specific special safeguards. To control for these 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 they have the expected negative sign. Importantly, their inclusion does not affect the other coefficients and this is also the case when we control for sector 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 A5 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 (43) given by $(R_{0V} - R_{mV}) / (R_{0V} + R_{mV})/2$. 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

[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.

the dependent variable.

Pre-accession growth 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 had the 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 A6 column 3 we find no significant effect of the initial uncertainty measure. This test also indicates that the coefficient on uncertainty did not change in this pre-accession period.[50]

We can provide some additional evidence that growth trends at the HS-6 level 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 A6 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. Consider a generalized version of the level equation (42) that allows the uncertainty coefficient to vary by year, subscript t, and includes time *by* sector effects, b_{tS}, in addition to industry (HS-6) fixed effects b_V.

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

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 $\tau_{tV} = \tau_{2000V}$ in the uncertainty measure. In this case we cannot identify $b_{\gamma t}$ for each year since the uncertainty regressor only varies across V and we include b_V. Instead, we estimate the coefficient change over time relative to a base year, namely $-(b_{\gamma t} - b_{\gamma 2000})$. The estimates in Table 4 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 fully enacted in 2002. The effect is uniformly positive and significant 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 found in the baseline.

Recall that the model has predictions not only for a change in state (from temporary MFN to WTO) but also for changes in policy regime within a state, e.g. changes in γ in the MFN state. By estimating the impact of uncertainty during the MFN state by year we can also see that the coefficients in years prior to

[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.

the WTO accession are not statistically different from each other. This suggests that minor changes in the legislation or in the relations between the U.S. and China did significantly affect Chinese firms' beliefs about losing the MFN status. Those beliefs were only revised after WTO accession. The point estimates increase until 2005 and stabilize in 2006, which may reflect a gradual reduction in γ until the full transition takes place, around 2005.

While the baseline and panel thus far estimate the change in the impact of uncertainty, $-(b_{\gamma t} - b_{\gamma 2000})$, we now provide estimates for the level of these coefficients. We can only do this in the panel because there is variation in the uncertainty measure in the period 1996-2000 because of changes in the applied tariffs (as the Uruguay Round was implemented). This allows us to identify pre- and post-accession coefficients. We construct the uncertainty measure for each industry year 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 $b_{\gamma post} \geq 0$, where the last prediction is an equality if the agreement eliminated this source of uncertainty. In the second column of Table 4 we find evidence that supports these 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. Note also that the difference in coefficients $b_{\gamma post} - b_{\gamma pre}$ is 0.68, which is the same as our corresponding baseline point estimate in column 3 of Table 2.

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 5 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 sector 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 an 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 use a semi-parametric approach that does not place much theoretical structure on the estimation and compare the fit with our linear approach. Second, 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. 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

[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.

$$\Delta \ln R_V = f\left(\tilde{U}_V\right) + b_\tau \Delta \ln \tau_V + b_d \Delta \ln D_V + b + u_V \tag{44}$$

Standard trade models with a gravity structure yield an estimation equation that is a special case of (44) 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. 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 (44) to estimate Robinson's (1988) double residual semi-parametric regression. Figure 6 presents the semi-parametric fit plotted against $1-\left(\frac{\tau_2}{\tau_m}\right)^{-3}$.[52] 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.[53]

The non-parametric results provide supporting evidence for our approximation of the uncertainty factor and choice of σ. We now examine these using NLLS. The model's structure implies a specific functional form for $f\left(\tilde{U}_V\right)$, which we employ in (44) to estimate the following equation using NLLS:[54]

$$\Delta \ln R_V = -\frac{b_d - \sigma + 1}{\sigma - 1} \ln\left(1 + \tilde{b}_\gamma \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right) + \frac{b_d}{\sigma - 1} \Delta \ln \tau_V + b_d \Delta \ln D_V + \tilde{b} + u_V \tag{45}$$

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 $b_d = k = b_\tau \frac{\sigma-1}{\sigma}$.[55] If the uncertainty factor 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

[52] 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.

[53] 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 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.

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

[55] 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.

columns 1 and 2 or 3 and 4 of Table 5.[56] 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 sector 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 (45). The last row of Table 5 shows that we are unable to reject this restriction.

3.6 Quantification

We now quantify the effect of the policy uncertainty reduction on trade, prices and consumer welfare.

Baseline exports, price and welfare

Using the parameter definitions in (42) we can provide an expression for the average "partial effect" over industries of eliminating uncertainty while holding everything else fixed, including the price index, as follows

$$\mathbb{E}\left(\ln R_{0V} - \ln R_{mV}\right)|_{\bar{\tau},\bar{D},\bar{P}} = b_\gamma \mathbb{E}\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) \leq b_\gamma \mathbb{E}\left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) \tag{46}$$

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 the uncertainty removal lead to export growth of up to 37 log points, as shown in the top left of Table 6.

To determine how close the upper bound is to the real effect recall from the model that $g \in [1, \left(P_2^D/P_m^D\right)^{\sigma-1}]$. From (46) we can see that even if $b_\gamma \neq 0$, as estimated, the average partial 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]

We employ $\left(P_2^D/P_m^D\right)^{\sigma-1}$ as an upper bound for g. In appendix A.5.1 we show that this 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. Using the baseline in column 4 of Table

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

[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 obtained from Census data and defined as Chinese imports/US shipments-Exports+Imports). 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%.

2 ($\sigma = 3$ and $k = 2.6$) 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 (46) we obtain what we call the partial effect in column 2 of Table 6, which is 34 log points. Since the bound for g relies on an approximation around the deterministic policy we employ 2005 values to calculate it but find that the partial effect is not very sensitive to reasonable alternative upper bounds for g.

Next we calculate the "average total effect", which adds the price impact generated by changing uncertainty alone to the partial effect described.[58]

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

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 6: 32 log points.

Another way to quantify the importance of uncertainty on trade is to ask what its trade cost equivalent is, i.e. how large a change in average trade 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 6 by dividing the impact of uncertainty calculated above by the transport cost elasticity, which implies a trade 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 6.[59]

One advantage of this approach is that it can be used not just to estimate the impacts of observed changes but also evaluate counterfactuals. For example, what would be the average ln change in exports if policy uncertainty was re-introduced in year t? Below we will examine such a counterfactual in the context of currency manipulation legislation, here we illustrate how it relates to the estimates we have discussed. In the absence of general equilibrium effects the impact of re-introducing pre-WTO uncertainty in year t is simply the last term in (46)—what we called the upper bound effect, $b_{\gamma}\mathbb{E}\left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)$. This equivalence between the quantification and counterfactual interpretation is due to the following (1) b_{γ} is a combination of deep parameters; (2) the counterfactual calls for re-introducing the pre-WTO value for $\frac{\tau_{2V}}{\tau_{mV}}$ (otherwise we would simply recompute this value) and (3) other variables that may have changed are log separable.

In the presence of general equilibrium effects we should recalculate $\ln P_0/P_m$ and g, which depend on year t product export shares and import penetration. In practice, for $t = 2005$ we obtain the estimates in Table

[58] We obtain this by adding the price effect subsumed in the A term in (41) to the partial effect represented by the middle expression in (46).

[59] 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.

6 because the upper bound for g and the price effects require evaluation around a deterministic equilibrium. But the values in Table 6 are not very sensitive to using reasonable alternative upper bounds for g and import penetration. In sum, the results in Table 6 also tell us that re-introducing policy uncertainty in 2005 would have lowered exports by about 32 log points on average.

Keeping in mind this counterfactual interpretation of our estimates we now examine the impact of uncertainty on consumer welfare. In particular we ask: what are the bounds on the growth in expected consumer welfare from raising policy uncertainty to its pre-agreement level? Recall that in (38) 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.[60]

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.[61] 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.[62]

Given the interest of the impact of trade on employment and wages in the transition period we also quantify the impact of uncertainty on aggregate exports for other years since WTO entry. We do so by applying the counterfactual above to the panel estimates from Table 4. In figure 7, the top line represents aggregate export value (in \$ billion) and the dashed one represents the counterfactual exports if uncertainty was re-introduced in year t. So the difference between them provides a measure of the impact of TPU on aggregate exports.[63]

[60] In appendix A.5.3 we show that we can approximate this welfare effect without the technology parameters because they are already reflected in the export level that we use to weight up the change in the cutoffs that generate the price index change.

[61] 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.

[62] Our model differs on some important dimensions: e.g. uncertainty, sunk costs, an outside good and no free entry in the domestic market. Both our model and most other trade models abstracts from services due to data constraints. 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 import penetration used in the calculations.

[63] More specifically the counterfactual is $\sum_V \hat{R}_{tV} = \sum_V R_{tV} \exp\left(-b_{\gamma T}\left(1 - \left(\frac{\tau_{2V}}{\tau_{tV}}\right)^{-\sigma}\right)\right)$ where $b_{\gamma T}$ represents each of the coefficients in Table 4 for $T = 2002 - 2006$.

We note three points from Figure 7. First, the panel estimates suggest that if policy uncertainty had remained then Chinese exports in 2002 would have remained largely unchanged relative to 2001.[64] The second point is that the log difference in 2005 and 2006 is similar, as the model would predict once exporters believe that the current policy regime is stable. Third, the magnitude of the steady state effect is very high: a reduction of over 35% of exports in 2005 if TPU was re-introduced. An ex-ante global general equilibrium study by Arce and Taylor (1997) calculated that if the U.S. *revoked* MFN status in the mid-1990's China's exports would fall 50%. The effect would likely be larger if applied in 2005 since applied tariffs have fallen. However, it suggests that the panel estimate of 35% for the *threat* of revoking the MFN status may be an over estimate. The estimate using the baseline is more reasonable: 30%, but still large so next we examine if this is partly due to non-linear impacts of the uncertainty term.

