Economic Uncertainty and Countercyclical Export Prices

Yizhi Wang *

This Version July 21, 2017

Abstract

I develop a monopolistic competition model of trade with firm heterogeneity and endogenous mark-ups. The model shows that exporters raise prices thus mark-ups in response to rising economic volatility in export markets. I then examine the hypotheses and investigate the impact of uncertainty on export prices using a panel dataset of Chinese firm exports in 2000-2010 and novel time-variant measures of market specific uncertainty. The empirical findings are broadly consistent with the theoretical predictions.

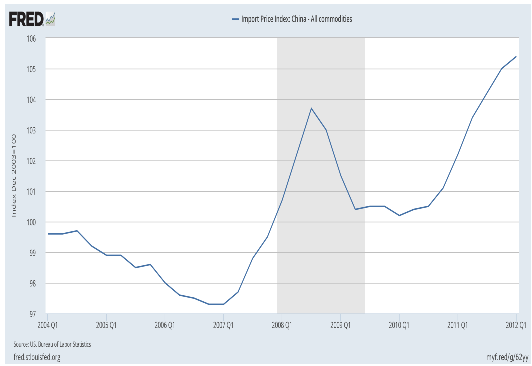
1 Introduction

Economic theory tells us that price will drop as the demand goes down. However, price index of U.S. imports from China surged during the 2007-2009 financial crisis while the economy was hit by a great demand shock. (see Figure 1a and 1b). My paper explores this phenomenon by connecting export prices and uncertainty, [1] and shows that firms decisions under uncertainty is of great importance to understand the change in this aggregate statistic.

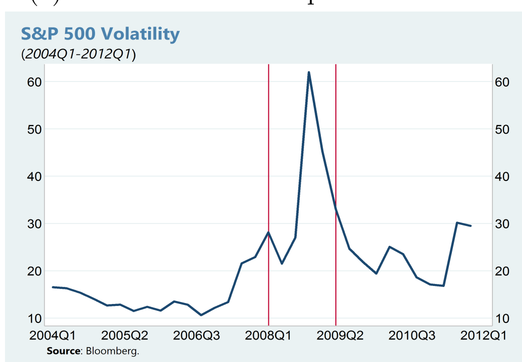
Removing the assumption that demand at the export markets is known with certainty at the time when the output and export decisions are made, a monopolistic competition model of trade with firm heterogeneity and risk-aversion suggests uncertainty could be a driver of export prices at economic

*George Washington University, Jerryw@gwmail.gwu.edu.

[1] Bloom (2014) refers to a single concept of uncertainty as a mixture of risk and uncertainty defined in Knight (1921), therefore risk and uncertainty terms are interchangeable. I will follow this routine.



(a) Pric Index of US Imports from China



(b) US Stock Volatility

Figure 1: Import Price Index & Volatility

downturns. To test the model predictions, a country-sector-year level uncertainty proxy constructed from Bloomberg stock data is used with Chinese customs data and manufacturing data. We show, both theoretically and empirically, that firms charge higher prices, thus mark-ups, facing rising uncertainty; and uncertainty deters entry when demand shock is severly negative.

The intuition behind the results is that exporters tend to charge a risk-premium when they choose to export to destination markets with demand uncertainty. Uncertainty may generate softer competition through a higher average price charged by the incumbents, thus is not necessary to deter entry even potential entrants demand higher premium for risk. This paper show empirically Chinese exporters are less willing to take risk by entering destination markets during the recent financial crisis.

Firm-level heterogeneity in response to uncertainty is further investigated empirically. The results show larger and more productive firms tend to absorb more uncertainty into their mark-ups, which is consistent with a hypothesis that bargaining power is of great importance to determine risk sharing behavior.

The sector-level results show uncertainty negatively influences sector exports, but the impact is much more significant during the crisis period mainly through extensive margin. [2]

In Melitz-type trade models, uncertainty in productivity is resolved before firms production decisions, and firms selling at the equilibrium have non-negative profits (see Melitz, 2003; Melitz and Ottaviano, 2008); in my model, firms make the decisions under economic uncertainty and those who choose to produce can still receive negative profits due to an ex post negative demand shock.

Exporter strategy under uncertainty has been studied in recent trade literature. Esposito (2016) shows that firms can reduce demand risk through geographical diversification. Evidence for the impact of uncertainty on firms market-entry and sourcing decisions has been widely documented (see Berman et al., 2015; Carballo, 2015; Nguyen, 2012), but little work has been done for export prices. Sousa et al. (2016) conclude that expenditure uncertainty has a negative effect on firm-level revenue, and firm-level heterogeneity will narrow the market share gap between high and low productivity firms. My work contributes to the export-under-uncertainty literature by establishing direct link between demand uncertainty and export prices both theoretically and empirically.

Bloom (2014) points out that developing a wider set of uncertainty measures is important. Macroeconomic uncertainty is commonly measured by some country-time specific proxies which are invariant across sectors (see Bachmann et al., 2012); sector or firm level demand uncertainty can be measured by calculating the standard deviation of revenue over the past periods, but this moving average approach is less likely to capture sharp change in uncertainty over time (see Sousa et al., 2016; Dyer et al., 2014; Banker et al., 2013). My paper contributes to the uncertainty measure literature by constructing a country-sector-year level proxy using Bloomberg data.

