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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). Policymakers attempt to address this by committing to predictable policy regimes.[1] We model the interaction of economic and policy uncertainty and show how governments can 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 to more foreign volatility (cf. DiGiovanni 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 tariff 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). However, the evidence is scarcer when it comes to policy uncertainty. This is unfortunate since thousands of firms worldwide rank it as an important business constraint (World Bank, 2004) and some prominent policy makers and economists believed it held back the U.S. recovery from the 2008 crisis.[2] The scarce evidence is partly due to the difficulty in measuring policy uncertainty, identifying its causal impact on specific investment decisions (Rodrik, 1991), and unbundling it from economic uncertainty.

The international trade setting provides a useful framework to overcome these problems. First, a firm's entry into an export market involves a sunk cost (cf. Roberts and Tybout, 1997) that can generate a higher option value of waiting to enter when uncertainty increases. Adverse foreign income shocks may trigger changes to trade policy and protectionist remedies in the destination market that expose the firm to international policy uncertainty. They include the threat of increasing protection by ending an agreement (e.g. Brexit), starting a trade war (e.g. the U.S. under the 45th president, cf. Handley and Limão, 2017b) or other policies that may magnify the shock to exporters while targeting other objectives.[3] Second, detailed records of firms' international transactions allow us to identify market entry, exit and sales at the product level and at a high frequency. Finally, firms face very heterogeneous economic and trade policy uncertainty across different countries.

The trade setting is also interesting in its own right. First, the global integration of production and the increasing share of exports in firms' sales have considerably increased exposure to foreign trade policy uncertainty (TPU). Second, while many trade models assume policy is a static parameter, Handley (2014) and Handley and Limão (2015) show it can be quite uncertain. Third, the impact of TPU during a period of high economic uncertainty has not been explored. Fourth, preferential trade agreements (PTAs) increase bilateral trade (cf. Baier and Bergstrand, 2007). Understanding the potential insurance value emphasized by various PTAs can help explain why they have such large trade effects, which has become particularly

[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).

[2] See for example, "Minutes of the Federal Open Market Committee," August 9, 2011, <http://federalreserve.gov/monetarypolicy/fomcminutes20110809.htm> (accessed 1/19/2018); "Uncertainty and the Slow Recovery," Wall Street Journal, January 4, 2010. Becker, Gary S., Steven J. Davis and Kevin M. Murphy

[3] These other objectives could include increasing local demand and prices (Eichengreen, 1981) or devaluing exchange rates through import tariffs, export subsidies and other instruments (Farhi et al., 2013).

important given recent U.S. threats to exit NAFTA and the U.K. vote to leave the EU.[4]

Our work also contributes to understanding the magnitude and dynamics of the Great Trade Collapse (GTC). This worldwide 12 percent contraction of trade in 2009 was the largest since World War II. The 2.7 percent decline in world GDP was insufficient to account for the magnitude of the GTC in the context of standard models, which sparked considerable research. Different hypotheses to explain the magnitude of the GTC 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). Each of these factors can explain part of the collapse but not necessarily all of it nor the fast partial recovery of international trade.

The collapse was particularly large for certain 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 the 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— denoted by the 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. This average differential growth was large enough to halt the decline in the aggregate share of exports to PTAs seen in Figure 2(a), and reverse it. In section 2 we show that this differential is robust to controlling for standard determinants of trade including income and price index changes and is only present for countries with sufficiently high income risk.

One possible explanation for this export differential is an increase in applied protection in non-PTA markets. However, the WTO and other organizations monitored and ultimately found only limited increases in such measures.[5] 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.[6] These facts lead us to explore an alternative explanation of the GTC and the recovery: changes in uncertainty about other countries' policies combined with economic uncertainty. 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." [7] Second, there was recent econometric evidence of increases in import protection following downturns (Bown and Crowley, 2013b). Early in the crisis such increases seemed likely given some government interventions to stimulate markets while discriminating

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

[5]WTO, OECD and UNCTAD 2010, "Report on G20 Trade and Investment Measures."

[6]We also verify that changes in applied protection do not substantially affect U.S. exports in this period. This is in sharp contrast with the Great Depression of 1930, where increases in barriers affected 35% of tariff schedule lines and accounted for a large fraction of the trade contraction (Madsen, 2001).

[7]G-20 Communique, April 2, 2009. <www.g20.utoronto.ca/2009/2009communique0402.html>. According to the Director General of the WTO this institution provides " [...] the everyday economy, with a collective insurance policy against the disorder caused by unilateral actions, whether open or disguised; a guarantee of security for transactions in times of crisis, henceforth an element of resilience that is vital to the running of a globalized world. In short, a global insurance policy for a global real economy. This is why it is extremely important to continue with the Doha Round amidst the turmoil currently affecting the world of finance, but which might just hit the world economy tomorrow, so that the WTO can continue to act as a shock absorber." Pascal Lamy, 10/1/2008, <www.wto.org/english/news_e/sppl_e/sppl102_e.html> (accessed 12/16/2017)

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). One measure of this TPU is the fraction of U.S. newspaper articles about international trade that also included terms related to uncertainty. We construct such an index in section 4 and find a clear increase around the months of the GTC, which is partially reversed by the end of 2009.

We address the following specific 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 collapse 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, we develop a model consistent with the main features of the data and then empirically assess the role of 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 via firm export investments to specific markets, for which we use the Longitudinal Firm Trade Transaction Database (LFTTD) from the Census Bureau. We highlight three key 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. While most measures of export value and export participation return to their pre-crisis peak by the end of 2011, they remained well below the levels implied by their pre-crisis growth 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 declines by about 9% and the number of firm-country-product varieties declines by 11% between 2008Q3 and 2009Q2. Underlying the net (negative) growth in firm export participation and export flows across products is a substantial degree 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 significant differences in the margins of adjustment across countries. Firms adjusted significantly less through the extensive margin when exporting to PTAs than to non-PTA countries.

Some of these stylized facts motivate elements of the dynamic model we develop where heterogeneous firms face policy and economic uncertainty. We expand the framework in Handley and Limão (2015) in three ways that are central for the analysis of the GTC. First, we introduce demand uncertainty arising from trade policy *and* economic conditions (aggregate income). Second, we examine the dynamics of exporting more broadly, including export exit and re-entry. Third, we derive the policy preferences of a government in terms of foreign policy level and uncertainty.

To understand the basic insight underlying the approach consider the following setup. Firms pay a sunk cost to start exporting under demand uncertainty; this generates an option value of waiting to enter any given foreign market (defined as a country-industry pair iV). Shocks to foreign demand, a, arrive with probability γ, and are drawn from a distribution $M_i(a)$. In this setting, a higher γ implies a more volatile and thus uncertain demand, which increases the option value of waiting to enter. Moreover, increases in γ are amplified in riskier markets—those with a distribution $M_j(a)$ that is second order stochastically dominated by $M_i(a)$—since firms face a higher expected profit loss if conditions worsen.

We model joint shocks and derive the associated predictions as follows. The demand level $a_{iV}(y_i/\varsigma_{iV})$ is increasing in income, y_i, and decreasing in a protection measure, ς_{iV}, which shifts demand away from foreign goods. In the presence of a single source of shocks an increase in risk in either implies higher demand risk. However, in the presence of multiple shocks we must account for their interaction so we derive the distribution of a_{iV} as a function of the underlying joint density, $h_{iV}(y,\varsigma)$. We argue that trade agreements can affect the risk of trade policy but not necessarily that of the income process. Thus we model them as a choice of current policies and their future distribution conditional on income. For specific distributions we show that increases in conditional policy risk also increase demand risk and lower entry. Moreover, if a riskier conditional policy distribution is more likely in low income periods (as suggested by the evidence in Bown and Crowley, 2013a) then there would be good reason for firms to be concerned about this channel in the GTC.

More generally, we show that a government that values export market access and is export risk averse prefers a trade agreement characterized by foreign reductions in current protection and demand risk. We characterize the effects of such an agreement on entry and exports: upon implementation it increases entry by reducing both current protection and uncertainty. However, the agreement has two opposing effects on entry and exports if there is an exogenous future increase in volatility, 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 γ. The offsetting **insurance effect** captures the complementarity of volatility and risk: increases in γ are mitigated for PTAs since they contain policy commitments that lower demand risk.

The model guides the empirical approach. It provides a decomposition of demand risk into a policy component and a policy and income interaction that capture the proportional profit loss for exporters when conditions worsen. The joint risk component is proportional to the tail risk in income that we estimate by for each destination. The model predicts that volatility shocks have differential effects based on the policy risk. Thus we explore variation across U.S. export destinations depending on whether they have a PTA. 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 can already see that the behavior of the aggregate PTA share is driven precisely by those industries, where importers have higher market power.

To test this in more detail we use the firm level data, interact the economic and policy risk measures, and allow them to have time-varying coefficients. The latter occurs in the model only when there is an uncertainty regime switch due, for example, to a shock to demand volatility, γ. We use quarterly data to identify if there was a regime switch, to allow for offsetting shocks within any given year, and to match the timing of the GTC closely. We control for changes in foreign GDP and include country-industry and quarter-year fixed effects in the baseline to control for other potential factors affecting export outcomes.

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 of varieties 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.

We find additional evidence for the policy risk channel by splitting the sample according to import market power. The higher net exit for non-PTA relative to PTA markets is stronger in high market power industries and translate 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 PTAs 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.[8] 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 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., forth.; Ossa, 2014).

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

2 U.S. Export Dynamics and the Great Trade Collapse – Market and Firm Heterogeneity

Our contribution in this section is twofold. First, we provide reduced form evidence that U.S. bilateral export growth in the trade collapse was heterogeneous across PTA and non-PTA markets and that this differential is related to the degree of economic uncertainty. We then discuss these findings in the context of the institutional features of the GATT/WTO and the PTAs. Second, we employ customs transaction quarterly data to 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. These findings motivate and inform the theoretical model and the subsequent empirical approach.

[8]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

2.1 Market Heterogeneity: Economic and Policy Uncertainty

Figure 1 shows that average U.S. export growth was relatively higher to PTA destinations in the GTC. We quantify this differential using a difference-in-difference (D-i-D) specification and find that it cannot be explained by standard gravity determinants unless augmented to include the interaction of economic and policy uncertainty. We describe these regressions and our sample in detail in Appendix C.1.

Similarly to Figure 1, we use the change in exports relative to the corresponding quarter in 2002 for country i at time t , $\Delta_{t,2002} \ln X_{it}$. We control for a common annual trend as well as quarter dummies, $\mathbf{Q_t}$. We include indicators for PTA_{it} and $CRISIS_t$—unity starting in 2008Q4—and their interaction.[9] During the crisis there was a 38 log point (lp henceforth) decline in exports to non-PTA partners (relative to the trend), which is 11 lp below the growth to PTAs.

$$100 \times \Delta_{t,2002} \widehat{\ln X}_{it} = \underset{[7.2]}{11.3} CRISIS_t \times PTA_{it} - \underset{[4.3]}{38.3} CRISIS_t - \underset{[3.4]}{4.1}\, PTA_{it} + \underset{[0.7]}{13.4} TREND_t + \mathbf{Q_t}$$

This 11 lp differential could be due to variation in importer real GDP and prices. To examine this we control for these importer determinants, as well as for supplier shocks—measured by U.S. production and U.S. GDP deflator changes. After controlling for these standard gravity determinants the mean interaction is still 10 lp, but the time trend becomes small and insignificant.

To understand the dynamics instead of simply the mean effects we re-run this gravity equation omitting the $PTA \times CRISIS$ and the time trend and then plot a local polynomial through the residuals in Figure 3(a). The non-PTA residuals (solid blue) show that the standard gravity determinants account for the trend prior to the crisis but the collapse and recovery are still evident. In contrast, the PTA residuals (solid red) are flat when the crisis starts and increase substantially in the last 4-5 quarters of the sample.

If economic risk has heterogeneous effects over time and markets with different TPU then accounting for it should reduce the difference in the residuals between PTAs and other destinations. The measure we use here is the standard deviation of real, annual log GDP growth in each country from 2000-2012. We augment the standard gravity specification described above with this measure of realized demand volatility and its interaction with PTA and Crisis. The local polynomial through its residuals are shown as dashed lines in Figure 3(a). We find that the PTA and non-PTA lines are now considerably closer, particularly during the onset of the crisis. There is still some divergence in the last period of the sample that suggests the model and subsequent estimation should allow for the impact of uncertainty to change during the recovery.

Using this last specification we compute the differential PTA effects for alternative economic risk levels. The left panel in Figure 3(b) shows that prior to the crisis the differential is positive but mostly independent of economic risk. However, during the crisis the differential is strongly increasing in economic risk (right panel). At the lowest risk level the differential between PTA and non-PTA exports is similar across periods but at the mean economic risk that differential was 12 lp.

This evidence suggests that the interaction of economic and policy uncertainty can reduce exports. However, we must go beyond aggregate data to better identify the mechanism at work, control for other factors and quantify the roles of economic and policy uncertainty. The model derives conditions when these interactions are important and demonstrates how they operate through firms' investment decisions, and

[9] PTA_{it} controls for any growth differential for the countries that switched into PTA status during the pre-crisis period. The PTA countries are fixed during the crisis period.

provides a framework to measure risk and model the adjustment dynamics.

2.1.1 Discussion and Interpretation

Trade agreements typically constrain the flexibility of policymakers to respond to shocks by including permanent commitments to reduce trade barriers. These commitments could actually increase risk because a policymaker cannot use trade policy to respond to other shocks. Our results thus far suggest that even if such forces are at work, there is some beneficial interaction between trade agreements, potential protectionism, and income risk that increases export growth, especially during a period of widespread, adverse economic shocks.

The differential we identified applies to PTAs specifically and raises the question of why this is present relative to 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). 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.

2.2 Firm Heterogeneity and Dynamics

To understand the broad patterns of firm-level export dynamics during the GTC and if uncertainty contributed to it via an option value of waiting we now examine firm export entry and exit behavior.

2.2.1 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 4 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%, which is striking given their average annual growth between 2002 and 2007 was 6.5%. By the end of 2010 exports recover to their pre-crisis peak *level* but remained below their pre-crisis trend.

The large changes in the extensive margin are not merely driven by the granularity of varieties. In Figure 4 we see similar patterns for firm-destinations and the total number of exporting firms. Large net entry changes can occur relatively fast if there is enough churning, which is what 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 is not simply a reflection of 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%.[10]

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 6(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.[11]

2.2.2 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.[12] 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 zeros for entry and exit as

$$\hat{x}^m_t = \frac{x^m_{vi,t} - x^m_{vi,t-4}}{\frac{1}{2}[x^m_{vi,t} + x^m_{vi,t-4}]}.$$

This growth rate is bounded on $[-2, 2]$, symmetric around zero, and equivalent to log changes up to a 2$^{\text{nd}}$ order Taylor expansion. We compute the share $s^m_{vi,t} = \frac{x_{vi,t}+x_{vi,t-4}}{X_t+X_{t-4}}$ 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

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

In Figure 5 we plot the resulting annual growth, by quarter, of the intensive and extensive (the sum of entry and exit) margins. Both contribute negatively to total export growth during the start of the crisis. The decline in the intensive margin was relatively 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 entering (and exiting).

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. [13] 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

[10] 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 5-6 and Table 1 reflect the regression sample described in section 4.4.

[11] 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, for example, Ghironi and Melitz (2005) and Bilbiie et al. (2012)

[12] See Data Appendix B.2 for more details.

[13] 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.

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 6(b) we use our regression sample and 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. In fact, by the last period in the sample the net extensive margin contributed about -8 percentage points to the cumulative decline of -20 for exports.

2.2.3 Growth Decompositions by PTA Status

In Figure 7(a) we decompose the margins of export growth in Figure 5 by PTA status. The export decline toward PTAs was more strongly affected by the intensive margin, whereas for non-PTAs both margins are important. The contribution of the extensive margin prior to the crisis was, on average, similar for PTA and non-PTA destinations. But the contribution of the extensive margin for non-PTA countries was higher in each quarter of the GTC.

We also compute cumulative growth rates by PTA status relative to its trend prior to the GTC. In the left panel of Figure 7(b) we see that by 2009Q3 the extensive margin is 15 percentage points of the total 40 point reduction in exports for non-PTA countries. In the right panel of Figure 7(b) for PTA exports the total reduction in trade is slightly less, 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 when it is again similar to the PTA contribution. 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 are less than 15 points below trend, of which only 5 points are due to the extensive margin.

2.2.4 Robustness and Comparison with Other Countries

The collapse in the number of U.S. exporting firms and the role of the extensive margin in the GTC is larger than that reported for the few other countries where such data has been analyzed. For France the decline in the number of exporters was 7% between October 2008 and April 2009 (Bricongne et al. 2012), but this simply accelerated an existing downward trend whereas in the U.S. the decline reversed a strongly positive trend. In Belgium there is actually an increase in exporting firms of about 1% between the first semester of 2008 and that of 2009 (Behrens et al., 2013). In both France and Belgium, the intensive margin explains more of the decline in exports during the collapse and that is also the case for Spain (Eppinger et al., 2017).

There are at least two plausible reasons for the extensive margin to have played a larger role in the U.S. than in European countries. First, most of the exports are headed to PTA partners: 65% and 76% of French and Belgian exports respectively went to the EU-27. The PTA share would be even higher if it also included the EU's additional PTAs with many other countries. The firm and aggregate dynamics reflect the incentives to trade within PTAs and in that sense are consistent with our findings for the U.S. PTA sub-sample, where we find a larger intensive margin contribution. Second, there are different ways to measure the contributions of the intensive and extensive margins. Similarly to the French study, we use midpoint growth rates but we focus on quarterly rather than monthly data. The Belgian study defines the intensive margin as the average exports per firm and compares aggregates of the first 6 months of 2008 with the first 6 months of 2009. If we do the same we continue to find a large extensive margin effect.

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 the intensive and extensive margins dynamics. The decompositions show that: (i) 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; (ii) the intensive margin collapse (and recovery) was somewhat faster and stronger than the extensive margin; and (iii) there is less extensive margin adjustment toward PTA markets.

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 dimensions. First, we allow destination specific export exit and re-entry, which captures the heterogeneity just documented. Second, we allow for uncertainty in any foreign "business conditions", denoted a, that summarizes the impact of not only foreign trade policy but any other shocks affecting export profit, e.g. income. 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 uncertainty in a lower net export entry due to a standard option value of waiting argument. The uncertainty increases can arise from increases in either demand volatility or its tail risk and we show these 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 the impact of PTAs on entry and trade occurs via changes in policy risk, both directly and through its interaction with economic risk.

We allow for states with high or low risk in a arising from different policy risk and allow PTAs to affect their likelihood. PTAs can increase entry by lowering the probability of high risk periods, an insurance effect. We also allow PTAs to affect the current policy level, which increases entry upon implementation but also introduces a potential future loss in this preferential market access. 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.

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 can observe 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, which 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 $\sigma = 1/(1-\rho) > 1$. A firm v faces a standard CES demand in i at time t,

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

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}, is exogenous and summarizes all payoff relevant information for the current period.