Non-linear estimates and risk decomposition

The quantification we used thus far employed the baseline estimates that relied on a linear approximation of the uncertainty factor, U. We now use the non-linear estimates in Table 5, which did not require an approximation. The equivalent of the partial effect in (46) is given by

$$\begin{aligned} \mathbb{E}\left(\ln R_{0V} - \ln R_{mV}\right)|_{\tau,D,P} &= -\left(k-\sigma+1\right)\mathbb{E}\left[\ln U_m\left(\tilde{\omega}_V\right)\right] \\ &= -\frac{b_d-\sigma+1}{\sigma-1}\mathbb{E}\left[\ln\frac{1+\tilde{b}_\gamma\left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}}{1+\tilde{b}_\gamma/g}\right] \end{aligned} \tag{47}$$

where the first line assumes, consistent with evidence, that uncertainty is insignificant after the agreement. 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 7 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. This is 10 log points lower than the baseline in column 3 of Table 6. The lower effect reflects both the nonlinearity of the impact of the uncertainty variable and the higher elasticity of exports to transport costs due to removing outliers (which generates a stronger role for the price index change on exports). When we aggregate the industry effects we find that re-introducing the threat of column 2 tariffs would reduce Chinese exports by 22%, which amounts to about \$55 billion in 2005.

While the trade impact under NLLS is lower, the price index change due to the uncertainty ends up being identical to the baseline, -0.8, and thus so is the welfare impact. Revoking the MFN status in 2005 and imposing column 2 tariffs would have increased the price index by 3.3%.

[64] This is a large effect but not completely implausible given that the U.S. and Chinese GDP growth rates in 2002 were similar to those in 2001 (when trade was indeed flat) and only in 2003 did they recover from the recession.

[65] In Table 5 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.

Given that the NLLS estimates are the most consistent with the model and are also the most conservative ones they constitute our preferred specification in terms of quantification and we will use it for subsequent exercises.

One such exercise examines what fraction of export growth due to the agreement is attributable a policy risk reduction, i.e. a mean preserving tariff risk reduction. If MFN tariffs prior to the agreement were at their long-run mean then it is simple to show that the full impact of an agreement that decreases γ is due to a policy 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. In Appendix B.3 we show how to decompose the impact of the agreement into a mean and risk component. The risk component is given by the counterfactual impact of a reduction in γ *if* tariffs were at their long-run mean and accounts for about 40 percent of the average partial effect in Table 7.

Counterfactual trade and welfare effects of tariff threats to "currency manipulators"

Since the mid-2000s recurring bills in the U.S. Congress have called for import barriers to be imposed on "currency manipulators". The main target of such bills has been China, which until July 2005 pegged to the dollar at a rate that was considered by many to be "undervalued". After that date the peg was removed and by late 2011 the RMB had revalued by about 30%. Early bills included provisions for across-the-board tariffs of 27.5% on all Chinese goods. Related legislation would require a review process and impose countervailing duties equal to the implied export subsidy given by the undervaluation percentage.[66]

The U.S. House passed such a bill in 2010, the Senate passed a version in 2011 but it did not become a law. We use the model to compute the counterfactual effect of uncertainty over tariffs that would be generated if such a bill became a law. More specifically, we ask what would be the effect on trade and welfare of a law requiring periodic currency reviews and threatened high countervailing duties in case of a currency manipulation status. This law would be much like the MFN renewal process that we analyzed. To apply our estimates we assume that Chinese exporters believe that the probability of currency manipulation tariffs is similar to that of column 2 tariffs during the MFN renewal. We use a currency tariff threat of 27.5% percent on all goods, which is added to the MFN tariff, as proposed in early legislation. We then use the NLLS estimates to compute the counterfactual for 2012—the most recent year where the data is available.

We calculate that currency manipulation laws that include tariff threats would lower Chinese exports to the U.S. by 21 percent. This includes the effect of the increase in the price index, which implies a welfare loss for consumers of 1.1μ, so larger than the MFN renewal process.[67,68]

[66] Methods for determining the magnitude of currency undervaluation vary substantially across legislation. Countervailing duty triggers for currency undervaluation have also been demanded as a component of prospective free trade agreements such as the Trans-Pacific Partnership (Morrison and Labonte, 2013).

[67] The loss is larger despite the fact that in the currency trade war scenario, tariffs would increase to an average of 31, which is comparable to the threat of column 2 tariffs in 1990s. The reason for the larger effect is that the Chinese import penetration grew from 0.04 in 2005 to 0.07 in 2012.

[68] Even if the probability of currency tariffs was believed to be half that of column 2 tariffs the impacts would be large: Chinese exports would decrease by 12% and the US price index would rise by 0.5 log points relative to 2012. These calculations assume

This exercise further illustrates the large impacts of TPU and how our approach can be used evaluate interesting counterfactuals.

3.7 Additional Results: policy uncertainty and entry

We now examine the effect of TPU on entry. We first explore the 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 $G(c^U_{tV})N_V$ —the fraction of all available Chinese varieties that have costs below the entry threshold. Moreover, 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} is exactly equal to that fraction. We can then use the Pareto assumption and the derived cutoff, c^U_{tV}, to provide a general expression for the number of varieties and then take the difference between 2005 and 2000, as done for exports, to obtain

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

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 $k/(k - \sigma + 1)$. 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

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

We focus on the NLLS estimates for the export equation that are closer to the theoretical model (column 2 Table 5). We find that reducing uncertainty increased Chinese exported varieties by 48 log points if we ignore the price index effect and 44 log points when we do take it into account. These results also apply to the growth of firms that upgrade since the model predicts that their cutoff is proportional to the entry cutoff up to a constant factor.

To examine if there is additional evidence for the entry predictions we also explore the 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

all else equal and abstract from any resulting effects of changes in the exchange rate or Chinese tariffs. In our model Chinese tariff retaliation would reduce the profits of US exporters but not the welfare of US consumers or US imports of differentiated goods as long as countries remained diversified. But in practice these other factors can alter the exact magnitudes we calculate.

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.[69] 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

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

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

In Table 8, 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 sector 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 the appendix we show how to use these estimates to quantify the impact of uncertainty on entry in an exercise similar to the one using the export estimates.[70] However, our preferred quantification is the more conservative one using the NLLS estimates according to which the uncertainty impact on entry was 44 log points. This is still a large effect, particularly when we consider that the *total* growth in the number of Chinese exporting firms to the world over 2000-2005 was 0.83 (Ma et al., 2013).

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

[69] 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.

[70] Appendix Table A7 contains the estimates. 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 trade cost advalorem equivalent, which is 0.25, and verify that it is higher than for trade flows (0.13).

and subject Chinese imports to Smoot-Hawley tariffs. While recent work focuses on the costs of the Chinese export boom to employment and wages, we focus on the potential for gains from reducing TPU.

We derive observable, theory-consistent measures of TPU 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%. According to our most conservative estimates this threat had large effects on trade and if it was re-imposed in 2005 it would have lowered Chinese exports by at least 22%. 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 that remove policy uncertainty, even if applied tariff changes are small.

Our findings have implications beyond this particular important event. We show how to calculate the impact of threats tariffs against "currency manipulators" and find that implementing such legislation in 2012 would have had similar trade effects to removing China's permanent MFN status higher welfare cost to U.S. consumers. More broadly, our results provide evidence that one of the important channels through which the WTO can increase trade and welfare is by reducing TPU. This finding is novel because it suggests that even if two countries achieve low cooperative tariffs in a repeated game, like the U.S. and China in 1990s, the threat the non-cooperative outcome generates enough uncertainty to have real effects on economic activity. In future work we will investigate firm-level decisions to invest in entry and new technology to directly test the impact of TPU on each channel.

References

Amiti, M. and C. Freund. (2010). The Anatomy of China's Export Growth, *China's Growing Role in World Trade*, Eds. Robert C. Feenstra and Shang-Jin Wei, University of Chicago Press, p. 35-56

Arce, H. and Taylor, C. (1997), The effects of changing U.S. MFN status for China, *Review of World Economics*, 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*.

Bagwell, K. and Staiger, R. W. (1999). An Economic Theory of GATT. *American Economic Review*, 89(1):215–248.

Bagwell, K., and Staiger, R.W. (2011). What Do Trade Negotiators Negotiate About? Empirical Evidence from the World Trade Organization, *American Economic Review*, 101(4): 1238-73.

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), in *China's Growing Role in World Trade*, University of Chicago Press, p. 345-387.

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.

Broda, C., N. Limão, and Weinstein, D. (2008). Optimal Tariffs and Market Power: The Evidence, *American Economic Review*, 98(5): 2032-2065.

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.

Impullitti, G. Irarrazabal, A and Luca Opromolla. (2013). A Theory of Entry Into and Exit From Export Markets, *Journal of International Economics*, (90)1, p.75-90.

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.

Ludema, R. and A. M. Mayda (Forthcoming). Do Terms-of-Trade Effects Matter for Trade Agreements? Theory and Evidence from WTO Countries, *Quarterly Journal of Economics*.

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

Morrison, W. M. and M. Labonte (2013). China's Currency Policy: An Analysis of the Economic Issues, CRS 21625.

Ossa, R. (2013). 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 derive the entry thresholds in section 2.2 and prove Proposition 1.

Derivation of expected value of exporting (MFN), eq. (8)

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

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

Derivation of expected value of waiting (MFN), eq. (12)

To obtain (12) we simplify (11) using (9) and (7) evaluated at the threshold for entry at MFN along with (4), i.e. $\Pi_e(a_m,c_m^U)-K=\Pi_w(a_m,c_m^U)$

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

Proof of Proposition 1 (Policy Uncertainty and Entry in Partial Equilibrium):
a. The export entry cost cutoff under MFN policy uncertainty, c_m^U, is proportional to its deterministic counterpart, c_m^D, by the uncertainty factor, $U_m(\omega,\gamma)$,in eq. (14).

Entry cutoff at MFN: $c_m^U=c_m^D U_m(\omega,\gamma)$

We plug in the value of export in (8) and the value of waiting in (12) into the indifference condition in (4) and re-arrange. We simplify notation by 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 $\left(1-\beta t_m\right)\Pi$ 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 obtain

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

b. $c_m^U < c_m^D$ and $d\ln c_m^U/d\gamma = d\ln U_m/d\gamma < 0$ if and only if $\tau_2 > \tau_m$ and $t_{m2} > 0$, otherwise $c_m^U = c_m^D$.

$c_m^U < c_m^D$ iff $\tau_2 > \tau_m$ and $t_{m2} > 0$ otherwise $c_m^U = c_m^D$

Since $c_m^U/c_m^D = U_m$ we first show the condition is necessary and sufficient for $U_m < 1$.

$$\begin{aligned}U_m = \left[\frac{1-\beta}{1-\beta\tilde{t}}\left(1+\frac{\beta t_{m2}}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right]^{\frac{1}{\sigma-1}} &< 1 \qquad (53)\\ \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\left[\left(1-\beta\right)\frac{\beta t_{m2}}{1-\beta t_{22}}\right] &< 1-\beta\left(1-t_{m2}+t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}}\right)-\left(1-\beta\right)\\ \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\frac{t_{m2}}{1-\beta t_{22}} &< \frac{t_{m2}}{1-\beta t_{22}}\end{aligned}$$

The second line uses the definition of $\tilde{t}$ and the third simplifies. Thus $U_m < 1$ iff $\tau_2 > \tau_m$ and $t_{m2} > 0$, otherwise $U_m = 1$ and so $c_m^U = c_m^D$.