The apparent resilience of producer, as well as consumer, prices at economic downturns have been documented by the customer market literature. In recent works, Gilchrist et al. (2017) show that financially weak firms significantly increased their prices in 2008 subprime crisis, and attribute it

[2] The period of subprime crisis is defined as 2007 to 2010 in the empirics.

to firm-level investment strategy. This strand of literature originating from Chevalier and Scharfstein (1996) presents demand rigidity and capital market imperfections as incentives for firms to build market share by lowering prices when the economy is good, and deviate from price reductions when the day is bad. And it further suggests that the countercyclical prices are due to countercyclical markups.

The relevance of credit constraints and export prices has been studied in recent international trade literature. The empirical works show mixed evidence on the relationship between them. Fan et al. (2015) show that the impact of credit constraint on Chinese export prices relying on the quality adjustment effect, and tighter credit constraint significantly lowers export prices. Secchi et al. (2016) find that constrained Italian exporters charge higher prices than unconstrained ones do. They further show input costs only account for part of the observed price gap between constrained and unconstrained exporters, and conclude that mark-up difference driven by financial constraint is of great importance to understand export prices dynamic. Eckel and Unger (2016, CEPR Discussion Paper) show whether export prices are positively or negatively correlated to credit constraint and variable trade costs depends on the sector-level R&D intensity. Considering the fact that exporters credit constraint is usually tighter at recessions, dependence of export prices on the financial constraint may shed a light on countercyclical export prices. My paper therefore proposes uncertainty and firm risk-aversion can be an alternative mechanism to explain the observation of countercyclical export prices except for financial constraints.

My paper is also related to a large body of literature studying export prices, quality and exchange rate pass-through. [3] While the quality sorting and the efficiency sorting in the literature suggest the opposite effects for average price at extensive margin, it is critical to understand firm-level export prices before a discussion on the aggregate price index. The quality sorting literature, as in models of Kugler and Verhoogen (2012), Baldwin and Harrigan (2011), suggests high-productivity firms charge higher prices for their goods with higher quality and costs. The exit of low-productivity exporters therefore pushes the average price up. On the contrary, the efficiency sorting as introduced by Melitz (2003) consider firms compete only in price. Low-productivity firms charge higher prices due to higher costs. In this set-up, the implication of firm exit is opposite to that in the quality sorting. That is average price will decrease due to the dropout of those less competitive firms. The empirical work in this paper supports the efficiency

[3] Unit price is commonly used as a proxy for goods quality.

sorting hypothesis using Chinese data.

The remainder of this article is organized as follows. Section 2 introduces a model accommodating the observation of positive correlation between firm/sector-level export prices and uncertainty. Section 3 discusses the data sets used for the analysis. Section 4 presents the empirical methodology and the main empirical findings and section 5 draws a conclusion.

2 Model

I develop a monopolistically competitive model of trade with firm heterogeneity and uncertain demand. In this model, a risk-averse exporter's mark-up depends on both toughness of competition and uncertainty. An exporter charges a higher price thus mark-up when faces softer competition, or higher uncertainty.

Let S define the set of countries. $\forall$ country $i \in S$, there are L_i workers and each worker is endowed with 1 unit of labor. Each country has a homogeneous goods sector with perfect competition. The marginal cost in producing 1 unit of this good is 1 unit of labor. Take this homogeneous good as numeraire, then the wage for the workers in this sector equals 1. Each country also has a heterogeneous sector with a continuum of possible differential varieties defined by Ω. And a firm produces one variety ω.

Productivity of a firm in the heterogeneous sector, defined as φ, is drawn from a distribution function $G(\varphi)$. Iceberg transport costs for exporter i to destination j and the utility loss associated with sunk entry costs are denoted by τ_{ij} and f_E respectively.

Entry is endogenous following Melitz and Ottaviano (2008).

Firms make their decision according to the timeline below,

Choose location to enter $\longrightarrow$ Pay sunk entry costs $\longrightarrow$ Observe productivity φ $\longrightarrow$ Production/Exit/Export decisions $\longrightarrow$ Observe demand shock $v_j(\omega)$.

2.1 Consumer's Problem

The utility maximization problem for a representative consumer in country j is as follows

$$
\begin{aligned}
\underset{q_j^c(\omega)}{\text{Max}} \quad & u_j^c = q_{j0}^c + \int_{\omega\in\Omega_j} (\alpha + v_j(\omega)) q_j^c(\omega) d\omega - \frac{1}{2}\gamma \int_{\omega\in\Omega_j} q_j^c(\omega)^2 d\omega \\
& - \frac{1}{2}\eta \left(\int_{\omega\in\Omega_j} q_j^c(\omega) d\omega \right)^2 \\
\text{s.t} \quad & \int_{\omega\in\Omega_j} p_j(\omega) q_j^c(\omega) d\omega + p_{j0}^c q_{j0}^c = w_j
\end{aligned}
$$

Where q_{j0}^c is the consumption in homogeneous good sector, $q_j^c(\omega)$ is the consumption of variety ω, and $v_j(\omega)$ is the country-variety-specific demand shifter which captures the idea of economic uncertainty. The parameters α and η capture the substitution pattern between the numeraire and the differentiated variety respectively. That is the higher the α or the lower the η, the higher weight to differentiated goods sector; γ represents the degree of product differentiation between the varieties, i.e: low γ indicates goods are easy to substitute in the heterogeneous sector.

