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Economic and Policy Uncertainty: Export Dynamics and the Value of Agreements

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ECONOMIC AND POLICY UNCERTAINTY: EXPORT DYNAMICS AND THE VALUE OF AGREEMENTS*

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ABSTRACT: We examine the interaction of economic and policy uncertainty in a dynamic, heterogeneous firms model. Uncertainty about foreign income, trade protection and their interaction dampens export investment. This can be mitigated by trade agreements, which are particularly valuable in periods of increased demand volatility. We use firm data to establish new facts about U.S. export dynamics in 2003-2011 and estimate the model. We find a significant role for uncertainty in explaining the trade collapse in the 2008 crisis and partial recovery in its aftermath. Consistent with the model predictions, we find that the negative effects worked (1) through the extensive margin, (2) in destinations without preferential agreements with the U.S. (accounting for over half its trade) and (3) in industries with higher potential protection. U.S. exports to non-preferential markets would have been 6.5% higher under an agreement—equivalent to an 8% foreign GDP increase. These findings highlight and quantify the value of international policy commitments through agreements that mitigate uncertainty, particularly during downturns.

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1 Introduction

Uncertainty increases during downturns and a growing literature examines the effects of either economic or policy uncertainty shocks (Bloom, 2014). The interaction between these shocks may amplify uncertainty; for example, government actions to ameliorate downturns can increase policy uncertainty (Pastor and Veronesi, 2013). This is one reason policymakers attempt to commit to predictable policy regimes.[1] We provide a model for the interaction of economic and policy uncertainty and a motive for governments to address it through agreements. We focus on trade policy given its international externalities; responsiveness to economic and political shocks (cf. Bown and Crowley, 2013a); and because trade can expose industries and firms to more foreign volatility (di Giovanni and Levchenko, 2012; Fillat and Garetto, 2015). We estimate the model using data on firms' international trade decisions during the 2008 recession and recovery—a period when international trade collapsed and fear of a trade war was widespread.

The impact of uncertainty on firm investments is theoretically understood (cf. Bernanke, 1983; Dixit, 1989) and there is growing empirical evidence for this mechanism (Bloom, 2009; Bloom et al., 2007). Discussion of policy uncertainty is common among businesses, policymakers and economists, but the evidence on the role of policy uncertainty remains limited. The lack of evidence stems in part from the difficulties in measuring policy uncertainty, identifying its causal impact on specific investment decisions (Rodrik, 1991), and disentangling it from economic uncertainty.

The international trade context is well suited to evaluate and quantify the importance of policy uncertainty. Using firm level trade transactions data to identify investments in market entry and exit, we can better match theoretical predictions to data and estimate and quantify the effects of economic and policy uncertainty. Sunk costs of export market entry (cf. Roberts and Tybout, 1997) can generate a higher option value of waiting to enter when uncertainty increases. Adverse foreign income shocks are especially salient for exporting firms and may trigger changes to trade policy and protectionist remedies in the destination market. Recent increases in policy uncertainty include the threat of increasing protection by ending a trade agreement (e.g. Brexit) or starting a trade war (e.g. the U.S. under the 45th president, cf. Handley and Limão, 2017b).

We combine theory and evidence to address the following questions: How do international economic and trade policy uncertainty and their interaction affect firms' trading decisions? What was the role of this uncertainty during the Great Trade Collapse (GTC) and subsequent recovery and how was it affected by international trade agreements? Our approach to answering these questions is first, to document the dynamics of U.S. exports during the GTC using aggregate and firm level data. Second, to develop a model consistent with the main features of the data. Third, to empirically assess the role of trade policy uncertainty (TPU), economic uncertainty and their interaction in the GTC for U.S. firms' exporting behavior.

An important part of the mechanism we explore is the impact of uncertainty on firm export investments to specific markets, for which we use the Longitudinal Firm Trade Transaction Database (LFTTD) from the Census Bureau. We highlight three findings from this data. First, the export collapse was dramatic but followed by a quick partial recovery. The collapse started in the fourth quarter of 2008 and reached its trough in the second quarter of 2009. Most measures of export value and participation return to their pre-crisis peak by the end of 2011, but remained well below the levels implied by their pre-crisis growth

[1] For example, in 2016 the G-20 stated that "We will [...] clearly communicate our macroeconomic and structural policy actions to reduce policy uncertainty, minimize negative spillovers and promote transparency." G-20 Leaders' Communique: Hangzhou Summit, September 5, 2016, <http://www.g20.utoronto.ca/2016/160905-communique.html > (accessed 1/19/2018).

trend. Second, both the intensive and extensive margins played important roles. The share of the extensive margin—the creation and destruction of bilateral firm-country-product trade flows—was about one third of the contraction of U.S. export growth, a larger role than has been documented for other countries. The number of exporting firms declined about 9% and the number of firm-country-product varieties declined 11% between 2008Q3 and 2009Q2. Underlying the net (negative) growth in firm export participation and export flows across products is a substantial amount of churning. While many firms continue domestic operations during the recession, there is a persistent growth reduction in the number of products exported and countries served. Third, there were notable differences in the margins of adjustment across countries. Firms adjusted less through the extensive margin when exporting to PTAs than to non-PTA countries.

Modeling the interactions of policy and economic uncertainty is motivated in part by international efforts to promote policy cooperation following the economic shocks of the financial crisis and GTC. Several factors suggest the crisis increased firm uncertainty about future protection. First, there was widespread discussion of a trade war—similar to the one in the 1930's partially triggered by the depression—that prompted members of the G-20 and other institutions to assure that "We will not repeat the historic mistakes of protectionism of previous eras."[2] Second, increases in import protection often follow economic downturns (Bown and Crowley, 2013b). Early in the crisis protectionism seemed likely given some government interventions to stimulate markets while discriminating against foreign firms, e.g. the "Buy American" clause in the U.S. stimulus bill (Eichengreen and Irwin, 2010). Moreover, WTO members with which the U.S. did not have PTAs had room to increase import protection in a legal way both because several have applied tariffs below the binding ceilings negotiated at the WTO (Foletti et al., 2011) and access to various escape clauses (as we discuss in section 2). Nevertheless, the WTO and other organizations monitored and ultimately found only limited increases in applied protection in non-PTA markets.[3] Likewise, Kee et al. (2013) find that new trade barriers affected only 1% of traded products and accounted for less than 2% of the observed collapse.

We provide a model of multiple, interacting sources of uncertainty. The theory provides new insights on the role of trade agreements for export dynamics linked to the estimation. We highlight three novel elements.

First, we introduce demand uncertainty arising from trade policy *and* economic conditions (aggregate income). We model shocks to both through a volatility parameter γ, the probability that a shock arrives. Higher demand uncertainty reduces investment, but with multiple sources of shocks we must account for their interaction. We derive expected demand as a function of the underlying joint density of shocks. We show that trade agreements can affect the uncertainty of trade policy and reduce overall demand uncertainty, conditional on income, because they entail a commitment to current policies and their future distribution. Shifts toward riskier, i.e. more uncertain, policy distributions are more likely when income falls. So firms may have perceived lower uncertainty in the GTC for exports covered by a PTA even as the volatility of shocks increased.

Second, we derive the policy preferences of a government in terms of foreign policy level and uncertainty. We compare uncertain regimes by ranking the riskiness of demand distributions by second-order stochastic dominance (SSD). We show a government that values export market access and that is export risk averse prefers a trade agreement characterized by foreign reductions in both current protection and demand uncertainty. We characterize the effects of such an agreement on entry and exports: upon implementation it

[2]G-20 Communique, April 2, 2009. <www.g20.utoronto.ca/2009/2009communique0402.html> (accessed 12/16/2017).

[3]WTO, OECD and UNCTAD 2010, "Report on G20 Trade and Investment Measures." This is in sharp contrast with the Great Depression, where increases in barriers affected 35% of tariff schedule lines and accounted for a large fraction of the trade contraction (Madsen, 2001)

increases entry by reducing protection and uncertainty. However, the agreement has two opposing effects on entry and exports if there is an exogenous future increase in the volatility of shocks through γ. Low policy barriers increase current exports but also increase future **market access risk:** if a shock does occur, there is more to lose — a negative effect that is increasing in shock volatility. The offsetting **insurance effect** arising from the complementarity of shock volatility and the overall riskiness of demand, i.e. the effect on entry of greater shock volatility is amplified where demand is more uncertain. The policy commitments contained in a PTA can shift expected demand toward less risky distributions and mitigate uncertainty for exporters, especially during crises.

Third, we examine the dynamics of exporting, including export exit and re-entry and their contribution to aggregate export growth before and after the crisis. The model provides a decomposition of demand risk into two components: one includes only policy and the other its joint interaction with income. Our approach employs firm level data at quarterly frequency to match the timing of the trade collapse and recovery closely. We map our theoretical predictions to these data and thus contribute to understanding the magnitude and dynamics of the GTC.

We highlight the following empirical results. First, net exit was higher in non-PTA markets with higher income and policy risk and these risks are complements. Second, for PTA markets there is market access risk, but it is more than offset by the insurance effect so that uncertainty had a differentially smaller impact in those markets. Third, the net exit translates into significant export effects through the contribution of the extensive margin to total growth; we find no evidence of PTA uncertainty differentials for continuing firms. Fourth, the PTA uncertainty differentials reach their peak in the first four quarters of the crisis and are reversed only partially in the remaining two years. Therefore the cumulative impact is significant even three years after the start of the crisis. Fifth, we find additional evidence for the policy risk channel by splitting the sample into high and low potential protection industries. We do so using measures of importer market power that are proportional to optimal non-cooperative tariffs in a trade war. The net exit for non-PTA relative to PTA markets is stronger in high market power industries and translates into large export impacts. Moreover, these market power differentials are only present in the extensive margin.

We quantify the role of uncertainty and agreements by computing counterfactual paths for net exit and exports relative to a scenario where their respective growth remains at its pre-crisis average. By 2011Q4 average net exit for non-PTA destinations was 15 log points below the no-crisis path. Most of this effect would be eliminated if those countries had a PTA. Applying this counterfactual to average exports we find similar results for the extensive margin. This implies that aggregate U.S. exports to non-PTA destinations would have been 6.5% higher under an agreement—equivalent to an 8% GDP increase in those destinations.

Our findings suggest that the current network of trade agreements can lower uncertainty, particularly in high policy risk industries. The role of GATT/WTO membership is less clear. This institution was meant to prevent a recurrence of the 1930's trade war. While our results indicate an initial increase in uncertainty in WTO members—the large majority of the non-PTA countries in our sample—it did not translate into substantial protection and the risk receded partially, perhaps because of WTO monitoring mechanisms and commitments.[4] Thus we contribute to the understanding of policy flexibility and potential protectionism over the business cycle (Bagwell and Staiger, 2003; Barattieri et al., 2017) and the role of trade policy

[4] WTO Director General Pascal Lamy noted this at the time in 2009, stating that "Today as the economic crisis bites into our economies, and as protectionist pressures knock on our doors, we must recall the importance of the insurance policy against protectionism that the WTO offers through 60 years of global rule-making, and its dispute settlement system." www.wto.org/english/news_e/sppl_e/sppl112_e.htm

commitments in the presence of economic and lobbying shocks (Amador and Bagwell, 2013; Beshkar et al., 2015; Limão and Maggi, 2015) and the implications of potentially high tariffs if cooperation breaks down (Nicita et al., 2018; Ossa, 2014).

Finally, the implications for international trade are broadly important. First, it is well known that PTAs can increase bilateral trade substantially (cf. Baier and Bergstrand, 2007). Handley (2014) and Handley and Limão (2015) show TPU is important for firm export entry, but emphasize permanent *reductions* in policy uncertainty from implementing agreements rather than ongoing dynamic interactions with other sources of risk. The of impact TPU on trade during a period of high *economic* uncertainty has not been explored with firm data. Further understanding the potential insurance value emphasized by various PTAs can help explain why they have such large trade effects, which has become particularly important given recent U.S. threats to exit NAFTA and the U.K. vote to leave the EU.[5]

In section 2 we provide descriptive evidence of U.S. export dynamics in 2003-11. This informs the theoretical model in section 3. In section 4, we test entry and export growth predictions. In section 5 we quantify how these outcomes were affected by uncertainty and agreements during the GTC and recovery.

2 U.S. Export Dynamics, Firms, and the Great Trade Collapse

Our contribution in this section is twofold. First, we characterize U.S. firms' export dynamics, decompose aggregate exports into intensive and extensive margins of adjustment and show they were heterogeneous across PTA status in a way that is consistent with the uncertainty mechanism. Second, we discuss these findings in the context of the institutional features of the GATT/WTO and PTAs. These motivate and inform the theoretical model and the subsequent empirical approach.

2.1 The Great Trade Collapse

The GTC was a worldwide phenomenon with several competing explanations for its magnitude. These include: (i) changes in the composition of demand (Eaton at al., 2016); (ii) the collapse of trade credit (Chor and Manova, 2012; Amiti and Weinstein, 2011); (iii) the disintegration of international supply chains (Bems et al., 2011); (iv) the inventory cycles of firms (Alessandria et al., 2010); and (v) economic uncertainty (Novy and Taylor, 2014; Greenland et al., 2016). Each of these factors can explain part of the collapse for certain countries but not necessarily all of it nor the fast partial recovery of international trade.

The collapse was especially large for some countries; U.S. exports between 2008Q3 and 2009Q2 contracted by 22% whereas its GDP contracted by 3%. Most research has focused on the collapse but U.S. aggregate exports started expanding again by the end of 2009, which suggests a change in expectations about future conditions. Despite this change, the initial decline was so large that it took until 2010Q4 for exports to recover to their pre-crisis peak. Figure 1 provides an initial piece of evidence that PTAs provided some insurance for U.S. exporters. We fit a local polynomial mean through U.S. cumulative bilateral export growth to PTA and non-PTA destinations. The average growth relative to 2002 behaves similarly for both groups until the financial crisis in 2008Q4 (solid red line). Afterwards, PTA exports decline by slightly less, recover to the pre-crisis peak earlier, and ultimately have higher cumulative growth from 2009.

[5]See Limão (2016) for a review of the motives and trade effects of PTAs including the role of uncertainty.

The average differential growth toward PTA countries was large enough to halt the decline in the aggregate share of exports to PTAs seen in Figure 2(a) and reverse it. To further explore this differential, we also exploit variation in policy risk across industries, which depends among other things on the degree of import market power a country has in an industry, as found in Broda et al. (2008). Using their definition in Figure 2(b) we see that the behavior of the aggregate PTA share is driven precisely by those industries where importer market power and thus potential protection was high.

2.2 Entry and Exit Dynamics

Aggregate U.S. exports reached their pre-crisis peak in the second quarter of 2008 after several years of sustained growth. On the extensive margin, U.S. exports reached a peak in 2008Q3. This is shown in Figure 3 where we define **varieties** as a firm-country-product triplet (the product is an HS10 code). Normalizing varieties to unity at their peak in 2008Q3 we see that by the first quarter of 2009 the total number of varieties exported by the U.S. to all destinations decreased by 11%, sharply reversing their average annual growth between 2002 and 2007 of 6.5%. By the end of 2010 exports recovered to their pre-crisis peak *level* but remained below their pre-crisis trend.

The large changes in the extensive margin are not driven by the granularity of varieties. In Figure 3 there are similar patterns for firm-destinations and the total number of exporting firms. Large net entry changes can occur relatively fast given the high churning rates we observe in exporting. For example, between 2003 and 2007 the average gross entry rate for firms exporting in quarter t but not at $t-4$ was 38% and the gross exit was 34%; for the first 4 quarters of the crisis entry fell to 33% and exit jumped to 38%. Moreover, the decline in annual export net entry does not reflect domestic behavior in the Great Recession. Prior to the crisis average annual domestic entry and exit were both roughly 10%. During the first 4 quarters of the crisis, entry fell to 7.7% and shutdowns increased to 11%.[6]

In section 4 we focus on quarterly, year-on-year entry and exit rates within country-industry pairs, where churning is even higher. To illustrate, Figure 5(a) uses our subsequent regression subsample to plot the cumulative change in net entry and the contributions of entry and exit in deviations relative to trend growth from 2003Q1 to 2008Q3. Both entry and exit contribute equally in the first year of the trade collapse. But while exit rates recover to trend, the entry contribution remains depressed through 2011.[7]

2.3 Aggregate Growth Decomposition

To determine the quantitative importance of these variety dynamics for aggregate exports we decompose the growth of the latter into its intensive and extensive margins. We index trade value flows, $x^m_{vi,t}$, by firm-product (v), destination (i), time (t) and type $m \in \{ENTRY, EXIT, CONT\}$. The extensive margin is the sum of ENTRY ($x_{vi,t} > 0$ and $x_{vi,t-4} = 0$) and EXIT ($x_{vi,t} = 0$ and $x_{vi,t-4} > 0$). The intensive margin is comprised of continuers ($x_{vi,t}, x_{vi,t-4} > 0$). We compute a midpoint growth rate that can accommodate

[6] These extensive margin figures for exporting reflect the universe of all trade transactions in the LFTTD matched to a firm in a Census Business Register. The domestic entry and exit rates are for the Longitudinal Business Database (LBD). Our subsequent aggregate decompositions in Figures 4-6 and Table 1 reflect the regression sample described in section 4.4.

[7] The high export churning rate in the presence of sunk costs is important since it allows a relatively fast adjustment when conditions worsen even if exit from a market is mainly due to attrition. See Ghironi and Melitz (2005) and Bilbiie et al. (2012)

zeros for entry and exit as[8]

$$\hat{x}_t^m = \frac{x_{vi,t}^m - x_{vi,t-4}^m}{\frac{1}{2}[x_{vi,t}^m + x_{vi,t-4}^m]} \in [-2, 2].$$

We compute the share $s_{vi,t}^m = \frac{x_{vi,t}+x_{vi,t-4}}{X_t+X_{t-4}}$ in average total exports from t to $t-4$. We let $I_m = 1$ if a trade flow belongs to margin m and write the aggregate export midpoint growth rate as the sum of these mutually exclusive margins

$$\hat{X}_t = \sum_{i,v} \sum_m I_m \times s_{vi,t}^m \times \hat{x}_{vi,t}^m. \tag{1}$$

In Figure 4 we plot the resulting annual growth, by quarter, of the intensive and extensive (the sum of entry and exit) margins. Both contribute to negative export growth when the crisis begins. The decline in the intensive margin was larger but so was its reversal. One potential reason is that adjustments through the extensive margin may be dampened by the presence of sunk costs of entry.

This decomposition also shows the extensive margin in terms of varieties is important for U.S. export growth. Before the crisis this margin accounted for about half of that growth, 57% and 43% in the third quarter of 2007 and 2008, respectively.[9] From 2008Q4 to 2009Q3, the extensive margin accounted for about 25% of the observed decline in aggregate exports. After exports started to grow again the extensive margin contributed positively, but a smaller share than prior to the crisis. The average extensive margin share was 24% and 36% for the years beginning in 2009Q4 and 2010Q4. We summarize these results in Table 1.

In Figure 5(b) we decompose the net extensive margin into its components and their contribution to cumulative total export growth relative to the 2003Q1-2008Q3 trend. The contribution of gross entry to total export growth falls about 5 percentage points and the contribution of exit falls about 7 percentage points in 2008Q4 to 2009Q3. This is a net swing of about 12 points in the contribution of the extensive margin to total export growth. The deviation from trend diminishes over time, but remains important even after the intensive margin begins to recover toward trend after 2009. By the last period in the sample the net extensive margin contributed about -8 percentage points to the cumulative decline of -20 for exports.

2.4 Growth Decompositions by PTA Status

In Figure 6(a) we decompose the margins of export growth in Figure 4 by PTA status. The export decline toward PTAs was more strongly affected by the intensive margin, whereas for non-PTAs both margins are important. Prior to the crisis the extensive margin contribution was similar for PTA and non-PTA destinations. But in each quarter of the GTC the non-PTA contribution of the extensive margin was higher.

We also compute cumulative growth rates for non-PTA and PTA exports relative to trend prior to the GTC. In the left panel of Figure 6(b) the extensive margin is 15 percentage points of the 40 point reduction in exports for non-PTA countries by 2009Q3. In the right panel the total reduction in PTA exports is around 35 percent, but the extensive margin is less than 10 points of the total. The decline in cumulative growth from the extensive margin is greater for non-PTA exports until the end of 2010. A full three years after the onset of the trade collapse, total exports to non-PTA markets are about 25 percentage points below trend with the extensive margin contributing 10 points. PTA exports, in contrast, are less than 15 points below trend and the extensive margin contributions only 5 points.

[8] This growth rate symmetric around zero, and equivalent to log changes up to a 2$^{\text{nd}}$ order Taylor expansion.

[9] Kehoe and Ruhl (2013) find a smaller role of the extensive margin and only towards countries with trade policy changes, but they use product level data.

2.5 Discussion and Interpretation

To summarize, by the end of 2011 export growth remained substantially below the pre-crisis trend, particularly for non-PTA destinations, and there were significant roles for intensive and extensive margin dynamics. We find that (i) overall export growth toward PTA destinations was relatively higher during the financial crisis and recovery; (ii) the extensive margin played an important role in the recent evolution of U.S. exports, and accounted for up to a third of annual export growth in the 3 years after the onset of the financial crisis; (iii) the intensive margin collapse (and recovery) was somewhat faster and stronger than the extensive margin; and (iv) there is less extensive margin adjustment toward PTA markets.

The differences between PTA and non-PTA export dynamics raise the question of why this is present relative to the WTO commitments that most non-PTA countries in our sample also undertook. Here we describe two broad reasons. First, tariff commitments in the WTO take the form of maximum tariffs, often positive, and several countries' applied tariffs were below them; in the PTAs we consider those commitments are typically a zero tariff. Moreover, the WTO explicitly allows for those commitments to be renegotiated up whereas the expectation in PTAs has been that the commitments would remain fixed (that may be changing with Brexit and U.S. renegotiations). Second, agreements are self-enforcing and thus cooperation is typically higher in PTAs where monitoring of policies is easier and incentives to retaliate are stronger since there are fewer other countries to free ride on. In contrast, the incentive to deviate and increase protection for a short-run payoff can be large in downturns (Bagwell and Staiger, 1990; 2003) and in the presence of scarce enforcement power the WTO has safety valves that allow its members to legally increase protection above negotiated levels (cf. Hoekman and Kostecki, 2009, Ch.9).[10]

We now provide a model to better interpret these facts and provide an econometric framework to estimate the impact of economic and policy uncertainty on firm export decisions.

3 Export Dynamics under Economic and Policy Uncertainty

We develop a dynamic model of firm export decisions under multiple uncertainty shocks to provide insight about their interaction and guide the estimation. We extend Handley and Limão (2015) in three important dimensions. First, we introduce destination specific export exit and re-entry, which captures the heterogeneity just documented. Second, we allow for uncertainty in any foreign business conditions, denoted by a, that capture foreign trade policy, other shocks affecting export profit, and their interaction. Third, we model the government preferences for foreign market access under uncertainty to derive predictions for PTAs upon accession and in response to uncertainty shocks.

We show that increases in the uncertainty of a lower net export entry due to a standard option value of waiting argument. Increased uncertainty can arise from changes in demand volatility or its tail risk, which we show are complements. These results apply to any setting with multiple sources of underlying risks in a, provided they arrive simultaneously. We decompose the risk in a into a policy and an economic component and show that PTAs impact on entry and trade occurs via changes in policy risk, both directly and through its interaction with economic risk.

[10]For example, article XIX provides a safeguard allowing governments to increase protection when a domestic industry is hurt by imports, since PTA partners are often exempted from such safeguards a U.S. firm faces a lower risk of protection in PTA markets.

We introduce heterogeneous risks in a across states arising from different policy risks and allow PTAs to affect these states' likelihood. Then we show that PTAs can increase entry by lowering the probability of high risk states, what we call an *insurance effect*. We also let PTAs affect the current policy level, this increases entry upon implementation but also introduces a higher potential future loss from preferential market access, a *market access risk effect*. Therefore, lower entry due to increases in demand volatility, e.g. in the Great Recession, is mitigated by PTAs that provide insurance against loss of future market access but amplified by their current market access risk. A PTA's net impact depends on the relative importance of the two effects, the correlation between economic and policy shocks, and the level of trade protection.

3.1 Environment

The operating profit for an incumbent monopolistically competitive firm that exports a differentiated good, v, to country i is determined as follows. At the start of each period t a firm observes all relevant information before making its production and pricing decisions for that period. This assumption and the absence of any adjustment costs implies that after entry with a particular technology firms simply maximize operating profits in a market, π_{ivt}, period by period. So operating profits are derived similarly to monopolistic competition models in a deterministic setting.

There are $V+1$ industries; one producing a homogeneous, freely traded numeraire good and the remaining producing differentiated goods. Total expenditure on goods in country i is denoted by Y_{it} with a fixed exogenous fraction ε_V spent on each industry V and the remaining on the numeraire. Consumers have constant elasticity of substitution preferences over goods in each industry V with $\sigma > 1$. A firm v faces a standard CES demand in i at time t,

$$q_{ivt} = \left[D_{iVt}\left(\tau_{iVt}\right)^{-\sigma}\right] p_{ivt}^{-\sigma} = a_{iVt} p_{ivt}^{-\sigma} \tag{2}$$

where $D_{iVt} = \varepsilon_V Y_{it}\left(P_{iVt}\right)^{\sigma-1}$ and P_{iVt} is the CES price aggregator over varieties in each V. The consumer price is equal to the producer price, p_{ivt}, times the ad valorem tariff policy factor in industry V, $\tau_{iVt} \geq 1$. From the firm's perspective, the **business conditions** term, $a_{iVt} = D_{iVt}\left(\tau_{iVt}\right)^{-\sigma}$, is exogenous and summarizes all payoff relevant information for time t.

Labor is the only factor of production. It has constant marginal productivity in the numeraire sector so the wage is normalized to unity. Differentiated goods are produced with a constant marginal cost, characterized by a labor coefficient of c_v. At the start of each period firms know the demand conditions, their productivity and σ. They choose prices to maximize operating profits in each period, $\pi_{ivt} = \left(p_{ivt} - c_v\right) q_{ivt}$, leading to a standard mark-up rule over cost, $p_v = c_v/\rho$ where $\rho = (\sigma-1)/\sigma$. Using the optimal price and demand we obtain the export revenue received by the producer, and the associated operating profit:

$$p_{ivt} q_{ivt} = a_{iVt} c_v^{1-\sigma} \rho^{\sigma-1} \tag{3}$$

$$\pi_{ivt} = a_{iVt} c_v^{1-\sigma} \tilde{\sigma} \tag{4}$$

where $\tilde{\sigma} \equiv (1-\rho)\,\rho^{\sigma-1}$.[11] We describe the main results in the context of policies that affect demand but they apply to any set of policies that affect profitability in a market (e.g. by multiplying a_{iVt} by a probability

[11] We can extend the framework to allow for upgrades and downgrades of technology; for now (4) represents the exporting operating profit of a firm that drew a technology c_v and observed demand conditions in importer i industry V of a_{iVt}.

of expropriation or a profit tax).

3.2 Exporter Dynamics under Economic and Policy Uncertainty

In this environment we can analyze firm decisions in any given industry-export market separately so below we omit the industry subscript. Unless otherwise stated all the variables vary by industry-export market, except for c_v.[12] We start by characterizing uncertainty using a generalized demand regime via a mixture of distributions. This approach allows us to parameterize the risk heterogeneity across destinations and explore how PTAs can affect these risks and their interaction across multiple sources.

Firms face uncertainty about the future path of business conditions, a_t, and its underlying sources, which they take as given. We assume the mass of exporters relative to domestic producers in the foreign destination is sufficiently small that their entry decisions have a negligible impact on the price index in that destination.[13] To start exporting to a specific market a firm must incur a sunk cost, K. Given the current conditions it will be optimal to enter if the expected value of exporting, Π_e, net of K is at least as high as the expected value of waiting, Π_w. So the marginal entrant at any given a_t is the firm with cost equal to the cutoff, c_t^U, defined by

$$\Pi_e\left(a_t, c_t^U, r\right) - K = \Pi_w\left(c_t^U, r\right). \tag{5}$$

Before export entry the firm observes the current conditions in the market, a_t, and uses this along with information about the demand "regime" defined below to form expectations regarding future profits. Firms believe that a demand shock in the following period occurs with probability γ and when it does the new demand parameter, a', is drawn from some distribution M, independent of the current business conditions.

Firms take the *generalized demand regime* $r = \{\gamma, M\}$ as given and time-invariant. The distribution reflects the multiple, potential sources of uncertainty in business conditions. It is defined as follows: $M\left(m_s, H_s\left(a\right)\right) = \sum_{s\in S} m_s H_s\left(a\right)$, which is a mixture over $S \geq 1$ exogenous distributions H_s for the mutually exclusive combinations of states with fixed mixing weights $m_s \in [0,1]$ and $\sum_s m_s = 1$. This characterization of the demand regime has several advantages. First, different regimes can encompass a range of situations, e.g. if $\gamma = 0$ there is no uncertainty; if $\gamma = 1$ then demand is i.i.d. If $\gamma \in (0,1)$ then it captures demand persistence and there are imperfectly anticipated shocks of uncertain magnitude. Second, it capture multiple sources of shocks driving a without assuming explicit distributions. Third, by varying the weights across what we refer to as **uncertainty states,** s, we can characterize heterogeneous risk across destinations or industries and isolate the source of that risk, e.g. by shifting probability from a state s with negligible policy risk to another where it is high.

The theory focuses on a simple setting where firms have no per period fixed cost after entry. Therefore, it is always optimal after to export. We allow a firm's export entry capital to specific markets to fully depreciate with probability d, which is independent across markets. The depreciation process is simple: at the end of each period the export capital either fully depreciates or remains intact. When this occurs, the

[12]To focus on export entry decisions we assume zero domestic entry costs and a constant domestic mass of potential firms in each industry. These assumptions imply a fixed number of active domestic firms, which is relaxed in the estimation section.

[13]The standard assumption we make is that monopolistically competitive firms are sufficiently small relative to the measure of firms in industry V, country i to ignore their own effect on the price index or aggregate goods' expenditure. We add a "small" exporter assumption to focus on the direct effects of demand uncertainty on operating profits rather than indirect GE effects. Handley and Limão (2017) allow for GE effects of policy uncertainty via the price index. This introduces adjustment dynamics, as the price index adjusts to entry and exit, and tends to attenuate but not overturn, the direct effects of tariff policy on entry decisions. Carballo (2015) extends this framework to analyze related-party trade.

firm can only export if it repays a sunk cost that is independent of whether or not it previously exported. This process generates exit from exporting without firm death, so the model is consistent with that feature of the data and allows for exit in a subset of markets (whereas if the firm only exited upon death it would always exit all markets). We also allow for re-entry, which is again observed in the data, provided the firm decides to pay K again.