$d\ln c_m^U/d\gamma = d\ln U_m/d\gamma < 0$ iff $\tau_2 > \tau_m$ *and* $t_{m2} > 0$

From part (a) of the proposition $c_m^U = c_m^D U_m\left(\omega,\gamma\right)$ and since c_m^D is independent of γ, we have $\frac{d\ln c_m^U}{d\gamma} = \frac{d\ln U_m(\omega,\gamma)}{d\gamma}$. Using (14) we obtain

$$\begin{aligned}\frac{d\ln c_m^U}{d\gamma} &= \frac{1}{\sigma-1}\frac{d}{d\gamma}\left[\ln\frac{1-\beta}{1-\beta\tilde{t}}\left(1+\frac{\beta\gamma t_2}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right]\\ \frac{d\ln c_m^U}{d\gamma} &= \frac{1}{\sigma-1}\left(-\frac{d\ln\left(1-\beta\tilde{t}\right)}{d\tilde{t}}\frac{d\tilde{t}}{d\gamma}+\frac{d}{d\gamma}\ln\left(1+\frac{\beta\gamma t_2}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right)\\ \frac{d\ln c_m^U}{d\gamma} &= \frac{1}{\sigma-1}\frac{\beta t_2}{1-\beta t_{22}}\left(-\left(\frac{1-\beta}{1-\beta\tilde{t}}\right)+\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\Big/\left(1+\frac{\beta\gamma t_2}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right) \qquad (54)\end{aligned}$$

where the third line uses $\tilde{t}\equiv 1-t_{m2}+t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}} = 1-\gamma t_2+\gamma t_2\frac{\beta t_{2m}}{1-\beta t_{22}}$ and simplifies.

$$\begin{aligned}\frac{d\ln c_m^U}{d\gamma} &< 0\\ \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} &< \left(1+\frac{\beta\gamma t_2}{1-\beta t_{22}}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\left(\frac{1-\beta}{1-\beta\tilde{t}}\right)\\ \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\left[1-\frac{\beta\gamma t_2}{\left(1-\beta t_{22}\right)}\left(\frac{1-\beta}{1-\beta\tilde{t}}\right)\right] &< \left(\frac{1-\beta}{1-\beta\tilde{t}}\right) \qquad (55)\end{aligned}$$

The term in brackets on the LHS simplifies to the term on the RHS, $\left(\frac{1-\beta}{1-\beta\tilde{t}}\right)$, after we use the definition for $\tilde{t}$ as well as $t_{2m} = 1 - t_{22}$. Thus this inequality holds if and only if $\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma} < 1$. Moreover $t_{m2} = \gamma t_2 > 0$ is necessary since $U_m(\omega, \gamma)$ depends on γ only through t_{m2} and $t_{m2} > 0$.

c. $c_m^U < c_0^U = c_0^D$ *if* $\tau_2 > \tau_m$ *and* $t_{m2} > 0$ *or* $\tau_0 < \tau_m$ *or both.*

If $\tau_2 > \tau_m$ *and* $t_{m2} > 0$ then $c_m^U < c_m^D$, as shown in part (b). Since we assume that $t_{00} = 1$ we have $c_0^D = c_0^U$. If $\tau_0 \leq \tau_m$ then $c_m^D \leq c_0^D$ (from (3)) and therefore $c_m^U < c_m^D \leq c_0^D = c_0^U$. If tariff increases are not possible ($\tau_2 = \tau_m$ and/or $t_{m2} = 0$) then $c_m^U = c_m^D < c_0^D = c_0^U$ if $\tau_0 < \tau_m$. The first equality is shown in part (b) and the inequality is from (3).□

Ordering of cutoffs in (16)

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

In the proof of proposition 1 we provide the conditions for $c_m^U < c_m^D \leq c_0^U = c_0^D$. In the text we showed that $c_2^U = c_2^D$. Thus here we prove the statement in the text that $c_2^U < c_m^U$ if and only if $\omega < 1$.

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

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

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

This is the same inequality as in (55) that we showed to hold iff $\frac{\tau_2}{\tau_m} < 1$.

A.2 Technological upgrade threshold

In this appendix we derive the upgrade thresholds in section 2.3 and prove Proposition 2.

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

$$\Pi_{wz}(a_0, c, z) = \Pi_e(a_0, c) \tag{56}$$

for the remaining states we have $\Pi_{wz}(a_m, c, z)$, given by (22) in the text and for $s = 2$ we have the following for $c \in [c^U_{2z}, c^U_{mz}]$

$$\begin{aligned} \Pi_{wz}(a_2, c, z) &= \pi(a_2, c) + \beta\left[t_{22}\Pi_{wz}(a_2, c, z) + t_{2m}\left[\Pi_{ez}(a_m, zc) - K_z\right]\right] \qquad (57) \\ \Pi_{wz}(a_2, c, z)\,(1 - \beta t_{22}) &= \pi(a_2, c) + \beta t_{2m}\left[\Pi_{ez}(a_m, zc) - K_z\right] \end{aligned}$$

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

Using (22), (57) and (21) we obtain

$$\begin{aligned} \Pi_{wz}(a_m, c^U_{mz}, z)\,(1 - \beta t_{mm}) &= \pi(a_m, c^U_{mz}) \\ &+ \beta\left[\frac{t_{m2}}{1 - \beta t_{22}}\left[\pi(a_2, c^U_{mz}) + \beta t_{2m}\left[\Pi_{ez}(a_m, zc^U_{mz}) - K_z\right]\right] + t_{m0}\left[z^{1-\sigma}\Pi_e(a_0, c^U_{mz}) - K_z\right]\right] \\ \Pi_{wz}(a_m, c^U_{mz}, z)\left(1 - \beta\hat{t}\right) &= \pi(a_m, c^U_{mz}) + \beta\left[\frac{t_{m2}}{1 - \beta t_{22}}\pi(a_2, c^U_{mz}) + t_{m0}\left[z^{1-\sigma}\frac{\pi(a_0, c) + \beta t_{0m}\Pi_e(a_m, c)}{1 - \beta t_{00}} - K_z\right]\right] \end{aligned}$$

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

Proof of Proposition 2

When firms can pay a sunk cost to upgrade their export technology and the upgrading parameter is sufficiently low ($\phi < \bar{\phi} \leq 1$) we have the results in (a)-(d)

(a) the export entry cutoffs are given by Proposition 1

This requires the existence of a critical $\bar{\phi}$ such that the marginal entrant into exporting in any state will never upgrade in any state. In that case the value of starting to export and the value of waiting for the marginal export entrant in any state s and thus the entry cutoffs are given by Proposition 1. For the critical $\bar{\phi}$ it is sufficient to obtain the condition for ϕ such that $c^U_{0z}(\phi) < c^U_2$ since in that case we have $c^U_{0z}(\phi) < c^U_2 < c^U_m \leq c^U_0$ where the last two inequalities are shown in appendix A.1. Given that the agreement is an absorbing state we have $c^U_{0z} = c^D_{0z}$, which is given by (17). Moreover, as we showed in section 2.2 $c^U_2 = c^D_2$. Thus we require

$$c^U_{0z} = c^D_{0z} = \left[\frac{a_0\left(z^{1-\sigma} - 1\right)}{(1-\beta)K_z}\right]^{\frac{1}{\sigma-1}} < \left[\frac{a_2}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}} = c^D_2 = c^U_2$$

$$\phi < \left[\frac{\tau_2}{\tau_0}\right]^{\frac{-\sigma}{\sigma-1}}$$

so $\bar{\phi} = \left(\frac{\tau_2}{\tau_0}\right)^{\frac{-\sigma}{\sigma-1}}$. Using the definition of ϕ, we require $\left(z^{1-\sigma} - 1\right)\frac{K}{K_z} < \left(\frac{\tau_2}{\tau_0}\right)^{-\sigma}$.

(b) the upgrading cutoff is proportional to the entry cutoff: $c^U_{sz}/c^U_s = \phi$ *for all* s

We must first derive the cutoffs in each state.

Worst case upgrade cutoff: c_{2z}^{U}

Using the cutoff in (20) and evaluating at the equilibrium value of exporting for the marginal upgrader at $s=2$ (21) and value of waiting in (57) we obtain

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

where the second line uses (7) and the third one uses $t_{2m} + t_{22} = 1$. Using this result, part (a) of this proposition, the entry cutoffs in Proposition 1 and the deterministic upgrade in (17) we obtain

$$\frac{c_{2z}^U}{c_2^U} = \frac{c_{2z}^D}{c_2^D} = \phi$$

Agreement upgrade cutoff: c_{0z}^U

Using the cutoff condition (20), as well as (21) and (56) we obtain

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

where the second line uses (7) and (8). We can factor out the cost and solve the general expression above in the same way we did for the entry cutoff. But given our assumption that $t_{00} = 1$ we obtain $U_0 = 1$ and

$$c_{0z}^U|_{t_{00}=1} = \left[\frac{a_0\left(z^{1-\sigma}-1\right)}{(1-\beta)\, K_z}\right]^{\frac{1}{\sigma-1}} = c_{0z}^D$$

Using this result, part (a) of this proposition, the entry cutoffs in Proposition 1 and the deterministic upgrade in (17) we obtain

$$\frac{c_{0z}^U}{c_0^U} = \frac{c_{0z}^D}{c_0^D} = \phi$$

MFN upgrade cutoff: c_{mz}^U

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

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

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

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 (8) and $\tilde{t} \equiv 1 - t_{m2} + t_{m2}\frac{\beta t_{2m}}{1-\beta t_{22}}$.