Maximizing (1) subject to (2) gives us the representative consumer's demand for variety ω in market j,

$$p_j(\omega) = \alpha + v_j(\omega) - \gamma q_j^c(\omega) - \eta Q_j^c \tag{1}$$

$$Q_j^c = \int_{\omega\in\Omega_j} q_j^c(\omega) d\omega \tag{2}$$

Let Ω_j^* be the set of firms selling at the equilibrium and $|\Omega_j^*| = N_j$. Therefore N_j is the number of firms at the equilibrium in country j. Rewrite (3) as

$$q_j^c(\omega) = \frac{\alpha}{\gamma} + \frac{v_j(\omega)}{\gamma} - \frac{\eta}{\gamma} Q_j^c - \frac{1}{\gamma} p_j(\omega) \tag{3}$$

Substituting (5) into (4) leads to

$$Q_j^c = \frac{(\alpha + \bar{v_j}) N_j - \bar{p_j} N_j}{\gamma + \eta N_j} \tag{4}$$

$$\bar{p_j} = \frac{\int_{\omega\in\Omega_j^*} p_j(\omega) d\omega}{N_j} \tag{5}$$

$$\bar{v_j} = \frac{\int_{\omega\in\Omega_j^*} v_j(\omega) d\omega}{N_j} \tag{6}$$

$$
\begin{aligned}
p_{max_j(\omega)} &= \alpha + v_j(\omega) - \eta Q_j^c \\
&= \bar{p}_{max_j} + v_j(\omega) \\
&= \frac{\alpha\gamma + \eta N_j(\bar{p_j} - \bar{v_j})}{\gamma + \eta N_j} + v_j(\omega)
\end{aligned} \tag{7}
$$

Thus, a firm competes in market j will face the following demand equation

$$
\begin{aligned}
q_j(\omega) &= L_j q_j^c(\omega) \\
&= \frac{L_j}{\gamma}(p_{max_j} - p_j(\omega)) \\
&= \frac{L_j}{\gamma}(\bar{p}_{max_j} + v_j(\omega) - p_j(\omega))
\end{aligned} \tag{8}
$$

Let ϵ define the elasticity of demand,

$$\epsilon = [\frac{p_{max_j}}{p_j(\omega)} - 1]^{-1}$$

Assuming $p_{max_j} \leq \alpha + v_j(\omega)$, lower average prices $\bar{p}_j$, larger number of firms selling at the equilibrium N_j, or a negative preference shock $v_j(\omega)$ indicate lower choke price p_{max_j}, therefore higher elasticity of demand ϵ. And high-productivity firms (low-price firms) face lower demand elasticity.

The source of uncertainty after entry is that firms fail to observe the actual $v_j(\omega)$, even they know all the aggregate indexes, i.e., $\bar{p_j}, \bar{N_j}$, and $\bar{v_j}$, while choosing their output level for each destination market. I assume $v_j(\omega)$ distributed with a mean of μ_{v_j} and a variance of $\sigma^2_{v_j}$ ($E[v_j(\omega)] = \mu_{v_j}$ and $Var[v_j(\omega)] = \sigma^2_{v_j}$ $\forall$ ω).

2.2 Firm's Problem

Firms located in country i face uncertain demand at the time the export contracts are signed. I assume firms decide their delivery level $q_{ij}(\omega)$ for each destination j before they know the realized value of $v_j(\omega)$; and equilibrium price $p_{ij}(\omega)$ is determined ex post following the realized demand shifter $v_j(\omega)$; firms cannot adjust quantity based on the observation of demand shock. Firms are assumed to be risk-averse with mean-variance utility function.

A firm located in country i exporting to destination j with iceberg trade costs, τ_{ij}, obtains profit π_{ij} from market j,

$$\pi_{ij}(\varphi) = p_{ij}(\varphi)q_{ij}(\varphi) - \frac{w_i\tau_{ij}}{\varphi}q_{ij}(\varphi)$$

and $\tau_{ij} = 1$ if $i = j$, otherwise $\tau_{ij} > 1$.

The firm maximizes its expected utility given $\bar{p}_{max_j}$

$$\begin{aligned}
\underset{q_{ij}}{\text{Max}} \quad \Pi_{ij} &= E(\pi_{ij}) - \rho Var(\pi_{ij}) \\
&= E(p_{ij})q_{ij} - \frac{w_i \tau_{ij}}{\varphi} q_{ij}(\omega) - \rho \sigma^2_{v_j} q^2_{ij} \\
\text{s.t} \qquad p_{ij}(\omega) &= -\frac{\gamma}{L_j} q_{ij}(\omega) + \bar{p}_{max_j} + v_j(\omega)
\end{aligned}$$

The optimal output level is,

$$q^*_{ij} = q_{ij}(\omega)^* = \frac{\bar{p}_{max_j} + \mu_{v_j} - \frac{w_i \tau_{ij}}{\varphi}}{2(\gamma / L_j + \rho \sigma^2_{v_j})}. \tag{9}$$

Substitute the optimal output into the demand, the realized price is

$$p_{ij}(\omega)^* = \bar{p}_{max_j} - \frac{\gamma(\bar{p}_{max_j} + \mu_{v_j} - \frac{w_i \tau_{ij}}{\varphi})}{2(\gamma + L_j \rho \sigma^2_{v_j})} + v_j(\omega) \tag{10}$$

To simplify the model solutions, we further assume that $p_{ij}(\omega)^* \geq 0$.