The supply side is also standard in trade models. There is a single factor, labor, which 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, which is heterogeneous across firms. As we noted, at the start of each period firms know the demand conditions, their productivity and σ. Therefore they choose prices to maximize operating profits in each period, $\pi_{ivt} = \left(p_{ivt} - c_v\right) q_{ivt}$, leading to the 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 $\tilde{\sigma} \equiv (1-\rho)\,\rho^{\sigma-1}$.[14] 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 of expropriation or a profit tax). The broader interpretation is useful in the context of recent agreements that address several policies beyond tariffs (cf. Limão, 2016).

3.2 Exporter Dynamics

We now examine the firm's export decisions. Given 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.[15] Firms face uncertainty about the future path of business conditions, a_t, 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

[14] 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}.

[15] 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.

on the price index in that destination.[16]

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 $H(a)$, independent of the current business conditions. Firms take the *demand regime* $r = \{\gamma, H(a)\}$ as given and time-invariant. This characterization allows for persistent demand in a tractable way. Moreover, 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; alternatively if $\gamma \in (0,1)$ then there are imperfectly anticipated shocks of uncertain magnitude. The results in this section can be applied to any underlying shocks of a that arrive simultaneously at rate γ and yield an a' with a time-invariant distribution $H(a)$. In the next section we describe the regime in terms of more fundamental economic and policy processes.

We can generalize certain results to allow for period fixed costs, which would lead some incumbent firms to choose not to export in particular periods or simply exit. However, because of data limitations we are not able to distinguish between certain types of decisions.[17] Thus, the theory focuses on a simple setting where firms have no per period fixed cost, so that after entry they always optimally choose to export. We allow a firm's export entry capital to specific markets to depreciate; when it does so fully the firm can only export if it again pays a sunk cost that is independent of whether or not it previously exported. The depreciation process is simple: at the end of each period the export capital either fully depreciates or remains intact. The firm correctly expects this to occur with a fixed probability d, which is independent across markets. This process generates exit from exporting without firm death, so the model is still consistent with that observed feature in 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. 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); and so each entry decision can be made

[16] The standard assumption, that we also make, is that monopolistically competitive firms are sufficiently small relative to the total number (measure) of firms in industry V available in country i to take into account any effect that they may have on the price index or aggregate goods' expenditure. To this we add a "small" exporter assumption which allows us to provide sharper results by focusing on the direct effects of the demand uncertainty on operating profits rather than indirect general equilibrium effects. Handley and Limão (2017) allow for general equilibrium effects of policy uncertainty via impacts on the price index. Doing so introduces adjustment dynamics, as the price index adjusts to entry and exit, and tends to attenuate, rather than overturn, the direct effects of tariff policy on entry decisions. Carballo (2015) extends this framework to analyze related-party trade.

[17] For example, without data on capital expenditures for particular export decisions we are unable to distinguish between a firm that suspends exporting for a number of periods and then restarts (without paying a re-entry cost) and one that chose to exit (and sold any residual exporting capital) but subsequently decides to re-enter.

independently of future re-entry. This implies that we can solve the dynamic entry decision problem as if the firm had only one possibility to enter an export market and had to choose when to do so, and then note that if it ever loses its capital (with probability d) it will again be in the position to make another entry decision unless the firm as a whole dies (with probability δ). So the firm's effective discount rate used to value future export payoffs is $\beta = (1-\delta)(1-d) < 1$.[18]

One implication of this framework is that while exit rates are exogenous, the measured gross exit still depends on current conditions and thus 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 is simply the death rate δ, since the firms that lost their export capital re-enter. The same is true if conditions have improved. However, in periods where conditions worsened the measured exit is above δ since some surviving firms that lost their export capital prefer not to enter. The adjustment dynamics relevant for the empirical approach are derived in section 3.5.

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

$$\Pi_e(a_t, c, r) = \pi(a_t, c) + \beta[\underbrace{(1-\gamma)\Pi_e(a_t, c, r)}_{\text{No Shock}} + \underbrace{\gamma\mathbb{E}\Pi_e(a', c, r)}_{\text{Shock}}], \tag{6}$$

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, H.[19]

The expected value of waiting is

$$\Pi_w(c, r) = 0 + \beta\underbrace{(1-\gamma+\gamma H(\bar{a}))\Pi_w(c, r)}_{\text{Wait}} + \beta\underbrace{\gamma(1-H(\bar{a}))(\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) - K)}_{\text{Enter}}. \tag{7}$$

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 $\gamma H(\bar{a})$. 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

$$\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) = \mathbb{E}\pi(a' \geq \bar{a}, c, r) + \beta(1-\gamma)\mathbb{E}\Pi_e(a' \geq \bar{a}, c, r) + \beta\gamma\mathbb{E}\Pi_e(a', c, r). \tag{8}$$

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 $a_t = \bar{a}(c_t^U)$.[20] If a firm has costs equal to this threshold

[18] 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.

[19] This term is time invariant because the distribution of future conditions *after a shock*, $H(a')$, 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.

[20] 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.

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 (6), (7) and (8), 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:

$$K = \frac{\pi(a_t, c_t^U)}{1-\beta(1-\gamma)} + \frac{\beta\gamma}{1-\beta}\frac{\mathbb{E}\pi(a', c_t^U)}{1-\beta(1-\gamma)} + \frac{\beta\gamma\left(1-H(a_t)\right)}{1-\beta}\frac{\pi(a_t, c_t^U) - \mathbb{E}\pi\left(a' \geq a_t, c_t^U\right)}{1-\beta(1-\gamma)}. \tag{9}$$

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. 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.

Re-arranging eq. (9) and using the operating profit function we obtain c_t^U for any a_t:

$$c_t^U = c_t^D \times U_t = \left[\frac{a_t\tilde{\sigma}}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}} \times \left[1 + \frac{\beta\gamma\left[\omega\left(a_t\right)-1\right]}{1-\beta\left(1-\gamma\right)}\right]^{\frac{1}{\sigma-1}} \tag{10}$$

Thus, the cutoff under uncertainty is lower than the deterministic cutoff, c_t^D, whenever the uncertainty term, denoted by U_t, is lower than unity. This occurs if and only if $\omega\left(a_t\right) - 1 < 0$. This term is a measure of tail risk conditional on a shock.

$$\omega\left(a_t\right) - 1 = -H(a_t)\frac{a_t - \mathbb{E}(a' \leq a_t)}{a_t} \;\in (-1, 0] \tag{11}$$

It represents the expected proportional reduction in operating profits if we start at a_t and a shock occurs with probability $H(a_t)$ that worsens conditions (see Appendix A.1).

We examine the effects of an increase in demand regime uncertainty defined as follows.

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'.

Proposition 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: $\frac{\partial \ln c_t^U(\gamma, H')}{\partial\gamma} \leq \frac{\partial \ln c_t^U(\gamma, H)}{\partial\gamma}$.

Let us first consider increases in γ at a given H. First note that $\frac{\partial \ln c_t^U}{\partial\gamma} \leq 0$ from eq. (10) with a strict inequality for all $a_t > a_{\min}$ since in that case $\omega\left(a_t\right) < 1$ and thus $c_t^U(\gamma', H) < c_t^U(\gamma, H)$ iff $\gamma' > \gamma$. The higher probability of a shock makes both higher and lower demand levels more likely but it is only the latter possibility that affects the entry decision, because the benefits of demand levels above the entry trigger also accrue to waiting firms since they can enter.

Next consider a regime with a riskier distribution H' at a given γ. From eq. (11) we see that this change in distribution only affects the proportional loss term and thus $c_t^U(H') \leq c_t^U(H)$ iff it implies $\omega'(a_t) \leq \omega(a_t)$. In the appendix we show that this condition holds for any a_t iff H SSD H': the latter has thicker tails and thus implies larger losses conditional on a bad shock.[21]

Neither of the effects above requires additional restrictions on the long-run mean of a across the regimes. However, both results hold if we restrict that mean to be identical so we can identify pure risk effects in the following sense. If we consider H' to be a mean preserving spread of H then by construction a has the same long-run mean under both, and this spread implies that H SSD H' so the result follows for all $a_t < a_{\max}$. Any shocks to γ leave the long-run mean of a unaffected, since $\mathbb{E}(a')$ is determined by H. Moreover, if we evaluate shocks to γ at the long-run mean of demand conditions, $a_t = \mathbb{E}(a')$, then these shocks will not affect the mean of a at any point T, i.e. $\mathbb{E}(a_T|a_t) = \mathbb{E}(a')$ for all T and is independent of γ. So the proposition holds even if we constrain the regimes to have the same long-run mean of a.

The entry results in proposition 1 also apply to total industry exports since in this model they are proportional to entry.

The proposition also points that the reduction in entry due to increases in γ is magnified for countries or industries with a riskier H, which follows directly from the first two parts since $\frac{\partial \ln c_t^U}{\partial \gamma} \propto \omega(a)$. Our empirical approach explores this insight by examining whether a given common increase in γ, the probability of a demand shock, had differential effects across riskier industries or countries. To better understand our empirical approach and the need for modeling the different shocks consider the following first order Taylor approximation of (10) for γ around 0 and some ω around a pre-GTC initial value, a_0:

$$\ln c_t^U = \frac{1}{\sigma-1}\frac{\beta}{1-\beta}\left[\omega\left(a_0\right)-1\right]\gamma_t + \frac{1}{\sigma-1}\ln\left[\frac{a_t\tilde{\sigma}}{(1-\beta)K}\right] + e_t \tag{12}$$

where e_t is an approximation error. If the only source of foreign demand uncertainty was trade policy shocks then the predictions during the GTC for entry would be clear: we could measure variation in the potential loss $\omega\left(a_0\right)$ across countries or industries then changes in its estimated coefficient would inform us whether γ_t changed. For example, whether there was an increase in γ for non-PTA relative to PTA destinations. However, there exist multiple sources of uncertainty and it is then less clear how to measure ω and even if we could measure the overall risk in a we would then still want to identify the contributions of alternative shocks. Therefore, in the following section we derive the cutoff in the presence of multiple shocks and the conditions under which they reduce entry and exports and how PTAs can affect economic and policy uncertainty.

3.3 Economic and Policy Sources of Demand Uncertainty

We now unbundle demand uncertainty into an economic and a policy component and examine how they affect firm decisions. The first step is to characterize uncertainty using a generalized demand regime via a mixture of distributions that allows us to represent heterogeneous risk across destination and subsequently derive how it is affected by PTAs. The second step is to decompose business conditions into its underlying shocks.

[21] The weak inequality simply allows for the *possibility* that the distributions overlap at low a_t. Handley and Limão (2015) derive the impact of γ in the context of tariff uncertainty. Proposition 1 applies it to a general demand shock and extends it by providing necessary and sufficient conditions on H for entry to fall.

3.3.1 Heterogeneous Uncertainty States

We define a generalized demand regime $r_m = \{\gamma, M(m_s, H_s(a))\}$ containing an arrival parameter for any demand shock, γ, and a CDF M from which a is drawn after any type of shock. The multiple shocks are reflected in the distribution $M(m_s, H_s(a)) = \sum_{s\in S} m_s H_s(a)$, 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 approach has two advantages. First, it can capture multiple sources of shocks driving a without assuming explicit distributions. Second, by varying the weights across what we refer to as **uncertainty states,** s, we can characterize heterogeneity in risk across destinations or industries and isolate the source of that risk, e.g. by shifting probability from a cooperation state s with negligible policy risk to another where it is high. Our notation distinguishes between the exogenous distribution H used in the previous section because M can reflect endogenous mixing weights over distributions H_s. The following extension of proposition 1 establishes the basic results we will explore when governments are choosing a PTA.

Proposition 2: Uncertainty Shocks and Entry Under Multiple Shocks

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

(a) the entry cutoff is

$$c_t^U = \left[\frac{a_t\tilde{\sigma}}{(1-\beta)K}\right]^{\frac{1}{\sigma-1}} \times \left[1 + \frac{\beta\gamma\left[\bar{\omega}_t - 1\right]}{1-\beta(1-\gamma)}\right]^{\frac{1}{\sigma-1}} \tag{13}$$

$$\bar{\omega}_t - 1 = \sum_{s\in S} m_s \omega_s(a_t) - 1 \in (-1, 0] \tag{14}$$

$$\omega_s(a_t) - 1 = -H_s(a_t)\frac{a_t - \mathbb{E}_s(a' \leq a_t)}{a_t} \in (-1, 0] \tag{15}$$

(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 $c_t^U(\gamma, M(\Delta m_s, H_s)) \leq c_t^U(\gamma, M(m_s, H_s))$.

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

The proof is simple given what is established in proposition 1, which corresponds to the special case where $m_s = 1$. Under multiple shocks we continue to assume that the a' after a shock is independent of a_t but now there is a constant probability $m_s \leq 1$ that it is drawn from different H_s. So, the entry rule is still defined by (5) and the form of the value of exporting and waiting in (6) and (7) are unchanged. Therefore the entry cutoff expression is still (10) but now the tail risk is derived using the distribution $M = \sum_{s\in S} m_s H_s(a)$ and is a weighted average, $\bar{\omega}_t$ in (14), of the underlying risks, $\omega_s(a_t)$, defined similarly to ω but now using the respective H_s in (15).[22]

We illustrate key points of propositions 1 and 2 in Figure 8 assuming a is log normal (Appendix A.3 provides details on the parameterization). Panel (a) shows CDFs where the black line represents H_s and

[22]The proof of Proposition 1 shows that if the distribution of a is $M(a)$ then $\omega(a_t) - 1 = -\frac{1}{a_t}\int_0^{a_t} M(a)\,da$ and using the mixture definition of M we obtain $\omega(a_t) - 1 = -\sum_{s\in S} m_s \frac{1}{a_t}\int_0^{a_t} H_s(a)\,da$. This is equivalent to $\omega(a_t) = \sum_{s\in S} m_s\omega_s(a_t)$ since $\omega_s(a_t) - 1 = -\frac{1}{a_t}\int_0^{a_t} H_s(a)\,da$ and $\sum_s m_s = 1$.

it SSD $H_{s'}$ (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 normalized 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. $100 \times U_t = 100 \times \ln c^U(a_t, \gamma = 1)/c^D(a_t, \gamma = 0)$. At every $a_t > 0$ we see the riskier market (red) has a larger reduction than the least risky, proposition 1, and of any mixture of the two (dashed), proposition 2.[23]

3.3.2 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:

$$a_{Vt} = \varepsilon_V \frac{y_t}{\varsigma_{Vt}}. \tag{16}$$

where ε_V denotes the share of expenditure in industry V, $y_t = Y_t/\tilde{P}_t$ is a real income effect, and $\varsigma_{Vt} = \frac{P_{Vt}}{\tilde{P}_t}\left(\frac{\tau_{Vt}}{P_{Vt}}\right)^{\sigma}$ is a policy effect. The aggregate price index for a country is $\tilde{P}_t = \prod (P_{Vt})^{\varepsilon_V}$, the Cobb-Douglas aggregator over the CES price indices of the differentiated industries, P_{Vt}.[24] 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.[25] 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:

$$H_s(a_t) = \int_0^{\varsigma^{\max}} \int_0^{y = a_t \varsigma/\varepsilon} h_s(y, \varsigma)\, dy d\varsigma. \tag{17}$$

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.

[23]Moreover, this example shows that the entry impact is largest at higher a, since there is more downside, and the differential across markets is stronger around the mean, $a_t = 1$. This suggests that during a period where trade is considerably higher than average, e.g. prior to 2008, then even if there is much volatility its effect will be similar across markets (as suggested by the aggregate gravity). However, if conditions revert to the mean or slightly below, e.g. during the crisis, then that differential can be important. In mapping the model to this event we focus on a change in γ around an initial set of conditions, so at some initial ω, and thus the estimates will not reflect the particular effect just described. But it is useful in illustrating the asymmetric effect of higher volatility on differential entry across markets under good conditions vs. average ones.

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

[25]Moreover, there is evidence that PTAs can also change protection against non-members (Limão, 2016). If it increases protection against non-members and they are sufficiently large then P_{Vt} would be higher and this additional effect of PTAs would be reflected as a lower ς_{Vt}.

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 τ_{Vt} (which would increase ς_t) or labor endowment (which would increase y_t) and then provide a specific stochastic process for them. In the appendix we do so to illustrate how variation in risk in specific components and their interaction translates into changes in demand risk.[26]

3.3.3 Conditional Policy Risk

To understand the role and interaction of multiple shocks we first consider a baseline with a single state, so $ms = 1$, and a single source of risk. Suppose that income is permanently fixed at y_T, so the probability of a reduction in a is a special case of (17):

$$H_s\left(a_t|y_T\right) = \int_{\varsigma=\varepsilon y_T/a_t}^{\varsigma^{\max}} h_s\left(\varsigma|y_T\right) d\varsigma = 1 - H_\varsigma\left(\varsigma_t|y_T\right) \tag{18}$$

This is simply the probability of an increase in ς given y_T, and thus countries or industries with a safer conditional policy distribution, a $H_\varsigma\left(\varsigma_t|y_T\right)$ that SSD $H'_\varsigma\left(\varsigma_t|y_T\right)$, have higher entry. If two uncertainty states are possible then proposition 2 shows that a country with higher probability $m_{s'}$ of the riskier policy shock has lower entry.

A simple extension illustrates the interaction of policy with income. Consider two states, s and s', with respective income fixed at y_T and y'_T respectively. The policy is drawn from a distribution, $H_\varsigma\left(\varsigma_t|y\right)$. If $y_T > y'_T$ and $H_\varsigma\left(\varsigma_t|y\right)$ is independent of income then demand is riskier in s' since H_s stochastically dominates $H_{s'}$ in the first and thus second order sense. To neutralize this mean effect let's expand the set of underlying shocks to $x_t = \{y_t, \varsigma_t, \varepsilon_t\}$ and allow for the shocks in ε to occur simultaneously with income and be such that they offset it, i.e. $\varepsilon y = \varepsilon' y'$. This implies there are aggregate income shocks without changes in the differentiated industry expenditure. If $H_\varsigma\left(\varsigma_t|y\right)$ is independent of income then demand is equally risk in s and s' and thus no differences in entry across countries even if they have different probabilities of shocks. However, if the probability of decreasing protection is increasing in aggregate income then $H_\varsigma\left(\varsigma_t|y_T\right) > H_\varsigma\left(\varsigma_t|y'_T\right)$ for each ς_t and thus demand is less risky in s than s'. As should be clear by now the same occurs under the weaker condition that $H_\varsigma\left(\varsigma_t|y_T\right)$ SSD $H_\varsigma\left(\varsigma_t|y'_T\right)$. In sum, if conditional policy risk is decreasing in income then those states s' characterized by lower aggregate income (but identical industry expenditure) will have higher overall demand risk. Thus, according to proposition 2, there is lower export entry into countries with higher probability of low income shocks and in this example the effect occurs only because of higher policy risk under low income.