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

$$
\begin{aligned}
c^U_{mz} &= \left[\frac{a_m\left(z^{1-\sigma}-1\right)}{\left(1-\beta\tilde{t}\right)K_z}\left(1+\frac{\beta t_{m2}}{1-\beta t_{22}}\frac{a_2}{a_m}\right)\right]^{\frac{1}{\sigma-1}} \\
c^U_{mz} &= c^D_{mz}\underbrace{\left[\frac{1-\beta}{1-\beta\tilde{t}}\left(1+\frac{\beta t_{m2}}{(1-\beta t_{22})}\left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\right)\right]^{\frac{1}{\sigma-1}}}_{U_m} \qquad (58)
\end{aligned}
$$

Using this relationship, part (a) of this proposition, the entry cutoffs in Proposition 1 and the deterministic upgrade in (17) we obtain

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

(c) c^U_{mz} is lower than its deterministic counterpart by the uncertainty factor in (14) ($c^U_{mz} = U_m c^D_{mz} < c^D_{mz}$) and decreasing in MFN policy uncertainty ($d\ln c^U_{mz}/d\gamma = d\ln U_m/d\gamma < 0$) iff tariff increases are possible;

In proving part (b) we derive $c^U_{mz} = c^D_{mz}U_m$ in (58) and see that U_m is the expression in (14).

Using part (b) of the proposition we have $d\ln c^U_{mz}/d\gamma = d\ln U_m/d\gamma < 0$ since c^D_{mz} is independent of γ so we can use the proof of the semi-elasticity of entry in proposition 1.

(d) $c^U_{mz} < c^U_{0z} = c^D_{0z}$ if tariff increases are possible or tariffs are lower under the agreement ($\tau_0 < \tau_m$) or both.

From part (b) $c^U_{0z} = c^D_{0z}$ and $c^U_{mz}/c^U_{0z} = c^U_m/c^U_0$. Thus the proof of proposition 1b applies here. $\square$

A.3 Entry, prices and welfare under TPU (general equilibrium)

In this section we derive the worst case cutoff in general equilibrium and prove Propositions 3 and 4.

Deriving $c_{2T}^{U}=c_{2T}^{D}$

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

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

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

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

Proof of Proposition 3 (Policy Uncertainty and Entry in General Equilibrium):

a. The export cost cutoff under MFN policy uncertainty, $c_m^U{=}c_m^D\,U_m\left(\tilde{\omega}_V,\gamma\right)\frac{P_m}{P_m^D}$ *where* $U_m\left(\tilde{\omega}_V,\gamma\right)$ *is in eq. (31).*

$c_m^U=U_m\left(\tilde{\omega}_V,\gamma\right)\frac{P_m}{P_m^D}$

The functional form for the expected value of export at $s=m$ is the same as in the baseline (6) and that is also the case for the value of waiting, given by (11). But they are different from the baseline under $s=2$ due to transition dynamics. More specifically, we require

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

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 (6) and $\Pi_w(a_{2T=0},c_m^U)$ in (11) we obtain respectively

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

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

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

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

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

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

where $U_m\left(\tilde{\omega}, \gamma\right)$ is the expression in (31), which is similar to the one in the absence of GE effects, $U_m\left(\omega, \gamma\right)$, in (14) except that instead of ω we now have $\tilde{\omega} = \left(\frac{\tau_2}{\tau_m}\right)^{-\sigma}\frac{(1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t A_{2t}}{A_m}$.

b. If $\left(\tau_{2V}/\tau_{mV}\right)^{-\sigma} < 1$, $t_{m2}\left(\gamma\right) > 0$ and $\left(\tau_{2V}\right)^{-\sigma}\left(P_2^D\right)^{\sigma-1} \leq \left(\tau_{mV}\right)^{-\sigma}\left(P_m^D\right)^{\sigma-1}$ for all V then $c_{mV}^U \leq c_{mV}^D$ all V (at least one strict) and $P_m > P_m^D$;

In part (a) we show $c_{mV}^U = c_{mV}^D\frac{P_m}{P_m^D}U_{mV}$. Here we first show that $U_{mV} < 1$ if $\left(\tau_{2V}\right)^{-\sigma}\left(P_2^D\right)^{\sigma-1} \leq \left(\tau_{mV}\right)^{-\sigma}\left(P_m^D\right)^{\sigma-1}$ for all V. Since there are no legacy firms at $s = m$, the price index is exactly $P_m\left(\mathbf{c}_m^U, \tau\right)$. Then if all c_{mV}^U decrease then P_m must increase (since $\partial P_m/\partial c_V < 0$ for all V). Moreover, we show that the case when P_m decreases and c_{mV}^U increases for all V does not satisfy the equilibrium condition $c_{mV}^U = c_{mV}^D\frac{P_m}{P_m^D}U_{mV}$.

$U_m\left(\tilde{\omega}, \gamma\right) < 1$ 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 $t_{2m} = 1 - t_{22}$.

$\tilde{\omega} < 1$ if $\left(\tau_{2V}\right)^{-\sigma}\left(P_2^D\right)^{\sigma-1} \leq \left(\tau_{mV}\right)^{-\sigma}\left(P_m^D\right)^{\sigma-1}$

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

The equivalence is due to the profit definition. The inequality holds since $\pi_{2t} < \pi_2$ for all t (lower profits under transition than steady state) and $\left(1 - \beta t_{22}\right)\sum_{t=0}^{\infty}\left(\beta t_{22}\right)^t \pi_2 = \pi_2 \leq \pi_m$ where the inequality holds whenever the direct effect dominates (given by condition in (28)).

$P_m > P_m^D$ and $c_{mV}^U \leq c_{mV}^D$ (at least one strict)

Possible cases

1) $\frac{c^U_{mV}}{c^D_{mV}} = \frac{P_m}{P^D_m} U_{mV} \geq 1 \Rightarrow \frac{P_m}{P^D_m} > \min 1/U_{mV} > 1$ for all V: can't be an equilibrium since if $\frac{c^U_{mV}}{c^D_{mV}} \geq 1$ for all V then $\frac{P_m}{P^D_m} \leq 1$.

2) $\frac{c^U_{mV}}{c^D_{mV}} = \frac{P_m}{P^D_m} U_m \leq 1$ for all V (at least one strict) requires us to consider two cases.

i. $\frac{P_m}{P^D_m} \leq 1$: can't be an equilibrium since it implies $\frac{c^U_{mV}}{c^D_{mV}} < 1$ for all V and thus $\frac{P_m}{P^D_m} > 1$.

ii. $\frac{P_m}{P^D_m} \in (1, \min 1/U_{mV}]$: no contradiction since when $\frac{c^U_{mV}}{c^D_{mV}} \leq 1$ for all V (with at least one strict) then $\frac{P_m}{P^D_m} > 1$.

c. If $(\tau_{2V}/\tau_{mV})^{-\sigma} < 1$, $t_{m2}(\gamma) > 0$, $(\tau_{2V})^{-\sigma} \left(P^D_2\right)^{\sigma-1} \leq (\tau_{mV})^{-\sigma} \left(P^D_m\right)^{\sigma-1} \leq (\tau_{0V})^{-\sigma} \left(P^D_0\right)^{\sigma-1}$ for all V then $c^U_{mV} \leq c^U_{0V} = c^D_{0V}$ all V (at least one strict) and $P_m > P_0 = P^D_0$

In part (b) we show that under these conditions (without requiring $(\tau_{mV})^{-\sigma} \left(P^D_m\right)^{\sigma-1} \leq (\tau_{0V})^{-\sigma} \left(P^D_0\right)^{\sigma-1}$) we obtain $c^U_{mV} \leq c^D_{mV}$, thus it is sufficient to show $c^D_{mV} \leq c^D_{0V} = c^U_{0V}$

If $\tau_m = \tau_0$ then the result is trivial since then $c^D_{mV} = c^D_{0V}$ and $P_m > P^D_m = P^D_0$ where in the price relationship the inequality is from part (b) and the equality is due to $\tau_m = \tau_0$ and $c^D_{mV} = c^D_{0V}$.

If $\tau_m \geq \tau_0$ then $c^D_{mV} \leq c^D_{0V}$ requires

$$\left[\frac{A^D_m \tau_{mV}{}^{-\sigma} d^{1-\sigma}_V}{(1-\beta) K}\right]^{\frac{1}{\sigma-1}} \leq \left[\frac{A^D_0 \tau_{0V}{}^{-\sigma} d^{1-\sigma}_V}{(1-\beta) K}\right]^{\frac{1}{\sigma-1}}$$
$$(\tau_{mV})^{-\sigma} \left(P^D_m\right)^{\sigma-1} \leq (\tau_{0V})^{-\sigma} \left(P^D_0\right)^{\sigma-1}$$

which is satisfied for all V given our assumption that the tariff effect dominates. Therefore $c^U_{mV} \leq c^U_{0V} = c^D_{0V}$. Moreover $P_m > P_0 = P^D_0$ because $P_m > P^D_m$ (part b) and $P^D_m \geq P^D_0$ if $\tau_m \geq \tau_0$.□

Proof of Proposition 4 (Policy Uncertainty, Prices and Consumer Welfare in General Equilibrium):

If tariff increases are possible and the direct effect of worst case tariffs dominates then
(a) an increase in MFN policy uncertainty increases the importer's price index in the MFN state by $\frac{d \ln P_m}{d\gamma}|_{\gamma=0}$ given by (36) and lowers consumer welfare in that state by $-\mu \frac{d \ln P_m}{d\gamma}|_{\gamma=0}$.

The expression for $\frac{d \ln P_m}{d\gamma}|_{\gamma=0}$ is derived in section A.5.2 where we show it is positive.

Therefore $-\mu \frac{d \ln P_m}{d\gamma}|_{\gamma=0} < 0$ and we need only show it represents a welfare effect in the MFN state. To see this recall that workers have direct utility $Q^\mu q_0^{1-\mu}$ where Q is the CES aggregator over all varieties and $\mu \in (0,1]$. Since q_0 is the numeraire, the period indirect utility is $\tilde{\mu} P_m^{-\mu}$ where $\tilde{\mu} = w_e k_L \mu^\mu (1-\mu)^{(1-\mu)}$ is constant since k_L is the period labor endowment and the wage of the exporter $w_e = 1$ in the diversified equilibrium. Thus the growth in the period utility due to a change in γ is $-\mu \frac{d \ln P_m}{d\gamma}$.