Prediction 1 Given $\bar{p}_{max_j}$, both $p^*_{ij}(\omega)$ and the mark-up, price over marginal cost, increase in the uncertainty proxy $\sigma^2_{v_j}$; and $p^*_{ij}(\omega)$ decreases in productivity φ, but the mark-up increases in φ if the unexpected demand is not too small, $(v_j(\omega) - u_{v_j} \ll 0)$; q^*_{ij} decreases in $\sigma^2_{v_j}$ (see Appendix).

The above partial equilibrium results can be understood as the short-run effect of uncertainty; while the general equilibrium results, which we will discuss in the following, can be considered as the long-run effect.

2.3 Market Entry and Exit

Exit is driven by demand. Firms will exit from market j if $\Pi_{ij} \leq 0$. For the marginal firms in market j with productivity φ^*_{ij}, $\Pi_{ij} = 0$ indicates

$$\bar{p}_{max_j} + \mu_{v_j} = \frac{w_i \tau_{ij}}{\varphi^*_{ij}} = MC^*_{ij} \tag{11}$$

$$\varphi^*_{ij} = \frac{w_i \tau_{ij}}{\bar{p}_{max_j} + \mu_{v_j}}$$

Firms exit when their marginal cost, $MC_{ij} \geq MC^*_{ij}$.

Define $\pi_i \equiv \sum_{j \in S} \pi_{ij}$, and $U_i \equiv E(\pi_i) - \rho Var(\pi_i)$. Assuming non-correlated markets, i.e: $Cov(v_k, v_m) = 0 \; \forall \; k \neq m$, then $U_i = \sum_{j \in S} [E(\pi_{ij}) - \rho Var(\pi_{ij})]$. Prior to entry, firm's expected utility is given by $\int_{\varphi^*_i}^{+\infty} U_i dG(\varphi) -$

f_e, where $G(\varphi)$ defines the cumulative distribution function of productivity φ in country i, and f_e defines the loss of utility associated with the sunk entry costs.

$$U_i(\varphi) = \sum_{j \in S} \frac{(\bar{p}_{max_j} + \mu_{v_j} - \frac{w_i \tau_{ij}}{\varphi})^2}{4(\frac{\gamma}{L_j} + \rho \sigma_{v_j}^2)} \tag{12}$$

Assuming φ is Pareto distributed with the probability density function $g_i(\varphi) = \frac{\theta_i}{\varphi^{\theta_i+1}}$, the free entry condition can be written as

$$\int_{\varphi_i^*}^{+\infty} U_i(\varphi) \frac{\theta_i}{\varphi^{\theta_i+1}} d\varphi = f_E, (\theta_i > 0) \tag{13}$$

The free entry condition can be used to pin down φ_i^* which in turn decides the number of firms in the equilibrium, N_j, and number of firms entering the market N_E^k, $\forall k \in S$.

2.4 Two-country Solution

In the previous section, I use a multiple-country model to present the partial equilibrium effects of uncertainty on firm and sector level performance variables. To assess the general equilibrium effects of uncertainty and keep the solution tractable, I refer to a simplified two-country model, i.e: $S = i, j$.

A firm located in country i receives profits from both domestic and foreign markets,

$$U_i(\varphi) = \frac{(\bar{p}_{max_i} + \mu_{v_i} - \frac{w_i \tau_{ii}}{\varphi})^2}{M_i} + \frac{(\bar{p}_{max_j} + \mu_{v_j} - \frac{w_i \tau_{ij}}{\varphi})^2}{M_j} \tag{14}$$

thus the free entry condition can be written as

$$\frac{\theta_i}{M_i} \int_{\varphi_i^*}^{+\infty} (1/\varphi_i^* - 1/\varphi)^2 \varphi^{-\theta_i - 1} d\varphi + \frac{\theta_i \tau_{ij}^2}{M_j} \int_{\varphi_{ij}^*}^{+\infty} (1/\varphi_{ij}^* - 1/\varphi)^2 \varphi^{-\theta_i - 1} d\varphi = f_e \tag{15}$$

For the marginal firms selling in market j,

$$\bar{p}_{max_j} + \mu_{v_j} = \frac{w_i \tau_{ij}}{\varphi_{ij}^*} = \frac{w_j \tau_{jj}}{\varphi_j^*} \tag{16}$$

which indicates $\varphi_{ij}^* = \varphi_j^* \tau_{ij}$.

$$\frac{\theta_i K_i}{M_i} (1/\varphi_i^*)^{\theta_i + 2} + \frac{\theta_i K_i}{M_j} \tau_{ij}^{-\theta_i} (1/\varphi_j^*)^{\theta_i + 2} = f_e \tag{17}$$

$$K_j = \frac{1}{\theta_j} - \frac{2}{\theta_j + 1} + \frac{1}{\theta_j + 2}$$

The condition can be used to solve for the cutoff productivities, i.e: $\varphi_i^*, \varphi_j^*, \varphi_{ij}^*$ and φ_{ji}^*. Without loss of generality, assuming $\theta_i = \theta_j = \theta$,

$$\varphi_j^* = [\frac{\theta K(\tau_{ji}^{\theta} - \tau_{ij}^{-\theta})}{f_E M_j(\tau_{ji}^{\theta} - 1)}]^{\frac{1}{\theta+2}} \tag{18}$$

$$M_j = 4(\frac{\gamma}{L_j} + \rho\sigma_{v_j}^2)$$

We can show $\varphi_{ii}^* = \varphi_i^* > \varphi_{ij}^*$ (see Appendix).