The simple case above can be further extended to illustrate an incentive for certain PTAs to move away from states with higher policy risk when other shocks are present (more on whether and when that is optimal is discussed below). In the example above that requires a decrease in $m_{s'}$, which is also the low income state, but a similar insight applies if we constrain the PTA to leave the probability of low income unchanged. To do so we simply aggregate the states described above and add another set with similar income distribution

[26] More specifically, under a log normal distribution $h_s\left(y, \varsigma\right)$ we show that any increases in income or policy risk parameters will (i) generate a riskier demand distribution, $H_s\left(a\right)$, if their correlation coefficient η_s is sufficiently close to zero and (ii) never decrease the risk in $H_s\left(a\right)$ for any η_s. Part (i) only holds if the correlation is not too extreme because of the risk interaction. If income and policy are highly positively correlated then policy becomes freer when income is low and thus higher policy risk can help offset income risk. If the correlation is highly negative then higher policy risk can increase the mean of a and thus we can't rank its new uncertainty relative to the original. Moreover, if policy and income are negatively correlated there always exists some increase in the risk of either that increases overall demand risk.

but different policy risk. Specifically, assume that with probability m we get either s, or s', and add a second group of shocks, S and S', with probability $1-m$. We restrict the income distributions to be the same across the set of shocks: under both S and s (S' and s') the income is y_T (y'_T) with equal probability p ($1-p$). Finally, the policy distribution is identical and equal to H_ς under S or S', and that is also the case with probability p under s. But under s' (with probability $1-p$) the policy distribution is $H_\varsigma(\varsigma_t|y'_T)$. So if $H_\varsigma(\varsigma_t|y_T)$ SSD $H_\varsigma(\varsigma_t|y'_T)$ there is higher average policy risk under s or s' and an incentive to lower m through a PTA.

The evidence in Bown and Crowley (2013a) suggests that it is plausible to assume firms believe that policy risk is higher during low income periods. However, the exact conditional policy risk conditions above may not hold for all countries and time periods. Therefore, instead of assuming those conditions or employing specific distributions to determine whether income and policy risks are complementary, we derive entry predictions for PTAs under the general distribution in (17).

3.4 Agreements, Endogenous Uncertainty and Trade

We derive the differential impacts of uncertainty shocks on PTAs in two steps. First, we identify the policy parameters that they 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 (cf. Limão, 2016). 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 and that PTAs also affect the response of exporters to future uncertainty shocks.

PTAs internalize the costs of certain policies on foreign exporters. Thus in our setting we say 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. However, 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_m, 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 $h_s(y)$, nor the arrival of any demand shock, γ. PTAs may be able to affect the probability, or belief, that certain policy states occur. We capture this in a parsimonious way by allowing PTAs to affect any belief parameter, m_s, over any s that has different conditional policy distributions, $h_s(\varsigma|y)$, but identical income distributions, $h(y)$. Finally, we assume that there are only two possible relevant uncertainty states with identical income distributions, s' with probability m, and s with probability $1-m$.[27] 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

[27] 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.

with income for which we have little direct evidence.[28]

In sum, under a PTA two parameters may change: beliefs about probability of shocks and the level of the current policy $\left\{\Delta_m^{PTA} = m^{PTA} - m, \Delta_\varsigma^{PTA} = \varsigma_t^{PTA} - \varsigma_t\right\}$. The difference in the PTA and non-PTA loss terms is thus given by

$$\bar{\omega}_t^{PTA} - \bar{\omega}_t = \underbrace{\left[\omega_{s'}\left(a_t\left(\varsigma_t\right)\right) - \omega_s\left(a_t\left(\varsigma_t\right)\right)\right]\Delta_m^{PTA}}_{\textbf{Insurance}} + \sum\nolimits_{s\in S} m_s^{PTA} \underbrace{\left[\omega_s\left(a_t\left(\varsigma_t^{PTA}\right)\right) - \omega_s\left(a_t\left(\varsigma_t\right)\right)\right]}_{\textbf{Market Access Risk}} \tag{19}$$

We decompose the PTA differential into an insurance and a market access risk effect. The first 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 3. That 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 the reduced form government objective as

$$G = G\left(a_t, M\left(a\right), \gamma\right) \tag{20}$$

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 where $G_{a_t}|_{\gamma=0} > 0$ 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.[29] Both conditions hold at any given γ since we assume the agreement does not affect it, but demand volatility clearly affects the agreement since 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.[30] The reduced form objective in (20) 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.

[28]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.

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

[30]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.

Proposition 3: 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 ($[\omega_{s'}(a_t) - \omega_s(a_t)]\,\Delta_m^{PTA} > 0$) increases entry for given $\gamma > 0$ and mitigates the impact of uncertainty shocks ($\gamma' > \gamma$) due to an insurance effect.

(b) the reduction in applied protection ($\Delta_\varsigma^{PTA} < 0$) increases entry for given $\gamma \geq 0$ but magnifies the impact of uncertainty shocks ($\gamma' > \gamma$) due to increased market access risk.

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. In the presence of multiple sources of shocks the motives for PTAs are similar but the policy distribution that minimizes demand risk must now account both for its direct effect in the absence of income risk and the interaction of the risks, as discussed above; this will also be clearer in the decomposition below.

The proposition then establishes the entry impacts of the PTA. The effects upon implementation at a given γ are obtained using the entry cutoff in (13), 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 2, at the lower tariff or risk implied by such a PTA.[31] Proposition 3 highlights two opposing effects. Under lower export risk the insurance effect implies a positive entry differential, since, as we show in proposition 2, γ and risk are complements. But when the PTA also lowers current protection it increases market access at risk, which magnifies the reduction in entry from an uncertainty shock.

Which of these opposing 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 $\left\{\Delta_m^{PTA}, \Delta_\varsigma^{PTA}\right\}$. However, we note that in periods when applied protection is already low for most countries Δ_ς^{PTA} is necessarily small and if at the same time there is a high probability of the riskier shock then there is a larger scope for Δ_m^{PTA} and the insurance effect would dominate. On the other hand, in markets where protection is high and PTAs can't credibly change the belief about future shocks the negative market access risk dominates. We will be able to estimate a net effect of uncertainty shocks on entry for PTAs and if we find it is mitigated relative to non-PTAs then we can conclude that there is an insurance effect and it dominates.

3.4.1 Decomposition, Interaction and Heterogeneity of Risks

Our objective in the estimation section is to 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

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

income density by $h(y,\Sigma_y)$, where Σ_y indexes its riskiness such that $h(y,\Sigma_y)$ SSD $h\left(x,\Sigma_y^{'}\right)$ if $\Sigma_y^{'} > \Sigma_y$.[32] We can then write

$$\bar{\omega}_t \approx \underbrace{\bar{\omega}\left(a_t, \Sigma_y = 0\right)}_{\textbf{Policy Risk}} + \underbrace{\left.\frac{\partial \bar{\omega}\left(a_t, \Sigma_y\right)}{\partial \Sigma_y}\right|_{\Sigma_y = 0} \cdot \Sigma_y}_{\textbf{Joint Risk}} \tag{21}$$

where we continue to treat the mixture weights for non-PTA as exogenous. The first term reflects only average policy risk across the states, $\bar{\omega}\left(a_t, \Sigma_y = 0\right) = \sum_{s \in S} m_s \omega_s^{\varsigma}\left(\varsigma_t | y_T\right)$, where $\omega_s^{\varsigma}\left(\varsigma_t\right)$ is defined by (15) but using ς_t and its conditional distribution directly. The second term captures the average change in the loss term when income risk is added to a situation with policy risk and thus we term it joint risk.

In the special case without policy risk the joint term will simply capture income risk and we are able to nest this in the estimation.[33]

Heterogeneous risk across countries

Treating Σ_y as a parameter we can write the loss differential in (19) as an approximation of policy and interaction risk:

$$\bar{\omega}_t^{PTA} - \bar{\omega}_t \approx \underbrace{\left[\bar{\omega}_t^{PTA} - \bar{\omega}_t\right]|_{\Sigma_y = 0}}_{\textbf{Policy Risk difference}} + \underbrace{\left.\frac{\partial\left[\bar{\omega}_t^{PTA} - \bar{\omega}_t\right]}{\partial \Sigma_y}\right|_{\Sigma_y = 0} \cdot \Sigma_y}_{\textbf{Joint Risk difference}} \tag{22}$$

The policy risk difference is simply (19) evaluated in the limit where $\Sigma_y = 0$. Proposition 3 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).[34]

The second term in (22) 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** $\frac{\partial \bar{\omega}_t^{PTA}}{\partial \Sigma_y} = \frac{\partial \bar{\omega}_t}{\partial \Sigma_y}$ and thus we can reject independence if we estimate a non-zero joint risk difference. Moreover, if that 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

There is also variation in risk across industries. Our goal is to identify whether there was an increase in the probability of non-cooperation in trade policy (or a trade war) and thus we model and explore differential

[32] 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.

[33] In this case $\bar{\omega}_t|_{\Sigma_\varsigma = 0} = \omega^y\left(y_t\right)$ where $\omega^y\left(y_t\right)$ is defined by (15) but using y and its distribution directly, which is assumed constant across states since the PTA does not affect it. Thus if in the estimation we use $\omega^y\left(y_t\right) - 1$ instead of Σ_y then we capture the income risk fully if no policy risk were present. We can also use this measure in the presence of policy risk without changing any sign predictions because $\omega^y\left(y_t\right) - 1 \approx \frac{\partial \omega^y\left(y_t, \Sigma_y\right)}{\partial \Sigma_y}|_{\Sigma_y = 0} \Sigma_y$ and $\frac{\partial \omega^y\left(y_t, \Sigma_y\right)}{\partial \Sigma_y}|_{\Sigma_y = 0} < 0$, the average interaction risk in (21) now becomes $\frac{\partial \bar{\omega}\left(a_t, \Sigma_y\right)}{\partial \Sigma_y}|_{\Sigma_y = 0} \frac{\omega^y\left(y_t\right) - 1}{\frac{\partial \omega^y\left(y_t, \Sigma_y\right)}{\partial \Sigma_y}|_{\Sigma_y = 0}}$, so it simply rescales the coefficient.

[34] Moreover, the insurance effect can only be achieved by a reduction in policy risk. If $\Sigma_y = 0$ then the distribution of a is given by (18) and as we showed it depends only on the conditional policy distribution, $H_{\varsigma}^s\left(\varsigma_t, |y_T\right)$. Therefore $\Delta_m^{PTA}\left(\Sigma_y = 0\right)$ decreases the probability of riskier policy.

industry risks in such a state. To capture this we now denote s as a cooperation state and s' as the non-cooperation or trade war state where the latter is characterized by higher policy risk at any given income, $\Sigma^{s'}_{\varsigma|y_T} > \Sigma^{s}_{\varsigma|y_T}$. Suppose there are two industries, $V = HI, L$, with respective probabilities of switching to s' equal to $m^{HI} > m^{L}$, so at any common $\varsigma_{Vt} = \varsigma_t$ the HI industry has a riskier policy since the aggregate income distribution is common to both. Similarly to the PTA we can decompose the overall risk differential across industries faced in any given destination as follows.

$$\bar{\omega}^{L}_{t} - \bar{\omega}^{HI}_{t} = \left[\omega_{s'}\left(a_t\left(\varsigma_{L,t}\right)\right) - \omega_{s}\left(a_t\left(\varsigma_{L,t}\right)\right)\right]\Delta^{L}_{m} + \sum\nolimits_{s\in S} m^{L}_{s}\left[\omega_{s}\left(a_t\left(\varsigma_{L,t}\right)\right) - \omega_{s}\left(a_t\left(\varsigma_{HI,t}\right)\right)\right] \qquad (23)$$

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

To identify high risk industries as defined above 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 will, all else equal, be more attractive in industries where the importer has higher market power. Broda et al. (2008) find evidence that prior to WTO accession tariffs 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 such industries than those for low market power relative to the non-cooperation state and so $\Delta^{L}_{m} < 0$.

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 in the ones 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 $\varsigma_{HI,t\in s} \geq \varsigma_{L,t\in s}$.[35]

Consider first the case where the agreement internalizes all market power incentives so the only source for the differential in (23) 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 (23) 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 3(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 the PTA subsample. 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 (23) is present under a null hypothesis of full internalization in a PTA).[36]

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

[36] The differential in (23) has a policy and joint risk component and the expression is similar to the one for PTAs in (22) 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

Heterogeneous risk across countries and industries

We will test whether the market power incentives described are present in destination countries that are WTO members but do not have a PTA. If that industry differential is present then it is also interesting to test if it is stronger than under PTAs. 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 period, s, exporters face the same protection in a WTO or PTA destination, $\varsigma^{PTA}_{L,t\in s} = \varsigma_{L,t\in s}$, and the same probability of non-cooperation, $m_L = m^{PTA}_L$ (possibly because there is no market power incentive for industry L). Assume also there is at least partial internalization under the WTO and the same or more internalization under the PTA (since under the WTO there is potential for negotiation externalities). Finally, take the limit case where for the PTA there is full internalization, so $\varsigma_{HI,t\in s} \geq \varsigma^{PTA}_{HI,t\in s} = \varsigma^{PTA}_{L,t\in s}$ (plausible since several PTAs feature duty free treatment across most industries). For a common income level across two destinations we then have:

$$\left[\bar{\omega}^L_t - \bar{\omega}^{HI}_t\right] - \left[\bar{\omega}^{PTA,L}_t - \bar{\omega}^{PTA,HI}_t\right] = \left[\omega_{s'}\left(a_t\left(\varsigma_{L,t}\right)\right) - \omega_s\left(a_t\left(\varsigma_{L,t}\right)\right)\right]\left(\Delta^L_m - \Delta^{PTA,L}_m\right) + \sum\nolimits_{s\in S} m^L_s\left[\omega_s\left(a_t\left(\varsigma_{L,t}\right)\right) - \omega_s\left(a_t\left(\varsigma_{HI,t}\right)\right)\right]. \quad (24)$$

The overall differential is positive only if there is higher probability of non-cooperation in the WTO than in the PTA. To see this note that $\varsigma_{HI,t\in s} \geq \varsigma_{L,t\in s}$ implies the term on the second line of the RHS is negative and so we require the first term to be positive. This first term 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 $\varsigma^{PTA}_{L,t\in s} = \varsigma_{L,t\in s}$ and (2) the difference in probabilities: $\Delta^L_m < \Delta^{PTA,L}_m \Leftrightarrow m_H > m^{PTA}_H$ when $m_L = m^{PTA}_L$.

This double difference will also 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.

3.5 Adjustment Dynamics

Sunk costs generate adjustment dynamics and these are asymmetric depending on whether conditions improve or deteriorate. We model the entry and exit dynamics in order to derive and interpret the estimation equation. The main objective is to relate net entry growth to the changes in the cutoffs. The number of firms (or varieties) exported to a particular market in a given industry (both subscripts omitted) at any t is given by

$$N_t = nF_t + \lambda^h_t \quad (25)$$

where $F_t \equiv F(c^U_t)$ is the fraction of the n firms in the home country with costs below the current cutoff. The last term, $\lambda^h_t \geq 0$, captures the number of legacy firms, those currently exporting but with $c_v > c^U_t$, which is only possible if they entered under better conditions and remain since profits are positive and the sunk cost is paid. Therefore, $\lambda_t = 0$ if $c^U_t \geq \max c^U_T$, or if enough time has passed since the last period when conditions

it to be negative this indicates partial internalization: $\varsigma_{HI,t\in s} \geq \varsigma_{L,t\in s}$. Moreover, if the income interaction term is positive then we can conclude that the insurance effect (the role of the agreement in curbing future market access risk) is relatively more important (compared to market access risk) in the presence of income risk.

worsened; we denote the last period before t when that occurred as $\lambda_t^0 = 0$. To model periods where $\lambda_t^h > 0$ as a function of observables we need to consider all possible histories of shocks. To maintain tractability we can either restrict attention to a small discrete number of values of a or, as we do, focus on modeling the most plausible and relevant histories for the empirical exercise. We consider three potential mutually exclusive histories and define a period indicator function for each $\mathbf{1}_t^h = 1$ where $h = \{0, +, -\}$ denotes an expansion, recovery or decline of business conditions with associated legacy given by:

$$\lambda_t^h = \begin{cases} 0 & \mathbf{1}_t^0 = 1 : c_t^U \geq \max c_T^U \\ \beta^t n \left[F_0 - F_t\right] & \mathbf{1}_t^+ = 1 : c_t^U \geq \max c_{T \neq 0}^U \\ \beta \sum_{T=1}^t \beta^{t-T} n \left[F_{T-1} - F_T\right] & \mathbf{1}_t^- = 1 : c_t^U \leq c_{t-1}^U \leq ... < c_0^U . \end{cases} \tag{26}$$

The first line captures periods where conditions are stable or expanding so there is no legacy, e.g. prior to the crisis. The second line captures recovery periods with conditions better than at any point in the crisis but still below the pre-crisis peak; it reflects the fraction of exporters between the peak and current cutoff times their probability of survival over the last t periods, β^t. The last line captures the decline at the outset of a crisis such as the GTC and subsequent periods until a recovery starts. The legacy term in the latter case reflects the fraction of exporters that survive and have costs below the current cutoff, e.g. a share β of the $n\left[F_{t-1} - F_t\right]$ exporters survive in the interval between the current and previous cutoff and we accumulate these over all adjacent cutoffs.

Using (25), (26), and defining the cumulative growth, for any Z, relative to the previous expansion period as $\hat{Z}_t \equiv \frac{Z_t}{Z_0} - 1$, 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.

$$\hat{N}_t = \begin{cases} \hat{F}_t & \mathbf{1}_t^0 = 1 \\ \left(1 - \beta^t\right) \hat{F}_t & \mathbf{1}_t^+ = 1 \\ \left(1 - \beta^t\right) \hat{F}_t + (1 - \beta) \sum_{T=1}^{T=t-1} \beta^{t-T} \left(\hat{F}_T - \hat{F}_t\right) & \mathbf{1}_t^- = 1 \end{cases} \tag{27}$$

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. $\hat{N}_{t+1}^+ - \hat{N}_t^-$.[37] 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.

Figure 9 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 9(b) and it evolves as described by $\mathbf{1}_t^+$ in (27). If the new γ^{High} was permanent then this decline would continue as shown by the dashed line and

[37] In the appendix we extend (27) to incorporate growth in n. This augments the expression by a domestic firm growth term, $\hat{n}_t$, that enters with a coefficient of one for each of the possible histories in (27) and an interaction of $\hat{n}_t$ and $\hat{F}_t$. In the estimation we consider log growth and first order approximations so we ignore that interaction and control for the growth in domestic firms in any given period using a flexible set of fixed effects.

eventually asymptote until all firms with costs above $c(\gamma_t^{High})$ exit this market. Alternatively, if a part of the uncertainty shock is reversed, as shown by the partial reversal to a lower γ_t^{Low} in period 2. This induces some new entry as reflected in the upwards jump in panel (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 several robustness exercises and quantify the main channels highlighted by the model.