We can also show that this corresponds to the "within state welfare effect" that is one of the two impacts of γ on *expected* welfare for consumers, as discussed after this proposition. Using $t_{m2} = \gamma t_2$ and $t_{m0} = \gamma(1-t_2)$ we solve for the expected welfare of a worker starting at $s = m$ in equation (37) as

$$\begin{aligned} W_m &= \tilde{\mu} P_m^{-\mu} + \tilde{\beta} \left[\gamma (1-t_2) W_0 + \gamma t_2 W_{2m} + (1-\gamma) W_m\right] \\ &= \frac{\tilde{\mu} P_m^{-\mu}}{1-\tilde{\beta}(1-\gamma)} + \frac{\tilde{\beta}\gamma}{1-\tilde{\beta}(1-\gamma)} \left[(1-t_2) W_0 + t_2 W_{2m}\right] \end{aligned}$$

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.(38) as follows

$$\frac{d\ln W_m}{d\gamma}\bigg|_{\gamma=0} = \left(\frac{1}{W_m}\tilde{\mu}\frac{-\mu P_m^{-\mu-1}\frac{dP_m}{d\gamma}\left(1-\tilde{\beta}\right) - P_m^{-\mu}\tilde{\beta}}{\left(1-\tilde{\beta}\right)^2} + \frac{1}{W_m}\frac{\tilde{\beta}}{1-\tilde{\beta}}\left[\left(1-t_2\right)W_0 + t_2 W_{2m}\right]\right)|_{\gamma=0}$$

$$= \left(\frac{\tilde{\mu}\left(P_m^D\right)^{-\mu}}{1-\tilde{\beta}}\right)^{-1}\left(\tilde{\mu}\frac{-\mu\left(P_m^D\right)^{-\mu-1}\frac{dP_m}{d\gamma}|_{\gamma=0}\left(1-\tilde{\beta}\right) - \left(P_m^D\right)^{-\mu}\tilde{\beta}}{\left(1-\tilde{\beta}\right)^2} + \frac{\tilde{\beta}}{1-\tilde{\beta}}\left[\left(1-t_2\right)W_0 + t_2 W_{2m}\right]|_{\gamma=0}\right)$$

$$= -\mu\frac{d\ln P_m}{d\gamma}|_{\gamma=0} - \frac{\tilde{\beta}}{1-\tilde{\beta}}\left(\frac{W_m - \left(1-t_2\right)W_0 - t_2 W_{2m}}{W_m}\right)|_{\gamma=0}$$

where the impact of γ on W_0 and W_2 disappears around $\gamma = 0$.

(b) consumer expected welfare is higher under an agreement that eliminates uncertainty even if tariffs remain at MFN levels.

To prove this we show that $W_0 - W_m > 0$ and $W_0 - W_{2t} > 0$

$$W_0 - W_m = W_0 - \frac{\tilde{\mu}P_m^{-\mu}}{1-\tilde{\beta}\left(1-\gamma\right)} - \frac{\tilde{\beta}\gamma}{1-\tilde{\beta}\left(1-\gamma\right)}\left[\left(1-t_2\right)W_0 + t_2 W_{2m}\right]$$

$$= W_0\left[\frac{1-\tilde{\beta}+\tilde{\beta}t_2}{1-\tilde{\beta}\left(1-\gamma\right)}\right] - \frac{\tilde{\mu}P_m^{-\mu}}{1-\tilde{\beta}\left(1-\gamma\right)} - \frac{\tilde{\beta}\gamma}{1-\tilde{\beta}\left(1-\gamma\right)}t_2 W_{2m}$$

$$= \left(\frac{1}{1-\tilde{\beta}\left(1-\gamma\right)}\right)\left[\tilde{\beta}t_2\left(W_0 - W_{2m}\right) + \left(1-\tilde{\beta}\right)W_0 - \tilde{\mu}P_m^{-\mu}\right]$$

$$= \left(\frac{1}{1-\tilde{\beta}\left(1-\gamma\right)}\right)\left[\tilde{\beta}\gamma t_2\left(W_0 - W_{2m}\right) + \tilde{\mu}\left(P_0^{-\mu} - P_m^{-\mu}\right)\right]$$

$$W_0 - W_m > \left(\frac{1}{1-\tilde{\beta}\left(1-\gamma\right)}\right)\left[\tilde{\beta}\gamma t_2\left(W_0 - W_m\right) + \tilde{\mu}\left(P_0^{-\mu} - P_m^{-\mu}\right)\right]$$

$$W_0 - W_m > \tilde{\mu}\frac{P_0^{-\mu} - P_m^{-\mu}}{1-\tilde{\beta}\left(1-t_{m0}\right)} > 0$$

where the fourth line uses $W_0 = \frac{\tilde{\mu}P_0^{-\mu}}{1-\tilde{\beta}}$. The fifth line used $W_m > W_{2m}$ since the latter entails higher tariffs and price indices (and so lower consumer welfare) until there is a shock that leads back to the MFN state. The last line solves for $W_0 - W_m$ and is positive because if agreement tariffs do not change relative to MFN

then $P_0^{-\mu} > P_m^{-\mu}$ since these states would differ only because of γ and $\frac{d\ln P_m}{d\gamma}|_{\gamma=0}>0$, as shown in part (a). If tariffs under the agreement are lower then $P_0^{-\mu}$ is even higher. Moreover, as we show in the transition $W_{2m} \geq W_{2t}$ because the price index rises as firms exit so $W_m > W_{2t}$ and thus $W_0 > W_{2t}$.$\square$

A.4 Technological upgrade threshold under TPU (general equilibrium)

This section extends the general equilibrium analysis of TPU to allow for upgrading as described at the end of section 2.4.4.

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 direct effect dominates, 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 (19).

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 (17) 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

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

which we replace in the value of waiting at MFN

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

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

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

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

where $U_m\left(\tilde{\omega},\gamma\right)$ is the same expression we found for (31) so $c^U_{mz}=\phi c^U_m\left(\tilde{\omega}\right)$ and the upgrade cutoff shares the properties of the entry cutoff derived in Proposition 3.

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 $g \equiv \frac{(1-\beta t_{22})\sum_{t=0}^{\infty}(\beta t_{22})^t A_{2t}}{A_m} \leq \left(\frac{P_2^D}{P_m^D}\right)^{\sigma-1}$ so $g \leq \exp\left((\sigma-1)\ln\frac{P_2^D}{P_m^D}\right)$. 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

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

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

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

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

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

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

$$\begin{aligned}
\frac{\partial \ln P\left(c^{D},\tau\right)}{\partial \ln \tau_{V}} &= \frac{1}{1-\sigma}\partial \ln\left[\textstyle\sum_{V,ch} N_{V}\displaystyle\int_{0}^{c_{1}^{D}}\left(\left(w_{e}d_{V}c/\rho\right)\tau_{V}\right)^{1-\sigma}dG\left(c\right)+\textstyle\sum_{V,C\neq china}\displaystyle\int_{v\in\Omega_{VC}}\left(p_{v}\right)^{1-\sigma}dv\right]/\partial \ln \tau_{V}\\
&= \frac{1}{1-\sigma}\frac{\tau_{mV}}{P_{m}^{1-\sigma}}\partial\left[\textstyle\sum_{V,ch} N_{V}\displaystyle\int_{0}^{c_{1}^{D}}\left(\left(w_{e}d_{V}c/\rho\right)\tau_{V}\right)^{1-\sigma}dG\left(c\right)\right]/\partial\tau_{mV}\\
&= \frac{1}{P_{m}^{1-\sigma}}N_{V}\int_{0}^{c_{1}^{D}}\left(\left(w_{e}d_{V}c/\rho\right)\tau_{V}\right)^{1-\sigma}dG\left(c\right)\\
&= \frac{\tau_{V}R_{V}}{E}
\end{aligned}$$

where the last line follows after using $a = E\left(1-\rho\right)\left(w_{e}d/P\rho\right)^{1-\sigma}\tau_{sV}{}^{-\sigma}$ and $R_{tV} = a_{tV}\sigma N_{V}\int_{0}^{c_{1}^{D}}\left(c\right)^{1-\sigma}dG\left(c\right).$

Weighted effect of tariff on cutoff

$$\begin{aligned}
d\ln c_{V}\left(P^{D},\tau_{V}\right) &= \frac{\partial \ln c_{V}\left(P^{D},\tau_{V}\right)}{\partial \ln \tau_{V}}d\ln\tau_{V}+\frac{\partial \ln c_{V}\left(P^{D},\tau_{V}\right)}{\partial \ln P^{D}}d\ln P\\
I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln c_{V}\left(P^{D},\tau_{V}\right) &= \frac{-\sigma}{\sigma-1}I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln\tau_{V}+Id\ln P
\end{aligned}$$

Impact of tariffs on P

Replacing the cutoff effect above in the price expression and simplifying

$$\begin{aligned}
d\ln P\left(\mathbf{c}^{D},\tau\right) &= \frac{k-\sigma+1}{\left(1-\sigma\right)}\left(\frac{-\sigma}{\sigma-1}I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln\tau_{V}+Id\ln P\right)+I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln\tau_{V}\\
d\ln P\left(\mathbf{c}^{D},\tau\right)\left[1-I\frac{k-\sigma+1}{\left(1-\sigma\right)}\right] &= \frac{k-\sigma+1}{\left(1-\sigma\right)}\left(\frac{-\sigma}{\sigma-1}I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln\tau_{V}\right)+I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln\tau_{V}\\
d\ln P\left(\mathbf{c}^{D},\tau\right) &= \left[\left(\frac{-\sigma}{\sigma-1}\right)\frac{k-\sigma+1}{\left(1-\sigma\right)}+1\right]\frac{I}{1-I\frac{k-\sigma+1}{\left(1-\sigma\right)}}\textstyle\sum_{V}\dfrac{\tau_{mV}R_{mV}}{\sum_{V}\tau_{mV}R_{mV}}d\ln\tau_{V}
\end{aligned}$$

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

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

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

$$\begin{aligned}
d\ln P\left(\mathbf{c}^{D},\tau,\mathbf{d}\right) &= \frac{k-\sigma+1}{\left(1-\sigma\right)}\left(-I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln d_{V}+Id\ln P\right)+I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln d_{V}\\
d\ln P\left(\mathbf{c}^{D},\tau,\mathbf{d}\right)\left[1-I\frac{k-\sigma+1}{\left(1-\sigma\right)}\right] &= \left(I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln d_{V}\right)\dfrac{k}{\sigma-1}\\
d\ln P\left(\mathbf{c}^{D},\tau,\mathbf{d}\right) &= \left[\frac{k}{\left(k-\sigma+1\right)I+\left(\sigma-1\right)}\right]I\textstyle\sum_{V}\dfrac{\tau_{V}R_{V}}{\sum_{V}\tau_{V}R_{V}}d\ln d_{V}
\end{aligned}$$