The cut-off φ_j^* thus depends on bilateral trade costs, sunk entry utility f_E , distribution parameter θ, demand parameter γ, market size L, Arrow−Pratt risk aversion measure ρ, and uncertainty proxy $\sigma_{v_j^2}$. It is worth emphasizing that the productivity cut-off is independent of the realized value of demand shock $v_j(\omega)$ due to the timing of firms' decisions.

Prediction 2 The entry productivity cutoff decreases in uncertainty proxy at the destination market, $\frac{\partial\varphi_j^*}{\partial\sigma_{v_j}^2} < 0$; and the average productivity of firms at the equilibrium will fall due to the rise in uncertainty, $\frac{\partial\bar{\varphi}_j}{\partial\sigma_{v_j}^2} < 0$.

Combining φ_j^* with (9) and (10), the general equilibrium effects of uncertainty on firm-level prices and outputs can be derived.

Prediction 3 Export prices increase in uncertainty at the destination market, $\frac{\partial p_{ij}^*}{\partial\sigma_{v_j}^2} > 0$; export quantities decreases in uncertainty at the destination market, $\frac{\partial q_{ij}^*}{\partial\sigma_{v_j}^2} < 0$.

Given the model assumption that marginal cost is independent of uncertainty, export markups therefore increase in uncertainty due to the effect of export prices.

2.4.1 Prices and product variety

Price level in country j consists of both the prices of domestic producers, $p_j^*(\omega)$, and the prices of exporters from country i, p_{ij}^*. These prices can be written as:

$$p_{ij}^*(\omega) = \bar{p}_{max_j} - \frac{\gamma(\bar{p}_{max_j} + \mu_{v_j} - \frac{w_i\tau_{ij}}{\varphi})}{2(\gamma + L_j\rho\sigma_{v_j}^2)} + v_j(\omega), \varphi \in [\tau_{ij}\varphi_j^*, +\infty]$$

$$p_j^*(\omega) = \bar{p}_{max_j} - \frac{\gamma(\bar{p}_{max_j} + \mu_{v_j} - \frac{w_j \tau_{jj}}{\varphi})}{2(\gamma + L_j \rho \sigma_{v_j}^2)} + v_j(\omega), \varphi \in [\varphi_j^*, +\infty]$$

where the productivity of domestic firms $\varphi \in [\varphi_j^*, +\infty]$, and the productivity of exporters discounted by the trade costs $\varphi/\tau_{ij} \in [\varphi_j^*, +\infty]$ have identical distribution over the support (see Appendix). Assuming the distribution of variety-specific shifter $v_j(\omega)$ independent of φ, the above prices can be interpreted as the shifter plus a non-variety-specific component. Therefore, the non-variety-specific component of domestic firms in market j, $p_j^*(\omega) - v_j(\omega)$, and that of exporters producing in i, $p_{ij}^*(\omega) - v_j(\omega)$, are also distributed identically and the cumulative distribution function is defined as $G_D(\varphi)$. The average price in country j thus is given by

$$\begin{aligned} \bar{p_j} &= \frac{\int_{\omega \in \Omega_j^*} p_j(\omega) d\omega}{N_j} \\ &= \int_{\varphi_j^*}^{+\infty} (p_j(\varphi) - v_j(\omega)) dG_D(\varphi) + \frac{\int_{\omega \in \Omega_j^*} v_j(\omega) d\omega}{N_j} \qquad (19) \\ &= \underbrace{(1/\varphi_j^*)}_{\text{Selection Effect}} \times \underbrace{\Phi(\sigma_{v_j}^2; \gamma, L_j, \theta, \rho)}_{\text{Risk-aversion Effect}} + \underbrace{\bar{v_j} - \mu_{v_j}}_{\text{Error of Sampling}} \\ \Phi(\sigma_{v_j}^2; \gamma, L_j, \theta, \rho) &= 1 - \frac{\gamma}{2(\gamma + L_j \rho \sigma_{v_j}^2)(\theta + 1)} \end{aligned}$$

Combining (19) with (7) and (11) to solve the number of firms selling in country j at the equilibrium:

$$N_j = 2\varphi_j^*(\theta + 1)(\gamma + L_j \rho \sigma_{v_j}^2)(\alpha + u_{v_j} - 1/\varphi_j^*)/\eta \qquad (20)$$

Prediction 4 The average price increases in uncertainty at the destination market, $\frac{\partial \bar{p}_j}{\partial \sigma_{v_j}^2} > 0$.

The change in average price is a combination of selection effect and risk-aversion effect, i.e., as the rise in uncertainty, the less productive firms selected into the equilibrium charge higher prices than those incumbents, and the surviving firms charge a higher price as well. These two effects together push the average price up.[4]

[4]If the economy is really bad, i.e., $\bar{v_j}$ is negative and small, sector-level price will fall even we have selection effect and risk-aversion effect.

The effect of uncertainty on average price can be decomposed as the extensive and intensive margin,

$$\frac{d\bar{p_j}}{d\sigma^2_{v_j}} = \underbrace{\frac{\partial \bar{p_j}}{\partial p_j(\varphi)}\frac{dp_j(\varphi)}{d\sigma^2_{v_j}}}_{\text{Intensive Margin}} + \underbrace{\frac{\partial \bar{p_j}}{\partial \varphi^*_j}\frac{d\varphi^*_j}{d\sigma^2_{v_j}}}_{\text{Extensive Margin}} > 0$$

Both of these two effects are positive, and the empirics show intensive margin, the pricing behavior of firms, is the main force which drove the average price up with increasing uncertainty.