4.1 Approach

We first model the impact of uncertainty on 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 $F(c_{iVt}^U)$ has marginal cost below the cutoff and exports to i at t. In section 3.5 we show that sunk costs generate the possibility of legacy firms so the total number of exporters in periods of crisis or recovery is $N_{iVt} \geq N_V F(c_{iVt}^U)$. Moreover, we related the growth in exporters to that of cutoffs in equation (27), which we can express for any of the relevant periods as:

$$\hat{N}_t = \left(1 - \left(\mathbf{1}_t^+ + \mathbf{1}_t^-\right)\beta^t\right)\hat{F}_t + \mathbf{1}_t^-\,(1-\beta)\textstyle\sum_{T=1}^{t-1}\beta^{t-T}\left(\hat{F}_T - \hat{F}_t\right) \tag{28}$$

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

$$\begin{aligned} \ln\frac{N_{iVt}}{N_{iV0}} &= b_t^h k\left(\ln\frac{U_{iVt}}{U_{iV0}} + \ln\frac{c_{iVt}^D}{c_{iV0}^D}\right) + \tilde{e}_{iVt} \\ &= b_t^h \frac{k}{\sigma-1}\left(\frac{\beta}{1-\beta}\gamma_t \cdot [\bar{\omega}_{iV0} - 1] + \ln\frac{a_{iVt}}{a_{iV0}}\right) + \tilde{u}_{iVt} \end{aligned} \tag{29}$$

In the first line $\tilde{e}_{iVt}$ represents a log growth approximation error plus any lagged cutoff differences during a multi-period crisis.[38] The last line uses the expression for the cutoff in (13) approximated around $\gamma_t = 0$ and a pre-crisis level of the potential loss, $\bar{\omega}_{iV0}$, defined by (14).[39] We can anticipate part of the identification

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

[39] 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, $\bar{\omega}_{iV0} < 0$.

The magnitude of the coefficients on the uncertainty and business conditions depends on the history coefficient $b_t^h \equiv \left(1 - \left(\mathbf{1}_t^+ + \mathbf{1}_t^-\right)\beta^t\right) \in (0,1]$, 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 outcomes 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.[40]

4.2 Measurement

Uncertainty Shocks and Risk Heterogeneity

We capture the shocks to γ_t by allowing for regime switches, i.e. by allowing for the coefficients of the impact of $\bar{\omega}_{iV0}$ on entry (and exports) to be different over time, namely in the pre-crisis years vs. the initial crisis and recovery periods.

To estimate the differential impacts of uncertainty shocks we approximate $\bar{\omega}_{iV0}$ in (29), around a baseline category, e.g. non-PTA country, and add the differential, e.g. for a PTA; these are respectively the first and second terms in (30). More generally, we let $W_{i,V0} = \{0,1\}$ be a binary indicator for a PTA country or high market power industry and write the risk as

$$\begin{aligned} \bar{\omega}_{iV0} - 1 = &\left\{ \bar{\omega}_0|_{\Sigma_y=0} + \left[\frac{\partial \bar{\omega}_0}{\partial \Sigma_y}\right]_{\Sigma_y=0} \cdot \Sigma_{yi} \right\} + W_{i,V0} \left\{ \left[\bar{\omega}_0^W - \bar{\omega}_0\right]_{\Sigma_y=0} + \left[\frac{\partial\left[\bar{\omega}_0^W - \bar{\omega}_0\right]}{\partial \Sigma_y}\right]_{\Sigma_y=0} \cdot \Sigma_{yi} \right\} + \tilde{w}_{iV0} \\ = &\left\{ \overline{w}^\tau + \overline{w}^j \cdot (\omega_{i0}^y - 1) \right\} + W_{i,V0} \left\{ \Delta\overline{w}^\tau + \Delta\overline{w}^j \cdot (\omega_{i0}^y - 1) \right\} + w_{iV0} \end{aligned} \tag{30}$$

The first line uses the approximation around no income risk and a common income using equations (21) and (22). The second line first replaces Σ_{yi} with its associated tail risk measure using the following approximation: $\omega_{i0}^y - 1 \approx \frac{\partial \omega_0^y}{\partial \Sigma_y}|_{\Sigma_y=0} \cdot \Sigma_{y,i}$; we discuss its measurement below.[41] The second line also simplifies the notation and relates some of the average effects we eventually estimate with their structural counterparts. The approximation error is captured by w_{iV0}. The policy risk for non-PTA countries in the absence of income risk is denoted by $\overline{w}^\tau \equiv \bar{\omega}_0|_{\Sigma_y=0}$; in the baseline estimation this is an average over all industries. The corresponding average policy risk differential is denoted by $\Delta\overline{w}^\tau$. The average change in overall risk for non-PTAs with income uncertainty is given by the second term where $\overline{w}^j \equiv \frac{\partial \bar{\omega}_0}{\partial \Sigma_y} / \frac{\partial \omega_0^y}{\partial \Sigma_y}\Big|_{\Sigma_y=0}$. The corresponding differential is given by $\Delta\overline{w}^j \equiv \frac{\partial\left[\bar{\omega}_0^W - \bar{\omega}_0\right]}{\partial \Sigma_y} / \frac{\partial \omega_0^y}{\partial \Sigma_y}\Big|_{\Sigma_y=0}$. In section 4.6 we test for differences in (30) across industry market power.

[40] In this model uncertainty reduces export values only through the extensive margin, and thus the elasticity of export values with respect to uncertainty is predicted to be lower than on the number of exporters. We can see this clearly in periods of expansion since if we aggregate the firm sales given by (3) and difference them over time we obtain (29) except with a smaller uncertainty coefficient, $\frac{k-\sigma+1}{\sigma-1}\frac{\beta}{1-\beta} < \frac{k}{\sigma-1}\frac{\beta}{1-\beta}$.

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

In section 3.4 we derived several implications, which we now relate to the parameters described above. First, the model predicts a negative average effect of policy risk, so $\overline{w}^{\tau} < 0$. Second, in the presence of multiple sources of risk $\overline{w}^{j}$ need not be positive but if we estimate that $\overline{w}^{j} > 0$ then income uncertainty augments joint risk and otherwise it decreases it.[42] The overall differential is predicted to be positive if the insurance effect dominates, i.e. $\Delta\overline{w}^{\tau} + \Delta\overline{w}^{j} \cdot (\omega_{i0}^{y} - 1) > 0$. Moreover, a negative policy risk differential, $\Delta\overline{w}^{\tau} < 0$, provides evidence for market access risk, whereas evidence that $\Delta\overline{w}^{j} \neq 0$ implies a rejection of policy and income risk independence; and finally if $\Delta\overline{w}^{j} < 0$ then the insurance effect is relatively more important (compared to market access risk) in the presence of income risk.

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, $\omega_{i0}^{y} - 1 = -H_y\left(Y_i'\right)\left(1 - \mathbb{E}_Y[Y_i' < Y_{i,0}]/Y_{i,0}\right)$, 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. One concern with using this approach is that the loss may be highly dependent on when exactly we measure it. Two countries may have an identical value for this measure at some point prior to the crisis, but one may have a larger loss if the shock was very large because of a fatter left tail. To account for the possibility that the 2008 crisis may have increased the likelihood of extreme shocks we compute the conditional loss for a particularly bad shock—one at least at the 5th percentile 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). Thus we measure $\omega_{i0}^{y} - 1 = -H_Y \cdot risk_{Y_i}$. If the distribution at the time of the crisis was unchanged then H_Y would be 0.05, but if such large shocks became more likely then it would be higher. Thus we simply assume H_Y remains similar across countries and let it be absorbed in the coefficient to be estimated. 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.

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 thus changes in $a_{iVt} = \varepsilon_{iV} \frac{y_{it}}{\varsigma_{iVt}}$ are driven by those components and using their definitions we have $\frac{a_{iVt}}{a_{iV0}} = \frac{Y_{it}}{Y_{i0}}\left(\frac{\tau_{iVt}}{\tau_{iV0}}\right)^{\sigma}$.[43] 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 e.g. Bown and Crowley, 2013b). Therefore, in the baseline we model changes in applied protection as reflecting a common shock $\tau_{iV,t} = \tau_{iV}\tau_t$ and in the robustness checks we control for changes in non-tariff barriers. We control directly for GDP growth. In sum, our baseline empirical model for business conditions is

$$\ln \frac{a_{iVt}}{a_{iV0}} = \ln \frac{Y_{it}}{Y_{i0}} + \overline{a}_t + \Delta\overline{a}_t \cdot W_{i,V0} \tag{31}$$

which includes the income change and $\bar{a}_t$: any common shocks to policy (or other factors determining a)

[42]To see this note that $\text{sgn}\left(\overline{w}^{j}\right) = -\text{sgn}\left(\frac{\partial\bar{\omega}_0}{\partial\Sigma_y}|_{\Sigma_y=0}\right)$ since $\frac{\partial\omega_0^y}{\partial\Sigma_y}|_{\Sigma_y=0} < 0$. With no policy risk $\bar{\omega}_0 = \omega_0^y$ so $\overline{w}^{j} = 1$.

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

across all iV in the baseline group. Given the negligible changes in applied policies our baseline interpretation for the 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/unmeasured differential changes, which are captured by $\Delta\overline{a}_t$ and are also controlled for via the interaction of the indicator $W_{i,V0}$.

The estimation relaxes the following assumptions used in the theory related to the determination of c^D. First, the theory assumes that sunk costs (K_{iV}), industry expenditure shares (ε_{iV}), the number of producers and the industry price indices are iV specific but constant. The estimation controls for time variation in any of these variables as long as they take the following form: $x_{iV,t} = x_{iV}x_t$ such that $\Delta \ln x_{iV,t} = \Delta \ln x_t$ (possibly augmented with an idiosyncratic component), so these are also reflected in $\overline{a}_t$. Any additional PTA-industry differential in these variables is captured by $\Delta\overline{a}_t$. Similarly, the estimation 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 $W_{i,V}$. We will also describe a more general specification that allows for country and industry effects in changes to control for additional unobserved heterogeneity.

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 then propose a difference-*of*-differences strategy that addresses additional identification threats such as pre-existing trends.

Replacing the uncertainty terms in (30) and the business conditions in (31) into (29) we obtain

$$\ln\frac{N_{iVt}}{N_{iV0}} = \Gamma_t^{\tau} + \Gamma_t^{j}\cdot risk_{Y_i} + \left[\Gamma_t^{\Delta\tau} + \Gamma_t^{\Delta j}\cdot risk_{Y_i}\right]\cdot W_{i,V0} + \Gamma_t^{y}\cdot\ln\frac{Y_{it}}{Y_{i0}} + u_{iVt} \;\; \text{each } t \tag{32}$$

The policy effect in the absence of income risk is $\Gamma_t^{\tau} \equiv b_t^h\frac{k}{\sigma-1}\left(\frac{\beta}{1-\beta}\gamma_t\overline{w}^{\tau} + \bar{a}_t\right)$—capturing 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 $\Gamma_t^{\Delta\tau} \equiv b_t^h\frac{k}{\sigma-1}\left(\frac{\beta}{1-\beta}\gamma_t\Delta\overline{w}^{\tau} + \Delta\overline{a}_t\right)$. The term $\Gamma_t^{j} \equiv -b_t^h\frac{k}{\sigma-1}\frac{\beta}{1-\beta}H_Y\gamma_t\overline{w}^{j}$ reflects the impact of income uncertainty on joint risk for the baseline group and the respective differential is

$$\Gamma_t^{\Delta j} \equiv -b_t^h\frac{k}{\sigma-1}\frac{\beta}{1-\beta}H_Y\gamma_t\Delta\overline{w}^{j}. \tag{33}$$

Finally, the income effect is $\Gamma_t^{y} \equiv b_t^h\frac{k}{\sigma-1} > 0$. The error terms discussed after (29) and in the approximation to tail risk in (30) are reflected in u_{iVt}.[44]

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,

[44] Specifically, $u_{iVt} = \tilde{e}_{iVt} + b_t^h\frac{k}{\sigma-1}\left[(e_{iVt} - e_{iV0}) + \frac{\beta}{1-\beta}\gamma_t\cdot w_{iV0}\right]$.

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 $\Delta\bar{a}_t$.

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 (32) to those obtained using $T = t + s$, both relative to a common baseline. Across periods of duration s that are expansions we have $\Gamma_{t+s}^{\Delta j}/\Gamma_t^{\Delta j} = \gamma_{t+s}/\gamma_t$ (since $b_t^h = 1$); this ratio changes if and only if γ changes. In periods of decline or recovery, that is not necessarily the case.[45] Nonetheless, we can conclude that $\Gamma_{t+s}^{\Delta j}/\Gamma_t^{\Delta j} \in [0, 1]$ 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 (32) is in differences so it 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. For example, there may be idiosyncratic growth in the number of U.S. firms, sunk costs, expenditure shares, or other U.S. and destination market characteristics kept constant in the model. Thus we control for pre-existing destination-by-industry growth trends, denoted by α_{iV} by using a difference-of-differences approach. This approach also controls for pre-existing trends in factors excluded from the model, e.g. increasing production and financial integration due to reductions in information and transportation costs.[46]

Here are some specific concerns this approach addresses. First, if exporting growth to non-PTAs was persistently lower then it could imply a negative policy risk effect, $\Gamma_t^\tau < 0$, even if the crisis had no impact. This possibility is clearly rejected by the stylized facts that show a sharp reversal from positive to negative growth. But that reversal suggests that the true impact of the crisis on growth is larger than what might be implied by Γ_t^τ in (32). More generally, we will not interpret Γ_t^τ as simply applied policy shocks since they can capture any shocks common to all country-industry pairs iV in a given period, which we control for by using time effects, α_t. If any pre-existing growth trend exists but is common between PTA and non-PTA then we could still interpret the estimate of $\Gamma_t^{\Delta\tau}$ as the average differential impact of the crisis on export growth.

Second, a similar concern applies if the pre-existing trend is correlated with the interaction risk measure in which case using (32) we could find $\Gamma_t^j < 0$ even in the absence of uncertainty. This is less of a concern for the differential coefficient $\Gamma_t^{\Delta j}$. However, we also want an estimate for Γ_t^j and focusing on and interpreting magnitudes of the differential would only be valid if the correlation between the trend and risk was similar for PTA and non-PTA. More generally, if PTA partner selection depends at least in part on their permanent growth potential then controlling for α_{iV} will address this selection issue.

To implement this and interpret the coefficients we start with (32) and take annual differences for each quarter-year observation at time t and denote these changes by $\Delta_4 x_t \equiv x_t - x_{t-4}$.

$$\Delta_4 \ln N_{iVt} = \Delta_4 \left\{ \Gamma_t^\tau + \Gamma_t^j \cdot risk_{Y_i} + \left[\Gamma_t^{\Delta\tau} + \Gamma_t^{\Delta j} \cdot risk_{Y_i} \right] \cdot W_{i,V0} + \Gamma_t^y \cdot \ln \frac{Y_{it}}{Y_{i0}} + u_{iVt} \right\} \quad + \alpha_t + \alpha_{iV}. \quad (34)$$

The left hand side of (34) is simply the annual growth in the outcome variable since we can use a common

[45] The model dynamics predicts $\Gamma_{t+s}^{\Delta j}/\Gamma_t^{\Delta j} = b_{t+s}^h \gamma_{t+s}/b_t^h \gamma_t \; > 1$ even if $\gamma_{t+s} = \gamma_t$ because $b_t^h = 1 - \beta^{T_t}$, which is increasing in T_t: the number of periods relative to the baseline reflected in N_{iV0}. The intuition is simple: when conditions worsen 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.

[46] We focus on the role of α_{iV} in accounting for trends in the outcome rather than the control variables because the latter can have time varying coefficients. We also show below that our results are robust to including industry-by-time effects, α_{Vt}.

baseline number of firms, N_{iV0}, for all t which gets differenced out.[47] The right-hand side contains the differenced terms from (32), 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

$$\Delta_4 \Gamma_t^x \equiv \Gamma_{t+4}^x - \Gamma_t^x, \text{ all } t \tag{35}$$

and can vary across t because of contemporaneous shocks but also lagged ones in case of periods of decline or recovery. We start with any $t \in h = 0$, i.e. expansion periods such that $b_t^{h=0} = 1$ and thus $\Delta_4 \Gamma_t^{\Delta j} = -\frac{k}{\sigma-1} \frac{\beta}{1-\beta} H_Y \Delta \overline{w}^j \times \Delta_4 \gamma_t$, with similar definitions applying for the remaining coefficients.[48] 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 may be identified as one of expansion. Thus we interpret the coefficients in that period in the way just described and use them as the baseline. Moreover, we are not interested in their variation *within* the pre-crisis period so we focus on the average coefficients over all t before 2008Q4, e.g.

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

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 (35) 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

$$\begin{aligned} \bar{\Gamma}_p^x &\equiv \overline{\Delta_4 \Gamma_{t \in p}^x} \ \ , p = \{0, 1, 2, 3\} \\ \bar{\Gamma}_{p-0}^x &\equiv \bar{\Gamma}_p^x - \bar{\Gamma}_0^x \ \ , p = \{1, 2, 3\}. \end{aligned} \tag{36}$$

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 as the evidence suggested in section 2.

We then stack the differenced equations in (34) and use indicator variables Q_p for the periods. As we discuss below, after we control for country–by-industry and time effects we can identify the uncertainty

[47] Recall that in section 3.5 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.

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

effects during the crisis relative to the baseline, $\bar{\Gamma}^{x}_{p-0}$. Thus we write the estimation equation as

$$\Delta_4 \ln N_{iVt} = \left\{\bar{\Gamma}^{\tau}_0 + \bar{\Gamma}^{j}_0 \cdot risk_{Y_i} + \left[\bar{\Gamma}^{\Delta\tau}_0 + \bar{\Gamma}^{\Delta j}_0 \cdot risk_{Y_i}\right] \cdot W_{i,V0}\right\} + \alpha_t + \alpha_{iV} \tag{37}$$
$$+ \sum_{p=1}^{p=3} \left\{\bar{\Gamma}^{\tau}_{p-0} + \bar{\Gamma}^{j}_{p-0} \cdot risk_{Y_i} + \left[\bar{\Gamma}^{\Delta\tau}_{p-0} + \bar{\Gamma}^{\Delta j}_{p-0} \cdot risk_{Y_i}\right] \cdot W_{i,V0}\right\} \cdot \ Q_p$$
$$+ \sum_{p=0}^{p=3} \Delta_4 \left(\Gamma^{y}_{p} \cdot \ln \frac{Y_{it}}{Y_{i0}}\right) \cdot \ Q_p + \Delta_4 u_{iVt}$$

The relation to the model predictions can be further clarified by again considering Figure 9. 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. at any point prior to the start of the crisis 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 $\Gamma^{\Delta\tau}_0$ and $\Gamma^{\Delta j}_0$ (estimated by using $W_{i,V0} = PTA_{it}$ for $t \in p = 0$ in the first line of (37)), which provides additional evidence about the model and in isolating some of the impacts of the crisis.[49]

Uncertainty and export dynamics predictions

We summarize the predictions we test using (37) and label them **Pred. 1-6**. Predictions 1 and 4 concern the existence of uncertainty shocks and joint risk and do not require country variation or estimates of PTA differentials. The other predictions are identified from interactions with PTA indicators.