Given this setup, the initial entry decision is independent of whether a firm will ever be able to re-enter that market or not after re-paying the cost, provided we use an effective discount rate that reflects the probability that the capital survives, given by $1 - d$.[14] This implies that we can solve for entry as if the firm had only one possibility to enter an export market and had to choose when to do so. Then if the firm's capital depreciates it will evaluate the entry decision again unless the whole firm dies (with probability δ). So the firm's effective discount rate used to value future export payoffs is $\beta = (1-\delta)(1-d) < 1$.[15]

One implication of this framework is that while exit rates are exogenous, the measured gross exit still depends on current conditions and on entry cutoffs. In stationary states, where c_t^U and entry decisions are unchanged relative to the previous period, the measured gross exit rate equals the death rate δ, since the firms that lost their export capital re-enter. The same is true if conditions improve. But in periods where conditions worsened the measured exit exceeds δ since some surviving firms that lost their export capital do not re-enter. The relevant adjustment dynamics for the empirical approach are derived in section 3.4.

We derive solutions for the values of entry Π_e and waiting Π_w and solve for the cutoff condition under uncertainty in Appendix A. The following proposition provides the key expressions for the cutoff and how it changes with uncertainty shocks.

Proposition 1: Uncertainty Shocks and Entry Under Multiple Shocks

Under an uncertainty demand regime $r = \{\gamma, M(m_s, H_s(a))\}$ with volatility γ and conditional probability m_s for each shock s

(a) For any given value of a_t, the cutoff c_t^U for the firm that is indifferent between entry or waiting at time t is defined by

$$c_t^U = c_t^D \times U_t = \left[\frac{a_t\tilde{\sigma}}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}} \times \left[1 + \frac{\beta\gamma\left[\bar{\omega}(a_t) - 1\right]}{1-\beta(1-\gamma)}\right]^{\frac{1}{\sigma-1}} \tag{6}$$

$$\bar{\omega}(a_t) - 1 = \sum_{s\in S} m_s\omega_s(a_t) - 1 \in (-1, 0] \tag{7}$$

$$\omega_s(a_t) - 1 = -H_s(a_t)\frac{a_t - \mathbb{E}_s(a' \le a_t)}{a_t} \in (-1, 0]. \tag{8}$$

(b) shifts towards any given riskier shock, $\Delta m_{s'} = -\Delta m_s > 0$ where H_s SSD $H_{s'}$ increase overall demand uncertainty and lower entry $c_t^U(\gamma, M(m_s + \Delta m_s, H_s)) \le c_t^U(\gamma, M(m_s, H_s))$.

(c) the entry effect in (a) is magnified by demand volatility: $\frac{\partial \ln c_t^U(\gamma, M(m_s, H_s))}{\partial\gamma} > \frac{\partial \ln c_t^U(\gamma, M(m_s+\Delta m_s, H_s))}{\partial\gamma}$.

For any given value of a_t, we obtain a cutoff c_t^U for the firm that is indifferent between entry or waiting at

[14]The intuition should be clear: the re-entry decision of any given firm is independent of its past export status if it has lost all its export capital. There is no other measure of experience or presence in the market that is relevant for exporting; each entry decision can be made independently of future re-entry. We prove this in the NBER working paper (Carballo et al., 2018).

[15]Since there is a fixed probability of death, δ, there is an equal probability of new firms being born to replace those that die, which maintains a constant mass of active domestic firms.

time t. The cutoff under uncertainty is lower than the deterministic cutoff, c_t^D, whenever the uncertainty factor, denoted by U_t, is less than unity. This occurs if and only if $\bar{\omega}(a_t) - 1 < 0$, which measures tail risk to operating profits conditional on a shock while allowing for heterogeneous risks across states. We prove the results in the appendix. Here we provide intuition and a graphical representation.

The attenuation of the cutoff under uncertainty relative to a deterministic model in part (a) can be understood more intuitively by examining the $\omega_s(a_t)$ terms. Specifically, each $\omega_s(a_t)$ is the expected proportional loss in operating profits conditional on current business conditions, a_t, times the probability $H_s(a_t)$ of a shock that worsens conditions in state s. Within each state, $\mathbb{E}_s$ is the expectation operator over distribution H_s. Then $\bar{\omega}(a_t)$ is the average of these expected losses weighted by probability m_s of each state. The dependence of the entry cutoff on current conditions and the probability and magnitude of adverse shocks is an example of the "bad news" principle (Bernanke, 1983). The opportunity cost of entry is that the firm loses the option value of waiting for conditions to improve, i.e. trading future upside risk against current and expected profits net of entry and waiting today. When the future is more uncertain, this tradeoff is higher and more firms optimally wait to enter.

For part (b), we start by considering a riskier distribution M' at a given γ. For concreteness, assume that there is a change in the probability of the shock s such that $\Delta m'_s = -\Delta m_s$ where H_s SSD H'_s. From eq. (6) we see that this change in distribution only affects the proportional loss term and thus $c_t^U(M') \leq c_t^U(M)$ if and only if it implies $\bar{\omega}'(a_t) \leq \bar{\omega}(a_t)$. In the appendix we show that this condition holds for any a_t if and only if H_s SSD H'_s: the latter has thicker tails and thus implies larger losses conditional on a bad shock.

This effect does not require additional restrictions on the long-run mean of a across the regimes. It continues to hold if we restrict that means to be identical and compare pure risk effects. If we hold the long run mean of a fixed and construct H'_s as a mean preserving spread of H_s, then this implies that H_s SSD H'_s and the result follows for all $a_t < a_{\max}$. We illustrate this point in Figure 7 assuming a is log normal. Panel (a) shows CDFs of H_s (black) that is SSD by $H_{s'}$ (red). These correspond to the extreme cases where $m_s = 1$ and $m_s = 0$ respectively with any other weight representing intermediate risk, e.g $m_s = 1/2$ (dashed). We focus on mean preserving spreads of a and normalize the distributions such that $\mathbb{E}(a) = 1$. Panel (b) shows the impact of increasing volatility from none to the maximum on the cutoff at any a_t, i.e. $100 \times \ln U_t = 100 \times \ln\left[c^U(a_t, \gamma = 1) / c^D(a_t, \gamma = 0)\right]$. At every $a_t > 0$ we see the riskier market (red) has a larger reduction than the least risky and of any mixture of the two (dashed) as shown in Proposition 1(b).

The magnification of the entry reduction from higher γ for countries or industries with riskier H distributions follows from Proposition 1(b). For $\gamma = 0$ the entry cutoff is equal to the the deterministic cutoff regardless of the underlying H distributions. Now suppose γ increases to unity as in Figure 7(b). There is a positive complementarity between volatility of shocks and underlying tail risk. For any level of business conditions, the entry cutoff will fall more if the higher volatility exposes the exporter to a riskier distribution of shocks. This arises because the response of $\ln c_t^U$ to changes in γ is proportional to $\bar{\omega}(a_t; M(m_s, H_s))$. Expected losses are larger after shifts toward riskier distributions: $\bar{\omega}(a_t; M(m_s + \Delta m_s, H_s)) < \bar{\omega}(a_t; M(m_s, H_s))$. Our empirical approach explores this insight by examining whether a common increase in γ, the probability of a demand shock, had differential effects across riskier industries or countries. The entry results in Proposition 1 extend to industry exports since in this model they are proportional to the entry cutoff.

3.2.1 Sources of Risk

Next we characterize demand tail risk in terms of its sources. From (2) we see that a reflects both the trade policy and an overall demand shifter in each industry: $D_{Vt} = \varepsilon_V Y_t (P_{Vt})^{\sigma-1}$. All variables other than the structural parameters σ and ε below can vary by destination i so we omit that subscript. We separate out the economic and policy components by rewriting a as:

$$a_{Vt} = \varepsilon_V \frac{y_t}{\varsigma_{Vt}}. \tag{9}$$

where ε_V denotes the share of expenditure in industry V, $y_t = Y_t/\tilde{P}_t$ is a real income effect, and $\varsigma_{Vt} = \frac{P_{V_t}}{\tilde{P}_t}\left(\frac{\tau_{Vt}}{P_{Vt}}\right)^{\sigma}$ is a policy effect. The aggregate price index for a country is $\tilde{P}_t = \prod (P_{Vt})^{\varepsilon_V}$, and the Cobb-Douglas aggregator over the CES price indices of the differentiated industries is P_{Vt}.[16] The policy component, ς_{Vt}, can be interpreted as a price substitution effect: when the relative price of an import decreases there is substitution towards it from other varieties (at a rate $\sigma > 1$ if in the same industry and at a unit elasticity across industries). Modeling the policy component as a price substitution effect implies the insights below apply to any trade policies that reduce price wedges and thus induce substitution towards varieties from the preferential partner. This is important because recent PTAs include various such barriers beyond tariffs. The results below apply for each differentiated industry so we omit the V subscript.

To derive the distribution of a' we model the process for the underlying shocks $x_t = \{y_t, \varsigma_t\}$. With probability $1-\gamma$ neither is expected to change so $x' = x_t$ and with probability $\gamma \cdot m_s$ there is a new x'_s with time invariant joint density $h_s(y, \varsigma)$. Using the standard formula for the distribution of a ratio we obtain the CDF of $a_t = \varepsilon \frac{y_t}{\varsigma_t}$ conditional on a demand shock in state s:

$$H_s(a_t) = \int_0^{\varsigma^{\max}} \int_0^{y=a_t\varsigma/\varepsilon} h_s(y, \varsigma)\, dy d\varsigma. \tag{10}$$

We place few restrictions on these densities to allow them to reflect either a purely statistical relation between shocks determining y_t and ς_t or equilibrium effects between these variables. Thus the framework can be applied to alternative models for the determination of policy, aggregate income, and prices.

An alternative is to place some additional structure on the model, derive how y_t and ς_t depend on specific exogenous parameters such as increases in tariffs (that would increase ς_t) or labor endowments (that would increase y_t) and then provide a specific stochastic process for them. In online appendix D.2 we illustrate how variation in risk in specific components and their interaction translates into changes in demand risk using a bivariate log normal distribution.

3.3 Agreements, Endogenous Uncertainty and Trade

We now employ the model to derive the differential impacts of uncertainty shocks on firms' export decisions depending on whether countries have a PTA. First, we identify the policy parameters that PTAs may change and map them to the model. Second, to determine the predicted direction of the changes under a PTA, we model government preferences that reflect two central objectives of trade agreements: improved export market access and reduced risk. We derive the impacts of the agreement desired by such a government on specific policy parameters and consequently on exports. We show there are direct effects upon implementation

[16] In the presence of a numeraire homogeneous good we have $\Sigma\varepsilon_V = \varepsilon < 1$.

and that PTAs also affect the response of exporters to future uncertainty shocks.

PTAs internalize the costs of certain policies on foreign exporters. A government has a **PTA motive** if its objective evaluated at non-PTA policies, denoted by G^M, can be improved via some change in the foreign policy parameters faced by its exporters, i.e. if $G^{PTA} > G^M$. Most PTA models are deterministic so governments need only choose some initial policy level, ς_t^{PTA}, which remains in place indefinitely. But if there are time-varying incentives for governments to set protection, then we must specify whether and how a PTA affects future policy. This amounts to asking which parameters of the demand regime, r, can be affected by PTAs and how they impact the exporter government.

We assume PTAs are unable to affect the income distributions, i.e. the marginal densities $h_s(y)$, or the arrival of any demand shock, γ. PTAs may affect the probability, or belief, that certain policy states occur. We capture this in a parsimonious way by allowing PTAs to affect m_s, the belief parameter for any state s that has different conditional policy distributions, $h_s(\varsigma|y)$, but the same income distributions $h(y)$ Additionally, we assume there are only two possible uncertainty states with identical income distributions: s' with probability m and s with probability $1-m$.[17] Moreover, we assume that the difference in $h_s(\varsigma|y)$ implies that we can rank the distributions of a according to risk and without loss of generality denote s as the state characterized by lower overall demand risk so H_s SSD $H_{s'}$. This can capture various differences in the policy distribution across the states, e.g. in one state the policy may be highly responsive to income, or the policy distributions may be independent of income in both states but $h_s(\varsigma|y)$ may be riskier. The objective is to provide predictions without requiring specific assumptions about the risk in $h_s(\varsigma|y)$ in different states since its impact on overall risk will depend on the relationship with income for which we have little direct evidence.[18]

In sum, two parameters may change under a PTA: beliefs about probability of shocks, $\Delta_m^{PTA} = m^{PTA} - m$, and the current policy level, $\Delta_\varsigma^{PTA} = \varsigma_t^{PTA} - \varsigma_t$. Therefore the uncertainty differences between PTA and non-PTA are captured by difference in loss terms,which can be decomposed as follows:

$$\bar{\omega}_t^{PTA} - \bar{\omega}_t = \underbrace{\left[\omega_{s'}\left(a_t\left(\varsigma_t\right)\right) - \omega_s\left(a_t\left(\varsigma_t\right)\right)\right]\Delta_m^{PTA}}_{\textbf{Insurance}} + \sum_{s\in S} m_s^{PTA} \underbrace{\left[\omega_s\left(a_t\left(\varsigma_t^{PTA}\right)\right) - \omega_s\left(a_t\left(\varsigma_t\right)\right)\right]}_{\textbf{Market Access Risk}} \tag{11}$$

The insurance effect captures changes in the probability of different export shocks that hold current policies and income distribution fixed. This insurance effect is positive if $H_{s'}$ is riskier and $\Delta_m^{PTA} < 0$ since then the PTA reduces future market risks; below we show this occurs if the government is export risk averse. The current market access risk term is negative if $\Delta_\varsigma^{PTA} < 0$, i.e. if a PTA lowers current barriers because doing so improves current conditions and implies that when a future shock does occur then the proportional loss is larger, as we show in proposition 2. This risk is not eliminated except in a limit case where the policy is credibly and permanently fixed, which may not be feasible or optimal in the presence of income shocks.

In the context of trade negotiations, market access improvements correspond to changes in policies that increase export sales (and thus profits). In our model foreign policy only affects exports via a so we write

[17] There can be an arbitrary number of other shocks that draw from different income distributions but since we assume the PTA is unable to affect their probability we set their probability to zero.

[18] We do not specify how an agreement should be designed to achieve this change in beliefs since we will not explore such details in the empirical section. However, a number of dimensions seem potentially important, including whether it covers a broad range of policies (so it is hard to substitute tariffs for non-tariff barriers for example), contains escape and contingent protection clauses and how easy it is to renegotiate.

the reduced form government objective as

$$G = G\left(a_t, M\left(a\right), \gamma\right) \tag{12}$$

and say the **government values market access and is export risk averse** if (i) $G_{a_t} > 0$ and (ii) $G\left(a_t, M\left(a\right), \gamma\right) \geq G\left(a_t, M'\left(a\right), \gamma\right)$ for all a_t whenever M SSD M' (with equality at $\gamma = 0$). The partial effect of a_t on G in condition (i) holds in standard policy models without uncertainty; in these models $G_{a_t}|_{\gamma=0} > 0$ typically reflects a government's social or political weight given to a measure of aggregate export profits. We assume this continues to hold under uncertainty but note that G_{a_t} may now be smaller since it reflects improvements in current market access from current policy that are temporary and change with probability γ. Condition (ii) is a natural definition of export risk aversion when a affects G only through the export channel.[19] Both conditions hold at any given γ since we assume the agreement does not affect it. But demand volatility clearly affects the agreement. If $\gamma = 0$ permanently, then there would be no motive for the agreement to address risk. We assume that governments treat γ as a fixed parameter (as firms do) so the agreement reflects the level of γ when signed.[20] The reduced form objective in (12) is sufficient to establish when an exporter government has a motive for a PTA; what the desired changes in policy and risk are and how each affects entry.

Proposition 2: Agreements, Endogenous Uncertainty and Entry Impacts

If an exporting government values market access and is export risk averse then it has a motive for a PTA, $G^{PTA} > G^{M'}$, so $\left\{\Delta_m^{PTA}, \Delta_\varsigma^{PTA}\right\} \neq \mathbf{0}$ and

(a) the reduction in export risk ($\left[\omega_{s'}\left(a_t\right) - \omega_s\left(a_t\right)\right]\Delta_m^{PTA} > 0$) increases entry for given $\gamma > 0$ and mitigates the impact of uncertainty shocks due to an insurance effect $\left(\frac{\partial\left[\omega_{s'}\left(a_t\right) - \omega_s\left(a_t\right)\right]\Delta_m^{PTA}}{\partial\gamma} > 0\right)$.

(b) the reduction in applied protection ($\Delta_\varsigma^{PTA} < 0$) increases entry for given $\gamma \geq 0$ but magnifies the impact of uncertainty shocks due to increased market access risk $\left(\frac{\partial^2 \ln c^U}{\partial\gamma\partial a} < 0\right)$.

As a benchmark, if foreign tariffs were the only source of uncertainty then the exporter would have a PTA motive to reduce them to their minimum and lower risk in a by shifting away from the riskier policy distribution. With multiple sources of shocks the motives for PTAs are similar but the chosen policy distribution that minimizes demand risk may be different since it must now account both for its direct effect in the absence of income risk and the interaction of the risks in a way that will be clearer in the decomposition below.

The proposition establishes the entry impacts of a PTA. The effects upon implementation at a given γ are obtained using the entry cutoff in (6), which is decreasing in ς_t and export risk. The differential effects of unanticipated uncertainty shocks for PTAs are obtained by evaluating the impact of γ on entry, from proposition 1, at the lower tariff or risk implied by such a PTA.[21] Proposition 2 highlights two opposing effects. Under lower export risk the insurance effect implies a positive entry differential because γ and risk

[19] It could reflect income risk aversion—the underlying motive for endogenous uncertainty reducing agreements in Maggi and Limão (2015).

[20] We can also consider a more flexible agreement contingent on changes in future γ and a if contracting costs were sufficiently low; we conjecture this would generate an additional insurance channel relative to the one we identify under a non-contingent agreement. We do not require constraints on G_γ unless we perform comparative statics exercises with respect to the initial conditions. In reasonable models we expect $G_\gamma < 0$ at high a_t, to prolong good times and reduce uncertainty but positive at sufficiently low a_t, to exit bad times more rapidly.

[21] This takes $\left\{\Delta_m^{PTA}, \Delta_\varsigma^{PTA}\right\}$ as given since we assume the agreement depends only on the initial γ.

are complements. But when the PTA also lowers current protection it increases market access risk and this effect magnifies the reduction in entry from an uncertainty shock.

Which of these effects is likely to dominate? To determine this theoretically we would require a more specific government objective and negotiation model to incorporate the costs of changing each policy to derive the equilibrium levels of $\{\Delta_m^{PTA},\ \Delta_\varsigma^{PTA}\}$. However, in periods when applied protection is already low for most countries, Δ_ς^{PTA} is necessarily small; if at the same time there is a high probability of the riskier shock then there is a larger scope for Δ_m^{PTA} hence the insurance effect would dominate. In markets where protection is high and PTAs can't credibly change beliefs about future shocks, the negative market access risk dominates. We will estimate a net effect of uncertainty shocks on entry for PTA exports. If we find a negative impact of increased uncertainty for non-PTAs and it is mitigated for PTAs, then we can conclude that there is a PTA insurance effect and it dominates market access risk.

3.3.1 Decomposition, Interaction and Heterogeneity of Risks

In the estimation section we go beyond the net entry effect of uncertainty shocks. First, we aim to identify whether PTA policy and income risks are independent. Second, we want to determine if their interaction increases the relative importance of the insurance effect. We model the additional impacts that arise when income risk is added to an initial situation with only policy risk. The resulting decomposition is employed to estimate the impact of joint shocks, which are rare and hard to measure, by using the interaction of individual risks.

To decompose the risks we first define a measure of income uncertainty. Recall that the joint density is $h_s(y, \varsigma)$ and the PTA holds constant the marginal density of income across s. We denote that common income density by $h(y, \Sigma_y)$, where Σ_y indexes its riskiness such that $h(y, \Sigma_y)$ SSD $h(y, \Sigma_y^{'})$ if $\Sigma_y^{'} > \Sigma_y$.[22] Treating Σ_y as a parameter we can then write

$$\bar{\omega}_t \approx \underbrace{\bar{\omega}(a_t, \Sigma_y = 0)}_{\textbf{Policy Risk}} + \underbrace{\left.\frac{\partial \bar{\omega}(a_t, \Sigma_y)}{\partial \Sigma_y}\right|_{\Sigma_y = 0} \cdot \Sigma_y}_{\textbf{Joint Risk}} \tag{13}$$

where we continue to treat the mixture weights for non-PTA as exogenous. The first term reflects only average policy risk across the states, $\bar{\omega}(a_t, \Sigma_y = 0) = \sum_{s \in S} m_s \omega_s^\varsigma(\varsigma_t | y_t)$, where $\omega_s^\varsigma(\varsigma_t | y_t)$ is defined by (8) but using ς_t and its conditional distribution directly. The Joint Risk term captures the average change in the loss term when income risk is added to the policy risk.[23]

Heterogeneous risk across countries

[22] In certain cases it is simple to map Σ_y to a single parameter, e.g. if $y \sim \ln N(\mu_y - \alpha\Sigma_y^2/2, \Sigma_y^2)$ and $\alpha = 1$ then increases in Σ_y imply a MPS of y and if $\alpha \geq 1$ then the new distribution is SSD by the original one.

[23] In the special case without policy risk the joint risk term will simply capture income risk. We are able to nest this in the estimation and evaluate its relevance empirically. In this case $\bar{\omega}_t|_{\Sigma_\varsigma = 0} = \omega^y(y_t)$ where $\omega^y(y_t)$ is defined by (8) but using y and its distribution directly, which is assumed constant across states since the PTA does not affect it. Thus, using $\omega^y(y_t) - 1$ instead of Σ_y in the estimation captures the income risk fully if there is no policy risk.

Using (13), we can write the loss differential in (11) as an approximation of policy and interaction risk:

$$\bar{\omega}_t^{PTA} - \bar{\omega}_t \approx \underbrace{\left[\bar{\omega}_t^{PTA} - \bar{\omega}_t\right]|_{\Sigma_y=0}}_{\textbf{Policy Risk difference}} + \underbrace{\left.\frac{\partial\left[\bar{\omega}_t^{PTA} - \bar{\omega}_t\right]}{\partial\Sigma_y}\right|_{\Sigma_y=0} \cdot \Sigma_y}_{\textbf{Joint Risk difference}} \tag{14}$$

The policy risk difference is simply (11) evaluated in the limit where $\Sigma_y = 0$. Proposition 2 is still valid in this limit case and implies that there is a negative market access risk and positive insurance one, which respectively exacerbate and mitigate the impact of uncertainty shocks. Since we estimate the net effect of policy risk on entry we will only be able to determine if either a market access risk is present for sure (if $\left[\bar{\omega}_t^{PTA} - \bar{\omega}_t\right]|_{\Sigma_y=0}$ is negative), or an insurance effect (if positive).[24]

The second term in (14) captures the marginal impact of income risk on the insurance and market access risk differentials. This difference in the joint risks informs us about their interdependence since $\bar{\omega}_t^{PTA} - \bar{\omega}_t$ differs only due to the policy components, $\left\{\Delta_m^{PTA}, \Delta_\varsigma^{PTA}\right\}$. Thus we say that **PTA policy and income risk are independent if** $\frac{\partial\bar{\omega}_t^{PTA}}{\partial\Sigma_y} = \frac{\partial\bar{\omega}_t}{\partial\Sigma_y}$. We can reject independence if we estimate a non-zero joint risk difference. Moreover, if the interaction term is positive then we can conclude that the insurance effect is relatively more important (compared to market access risk) in the presence of income risk.

Heterogeneous risk across industries

Variation in policy risk is also present across industries conditional on the country. We model this variation here in order to examine its implications empirically. We now denote s as a cooperation state and s' as the non-cooperation or trade war state. Non-cooperation is characterized by higher policy risk at any given income. We index riskiness of policy distributions conditional on income using $\Sigma_{\varsigma|y}^s$ such that $\Sigma_{\varsigma|y}^{s'} > \Sigma_{\varsigma|y}^s$ if $h(\varsigma|y, \Sigma_{\varsigma|y}^s)$ SSD $h(\varsigma|y, \Sigma_{\varsigma|y}^{s'})$. Suppose there are two industries, $V = \{HI,\ L\}$, with respective probabilities of switching to s' equal to $m^{HI} > m^L$. At any common $\varsigma_{Vt} = \varsigma_t$ the HI industry has a riskier policy since the aggregate income distribution is common to both. We can decompose the overall risk differential across industries faced in any given destination

$$\bar{\omega}_t^L - \bar{\omega}_t^{HI} = \left[\omega_{s'}\left(a_t\left(\varsigma_{L,t}\right)\right) - \omega_s\left(a_t\left(\varsigma_{L,t}\right)\right)\right]\Delta_m^L + \sum_{s\in S} m_s^L\left[\omega_s\left(a_t\left(\varsigma_{L,t}\right)\right) - \omega_s\left(a_t\left(\varsigma_{HI,t}\right)\right)\right] \tag{15}$$

The first term is positive and reflects a lower probability of non-cooperation in industry L , $\Delta_m^L \equiv m^L - m^{HI} < 0$, and the increased demand risk in the non-cooperation state, $\omega_{s'} < \omega_s$. The second term depends on the probability of switching regimes and the expected losses relative to the cooperative policy level and thus market access.

To identify high risk industries we rely on the theory and evidence of the determinants of protection in non-cooperative settings. A well established motive for trade agreements such as the WTO is the need to internalize terms-of-trade effects (Bagwell and Staiger, 1999). If some of the cost of a tariff is passed through to foreign exporters then the country imposing it has import market power. Therefore, the incentive to increase protection in response to aggregate shocks will be more attractive, all else equal, in industries where the importer has higher market power. Broda et al. (2008) find evidence that prior to WTO accession tariffs

[24] Moreover, the insurance effect can only be achieved by a reduction in policy risk. If $\Sigma_y = 0$ then the distribution of a depends only on the conditional policy distribution, $H_\varsigma^s(\varsigma_t, |y_T)$. Therefore $\Delta_m^{PTA}(\Sigma_y = 0)$ decreases the probability of riskier policy.

for any country are increasing in import market power. Evidence from WTO accession shows that it reduces precisely those incentives for tariffs (Bagwell and Staiger, 2011) and countries are more likely to bind (place a maximum) on such industries in the agreement (Beshkar et al., 2015). This indicates that a reduction in risk is more likely for high market power industries than those for low market power relative to the non-cooperation state and so $\Delta_m^L < 0$. We say there is **full internalization of market power** incentives during cooperation if both industries draw the same policy during periods of cooperation, $\varsigma_{HI,t\in s} = \varsigma_{L,t\in s}$. However, WTO accession does not necessarily eliminate all the incentives to exploit market power either because it does not cover all policies (cf. Broda et al.,2008 evidence for the U.S.) or even where it does there is imperfect removal of market power incentives due to free riding during negotiations (Ludema and Mayda, 2013). This suggests there is only **partial internalization of market power** incentives, which we define as $\varsigma_{HI,t\in s} \geq \varsigma_{L,t\in s}$.[25]

Consider first the case where the agreement internalizes all market power incentives so the only source for the differential in (15) is the first term. The differential for L is positive, i.e. there is an insurance effect for low market power (MP), if and only if $m^L < m^{HI}$. If there is only partial internalization then the second term in (15) is negative because potential losses for L are higher (at a given m) if it has lower protection than HI. Then the overall differential is again positive only if $m^L < m^{HI}$. Therefore, applying proposition 2(a) in this context the model predicts that uncertainty shocks have a differential positive effect on industries with safer policy only if non-cooperation is possible (recall the maintained assumption is that under the cooperation state both industries have similar distributions). A stricter test is whether there is any differential effect across industries for PTA partners. If we find none then it would suggest that the PTA eliminated the risk of non-cooperation from market power incentives (since only the first term in (15) is present under a null hypothesis of full internalization in a PTA).[26]

Heterogeneous risk across countries and industries

Combining the two sources of heterogeneity in risk, country and industry, we can further evaluate the decomposition of risks and the underlying mechanisms. Doing so will provide evidence on the probability of non-cooperation and thus the insurance role of PTAs relative to WTO membership. The following simple example below illustrates this prediction.

Suppose that in the current cooperation state, s, exporters face the same protection in a WTO or PTA destination, $\varsigma_{L,s}^{PTA} = \varsigma_{L,s}$, and the same probability of non-cooperation, $m_L = m_L^{PTA}$ (possibly because there is no market power incentive for industry L). We also assume at least partial internalization under the WTO and the same or more internalization under the PTA. To fix ideas, take the limit case where there is full internalization for PTA, so $\varsigma_{HI,s} \geq \varsigma_{HI,s}^{PTA} = \varsigma_{L,s}^{PTA}$. This is consistent with duty free treatment across most industries present in many PTAs. Then for a common income level across two destinations we have:

$$\left[\bar{\omega}_t^L - \bar{\omega}_t^{HI}\right] - \left[\bar{\omega}_t^{PTA,L} - \bar{\omega}_t^{PTA,HI}\right] = \left[\omega_{s'}\left(a_t\left(\varsigma_{L,t}\right)\right) - \omega_s\left(a_t\left(\varsigma_{L,t}\right)\right)\right]\left(\Delta_m^L - \Delta_m^{PTA,L}\right) + \sum_{s\in S} m_s^L\left[\omega_s\left(a_t\left(\varsigma_{L,t}\right)\right) - \omega_s\left(a_t\left(\varsigma_{HI,t}\right)\right)\right]. \quad (16)$$

The overall differential is positive only if there is higher probability of non-cooperation in the WTO than in

[25] All statements hold any domestic political economy determinants constant across industries.

[26] The differential in (15) has a policy and joint risk component and the expression is similar to the one for PTAs in (14) but applies to L vs. HI, so we omit it. If there were full internalization then the policy component would be positive, so if we find it to be negative this indicates partial internalization: $\varsigma_{HI,s} \geq \varsigma_{L,s}$.

the PTA. Because $\varsigma_{HI,s} \geq \varsigma_{L,s}$ the term on the second line of the RHS is negative. We require the first term to be positive. It is the product of two negative differences: (1) the difference between non-cooperation and cooperation, which is common for WTO and PTA since it is evaluated at $\varsigma_{L,s}^{PTA} = \varsigma_{L,s}$ and (2) the difference in probabilities: $\Delta_m^L < \Delta_m^{PTA,L} \Leftrightarrow m_H > m_H^{PTA}$ when $m_L = m_L^{PTA}$. This double difference will later be useful in (i) controlling for any other possible effects of HI vs. L in the crisis unrelated to market power and (ii) ruling out the possibility that income is the only source of demand risk and that differences in PTA and non-PTA in the crisis are driven by heterogeneous shocks to γ.