However, the impact of uncertainty $\sigma^2_{v_j}$ on number of firms at the equilibrium N_j is ambiguous. The rise in uncertainty proxy will lower the productivity cut-off which indicates a less competitive market; however, the increase in uncertainty may also deter potential entrants. The total effect is determined by the relative magnitude of these two forces.

2.4.2 Number of entrants, domestic producers, and exporters

The number of sellers in market j, N_j, is comprised of domestic producers and exporters from country i. Given entrants in country i and j are N^i_E and N^j_E respectively, there are $(1 - G(\varphi^*_j))N^j_E$ domestic producers and $(1 - G(\varphi^*_{ij}))N^i_E$ exporters selling in market j satisfying $(1 - G(\varphi^*_j))N^j_E + (1 - G(\varphi^*_{ij}))N^i_E = N_j$. This condition is also true for country i, the number of entrants in both countries hence can be solved.

$$N^j_E = \frac{(\varphi^*_j)^\theta (N_j - (\varphi^*_i/\varphi^*_{ij})^\theta N_i)}{1 - \tau_{ij}^{-\theta}\tau_{ji}^{-\theta}} \tag{21}$$

The impact of uncertainty $\sigma^2_{v_j}$ on the number of entrants from country i and country j is ambiguous.

To better understand the implications of this model, one can consider the following two situations (see Appendix).

If τ_{ij} is high, the number of firms selling in country j N_j will increase as the rise in uncertainty $\sigma^2_{v_j}$. However, we are not sure the impact on N^j_E and N^i_E without further assumptions on the model parameters.

If τ_{ij} is low, the number of firms selling in country j, N_j, will decrease with the rise in uncertainty $\sigma^2_{v_j}$. And the number of entrants from country i will increase, while the number of entrants from country j will decrease. Intuitively, increase of uncertainty in a more open market will bring higher importing competition through a lower productivity cut-off, thus the number of domestic entrants will drop.

3 Data

The implications of the model are put into test with Chinese customs data, Chinese firm level production data and Bloomberg stock data. Relevant Macroeconomic controls are obtained from World Economic Outlook Database published by International Monetary Fund and Penn World tables. Tariff data can be accessed through the WTO and the trade analysis and information system (TRAINS).

3.1 Chinese Customs Data

The export data from China's General Administration of Customs reports eight-digit harmonized system (HS-8) code monthly transactions by firm-destination. It covers relevant information such as free-on-board (FOB) value and volume. This monthly data is collapsed to annual level from 2000 to 2010. Considering the possible different strategies to conduct processing and ordinary trade, I keep transactions for ordinary trade only for my analysis.

3.2 Firm-Level Production Data

The firm-level production data from China's National Bureau of Statistics (NBS) contains complete information on the three major accounting statements (i.e. balance sheet, profit and loss account, and cash flow statement) of manufacturing firms from 1999 to 2007. This dataset includes all state-owned enterprises (SOEs) and non-SOEs whose annual sales are above RMB 5 million. Following Feenstra et al. (2013a) and Yu (2014), I drop observations if any of the following are true:

(i) total assets or net fixed assets or sales revenue are missing;

(ii) number of employees is less than 8;

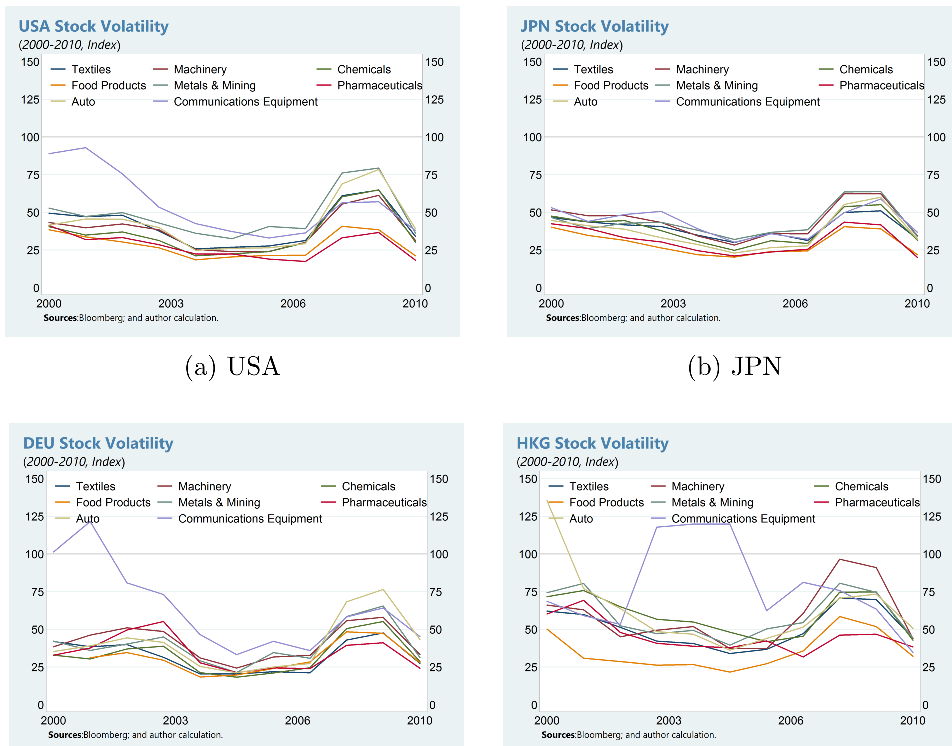
(iii) pure trading firms (identified by key Chinese characters).