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

Pred. 2: PTA policy and income risk independence. If $\bar{\Gamma}^{\Delta j}_{p-0} \neq 0$ then we reject a null hypothesis of risk independence ($\Delta\overline{w}^{j} = 0$ all $t \in p$) since it implies $\Gamma^{\Delta j}_{p} = 0 = \Gamma^{\Delta j}_{0}$. Similarly if $\bar{\Gamma}^{\Delta j}_{0} \neq 0$, 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 sgn $\frac{\bar{\Gamma}^{\Delta j}_{0}}{\bar{\Gamma}^{\Delta j}_{p}}$ = sgn $\frac{\left(\overline{\Delta_4 b^h_t \gamma_t}\right)_{t\in 0}}{\left(\overline{\Delta_4 b^h_t \gamma_t}\right)_{t\in 1}} < 0$ and $\bar{\Gamma}^{\Delta j}_{p} \neq 0$ 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.[50]

[49]The importer market power definition is constant over the full sample period, so the baseline period coefficients in the first line of (37) are not separately identified since we include α_t and α_{iV} fixed effects.

[50]Note that the ratio eliminates the term $\Delta\overline{w}^{j}$ that is assumed common (or at least of same sign) across the periods.

Pred. 4: Income uncertainty and joint risk. Since $\text{sgn}\,\bar{\Gamma}^{j}_{p=1-0} = -\,\text{sgn}\left(\overline{\Delta_4\left(b^h_t\gamma_t\right)}_{t\in 1} - \left(\overline{\Delta_4 b^h_t\gamma_t}\right)_{t\in 0}\right)\overline{w}^j$ if we find $\bar{\Gamma}^{j}_{p=1-0} < 0$ and evidence for increase in uncertainty (using Pred. 3) then this implies that $\overline{w}^j > 0$, i.e. 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 $\Delta\overline{w}^{\tau} + \Delta\overline{w}^{j}\cdot\left(\omega^{y}_{i0}-1\right) > 0$. We test this by computing the following average effect over countries:

$$\mathbb{E}_i\left(\bar{\Gamma}^{\Delta\tau}_{p-0} + \bar{\Gamma}^{\Delta j}_{p-0}\cdot risk_{Y_i}\right) = \frac{k}{\sigma-1}\frac{\beta}{1-\beta}\left\{\Delta_4\overline{\left(b^h_t\gamma_t\right)}_{t\in p} - \Delta_4\overline{\left(b^h_t\gamma_t\right)}_{t\in 0}\right\}\left[\Delta\overline{w}^{\tau} + \Delta\overline{w}^{j}\cdot\mathbb{E}_i\left(\omega^{y}_{i0}-1\right)\right] \quad (38)$$

The RHS expression is obtained using the definitions for $\Gamma^{\Delta j}_{t}$ in (33), and $\Gamma^{\Delta\tau}_{t}$ in the text, along with their difference and average respectively in (35) and (36); and $\omega^{y}_{i0} - 1 = -H_Y\cdot risk_{Y_i}$.[51]

We can also identify the effect gross of the pre-crisis differentials as

$$\mathbb{E}_i\left(\bar{\Gamma}^{\Delta\tau}_{p-0} + \bar{\Gamma}^{\Delta\tau}_{0} + \left(\bar{\Gamma}^{\Delta j}_{p-0} + \bar{\Gamma}^{\Delta j}_{0}\right)\cdot risk_{Y_i}\right) = \frac{k}{\sigma-1}\frac{\beta}{1-\beta}\left\{\overline{\Delta_4\left(b^h_t\gamma_t\right)}_{t\in p}\right\}\left[\Delta\overline{w}^{\tau} + \Delta\overline{w}^{j}\cdot\mathbb{E}_i\left(\omega^{y}_{i0}-1\right)\right] \quad (39)$$

Given evidence that $\text{sgn}\,\frac{\bar{\Gamma}^{\Delta j}_{0}}{\bar{\Gamma}^{\Delta j}_{p}} < 0$ and $\text{sgn}\,\bar{\Gamma}^{j}_{p=1-0} < 0$ the term in {} is positive (increasing volatility) and thus the sign of any significant expressions we compute using the LHS would reflect the sign of $\Delta\overline{w}^{\tau} + \Delta\overline{w}^{j}\cdot\mathbb{E}_i\left(\omega^{y}_{i0}-1\right)$.

Pred. 6: Evolution and cumulative effects of uncertainty. The adjustment dynamics imply that we may obtain significant impacts from the uncertainty variables after an increase in γ in the first crisis period even if γ does not increase further in subsequent periods. Therefore we compute cumulative effects by adding the expressions in (38) or (39) over periods. This will also inform us about whether any initial effects are subsequently overturned. Even if the overall uncertainty effects are not reversed, we are also interested in determining if they may have subsided after the first crisis period, which we test by using $\bar{\Gamma}^{\Delta j}_{2-0}/\bar{\Gamma}^{\Delta j}_{1-0} = \frac{\overline{\Delta_4\left(b^h_t\gamma_t\right)}_{t\in 2} - \overline{\Delta_4\left(b^h_t\gamma_t\right)}_{t\in 0}}{\overline{\Delta_4\left(b^h_t\gamma_t\right)}_{t\in 1} - \overline{\Delta_4\left(b^h_t\gamma_t\right)}_{t\in 0}} < 1$. Moreover, we can compare this to alternative values to test some of our identifying assumptions. First, if $\overline{\Delta_4 b^h_t\bar{a}_{t\in p}} \approx 0$ then we should obtain $\bar{\Gamma}^{\Delta\tau}_{2}/\bar{\Gamma}^{\Delta\tau}_{1} = \bar{\Gamma}^{\Delta j}_{2}/\bar{\Gamma}^{\Delta j}_{1}$. Second, if the change between those periods is due to γ, rather than the differential effects $\Delta\overline{w}^{\tau}$ and $\Delta\overline{w}^{j}$ that we assume are fixed, then we should also get similar values for $\bar{\Gamma}^{j}_{2-0}/\bar{\Gamma}^{j}_{1-0}$. From Figure 9(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.

Income predictions

We implement (37) by approximating $\Delta_4\left(\Gamma^{y}_{p}\cdot\ln\frac{Y_{it}}{Y_{i0}}\right)$ with $\Gamma^{y}_{p}\ln\Delta_4\ln Y_{it}$. This exact specification of the income term along with the restriction that $\Gamma^{y}_{p} = \Gamma^{y}$ would arise from this model if we removed sunk costs

[51] This test assumes a negligible *average* unobserved growth differential in business conditions in PTAs. When exploring the market power dimension we can relax this assumption by controlling for country-by-time effects. We assume that, conditional on any country-specific growth trends, any unobserved growth differential in business conditions in PTAs in any quarter, $\Delta_4\bar{a}_t$, is negligible when averaged over all quarters in any given p, such that $\overline{\Delta_4 b^h_t\bar{a}_{t\in p}} \approx 0$. Otherwise there would be an additional term in (38) equal to $\frac{k}{\sigma-1}\left(\left(\overline{\Delta_4\left(b^h_t\bar{a}_t\right)}\right)_{t\in p} - \left(\overline{\Delta_4\left(b^h_t\bar{a}_t\right)}\right)_{t\in 0}\right)$.

(or if there were no exit adjustment dynamics). If we find it varies over time this provides evidence for sunk costs and adjustment dynamics. By allowing Γ_p^y to vary we hope 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.

Finally, note that if we reject a constant Γ_p^y then our model predicts the coefficient will be positive but we will not have an exact structural interpretation for it since it will capture current and lagged impacts. We test if the uncertainty coefficients are robust to addressing any omitted income lagged terms in the robustness section by controlling for country-time effects, which we can do in the context of the market power estimates.

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. Using these data, we construct measures of the number of 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. For each industry-by-destination we track the value of exports and entry and exit of firms down to the HS-10 digit level. We measure entry, exit, and export growth for each quarter relative to the same quarter in the previous year. Using these definitions, our main empirical specifications focus on the dynamics of the number of traded firm-product varieties with any exports within a country×HS-2×quarter cell. We aggregate all exports (or number of varieties) and measure their growth in logs or midpoint growth formulas.[52] 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 country and industry.

Country Sample and PTA Definition

Our main empirical approach compares U.S. export growth to its PTA partners relative to those without in 2003Q1 to 2011Q3. During this period, the U.S. implemented PTAs with 17 countries, but a number of them are 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 or earlier and that had quarterly GDP data available from 2001 to 2011. Thus in our sample the PTAs used and their implementation dates are 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. We exclude countries from the analysis entirely if they switch into PTA membership from 2007 to 2011, e.g. Dominican Republic (2007), Peru (2009), Costa Rica (2009), and others. Other countries lack sufficient quarterly GDP data, these include PTA countries in our period, Jordan (2001) and Bahrain (2006), and also non-PTA countries, but they make up a small share of U.S. exports. Colombia and South Korea are non-PTA countries in our sample period since these agreements had not entered into force until after 2011. The full list of countries appears in Appendix Table C3.

[52] We use nominal trade values and foreign GDP growth in U.S. dollars. U.S. inflation is fairly constant over the 2003-2011 period and all of our regressions absorb time and country effects. Our results are robust in section 4.6 to country-quarter-year effects that absorb all time-varying foreign shocks including prices.

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 67 countries, which still covers most U.S. export transaction value in the LFTTD.

We construct the income uncertainty measure as described in the measurement section. Recall it captures the proportional loss in profits from a large negative shock: $risk_{Y_i} = 1 - \mathbb{E}_Y[Y_i' < \hat{Y}_i^{0.05}]/Y_{i,T}$ where $T =$2001Q4. We prefer this measure of income uncertainty given it has a structural interpretation but also note that it is correlated with alternative ones. Our measure $risk_{Y_i}$, 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 and not GDP per capita. Second, the period leading up to the great recession was one of expansion: most countries in our sample are growing, on average, from 2002 to 2008. Third, the U.S. dollar depreciated on a trade weighted basis by about 30% from 2002 to 2008, which is reflected in the U.S. dollar denominated GDP measures.

In sum, our regression sample includes 67 countries. Exports to these countries 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 only drops about 12% of the value of the firm-matched data due to missing GDP data, PTA switching in the crisis and the requirement of a positive flow in a HS-2×time×country cell.[53]

High/Low Market Power Indicators

We construct market power indicators using the elasticity estimates for the U.S. from Broda et al. (2008). The point estimates of these elasticity measures are imprecise and using them directly would introduce substantial noise into our regressions. Instead, we take the median elasticity within an HS-2 industry over the set of HS-4 digit estimates. We then rank the *inverse* of these median estimates from high to low and assign the top two terciles to the High Market Power group and the bottom tercile to Low. In practice the High category contains industries with a median elasticity less than 5.

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 the clusters defined at the country×quarter-year periods.[54]

[53] 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 private citizens, agriculture, etc.

[54] We report country×quarter-year clusters because our uncertainty measures have no variation at higher disaggregation and our panel is estimated at the country-industry-quarter-year level. Our results are robust to adjusting standard errors for two-way

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, which is consistent with the presence of adjustment dynamics, possibly due to sunk costs.[55]

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 (37). 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 in the first crisis period 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 as $\Delta_4 \gamma_{t \in 0} \neq 0$. 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. To obtain the full risk effect of PTAs we combine $\bar{\Gamma}_{1-0}^{\Delta \tau}$ with the estimates of $\bar{\Gamma}_{1-0}^{\Delta j}$ and $\mathbb{E}_i\left(risk_{Y_i}\right) = 0.21$ for PTAs to compute the LHS of (38). 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).[56]

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 (38) is zero in magnitude and insignificant. So the cumulative effect for varieties by the end of the sample reflects the first period effect. We also find $\bar{\Gamma}_{2-0}^{\Delta j}/\bar{\Gamma}_{1-0}^{\Delta j} < 1$ so uncertainty subsides after the first period (Pred. 6). 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.[57]

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

clustering on the country-industry panel identifier and quarter-year time effects.

[55] 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.

[56] The effect remains positive (and is larger) if we either evaluate (38) 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 (39), 8.1 lp.

[57] We also find that $\bar{\Gamma}_{2-0}^{\Delta \tau}/\bar{\Gamma}_{1-0}^{\Delta \tau} = .39$ 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.

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 $\bar{\Gamma}^{j}_{p-0}$ estimates are negative, significantly different from zero and vary across periods, all of which are similar to the net entry results. Moreover, $\bar{\Gamma}^{j}_{p-0}$ for gross entry and exit are similar in magnitude within each $p = 1, 2$. The estimated $\bar{\Gamma}^{\Delta j}_{1-0}$ is positive and $\bar{\Gamma}^{\Delta\tau}_{1-0}$ is negative and significant for both entry and exit, again similar to net entry. Computing the LHS of (38) 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 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.[58] 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 (38) 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

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

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 2.2 re-indexed to a country-industry-time cell:

$$\hat{X}_{iVt} \equiv \frac{X_{iVt} - X_{iVt-4}}{[X_{iVt} + X_{iVt-4}]/2} = \textstyle\sum_m I_m s^m_{iVt} \hat{X}^m_{iVt} \tag{40}$$

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 Table 4(a) column 2 (midpoint) and in column 1 in terms of sign and significance.[59]

We decompose the growth rate using each $s^m_{iVt}\hat{X}^m_{iVt}$ in (40) 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.[60] Computing the PTA differential uncertainty effect in the LHS of (38) 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.[61] The overall PTA differential effect using the expression on the LHS of (38) 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.

In sum, these differential impacts of uncertainty on PTAs are consistent with the gravity estimates in section 2.1 and extend them to show the role of uncertainty through the extensive margin. Figure 10

[59] 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.

[60] The most directly comparable results are those using midpoint growth (column 2 of Table 3(a)) but these are similar to those using log growth. The discussion refers to parameters to simplify the exposition but we note that their exact structural interpretation, as derived before, applies to a ln growth equation for entry and exit, however the sign predictions are similar and those are the ones we focus on. In column 4 of Table 4(a) we find that all non-PTA estimates for the income 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 for all but the last one. The significant PTA coefficients have the same signs as those in Table 3 (corresponding to $\bar{\Gamma}^{\Delta j}_{p-0}$ and $\bar{\Gamma}^{\Delta\tau}_{p-0}$ in $p = 1, 2$) whereas for $p = 3$ these coefficients are insignificant, similarly to Table 3. We continue to find a reversal of the sign of the uncertainty effect of PTAs relative to the pre-crisis period. The impact of risk on non-PTA declines by the second period, $\bar{\Gamma}^j_{2-0}/\bar{\Gamma}^j_{1-0} = .55$, by a similar amount to the PTA differential impact, $\bar{\Gamma}^{\Delta j}_{2-0}/\bar{\Gamma}^{\Delta j}_{1-0} = .52$, this is what we expect if the only relevant change for those coefficients between those periods is due to γ and uncertainty subsides after the first period.

[61] 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.

summarizes these points by comparing the marginal effects before the crisis with their average in the three remaining periods—analogously to Figure 3(b). 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 or entry and exit behavior from market iV. 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 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 variation over time in alternative forms of protection and, since these are very diverse, we do so using a coverage ratio. For each iVt we compute the fraction of its HS6 products covered by any TTB (the results are similar if we use a trade weighted coverage ratio). 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.

- **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:** 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.[62] 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, as we described in section 2.1.1. 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 Appendix Table C4 we obtain similar results for the period coefficients common to the baseline. There is already a negative impact of risk for non-PTA

[62] We also find a larger increase in the GDP elasticity for durables in first crisis period.

entry in 2007Q4-2008Q3, perhaps because it includes the first 10 months of the recession, but no *overall* differential for the PTA coefficients. Moreover, any 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 (columns 3 and 4).

- **Relation to news index of TPU:** Additional motivation for the regime switching approach to uncertainty and timing we employ is given in the newspaper-based index of TPU in Figure 11. This is the trade policy equivalent of the increasingly used Baker et al. (2016) Economic Policy Uncertainty news index. It is constructed by taking the number of articles in the main U.S. newspapers that contain the words "trade policy" OR "international trade" and determining which fraction of them also contain the words "uncertainty" OR "uncertain". We describe the construction in Appendix C. The series is normalized to 100 at its own time-series mean. There are three important points related to the timing in our estimation strategy. First, n the pre-crisis period the index is declining on average and its mean is 84%, below that of the full sample. Second, there is a clear increase around the months of the crisis and trade collapse denoted by light red shading. The mean over the crisis months is 127 and we cannot reject that a structural break occurs in 2008Q4. Third, that large increase is partially reversed and the index remains below its peak crisis level for most of the remaining two periods in our sample.[63] We find this index to be informative and consistent with the interpretation of our findings of increased uncertainty in the first crisis period followed by a partial reversal.[64]

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 (24) 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, $\bar{\Gamma}_{1-0}^{\Delta j}$, are positive and significant in the first period of the crisis, suggesting that policy and income uncertainty were not independent in either sample

[63] The uptick in the last few months of 2011 may be partially related to the expiration of punitive tariffs on Chinese tires or the upcoming passage of PTAs with Korea and Colombia in 2012.

[64] We do not use this index in the estimation for three reasons: (1) it only provides aggregate time series variation absorbed by our time fixed effects; (2) while we could identify interactions it with another country or industry exposure measure interpreting a U.S.-based news measure as exogenous foreign uncertainty shocks is tenuous, and; (3) our goal is to provide a structural interpretation of parameters and quantify the effects of economic and policy uncertainty, which we cannot do that with reduced form, aggregate measures of TPU.

(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 gamma 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 whereas it is only 3.5 for low. This indicates a higher probability of non-cooperation in WTO members where protection would potentially be higher. 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 12 shows the export midpoint growth differentials for each MP 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 12: 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.[65] Second, the positive differential is consistent with the model prediction in (24) that, in industries with riskier trade policies, there is a higher probability of non-cooperation for non-PTAs than PTAs.

[65] We return to these differentials and quantify their cumulative effect on export growth in section 4.7.

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.

4.7 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 also examine how much the partial uncertainty reversal contributed to the recovery. We examine average effects for net entry and exports and then aggregate these effects and provide the permanent income equivalent of this PTA treatment.

4.7.1 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 (37) 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:

$$\mathbb{E}\left[\overline{\Delta_4 \ln N_{iVp}}|W_i = 1, \mathbf{z}_i\right] = \mathbb{E}\left[\overline{\Delta_4 \ln N_{iVp}} \mid W_i = 0, \mathbf{z}_i\right] + \left[\bar{\Gamma}_p^{\Delta\tau} + \bar{\Gamma}_p^{\Delta j} \cdot \mathbb{E}\left(risk_{Y_i}|W_i = 0\right)\right] \quad \forall p \tag{41}$$

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 (41) 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:

$$\begin{aligned}\mathbb{E}\left[\left(\overline{\Delta_4 \ln N_{iVp-0}}\right) \mid W_i = 1, \mathbf{z}_i\right] = \mathbb{E}\left[\left(\overline{\Delta_4 \ln N_{iVp-0}}\right) \mid W_i = 0, \mathbf{z}_i\right] \\ + \left[\bar{\Gamma}_{p-0}^{\Delta\tau} + \bar{\Gamma}_{p-0}^{\Delta j} \cdot \mathbb{E}\left(risk_{Y_i} \mid W_i = 0\right)\right] \quad \forall p.\end{aligned} \tag{42}$$

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 13(a) represents the first term on the RHS of (42). For $p = 1$ net entry was 15 lp below the no-crisis counterfactual. The dashed line adds the term in the second line of (42) and it offsets 13 lp, or most of the observed decline.[66] 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.