3.4 Adjustment Dynamics

Sunk costs generate adjustment dynamics and these are asymmetric depending on whether conditions improve or deteriorate. We model the dynamics to relate net entry growth to the changes in the current cutoff condition and the stock of exporters. The number of firms (or varieties) exported to a particular market in a given industry (both subscripts omitted) at any t is

$$N_t = nF_t + \lambda_t^h \tag{17}$$

There is a fraction $F_t \equiv F(c_t^U)$ of the n firms in the home country with costs below the current cutoff. The final term, $\lambda_t^h \geq 0$, captures the surviving stock of legacy exporters with $c_v > c_t^U$. When $\lambda_t^h > 0$ there is a set of firms that entered under at $t = 0$ or earlier when conditions were better. To fully model $\lambda_t^h > 0$ as a function of observables we would need to consider all possible histories of shocks. To maintain tractability we model the most plausible histories for the empirical exercise. We define three mutually exclusive histories by the indicator function $\mathbf{1}_t^h = 1$ with the superscript $h = \{0, +, -\}$ denoting an expansion, recovery or decline of business conditions. The legacy firm adjustment is:

$$\lambda_t^h = \begin{cases} 0 & \mathbf{1}_t^0 = 1 : c_t^U \geq \max\{c_s^U\}_{s=0}^t \\ \beta^t n \left[F_0 - F_t\right] & \mathbf{1}_t^+ = 1 : c_t^U \geq c_{t_0}^U > c_t^U \geq \max\{c_s^U\}_{s=1}^t \\ \beta \sum_{T=1}^t \beta^{t-T} n \left[F_{T-1} - F_T\right] & \mathbf{1}_t^- = 1 : c_t^U \leq c_{t-1}^U \leq ... < c_0^U. \end{cases} \tag{18}$$

The first line captures periods where conditions are stable or expanding so there is no legacy. The second captures periods of recovery that remain below the pre-crisis peak at $t = 0$. It accounts for the fraction of exporters the interval $[c_t^U, c_0^U]$ that survived for the last t periods, β^t. The last line captures the periods of decline until a recovery starts with the duration since $t = 0$ denoted by T. The legacy firms in a decline are the fraction of accumulated exporters that survive in adjacent intervals $[c_t^U, c_{t-1}^U]$ above the current cutoff.

Using (17), (18), and defining the cumulative growth, for any Z, relative to the previous expansion period as $\hat{Z}_t \equiv \frac{Z_t}{Z_{t_0}} - 1$, we have the following relationship between the growth in the number of exporters, $\hat{N}_t$, and the growth in the probability of a low enough cost to enter exporting, $\hat{F}_t$, for each history.

$$\hat{N}_t = \begin{cases} \hat{F}_t & \mathbf{1}_t^0 = 1 \\ \left(1 - \beta^t\right) \hat{F}_t & \mathbf{1}_t^+ = 1 \\ \left(1 - \beta^t\right) \hat{F}_t + (1 - \beta) \sum_{T=1}^{T=t-1} \beta^{t-T} \left(\hat{F}_T - \hat{F}_t\right) & \mathbf{1}_t^- = 1 \end{cases} \tag{19}$$

Figure 8 illustrates possible uncertainty paths and the resulting adjustment dynamics relative to an initial period with $\gamma_0 = 0$ for a high and low risk market. The unanticipated increase to $\gamma_t^{High} > 0$ in the first period generates the negative growth in N_t depicted in Figure 8(b) and it evolves as described by $\mathbf{1}_t^+$ in (19). If the new γ^{High} was permanent then this decline would continue as shown by the dashed line and eventually asymptote until all firms with costs above $c(\gamma_t^{High})$ exit this market. Alternatively, the uncertainty shock could be partially reversed, as shown the reduction to γ_t^{Low} in period 2. The partial reversal induces some new entry that is reflected in the upwards jump in panel 9(b). However, for any $\gamma_t^{Low} > 0$ the model predicts a gradual reduction in N until the only exporters are those with costs below $c(\gamma_t^{Low})$. A similar qualitative path applies to export growth.

In sum, the model predicts a gradual decline in N and exports if uncertainty increases in the initial period of the crisis. This decline is larger for higher risk (black line) than lower risk markets. Moreover, the negative and differential effects persist if uncertainty remains unchanged or is not fully reversed.

4 Estimation

We provide an estimation equation based on the model and a strategy to identify the impact of economic and policy uncertainty on trade outcomes during the GTC and recovery. Next, we present our baseline estimates for various margins of firm export participation; report robustness exercises and quantify the main channels highlighted by the model.

4.1 Approach

We first model the number of firms (or varieties) exporting to destination i in an industry V, N_{iVt}. If there are N_V domestic producers in V then a fraction $F(c^U_{iVt})$ has marginal cost below the cutoff and exports to i at t. In section 3.4 we show that sunk costs generate the possibility of legacy firms so the total number of exporters in periods of crisis or recovery is $N_{iVt} \geq N_V F(c^U_{iVt})$. Moreover, we related the growth in exporters to that of cutoffs in equation (19), which we can express for any of the relevant periods as:

$$\hat{N}_t = \left(1 - \left(\mathbf{1}_t^+ + \mathbf{1}_t^-\right)\beta^t\right)\hat{F}_t + \mathbf{1}_t^-\,(1-\beta)\textstyle\sum_{T=1}^{t-1}\beta^{t-T}\left(\hat{F}_T - \hat{F}_t\right) \tag{20}$$

In stationary periods or ones with an expansion the indicator variables are $\mathbf{1}_t^+ = \mathbf{1}_t^- = 0$ and the expression reduces to the growth in the probability of entry, $\hat{F}_t$. Rewriting using log growth approximations, so $\hat{N}_t \approx \ln\frac{N_t}{N_0}$, and assuming, $F(c) = (c/c_V)^k$, where $k > \sigma - 1$, so $\hat{F}_t \approx k \ln\frac{c_t}{c_0}$, we obtain

$$\begin{aligned} \ln\frac{N_{iVt}}{N_{iV0}} &= b_t^h k\left(\ln\frac{U_{iVt}}{U_{iV0}} + \ln\frac{c^D_{iVt}}{c^D_{iV0}}\right) + \tilde{e}_{iVt} \\ &= b_t^h \frac{k}{\sigma-1}\left(\frac{\beta}{1-\beta}\gamma_t\cdot[\bar{\omega}_{iV0} - 1] + \ln\frac{a_{iVt}}{a_{iV0}}\right) + \tilde{u}_{iVt} \end{aligned} \tag{21}$$

In the first line $\tilde{e}_{iVt}$ represents a log growth approximation error plus any lagged cutoff differences during a multi-period crisis.[27] The last line uses the expression for the cutoff in (6) approximated around $\gamma_t = 0$ and a pre-crisis level of the potential loss, $\bar{\omega}_{iV0}$, defined by (7).[28] We can anticipate part of the identification

[27] It includes $\mathbf{1}_t^-\,(1-\beta)\sum_{T=1}^{t-1}\beta^{t-T}k\ln(c^U_{iVT}/c^U_{iVt})$, which is zero in the first crisis period ($t = T$) and if the main shocks to the cutoffs during periods of decline occur at the start of the crisis such that $c^U_{iVT} \approx c^U_{iVt}$ until a recovery starts. For these reasons we treat it as part of the error term in the baseline estimation.

[28] So $\tilde{u}_{iVt} = \tilde{e}_{iVt} + b_t^h\frac{k}{\sigma-1}(e_{iVt} - e_{iV0})$ where the last term is the error from the first order approximation of $\ln\frac{U_{iVt}}{U_{iV0}}$.

strategy here by noting that we explore a common demand volatility shock, γ_t, with heterogeneous impacts across countries or industries arising from different loss terms, $\bar{\omega}_{iV0}$.

The magnitude of the coefficients on the uncertainty and business conditions depends on the history coefficient $b_t^h \in (0,1]$, which is unity in expansion periods and is attenuated by a factor $\left(1-\beta^t\right)$ otherwise. If we estimate a single time difference or focus on an episode where all periods could plausibly represent expansions (cf. Handley and Limão, 2017a) then we can treat b_t^h as constant. That is not the case here so we need to model and structurally interpret the impacts of uncertainty across multiple periods including ones of potential expansion (pre-crisis), decline (initial crisis), and recovery.

We focus on entry and exit of firms or varieties, since both have similar predictions as long as sunk export costs are at the variety-destination level. We also examine the implications for industry exports, which are qualitatively similar to those for the extensive margin.

4.2 Measurement

Uncertainty Shocks and Risk Heterogeneity

We capture the shocks to γ_t by allowing for regime switches, i.e. for the coefficients of the impact of $\bar{\omega}_{iV0}$ to change between the pre-crisis years, the onset of the crisis, and recovery periods.

We define a binary indicator $W_{i,V0} = \{0,1\}$ for a PTA country or high market power industry. We then approximate $\bar{\omega}_{iV0}$ in (21), around the baseline group $W_{i,V0} = 0$, e.g. non-PTA country, and add the differential for $W_{i,V0} = 1$; these are respectively the first and second terms in (22) defined here

$$\begin{aligned}\bar{\omega}_{iV0} - 1 &= \left\{ \bar{\omega}_0|_{\Sigma_y=0} + \left[\frac{\partial \bar{\omega}_0}{\partial \Sigma_y}\right]_{\Sigma_y=0} \cdot \Sigma_{yi} \right\} + W_{i,V0} \left\{ \left[\bar{\omega}_0^W - \bar{\omega}_0\right]_{\Sigma_y=0} + \left[\frac{\partial\left[\bar{\omega}_0^W - \bar{\omega}_0\right]}{\partial \Sigma_y}\right]_{\Sigma_y=0} \cdot \Sigma_{yi} \right\} + \tilde{w}_{iV0} \\ &= \left\{ risk_\tau + risk_J \cdot (\omega_{i0}^y - 1) \right\} + W_{i,V0} \left\{ \Delta risk_\tau + \Delta risk_J \cdot (\omega_{i0}^y - 1) \right\} + w_{iV0} \qquad (22)\end{aligned}$$

The first line uses the approximation around no income risk and a common income level using equations (13) and (14). The second line replaces Σ_{yi} with its associated tail risk measure using the following approximation: $\omega_{i0}^y - 1 \approx \frac{\partial \omega_0^y}{\partial \Sigma_y}|_{\Sigma_y=0} \cdot \Sigma_{y,i}$.[29] We then simplify by replacing approximated structural variables with the labeled average effects we ultimately estimate, $risk_z$, where subscript z is τ for policy risk and J for joint risk. In section 3.3 we derived several related implications that we now describe.

- $risk_\tau \equiv \bar{\omega}_0|_{\Sigma_y=0}$ is the policy risk for non-PTA countries in the absence of income risk and the model predicts a negative effect, $risk_\tau < 0$.
- $\Delta risk_\tau = \left[\bar{\omega}_0^W - \bar{\omega}_0\right]_{\Sigma_y=0}$ is the average policy risk differential when $W = 1$. A negative $\Delta risk_\tau$ differential provides evidence for market access risk.
- $risk_J \equiv \left.\frac{\partial \bar{\omega}_0}{\partial \Sigma_y} \middle/ \frac{\partial \omega_0^y}{\partial \Sigma_y}\right|_{\Sigma_y=0}$ is the average joint overall risk for non-PTAs with income uncertainty. With multiple sources of risk this effect need not be positive, but if we estimate that $risk_J > 0$ then income

[29] The approximation expression and interpretation is the same whether or not $W_{i,V0} = 1$ since we assume the marginal distribution of income is independent of policy.

uncertainty augments joint risk and otherwise it decreases it.[30]

- $\Delta risk_J \equiv \frac{\partial[\bar{\omega}_0^W - \bar{\omega}_0]}{\partial \Sigma_y} \Big/ \frac{\partial \omega_0^y}{\partial \Sigma_y}\Big|_{\Sigma_y=0}$ is the differential for PTAs when $W = 1$. Evidence that $\Delta risk_J \neq 0$ implies a rejection of policy and income risk independence. If $\Delta risk_J < 0$ then the insurance effect is relatively more important (compared to market access risk) in the presence of income risk.

If the insurance effect dominates market access risk, then the overall differential $\Delta risk_\tau + \Delta risk_J \cdot (\omega_{i0}^y - 1)$ in (22) is positive. The approximation error is captured by w_{iV0}. In the baseline estimation these are averages over all industries. In section 4.6 we test for differences in (22) across industry market power.

Income Risk Measurement

To model income risk we focus on aggregate GDP, measured in dollars. The model implied measure for the conditional loss from the economic shock at any given policy level is the probability of a reduction in GDP times the associated expected proportional change, $\omega_{i0}^y - 1 = -H_y(Y_i')(1 - \mathbb{E}_Y[Y_i' < Y_{i,0}]/Y_{i,0})$, which varies only across countries. Using an empirical model for GDP, we can calculate both of the components for $\omega_{i0}^y - 1$ for any given country and period before the crisis. Since the 2008 crisis may have increased the likelihood of extreme shocks we compute the conditional loss for a particularly bad shock—the 5th percentile or worse of the estimated change in GDP for each i—and compute the resulting loss as $risk_{Y_i} = 1 - \mathbb{E}_Y[Y_i' < \hat{Y}_i^{0.05}]/Y_{i,T}$ where T =2001Q4 (see appendix B.1 for details). This is a measure of $\omega_{i0}^y - 1 = -H_Y \cdot risk_{Y_i}$. We assume H_Y remains similar across countries and is absorbed in the coefficient to be estimated.[31] Our measure, $risk_{Y_i}$, has a rank correlation of 0.8 with the standard deviation of changes in ln GDP over time for each country — a standard measure of income risk that is theoretically related. As such, we obtain very similar results using the standard deviation of GDP to measure income risk in robustness checks.

Other Economic and Policy Shocks

Following the theory we assume constant k, β and σ (both across U.S. industries and over the periods we consider) such that $\ln \frac{c_{iVt}^D}{c_{iV0}^D} = \frac{1}{\sigma-1} \ln\left(\frac{a_{iVt}}{a_{iV0}}\right)$. Moreover, the theory focuses on shocks to income and policy. The changes in $a_{iVt} = \varepsilon_{iV} \frac{y_{it}}{\varsigma_{iVt}}$ are driven by those components and using their definitions we have $\frac{a_{iVt}}{a_{iV0}} = \frac{Y_{it}}{Y_{i0}}\left(\frac{\tau_{iVt}}{\tau_{iV0}}\right)^\sigma$.[32] We control directly for GDP growth. There were relatively small changes in tariffs faced by U.S. exporters in non-PTA markets in 2002-2008 and previous research has shown they changed little over the financial crisis period (see Bown and Crowley, 2013b). In the baseline we model changes in applied protection as a common shock $\tau_{iV,t} = \tau_{iV}\tau_t$ and control for changes in non-tariff barriers as robustness checks. In sum, our baseline empirical model for business conditions is

$$\ln \frac{a_{iVt}}{a_{iV0}} = \ln \frac{Y_{it}}{Y_{i0}} + \bar{a}_t + \Delta\bar{a}_t \cdot W_{i,V0}. \tag{23}$$

This includes the income change and $\bar{a}_t$: any common shocks to policy (or other factors determining a) across all iV in the baseline group. Given the negligible changes in applied policies our baseline interpretation for the

[30] This follows because $\operatorname{sgn}(risk_J) = -\operatorname{sgn}\left(\frac{\partial \bar{\omega}_0}{\partial \Sigma_y}|_{\Sigma_y=0}\right)$ since $\frac{\partial \omega_0^y}{\partial \Sigma_y}|_{\Sigma_y=0} < 0$. With no policy risk $\bar{\omega}_0 = \omega_0^y$ so $risk_J = 1$.

[31] If the distribution at the time of the crisis was unchanged then H_Y would be 0.05, but if large shocks became more likely then it would be higher. This approach addresses the concern that the loss measure depends on when we measure it. Two countries may have an identical value at some point before the crisis, but one may have a larger loss if a fatter left tail delivers a very large shock.

[32] This assumes the industry CES price index P_{iV} is constant over time. Below we discuss how to relax this in the estimation.

impacts of PTAs or high market power industries will be related to uncertainty effects. However, we recognize that those countries or industries may have had unobserved differential changes, which are captured by $\Delta\overline{a}_t$ and are also controlled for via the interaction of the indicator $W_{i,V0}$. We will also describe a more general specification that allows for country and industry effects in changes to control for additional unobserved heterogeneity.[33]

4.3 Empirical Specifications and Identification

4.3.1 Difference-in-differences

We first derive a difference-*in*-differences specification to provide an interpretation of the coefficients as differential impacts of the uncertainty shock on countries/industries with heterogeneous tail risk. We extend this to a difference-*of*-differences strategy to handle identification threats such as pre-existing trends.

Substituting the uncertainty terms in (22) and the business conditions in (23) into (21) we obtain

$$\ln\frac{N_{iVt}}{N_{iV0}} = \Gamma_t^{\tau} + \Gamma_t^{J}\cdot risk_{Y_i} + \left[\Gamma_t^{\Delta\tau} + \Gamma_t^{\Delta J}\cdot risk_{Y_i}\right]\cdot W_{i,V0} + \Gamma_t^{y}\cdot\ln\frac{Y_{it}}{Y_{i0}} + u_{iVt} \quad \text{each } t \tag{24}$$

The policy effect coefficient in the absence of income risk is $\Gamma_t^{\tau} \equiv b_t^h\frac{k}{\sigma-1}\left(\frac{\beta}{1-\beta}\gamma_t risk_{\tau} + \bar{a}_t\right)$ and it captures the impact of the common uncertainty shock, γ_t, and any change in applied policies, $\overline{a}_t$, on non-PTAs. The respective differential for the "treated" group (PTA) is $\Gamma_t^{\Delta\tau} \equiv b_t^h\frac{k}{\sigma-1}\left(\frac{\beta}{1-\beta}\gamma_t\Delta risk_{\tau} + \Delta\overline{a}_t\right)$. The joint risk coefficient (superscript J) is $\Gamma_t^{J} \equiv -b_t^h\frac{k}{\sigma-1}\frac{\beta}{1-\beta}H_Y\gamma_t risk_J$. It captures the impact of income uncertainty on joint risk for the baseline group. The differential effect is

$$\Gamma_t^{\Delta J} \equiv -b_t^h\frac{k}{\sigma-1}\frac{\beta}{1-\beta}H_Y\gamma_t\Delta risk_J. \tag{25}$$

Finally, the income effect is $\Gamma_t^{y} \equiv b_t^h\frac{k}{\sigma-1} > 0$.[34]

In terms of predictions, $\Gamma_t^J < 0$ indicates an increase in uncertainty and evidence that income uncertainty augments joint risk for non-PTAs. A finding that $\Gamma_t^{\Delta J}$ differs from zero provides evidence for an uncertainty shock and non-independent risks, and $\Gamma_t^{\Delta J} > 0$ indicates the insurance effect is relatively more important (compared to market access risk) in the presence of income risk. The predictions for $\Gamma_t^{\Delta\tau}$ depend on whether unobserved differential policy changes, $\Delta\overline{a}_t$, are negligible or controlled for. If that is the case then $\Gamma_t^{\Delta\tau} < 0$ indicates uncertainty and presence of market access risk for policy dominating the insurance. Moreover, we can then add the differential terms to test the model predictions for PTA (and market power). The differences-of-differences described below controls for possible unobserved $\Delta\overline{a}_t$.

To test how uncertainty shocks evolved over the crisis we compare the ratio of estimates, $\Gamma_{t+s}^{\Delta J}/\Gamma_t^{\Delta J}$, from using $T = t$ as in (24) to those obtained using $T = t + s$, both relative to a common baseline. Across periods

[33] The estimation relaxes the following assumptions used in the theory related to the determination of c^D. First, the estimation allows variation in sunk costs (K_{iV}), industry expenditure shares (ε_{iV}), the number of producers and the industry price indices are iV by controlling for time variation that takes the following form: $x_{iV,t} = x_{iV}x_t$ such that $\Delta\ln x_{iV,t} = \Delta\ln x_t$. So these are also reflected in $\overline{a}_t$. Any additional PTA or industry differentials are captured by $\Delta\overline{a}_t$. We also controls for changes in the number of U.S. producers: allowing both for common shocks across industries at any t, and differential impacts according to the indicator $W_{i,V}$.

[34] The error terms discussed after (21) and in the approximation to tail risk in (22) are in u_{iVt}. Specifically, $u_{iVt} = \tilde{e}_{iVt} + b_t^h\frac{k}{\sigma-1}\left[(e_{iVt} - e_{iV0}) + \frac{\beta}{1-\beta}\gamma_t\cdot w_{iV0}\right]$.

of duration s that are expansions we have $\Gamma^{\Delta J}_{t+s}/\Gamma^{\Delta J}_{t} = \gamma_{t+s}/\gamma_t$ (since $b^h_t = 1$); this ratio changes if and only if γ changes. In periods of decline or recovery, that is not necessarily the case.[35] Nonetheless, we can conclude that $\Gamma^{\Delta J}_{t+s}/\Gamma^{\Delta J}_{t} \in [0,1]$ only occurs when $\gamma_{t+s}/\gamma_t < 1$, i.e. if uncertainty fell between t and $t+s$.

4.3.2 Difference-of-differences

The specification in (24) removes any unobserved time and destination-by-industry determinants of the *number* of exporters. However, it does not address the possibility of pre-existing trends. We denote pre-existing destination-by-industry growth trends by α_{iV} and control for them by using a difference-of-differences approach. This also controls for pre-existing trends in factors excluded from the model, e.g. idiosyncratic growth in the number of firms, expenditure shares, or increasing production and financial integration due to reductions in information and transportation costs.

To implement this and interpret the coefficients we start with (24) and take annual differences for each quarter-year observation at time t and denote these changes by $\Delta_4 x_t \equiv x_t - x_{t-4}$.

$$\Delta_4 \ln N_{iVt} = \Delta_4 \left\{ \Gamma^{\tau}_t + \Gamma^{J}_t \cdot risk_{Y_i} + \left[\Gamma^{\Delta\tau}_t + \Gamma^{\Delta J}_t \cdot risk_{Y_i}\right] \cdot W_{i,V0} + \Gamma^{y}_t \cdot \ln \frac{Y_{it}}{Y_{i0}} + u_{iVt} \right\} \quad + \alpha_t + \alpha_{iV}. \quad (26)$$

The left hand side of (26) is simply the annual growth in the outcome variable since we can use a common baseline number of firms, N_{iV0}, for all t which gets differenced out.[36] The right-hand side contains the differenced terms from (24), which are given in $\{\}$. To these terms we add country-industry fixed effects, α_{iV}, and time fixed effects, α_t, where the latter control for any aggregate U.S. supply or global demand shocks or seasonality.

The differenced coefficients are related to the structural counterparts as follows

$$\Delta_4 \Gamma^x_t \equiv \Gamma^x_{t+4} - \Gamma^x_t, \text{ all } t \quad (27)$$

and can vary across t. To fix ideas, we start with an initial history $h = 0$ that is an expansion period. For any $t \in h = 0$ the history coefficient for dynamics is $b^{h=0}_t = 1$ and thus $\Delta_4 \Gamma^{\Delta J}_t = -\frac{k}{\sigma-1}\frac{\beta}{1-\beta} H_Y \Delta risk_J \times \Delta_4 \gamma_t$, with similar definitions applying for the remaining coefficients.[37] Such periods provide a useful baseline since they capture potential trends in variables such as uncertainty shocks, e.g. if demand uncertainty is falling over the expansion period. The large increase in exporters in the pre-crisis period indicates that on average it can be characterized as an expansion; we employ this interpretation of the coefficients and use that period

[35] The model dynamics predicts $\Gamma^{\Delta J}_{t+s}/\Gamma^{\Delta J}_t = b^h_{t+s}\gamma_{t+s}/b^h_t\gamma_t > 1$ even if $\gamma_{t+s} = \gamma_t$ because $b^h_t = 1 - \beta^{T_t}$, which is increasing in T_t: the number of periods relative to the baseline reflected in N_{iV0}. The intuition is simple: when conditions deteriorate at t some fraction of exporters with cost above the cutoff survive until $t+s$ and only then exit and do not re-enter even if there were no new shocks.

[36] Recall that in section 3.4 we show that after a decline or recovery the growth formula is valid relative to the last stationary period, so we use a common N_{iV0} for all t after the crisis starts. Moreover, we derived that under periods of expansion the formula holds relative to any stationary state, so assuming that the pre-crisis (and possibly the end of the sample) are periods of expansion we can choose the same baseline as used for the crisis.

[37] Specifically, if $t \in h = 0$ then $\Delta_4 \Gamma^J_t \equiv -\frac{k}{\sigma-1}\frac{\beta}{1-\beta} H_Y risk_J \times \Delta_4 \gamma_t$; $\Delta_4 \Gamma^{\tau}_t \equiv \frac{k}{\sigma-1}\left(\frac{\beta}{1-\beta} risk_\tau \times \Delta_4\gamma_t + \Delta_4 \bar{a}_t\right)$ and $\Delta_4 \Gamma^{\Delta\tau}_t \equiv \frac{k}{\sigma-1}\left(\frac{\beta}{1-\beta}\Delta risk_\tau \times \Delta_4 \gamma_t + \Delta_4\left(\Delta \bar{a}_t\right)\right)$. Note that in such periods this approach eliminates any unobserved trends in business conditions if they are country-industry specific so $\Delta_4 \bar{a}_t = \Delta_4\left(\Delta \bar{a}_t\right) = 0$. Then the policy coefficients reflect only the relevant model parameters.

as the baseline. We focus on the average coefficients over all t before 2008Q4, e.g.

$$\bar{\Gamma}_p^{\Delta J} \equiv -\frac{k}{\sigma-1}\frac{\beta}{1-\beta}H_Y \Delta risk_J \times \overline{\Delta_4 \gamma_{t\in p}} \quad , p=0,$$

with similar definitions applying for the remaining coefficients.

We allow for a regime switch when the crisis starts and for subsequent periods thus allowing b_t^h to differ across them. The average of the change in coefficients defined in (27) in each period is $\bar{\Gamma}_p^x$ and their difference relative to the baseline period is $\bar{\Gamma}_{p-0}^x$ are respectively defined as

$$\begin{aligned} \bar{\Gamma}_p^x &\equiv \overline{\Delta_4 \Gamma_{t\in p}^x} \quad , p=\{0,1,2,3\} \\ \bar{\Gamma}_{p-0}^x &\equiv \bar{\Gamma}_p^x - \bar{\Gamma}_0^x \quad , p=\{1,2,3\}. \end{aligned} \tag{28}$$

The baseline pre-crisis period, $p=0$, is longer and includes all t before Q408 whereas the remaining ones each include 4 quarters, e.g. $p=1$ spans Q408-Q309. Averaging over similar quarters improves precision while still allowing variation in the coefficients to capture any decline (at least in $p=1$) and possibly a recovery and return to an expansion history in later periods.

We then stack the differenced equations in (26) and use indicator variables Q_p for the periods. Thus we write the estimation equation as

$$\begin{aligned} \Delta_4 \ln N_{iVt} = &\left\{\bar{\Gamma}_0^\tau + \bar{\Gamma}_0^J \cdot risk_{Y_i} + \left[\bar{\Gamma}_0^{\Delta\tau} + \bar{\Gamma}_0^{\Delta J} \cdot risk_{Y_i}\right] \cdot W_{i,V0}\right\} + \alpha_t + \alpha_{iV} \\ &+ \sum_{p=1}^{p=3} \left\{\bar{\Gamma}_{p-0}^\tau + \bar{\Gamma}_{p-0}^J \cdot risk_{Y_i} + \left[\bar{\Gamma}_{p-0}^{\Delta\tau} + \bar{\Gamma}_{p-0}^{\Delta J} \cdot risk_{Y_i}\right] \cdot W_{i,V0}\right\} \cdot \ Q_p \\ &+ \sum_{p=0}^{p=3} \Delta_4 \left(\Gamma_p^y \cdot \ln \frac{Y_{it}}{Y_{i0}}\right) \cdot \ Q_p + \Delta_4 u_{iVt} \end{aligned} \tag{29}$$

The relation to the model predictions can be further clarified by again considering Figure 8. The long difference approach aimed to estimate the impact of γ on the cumulative $\ln N_t/N_0$, shown by the circular marker points representing each quarter for high risk markets (black) and low risk markets (green). The average of those effects within a period is shown by the red squares (high risk) and red diamonds (low risk). The 4-quarter difference measures how these change over time for non-PTA (after netting out any pre-trend). The variation in risk across markets identifies the difference between those averages in any given period.

4.3.3 Identification and Predictions

The "treatment status" $W_{i,V0}$ is determined prior to the crisis. For example, we define $W_{i,0}=1$ if the country had a PTA in force with the U.S. prior to 2008 and exclude any countries that switched status after that period to avoid confounding effects in that period. Some of the PTAs we use came into force during the pre-crisis period and these switchers provide identification for $\Gamma_0^{\Delta\tau}$ and $\Gamma_0^{\Delta j}$ (estimated by using $W_{i,V0} = PTA_{it}$ for $t \in p=0$ in the first line of (29)).

Uncertainty and export dynamics predictions

We summarize the predictions we test using (29) below.

Pred. 1: Existence of uncertainty shocks. If $\bar{\Gamma}_{p-0}^J \neq 0$ then we reject a null hypothesis of no uncertainty shocks, $\Delta_4 \gamma_t = 0$, since it would imply $\Delta_4 \Gamma_t^J = 0$ for all t.

Pred. 2: PTA policy and income risk independence. If $\bar{\Gamma}_{p-0}^{\Delta J} \neq 0$ then we reject a null hypothesis of risk independence ($\Delta risk_J = 0$ all $t \in p$) since it implies $\Gamma_p^{\Delta J} = 0 = \Gamma_0^{\Delta J}$. Similarly if $\bar{\Gamma}_0^{\Delta J} \neq 0$, then we reject risk independence in the pre-crisis, $\Delta_4 \gamma_{t \in 0} \neq 0$.

Pred. 3: Increased uncertainty during initial crisis period. If $\text{sgn}\, \frac{\bar{\Gamma}_0^{\Delta J}}{\bar{\Gamma}_p^{\Delta J}} = \text{sgn}\, \frac{\left(\overline{\Delta_4 b_t^h \gamma_t}\right)_{t \in 0}}{\left(\overline{\Delta_4 b_t^h \gamma_t}\right)_{t \in 1}} < 0$ and $\bar{\Gamma}_p^{\Delta J} \neq 0$ then volatility shocks switched signs and the most plausible is for volatility to be decreasing pre-crisis and increasing in the crisis. We can test similar predictions for subsequent periods.[38]

Pred. 4: Income uncertainty and joint risk. If we find $\bar{\Gamma}_{p=1-0}^J < 0$ and evidence for increase in uncertainty (using Pred. 3), then this implies that $risk_J > 0$ because $\text{sgn}\, \bar{\Gamma}_{p=1-0}^J =$ $-\,\text{sgn}\left(\overline{\Delta_4 \left(b_t^h \gamma_t\right)}_{t \in 1} - \left(\overline{\Delta_4 b_t^h \gamma_t}\right)_{t \in 0}\right) risk_J$. Thus income uncertainty augments joint risk.

Pred. 5: PTA insurance effects in crisis. PTAs provide an insurance effect and it dominates any market access risk if the overall differential impacts are positive, which requires $\Delta risk_\tau + \Delta risk_J \cdot (\omega_{i0}^y - 1) > 0$.