The NBS data provides revenue-based total factor productivity (TFP) and other firm characteristics, such as ownership status, number of employees, to merge with Chinese customs data.

3.3 Bloomberg Stock Market Volatility

The country-sector level uncertainty proxy is created by calculating the weighted average of stock price volatility using daily data. The constructed uncertainty proxy consists of eight Global Industry Classification Standard

(GICS) sectors and forty-six countries including all the major export markets of China (see Appendix). Figure 2 shows how the constructed proxy of the representative markets looks like,



(a) USA

(b) JPN

(c) DEU

(d) HKG

Figure 2: Bloombeg Uncertainty Proxy by Country

There are several important patterns of the constructed uncertainty proxy can be found above. First, it manages to respond to the important events, such as collapse of the dot-com bubble (2000-2002), subprime crisis (2007-2009). That is the change in uncertainty over time is well captured by the proxy. Second, the uncertainty proxy is highly correlated across sectors within a country. Third, the variation across country exists.

3.4 Matched Data Set

While the Chinese customs data and firm-level production data are widely used in the related research, researchers face some technical challenges in merging these two data sets (See Yu, 2014; Yu and Tian, 2012). Another issue we need take into account is to match the Bloomberg uncertainty proxy to the trade data at country-sector-year level. Since sectors in the Bloomberg data do not come with a corresponding HS code, concordance between HS-2 and GICS sectors is performed to categorize HS-2 sectors into GICS sectors (see Appendix).

4 Empirics

In this section, we start with testing the firm-level model predictions using the most disaggregate data at HS-8 level followed by the investigation on exporters' heterogeneous reponse to uncertainty. The aggregate implications of firm risk-aversion is further studied through firm-country-sector-level entry and exit decisions and country-sector-level exports. The empirics show the following: 1) the elasticity of price to uncertainty is positive, and the result holds after controlling for firm / product turnover; 2) the elasticity of export volume to uncertainty is negative; 3) high-performance exporters have higher elasticity of price to uncertainty; 4) high uncertainty only deters entry when the economy is in a recession; 5) sector exports are driven down by uncertainty through the extensive margin.

4.1 Main Results

The country-sector-level uncertainty proxy allows us to explore the variation in export prices across destinations, sectors and years. Unit value of exports can be defined as the ratio of FOB value divided by export volume for each firm-product-country-year observation, and unit value and price are used interchangeably throughout this paper. However, unit value will be a poor measure for export price if the unit of exports are inconsistent in the data (see Kugler and Verhoogen, 2012). Chinese customs data may suffer from the same unit consistency criticism. But this issue will less influence our results with the inclusion of firm-product fixed effects, given a product exported by the same firm is less likely to involve in inconsistent unit.

To test the prediction of unit price in the model, a benchmark regression equation is specified as follows,

$$ln(y^k_{ipjt}) = \beta_1 ln(UNC^k_{jt}) + \beta_2 ln(\bar{\varphi}^k_{it-1}) + \beta_x X^k_{jt} + \phi_{ip} + \mu_{jt} + \epsilon_{ipjt} \tag{22}$$

where i, p, k, j, t represent firm, product, sector, destination and year respectively. y^k_{ipjt} is the performance variable, i.e., unit value, quantity sold or revenue of product p, belonging to sector k, sold by exporter i to market j on year t; UNC_{jt}^{k} is a country-sector-year level uncertainty proxy, and the measure used in the analysis is standardized stock volatility[5]; $\bar{\varphi}_{it-1}^{k}$ is the standardized (by CIC-2-year) total factor productivity of firm i at the period of t-1; X_{jt}^{k} is a vector of country-sector-level control variables, such as tariff; ϕ_{ip} is the firm-product fixed effects to control for time-invariant firm, product or firm-product level effects; μ_{jt} is the country-year fixed effects, used to control for the factors that vary by country, by year, or by country-year pair.

VARIABLES (Y=Log Unit Value)	(1) Main	(2) Main	(3) Main	(4) Main
Log Volatility	0.0144**	0.0132**	0.0122***	0.0229***
	(0.00559)	(0.00573)	(0.00426)	(0.00635)
Log L1_TFP	-0.00588***	-0.00556***	-0.00511***	-0.00497***
	(0.00180)	(0.00182)	(0.00177)	(0.00185)
Log Tariff	-0.00204	-0.000819	0.0209***	-0.00209
	(0.00189)	(0.00195)	(0.00645)	(0.00189)
Log Country-HS2 Import		-0.00443***		
		(0.00137)		
Log Volatility x Log L1_TFP				0.00690***
				(0.00236)
Observations	1,595,649	1,517,371	1,595,649	1,595,649
R-squared	0.033	0.033	0.044	0.033
Number of Firm-Product(-Country)	412,645	397,018	890,863	412,645
Firm-Product FE	Yes	Yes	No	Yes
Country-Year FE	Yes	Yes	No	Yes
Firm-Product-Country FE	No	No	Yes	No
Year FE	No	No	Yes	No

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 1: Benchmark Results

The TFP measure in the benchmark regression is estimated by the method suggested by Ackerberg et al. (2006), and the result is robust for alternative TFP measures, such as Olley-Pakes and system-GMM. [6]

Column (1) of Table 1 displays the main findings that export prices are positively correlated to the uncertainty proxy, and negatively correlated to

[5] The stock volatility is divided by the average within its country-sector for each year.