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

We do similar exercises using exports. In Figure 14(a) we plot the average, observed cumulative growth across margins (solid line). The extensive margin growth has an average reduction of almost 20 points in $p = 1$ for the non-PTA countries relative to a no-crisis counterfactual; this 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 in $p = 1$ and an additional 2 points in period $p = 2$. The interaction of policy and income effects explain a considerable portion of the average extensive margin growth, which helps explain the reduction in exports that persisted 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 14(b). The mechanics of this exercise are the same as Figure 14(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.

4.7.2 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 (40) 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. 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 7 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 (42) 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 $\sum_{i\in I,V}\left(s_{iVt} risk_{Y_i} | W_i = 0\right)$ 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 15(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.

4.7.3 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

$$\mathbb{E}\left[\left(\overline{\Delta_4 \ln N_{iVp-0}}\right) \mid \bar{\Gamma}^j_{p-0} = \bar{\Gamma}^j_{1-0}, \mathbf{z}_i\right] = \mathbb{E}\left[\left(\overline{\Delta_4 \ln N_{iVp-0}}\right) \mid W_i = 0, \mathbf{z}_i\right] + \left(\bar{\Gamma}^j_{1-0} - \bar{\Gamma}^j_{p-0}\right) \cdot \mathbb{E}\left(risk_{Y_i} \mid W_i = 0\right). \tag{43}$$

This counterfactual is represented by the dotted line in Figure 13(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 15(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.

4.7.4 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 (38) to the estimated income coefficient times a counterfactual average income change $\widehat{\Delta \ln Y_p}^{CF}$ for each period:

$$\Gamma^y_p \cdot \widehat{\Delta \ln Y_p}^{CF} = \mathbb{E}_i\left(\bar{\Gamma}^{\Delta\tau}_{p-0} + \bar{\Gamma}^{\Delta j}_{p-0} \cdot risk_{Y_i}\right), \tag{44}$$

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 15 where we plot the counterfactual non-PTA export growth under a PTA. In Figure 15(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_p^y 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.

5 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 crisis—a benefit that can't ignored in the evaluation of whether to exit (or enter) these agreements.[67]

[67]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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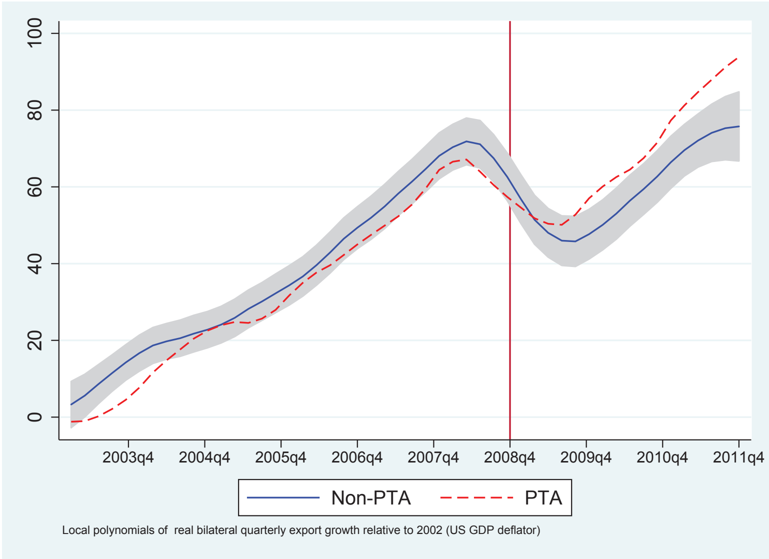
Figures

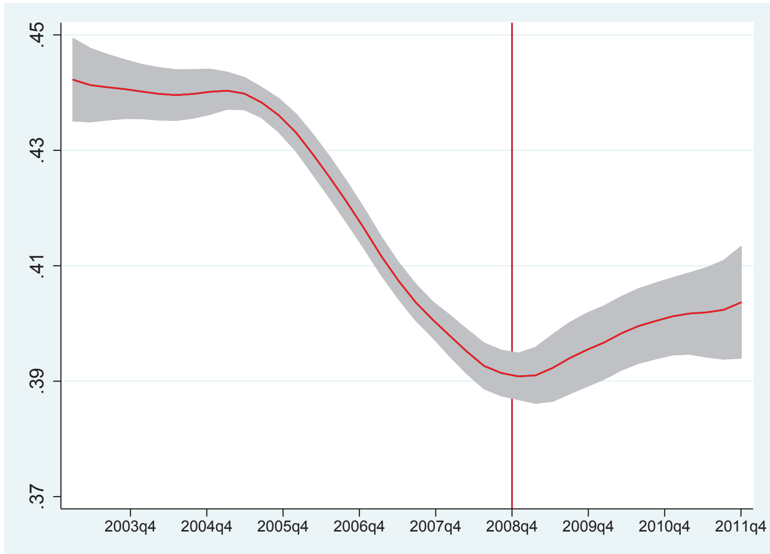
Figure 1: Export Growth to PTA and non-PTA destinations, 2002-2011



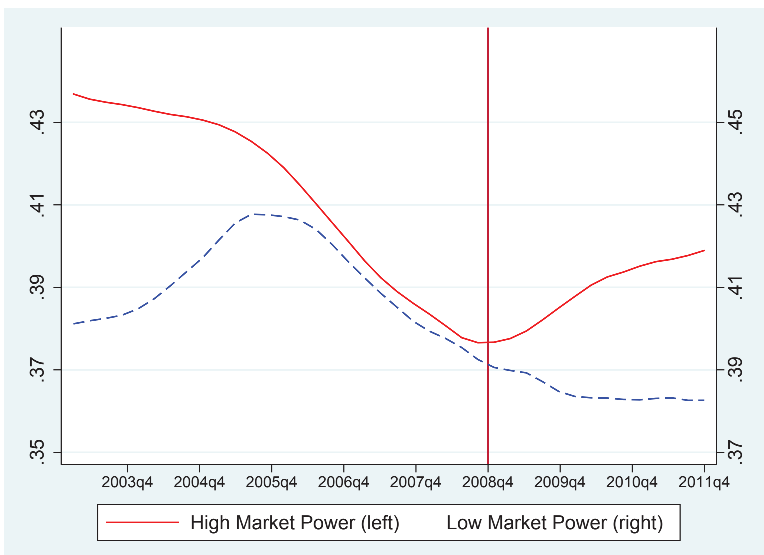
Notes: Cumulative log growth relative to same quarter in 2002. PTA and non-PTA subsample correspond to list in Table A2. Source: Constructed from Census Foreign Trade Data as described in the Data Appendix.

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

(a) Share toward PTA countries



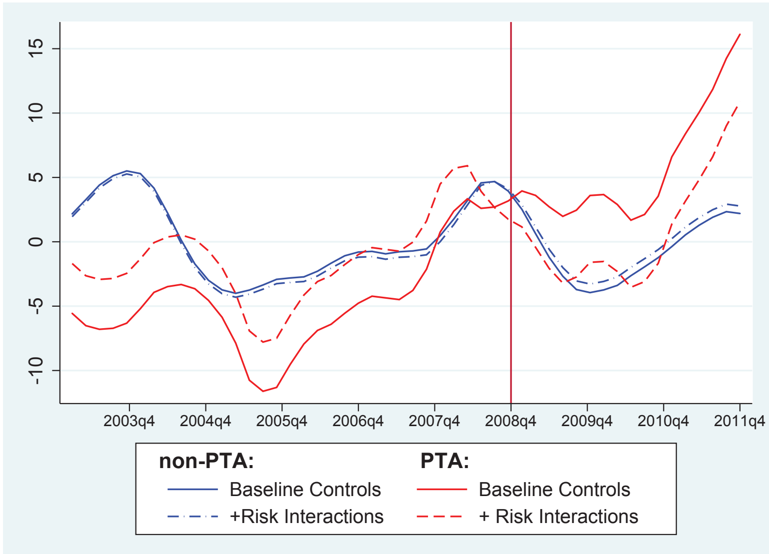
(b) Shares for high vs. low market power industries



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: Interaction of Economic Uncertainty and Trade Policy and U.S. Aggregate Export Dynamics

(a) Export Growth Residuals by PTA status: 2002-2011



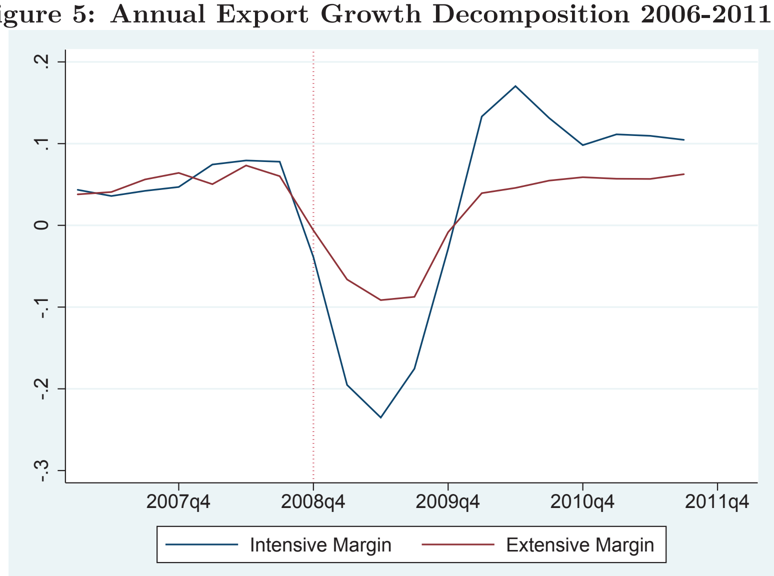
(b) PTA Export Growth Differential vs. GDP risk: Pre and post-crisis

Notes: (a) local polynomial mean plotted through residuals from regressions in columns 2 and 6 of Appendix Table C1. (b) marginal effects of PTA membership on export growth relative the income risk during the pre-crisis period (left) and crisis period (right). For both (a) and (b), PTA and non-PTA subsamples correspond to list in Table A2. Source: Constructed from Census Foreign Trade Data and IMF International Financial Statistics data as described in Appendix C.

Figure 4: 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.

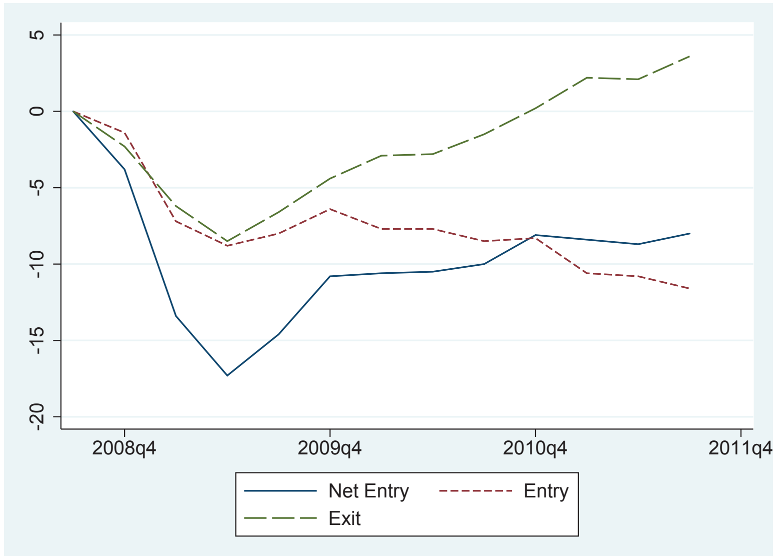
Figure 5: Annual Export Growth Decomposition 2006-2011Q3



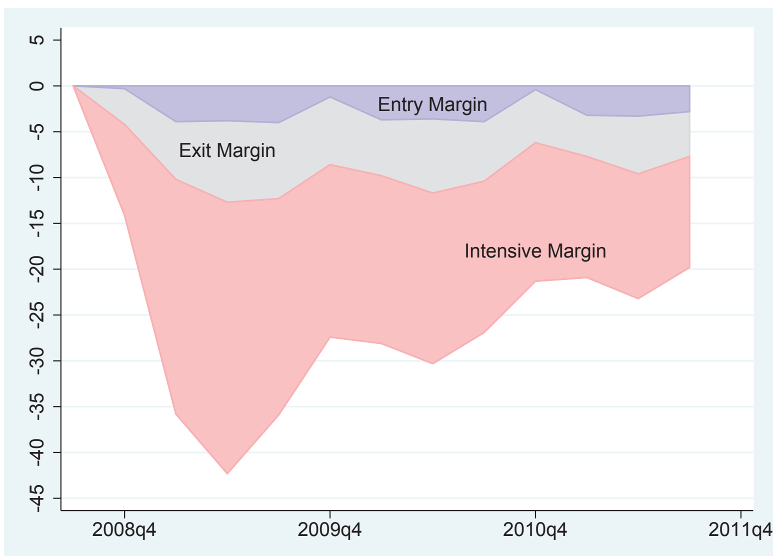
Notes: Constructed from Census LFTTD by quarter using regression sample data. Intensive and Extensive components sum to total export growth. Extensive margin computed over firm-country-product varieties.

Figure 6: Cumulative Decompositions by Export Margin, 2008Q4-2011Q3

(a) Aggregate variety net entry growth



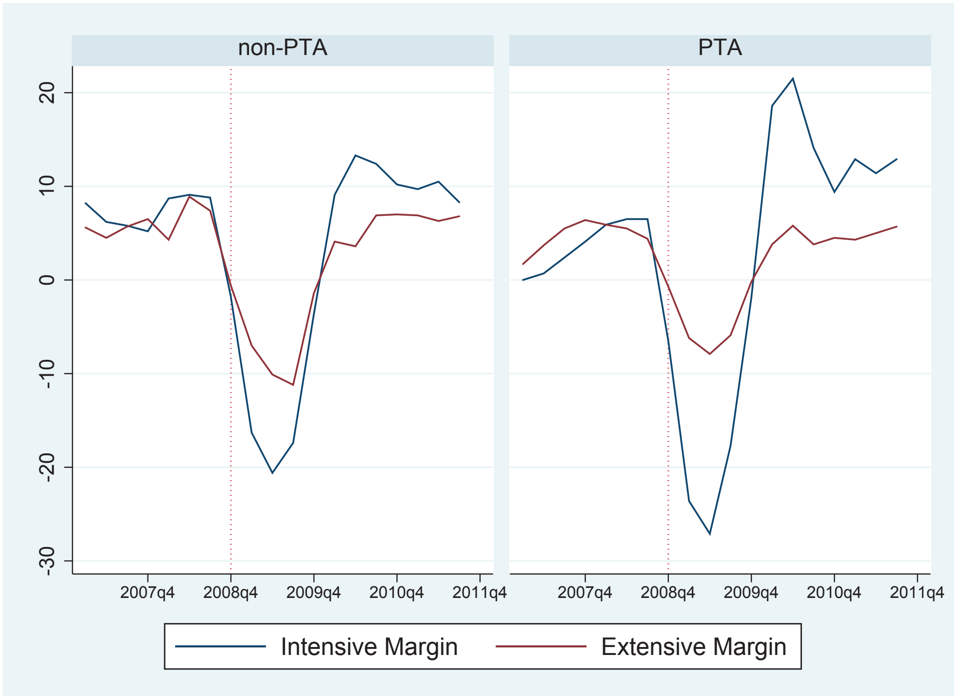
(b) Aggregate export growth



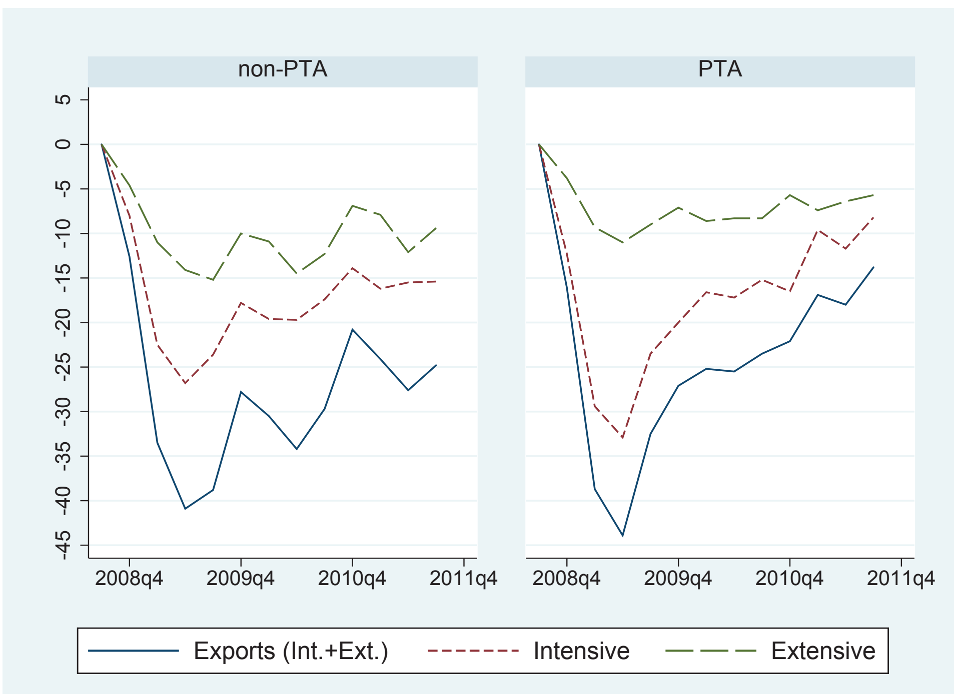
Notes: Constructed from Census LFTTD by quarter using regression sample data. Varieties defined by a firm-country-product triplet. (a) Entry and Exit components sum to net entry growth of varieties. Pre-trend computed from 2003Q1-2008Q3. Exit contribution in 2011 is positive relative to trend. (b) Entry 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 7: Export growth decomposition for non-PTA (left) vs. PTA (right)

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



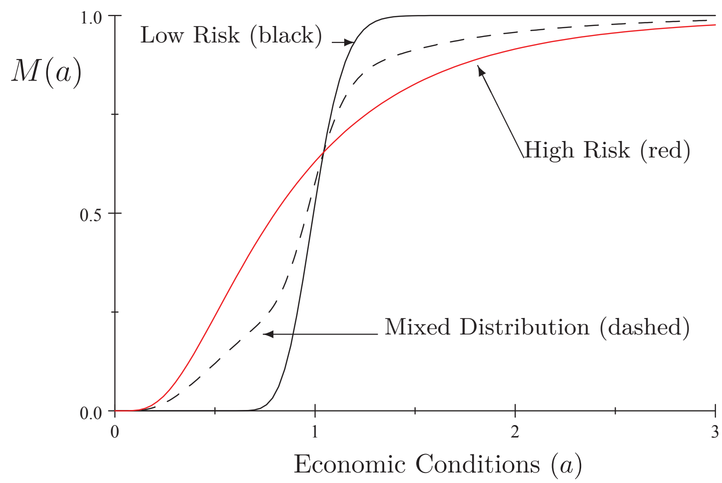
(b) Cumulative export growth decomposition, 2008Q4-2011Q3.