Pred. 6: Evolution and cumulative effects of uncertainty. The adjustment dynamics imply that an increase in γ in the first crisis period even if γ can have persistent effects. To test this we can compute cumulative effects over periods. This will also inform us about whether any initial effects are subsequently overturned or subside, which we test by using $\bar{\Gamma}_{2-0}^{\Delta J} / \bar{\Gamma}_{1-0}^{\Delta J} = \frac{\overline{\Delta_4 \left(b_t^h \gamma_t\right)}_{t \in 2} - \overline{\Delta_4 \left(b_t^h \gamma_t\right)}_{t \in 0}}{\overline{\Delta_4 \left(b_t^h \gamma_t\right)}_{t \in 1} - \overline{\Delta_4 \left(b_t^h \gamma_t\right)}_{t \in 0}} < 1$. From Figure 8(b) we see that if γ is not reversed then there should be similar effects across the three periods. If it is sufficiently reversed, then we should find the largest 4-quarter effect to be in the first period.[39]

Income predictions

We implement (29) by approximating $\Delta_4 \left(\Gamma_p^y \cdot \ln \frac{Y_{it}}{Y_{i0}}\right)$ with $\Gamma_p^y \ln \Delta_4 \ln Y_{it}$. This exact specification of the income term along with the restriction that $\Gamma_p^y = \Gamma^y$ would arise from this model if we removed sunk costs (or if there were no exit adjustment dynamics). If we find it varies over time this provides evidence for sunk costs and adjustment dynamics.[40]

4.4 Data

Firm-level Trade

Our primary source is the Longitudinal Foreign Trade Transactions Database (LFTTD). This links U.S. import and exports transactions to the firms in the Longitudinal Business Database (LBD), which covers the universe of non-farm private sector employers in the U.S. We construct measures of the number of

[38] Note that the ratio eliminates the term $\Delta risk_J$ that is assumed common (or at least of same sign) across the periods.

[39] Moreover, we can compare this to alternative values to test some of our identifying assumptions. First, if $\overline{\Delta_4 b_t^h \bar{a}_{t \in p}} \approx 0$ then we should obtain $\bar{\Gamma}_2^{\Delta \tau} / \bar{\Gamma}_1^{\Delta \tau} = \bar{\Gamma}_2^{\Delta J} / \bar{\Gamma}_1^{\Delta J}$. Second, if the change between those periods is due to γ, rather than the differential effects $\Delta risk_\tau$ and $\Delta risk_J$ that we assume are fixed, then we should also get similar values for $\bar{\Gamma}_{2-0}^J / \bar{\Gamma}_{1-0}^J$.

[40] By allowing Γ_p^y to vary we aim to mitigate concerns with the alternative specification that imposes Γ^y since in the latter case some of the variation in the uncertainty impacts in each period could simply be picking up the omitted variation in Γ_p^y.

firms exporting to a particular country and at the product level by month. We define industries at the 2 digit chapter level of the Harmonized System (HS). We define products at the HS-10 digit level after concording the product codes for time consistency as described in Appendix B.2. We measure entry, exit, and export growth for each quarter relative to the same quarter in the previous year. Our main empirical specifications focus on the dynamics of the total number of traded firm-product varieties with any exports within a country×HS-2×quarter cell. We define entry, exit and continuer margins, aggregate each group, and then calculate total growth and its decomposition across the margins using equation (1) for each cell.

Country Sample and PTA Definition

By the final period of our analysis timeframe the U.S. had PTAs with 17 countries, but we exclude a number of them because they were implemented after 2006 in the midst of the recession and trade collapse. We focus on seven countries that had a PTA in place by 2006 and that had quarterly GDP data available from 2001 to 2011: Israel (1985), Canada (1989), Mexico (1994), Chile (2004), Australia (2005), Guatemala (2006), and Morocco (2006). The set includes developed and developing countries and represents more than 40% of all U.S. exports. The full list of countries appears in Appendix Table C1.

Income Measures

We use quarterly GDP data from the IMF International Financial Statistics. All nominal GDP data is converted into U.S. dollars, which therefore incorporates exchange rate variation in demand. We use year-on-year quarterly GDP growth rates as control variable in the regression estimation. We also use the data from 2001-2012 to estimate an AR(1) process in the quarterly year-on-year log changes. This data restricts our sample to the 67 countries that cover most of the U.S. export value in the LFTTD.

We measure income uncertainty as described in section 4.2. We prefer this measure of income uncertainty given it has a structural interpretation but also note that it has a rank correlation of 0.80 or above with several alternative measures: standard error of the innovations in the estimated AR(1) model of income, the standard deviation of log changes in GDP, and a measure of $risk_{Y_i}$ at T =2001Q4 from AR(1) estimates in a different sample timeframe from 1990 to 2006.

The average growth in GDP in our sample is somewhat large, about 10 log points, which reflects three factors. First, we are measuring aggregate, nominal GDP rather than GDP per capita. Second, the period leading up to the crisis was one of expansion: most countries in our sample are growing from 2002 to 2008. Third, we measure U.S. dollar denominated GDP and the dollar depreciated on a trade weighted basis by about 30% from 2002 to 2008.

In sum, our regression sample includes 67 countries that account for 88% of all transactions by value that are matched to a firm in the LFTTD in an average quarter. So the sample selection due to missing GDP data, PTA switching in the crisis and the requirement of a positive flow in a HS-2×time×country cell is quantitatively small.[41]

High/Low Market Power Indicators

[41] The regression sample corresponds to 70-75% of U.S. total exports since not all trade transactions can be matched to a firm in the LFTTD or the exporter is not part of the non-farm employer universe, e.g. government entities, self-employed, agriculture, etc.

We construct market power indicators using the inverse foreign export supply elasticity estimates for the U.S. from Broda et al. (2008). Recall that they find that non-cooperative trade barriers are increasing in this measure of market power. The elasticity point estimates are imprecise so we take the median elasticity within an HS-2 industry over the set of HS-4 digit estimates. We then rank HS-2 industries by this median measure and assign the top two terciles to the High Market Power group and the bottom tercile to Low.

4.5 PTA Estimates

We start by estimating the impact of economic risk, PTA status and their interaction on U.S. exporters. All fixed bilateral destination-industry determinants are already differenced out, which controls for most standard time-invariant gravity determinants (e.g. distance, border, language) even if they have heterogeneous effects across industries. The destination-industry and time effects control for growth trends. All standard errors account for arbitrary correlation within clusters defined at the country×quarter-year periods.[42] We briefly note the impact of income on each of the outcomes we consider is positive and significant for all periods. The Γ_p^y coefficient typically changes over time, consistent with the presence of adjustment dynamics that may be due to sunk costs.[43]

4.5.1 Entry and Exit

Net entry of varieties

Column 1 of Table 3(a) provides the estimates for the log growth in varieties based on (29). The first three rows represent the non-PTA risk coefficients, $\bar{\Gamma}_{p-0}^J$, for each of the three one-year periods starting in the first crisis quarter: 2008Q4. All $\bar{\Gamma}_{p-0}^J$ estimates are significantly different from zero so we reject the null of no uncertainty shocks (Pred. 1). Since $\bar{\Gamma}_{p-0}^J$ differ across periods we conclude that they reflect some uncertainty shocks during the crisis period and not simply a common pre-period effect, $\bar{\Gamma}_0^J$. Those three coefficients are negative indicating that, conditional on an increase in uncertainty relative to the baseline (as evidenced below), income uncertainty augments joint risk (Pred. 4).

The fourth coefficient is $\bar{\Gamma}_{1-0}^{\Delta J} = 1.5$ and since this differential risk effect for PTAs is significantly different from zero we reject a null hypothesis of risk independence (Pred. 2) and of no uncertainty shocks. Moreover, $\bar{\Gamma}_0^{\Delta J} = -0.38$, so we can reject risk independence in the pre-crisis as well, that is $\Delta_4 \gamma_{t\in 0} \neq 0$. Combining these effects we obtain $\bar{\Gamma}_1^{\Delta J} = 1.12$ and the reversal of the uncertainty sign captured by sgn $\frac{\bar{\Gamma}_0^{\Delta J}}{\bar{\Gamma}_p^{\Delta J}} < 0$ indicates uncertainty fell prior to the crisis and then increased starting in 2008Q4 (Pred. 3). We also obtain significant policy differential effects, $\bar{\Gamma}_{1-0}^{\Delta\tau}$, which are negative suggesting the presence of market access policy risk in the absence of income risk.

We then obtain the full risk effect of PTAs (Pred. 5) by computing the LHS of following average effect over countries:

$$\mathbb{E}_i\left(\bar{\Gamma}_{p-0}^{\Delta\tau} + \bar{\Gamma}_{p-0}^{\Delta J} \cdot risk_{Y_i}\right) = \frac{k}{\sigma-1}\frac{\beta}{1-\beta}\left\{\Delta_4\overline{\left(b_t^h\gamma_t\right)}_{t\in p} - \Delta_4\overline{\left(b_t^h\gamma_t\right)}_{t\in 0}\right\}\left[\Delta risk_\tau + \Delta risk_J \cdot \mathbb{E}_i\left(\omega_{i0}^y - 1\right)\right] \quad (30)$$

[42]We use country×quarter-year clustering because our uncertainty measures have no variation at higher disaggregation. Results are robust to two-way clustering on the country-industry panel identifier and quarter-year time effects.

[43]Those coefficients are smaller than in basic gravity estimates for aggregate trade in part because we explore time variation over short periods and disaggregated data.

The RHS expression is obtained using the definitions for $\Gamma_t^{\Delta J}$ in (25), and $\Gamma_t^{\Delta\tau}$ in the text, along with their difference and average respectively in (27) and (28), and $\omega_{i0}^{y} - 1 = -H_Y \cdot risk_{Y_i}$.[44] We can also identify the effect gross of the pre-crisis differentials as

$$\mathbb{E}_i\left(\bar{\Gamma}_{p-0}^{\Delta\tau} + \bar{\Gamma}_0^{\Delta\tau} + \left(\bar{\Gamma}_{p-0}^{\Delta J} + \bar{\Gamma}_0^{\Delta J}\right) \cdot risk_{Y_i}\right) = \frac{k}{\sigma - 1}\frac{\beta}{1-\beta}\left\{\overline{\Delta_4\left(b_t^h\gamma_t\right)}_{t\in p}\right\}\left[\Delta risk_\tau + \Delta risk_J \cdot \mathbb{E}_i\left(\omega_{i0}^{y} - 1\right)\right] \quad (31)$$

Given evidence that sgn $\frac{\bar{\Gamma}_0^{\Delta J}}{\bar{\Gamma}_p^{\Delta J}} < 0$, as we noted above, and sgn $\bar{\Gamma}_{p=1-0}^{J} < 0$ the term in $\{\}$ is positive (increasing volatility). Thus the sign of any significant expressions we compute using the LHS would reflect the sign of $\Delta risk_\tau + \Delta risk_J \cdot \mathbb{E}_i\left(\omega_{i0}^{y} - 1\right)$.

Taking these expression directly to our estimates, we find the LHS of (30) for the first crisis period by combining the estimated $\bar{\Gamma}_{1-0}^{\Delta\tau}$ with $\bar{\Gamma}_{1-0}^{\Delta J}$ and $\mathbb{E}_i\left(risk_{Y_i}\right) = 0.21$ for PTAs. In Table 3(b) we show this effect is positive, 5.4 lp (Pred. 5), indicating that PTAs provided an insurance effect that dominated any market access risk (given the evidence for increase in uncertainty in Pred. 3).[45] In period 2 the signs of the PTA coefficients are the same as their counterparts in period 1, but their relative magnitude is about 1/3. The corresponding third period coefficients are close to zero and insignificant. The combined second (or third) period PTA effect that correspond to (30) is zero in magnitude and insignificant. So the cumulative effect for varieties by the end of the sample reflects the first period effect. We find $\bar{\Gamma}_{2-0}^{\Delta J}/\bar{\Gamma}_{1-0}^{\Delta J} < 1$ so uncertainty subsides after the first period (Pred. 6).[46]

Gross entry and exit of varieties

The second column of Table 3(a) replaces the log growth dependent variable with the midpoint growth. The results are nearly identical but we include them since they allow for an additive decomposition of net entry into gross entry (column 3) and exit (column 4). Increases in exit are measured as negative so the coefficients in columns 3 and 4 sum to column 2.

The basic net entry predictions we derived apply to the gross margins in the following sense. When a cost cutoff falls, the firms with cost above that threshold that exogenously exited that market do not return. This is captured by a higher gross exit and a lower gross entry relative to a baseline where the cutoff had remained unchanged.

For both margins, all $\bar{\Gamma}_{p-0}^{J}$ estimates are negative, significantly different from zero and vary across periods, all of which are similar to the net entry results. Moreover, $\bar{\Gamma}_{p-0}^{J}$ for gross entry and exit are similar in magnitude within each $p = 1, 2$. The estimated $\bar{\Gamma}_{1-0}^{\Delta J}$ is positive and $\bar{\Gamma}_{1-0}^{\Delta\tau}$ is negative and significant for both entry and exit, again similar to net entry. Computing the LHS of (30) we continue to find a positive effect for either margin, as shown in Table 3(b).

Gross exit accounts for a larger share of the PTA differential net of the baseline period but both margins have similar importance if we compute the PTA differential during the crisis period. This is due to a positive

[44] This test assumes a negligible *average* unobserved growth differential in business conditions for PTAs. We assume that, conditional on country-specific growth trends, any unobserved growth differential in $\Delta_4\bar{a}_t$ in PTAs in any quarter is negligible when averaged over all quarters in period p such that $\overline{\Delta_4 b_t^h \bar{a}_{t\in p}} \approx 0$. Otherwise there would be an extra term in (30) equal to $\frac{k}{\sigma-1}\left(\overline{\Delta_4\left(b_t^h\bar{a}_t\right)}_{t\in p} - \overline{\Delta_4\left(b_t^h\bar{a}_t\right)}_{t\in 0}\right)$.

[45] The effect remains positive (and is larger) if we either evaluate (30) at the non-PTA mean of $risk_{Y_i}$, 13 lp, or if we include the pre-crisis effects at the PTA mean, as shown in (31), 8.1 lp.

[46] Further, $\bar{\Gamma}_{2-0}^{\Delta J}/\bar{\Gamma}_{1-0}^{\Delta J} = 0.32$ and $\bar{\Gamma}_{2-0}^{J}/\bar{\Gamma}_{1-0}^{J} = 0.45$, the similar magnitudes are predicted by the model when the only relevant change for those coefficients between those periods is due to γ. We also find that $\bar{\Gamma}_{2-0}^{\Delta\tau}/\bar{\Gamma}_{1-0}^{\Delta\tau} = 0.39$ and the similarity to the other ratios is also predicted by the model if $\overline{\Delta_4 b_t^h \bar{a}_{t\in p}} \approx 0$ in these periods.

gross entry margin PTA differential effect in the pre-crisis period.

4.5.2 Exports

The model and predictions focus on the impact of uncertainty on entry and exit and thus the outcomes of non-continuing varieties. If the extensive margin is non-negligible, then the uncertainty effects will also be present in total export growth in any given industry-country. Thus we test the specific predictions of the model outlined in Predictions 1-6 using log export growth for all firms. Subsequently, we determine the relative importance of the extensive margin channel.

The export growth estimates in column 1 of Table 4(a) are consistent with the net entry results from Table 3 and yield similar implications for the central predictions in Predictions 1-6. The discussion refers to the signs of the uncertainty parameters since their exact magnitude according to the model is different for entry vs. exports.

In column 1 of Table 4(a) we find that all non-PTA estimates for the income risk coefficient are negative and differ across periods. These correspond to $\bar{\Gamma}^{J}_{p-0}$ in the entry derivation and thus indicate the presence of uncertainty shocks. The effect is strongest in the first period and significant at 1% for all but the last one. The PTA coefficients have the same signs as those in Table 3 in $p = 1, 2$ (corresponding to $\bar{\Gamma}^{\Delta J}_{p-0}$ and $\bar{\Gamma}^{\Delta\tau}_{p-0}$). For $p = 3$ these coefficients are insignificant, similarly to Table 3.[47] The impact of risk on PTA declines by the second period, $\bar{\Gamma}^{\Delta J}_{2-0}/\bar{\Gamma}^{\Delta j}_{1-0} = 0.41$, a ratio similar to net entry suggesting that both are capturing a similar reversal in uncertainty.

The PTA differential captured by the LHS of (30) at the mean PTA risk level is reported in column 1 of Table 4(b); it is positive and significant in the first crisis period and insignificant for the remaining periods. The cumulative effect at the end of the three years is positive and equal to 5 lp for growth in both average exports and in the number of varieties.

Export margins

The export growth in a given industry reflects the weighted sum of growth rates of continuing and non-continuing firms. So, the impact of uncertainty on exports described so far can also reflect impacts on continuing firms, particularly if their share dominates. To test if uncertainty is working through the extensive margin mechanism highlighted by the model we decompose export growth.

We use the midpoint growth rate measure from equation (1) introduced in section 2 re-indexed to a country-industry-time cell:

$$\hat{X}_{iVt} \equiv \frac{X_{iVt} - X_{iVt-4}}{[X_{iVt} + X_{iVt-4}]/2} = \textstyle\sum_m I_m s^m_{iVt} \hat{X}^m_{iVt} \qquad (32)$$

where X_{iVt} is total exports at the iVt level. As with aggregate exports, we can decompose country-industry aggregate exports into margins $m \in INT, EXT$. The intensive margin (INT) includes varieites with non-zero exports in both periods and the extensive (EXT) includes the contribution of all entry and exit of varieties.

We use the log growth sample for comparability, so all iVt observations have positive total exports at t and $t - 4$. The two growth measures are highly correlated and consequently we obtain similar results in

[47] We continue to find a reversal of the sign of the uncertainty effect of PTAs relative to the pre-crisis period.

Table 4(a) column 2 (midpoint) and in column 1 in terms of sign and significance.[48]

We decompose the growth rate using each $s^m_{iVt}\hat{X}^m_{iVt}$ in (32) as the dependent variable, so the coefficients in columns 3 and 4 add up to those in column 2. The estimates for the extensive margin in column 4 are consistent with the net entry results from Table 3 and yield similar implications for the central predictions in Pred. 1-6. Computing the PTA differential uncertainty effect in the LHS of (30) we find positive significant effects, of 6.6 for exports of non-continuers for $p = 1$. That effect becomes insignificant for the two remaining periods and considerably smaller. The cumulative differential is 4.5 so it remains positive at the end of the three years and mainly reflects the first period effect.

The intensive margin estimates in the third column show small and insignificant uncertainty effects in the first crisis period for both non-PTA and PTAs. This is consistent with the model focus on the extensive margin.[49] The overall PTA differential effect using the expression on the LHS of (30) is insignificantly different from zero for all periods and close to zero. Therefore the corresponding effect for overall export midpoint growth in column 2 in the first crisis period mainly reflects the extensive margin. For the remaining periods that overall differential is much smaller and statistically insignificant. We can further decompose the extensive margin into its additive entry and exit components. The PTA differential is only significant for exit, which is also the largest and has a cumulative impact of 7.7 by the end of the period.

Figure 9 summarizes these points by comparing the marginal effects before the crisis with their average in the three remaining periods. The left panel shows the midpoint PTA differential did not significantly vary with economic risk prior to the crisis (solid line) and nor did any of its margins. The right panel shows the interaction became positive on average in the remaining periods and that this was due to the change in the extensive margin response (dashed line). The slope for the continuing firms' exports (dash-dot) shows no significant change over time. Moreover, the PTA differential at the mean risk is positive in both periods but significantly larger during the crisis. In the quantification section we examine how the midpoint growth results can be aggregated.

4.5.3 Robustness and Alternative Explanations

We perform several robustness checks for the results in Tables 3 and 4. The differential results across export margins already indicate that our estimates do not simply capture country-time varying factors that affect both margins similarly. In what follows, we focus the description on net entry but the qualitative conclusions for the extensive margin of exports are similar.

- **Firms and varieties:** Certain firms export multiple products to any given destination-industry, iV. This raises the question if Table 3 simply reflects product churning by firms. In Table 5 we find this is not the case by aggregating firm exports to that market level and re-estimating entry and exit. The sign, magnitude and significance are very similar to Table 3. Thus while the robustness tests below apply to firm-product varieties, we obtain similar results if we instead use firm-industry dynamics.
- **Alternative measure of economic uncertainty:** The measure we use for the magnitude of the potential income shock is motivated by the model. It is highly positively correlated with other measures

[48] The magnitude of the midpoint coefficients is typically lower because this measure is bounded between 2 and -2 and so its standard deviation is lower by at least 1/3.

[49] After the first period we find negative significant coefficients for non-PTA. This may indicate some additional channel of uncertainty on the intensive margin growth rate, $\hat{X}^m_{iVt}$, or simply that $\hat{X}^m_{iVt} < 0$ for all markets but in riskier ones the extensive share decreased and thus it mechanically increases the intensive one.

of economic uncertainty that have been proposed such as the standard deviation of ln GDP, which we estimate as part of the AR(1) process. The results in Table 3 are robust to using this alternative measure (Table 6).

- **Changes in trade barriers:** We previously discussed there were no substantial changes in tariffs for most markets in this period. We can test the robustness of the results in Table 3 to certain tariff and non-tariff barriers as follows.
  - The baseline estimation allows for common shocks to tariffs by modelling $\frac{a_{iVt}}{a_{iV0}}$ as depending on $\frac{\tau_{iVt}}{\tau_{iV0}} = \frac{\tau_t}{\tau_0}$. We can also allow for those shocks to be industry specific, $\frac{\tau_{iVt}}{\tau_{iV0}} = \frac{\tau_{Vt}}{\tau_{V0}}$. Column 2 of Table 7 shows the results are robust to this by controlling for industry-by-quarter-year effects. Thus the PTA effects are not driven by differential movements in protection (or other factors) in specific industries that the U.S. may be more likely to export to those markets.
  - We can also explicitly control for temporary trade barriers (TTBs) and control for changes over time. These TTBs are available from the World Bank Global Anti-Dumping Database (Bown, 2016) at the destination-HS6-quarter-year level. Our main purpose is to control for time variation in alternative trade barriers. For each iVt we compute a coverage ratio as the fraction of its HS6 products covered by any TTB. We allow for the measure to have different coefficients in each period. The results shown in Table 7, column 4 are very similar to the baseline. Results are similar if we trade weight the coverage ratio.

- **Industry heterogeneity during the crisis:** A potential source of endogeneity is omitted industry characteristics. If U.S. exports to PTAs are focused on particular industries that had relatively more net entry over the full sample period then this is fully accounted for by the country-industry effects, α_{iV}. But if some of those industries behaved differently in the crisis then this can bias the estimates. In addition to the policy changes discussed above, the results are also robust to controlling for the following industry characteristics:
  - **Inventories:** As suggested by Alessandria et al. (2010) inventories played a role in explaining the downturn in the GTC. If certain industries are more likely/able to manage changes in demand by varying inventories (e.g. if goods are more durable or demand more volatile so they have previously invested in inventory management) then they may respond differently to the crisis. For example, firms in inventory-intensive industries may respond rapidly to the downturn by accumulating inventories and then de-accumulating, thus helping to explain a quick recovery. We construct measures of inventories in each industry and allow it to have heterogeneous effects during the crisis. In Table 7, column 3 we find the baseline results are robust to such controls. Details of inventory measures are in Appendix B.2.
  - **Durables and Composition Effects:** Eaton et al. (2016) and Levchenko et al. (2010) provide evidence that trade in durables was more strongly affected during the GTC. We classify industries with high share of trade in durables (top tercile) and re-estimate the baseline. In column 5 of Table 7 we control for differential net entry during the crisis by interacting that durability indicator with the crisis periods. The baseline is robust to this. In columns 6 and 7 we re-estimate separately for each sample. The results for either sample are qualitatively similar to the baseline. The first crisis period differential for the PTA is stronger for durables, 7.7 vs. 4.6. But the durable difference is less pronounced for the extensive margin of exports (7.7 vs. 6.3, tables available on request). So

the results are not driven by differences in durables export composition to PTA markets. Details of the durables classification are in Appendix B.2.

  - **Alternative mechanisms and unobserved heterogeneity:** One threat to identification could be that weakening credit conditions in constrained industries are responsible for some of the collapse or that stronger input-output linkages within PTAs promote more stable trade relationships. We already absorb country-industry effects that control for the time invariant component of these factors. Moreover, while we do not attempt to disentangle this mechanism, deeper trade integration and input-output linkages that result from PTAs may result from the security and predictability of the PTA rules and trade barriers. Subsequent trade growth and more robust trade relationships may reinforce policy commitments and reduce policy uncertainty. Finally, the baseline results are robust to any differential unobserved shocks by industry in the crisis, as we show in Table 7 column 2 where we include industry-by-quarter-year effects, α_{Vt}.

- **Timing:** We restrict the coefficients to be identical for all quarter-years until the start of the financial crisis. We test if the results are robust to this timing assumption by allowing the coefficients to also differ in 2007Q4-2008Q3. In columns 1 and 2 of Online Appendix Table C2 we obtain similar results for the period coefficients common to the baseline.[50]

4.6 Market Power Estimates

We estimate heterogeneous uncertainty effects across industries and find additional evidence that they are consistent with the trade policy mechanism. We first test whether the PTA differential is stronger for the subsample of high import market power industries where we expect a riskier trade policy for non-PTA countries, even though nearly all are WTO members. Second, we take differences of the PTA differential across high and low market power industries to quantify the differentials in (16) and find evidence consistent with a higher probability of non-cooperation in the WTO than in PTAs.

4.6.1 Entry and Exit

In Table 8(a) we estimate net entry as in Table 3 but split the sample into low (left panel) and high market power (right). We continue to control for country-industry effects and now the quarter-year effects in each sample control for any heterogeneous growth rates across these two industry groups.

For both samples the signs of the significant uncertainty coefficients match those in the baseline and Predictions 1-4. Non-PTA destinations had a reduction in entry from uncertainty in both high and low market power industries (Pred. 1 and 4). The PTA coefficients, $\bar{\Gamma}^{\Delta J}_{1-0}$, are positive and significant in the first period of the crisis, suggesting that policy and income uncertainty were not independent in either sample (Pred. 2) and increases initially (Pred. 3). Taken together, these results indicate that the pooled PTA results did not simply reflect an industry specific shock but a broader one, which is consistent with the changes in γ we emphasize.

The estimates in Table 8(b) show larger overall PTA differentials for high market power industries. In the first crisis period the differential is 6.2 lp for high vs. 3.5 for low. This indicates a higher probability of

[50] There is a negative impact of income risk for non-PTA entry in 2007Q4-2008Q3, but no *overall* differential for the PTA coefficients. The entry effect related to these variables was negligible for export values where we find no significant difference in the PTA or non-PTA coefficients in 2007Q4-2008Q3 (cols. 3 and 4).

non-cooperation in WTO members where protection would potentially be higher than PTA members. Both indicate an insurance effect dominates in the first period, as we found in the pooled sample (Pred. 5). In the second period the PTA differential falls substantially for both industry groups (and becomes statistically insignificant), indicating a partial reversal of the initial uncertainty. The high market power differential is never fully reversed so the cumulative effect by the end of the third period is 8.1 lp, whereas for low it is -2 lp. Both entry and exit contribute in the first period to the PTA differential in high and exit is stronger.

4.6.2 Exports

In Table 9(a) we re-examine exports as in Table 4(a) but splitting the industries. Predictions 1, 2 and 4 continue to hold for both high and low market power subsamples. There is evidence of an increase in uncertainty in the first period for high ($\frac{\bar{\Gamma}_0^{\Delta J}}{\bar{\Gamma}_p^{\Delta J}} = -0.69$, Pred. 3), but not for low. The associated overall PTA differentials in Table 9(b) are positive and significant in the first period for high but insignificant for the low sample. For the subsequent periods the differential for high is negligible and for low it is negative and statistically insignificant.

4.6.3 Evidence of Country, Industry, and Firm Heterogeneity

By contrasting the PTA differential *magnitudes* across market power samples and firm types we find additional evidence for the interaction mechanism and for robustness to potential omitted factors. The left panel in Figure 10 shows the export midpoint growth differentials for each market power sample and period from Table 9(b). For the first period it is 8.1 and significant for high and -1 for low; their difference has two implications. First, the overall export PTA differential is driven by high potential tariff industries thus supporting the model mechanism. Second, this difference of 9 percent between high and low removes country-by-time impacts common across industries indicating the robustness of the baseline estimates to that source of unobserved heterogeneity.

These patterns in total exports are driven by variety entry and exit as predicted by the model. This is clearly shown by the decomposition in Figure 10: the total export coefficients (left panel) follow the pattern of those for the extensive margin (right panel). The middle panel shows small PTA differentials for the continuing firms for both high and low MP industries, which is consistent with the small continuing variety effects in the baseline. The difference between high and low market power extensive margin coefficients in the first period is 7.7; it is quantitatively close to the baseline overall estimate of 6.6, which indicates that the latter are robust to differencing out country-by-time impacts even if specific to firm export entry decisions. There are two other important points about this high-low differential in the extensive margin. First, it remains positive (albeit smaller) and so the cumulative effect is also robust. Second, the positive differential is consistent with the model prediction in (16) that, in industries with riskier trade policies, there is a higher probability of non-cooperation for non-PTAs than PTAs.

Thus the baseline aggregate PTA export differential is driven by variety entry and exit—consistent with the option value mechanism—and mostly in high MP industries, consistent with the TPU-income source of uncertainty. The results indicate the U.S. exporters expected a higher probability of a trade war in high MP industries in non-PTAs than PTAs.

5 Quantification and Aggregation

To quantify the role of uncertainty we calculate the counterfactual growth for non-PTA destinations if they had been treated as PTAs relative to a no-crisis scenario. We estimate how much the partial uncertainty reversal contributed to the recovery. Finally, we examine average effects for net entry and exports and then aggregate these effects and provide the permanent income equivalent of this PTA treatment.

5.1 Average Effects

Baseline

To simplify notation we denote the average over all quarters in a given period p by $\overline{\Delta_4 \ln N_{iVp}}$. From (29) we see that under a counterfactual where the average non-PTA country is treated as a PTA but keeps constant all the variables, denoted $\mathbf{z}_i$, (risk, the original income and constant growth trend) then the differential effect is captured by $\bar{\Gamma}_p^{\Delta\tau}$ and $\bar{\Gamma}_p^{\Delta J}$. We rewrite this differential to isolate the counterfactual growth rate of interest on the LHS as follows:

$$\mathbb{E}\left[\overline{\Delta_4 \ln N_{iVp}}|W_i = 1, \mathbf{z}_i\right] = \mathbb{E}\left[\overline{\Delta_4 \ln N_{iVp}} \mid W_i = 0, \mathbf{z}_i\right] + \left[\bar{\Gamma}_p^{\Delta\tau} + \bar{\Gamma}_p^{\Delta J} \cdot \mathbb{E}\left(risk_{Y_i}|W_i = 0\right)\right] \quad \forall p \qquad (33)$$

We assume a no-crisis counterfactual where the average growth equals its pre-crisis average. To obtain the average effects relative to this counterfactual we use (33) for any $p > 0$ and subtract its value when $p = 0$. We denote this difference by a $p - 0$ subscript so $\overline{\Delta_4 \ln N_{iVp-0}} \equiv \overline{\Delta_4 \ln N_{iVp}} - \overline{\Delta_4 \ln N_{iV0}}$ and obtain:

$$\mathbb{E}\left[\left(\overline{\Delta_4 \ln N_{iVp-0}}\right) \mid W_i = 1, \mathbf{z}_i\right] = \mathbb{E}\left[\left(\overline{\Delta_4 \ln N_{iVp-0}}\right) |W_i = 0, \mathbf{z}_i\right] + \left[\bar{\Gamma}_{p-0}^{\Delta\tau} + \bar{\Gamma}_{p-0}^{\Delta J} \cdot \mathbb{E}\left(risk_{Y_i}|W_i = 0\right)\right] \quad (34)$$

for all p. This counterfactual eliminates any permanent PTA differentials unrelated to the crisis and non-PTA growth trends. Moreover, it has a simple interpretation as a log difference of levels. To see this take the first term on the RHS and note that by definition $\ln N_{iVt} = \ln N_{iVt-4} + \Delta_4 \ln N_{iVt}$; and in any $t \in p = 1$ the counterfactual where the growth was at pre-crisis average would be $\ln N'_{iVt} = \ln N_{iVt-4} + \overline{\Delta_4 \ln N_{iV0}}$, so their difference is $\ln N_{iVt}/N'_{iVt} = \Delta_4 \ln N_{iVt} - \overline{\Delta_4 \ln N_{iV0}}$ and we can then take expectations. We compute this relative number for $p = 2, 3$ by simply adding growth rates to cumulate them. The left-hand side has a similar interpretation but reflects the PTA treatment in the crisis (net of the pre-crisis effect).