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

In equation (36) we provide the semi-elasticity of the price index wrt γ as a function of $\varepsilon_V \equiv \partial \ln P(\mathbf{c}) / \partial \ln c_V^U$. We now show that this is similar to the deterministic elasticity derived in section (A.5.1) and then use it to to obtain the relationship between $P(.)$ and γ in terms of model 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). We also use the expression to evaluate the GE 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

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

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 ε_V as follows

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

We then rearrange the equilibrium expression for exports

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

Using the above relationship we obtain a compact expression for the price index elasticity

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

Semi-elasticity of P wrt γ

Using the expression for ε_V derived above in (36) and noting that $\tilde{\varepsilon}_V \equiv \frac{\varepsilon_V}{(1-\Sigma_V \varepsilon_V)}$ we obtain

$$\begin{aligned}
\left.\frac{d \ln P_m(\mathbf{c}_m)}{d\gamma}\right|_{\gamma=0} &= \frac{\beta t_2}{(\sigma-1)(1-\beta t_{22})} \sum\nolimits_V \tilde{\varepsilon}_{mV} (\tilde{\omega}_V - 1) \\
&= \frac{\beta t_2}{(\sigma-1)(1-\beta t_{22})} \sum\nolimits_V \frac{\frac{k-\sigma+1}{(1-\sigma)} \frac{\tau_{mV} R_{mV}}{E}}{1 - \frac{k-\sigma+1}{(1-\sigma)} \frac{\sum_V \tau_{mV} R_{mV}}{E}} (\tilde{\omega}_{mV} - 1) \\
&= \frac{\beta t_2}{(\sigma-1)(1-\beta t_{22})} \frac{(k-\sigma+1) I_m}{(k-\sigma+1) I_m + \sigma - 1} \Sigma_V r_{mV} (1 - \tilde{\omega}_{mV})
\end{aligned}$$

where $I_m \equiv \frac{\Sigma_V \tau_{mV} R_{mV}}{E}$ and $r_{mV} \equiv \frac{\tau_{mV} R_{mV}}{\Sigma_V \tau_{mV} R_{mV}}$. 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

$$\begin{aligned}
\textstyle\sum_V r_{mV} \frac{d\ln c_{mV}^U}{d\gamma}|_{\gamma=0} &= \textstyle\sum_V r_{mV} \left.\left[\frac{d\ln U_m\left(\tilde{\omega}_V\right)}{d\gamma} + \frac{d\ln P_m\left(\mathbf{c}_m\right)}{d\gamma}\right]\right|_{\gamma=0} \\
&= \textstyle\sum_V r_{mV} \frac{\beta t_2}{\left(\sigma-1\right)\left(1-\beta t_{22}\right)}\left(\tilde{\omega}_V - 1\right) + \frac{\beta t_2}{\left(\sigma-1\right)\left(1-\beta t_{22}\right)} \frac{\left(k-\sigma+1\right) I}{\left(k-\sigma+1\right) I + \sigma - 1} \textstyle\sum_V r_{mV}\left(1-\tilde{\omega}_V\right) \\
&= \frac{\beta t_2}{\left(\sigma-1\right)\left(1-\beta t_{22}\right)}\left(1 - \frac{\left(k-\sigma+1\right) I_m}{\left(k-\sigma+1\right) I_m + \sigma - 1}\right) \textstyle\sum_V r_{mV}\left(\tilde{\omega}_V - 1\right)
\end{aligned}$$

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

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 ($\Omega_{V,ch} \setminus \Omega^z_{V,ch}$).

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

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 s and 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 brackets 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

$$
\left.\frac{d \ln P_m(\mathbf{c}_m)}{d\gamma}\right|_{\gamma=0} = \frac{\beta t_2}{(\sigma-1)(1-\beta t_{22})} \frac{(k-\sigma+1) I_m}{(k-\sigma+1) I_m + \sigma - 1} \textstyle\sum_V r_{mV} (1 - \tilde{\omega}_{mV})
$$

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 $r_{mV} \equiv \frac{\tau_{mV} R_{mV}}{\sum_V \tau_{mV} R_{mV}}$.

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

$$
\textstyle\sum_V r_{mV} \displaystyle\left.\frac{d \ln c^U_{mV}}{d\gamma}\right|_{\gamma=0} = \left(1 - \frac{(k-\sigma+1) I_m}{(k-\sigma+1) I_m + \sigma - 1} \right) \frac{\beta t_2}{(\sigma-1)(1-\beta t_{22})} \textstyle\sum_V r_{mV} (\tilde{\omega}_V - 1)
$$

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

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 1 plus the column 2 (Smoot-Hawley) tariff rate at the HS6 level. For specific tariffs at the HS8, base year unit values from 1996 used for all years to compute the AVE tariff and then average at the HS6 level. 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}

$$\Delta_{mm} \ln R_V = -\Delta_{mm} b'_\gamma \left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + b_\tau \Delta_{mm} \ln \tau_V + b_d \Delta_{mm} \ln D_V + b' + \theta_V + u'_V. \tag{66}$$

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

$$\frac{\Delta_{m0} \ln R_V}{5} - \frac{\Delta_{mm} \ln R_V}{3} = b_\gamma \left(1 + \frac{\Delta_{mm} g'_m}{g_m}\right) \frac{\left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right)}{5} + b_\tau \left(\frac{\Delta_{m0} \ln \tau_V}{5} - \frac{\Delta_{mm} \ln \tau_V}{3}\right) \tag{67}$$

$$+ b_d \left(\frac{\Delta_{m0} \ln D_V}{5} - \frac{\Delta_{mm} \ln D_V}{3}\right) + b - b' + u_V - u'_V \tag{68}$$

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 Decomposition of policy credibility effect into mean and risk

Here we provide the analysis summarized in section 3.6 regarding the fraction of export growth due to the agreement attributable to a mean preserving tariff risk reduction. We first decompose the impact in any given industry of an agreement that permanently changes tariffs from τ_m to τ_0 into two components:

$$\ln \frac{R_V(\gamma_0, \tau_0)}{R_V(\gamma_m, \tau_m)} = \underbrace{\ln \frac{R_V(\gamma_0, \tau_m)}{R_V(\gamma_m, \tau_m)}}_{\text{Credibility}} + \ln \frac{R_V(\gamma_0, \tau_0)}{R_V(\gamma_0, \tau_m)} \tag{69}$$

where we write the exports as a reduced form function of the uncertainty parameter, γ_s, and applied tariff vector, τ_s, in a given state. Exports also depend on the threat tariffs but those are common across states so we omit them. The RHS follows by addition and subtraction of $\ln R_V(\gamma_0, \tau_m)$, the counterfactual export value if applied tariffs under the agreement (i.e. at γ_0) 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

$$\ln \frac{R_V(\gamma_0, \tau_m)}{R_V(\gamma_m, \tau_m)} = \ln \frac{R_V(\gamma_0, \bar{\tau})}{R_V(\gamma_m, \bar{\tau})} + \left[\ln \frac{R_V(\gamma_0, \tau_m)}{R_V(\gamma_0, \bar{\tau})} - \ln \frac{R_V(\gamma_m, \tau_m)}{R_V(\gamma_m, \bar{\tau})}\right] \tag{70}$$

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, $\ln \frac{R_V(\gamma_0, \bar{\tau})}{R_V(\gamma_m, \bar{\tau})}$, by using the partial effect expression in (47) evaluated at the mean tariff for each industry,$\bar{\tau}_V$. In order to compute the mean tariff we require two additional assumptions. First, that 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 7), we see that the risk reduction component is almost 40 percent of that value. 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.

B.4 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 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 $\ln(pcount_{tV}^{\max}) = \nu(\ln n_{hV})$ for all $\ln n_{tV}$ at least as high as $\ln n_{hV}$—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

$$\Delta \ln(pcount_V) = b_\gamma^e \left(1 - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + b_\tau^e \Delta \ln \tau_V + b_d^e \Delta \ln D_V + b^e + e_V \tag{71}$$

The estimation coefficients obtained from a linear regression rescale the parameters in (48) by ν'. The predicted coefficients are $b_\gamma^e = \frac{k}{\sigma-1} \frac{\beta t_{m2}}{1-\beta t_{22}} g \nu' \geq 0$, $b_\tau^e = \frac{-\sigma k}{\sigma - 1} \nu' \leq 0$ and $b_d^e = -k\nu' \leq 0$ and the constant $b^e = -b_\gamma^e \left(1 - g^{-1}\right) + \nu' \frac{k}{\sigma-1} \Delta \ln A$. 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 8.

Quantification

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

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

To compute the impact of uncertainty we first obtain an estimate of ν' using the cross equation restriction implied by the model $\nu' = b_d^e / b_d = 0.49/2.6 = 0.19$, 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 $\frac{b_\gamma^e}{\nu'} \mathbb{E}\left(g^{-1} - \left(\frac{\tau_{2V}}{\tau_{mV}}\right)^{-\sigma}\right) + k(\ln P_0/P_m)|_{\tau,D}$.

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) [1]	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	.
Sector Fixed Effects	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: $b_\tau = b_d(\sigma/(\sigma-1))$.

Sectors defined as each of the 21 HS sections comprising similar HS6 products.

Table 3
Export Growth from China (2000-2005): Robustness to Non Tariff Barriers

	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		
Sector Fixed Effects	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
Export Growth from China: Panel (1996-2006)

	1	2
Uncertainty Pre-effect (1996-2001)		-1.883**
[$-b_{\gamma pre}$<0]		[0.926]
Uncertainty Post-effect (2002-2006)		-1.208
[$-b_{\gamma post}$~0]		[0.933]
Uncertainty (2000)		
Coefficient relative to 2000 $b_{\gamma}=-(b_{\gamma t}-b_{\gamma 2000})$		
1996	-0.211	
[~0]	[0.268]	
1997	0.0277	
[~0]	[0.222]	
1998	-0.204	
[~0]	[0.166]	
1999	0.0775	
[~0]	[0.188]	
2000	.	
2001	0.22	
	[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]	
Tariff (ln)	-5.358***	-7.618***
[-]	[1.929]	[1.990]
Transport Costs (ln)	-2.378***	-2.384***
[-]	[0.223]	[0.225]
Observations	37,360	37,347
R-squared	0.03	0.03
HS6 & Sector by year fixed effects	yes	yes
Restriction p-value (F-test)	0.382	0.046

Notes:
Robust standard errors, adjusted for clustering on HS6 and sector-year, in brackets. *** p<0.01, ** p<0.05, *
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). Sectors defined as each of the 21 HS sections comprising similar HS6 products.