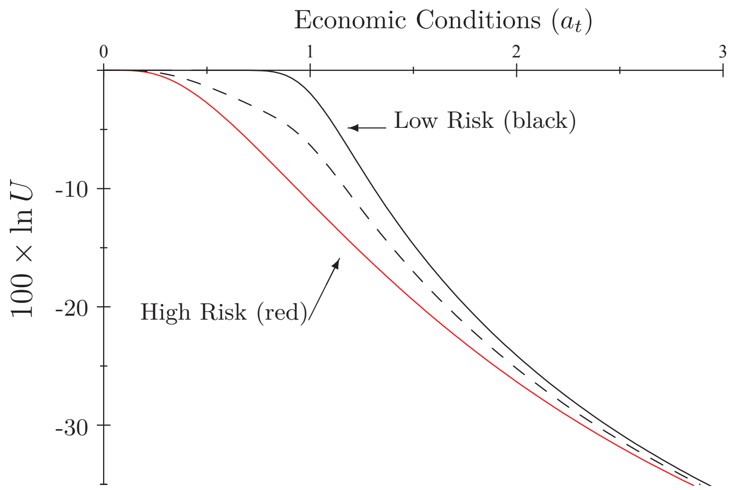
Notes: Constructed from Census LFTTD by quarter using regression sample data. Intensive and Extensive components sum to total export growth. Extensive margin computed over firm-country-product that enter or exit relative to same quarter in previous year. (a) Pre-crisis mean computed from 2003 to 2008Q3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

Figure 8: Increasing Risk in Business Conditions and Entry Cutoff

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



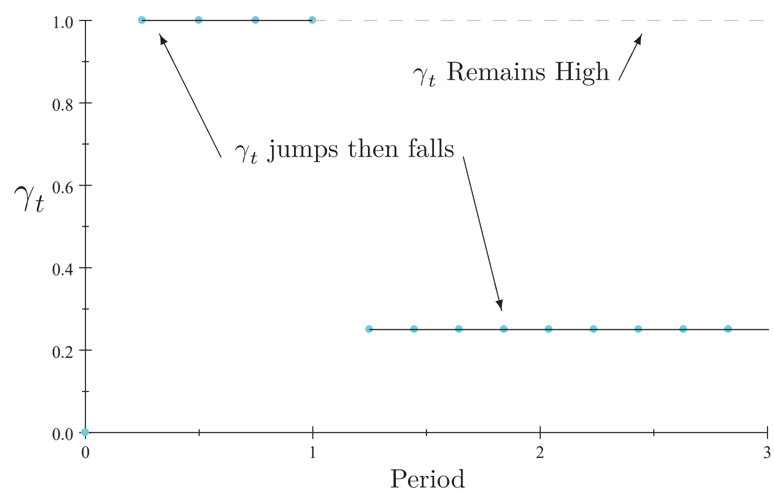
(b) Entry reduction from volatility ($\Delta\gamma = 1$) and current conditions, a_t, under low vs. high risks



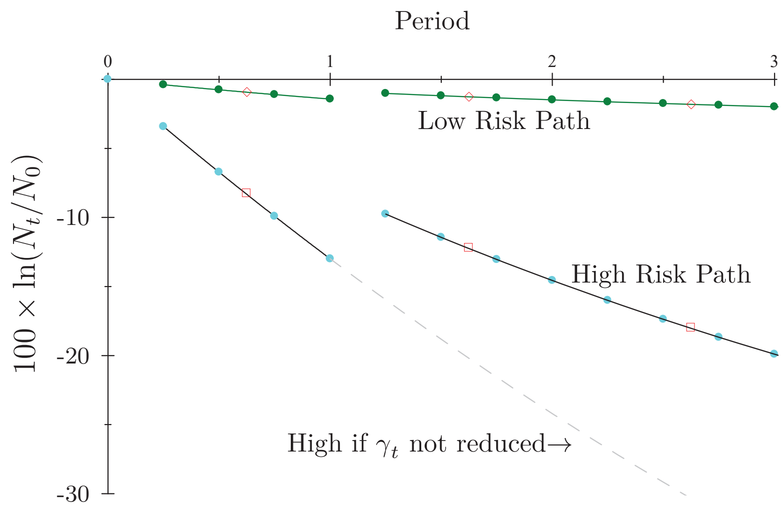
Notes: Low risk H_s (black, $m_s = 1$) and high risk $H_{s'}$ (red, $m_s = 0$) distributions of economic conditions where H_s SSD $H_{s'}$. Intermediate mixed distribution $m_s = 0.5$. All distributions normalized so that $E(a) = 1$ and increases in risk are a mean preserving spread. Panel (b) shows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

Figure 9: Uncertainty Shocks and Adjustment of Varieties in High vs. Low Risk Markets.

(a) Unanticipated uncertainty (γ) shock paths

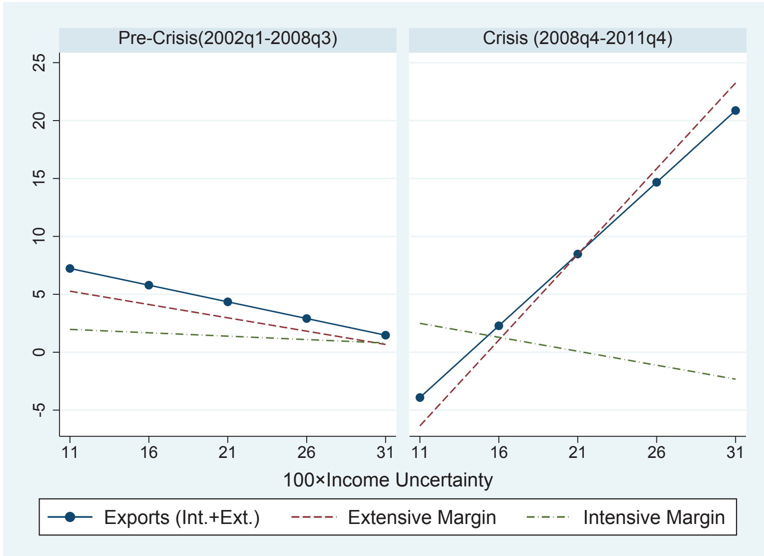


(b) Cumulative Variety growth, $\ln(N_t/N_0)$, in High vs. Low Risk markets



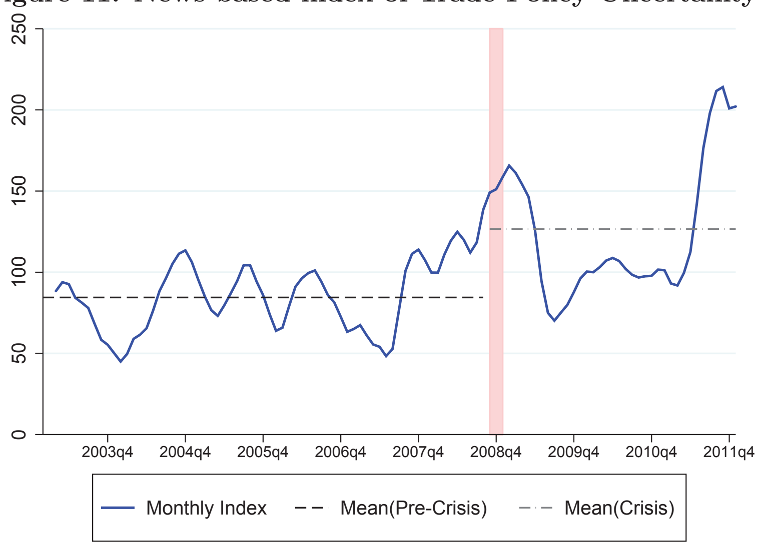
Notes: (a) The solid line with blue circles depicts a 4 quarter increase in uncertainty γ that is reduced in subsequent quarters but does not return to zero. The dashed line is the time path if γ remained high. (b) High income risk time path denoted in solid black and low income risk with green. Circles 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 10: PTA Export Growth Differential vs. Income Uncertainty — Pre and post-crisis decomposition



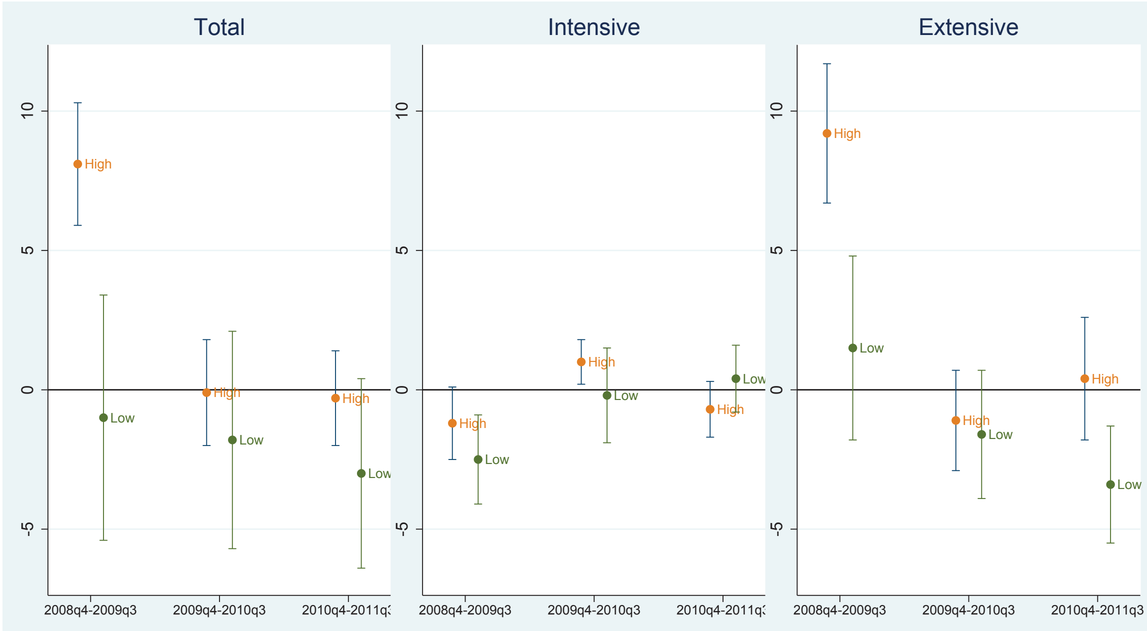
Notes: Computed using coefficients in Table 4, columns 2-4. Income uncertainty measure centered on the PTA mean ± one standard deviation.

Figure 11: News-based index of Trade Policy Uncertainty



Notes: Index of newspaper mentions of words "uncertainty" OR "uncertain" is the set of articles about international trade or trade policy. Light red shading indicates the first quarter of the financial crisis. Blue line is a lowess smoothed average over monthly data. Series is normalized to 100 at mean over the entire period. Pre-crisis mean (dashed line) is 84. Post-crisis mean (dash-dot line) is 127. Construction methodology follows Baker, Bloom and Davis (2016) and is described in the Appendix.

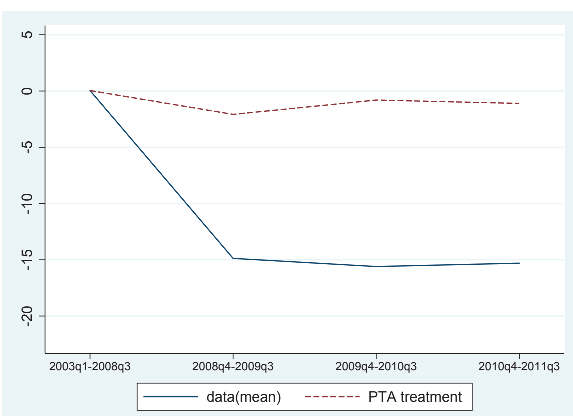
Figure 12: PTA Export Growth Differential Heterogeneity Across Industries and Firms



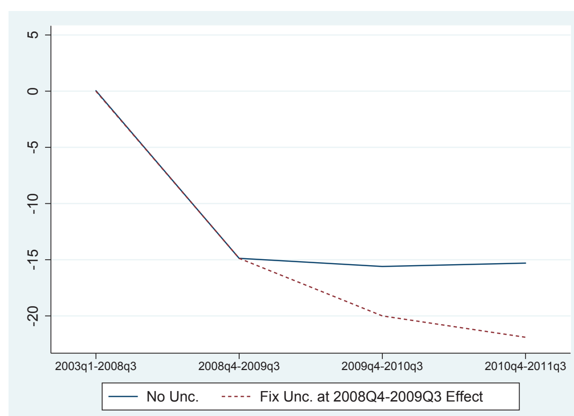
Notes: Point estimates and ones standard error bar from high and low market power industry PTA differentials computed in Table 9(b).

Figure 13: Counterfactual non-PTA Average Variety Growth $(100 \times \ln)$

(a) Treat non-PTA as if PTA



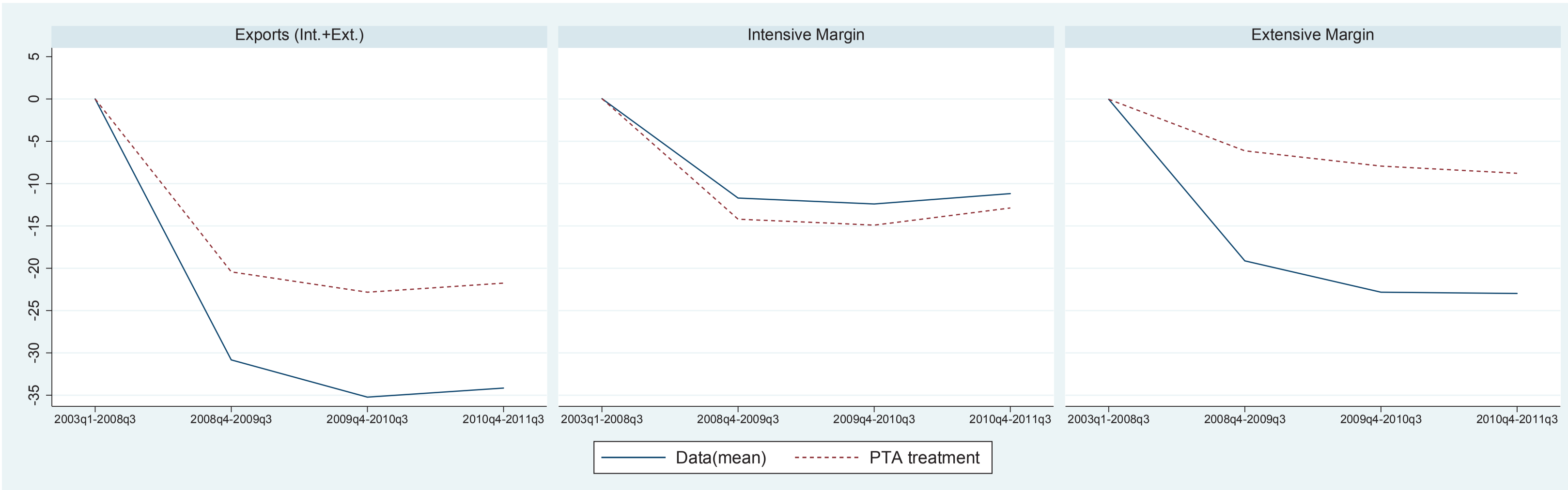
(b) No recovery of uncertainty after 2008Q4



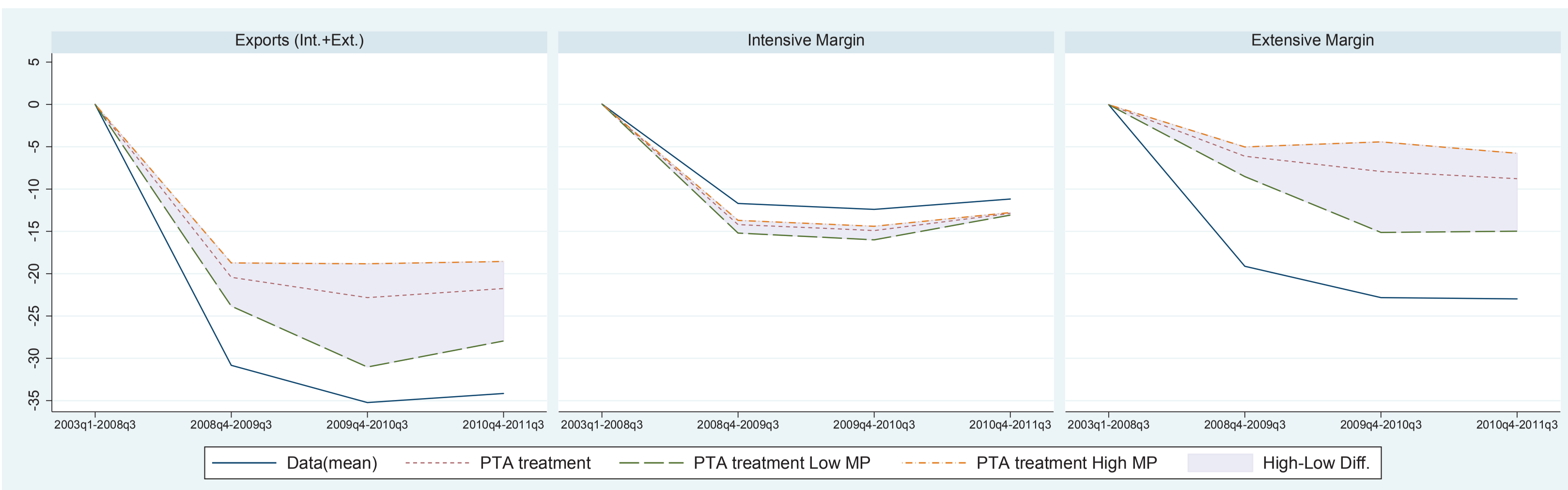
Notes: Computed at the mean of the non-PTA uncertainty measure of 0.26 using coefficients in Table 3. (a) See text for expressions for PTA treatment. (b) Fixed uncertainty counterfactual (dotted lines) computed by replacing estimated income uncertainty effects in 2009Q4-2011Q3 by estimated effect in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

Figure 14: Counterfactual non-PTA Average Export Growth if Treated as PTA

(a) Cumulative Effects by Margin



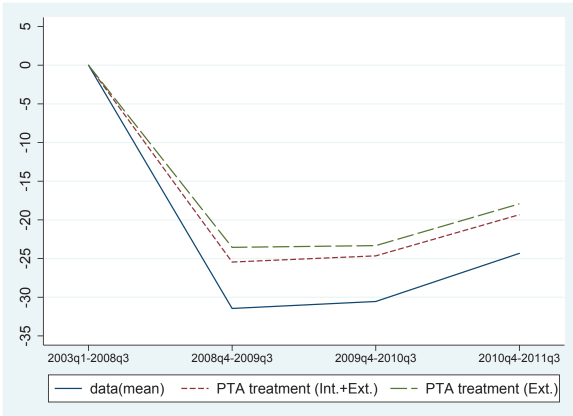
(b) Cumulative Effects by Margin for High and Low Market Power



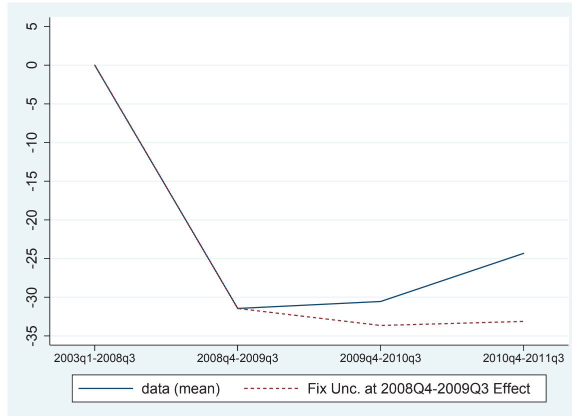
Notes: All effects computed at the mean of the non-PTA uncertainty measure of 0.26. See text for expressions used to compute counterfactual differences. Panel (a) uses coefficients in Table 4(a). See text for expressions. See text for expressions for PTA treatment. Panel (b) uses coefficients from the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

Figure 15: 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.