The solid line in Figure 11(a) represents the first term on the RHS of (34). For $p = 1$ net entry was 15 lp below the no-crisis counterfactual. The dashed line adds the term in the second line of (34) and it offsets 13 lp, or most of the observed decline.[51] The cumulative effect in the remaining periods remains flat as the growth returns to the pre-crisis level. By the final period a non-PTA would have had almost no average net entry decline if it had been treated as a PTA.

We do similar exercises using exports. In Figure 12(a) we plot the average, cumulative growth across margins (solid line, observed). The extensive margin growth has an average reduction of almost 20 points in $p = 1$ for non-PTA countries relative to a no-crisis counterfactual; the effect then tapers off. The PTA treatment on the extensive margin uses coefficients from Table 4, column 4 and offsets 13 points of that decline and an additional 2 points in period $p = 2$. The interaction of policy and income effects explain a

[51] This corresponds to the differential for Table 3(b) in the estimation section evaluated at the non-PTA mean risk.

considerable portion of the average extensive margin growth and help explain the persistent reduction in exports into 2011. The PTA differential is small and insignificant for continuing firms (middle panel). The overall average effect is simply the sum of the respective data and differential effects in the last two figures.

Market Power

To highlight differences across industries and export margins by market power, we compute the PTA treatment exercise for high vs. low market power in Figure 12(b). The mechanics are the same as Figure 12(a) described above, but we use the coefficients from Table 9(a) to break out the counterfactual effects by industry group. In section 4.6 we estimated a larger PTA differential in industries where market power is high. This counterfactual shows the effect across export growth margins and industries for non-PTA countries.

We plot the overall effect (short dash) for reference and focus on the difference between high and low. First, the high market power industry PTA treatment (dot-dash) is above the total overall effect and the low market power differential (long dashed) is below it. This suggests most of the overall total effect of PTAs is driven by high market power industries. Second, the difference between high and low, reflected in the shaded region, is positive and driven by the extensive margin (right panel). This difference of differentials is persistent for overall exports and the extensive margin, but not the intensive margin. So the counterfactual PTA treatment is not arising from unobserved country-time shocks to industries or countries. The heterogeneity we find is robust across these dimensions and consistent with the predictions of the model.

5.2 Aggregate Effects

We compute the aggregate impacts implied by the average export effects; addressing the possibility that riskier destinations may also have lower initial exports. Recall the growth formula in (32) shows that in a given industry-destination-time we have $\hat{X}_{iVt} = s^{EXT}_{iVt}\hat{X}^{EXT}_{iVt} + \left(1 - s^{EXT}_{iVt}\right)\hat{X}^{INT}_{iVt}$ where s^{EXT}_{iVt} represents the midpoint share for the extensive margin in that iVt flow. We can use the same property to aggregate further to any particular group of countries I, e.g. PTA and non-PTA

$$\hat{X}_{I,t} \equiv \frac{X_{I,t} - X_{I,t-4}}{[X_{I,t} + X_{I,t-4}]/2} = \sum_{i \in I,V} s_{iVt}\left[s^{EXT}_{iVt}\hat{X}^{EXT}_{iVt} + \left(1 - s^{EXT}_{iVt}\right)\hat{X}^{INT}_{iVt}\right]$$

where s_{iVt} is now the share of country i in all exports of Vt to group I: $s_{iVt} = \frac{X_{iVt}+X_{iVt-4}}{\sum_{i\in I,V}[X_{iVt}+X_{iVt-4}]}$. We plot this growth rate decomposition by PTA status in Figure 6 of section 2. We define the mean over the quarters in period p by $\overline{\hat{X}_{I,p}}$ and its deviation from the pre-crisis average by $\overline{\hat{X}_{I,p-0}}$. To obtain the aggregate version of the PTA treatment effect described by (34) we use $\overline{\hat{X}_{I,p-0}}$ as the first term and replace the second one with its export weighted average. Since $\sum_{i\in I,V} s_{iVt} = 1$ this amounts to multiplying the interaction coefficient, $\bar{\Gamma}^{\Delta J}_{p-0}$, by $\sum_{i\in I,V}(s_{iVt}risk_{Y_i}|W_i = 0)$ instead of using its simple average. To focus on the effects due to changes in coefficients we use a constant share, $\overline{s_{iV}}$, the average over the sample for each country and find the resulting weighted risk is 0.22. This is lower than the sample mean risk for non-PTA, which reflects the lower levels of exports to riskier countries.

The continuous line in Figure 13(a) represents $\overline{\hat{X}_{I,p-0}}$ and shows a 32 point decline for $p = 1$ in aggregate exports to non-PTA countries relative to a counterfactual with pre-crisis growth. The long dashed line adds the aggregated PTA treatment using the extensive margin coefficients in Table 4 (column 4). This offsets 8 points of the aggregate decline to non-PTA in $p = 1$. By 2011 a small part of the decline in $\overline{\hat{X}_{I,p-0}}$ had been reversed, but it was still over 24 points below a no-crisis counterfactual. The PTA treatment became smaller but was not reversed so the cumulative effect was still considerable, over 6 points. The dashed red line also adds the small (and insignificant) intensive margin effect, so the overall PTA treatment differential is due to the extensive margin, as highlighted by the model's mechanism.

5.3 Partial uncertainty reversal contribution to recovery

To determine if there was a partial reversal of the initial uncertainty shock and how much it contributed to the recovery we employ the following counterfactual. What would exports have been relative to no-crisis if the uncertainty parameters remained at their initial crisis level? For the number of firms this translates to

$$\mathbb{E}\left[\overline{\Delta_4 \ln N}_{iVp-0} | \bar{\Gamma}^J_{p-0} = \bar{\Gamma}^J_{1-0}, \mathbf{z}_i\right] = \mathbb{E}\left[\overline{\Delta_4 \ln N}_{iVp-0} | W_i = 0, \mathbf{z}_i\right] + \left(\bar{\Gamma}^J_{1-0} - \bar{\Gamma}^J_{p-0}\right) \mathbb{E}\left(risk_{Y_i} | W_i = 0\right). \quad (35)$$

This counterfactual is represented by the dotted line in Figure 11(b). For the first year ($p = 1$ corresponding to Q408) this simply reflects the data since by construction the second term is zero. But in the remaining periods $\bar{\Gamma}^J_{1-0} < \bar{\Gamma}^J_{p-0}$ (from Table 3 column 1) so if the initial uncertainty had remained then net entry would have been an additional 6.6 lp below the no-crisis scenario in the final period. We consider this the contribution of the partial reversal of uncertainty to average net entry recovery.

In Figure 13(b) we include a similar counterfactual for aggregate exports using the extensive margin (coefficients in Table 4(a) column 4). The dotted line shows there would be no recovery relative to the no-crisis counterfactual. The difference between the continuous and dotted lines represents the contribution of the partial reversal of uncertainty to aggregate exports to non-PTAs, which is 8.8 points by the last period.

In sum, if uncertainty had remained at initial levels then exports to non-PTAs would have been reduced by over 33 points. The partial reversal that occurred implied that reduction was only about 25.

5.4 Income Equivalents of PTA treatment

Using the baseline estimates we quantify the aggregate income change required in non-PTA destinations to match the PTA differential treatment in Table 10. We do so by equating the predicted differentials in (30) to the estimated income coefficient times a counterfactual average income change $\widehat{\Delta \ln Y_p}^{CF}$ for each period:

$$\Gamma^y_p \cdot \widehat{\Delta \ln Y_p}^{CF} = \mathbb{E}_i \left(\bar{\Gamma}^{\Delta\tau}_{p-0} + \bar{\Gamma}^{\Delta J}_{p-0} \cdot risk_{Y_i}\right), \quad (36)$$

where we use the trade weighted mean $\overline{risk}_{Y_i} = 0.22$. For example, the net entry differential using midpoint growth in period 1 is 6.4. We divide this by $\Gamma^y_1 = 0.429$ to obtain $\widehat{\Delta \ln Y_1}^{CF} = 15$ lp — the required income change in period 1 that is equivalent to the differential.

We focus on the dynamics of aggregate exports discussed in Figure 13 where we plot the counterfactual non-PTA export growth under a PTA. In Figure 13(a), the initial differential impact in the period 1 of the crisis is 10 points. In the absence of the PTA treatment, foreign income would have to grow by 11 lp. The required income growth for the extensive margin component is 15 lp, the same equivalent found for net entry. These initial period effects are large, but they are offset in periods 2 and 3 when the uncertainty effect on exports is partially reversed and the income coefficients Γ^y_p attenuate somewhat. Cumulating these we obtain the total income equivalent to the PTA treatment differentials over those 3 years: 5.6 lp for total export growth and 8.6 lp for the extensive margin.

In sum, the combined effect on U.S. exports of economic and trade policy uncertainty via the extensive margin was equivalent to a reduction in non-PTA income of 15 lp in the first crisis year and a 3-year equivalent of 8.6 lp by the end of 2011. These are larger than the actual foreign income changes in these periods.

6 Conclusion

We examine the interaction of economic and policy sources of demand uncertainty, their impact on firm export dynamics, and the role of trade agreements in mitigating them. We develop a model and derive the conditions for when the interaction of risks can amplify the response of firms and trade flows to higher demand volatility and how PTAs can mitigate it.

We provide a novel set of stylized facts for U.S. export dynamics that contributes to understanding the GTC and recovery. We use the theoretical model to guide the estimation and construction of measures that capture economic and policy risk and their interaction. There is net exit of varieties and lower exports by U.S. firms during the GTC caused by higher uncertainty, particularly in riskier markets, i.e. non-PTA export destinations, industries with potentially higher protectionism in a trade war, or both. These effects peaked in the first year of the crisis and were only partially reversed in the following two years. The cumulative effect is significant even three years after the start of the crisis. By 2011Q4 average net exit for non-PTA destinations was 15 lp below the no-crisis path. Most of this effect would be eliminated if those countries had a PTA. Applying this counterfactual to average exports we find similar results for the extensive margin. This implies that aggregate U.S. exports to non-PTA destinations would have been 6.5% higher under a PTA—equivalent to an 8% GDP increase in those destinations.

These findings highlight the insurance value of PTAs during economic crises—a benefit that can't be ignored in the evaluation of whether to exit (or enter) these agreements.[52]

[52] Future research should examine additional agreements and mechanisms such as whether PTAs deepen input-output linkages and reduce the risk of protectionism further as in Blanchard et al. (2016).

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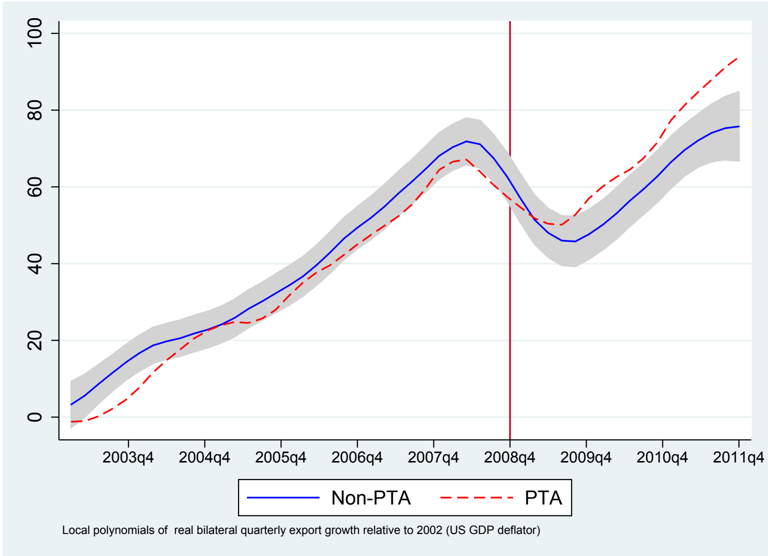
Figures

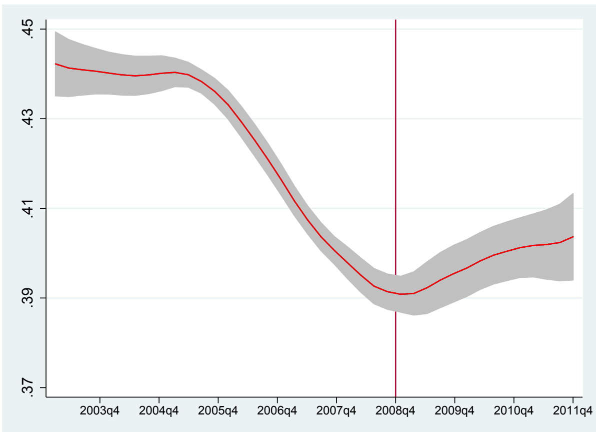
Figure 1: Export Growth to PTA and non-PTA destinations, 2002-2011



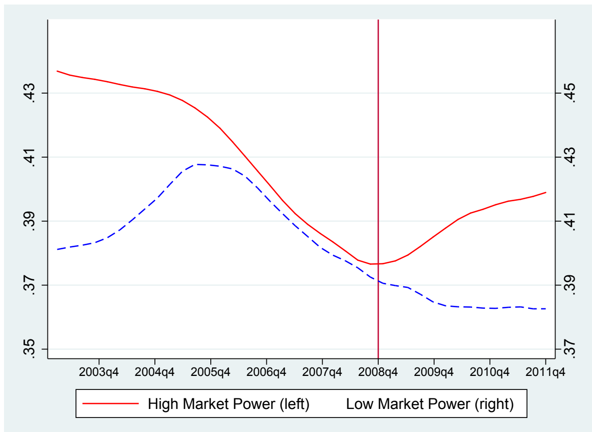
Notes: Cumulative log growth relative to same quarter in 2002. PTA and non-PTA subsample correspond to list in Table A2. Source: Constructed from Census Foreign Trade Data as described in the Data Appendix.

Figure 2: Evolution of U.S. PTA export shares, 2003-2011

(a) PTA Country Export Share

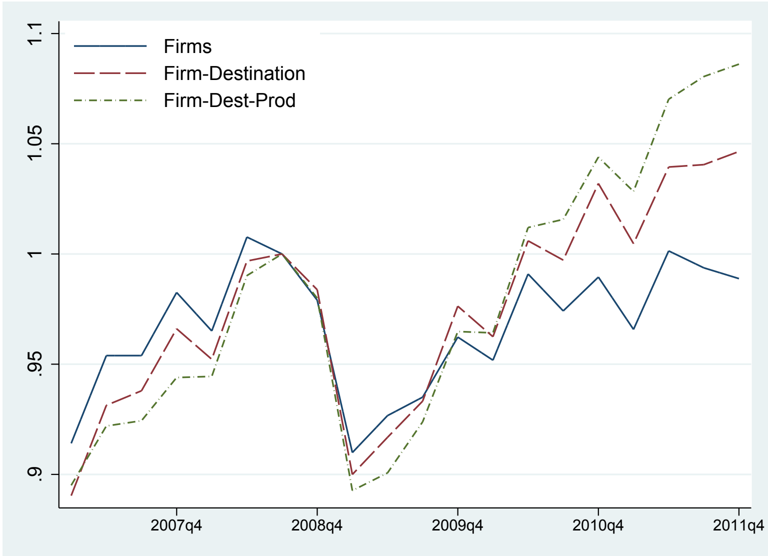


(b) High vs. low market power PTA share



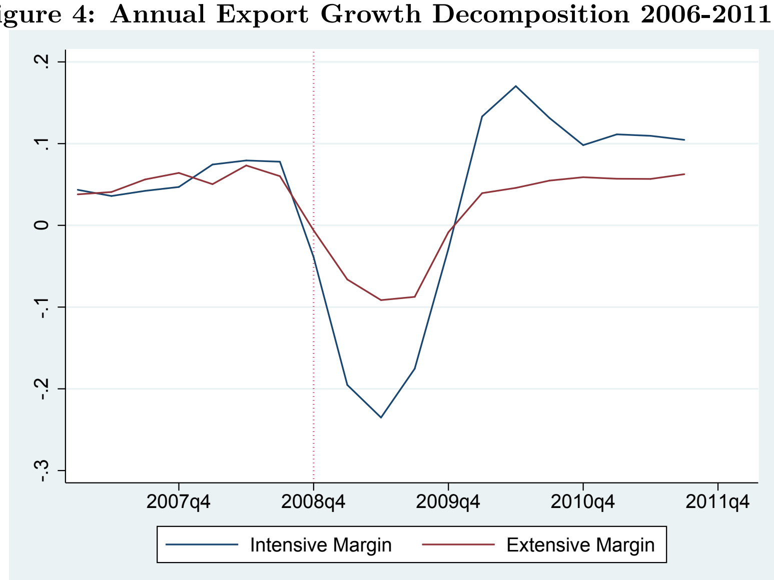
Notes: PTA group includes Australia, Chile, Guatemala, Israel, Morocco, and NAFTA. The group held fixed for entire sample so share changes not induced by timing of implementation. Other PTA countries excluded from denominator in the share calculation. See Table A2 for list of countries. Source: Constructed from Census Foreign Trade Data accessed via the USITC Dataweb.

Figure 3: U.S. Firm and Variety Dynamics 2006-2011Q3



Notes: Constructed from Census LFTTD by quarter for the universe of all trade transactions matched to firms. Products are defined at HS-10 digit level, concorded for time consistency.

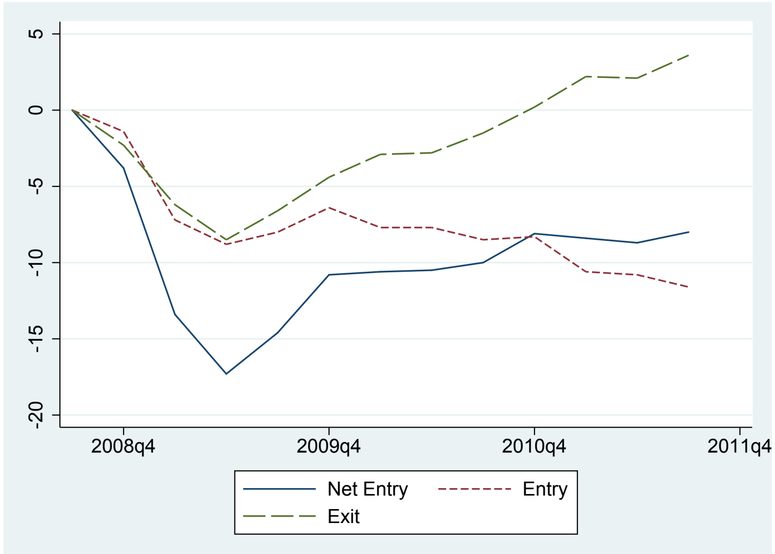
Figure 4: Annual Export Growth Decomposition 2006-2011Q3



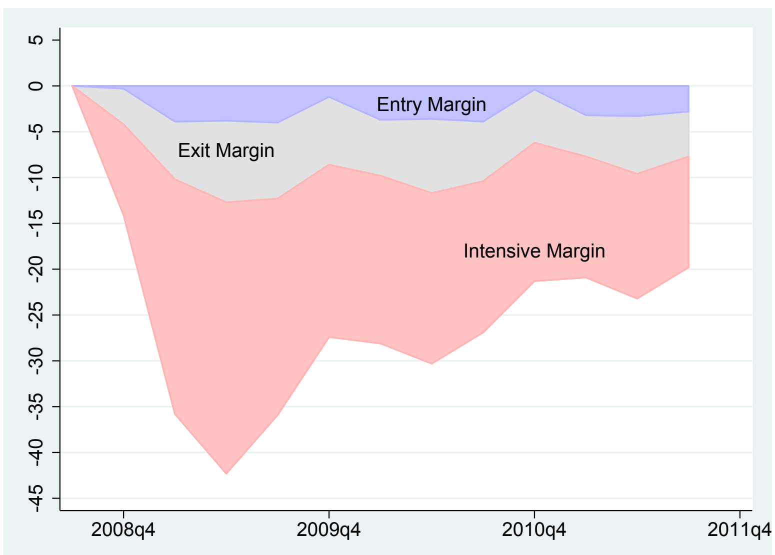
Notes: Constructed from Census LFTTD by quarter using regression sample data. Intensive and Extensive components sum to total export growth. Extensive margin computed over firm-country-product varieties.

Figure 5: Cumulative Decompositions by Export Margin, 2008Q4-2011Q3

(a) Aggregate variety net entry growth



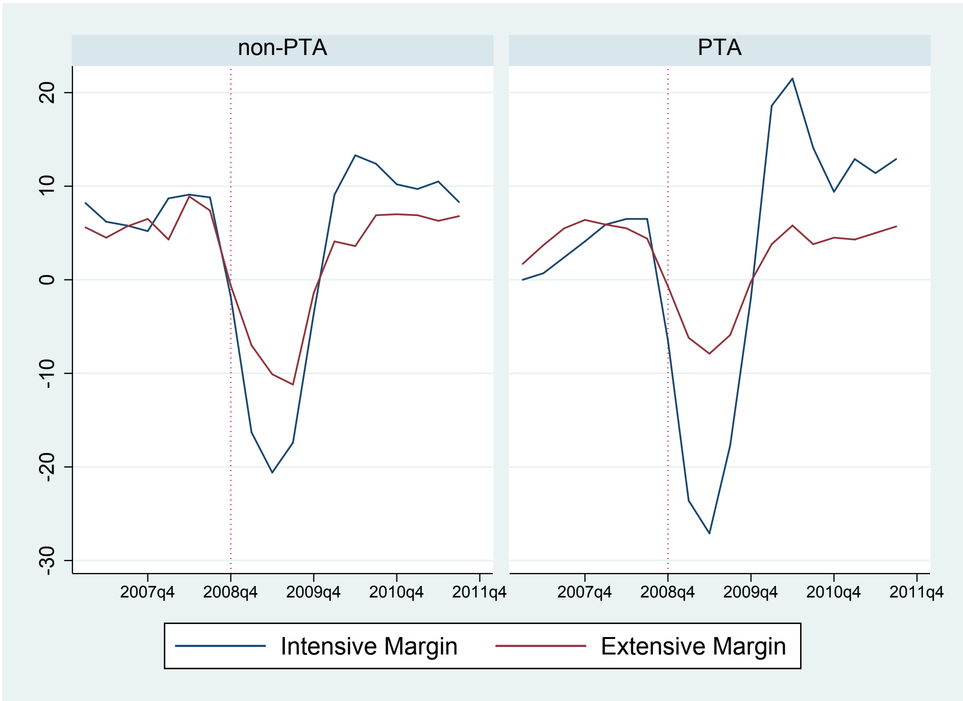
(b) Aggregate export growth



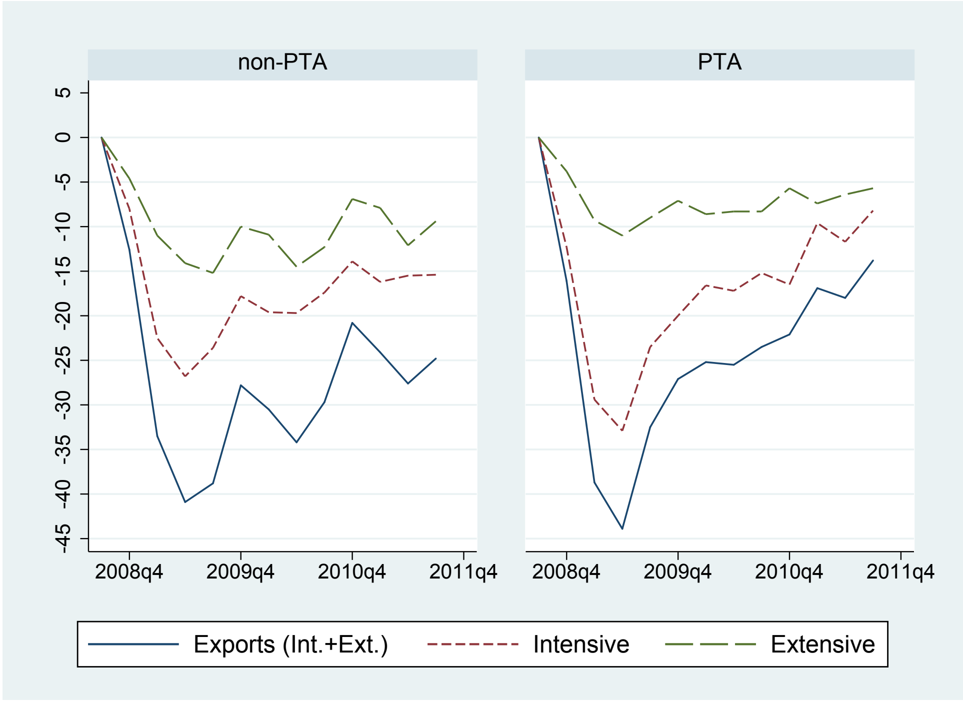
Notes: Constructed from Census LFTTD by quarter using regression sample data. Varieties defined by a firm-country-product triplet. (a) Entry and Exit components sum to net entry growth of varieties. Pre-trend computed from 2003Q1-2008Q3. Exit contribution in 2011 is positive relative to trend. (b) Entry and exit margins some to export growth contribution to extensive margin computed over firm-country-product varieties. Entry, exit and intensive margin component sum to aggregate export growth.

Figure 6: Export growth decomposition for non-PTA (left) vs. PTA (right)

(a) Annual export growth decomposition, 2006-2011Q3



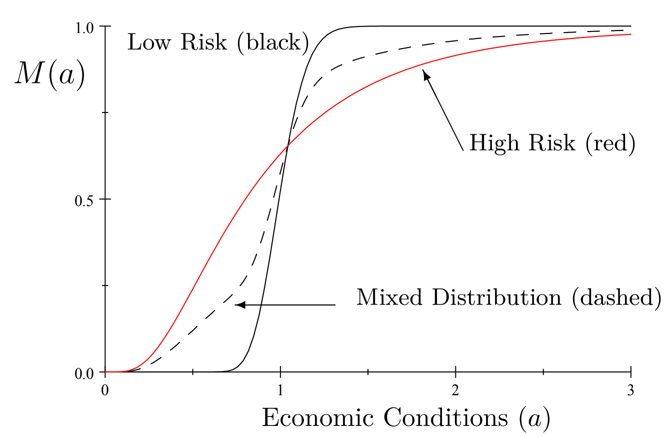
(b) Cumulative export growth decomposition, 2008Q4-2011Q3.



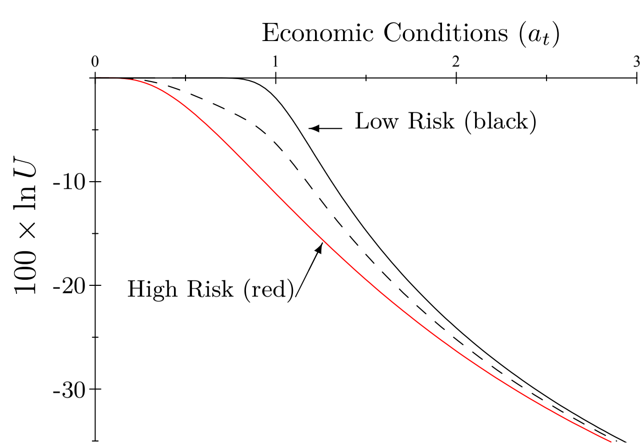
Notes: Constructed from Census LFTTD by quarter using regression sample data. Intensive and Extensive components sum to total export growth. Extensive margin computed over firm-country-product that enter or exit relative to same quarter in previous year. (a) Pre-crisis mean computed from 2003 to 2008Q3 by PTA and non-PTA groups.(b) Pre-trend computed from 2003Q1-2008Q3 by PTA and non-PTA groups.

Figure 7: Increasing Risk in Business Conditions and Entry Cutoff

(a) Increasing Risk in Business Conditions, $M(m_s, a)$



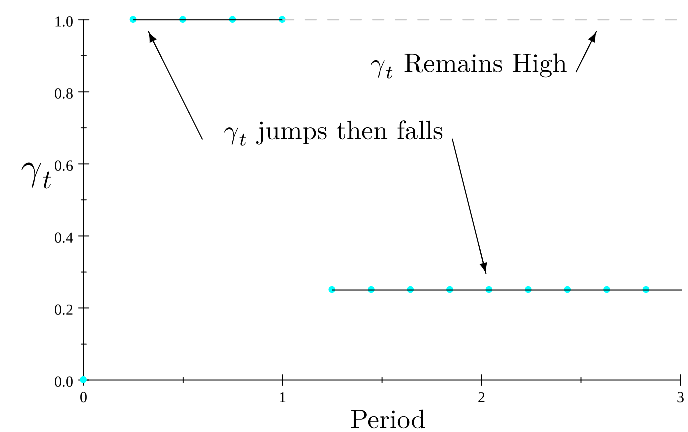
(b) Entry reduction from volatility ($\Delta\gamma = 1$) under low vs. high risks



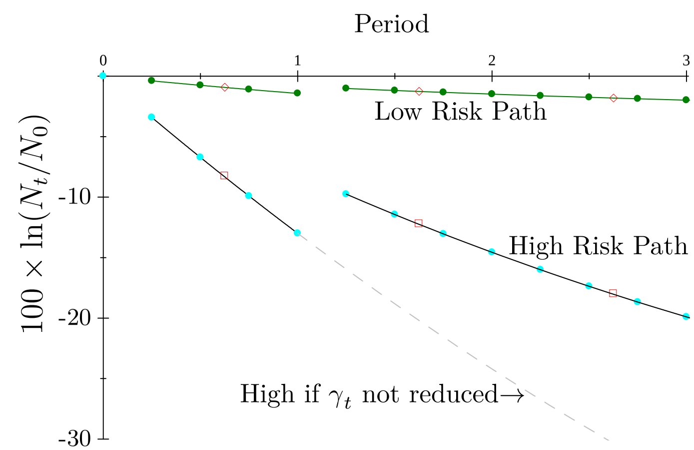
Notes: Low risk H_s (black, $m_s = 1$) and high risk $H_{s'}$ (red, $m_s = 0$) distributions of economic conditions where H_s SSD $H_{s'}$. Intermediate mixed distribution $m_s = 0.5$. All distributions normalized so that $E(a) = 1$ and increases in risk are a mean preserving spread. Panel (b) shows the change in log points for the entry cutoff in terms of the effect on the uncertainty factor $\ln U$. See main text for equations and details. (Appendix D.1 provides details on the parameterization)

Figure 8: Uncertainty Shocks and Adjustment of Varieties in High vs. Low Risk Markets.