Table 5
Export Growth from China (2000-2005): NLLS Estimates

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
Sector Fixed Effects	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 constraint 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 6
Contribution of Policy Uncertainty to Export Growth

	Upper bound	Partial	GE
Average export growth from lower uncertainty (Δln)	0.37	0.34	0.32
Ad Valorem transport cost equivalent of uncertainty (Δln)	0.14	0.13	0.13
Ad Valorem tariff equivalent of uncertainty (Δln)	0.094	0.088	0.086

Notes:
Quantification uses estimates 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)
Sectors defined as each of the 21 HS sections comprising similar HS6 products.

Table 7
Contribution of Policy Uncertainty to Export Growth: NLLS estimates

	Upper bound	Partial	GE
Average export growth from lower uncertainty (Δln)	0.29	0.26	0.22
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 NLLS estimates from column 2 of Table 5. 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 8
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	.
Sector Fixed Effects	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: $b\tau=bd(\sigma/(\sigma-1))$. 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 beginning and end of period - and zero-to-zero transitions that are non-traded throughout the sample period.

Table A1
Summary Statistics Across Regression Specifications

Table:	1-4, A2-3	A4	8,A7
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	
Sector Fixed Effects	no	no	yes	yes
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	
Sector Fixed Effects	no	no	yes	yes
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

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: $b\tau=bd(\sigma/(\sigma-1))$.

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	
Sector 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	
Sector 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 (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	
Sector Fixed Effects	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 σ=3

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

Table A6
Export growth from China: Robustness to Pre-Accession Growth 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.

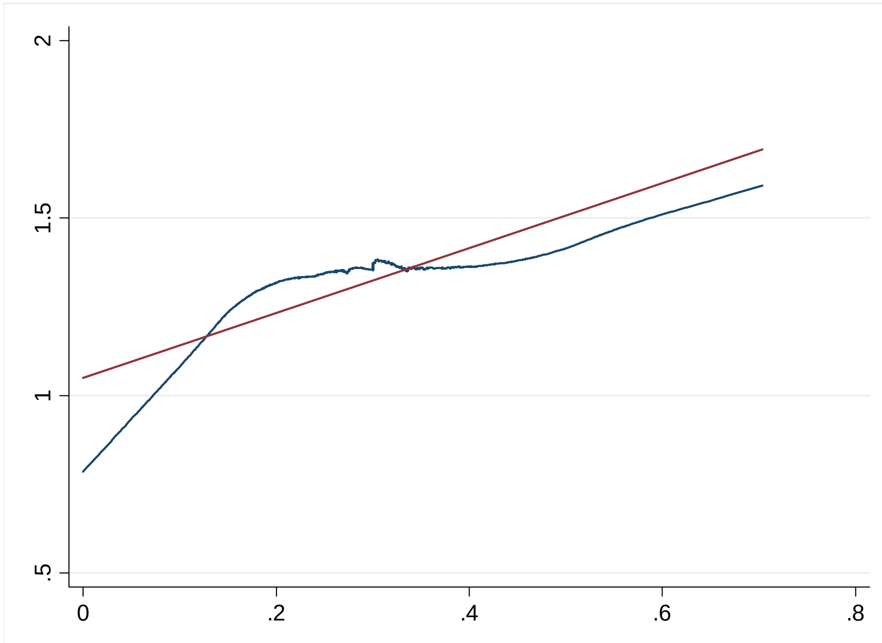
Table A7
Contribution of Policy Uncertainty to Variety Growth

	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 from column 4 of Table 8. 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.

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

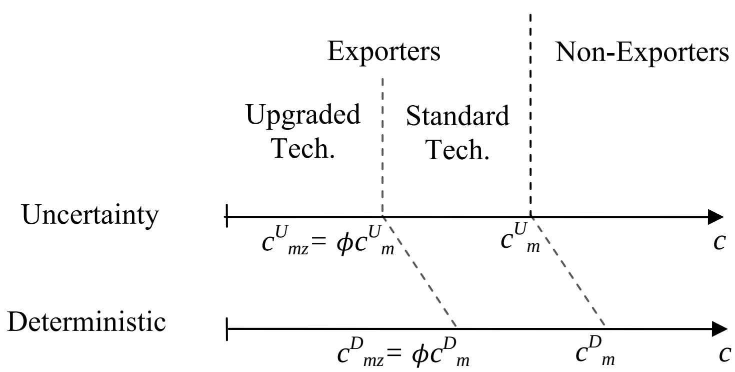
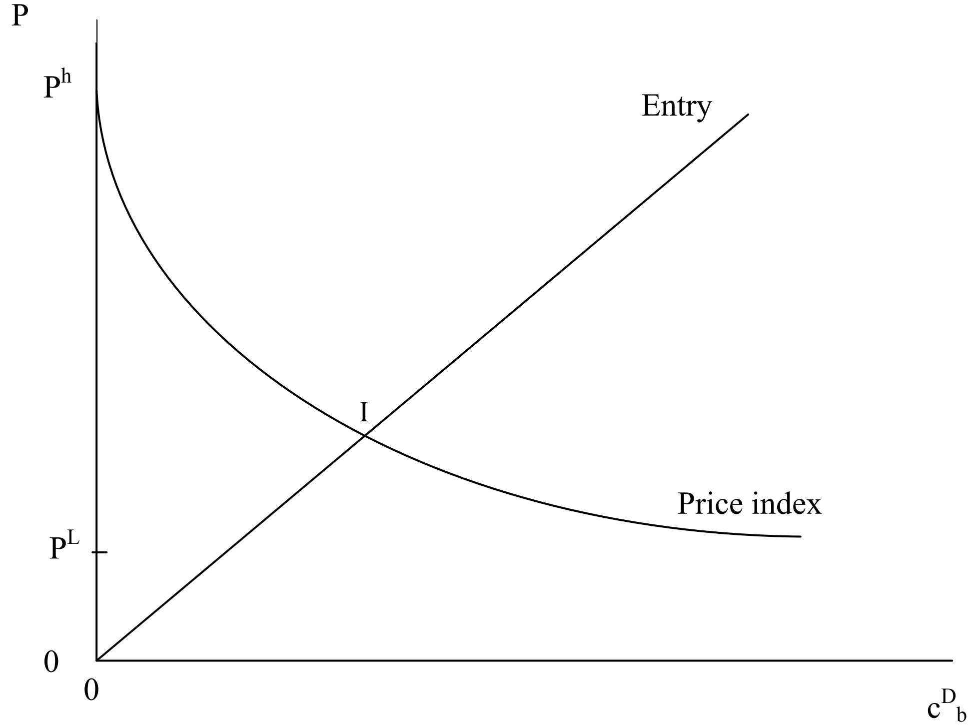
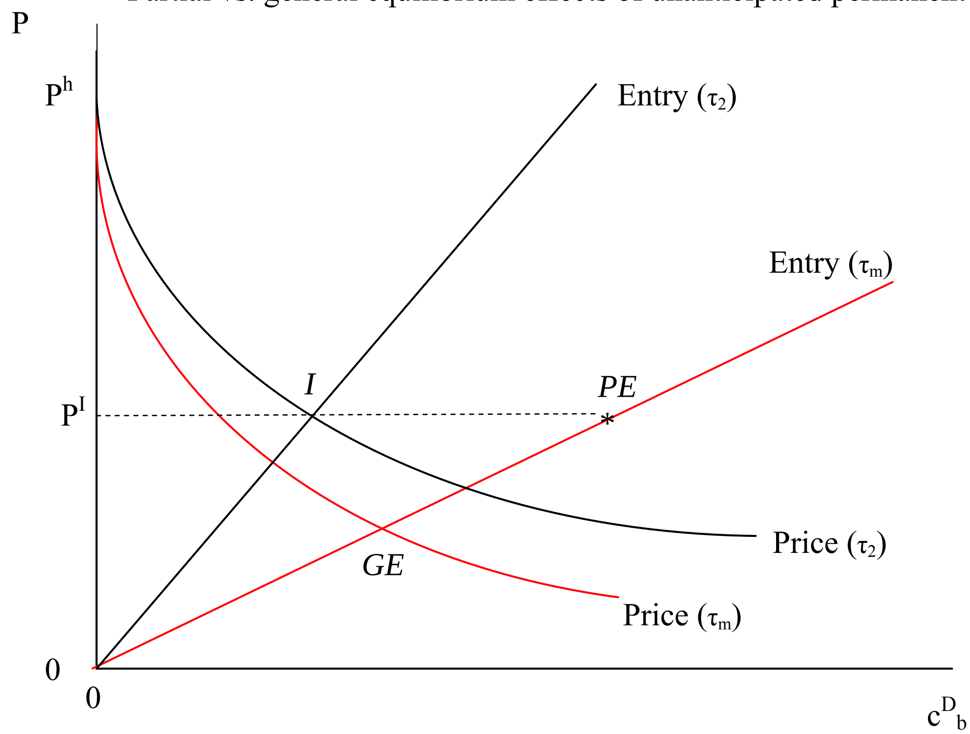