Tables

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

	Aggregate Export	Extensive Margin	Extensive Margin Growth Share		
Period	Growth	Growth	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 70 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 70 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	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 Cutoff: single uncertainty state

To derive the cutoff in eq. (10) we first combine (7) and (8) to obtain

$$\Pi_w(c,r) = \frac{\beta\gamma(1-H(\bar{a}))}{1-\beta+\beta\gamma(1-H(\bar{a}))}\left[\frac{\mathbb{E}\pi\left(a' \geq \bar{a}, c, r\right)}{1-\beta+\beta\gamma} + \frac{\beta\gamma}{1-\beta}\frac{\mathbb{E}\pi(a,c)}{1-\beta+\beta\gamma} - K\right]$$

then replace (6) in the entry indifference equation (5) and rearrange to obtain (9)

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

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 ω in (11) (after recognizing that $\mathbb{E}(a') - \left(1-H(a_t)\right)\mathbb{E}\left(a' \geq a_t\right) = H(a_t)\mathbb{E}(a' \leq a_t)$).

A.1.1 Proof of Proposition 1

We separate the proof 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**: $c_t^U\left(\gamma'\right) \leq c_t^U\left(\gamma\right)$.

Using (10) and the definition of U we obtain:

$$\begin{aligned}
\frac{\partial \ln c_t^U}{\partial \gamma} &= \frac{1}{\sigma-1}\frac{\partial}{\partial\gamma}\ln\left(1 + \frac{\beta\gamma\left[\omega\left(a_t\right) - 1\right]}{1-\beta\left(1-\gamma\right)}\right) \\
&= \frac{1}{\sigma-1}\frac{\beta\left(1-\beta\right)}{1-\beta(1-\gamma)}\frac{\omega(a_t) - 1}{1-\beta\left(1-\gamma\omega(a_t)\right)} \leq 0
\end{aligned} \tag{45}$$

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

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

From (10) we see that H affects entry only through ω 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

$\omega \geq \omega'$. To see that is the case we first rewrite ω as

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

where the first line uses definition of ω 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' and subtract from ω to obtain

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

If H SSD H' then the inequality in [] 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'.

A.1.2 Proof: Proposition 3

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

We first show that the government objective in (20) 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 (16). The inequality follows from $G_{a_t} > 0$.

In proposition 1 we show M SSD M' is equivalent to $\omega\left(a_t\right) \geq \omega'\left(a_t\right)$ for all a_t, a similar condition holds for the mixture case used in proposition 2. So the risk averse government benefits from a $\Delta_m^{PTA} = m^{PTA} - m$ such that

$$\begin{aligned}
m^{PTA}\omega_{s'}\left(a_t\right) + \left(1 - m^{PTA}\right)\omega_s\left(a_t\right) &\geq m\omega_{s'}\left(a_t\right) + \left(1 - m\right)\omega_s\left(a_t\right) \qquad (46) \\
\left[\omega_{s'}\left(a_t\right) - \omega_s\left(a_t\right)\right]\Delta_m^{PTA} &\geq 0
\end{aligned}$$

PTA entry effects

To derive the entry effects of PTAs we use the cutoff in (13).

Entry impacts of Δ_m^{PTA}. The cutoff is increasing in $\bar{\omega}$ (proposition 2b) 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

$$\frac{\partial \ln c_t^U}{\partial m}\Delta_m^{PTA} = \frac{[\omega_{s'}(a_t) - \omega_s(a_t)]\,\Delta_m^{PTA}}{\sigma - 1}\frac{\beta\gamma}{1-\beta\left(1-\gamma\bar{\omega}(a_t)\right)} > 0 \tag{47}$$

where the inequality is due to (46), $\bar{\omega} \in (0,1)$ and $\sigma > 1$.

A.2 Adjustment dynamics

Derivation of (27) Using (25), (26) we see $\hat{N}_t^0 = \hat{F}_t$ directly and derive $\hat{N}_t^+$ as follows

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

For crisis we first rewrite N_t^- using $\lambda_t^- = \beta\,[N_{t-1} - nF_t]$ 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 $\{0\}$.

Growth in domestic firms

The number of exporters is obtained by modifying (25) and the legacy terms in (26) and combining them to obtain

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

In accounting for legacy we adjust for the number of firms present in the period when the shock occurred. Note that we used $\lambda_t^- = \beta\,[N_{t-1} - nF_t]$ as explained in the derivation above. The growth rate relative to $N_0 = n_0 F_0$ is then

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

Comparing to (27) 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.

A.3 Log-normal shocks

We construct Figure 8 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 8(b) uses U and $\bar{\omega}$ derived in proposition 2. The specific expressions for the Figure 8(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: $\Sigma = 1/8, \Sigma' = 2/3, \gamma = 1, \sigma = 3, \beta = 0.765$.

A.4 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 $\varepsilon P^{\sigma-1}$.[68]

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).

[68] 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}.

Distribution of a under A1

$$\begin{array}{rl} x \sim \ln N(\mu_x, \Sigma_x) & \qquad\qquad\qquad x = \{D, f\} \\ a \sim \ln N(\mu, \Sigma) & \quad \mu = \mu_D + \mu_f \ ; \ \Sigma^2 = \Sigma_D^2 + \Sigma_f^2 + 2\eta\Sigma_f\Sigma_D \end{array} \tag{48}$$

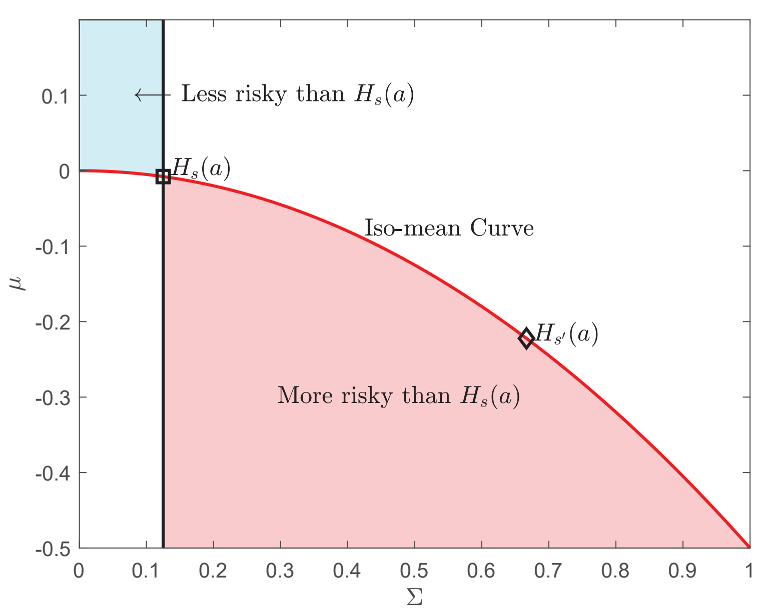
The log normal ensures non-negative values for each x, and thus for a; allows for heavy tails and provides a parametric ranking of distributions according to SSD.

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 A1 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 8 and the vertical line denotes the value of Σ used for H_s. So the box at the intersection represents H_s from Figure 8 and any $H_{s'}$ along the iso-mean with $\Sigma' > \Sigma$ represents a MPS, e.g. the diamond marks $H_{s'}$ plotted in Figure 8. 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 A1: 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 8. $H_s(a)$ 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 $H\left(\boldsymbol{\mu}_x, \boldsymbol{\Sigma}_x\right)$ SSD $H\left(\boldsymbol{\mu}_x', \boldsymbol{\Sigma}_x'\right)$

Proposition 4: 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 (48) 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 A1 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).

A.4.1 Proof: proposition 4

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 $\delta_x \equiv \mu'_x + (\Sigma'_x)^2/2 - \left(\mu_x + (\Sigma_x)^2/2\right) \leq 0$, where the latter is the percent decrease in the arithmetic mean of x , we denote the average of the scale parameters by $\bar{\Sigma}_x \equiv (\Sigma'_x + \Sigma_x)/2$.

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 $\eta \geq -\frac{\bar{\Sigma}_f}{\Sigma_D} \equiv \underline{\eta}$

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

(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**

B Appendix: Data

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

$$unc_{i,T} = 1 - \frac{\exp(\hat{a}_i + \hat{\rho}_i \Delta_4 \ln Y_{i,T} + \hat{\epsilon}_{i,0.05} + 0.5\widehat{\sigma}^2_{\epsilon,i})}{Y_{i,T}} \times \frac{\Phi\left(\frac{\hat{\epsilon}_{i,0.05}}{\widehat{\sigma}_{\epsilon,i}} - \widehat{\sigma}_{\epsilon,i}\right)}{0.05} \text{ for each } i \tag{49}$$

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

Aggregate Trade Flows: See Appendix, section C.1

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 (49)

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.

B.3 Trade Policy Uncertainty News Index

To obtain the data for Figure 11 we search for articles that contain the words “trade policy” OR “international trade” in the *Chicago Tribune, Boston Globe, LA Times, New York Times, Washington Post*, and *USA Today*. We save a count of these articles by newspaper and month. Then within these articles we search for the words “uncertainty" OR “uncertain". For each newspaper and month we construct the share of articles about international trade or trade policy that also mention uncertainty. We then normalize each newspaper series to have unit standard deviation over the time interval we observe it. We take the mean by month over all newspapers and normalize the series to its time series mean. In Figure 11 we plot a lowess smoothed line over the monthly time series. Other moving average or local polynomial smoothing produce a very similar qualitative conclusion.

C Appendix: Estimation

C.1 Aggregate Bilateral Gravity Regressions

This appendix describes the methodology and data used for the evidence in section 2.1. The data on "U.S. Trade in Goods by Country" is available at: `https://www.census.gov/foreign-trade/balance/index.html`. We combine it with quarterly IMF International Financial Statistics on foreign GDP converted to U.S. dollars, foreign GDP deflators, the U.S. industrial production index, and U.S. GDP deflator.[69] We focus on the group of countries subsequently used in our firm-level regression for comparability.

We compute the log difference between U.S. real exports to i at time $t \in [2003, 2011]$ relative to the same quarter in 2002, $\Delta_{t,2002} \ln X_{it}$. The general difference-in-difference (D-i-D) specification is

$$\Delta_{t,2002} \ln X_{it} = \beta CRISIS_t \times PTA_{it} + a_1 CRISIS_t + a_2 PTA_{it} + \mathbf{Z'_{it}} \cdot \mathbf{a_c} + \mathbf{Q_t} + \varepsilon_{it}, \tag{50}$$

where $CRISIS_t$ is a binary variable equal to unity from 2008Q4 to 2011 and PTA_{it} is a binary indicator for whether country i has a PTA with the U.S. at time t. Their interaction identifies the D-i-D estimate of differential growth for PTA export destinations after the crisis, β. The vector $\mathbf{Z_{it}}$ includes standard determinants used in the aggregate empirical gravity literature: the destination U.S. dollar denominated GDP growth as measure of foreign demand, the change in the U.S. index of industrial production as a measure of supply shocks, and changes in the importer and exporter GDP deflators.[70] We control for seasonality using dummies for quarters, $\mathbf{Q_t}$. Time invariant country characteristics, e.g. distance, are differenced out.

Table C1 reports the estimates using different sets of fixed effects and control variables. The baseline D-i-D estimate in column 1 includes only a common time trend in $\mathbf{Z_{it}}$. We estimate a negative and significant decline for non-PTAs of 38 lp during the crisis relative to the time trend, the PTA differential is $\hat{\beta}$ =11 lp. When we also include the standard gravity controls in $\mathbf{Z_{it}}$, the time trend becomes insignificant, but β remains similar; we omit this specification from the table but it is available on request. In column 2 we re-run this gravity equation after restricting $\beta = 0$ and examine the behavior of the corresponding residuals in Figure 3(a), which as described in the text shows that even after controlling for foreign demand growth and prices there is a sizable positive PTA differential in the crisis.

The estimates with the standard gravity controls are $\hat{\beta} = 10$ in column 4 and $\hat{\beta}$ =7.4 in column 5 (respectively without and with country-by-quarter effects).

We explore whether this PTA differential is related to uncertainty by constructing a reduced-form measure of realized demand risk ($GDPSD_i$): the standard deviation of real, annual log GDP growth in each country from 2000-2012. We include this measure in (50) and its interactions with $CRISIS$, PTA and $PTA \times CRISIS$ and estimate

$$\begin{aligned}\Delta_{t,2002} \ln X_{it} = {} & \beta CRISIS_t \times PTA_{it} + a_1 CRISIS_t + a_2 PTA_{it} + \mathbf{Z'_{it}} \mathbf{a_c} + \mathbf{Q_t} + \varepsilon_{it} \\ & + b_1 GDPSD_i + b_2 GDPSD_i \times CRISIS_t + b_3 GDPSD_i \times PTA_{it} \\ & + \beta_{HET} GDPSD_i \times CRISIS_t \times PTA_{it}\end{aligned} \tag{51}$$

[69] We use non-seasonally adjusted data whenever it is available, but 22% of the sample has either seasonally adjusted GDP or deflator data, which is one reason we include indicators for quarters in all regressions and in the robustness include country by quarter interactions.

[70] All nominal variables are deflated by the U.S. GDP deflator. About 3% of the sample uses annual foreign GDP deflators because quarterly counterparts are not available. All results are robust to dropping the foreign GDP deflators.

For ease of comparison across specifications we demean $GDPSD_i$ within the sample so that in columns 6 and 7 the estimate of β is the D-i-D estimate at $\overline{GDPSD_i} = 9.5$ lp. We obtain a similar $\hat{\beta} = 12$ lp. Our measure of economic uncertainty may capture a number of other country characteristics, e.g. institutions, fiscal and monetary policy regimes, and others. In this application we are most interested in its interaction with the crisis indicator, which is negative ($\hat{b}_2 < 0$), and the heterogeneity in the D-i-D effect estimated through the interaction with $CRISIS_t \times PTA_{it}$, which is clearly positive ($\hat{\beta}_{HET} > 0$). To address unobserved heterogeneity in countries correlated with $GDPSD_i$ we use country×quarter effects in column 7, which increases the precision of $\hat{b}_2$ and $\hat{\beta}_{HET}$ without changing the signs and interpretation of any other coefficients.[71]

As described in the main text, we plot a local polynomial through the residuals of the estimates in column 6 in Figure 3(a).

The marginal effect of PTA membership relative to non-PTA prior to the crisis plotted in the left panel of Figure 3(b) is $\hat{a}_2 + \hat{b}_3 GDPSD_i$ and for the remaining periods on the right panel we add $\hat{b}_2 + \hat{\beta}_{HET} GDPSD_i$. The bands around each represent 95% confidence intervals.

[71] These results are robust to including lags of GDP growth rates, U.S. GDP instead of U.S. industrial production, and/or omitting the foreign GDP deflators (which increases the set of countries slightly).

Table C1: Difference in Difference Estimates -- Change in Aggregate U.S. Exports (ln) 2003-2011 relative to 2002

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep. Variable: Change in Exports (ln)							
	Baseline	**Gravity Controls**					
Main Controls and Interactions	**D-i-D**	***Omit Crisis × PTA***		***+ Crisis × PTA***		***+ Risk Interactions***	
Crisis × PTA (D-i-D at means)	**0.113**	**-**	**-**	**0.100**	**0.0735****	**0.123**	**0.117*****
	[0.0719]			**[0.0659]**	**[0.0292]**	**[0.0757]**	**[0.0330]**
Crisis (= 1 if 2008Q4 to 2011, 0 else)	-0.383***	0.0337	0.0325	0.021	0.023	0.022	0.0227
	[0.0430]	[0.0824]	[0.0479]	[0.0827]	[0.0483]	[0.0828]	[0.0483]
PTA (= 1 if PTA member, 0 else)	-0.0408	0.121***	0.281***	0.0790**	0.247***	0.0798**	0.227***
	[0.0341]	[0.0308]	[0.0631]	[0.0322]	[0.0617]	[0.0378]	[0.0673]
Time Trend	0.134***	-	-	-	-	-	-
	[0.00728]						
Change in Importer GDP (USD)		0.704***	0.660***	0.701***	0.655***	0.703***	0.654***
		[0.0533]	[0.0557]	[0.0532]	[0.0557]	[0.0567]	[0.0563]
Change in U.S. Production Index		1.190**	1.225***	1.188**	1.222***	1.188**	1.224***
		[0.541]	[0.318]	[0.541]	[0.317]	[0.541]	[0.317]
Changes in Importer Prices (deflator)		0.362***	0.296***	0.365***	0.304***	0.378***	0.325***
		[0.0613]	[0.0797]	[0.0612]	[0.0799]	[0.0630]	[0.0844]
Change in U.S. Prices (deflator)		0.229	0.435	0.256	0.456	0.222	0.419
		[0.514]	[0.339]	[0.513]	[0.339]	[0.518]	[0.346]
Heterogeneity in Importer Demand Risk (Demeaned Interaction)							
Risk (St. Dev. of Foreign GDP growth)						0.0393	-
						[0.205]	
Crisis × Risk						-0.511	-0.357*
						[0.333]	[0.209]
PTA × Risk						-0.0545	-1.436
						[0.868]	[1.212]
Crisis × PTA × Risk						1.854	2.930***
						[1.473]	[0.761]
R-squared	0.156	0.04	0.78	0.33	0.78	0.33	0.78
Quarter Effects	Yes	Yes	No	Yes	No	Yes	No
Country × Quarter	No	No	Yes	No	Yes	No	Yes

Notes:

There are 2,328 observations in all specifications. Figure 3(a) uses the residuals from column 2 for baseline local polynomials plotted with solid lines. Residuals from column 6 used for local polynomials plotted with dashed lines. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Volatility is demeaned within the sample so that the coefficient on Crisis × PTA in row 1 is scaled into the marginal effect at the mean. For each year and quarter, exports are deflated by U.S. GDP deflator computed and the change in natural logs is computed relative to the same quarter in 2002.

Table C2: Summary Statistics – Aggregate Bilateral Gravity Regressions

Variable	Mean	St. Dev.
ΔExports (ln)	45.24	56.29
PTA (binary)	0.09	0.29
Crisis (binary)	0.36	0.48
ΔForeign GDP (ln)	52.25	32.73
ΔIndustrial Prod. Index (ln)	4.81	4.86
ΔUS GDP Deflator (ln)	11.91	5.68
ΔForeign GDP Deflator (ln)	25.05	26.59
St. Dev Foreign GDP Growth (ln)	9.50	5.15

Notes: 2,238 observations for each. All growth measures are cumulative growth relative to same quarter in 2002. Growth measures are in log points (100×ln). All nominal values are in U.S. dollars deflated by U.S. GDP deflator.

Table C3: 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 C4: 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.