(a) Unanticipated uncertainty (γ) shock paths

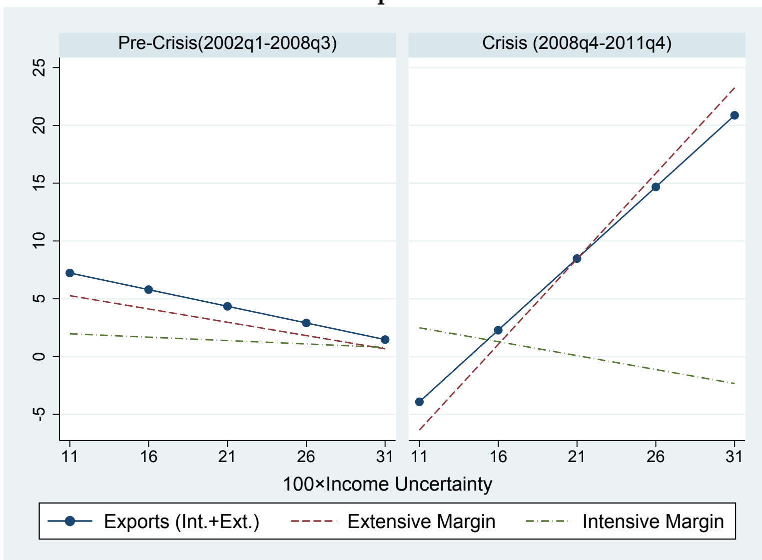


(b) Cumulative Variety growth, $\ln(N_t/N_0)$, in High vs. Low Risk markets



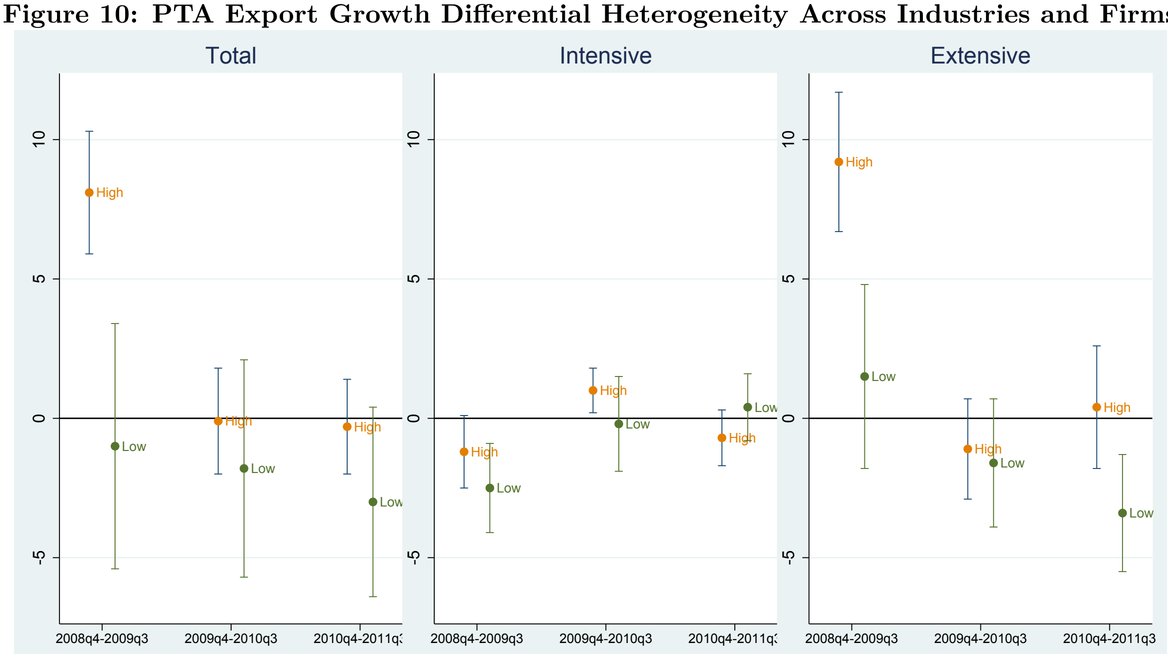
Notes: (a) The solid line with blue circles depicts a 4 quarter increase in uncertainty γ that is reduced in subsequent quarters but does not return to zero. The dashed line is the time path if γ remained high. (b) High income risk time path denoted in solid black and low income risk with green. Circles indicate each quarterly time point. The average for each period is given by red squares (high risk) and red diamonds (low risk). The gray dashed time path for high risk models when γ remains high after the first period. See main text for equations and details.

Figure 9: PTA Export Growth Differential vs. Income Uncertainty — Pre and post-crisis decomposition



Notes: Computed using coefficients in Table 4, columns 2-4. Income uncertainty measure centered on the PTA mean ± one standard deviation.

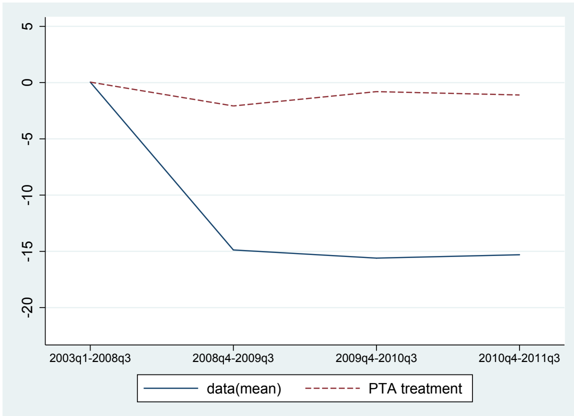
Figure 10: PTA Export Growth Differential Heterogeneity Across Industries and Firms



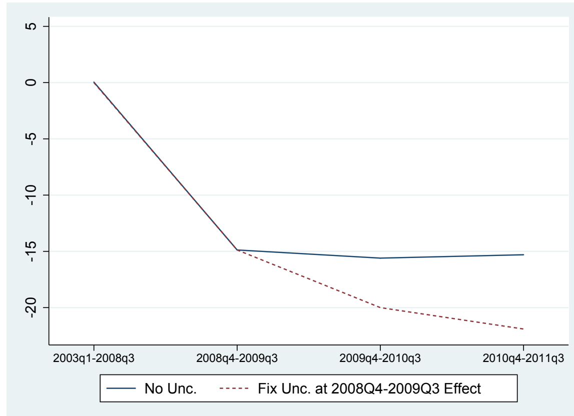
Notes: Point estimates and ones standard error bar from high and low market power industry PTA differentials computed in Table 9(b).

Figure 11: Counterfactual non-PTA Average Variety Growth ($100 \times \ln$)

(a) Treat non-PTA as if PTA



(b) No recovery of uncertainty after 2008Q4

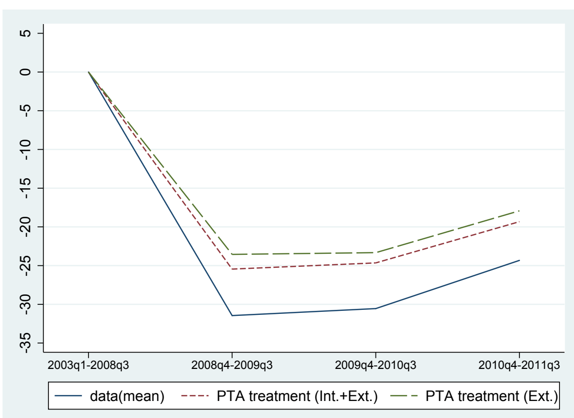


Notes: Computed at the mean of the non-PTA uncertainty measure of 0.26 using coefficients in Table 3. (a) See text for expressions for PTA treatment. (b) Fixed uncertainty counterfactual (dotted lines) computed by replacing estimated income uncertainty effects in 2009Q4-2011Q3 by estimated effect in 2008Q4-2009Q3 as if there was no reduction.

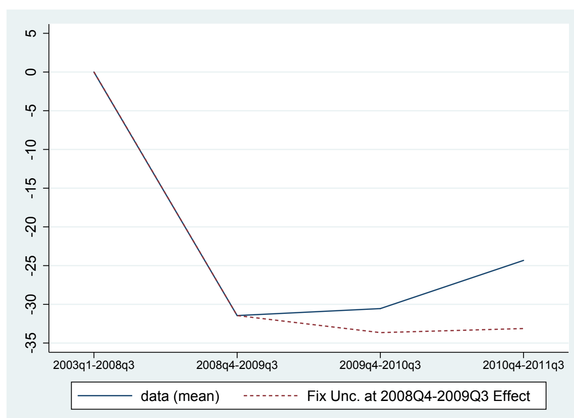
FIGURE 12 IS ON PAGE 48

Figure 13: Counterfactual non-PTA Aggregate Export Growth

(a) Treat non-PTA as if PTA



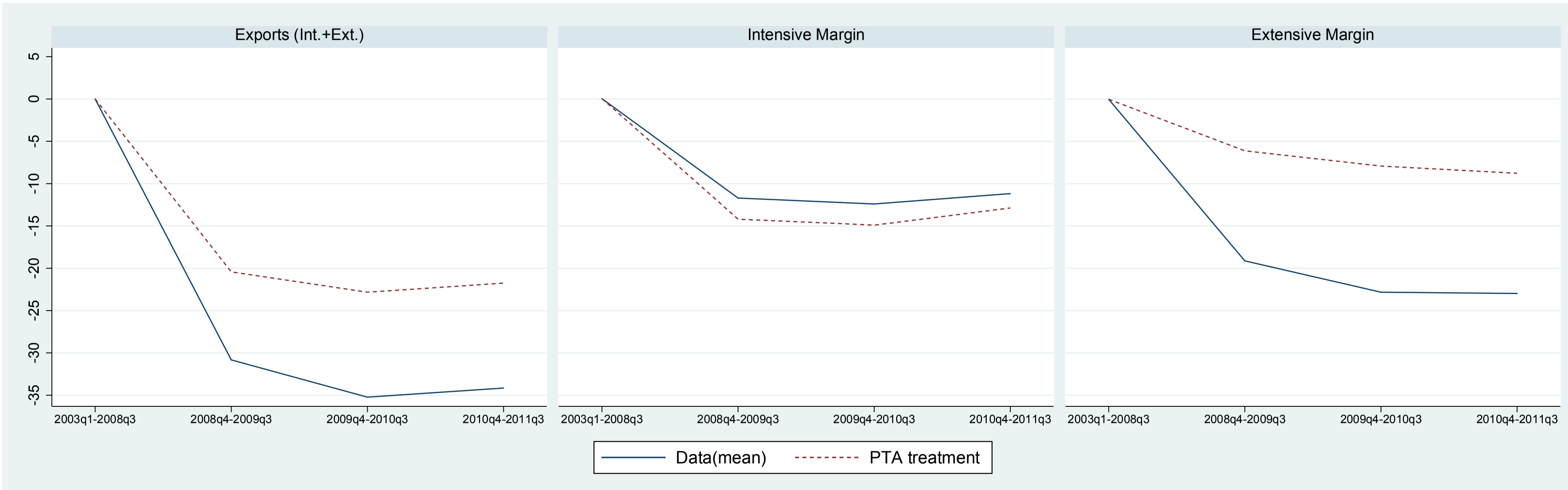
(b) No recovery of unc. after 2008Q4 — Extensive Margin Component



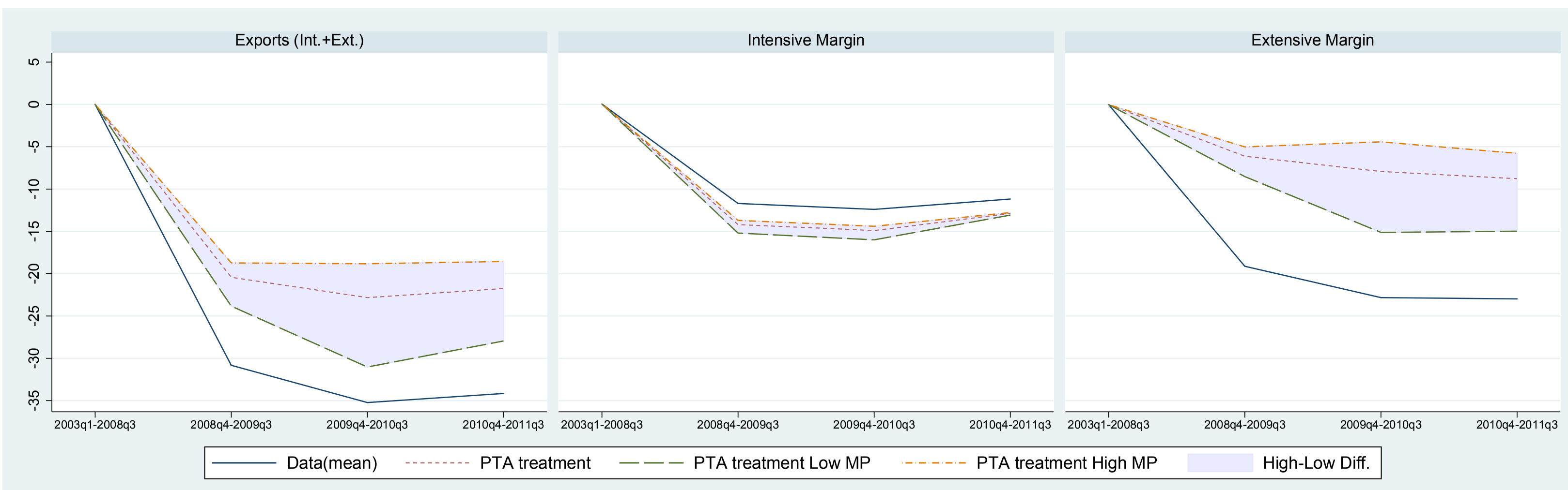
Notes: Computed at the weighted aggregate mean of the non-PTA uncertainty measure of 0.22 using coefficients in Table 4. (a) See text for expressions for PTA treatment. (b) Fixed uncertainty counterfactual (dotted lines) computed by replacing estimated income uncertainty effects in 2009Q4-2011Q3 by estimated effect in 2008Q4-2009Q3 as if there was no reduction. We graph the extensive margin component of total exports.

Figure 12: Counterfactual non-PTA Average Export Growth if Treated as PTA

(a) Cumulative Effects by Margin



(b) Cumulative Effects by Margin for High and Low Market Power



Notes: All effects computed at the mean of the non-PTA uncertainty measure of 0.26. See text for expressions used to compute counterfactual differences. Panel (a) uses coefficients in Table 4(a). See text for expressions. See text for expressions for PTA treatment. Panel (b) uses coefficients from the high and low market power industry samples in Tables 8(a) and 9(a).

Tables

Table 1: Aggregate Export Growth and Variety Extensive Margin Contribution-- Yearly Averages

Period	Aggregate Export Growth	Extensive Margin Growth	Extensive Margin Growth Share: Mean	Min.	Max.
2003q1-2008q3	9.6	3.6	0.36	0.17	0.58
2008q4-2009q3	-22.4	-6.3	0.25	0.14	0.33
2009q4-2010q3	13.4	3.3	0.24	0.21	0.29
2010q4-2011q3	16.5	5.9	0.36	0.34	0.38

Notes: Computed over the regression sample. Aggregate mid point growth means and extensive margin contribution by period. Mid point growth measure described in text where variety is defined at the firm-country-hs10 product

Table 2: Summary Statistics for country-quarter-HS2 industry regressions (2003-2011)

	Non-PTA	PTA	Full Sample
Uncertainty[1]	0.258	0.210	0.252
	[0.100]	[0.0499]	[0.0970]
Market Power[2]	0.69	0.66	0.69
	[0.462]	[0.473]	[0.463]
Growth in Variety Net entry[3]	0.0479	0.052	0.0484
	[0.426]	[0.310]	[0.414]
Entry Contribution	0.702	0.66	0.697
	[0.298]	[0.231]	[0.291]
Exit Contribution	-0.654	-0.608	-0.649
	[0.291]	[0.219]	[0.284]
Growth in Firms Net entry[3]	0.0448	0.0471	0.045
	[0.410]	[0.301]	[0.399]
Firm Entry Contribution	0.632	0.58	0.626
	[0.302]	[0.234]	[0.295]
Firm Exit Contribution	-0.587	-0.533	-0.581
	[0.294]	[0.223]	[0.287]
Growth in Exports (ln)	0.0945	0.105	0.0958
	[1.061]	[0.760]	[1.029]
Growth in Exports (midpoint)	0.0804	0.0943	0.0821
	[0.762]	[0.572]	[0.742]
Extensive Margin Variety Contribution	0.0486	0.0518	0.049
	[0.687]	[0.506]	[0.668]
Intensive Margin Contribution	0.0319	0.0425	0.0331
	[0.318]	[0.253]	[0.311]
PTA	0	1	0.119
	NA	NA	[0.323]
Growth in GDP (ln)	0.106	0.097	0.105
	[0.141]	[0.124]	[0.139]
Observations (rounded)	140,000	20,000	160,000

Notes: Sample means and standard deviations (in brackets). (1) Uncertainty estimates from AR(1) country-specific regressions. See details in main text. (2) Market power constructed from Broda, Limão and Weinstein (2008). (3) Quarterly year-to-year midpoint growth rate where "Growth" denotes the overall growth rate in a country-HS2-quarter cell, "Entry" correspond to the new firms or varieties (firm*product) flows while "Exit" corresponds to those that disapear.

Table 3(a): U.S. Export Varieties Entry and Exit (2003-2011)

	Net entry		Decomposition into:	
	Δln	**midpoint growth**	**Entry**	**Exit**
Non-PTA				
Uncertainty*Q408	-0.314***	-0.276***	-0.164***	-0.113***
	[0.0704]	[0.0648]	[0.0353]	[0.0380]
Uncertainty*Q409	-0.143***	-0.129**	-0.0714**	-0.0579**
	[0.0546]	[0.0504]	[0.0317]	[0.0264]
Uncertainty*Q410	-0.231***	-0.215***	-0.129***	-0.0857***
	[0.0506]	[0.0465]	[0.0315]	[0.0263]
PTA				
PTA*Uncertainty*Q408	1.499***	1.379***	0.723***	0.656***
	[0.276]	[0.264]	[0.158]	[0.145]
PTA*Q408	-0.261***	-0.239***	-0.142***	-0.0970***
	[0.0587]	[0.0563]	[0.0341]	[0.0320]
PTA*Uncertainty*Q409	0.478*	0.453*	0.445***	0.00780
	[0.251]	[0.237]	[0.131]	[0.131]
PTA*Q409	-0.105*	-0.0998*	-0.108***	0.00846
	[0.0566]	[0.0535]	[0.0282]	[0.0310]
PTA*Uncertainty*Q410	-0.0977	-0.0972	0.0527	-0.150
	[0.173]	[0.164]	[0.105]	[0.0949]
PTA*Q410	0.0201	0.0202	-0.0261	0.0464**
	[0.0396]	[0.0379]	[0.0241]	[0.0217]
PTA*Uncertainty	-0.383*	-0.365*	-0.134	-0.231**
	[0.203]	[0.191]	[0.120]	[0.111]
PTA	0.107**	0.101**	0.0549**	0.0460*
	[0.0468]	[0.0439]	[0.0268]	[0.0252]
Income Changes				
Change in GDP*Pre-Crisis	0.219***	0.207***	0.0864***	0.121***
	[0.0306]	[0.0284]	[0.0184]	[0.0141]
Change in GDP*Q408	0.458***	0.429***	0.182***	0.247***
	[0.0623]	[0.0563]	[0.0311]	[0.0309]
Change in GDP*Q409	0.320***	0.304***	0.128***	0.176***
	[0.0427]	[0.0397]	[0.0251]	[0.0212]
Change in GDP*Q410	0.308***	0.295***	0.114***	0.181***
	[0.0587]	[0.0542]	[0.0313]	[0.0352]
Observations	160,000	160,000	160,000	160,000
R-squared	0.049	0.051	0.260	0.240
Quarter-Year FE	Yes	Yes	Yes	Yes
Country*HS2 FE	Yes	Yes	Yes	Yes

Notes:
Aggregation level: country-HS2-quarter of varieties defined at the firm-country-hs10 level. Dependent variable in column 1 (2) is the ln (midpoint) growth in the number of varieties exported in a country-HS2-quarter. In columns 3 and 4 we use the midpoint growth for entering or exiting varieties in a similar cell. We use uncertainty estimates from AR(1) country-specific regressions. See details in text. Robust standard errors clustered at the destination country by time period level (pre-crisis period and the year long periods with start date denoted by the Q4## indicators). *,**,*** Sig. different from 0 at 10%, 5% and 1% respectively.

Table 3(b): PTA vs. Non-PTA Variety Entry Growth Differentials

	Net entry		Decomposition into:	
	Δln	**midpoint growth**	**Entry**	**Exit**
2008q4-2009q3	0.054	0.05	0.01	0.041
	[0.013]	[0.015]	[0.009]	[0.009]
2009q4-2010q3	-0.004	-0.005	-0.015	0.01
	[0.012]	[0.011]	[0.009]	[0.006]
2010q4-2011q3	0.000	0.000	-0.015	0.015
	[0.009]	[0.012]	[0.006]	[0.007]

Notes: Calculated from Table 3 coefficients for PTA in each period Q4yy at PTA mean risk.

Table 4(a): U.S. Export Growth and Extensive vs. Intensive Contributions (2003-2011)

	Export Growth		Decomposition into:	
	Δln	midpoint growth	Intensive	Extensive
Non-PTA				
Uncertainty*Q408	-0.487***	-0.272**	0.0444	-0.316***
	[0.144]	[0.106]	[0.0438]	[0.0901]
Uncertainty*Q409	-0.381***	-0.301***	-0.124***	-0.176**
	[0.117]	[0.0877]	[0.0368]	[0.0722]
Uncertainty*Q410	-0.183	-0.119	-0.0626**	-0.0560
	[0.111]	[0.0772]	[0.0283]	[0.0707]
PTA				
PTA*Uncertainty*Q408	1.845***	1.093**	-0.173	1.267***
	[0.527]	[0.428]	[0.178]	[0.385]
PTA*Q408	-0.306**	-0.180*	0.0204	-0.200**
	[0.120]	[0.0987]	[0.0390]	[0.0856]
PTA*Uncertainty*Q409	0.765	0.522	-0.136	0.658**
	[0.501]	[0.364]	[0.132]	[0.319]
PTA*Q409	-0.177	-0.116	0.0348	-0.151**
	[0.118]	[0.0852]	[0.0272]	[0.0742]
PTA*Uncertainty*Q410	0.340	0.258	0.244**	0.0141
	[0.348]	[0.265]	[0.110]	[0.234]
PTA*Q410	-0.0830	-0.0662	-0.0550**	-0.0112
	[0.0796]	[0.0614]	[0.0231]	[0.0544]
PTA*Uncertainty	-0.387	-0.288	-0.0587	-0.230
	[0.400]	[0.296]	[0.124]	[0.242]
PTA	0.133	0.104*	0.0262	0.0780
	[0.0858]	[0.0616]	[0.0224]	[0.0535]
Income Changes				
Change in GDP*Pre-Crisis	0.333***	0.272***	0.0537***	0.218***
	[0.0621]	[0.0462]	[0.0155]	[0.0387]
Change in GDP*Q408	0.881***	0.646***	0.132***	0.513***
	[0.113]	[0.0789]	[0.0357]	[0.0752]
Change in GDP*Q409	0.473***	0.400***	0.100***	0.300***
	[0.0916]	[0.0719]	[0.0303]	[0.0577]
Change in GDP*Q410	0.300**	0.267***	0.0983***	0.168**
	[0.133]	[0.0901]	[0.0333]	[0.0841]
Observations	160,000	160,000	160,000	160,000
R-squared	0.049	0.056	0.063	0.043
Quarter-Year FE	Yes	Yes	Yes	Yes
Country*HS2 FE	Yes	Yes	Yes	Yes

Notes

Aggregation level: country-HS2-quarter of varieties defined at the firm-country-hs10 level. Dependent variable in column 1 (2) is the ln (midpoint) growth of export value in a country-HS2-quarter. In columns 3 and 4 we decompose midpoint growth into continuing and entering or exiting varieties in a similar cell. We use uncertainty estimates from AR(1) country-specific regressions. See details in text. Robust standard errors clustered at the destination country by time period level (pre-crisis period and the year long periods with start date denoted by the Q4## indicators). *,**,*** Sig. different from 0 at 10%, 5% and 1% respectively.

Table 4(b): PTA vs. Non-PTA Export Growth Differentials

	Export Growth		Decomposition into:	
	Δln	midpoint growth	Intensive	Extensive
2008q4-2009q3	0.082	0.05	-0.016	0.066
	[0.026]	[0.02]	[0.013]	[0.022]
2009q4-2010q3	-0.017	-0.006	0.006	-0.013
	[0.024]	[0.018]	[0.008]	[0.019]
2010q4-2011q3	-0.012	-0.012	-0.004	-0.008
	[0.018]	[0.02]	[0.01]	[0.012]

Notes: Calculated from Table 4 coefficients for PTA in each period Q4yy at PTA mean risk.

Table 5: U.S. Export Firm-Industry Entry and Exit (2003-2011)

	Net entry		Decomposition into:	
	Δln	**midpoint growth**	**Entry**	**Exit**
Non-PTA				
Uncertainty*Q408	-0.289***	-0.259***	-0.138***	-0.121***
	[0.0652]	[0.0605]	[0.0339]	[0.0385]
Uncertainty*Q409	-0.117**	-0.107**	-0.0561*	-0.0509*
	[0.0514]	[0.0477]	[0.0340]	[0.0283]
Uncertainty*Q410	-0.202***	-0.190***	-0.126***	-0.0642**
	[0.0459]	[0.0421]	[0.0315]	[0.0269]
PTA				
PTA*Uncertainty*Q408	1.421***	1.310***	0.652***	0.658***
	[0.271]	[0.261]	[0.156]	[0.145]
PTA*Q408	-0.249***	-0.228***	-0.133***	-0.0948***
	[0.0571]	[0.0549]	[0.0334]	[0.0317]
PTA*Uncertainty*Q409	0.463*	0.420*	0.412***	0.00763
	[0.247]	[0.231]	[0.131]	[0.130]
PTA*Q409	-0.0964*	-0.0869	-0.105***	0.0184
	[0.0569]	[0.0532]	[0.0287]	[0.0311]
PTA*Uncertainty*Q410	-0.114	-0.102	0.0898	-0.191*
	[0.157]	[0.148]	[0.0940]	[0.0997]
PTA*Q410	0.0268	0.0237	-0.0404*	0.0641***
	[0.0365]	[0.0343]	[0.0217]	[0.0235]
PTA*Uncertainty	-0.339*	-0.314*	-0.0702	-0.244**
	[0.197]	[0.185]	[0.109]	[0.120]
PTA	0.0937**	0.0870**	0.0405	0.0465*
	[0.0463]	[0.0434]	[0.0250]	[0.0278]
Income Changes				
Change in GDP*Pre-Crisis	0.214***	0.203***	0.0787***	0.124***
	[0.0272]	[0.0254]	[0.0177]	[0.0134]
Change in GDP*Q408	0.422***	0.396***	0.177***	0.218***
	[0.0565]	[0.0514]	[0.0292]	[0.0292]
Change in GDP*Q409	0.304***	0.289***	0.109***	0.180***
	[0.0410]	[0.0383]	[0.0250]	[0.0217]
Change in GDP*Q410	0.281***	0.270***	0.138***	0.132***
	[0.0527]	[0.0485]	[0.0300]	[0.0335]
Observations	160,000	160,000	160,000	160,000
R-squared	0.027	0.029	0.135	0.122
Quarter-Year FE	Yes	Yes	Yes	Yes
Country*HS2 FE	Yes	Yes	Yes	Yes

Notes:
Aggregation level: country-HS2-quarter. Dependent variable in column 1 is log growth and col. (2) midpoint growth in the number of U.S. firms exporting in a country-HS2-quarter. Columns 3 and 4 use the midpoint growth for entering or exiting firms in a similar cell. We use uncertainty estimates from AR(1) country-specific regressions. See details in text. Robust standard errors clustered at the destination country by time period level (pre-crisis period and the year long periods with start date denoted by the Q4## indicators). *,**,*** Sig. different from 0 at 10%, 5% and 1% respectively.