Figure 3
Deterministic policy price and entry equilibrium



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

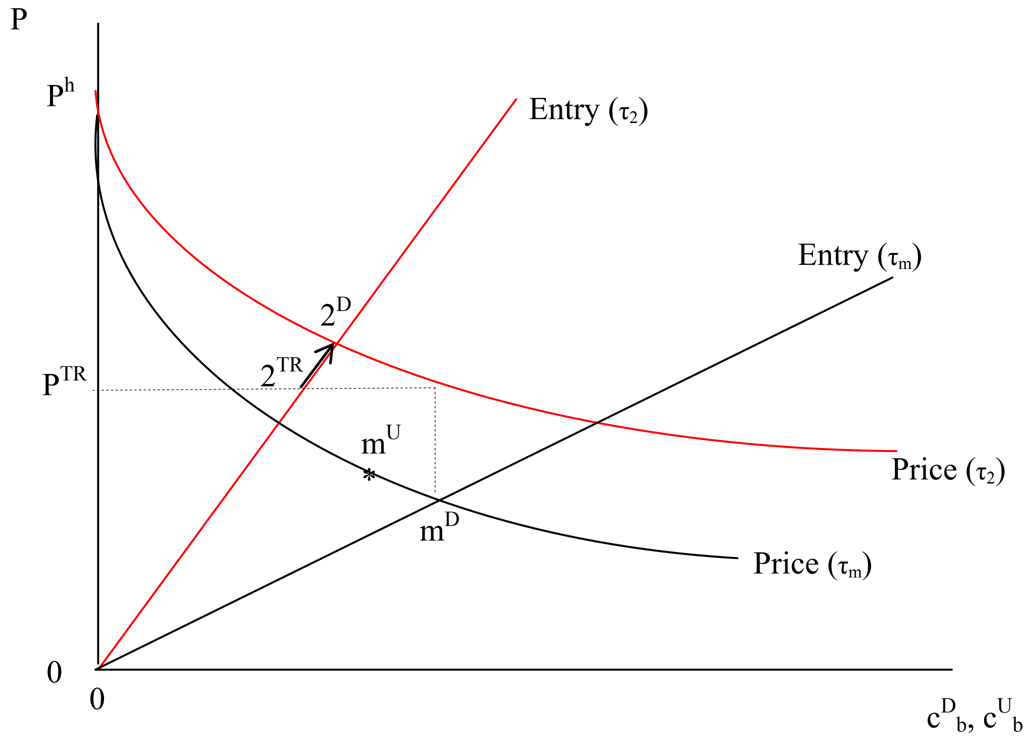
Figure 4
Partial vs. general equilibrium effects of unanticipated permanent liberalization



I: Initial equilibrium, *PE*: Equilibrium after tariff reduction in partial equilibrium
GE: general equilibrium. Radial decrease: $d\ln(\tau_V)=\delta<0$ for all V.

Figure 5

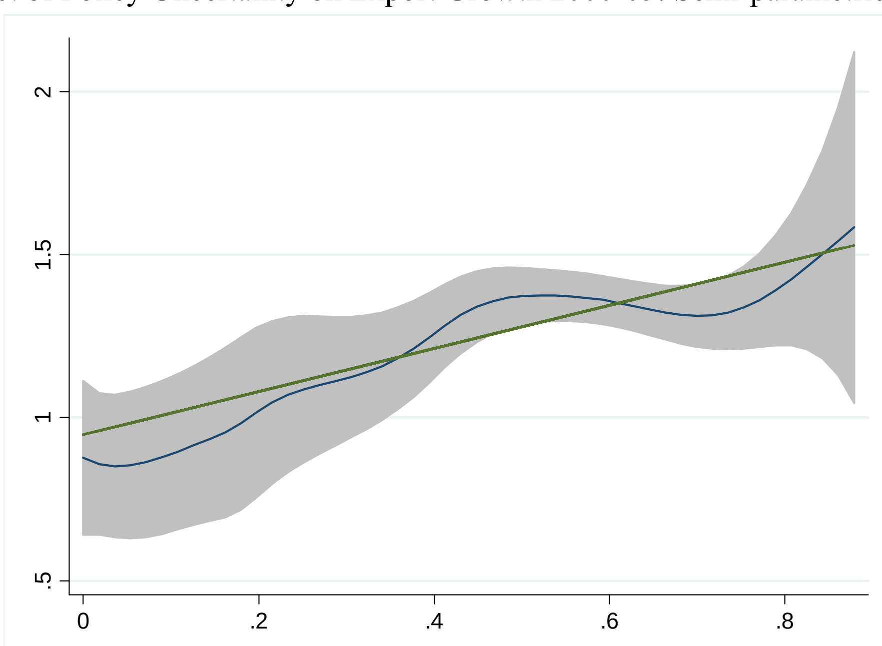
Transition dynamics after unanticipated permanent tariff increase



m^D: Initial MFN deterministic equilibrium, 2^{TR} : lower bound cutoff and price after tariff increase $d\ln(\tau_V)=\delta>0$
$2^{TR} \rightarrow 2^D$ transition path after switch to column 2 until steady state m^U: Uncertainty equilibrium (MFN)

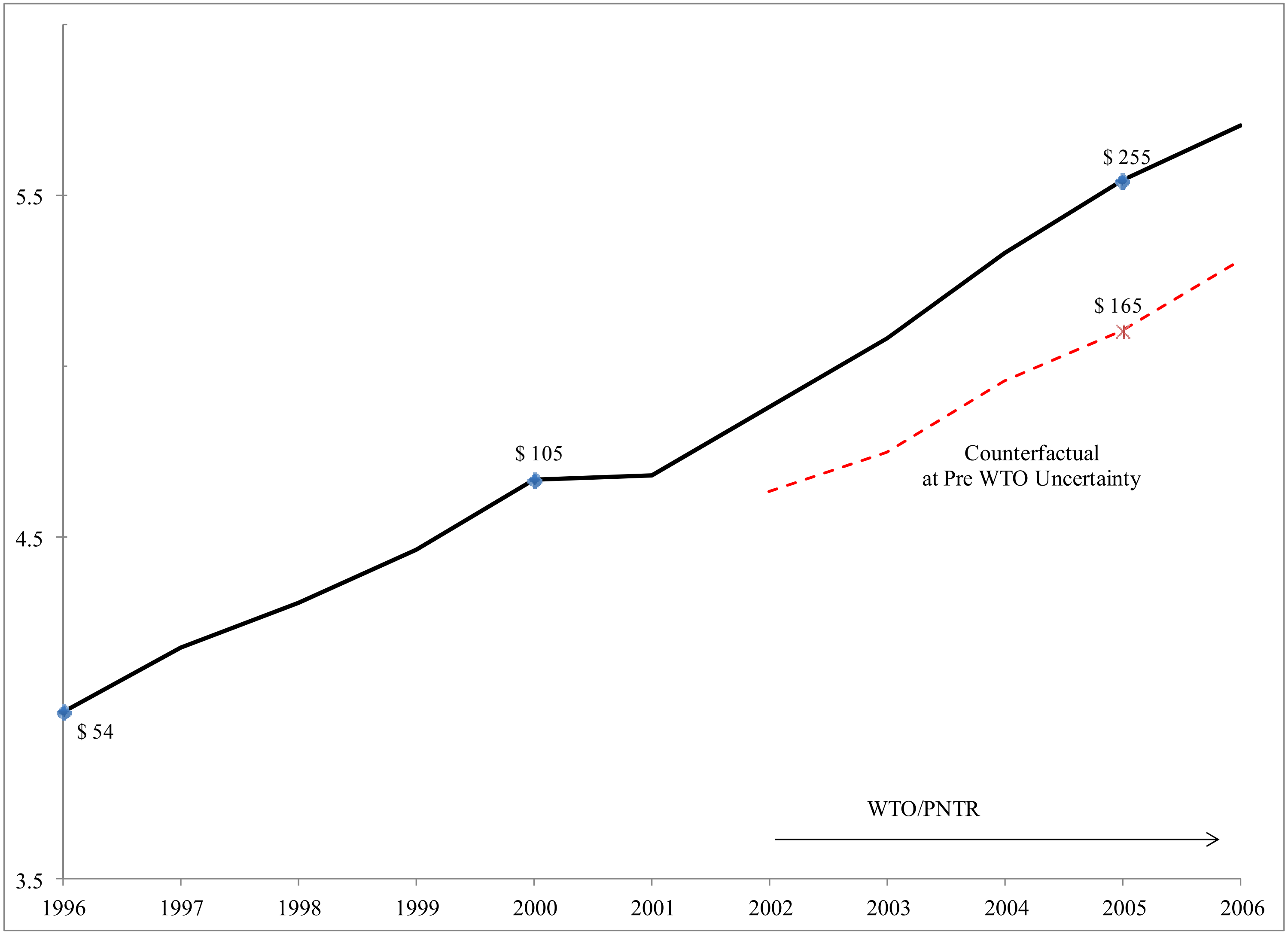
Figure 6

(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.

Figure 7
Aggregate Chinese Exports to U.S. 1996-2006:
Observed and Counterfactual at Pre-WTO Uncertainty
($ billion, ln scale)



Notes: Observed exports from Commtrade. Counterfactual uses the panel estimates as described in text

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 $A \equiv (1-\rho) E (w_e/P\rho)^{1-\sigma}$	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: $a_{sV} \equiv A\tau_{sV}{}^{-\sigma} d_V^{1-\sigma}$	2.2
c_s^D, c_s^U	cost cutoff for state s under deterministic (D) or uncertain policy (U)	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	$t_m \equiv t_{mm} + \beta \left[t_{m0} \frac{t_{0m}}{1-\beta t_{00}} + t_{m2} \frac{t_{2m}}{1-\beta t_{22}} \right]$	2.2
$\tilde{t}$	$\tilde{t} \equiv 1 - t_{m2} + t_{m2} \frac{\beta t_{2m}}{1-\beta t_{22}}$	2.2
U_s	Uncertainty factor in state s affecting entry and upgrade cutoffs	2.2
γ	policy persistence parameter, $\gamma \equiv 1 - t_{mm}$	2.2
ω	Operating profit in col. 2 vs. MFN, partial equil.: $\omega \equiv \ (\tau_2/\tau_m)^{-\sigma}$	2.2
t_2	probability of state $s = 2$ conditional on exiting MFN state	2.2
z	technology upgrade factor to marginal cost, $z < 1$	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 marginal cost 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
$\tilde{\omega}$	Operating profit in col. 2 vs. MFN, general equil.: $\omega \equiv (\tau_2/\tau_m)^{-\sigma} g$	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

Symbol	Description	Section
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
k	shape parameter of the Pareto distribution for productivity $G_V(c)$	2.5
α_V	industry specific distribution factor $\alpha_V \equiv \frac{N_V \sigma}{c_V^k} \frac{k}{k-\sigma+1}$	2.5
$\tilde{\alpha}_V$	industry modified factor in the export revenue $\tilde{\alpha}_V \equiv \alpha_V \left(\frac{1}{(1-\beta)K_V}\right)^{\frac{k-\sigma+1}{\sigma-1}}$	2.5
ζ_V	upgrading factor in exports for industry V, $\zeta_V \equiv 1 + \frac{K_z}{K}(\phi_V)^k > 1$.	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	A.5
ν	function mapping varieties to product counts	B.4