Table 6: U.S. Export Varieties Entry and Exit (2003-2011)
Robustness to alternative income uncertainty measure (St.Dev. Δln GDP)

	Net entry		Decomposition into:	
	Δln	**midpoint growth**	**Entry**	**Exit**
Non-PTA				
Uncertainty*Q408	-0.853***	-0.778***	-0.453***	-0.325**
	[0.249]	[0.232]	[0.129]	[0.126]
Uncertainty*Q409	-0.624***	-0.594***	-0.292**	-0.301**
	[0.230]	[0.214]	[0.122]	[0.120]
Uncertainty*Q410	-0.650***	-0.602***	-0.341***	-0.261**
	[0.217]	[0.198]	[0.131]	[0.105]
PTA				
PTA*Uncertainty*Q408	3.424***	3.170***	1.621***	1.549***
	[0.723]	[0.682]	[0.350]	[0.435]
PTA*Q408	-0.175***	-0.162***	-0.0981***	-0.0634**
	[0.0504]	[0.0476]	[0.0250]	[0.0313]
PTA*Uncertainty*Q409	0.928	0.871	1.098***	-0.227
	[0.646]	[0.615]	[0.336]	[0.328]
PTA*Q409	-0.0682	-0.0650	-0.0900***	0.0249
	[0.0469]	[0.0447]	[0.0243]	[0.0244]
PTA*Uncertainty*Q410	-0.0935	-0.0724	0.291	-0.364
	[0.541]	[0.511]	[0.299]	[0.274]
PTA*Q410	0.0135	0.0118	-0.0307	0.0425**
	[0.0405]	[0.0384]	[0.0225]	[0.0207]
PTA*Uncertainty	-0.417	-0.416	-0.137	-0.278
	[0.523]	[0.495]	[0.300]	[0.271]
PTA	0.0574	0.0551	0.0362	0.0189
	[0.0412]	[0.0391]	[0.0232]	[0.0212]
Income Changes				
Change in GDP*Pre-Crisis	0.235***	0.221***	0.0957***	0.125***
	[0.0309]	[0.0286]	[0.0185]	[0.0141]
Change in GDP*Q408	0.473***	0.439***	0.188***	0.251***
	[0.0623]	[0.0564]	[0.0315]	[0.0302]
Change in GDP*Q409	0.337***	0.322***	0.133***	0.188***
	[0.0444]	[0.0412]	[0.0260]	[0.0223]
Change in GDP*Q410	0.279***	0.266***	0.0954***	0.171***
	[0.0604]	[0.0557]	[0.0319]	[0.0359]
Observations	160,000	160,000	160,000	160,000
R-squared	0.049	0.051	0.259	0.240
Quarter-Year FE	Yes	0	Yes	Yes
Country*HS2 FE	Yes	0	Yes	Yes

Notes:

Aggregation level: country-HS2-quarter of varieties defined at the firm-country-HS10 level. Dependent variable in column 1 is log growth and col. 2 the midpoint growth in the number of varieties exported in a country-HS2-quarter. Columns 3 and 4 use the midpoint growth for entering or exiting firms in a similar cell. Income unceertainty measured as the standard deviation of ln GDP estimated using an AR(1) estimate for each country. Robust standard errors clustered at the destination country by time period level (pre-crisis period and the year long periods with start date denoted by the Q4## indicators). *,**,*** Sig. different from 0 at 10%, 5% and 1% respectively

Table 7: U.S. Export Varieties Net Entry (2003-2011) - Robustness to Additional Industry Controls

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Baseline	**Ind*QY FE**	**Inventory Controls**	**Temp. Barrier Controls**	**Durables**	**Low Dur. Share**	**High Dur. Share**
Non-PTA							
Uncertainty*Q408	-0.314***	-0.283***	-0.314***	-0.312***	-0.312***	-0.281***	-0.385***
	[0.0704]	[0.0703]	[0.0712]	[0.0704]	[0.0710]	[0.0818]	[0.0936]
Uncertainty*Q409	-0.143***	-0.142***	-0.148***	-0.143***	-0.147***	-0.138**	-0.169**
	[0.0546]	[0.0541]	[0.0549]	[0.0546]	[0.0562]	[0.0682]	[0.0749]
Uncertainty*Q410	-0.231***	-0.214***	-0.241***	-0.233***	-0.227***	-0.233***	-0.206***
	[0.0506]	[0.0511]	[0.0506]	[0.0505]	[0.0510]	[0.0643]	[0.0753]
PTA							
PTA*Uncertainty*Q408	1.499***	1.432***	1.456***	1.489***	1.533***	1.377***	1.894***
	[0.276]	[0.276]	[0.279]	[0.276]	[0.279]	[0.272]	[0.412]
PTA*Q408	-0.261***	-0.251***	-0.250***	-0.260***	-0.267***	-0.243***	-0.321***
	[0.0587]	[0.0587]	[0.0589]	[0.0588]	[0.0593]	[0.0571]	[0.0929]
PTA*Uncertainty*Q409	0.478*	0.482**	0.450*	0.480*	0.460*	0.245	0.981**
	[0.251]	[0.243]	[0.253]	[0.251]	[0.250]	[0.269]	[0.396]
PTA*Q409	-0.105*	-0.105*	-0.0997*	-0.105*	-0.102*	-0.0557	-0.213**
	[0.0566]	[0.0544]	[0.0565]	[0.0565]	[0.0564]	[0.0598]	[0.0945]
PTA*Uncertainty*Q410	-0.0977	-0.102	-0.0568	-0.114	-0.108	-0.218	0.175
	[0.173]	[0.171]	[0.180]	[0.173]	[0.173]	[0.228]	[0.307]
PTA*Q410	0.0201	0.0214	0.00877	0.0225	0.0219	0.0356	-0.0141
	[0.0396]	[0.0394]	[0.0411]	[0.0396]	[0.0397]	[0.0516]	[0.0731]
PTA*Uncertainty	-0.383*	-0.392*	-0.355*	-0.386*	-0.385*	-0.170	-0.911***
	[0.203]	[0.202]	[0.203]	[0.203]	[0.204]	[0.239]	[0.312]
PTA	0.107**	0.108**	0.107**	0.108**	0.107**	0.0596	0.222***
	[0.0587]	[0.0590]	[0.0588]	[0.0588]	[0.0593]	[0.0719]	[0.0888]
Control Period Interactions							
Control*Pre-Crisis			0.0254**	-0.0734	-		
			[0.0108]	[0.109]			
Control*Q408			0.0211**	0.312	-0.0719***		
			[0.0108]	[0.210]	[0.00903]		
Control*Q409			0.0210*	-0.120	-0.0288***		
			[0.0109]	[0.244]	[0.00813]		
Control*Q410			0.0109	0.426**	-0.0191**		
			[0.0103]	[0.212]	[0.00758]		
Observations	160,000	160,000	160,000	160,000	160,000	110,000	50,000
R-squared	0.049	0.082	0.050	0.049	0.049	0.042	0.074
Quarter-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country*HS2 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter-Year*HS2 FE	No	Yes	No	No	No	No	No

Notes:
Aggregation level: country-HS2-quarter of varieties defined at the firm-country-HS10 level. Dependent variable is the log growth in the number of varieties exported in a country-HS2-quarter. We use uncertainty estimates from AR(1) country-specific regressions. See details in text. Robust standard errors clustered at the destination country by time period level (pre-crisis period and the year long periods with start date denoted by the Q4## indicators). *,**,*** Sig. different from 0 at 10%, 5% and 1% respectively. GDP*Period Interactions included, but supressed from output.

Table 8(a): U.S. Export Varieties Entry and Exit by Import Market Power Sample (2003-2011)

	Low Market Power Industries				***High Market Power Industries***			
	Net entry	midpoint	Decomposition into:		Net entry	midpoint	Decomposition into:	
	Δln	growth	Entry	Exit	Δln	growth	Entry	Exit
Non-PTA								
Uncertainty*Q408	-0.256**	-0.227**	-0.133**	-0.0938*	-0.330***	-0.290***	-0.171***	-0.118***
	[0.100]	[0.0930]	[0.0594]	[0.0550]	[0.0813]	[0.0743]	[0.0401]	[0.0428]
Uncertainty*Q409	-0.147	-0.135	-0.0901	-0.0445	-0.131**	-0.118**	-0.0619*	-0.0564*
	[0.0950]	[0.0888]	[0.0592]	[0.0525]	[0.0627]	[0.0579]	[0.0356]	[0.0317]
Uncertainty*Q410	-0.332***	-0.314***	-0.213***	-0.102**	-0.177***	-0.162***	-0.0887***	-0.0737**
	[0.0819]	[0.0755]	[0.0548]	[0.0476]	[0.0612]	[0.0563]	[0.0341]	[0.0337]
PTA								
PTA*Uncertainty*Q408	2.104***	1.940***	1.118***	0.822***	1.159***	1.063***	0.509***	0.554***
	[0.377]	[0.349]	[0.251]	[0.215]	[0.335]	[0.319]	[0.170]	[0.170]
PTA*Q408	-0.407***	-0.374***	-0.237***	-0.136***	-0.182**	-0.165**	-0.0915**	-0.0739*
	[0.0822]	[0.0750]	[0.0559]	[0.0490]	[0.0745]	[0.0711]	[0.0377]	[0.0382]
PTA*Uncertainty*Q409	0.249	0.269	0.334*	-0.0647	0.584*	0.538*	0.496***	0.0415
	[0.329]	[0.314]	[0.198]	[0.182]	[0.300]	[0.283]	[0.146]	[0.155]
PTA*Q409	-0.0702	-0.0727	-0.0904**	0.0177	-0.121*	-0.113*	-0.116***	0.00373
	[0.0671]	[0.0642]	[0.0397]	[0.0409]	[0.0706]	[0.0664]	[0.0334]	[0.0371]
PTA*Uncertainty*Q410	0.242	0.228	0.0556	0.173	-0.266	-0.258	0.0493	-0.307***
	[0.298]	[0.276]	[0.194]	[0.156]	[0.202]	[0.192]	[0.116]	[0.115]
PTA*Q410	-0.0878	-0.0838	-0.0488	-0.0350	0.0732	0.0713	-0.0148	0.0861***
	[0.0655]	[0.0606]	[0.0441]	[0.0343]	[0.0468]	[0.0445]	[0.0267]	[0.0268]
PTA*Uncertainty	-0.190	-0.188	-0.0193	-0.169	-0.476**	-0.450**	-0.191	-0.259**
	[0.334]	[0.309]	[0.189]	[0.183]	[0.234]	[0.219]	[0.143]	[0.126]
PTA	0.0745	0.0721	0.0362	0.0359	0.122**	0.114**	0.0632*	0.0507*
	[0.0759]	[0.0699]	[0.0426]	[0.0422]	[0.0538]	[0.0505]	[0.0324]	[0.0272]
Income Changes								
Change in GDP*Pre-Crisis	0.145***	0.141***	0.0530**	0.0881***	0.252***	0.237***	0.101***	0.136***
	[0.0406]	[0.0376]	[0.0252]	[0.0228]	[0.0364]	[0.0337]	[0.0202]	[0.0174]
Change in GDP*Q408	0.338***	0.314***	0.142***	0.172***	0.510***	0.478***	0.200***	0.278***
	[0.0733]	[0.0673]	[0.0412]	[0.0412]	[0.0727]	[0.0656]	[0.0366]	[0.0351]
Change in GDP*Q409	0.314***	0.299***	0.158***	0.140***	0.318***	0.302***	0.114***	0.189***
	[0.0678]	[0.0632]	[0.0408]	[0.0373]	[0.0517]	[0.0478]	[0.0294]	[0.0257]
Change in GDP*Q410	0.137	0.139	0.100	0.0394	0.378***	0.358***	0.119***	0.239***
	[0.0952]	[0.0876]	[0.0650]	[0.0541]	[0.0745]	[0.0687]	[0.0365]	[0.0429]
Observations	50,000	50,000	50,000	50,000	110,000	110,000	110,000	110,000
R-squared	0.044	0.046	0.222	0.220	0.052	0.055	0.264	0.244
Quarter-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country*HS2 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
Country-HS2-quarter of varieties defined at the firm-country-hs10 level. For each panel, the dependent variable in column 1 is log growth and col. 2 the midpoint growth in the number of varieties exported in a country-HS2-quarter. Columns 3 and 4 use the midpoint growth for entering or exiting firms in a similar cell. We use uncertainty estimates from AR(1) country-specific regressions. See details in text. Robust standard errors clustered at the destination country by time period level (pre-crisis period and the year long periods with start date denoted by the Q4## indicators). *,**,*** Sig. different from 0 at 10%, 5% and 1% respectively. Market power indicator is the top 2 terciles of the inverse of the elasticity estimated in Broda, Limão and Weinstein (2008).

SEE PAGE 57 FOR TABLE 8(b)

Table 9(a): U.S. Export Growth and Extensive vs. Intensive Contributions by Import Market Power Sample (2003-2011)

	Low Market Power Industries				***High Market Power Industries***			
	Δln	midpoint growth	Decomposition into: Intensive	Extensive	Δln	midpoint growth	Decomposition into: Intensive	Extensive
Non-PTA								
Uncertainty*Q408	-0.539**	-0.331**	-0.0325	-0.298**	-0.472***	-0.248**	0.0759	-0.324***
	[0.225]	[0.150]	[0.0599]	[0.136]	[0.155]	[0.116]	[0.0477]	[0.0997]
Uncertainty*Q409	-0.339*	-0.314**	-0.228***	-0.0860	-0.374***	-0.278***	-0.0775**	-0.200**
	[0.187]	[0.134]	[0.0755]	[0.112]	[0.131]	[0.0969]	[0.0366]	[0.0837]
Uncertainty*Q410	-0.533***	-0.330***	-0.120**	-0.210*	-0.0149	-0.0135	-0.0375	0.0240
	[0.188]	[0.124]	[0.0527]	[0.118]	[0.137]	[0.0963]	[0.0347]	[0.0883]
PTA								
PTA*Uncertainty*Q408	2.600***	1.605**	-0.208	1.814***	1.430**	0.802*	-0.163	0.965**
	[0.920]	[0.698]	[0.268]	[0.628]	[0.557]	[0.445]	[0.185]	[0.391]
PTA*Q408	-0.520**	-0.347**	0.0192	-0.366***	-0.189	-0.0878	0.0226	-0.110
	[0.205]	[0.152]	[0.0575]	[0.137]	[0.121]	[0.0997]	[0.0404]	[0.0864]
PTA*Uncertainty*Q409	-0.0359	-0.211	0.0251	-0.237	1.162**	0.887**	-0.212	1.099***
	[0.805]	[0.546]	[0.219]	[0.451]	[0.504]	[0.375]	[0.140]	[0.372]
PTA*Q409	-0.0389	0.0265	-0.00734	0.0338	-0.246**	-0.187**	0.0548*	-0.242***
	[0.183]	[0.123]	[0.0474]	[0.100]	[0.118]	[0.0877]	[0.0280]	[0.0853]
PTA*Uncertainty*Q410	1.413**	1.002**	0.273	0.728*	-0.177	-0.102	0.228*	-0.330
	[0.600]	[0.399]	[0.201]	[0.403]	[0.410]	[0.320]	[0.134]	[0.325]
PTA*Q410	-0.344**	-0.240***	-0.0537	-0.187**	0.0436	0.0186	-0.0552*	0.0737
	[0.137]	[0.0912]	[0.0464]	[0.0944]	[0.0919]	[0.0729]	[0.0283]	[0.0736]
PTA*Uncertainty	0.00951	0.0940	-0.0979	0.192	-0.569	-0.468	-0.0346	-0.433
	[0.757]	[0.539]	[0.206]	[0.463]	[0.472]	[0.347]	[0.131]	[0.302]
PTA	0.0934	0.0476	0.0424	0.00520	0.149	0.129*	0.0170	0.113*
	[0.168]	[0.119]	[0.0374]	[0.105]	[0.0978]	[0.0696]	[0.0248]	[0.0636]
Income Changes								
Change in GDP*Pre-Crisis	0.156*	0.137**	0.0418*	0.0948*	0.417***	0.336***	0.0606***	0.276***
	[0.0943]	[0.0662]	[0.0245]	[0.0571]	[0.0694]	[0.0521]	[0.0179]	[0.0443]
Change in GDP*Q408	0.681***	0.447***	0.0378	0.410***	0.961***	0.727***	0.173***	0.554***
	[0.166]	[0.112]	[0.0558]	[0.0990]	[0.131]	[0.0946]	[0.0353]	[0.0899]
Change in GDP*Q409	0.206	0.219**	0.0780	0.141	0.580***	0.473***	0.110***	0.363***
	[0.141]	[0.102]	[0.0493]	[0.0867]	[0.106]	[0.0812]	[0.0321]	[0.0680]
Change in GDP*Q410	-0.0452	-0.0208	0.0878	-0.109	0.438***	0.382***	0.104***	0.278***
	[0.238]	[0.148]	[0.0705]	[0.142]	[0.146]	[0.108]	[0.0377]	[0.103]
Observations	50,000	50,000	50,000	50,000	110,000	110,000	110,000	110,000
R-squared	0.056	0.064	0.066	0.048	0.047	0.054	0.063	0.042
Quarter-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country*HS2 FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes

Aggregation level: country-HS2-quarter of varieties defined at the firm-country-HS10 level. For each panel, the dependent variable in column 1 is log growth and col. 2 the midpoint growth in the value of exports in a country-HS2-quarter. In columns 3 and 4 we decompose midpoint growth into continuing and entering or exiting varieties in a similar cell. We use uncertainty estimates from AR(1) country-specific regressions. See details in text. Robust standard errors clustered at the destination country by time period level (pre-crisis period and the year long periods with start date denoted by the Q4## indicators). *,**,*** Sig. different from 0 at 10%, 5% and 1% respectively. Mark power indicator is the top 2 terciles of the inverse of the elasticity estimated in Broda, Limão and Weinstein (2008).

SEE PAGE 57 FOR TABLE 9(b)

Table 8(b): PTA vs. Non-PTA Variety Entry Growth Differentials by Market Power

	Low Market Power Industries				*High Market Power Industries*			
	Net entry Δln	midpoint growth	Decomposition into: Entry	Exit	Net entry Δln	midpoint growth	Decomposition into: Entry	Exit
2008q4-2009q3	0.035	0.033	-0.003	0.036	0.062	0.058	0.015	0.042
	[0.019]	[0.021]	[0.014]	[0.012]	[0.019]	[0.015]	[0.008]	[0.008]
2009q4-2010q3	-0.018	-0.016	-0.02	0.004	0.002	0.0	-0.012	0.012
	[0.017]	[0.021]	[0.013]	[0.009]	[0.014]	[0.014]	[0.01]	[0.009]
2010q4-2011q3	-0.037	-0.036	-0.037	0.001	0.017	0.017	-0.004	0.022
	[0.016]	[0.015]	[0.01]	[0.011]	[0.011]	[0.01]	[0.006]	[0.008]

Notes: Calculated from Table 8(a) coefficients for PTA in each period Q4yy at PTA mean risk.

Table 9(b): PTA vs. Non-PTA Export Growth Differentials by Market Power

	Low Market Power Industries				*High Market Power Industries*			
	Δln	midpoint growth	Decomposition into: Intensive	Extensive	Δln	midpoint growth	Decomposition into: Intensive	Extensive
2008q4-2009q3	0.026	-0.01	-0.025	0.015	0.112	0.081	-0.012	0.092
	[0.046]	[0.044]	[0.016]	[0.033]	[0.039]	[0.022]	[0.013]	[0.025]
2009q4-2010q3	-0.046	-0.018	-0.002	-0.016	-0.002	-0.001	0.01	-0.011
	[0.039]	[0.039]	[0.017]	[0.023]	[0.025]	[0.019]	[0.008]	[0.018]
2010q4-2011q3	-0.047	-0.03	0.004	-0.034	0.006	-0.003	-0.007	0.004
	[0.033]	[0.034]	[0.012]	[0.021]	[0.022]	[0.017]	[0.01]	[0.022]

Notes: Calculated from Table 9(a) coefficients for PTA in each period Q4yy at PTA mean risk.

Table 10: Aggregate Counterfactual: PTA Treatment and Permanent Income Equivalents

		Export Margin: Total	Export Margin: Extensive
2008Q4-2009Q3	Predicted Growth	6.0	7.9
	Income Equiv.	**9.4**	**15.3**
2008Q4-2011Q3	Predicted Growth	5.0	6.5
	Income Equiv.	**5.6**	**8.6**

Notes: Predicted midpoint growth calculated from Table 4 coefficients using non-PTA weighted mean risk of 0.22. Income equivalent is the 100xΔln growth in importer income required to offset the uncertainty effect in any period using the permanent income elasticities for the respective period in Table 4. See the text for the formula.

A Appendix: Theory

A.1 Value functions under uncertainty

The expected value of starting to export at time t conditional on observing current conditions a_t is

$$\Pi_e(a_t, c, r) = \pi(a_t, c) + \beta[\underbrace{(1-\gamma)\Pi_e(a_t, c, r)}_{\text{No Shock}} + \underbrace{\gamma \mathbb{E}\Pi_e(a', c, r)}_{\text{Shock}}], \tag{37}$$

which includes current operating profits upon entering and the discounted future value. Without a shock the firm value next period remains $\Pi_e(a_t, c, r)$. If a shock arrives then a new a' is drawn, so the third term is the ex-ante expected value of exporting following a shock, $\mathbb{E}\Pi_e(a', c, r) = \mathbb{E}\pi(a', c)/(1-\beta)$, where $\mathbb{E}$ denotes the expectation over a fixed and known distribution, M.[53]

The expected value of waiting is

$$\Pi_w(c, r) = 0 + \beta \underbrace{(1-\gamma+\gamma M(\bar{a}))\Pi_w(c, r)}_{\text{Wait}} + \beta \underbrace{\gamma(1-M(\bar{a}))(\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) - K)}_{\text{Enter}}. \tag{38}$$

A non-exporter at t receives zero profits from that activity today. The continuation value remains at Π_w if either demand is unchanged, with probability $1-\gamma$, or changes to some level that is not sufficiently high to induce entry, with probability $\gamma M(\bar{a})$. If demand changes and is above some endogenous trigger level, $a' \geq \bar{a}$, then we obtain the third term, reflecting the expected value of exporting net of the sunk cost, K, conditional on the new demand being high enough to trigger entry. The conditional expected value of exporting if $a' \geq \bar{a}$ is given by

$$\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) = \mathbb{E}\pi(a' \geq \bar{a}, c, r) + \beta(1-\gamma)\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) + \beta\gamma\mathbb{E}\Pi_e(a', c, r). \tag{39}$$

A firm with costs c_v is indifferent between entering or waiting if demand is at a threshold level $a_{c_v} = \bar{a}(c_v)$. Instead, of solving for $\bar{a}(c_v)$ we characterize the marginal exporting firm at any current demand, which is characterized by a cost parameter c_t^U defined by $a_t = \bar{a}(c_t^U)$.[54] If a firm has costs equal to this threshold then in that period all other firms in that industry with lower costs also export to that particular destination.

We obtain an expression for this cutoff by using the entry condition in (5); the value functions in (37), (38) and (39), and the expression for $\mathbb{E}\Pi_e$. As an intermediate step to gain some intuition we note that for the marginal entrant the sunk cost must equal the following:

$$K = \frac{\pi(a_t, c_t^U)}{1-\beta(1-\gamma)} + \frac{\beta\gamma}{1-\beta}\frac{\mathbb{E}\pi(a', c_t^U)}{1-\beta(1-\gamma)} + \frac{\beta\gamma(1-M(a_t))}{1-\beta}\frac{\pi(a_t, c_t^U) - \mathbb{E}\pi(a' \geq a_t, c_t^U)}{1-\beta(1-\gamma)}. \tag{40}$$

If $\gamma = 0$ then there is no demand uncertainty and $K = \frac{\pi(a_t, c_t^D)}{1-\beta}$, i.e. it would be equal to the present discounted value of profits evaluated at the current demand, where c_t^D is the marginal cost for the marginal entrant when $\gamma = 0$. If demand can change then the current profit is discounted at a higher rate that captures the probability of a demand shock; K must now cover the value of profits until demand changes (first term), plus the expected profits following the change (second term), and the third term, which is the expected loss of entering today given that conditions can eventually improve. This last term is negative and captures the option value of waiting.

[53] This term is time invariant because the distribution of future conditions *after a shock*, $M(a')$, is time invariant so even if there is a new a at $t+1$ this provides no additional information at time t about future conditions. The conditional mean of a and the expected value of exporting, $\Pi_e(a_t, c, r)$, vary over time since they depend on current conditions.

[54] We can do so since a is common to all firms exporting to a given market in a given industry and the marginal cost is the only source of heterogeneity among such firms. Assuming a continuum of firms in any given industry with productivity that can be ranked according to a strictly increasing CDF, we can find the marginal export entrant for any a_t.

A.2 Cutoff: single uncertainty state

To derive the cutoff in eq. (6) from the text we rearrange (40) as follows

$$
\begin{aligned}
K &= \frac{\pi(a_t, c_t^U)}{1-\beta(1-\gamma)} + \frac{\beta\gamma}{1-\beta}\frac{\mathbb{E}\pi(a', c_t^U)}{1-\beta(1-\gamma)} + \frac{\beta\gamma\,(1-M(a_t))}{1-\beta}\frac{\pi(a_t, c_t^U) - \mathbb{E}\pi\left(a' \geq a_t, c_t^U\right)}{1-\beta(1-\gamma)} \\
\frac{a_t\left(c_t^D\right)^{1-\sigma}}{1-\beta} &= \frac{a_t\left(c_t^U\right)^{1-\sigma}}{1-\beta(1-\gamma)} + \frac{\beta\gamma}{1-\beta}\frac{\left(c_t^U\right)^{1-\sigma}\mathbb{E}(a')}{1-\beta(1-\gamma)} + \frac{\beta\gamma\,(1-M(a_t))}{1-\beta}\frac{a_t\left(c_t^U\right)^{1-\sigma} - \left(c_t^U\right)^{1-\sigma}\mathbb{E}\left(a' \geq a_t\right)}{1-\beta(1-\gamma)} \\
\left(\frac{c_t^U}{c_t^D}\right)^{\sigma-1} &= \frac{1-\beta}{1-\beta(1-\gamma)} + \frac{\beta\gamma}{1-\beta(1-\gamma)}\left(\frac{\mathbb{E}(a') + (1-M(a_t))\left[a_t - \mathbb{E}\left(a' \geq a_t\right)\right]}{a_t}\right) \\
\frac{c_t^U}{c_t^D} &= \left[1 + \frac{\beta\gamma\left[\bar{\omega}(a_t) - 1\right]}{1-\beta(1-\gamma)}\right]^{\frac{1}{\sigma-1}} \equiv U_t
\end{aligned}
$$

where the second line uses the equilibrium cutoff under no uncertainty, defined by $K = \frac{\pi(a_t, c_t^D)}{1-\beta}$ and the definition of the profit function. The third re-arranges and the fourth uses the definition of $\bar{\omega}$ in (7) (after recognizing that $\mathbb{E}(a') - (1-M(a_t))\,\mathbb{E}\left(a' \geq a_t\right) = M(a_t)\mathbb{E}(a' \leq a_t)$).

A.2.1 Proof of Proposition 1

In order to prove Proposition 1, we start by proving a lemma and then we use this lemma to prove Proposition 1. First, assume that there is only one state, $S = 1$ such that $M(a) = H_s(a)$ and we abuse notation by denoting as $H(a)$. Under this assumption, we state the following definition and lemma:

Definition: Uncertainty Ranking $r' = \{\gamma', H'(a)\}$ is more uncertain than r if it has either higher volatility, defined as $\gamma' > \gamma$, and/or risk, defined as H second-order stochastically dominating (SSD) H'.

Lemma 1: Uncertainty Shocks and Entry An increase in the demand regime uncertainty reduces net entry: $c_t^U(r') \leq c_t^U(r)$. Moreover, the volatility and risk components of uncertainty have a complementary effect on entry: $\frac{\partial \ln c_t^U\left(\gamma, H'\right)}{\partial\gamma} \leq \frac{\partial \ln c_t^U(\gamma, H)}{\partial\gamma}$.

We split the lemma into each of the components of the demand regime: $r = \{\gamma, H\}$ as follows.

(a) **For given H, a riskier demand regime ($\gamma' > \gamma$) reduces entry**: $c_t^U(\gamma') \leq c_t^U(\gamma)$.

Using (6), $S = 1$, and the definition of U we obtain:

$$
\begin{aligned}
\frac{\partial \ln c_t^U}{\partial\gamma} &= \frac{1}{\sigma-1}\frac{\partial}{\partial\gamma}\ln\left(1 + \frac{\beta\gamma\left[\bar{\omega}(a_t) - 1\right]}{1-\beta(1-\gamma)}\right) \\
&= \frac{1}{\sigma-1}\frac{\beta(1-\beta)}{1-\beta(1-\gamma)}\frac{\bar{\omega}(a_t) - 1}{1-\beta(1-\gamma\omega(a_t))} \leq 0
\end{aligned}
\tag{41}
$$

Recall that $\beta \in (0,1)$ and $\bar{\omega} \geq 0$ so the inequality follows iff $\bar{\omega}(a_t) - 1 = \omega_s(a_t) - 1 = -H(a_t)\frac{a_t - \mathbb{E}(a' \leq a_t)}{a_t} \leq 0$, which is true since the CDF $H(a_t) \leq 1$ and $\mathbb{E}(a' \leq a_t) \leq a_t$ (by definition). Moreover, $c_t^U(\gamma') < c_t^U(\gamma)$ for all $a_t > a_{\min}$ since then $\bar{\omega}(a_t) < 1$.

(b) **For given $\gamma > 0$, a riskier demand regime (H SSD H') reduces entry**: $c_t^U(H') \leq c_t^U(H)$

From (6), (7) and (8) we see that H affects entry only through ω_s and the latter only affects entry if $\gamma > 0$. Thus there is (weakly) less entry under r' than an alternative regime r with the same γ but a H that

SSD H' iff $\omega_s \geq \omega_s'$. To see that is the case we first rewrite ω as

$$\begin{aligned}\omega_s(a_t) &= 1 - H(a_t) + \frac{H(a_t)}{a_t}\int_0^{a_t} ah\left(a|a \leq a_t\right)da \\ &= 1 - H(a_t) + \frac{1}{a_t}\int_0^{a_t} adH\left(a\right) \\ &= 1 - H(a_t) + \frac{1}{a_t}\left(aH\left(a\right)|_0^{a_t} - \int_0^{a_t} H\left(a\right)da\right) \\ &= 1 - \frac{1}{a_t}\int_0^{a_t} H\left(a\right)da\end{aligned}$$

where the first line uses definition of ω_s and of the conditional mean and the second uses $h\left(a|a \leq a_t\right) = h\left(a\right)/H\left(a_t\right)$ and $dH\left(a\right) = h\left(a\right)da$. The third line uses integration by parts and the fourth simplifies. We can do the same for ω_s' and subtract from ω_s to obtain

$$\omega_s - \omega_s' = \frac{1}{a_t}\left[\int_0^{a_t} H'\left(a\right)da - \int_0^{a_t} H\left(a\right)da\right] \geq 0$$

If H SSD H' then the inequality in brackets follows for all a_t with strict inequality for at least some a_t. The weak inequality in $c_t^U\left(H'\right) \leq c_t^U\left(H\right)$ allows for the *possibility* that the distributions overlap at low a_t or if $a_t = a_{\max}$ and H is a mean preserving compression of H'.

The proof of Proposition 1 is simple given what is established in Lemma 1, which corresponds to the special case where $m_s = 1$. Lemma 1 shows that if the distribution of a is $M\left(a\right)$ then $\omega\left(a_t\right) - 1 = -\frac{1}{a_t}\int_0^{a_t} M\left(a\right)da$ and using the mixture definition of M we obtain $\omega\left(a_t\right) - 1 = -\sum_{s\in S} m_s \frac{1}{a_t}\int_0^{a_t} H_s\left(a\right)da$. This is equivalent to $\omega\left(a_t\right) = \sum_{s\in S} m_s\omega_s\left(a_t\right)$ since $\omega_s\left(a_t\right) - 1 = -\frac{1}{a_t}\int_0^{a_t} H_s\left(a\right)da$ and $\sum_s m_s = 1$. From here, the results from Proposition 1 follow from Lemma 1.

A.2.2 Proof: Proposition 2

PTA motive and policy parameter changes under market access and export risk averse objective

We first show that the government objective in (12) implies a PTA motive for lower current protection and reduced export risk. By definition the exporter government has a PTA motive if there is some change in $\left\{\Delta_\varsigma^{PTA}, \Delta_m^{PTA}\right\}$ s.t. $G^{PTA} > G^{M'}$. We modeled a government that values market access and is export risk averse as one where (i) $G_{a_t} > 0$ and (ii) $G\left(a_t, M\left(a\right), \gamma\right) \geq G\left(a_t, M'\left(a\right), \gamma\right)$ for all a_t whenever M SSD M' (with equality at $\gamma = 0$). Thus there is a $\Delta_\varsigma^{PTA} < 0$ that increases its objective since

$$\frac{dG\left(a_t, M\left(a\right), \gamma\right)}{d\varsigma} = G_{a_t}\frac{\partial a_t}{\partial\varsigma} = -G_{a_t}\frac{\varepsilon y}{\varsigma^2} < 0$$

where the first equality uses the fact that current policy affects G only through current business conditions and the chain rule; the second uses the definition of a in (9). The inequality follows from $G_{a_t} > 0$.

In Lemma 1 we show M SSD M' is equivalent to $\omega_s\left(a_t\right) \geq \omega_s'\left(a_t\right)$ for all a_t, a similar condition holds for the mixture case used in proposition 1. So the risk averse government benefits from a $\Delta_m^{PTA} = m^{PTA} - m$ such that

$$\begin{aligned}m^{PTA}\omega_{s'}\left(a_t\right) + \left(1 - m^{PTA}\right)\omega_s\left(a_t\right) &\geq m\omega_{s'}\left(a_t\right) + \left(1 - m\right)\omega_s\left(a_t\right) \\ \left[\omega_{s'}\left(a_t\right) - \omega_s\left(a_t\right)\right]\Delta_m^{PTA} &\geq 0\end{aligned} \tag{42}$$

PTA entry effects

To derive the entry effects of PTAs we use the cutoff in (6).

Entry impacts of Δ_m^{PTA}. The cutoff is increasing in $\bar{\omega}$ (proposition 1b) and thus higher under a PTA characterized by an insurance effect since as shown above it is characterized by $\bar{\omega}^{PTA} > \bar{\omega}$ if $\gamma > 0$. The effect is given by

$$\frac{\partial \ln c_t^U}{\partial m} \Delta_m^{PTA} = \frac{\left[\omega_{s'}(a_t) - \omega_s(a_t)\right] \Delta_m^{PTA}}{\sigma - 1} \frac{\beta\gamma}{1 - \beta\left(1 - \gamma\bar{\omega}(a_t)\right)} > 0 \tag{43}$$

where the inequality is due to (42), $\bar{\omega} \in (0, 1)$ and $\sigma > 1$.

A.3 Adjustment dynamics

Derivation of (19) Using (17), (18) we see $\hat{N}_t^0 = \hat{F}_t$ directly and derive $\hat{N}_t^+$ as follows

$$\begin{aligned} N_t &= nF_t + \beta^t n\left[F_0 - F_t\right] \\ \frac{N_t}{N_0} - 1 &= \frac{F_t}{F_0} - 1 + \beta^t \left[1 - \frac{F_t}{F_0}\right] \\ \hat{N}_t^+ &= \left(1 - \beta^t\right) \hat{F}_t \end{aligned}$$

For crisis we first rewrite N_t^- using $\lambda_t^- = \beta\left[N_{t-1} - nF_t\right]$ so the fraction of exporters β that survived from the previous period that have costs below the current cutoff, $N_{t-1} - nF_t$ and then iterate backwards to show that

$$\begin{aligned} N_t^- &= (1-\beta)\left[\textstyle\sum_{T=1}^{t} \beta^{t-T} nF_T\right] + \beta^t nF_0 \\ \frac{N_t^-}{N_0} - 1 &= (1-\beta)\left[\textstyle\sum_{T=1}^{t} \beta^{t-T} \frac{F_T}{F_0}\right] + \beta^t - 1 \\ \frac{N_t^-}{N_0} - 1 &= (1-\beta)\left[\textstyle\sum_{T=1}^{t} \beta^{t-T} \left(\frac{F_T}{F_0} - 1\right)\right] + \left\{\beta^t - 1 + (1-\beta) \sum_{T=1,\dots t} \beta^{t-T}\right\} \\ \hat{N}_t^- &= (1-\beta)\left(\hat{F}_t + \textstyle\sum_{T=1}^{t-1} \beta^{t-T} \hat{F}_T\right) \\ \hat{N}_t^- &= (1-\beta)\left(\hat{F}_t + \textstyle\sum_{T=1}^{t-1} \beta^{t-T} \hat{F}_t - \sum_{T=1}^{T=t-1} \beta^{t-T} \left(\hat{F}_t - \hat{F}_T\right)\right) \\ \hat{N}_t^- &= \left(1-\beta^t\right)\hat{F}_t + (1-\beta) \textstyle\sum_{T=1}^{T=t-1} \beta^{t-T} \left(\hat{F}_T - \hat{F}_t\right) \end{aligned}$$

where the third line uses the formula for a geometric sum so the last term is $\{0\}$.

There are four relevant points for estimation. First, we must allow for differential coefficients in expansion and other periods on the determinants of the cutoff changes. The elasticity of entry growth with respect to $\hat{F}_t$ is unity for expansion, which is higher than for recovery and crisis since the latter two reflect legacy. Second, in the first crisis period we have $\hat{N}_t = \left(1 - \beta^t\right) \hat{F}_t$, an expression similar to the recovery, and that is also the case if most of the shock occurs in that first period, so $\hat{F}_T \approx \hat{F}_t$. Otherwise, we need to adjust that growth upwards to account for recent cutoff changes, e.g. if the crisis lasts two periods we have that in the second one $\hat{N}_2 = \left(1 - \beta^2\right) \hat{F}_2 + (1-\beta)\beta\left(\hat{F}_1 - \hat{F}_2\right)$. Third, we can also use the results above to consider differential growth between any two periods, e.g. $\hat{N}_{t+1}^+ - \hat{N}_t^-$. Fourth, if we consider a constant elasticity distribution, such as Pareto, then $\hat{F}_t = \left(\hat{c}_t^U\right)^k - 1$ so we obtain a closed form solution for the elasticity of the growth in exporters with respect to the change of the current cutoff relative to the previous expansion.

Growth in domestic firms

The number of exporters is obtained by modifying (17) and the legacy terms in (18) and combining them to obtain

$$N_t = \begin{cases} n_t F_t & \mathbf{1}_t^0 = 1 \\ n_t F_t + \beta^t n_0 \left[F_0 - F_t\right] & \mathbf{1}_t^+ = 1 \\ n_t F_t + \beta\left[N_{t-1} - n_{t-1} F_t\right] & \mathbf{1}_t^- = 1 \end{cases}$$

In accounting for legacy we adjust for the number of firms present in the period when the shock occurred.

Note that we used $\lambda_t^- = \beta \left[N_{t-1} - nF_t\right]$ as explained in the derivation above. The growth rate relative to $N_0 = n_0 F_0$ is then

$$\hat{N}_t = \begin{cases} \hat{F}_t + \hat{n}_t \left(1 + \hat{F}_t\right) & \mathbf{1}_t^0 = 1 \\ \left(1 - \beta^t\right) \hat{F}_t + \hat{n}_t \left(1 + \hat{F}_t\right) & \mathbf{1}_t^+ = 1 \\ \left(1 - \beta\right) \left(\hat{F}_t + \sum_{T=1}^{t-1} \beta^{t-T} \hat{F}_T\right) + \hat{n}_t + \sum_{T=1}^{t} \beta^{t-T} \hat{F}_T \left(\hat{n}_T - \beta \hat{n}_{T-1}\right) & \mathbf{1}_t^- = 1 \end{cases}$$

Comparing to (19) we see there is an additional first order effect term, $\hat{n}_t$, common to all histories. The interaction term $\hat{n}_t \hat{F}_t$ is common to expansion and recovery. The interaction term for the crisis accounts for the fact that the potential number of firms changes along with the cutoff.

B Appendix: Data and Estimation

B.1 Income Risk Measure

To construct our measure of income risk, we assume that the log of GDP ($\ln Y_{i,t}$) for country i follows an AR(1) process in differences with a Gaussian distributed error term:

$$\Delta_4 \ln Y_{i,t+1} = a_i + \rho_i \Delta_4 \ln Y_{i,t} + \epsilon_{i,t+1}$$

We estimate the parameters for each i using quarterly frequency data for entire period from 2001 to 2012. We compute the uncertainty measure as the share of GDP that a country will lose in the next period if a bad shock arrives $unc_{i,T} = 1 - \mathbb{E}_Y[Y_i' < \hat{Y}_i^{0.05}]/Y_{i,T}$. We implement this empirically as

$$unc_{i,T} = 1 - \frac{\exp(\hat{a}_i + \hat{\rho}_i \Delta_4 \ln Y_{i,T} + \hat{\epsilon}_{i,0.05} + 0.5\widehat{\sigma}^2_{\epsilon,i})}{Y_{i,T}} \times \frac{\Phi\left(\frac{\hat{\epsilon}_{i,0.05}}{\widehat{\sigma}_{\epsilon,i}} - \widehat{\sigma}_{\epsilon,i}\right)}{0.05} \text{ for each } i \tag{44}$$

using T as the fourth quarter of 2001 and $\Phi(\cdot)$ is the CDF of a standard Normal distribution. Then a shock to growth rates at the 5th percentile of the income distribution is $\hat{\epsilon}_{i,0.05} = \Phi^{-1}(0.05) \times \widehat{\sigma}_{\epsilon,i}$ The resulting income uncertainty measure is the expected profit loss from a bad income shock to GDP in the fourth quarter of 2001. This approach highlights the role of severe shocks, such as the GTC. We use GDP levels in 2001 to construct the measure because it pre-dates our regression sample. Moreover, we hold this measure fixed over time for each country. The rank correlation of $unc_{i,T}$ and the $\hat{\sigma}_{\epsilon,i}$ estimate from the AR(1) is 0.82.

B.2 Data Sources and Definitions

Firm and Firm-Product Exports

- Firm: A firm is a single or multi-unit enterprise as defined in the Business Register (Standard Statistical Establishment List). Trade flows not matched to a firm are dropped.
- Firm-Product Variety: We concord 10 digit Schedule B export commodity codes (6 digit Harmonized System + 4 digit statistical classification) using the method of Pierce and Schott (2009). This ensures that entry, exit, and churning of varieties is not the result of spurious re-classification of commodities across statistical codes. We then define varieties within each destination and industry by the firm-product pair.
- Entry: A firm or firm-product variety that is traded at time t but was non-traded at time $t - 4$.
- Exit: A firm or firm-product variety that is non-traded at time t but was traded at time $t - 4$.
- Continuers: A firm or firm-product variety that is traded at both time t and $t - 4$.

Change in GDP (ln): Change in lnGDP from t to the same quarter in $t-4$

$\mathbf{PTA_{it}}$ **(binary):** Indicator for PTA membership. Source: website of U.S. Trade Representative for implementation dates. We use the seven countries that had a PTA in place by 2006 or earlier and quarterly GDP data. These countries and their implementation dates are: Israel (1985), Canada (1989), Mexico (1994), Chile (2004), Australia (2005), Guatemala (2006), and Morocco (2006).

Q4YY (binary): Indicator equal to unity for 4 quarter period between in 4th quarter(Q) of year YY $\in \{08, 09, 10\}$

Income Risk: Measure of income risk as defined in equation (44)

Temporary Trade Barrier (TTB) Coverage Ratio: Source: World Bank Global Anti-Dumping Database (Bown, 2016) available at `http://econ.worldbank.org/ttbd/gad/`. This database contains measures of TTBs by destination-HS6-quarter-year level. Definition: We include all measures in place but not revoked before 2003 or measures implemented any time from 2003 to 2011. We compute the coverage ratio as the fraction of its HS6 products within a destination-HS-2 digit industry covered by any TTB, which includes anti-dumping duties, countervailing duties, and special safeguards.

Inventory Levels (ln): Source: NBER-CES Manufacturing Productivity Database. Definition: We concord NAICS industry codes to HS 2-digit industry codes using the concordance to NAICS 2007 from Pierce and Schott (2009). We then compute mean inventory levels within an HS-2. In the robustness checks we include the log of this measure interacted with time period dummies. In unreported results we also use mean inventories weighted by total value of shipments for each industry in an HS-2.

High Durables Share (binary): We classify goods into durables and non-durables trade following the SITC-based classification in Engel and Wang (2011). We concord SITC into the HS and then compute the share of durables exports by destination and HS 2-digit industry in 2001 and 2002 using the LFTTD matched data. We discretize this pre-sample share into High Durables (top tercile of shares) and Low Durables (bottom two terciles).

High/Low Market Power Industry Groups: We describe construction in section 4.4. Low MP HS-2 Chapters are: 02, 04, 07, 08, 10-12, 15-22, 24-29, 31, 47, 48, 51-55, 72, 79, 80. High MP HS-2 Chapters are: 01, 03, 05, 06, 09, 13, 14, 23, 30, 32-46, 49, 50, 56-71, 73-76, 78, 81-97.

C Online Empirical Appendix

Table C1: List of non-PTA and PTA countries in regression sample

Non-PTA Countries		PTA Countries
Argentina	Kazakhstan*	Australia (2005)
Armenia, Republic of	Korea, Republic of	Canada (1989)
Austria	Kyrgyz Republic	Chile (2004)
Azerbaijan, Republic of*	Latvia	Guatemala (2006)
Belarus*	Lithuania	Israel (1985)
Belgium	Luxembourg	Mexico (1994)
Bolivia	Macao	Morocco (2006)
Botswana	Malaysia	
Brazil	Malta	
Bulgaria	Mauritius	
Colombia	Moldova	
Croatia	Netherlands	
Cyprus	New Zealand	
Czech Republic	Norway	
Denmark	Philippines	
Ecuador	Poland	
Estonia	Portugal	
Finland	Romania	
France	Russian Federation*	
Georgia	Serbia, Republic of*	
Germany	Slovak Republic	
Greece	Slovenia	
Hong Kong	South Africa	
Hungary	Spain	
Iceland	Sweden	
Indonesia	Switzerland	
Ireland	Thailand	
Italy	Turkey	
Jamaica	Ukraine†	
Japan	United Kingdom	

Notes: * Not WTO/GATT member during sample period. †Joins WTO in 2008.

Table C2: Entry and Export Growth--Robustness to Timing of Recession and Crisis

	Net entry		Export Growth	
	Δln	**midpoint growth**	**Δln**	**midpoint growth**
Non-PTA				
Uncertainty*Q407	-0.172***	-0.159***	0.0963	0.0772
	[0.0585]	[0.0536]	[0.108]	[0.0780]
Uncertainty*Q408	-0.345***	-0.305***	-0.463***	-0.253**
	[0.0717]	[0.0660]	[0.146]	[0.108]
Uncertainty*Q409	-0.174***	-0.158***	-0.359***	-0.283***
	[0.0563]	[0.0520]	[0.120]	[0.0900]
Uncertainty*Q410	-0.263***	-0.244***	-0.162	-0.102
	[0.0526]	[0.0483]	[0.115]	[0.0803]
PTA				
PTA*Uncertainty*Q407	0.559**	0.551**	0.0302	0.138
	[0.262]	[0.245]	[0.500]	[0.372]
PTA*Q407	-0.120**	-0.118**	0.0341	-0.00451
	[0.0581]	[0.0539]	[0.111]	[0.0819]
PTA*Uncertainty*Q408	1.631***	1.510***	1.831***	1.119***
	[0.277]	[0.266]	[0.532]	[0.434]
PTA*Q408	-0.290***	-0.268***	-0.294**	-0.180*
	[0.0591]	[0.0567]	[0.121]	[0.1000]
PTA*Uncertainty*Q409	0.607**	0.582**	0.748	0.544
	[0.252]	[0.239]	[0.499]	[0.368]
PTA*Q409	-0.133**	-0.128**	-0.165	-0.116
	[0.0568]	[0.0538]	[0.117]	[0.0860]
PTA*Uncertainty*Q410	0.0319	0.0321	0.320	0.279
	[0.178]	[0.170]	[0.356]	[0.278]
PTA*Q410	-0.00810	-0.00801	-0.0706	-0.0658
	[0.0408]	[0.0392]	[0.0813]	[0.0644]
PTA*Uncertainty	-0.499**	-0.482**	-0.414	-0.350
	[0.206]	[0.193]	[0.407]	[0.307]
PTA	0.131***	0.126***	0.132	0.114*
	[0.0472]	[0.0445]	[0.0880]	[0.0648]
Observations	160,000	160,000	160,000	160,000
R-squared	0.049	0.052	0.049	0.056
Quarter-Year FE	Yes	Yes	Yes	Yes
Country*HS2 FE	Yes	Yes	Yes	Yes

Notes:

Aggregation level: country-HS2-quarter of varieties defined at the firm-country-HS10 level. Dependent variable in column 1 is log growth and col. 2 the midpoint growth in the number of varieties exported in a country-HS2-quarter. For columns 3 and 4 it is the respective export values. We use uncertainty estimates from AR(1) country-specific regressions. See details in text. Robust standard errors clustered at the destination country by time period level (pre-crisis period and the year long periods with start date denoted by the Q4## indicators). *,**,*** Sig. different from 0 at 10%, 5% and 1% respectively. GDP growth by time period controls suppressed from output.

D Online Theory Appendix

D.1 Log-normal shocks

We construct Figure 7 by assuming a follows a log normal $H(\mu, \Sigma)$. If the arithmetic mean of a is normalized to unity then $\exp\left(\mu + \Sigma^2/2\right) = 1 \Leftrightarrow \mu = -\Sigma^2/2$ such that if $\Sigma' > \Sigma$ then $a' \tilde{} H(\mu', \Sigma')$ is a mean preserving spread of a. More generally, if $\mu = -\alpha\Sigma^2/2$ and $\alpha \geq 1$ then H SSD H' (cf. Levy, 1973). The graphs focus on the special MPS case so $\alpha = 1$. The mixture distribution is $M = mH + (1-m)H'$. Figure 7(b) uses U and $\bar{\omega}$ derived in proposition 2. The specific expressions for the Figure 7(a) and (b) are respectively:

$$\begin{aligned} M &= m\frac{(1-A)}{2} + (1-m)\frac{(1-A')}{2} \\ \ln U &= \frac{1}{\sigma-1}\ln\left(1 + \frac{\beta\gamma}{1-\beta(1-\gamma)}\left(-\frac{1}{a_t}\left(\int_0^{a_t}\left(m\frac{1-A}{2} + (1-m)\frac{1-A'}{2}\right)da\right)\right)\right) \end{aligned}$$

where $A \equiv \operatorname{erf}(-(\ln a - \mu)/(\Sigma\sqrt{2}))$; $A' \equiv \operatorname{erf}(-(\ln a - \mu')/(\Sigma'\sqrt{2}))$ and erf denotes the error function for the normal distribution.

Parameters: $\Sigma = 1/8, \Sigma' = 2/3, \gamma = 1, \sigma = 3, \beta = 0.765$.

D.2 Economic and Policy Risk Interaction: Implications for Demand Uncertainty and Agreements under log normal shocks

We assumed exogenous distributions, $H(a)$, and now show:

1. How it depends on the parameters of the joint density of two fundamental shocks x if $a = \prod x$
2. When increases in risk in either x increases risk in a
3. Conditions to map x to exogenous economic parameters.

The results below apply for each country-industry iV but we drop those subscripts and rewrite business conditions as:

$$a_t = D_t \times f_t$$

where $D_t = \varepsilon Y_t P_t^{\sigma-1}$ is the demand shifter common to domestic and foreign firms and $f_t \equiv \tau_t^{-\sigma}$ measures the "freeness" of trade and equals the relative demand of foreign to domestic varieties for any given producer price.

The distribution we model below is general enough to accommodate different relationships between the underlying shocks through different parameters. But if we wanted to map each distribution to specific variables then f would be mapped to an ad valorem tariff distribution for any given σ. The distribution of D reflects income spent on an industry and industry price index shocks. Under additional assumptions the distribution of D would be equal to the aggregate income distribution up to some industry level constant constant $\varepsilon P^{\sigma-1}$.[55]

Assumption 1: Joint log normal shocks.
$x = \{D, f\}$ are drawn from a bivariate log normal with correlation η and mean and standard deviation of each $\ln x$ denoted by (μ_x, Σ_x).

Distribution of a under A1

$$\begin{array}{lcl} x \sim \ln N(\mu_x, \Sigma_x) & & x = \{D, f\} \\ a \sim \ln N(\mu, \Sigma) & \mu = \mu_D + \mu_f \; ; & \Sigma^2 = \Sigma_D^2 + \Sigma_f^2 + 2\eta\Sigma_f\Sigma_D \end{array} \quad (45)$$

[55] This requires a fixed ε, as we assume and a fixed price index. The latter holds if the mass of domestic firms in each i is fixed and there are no fixed domestic costs of entry in that market, so P_{iVt}, is independent of Y_t, and if the exporter is small so P_{iVt} is independent of τ_{iVt}.

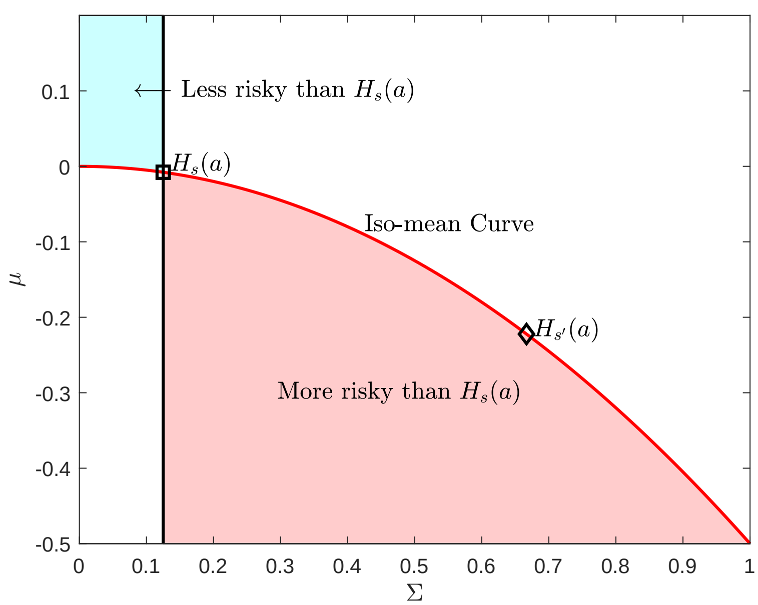
The log normal ensures non-negative values for each x, and thus for a; allows for heavy tails and provides a parametric ranking of distributions according to SSD.

SSD ranking for any log normal (Levy, 1973):
Under A1, $H_s(a)$ SSD $H_{s'}(a)$ iff (1) $\Sigma \leq \Sigma'$; (2) $\mu \geq \mu'$; and (3) $\mu + \Sigma^2/2 \geq \mu' + \Sigma'^2/2$ with either (1) and/or (2) strict.

Conditions (1) and (2) are required to rank normal distributions, e.g. $\ln a$, but ordering distributions of a also requires (3) to ensure $\mathbf{E}_s(a) \geq \mathbf{E}_{s'}(a)$. Since each x is also log normal we can apply the same ranking conditions to (μ_x, Σ_x).

Figure D1 shows the ranking over (μ, Σ). The red curve represents the combinations of parameters such that (3) holds with equality, in particular an iso-arithmetic mean $\mathbf{E}_s(a) = \exp\left(\mu + \Sigma^2/2\right) = 1$. This was the value used in Figure 7 and the vertical line denotes the value of Σ used for H_s. So the box at the intersection represents H_s from Figure 7 and any $H_{s'}$ along the iso-mean with $\Sigma' > \Sigma$ represents a MPS, e.g. the diamond marks $H_{s'}$ plotted in Figure 7. More generally, the depicted H_s SSD any $H_{s'}$ in the area below the iso-mean curve and $\Sigma \leq \Sigma'$. Any distribution in the area above the iso-mean with a parameter lower than Σ will SSD H_s. The remaining ones cannot be ordered. Only those along the vertical line can be ranked relative to H_s in the FOSD sense.

Figure D1: Risk Ranking of $H(a)$ and relation to Economic and Policy Risk



Notes: Red curve is the iso-arithmetic mean such that $\mathbf{E}_s(a) = \exp\left(\mu + \Sigma^2/2\right) = 1$. The box marks $H_s(a)$ and the diamond marks $H_{s'}(a)$ from Figure 7. $H_s(a)$ SSD any distributions in the region shaded in light red, i.e. the set of distributions s' with higher variance and mean that is equal to or lower than under $H_s(a)$). Any distributions in the region shaded in light blue SSD $H_s(a)$.

The following proposition examines the impact of risk shocks to x on demand uncertainty, i.e. on whether $H(\boldsymbol{\mu}_x, \boldsymbol{\Sigma}_x)$ SSD $H(\boldsymbol{\mu}'_x, \boldsymbol{\Sigma}'_x)$

Proposition A1: Impact of Economic and Policy Risk Shocks on Demand Uncertainty
If $a = \prod x$ and x is bivariate log normal with correlation η and parameters (μ_x, Σ_x) then

(a) Any increase in risk of either x (i) increases demand uncertainty for any $\eta \in [\underline{\eta}, \overline{\eta}]$ and (ii) never decreases demand uncertainty for any η.

(b) If $\eta \geq 0$ then there always exists some increase in the risk of either x that increases demand uncertainty.

To provide some intuition and implications consider first the case with uncorrelated shocks—included in the interval in (a) part(i) since $\underline{\eta} < 0 < \overline{\eta}$. An increase in the risk in x must satisfy conditions (1-3) applied to $\left(\mu_x, \Sigma_x^2\right)$ and when $\eta = 0$ we see in (45) that $\left(\mu, \Sigma^2\right)$ are linear in $\left(\mu_x, \Sigma_x^2\right)$ so the SSD conditions for a are also satisfied. When the initial $\left(\boldsymbol{\mu}_x, \boldsymbol{\Sigma}_x^2\right)$ generate the H_s shown in Figure D1 and $\eta = 0$ then there is an AMPS of either x that implies the $H_{s'}$ represented by the diamond and any other distribution of x that is riskier than the original and has similar Σ_x' will imply a distribution of a on the vertical line below that point.

Consider the case when all destinations have the same marginal income density, as our model assumes, and thus the same marginal distribution of D. If those shocks are uncorrelated with f then a non-PTA destination with riskier f has higher overall demand uncertainty. If $\eta < 0$ then the increase in Σ is lower than the increase in Σ_f . But if the correlation is sufficiently close to zero (or the other shock is not too variable) then the direct effect described under $\eta = 0$ dominates and uncertainty increases. If $\eta < \underline{\eta} < 0$ then $\Sigma' < \Sigma$ since policy shocks tend to at least partially offset the income shocks but the mean of a is also lower so we can't rank them.

The existing evidence suggests that it is more plausible that $\eta > 0$. In this case the increase in Σ is magnified so condition (1) is still satisfied but if $\eta > \overline{\eta}$ then a may have a higher arithmetic mean so (3) may fail. This mean effect arises in the presence of multiplicative shocks. Indeed if we considered the previous AMPS of f under $\eta > 0$ then the implied $H_{s'}$ would be above the diamond and cannot therefore be ranked relative to H_s but we can establish that it does not decrease uncertainty (part ii). Moreover, for the same increase in Σ_f there is always some increase in the uncertainty of f (with a low enough f) that implies a riskier a (part (b)).

This proposition highlights two new roles of policy risk increases in the presence of other shocks that are multiplicative: an insurance effect when $\eta < \underline{\eta} < 0$ and a mean effect when $\eta > \overline{\eta}$.

What are the implications of proposition 4 for the type of policy agreements that may emerge between different countries when they can only change policy uncertainty via the distribution of f (as opposed to changing any mixing weights m)? When the government is export risk averse, as we define in the text, then it would only accept an agreement that reduces foreign demand uncertainty, which rules out any agreements that increase policy uncertainty (proposition 4(a)-ii). Moreover, if $\eta > 0$, then the agreement must actually reduce policy uncertainty (proved below).

D.2.1 Proof: Proposition A1

We denote increases in uncertainty in x by $\Delta\Sigma_x \equiv \Sigma_x' - \Sigma_x \geq 0$, $\Delta\mu_x \equiv \mu_x' - \mu_x \leq 0$ (with either or both strict) and $\delta_x \equiv \mu_x' + \left(\Sigma_x'\right)^2/2 - \left(\mu_x + \left(\Sigma_x\right)^2/2\right) \leq 0$, where the latter is the percent decrease in the arithmetic mean of x , we denote the average of the scale parameters by $\bar{\Sigma}_x \equiv \left(\Sigma_x' + \Sigma_x\right)/2$.

Consider $x = f$ without loss of generality.

(a) Under A1 $H_s(a)$ SSD $H_{s'}(a)$ iff conditions (1)-(3) hold:

(1) Scale parameter condition: satisfied iff $\eta \geq -\frac{\bar{\Sigma}_f}{\Sigma_D} \equiv \underline{\eta}$

$$
\begin{aligned}
\Sigma^2 &\leq \left(\Sigma'\right)^2 \\
\Sigma_D^2 + \Sigma_f^2 + 2\eta\Sigma_f\Sigma_D &\leq \Sigma_D^2 + \Sigma_f'^2 + 2\eta\Sigma_f'\Sigma_D \\
\left(\Sigma_f - \Sigma_f'\right)\left(\Sigma_f + \Sigma_f'\right) &\leq 2\eta\Sigma_D\left(\Sigma_f' - \Sigma_f\right) \\
\eta &\geq -\frac{\left(\Sigma_f + \Sigma_f'\right)/2}{\Sigma_D}
\end{aligned}
$$

(2) Location parameter condition: satisfied all η

$$\begin{aligned} \mu &\geq \mu' \\ \mu_f + \mu_D &\geq \mu'_f + \mu'_D \Leftrightarrow \Delta\mu_x \leq 0 \end{aligned}$$

(3) Mean condition: satisfied iff $\eta \leq \frac{-\delta_f}{\Delta\Sigma_f}\frac{1}{\Sigma_D} \equiv \overline{\eta}$

$$\begin{aligned} \mu + (\Sigma)^2/2 &\geq \mu' + (\Sigma')^2/2 \\ \mu_f + \left(\Sigma_f^2 + 2\eta\Sigma_f\Sigma_D\right)/2 &\geq \mu'_f + \left(\Sigma_f'^2 + 2\eta\Sigma'_f\Sigma_D\right)/2 \\ -\eta\Sigma_D\Delta\Sigma_f &\geq \delta_f \end{aligned}$$

The second line in each of the conditions above uses the definitions of Σ and/or μ and the fact that Σ_D, μ_D and η are fixed.

To see the second part of (a), we need only show that for $\eta \notin (\frac{-\Sigma_f}{\Sigma_D}, \frac{-\delta_f}{\Delta\Sigma_f}\frac{1}{\Sigma_D}]$ the uncertainty of a can never decrease. Since (2) holds for all η a decrease in the uncertainty of a could only occur if $\mu = \mu'$, i.e. if $\Delta\mu_f = 0$ and in that case the scale and mean condition cannot simultaneously hold unless $\Sigma = \Sigma'$, which is impossible since an increase in uncertainty in f requires $\Delta\Sigma_f < 0$ if $\Delta\mu_f = 0$.

In the text we also claim that if $\eta \geq 0$ then a decrease in demand uncertainty for given economic uncertainty implies a reduction in policy uncertainty. This is shown using the conditions above by noting that $\eta \geq 0$ and $\Sigma \leq \Sigma' \Rightarrow \Sigma_f \leq \Sigma'_f$ and this along with the mean condition for a imply that the mean condition for the policy holds: $\delta_f \leq \eta\Sigma_D\left(\Sigma_f - \Sigma'_f\right) \leq 0$.

(b) From part (a) we see that if $\eta \geq 0$ then conditions (1) and (2) hold. Condition (3) holds for all η iff

$$\begin{aligned} \frac{-\delta_f}{\Delta\Sigma_f}\frac{1}{\Sigma_D} &\geq 1 \\ \delta_f &\leq -\Sigma_D\Delta\Sigma_f \\ \Delta\mu_f &\leq -\left(\left(\Sigma_f'^2 - \Sigma_f^2\right)/2 + \Sigma_D\Delta\Sigma_f\right) \end{aligned}$$

Since $\mu_f \in \mathbb{R}$ we can always find a μ'_f s.t. $\Delta\mu_f$ satisfies this condition.**QED**