[6] Since the lagged TFP is not available for 2009 and 2010, the latest available estimated TFP is used as the proxy for those years with missing TFP value.

TFP measure. Distinguishing the effects of uncertainty from the impact of demand shock is empirically challenging, since demand shock is highly correlated to uncertainty (see Bloom, 2014). To account for the effects of demand, column (2) controls for the two digit harmonized system code (HS-2) sector import value at the destination market. And it shows that the positive elasticity of price to uncertainty is persistent after controlling for the sector level demand. Column (3) uses an alternative set of fixed effects to explore the variation of prices over time within a firm-product-country triplet, while column (1), (2) and (4) take advantage of the variation across destination markets and years. Column (4) adds the interaction term of uncertainty and total productivity (TFP) to explore firm heterogeneity.

While the matched sample brings us the advantage of being able to control firm-level characteristics, the merge procedure may systematically bias the estimation. For example, small firms with lower management skill are more likely to involve in inaccurate information which prevent them from matching. Therefore, a robustness check with the unmatched data (not matched with NBS data) is performed. Table 2 shows the merge procedure does not drive the main finding on uncertainty elasticity of price.

VARIABLES(Y=Log Unit Value)	(1)	(2)
Log Volatility	0.00890***	0.0122***
	(0.00280)	(0.00220)
Log Tariff	0.000675	0.0172***
	(0.00101)	(0.00301)
Observations	7,113,235	7,113,235
R-squared	0.037	0.048
Number of Firm-Product	2,219,177	-
Number of Firm-Product-Country	-	4,289,428
Firm-Product FE	Yes	No
Country-Year FE	Yes	No
Firm-Product-Country FE	No	Yes
Year FE	No	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 2: Unmatched Sample

The increase in aggregate price index could be driven by the intensive margin and extensive margin of trade. An ideal dataset to test the importance of firm-level pricing strategy, the intensive margin, should be involved in as few firm-product turnovers as possible. Therefore, three alternative samples are created for the purpose of limiting the effects of the extensive margin. The idea is that we want to keep the variation over time for the same firm-product-country triplet. The results with these alternative samples are summarized in Table 3

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	new_sample	new_sample	intensive_1	intensive_1	intensive_3	intensive_3
Log Volatility	0.0163***	0.0261***	0.0163**	0.0307***	0.0163**	0.0288***
	(0.00614)	(0.00691)	(0.00828)	(0.00920)	(0.00747)	(0.00837)
Log L1_TFP	-0.00499***	-0.00399**	-0.00510**	-0.00371*	-0.00742***	-0.00674***
	(0.00189)	(0.00193)	(0.00214)	(0.00221)	(0.00226)	(0.00228)
Log Volatility x Log L1_TFP		0.00792***		0.0118***		0.00972***
		(0.00246)		(0.00315)		(0.00274)
Log Tariff	-0.00200	-0.00207	-0.000661	-0.000746	-0.00254	-0.00262
	(0.00226)	(0.00226)	(0.00319)	(0.00319)	(0.00298)	(0.00298)
Observations	1,121,792	1,121,792	615,345	615,345	714,583	714,583
R-squared	0.038	0.038	0.051	0.051	0.040	0.040
Number of firm_product	191,713	191,713	91,358	91,358	104,316	104,316
Firm-Product FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 3: Selected Samples

Column (1) and (2) keep those firm-product-country triplets show up at least twice over the sample period (2000-2010). Column (3) and (4) keep observations first appear before 2007, and appear at least once during the subprime crisis (2007-2009). Column (5) and (6) keep observations appear in 2007-2009 at least twice. The results based on the selected samples are consistent with those with the main sample.

The TFP measure in the benchmark regression is estimated by the method suggested by Ackerberg et al. (2006), and the result is robust for alternative TFP measures, such as Olley-Pakes and system-GMM. [7]

Given the prevalence of multiproduct exporters in Chinese customs data, I further construct firm-level samples following Berman et al. (2012) in order to exclude the changes in average prices coming from product composition of multiproduct firms. In column (1) and (2), I use a sample that keeps the

[7]Since the lagged TFP is not available for 2009 and 2010, the latest available estimated TFP is used as the proxy for those years with missing TFP value.

top product (HS-8) exported by the firm worldwide over the period of 2000 to 2010 in value; in column (3) and (4), I select the top product in terms of number of export destinations. The results are consistent with the previous findings.

VARIABLES	(1) Sample_3	(2) Sample_3	(3) Sample_4	(4) Sample_4
Log Volatility	0.00803	0.0197***	0.0142*	0.0268***
	(0.00848)	(0.00557)	(0.00846)	(0.00557)
Log L1_TFP	-0.00821**	-0.00822**	-0.00811**	-0.00807**
	(0.00342)	(0.00341)	(0.00346)	(0.00345)
Log Tariff	0.000792	-0.0224***	0.00161	-0.0227***
	(0.00293)	(0.00245)	(0.00289)	(0.00244)
Log Real Exchange Rate		0.000717***		0.000931***
		(0.000250)		(0.000244)
Observations	395,662	395,411	413,764	413,506
R-squared	0.044	0.039	0.042	0.038
Number of fcode_num	35,096	35,086	35,690	35,680
Firm FE	Yes	No	Yes	No
Country-Year FE	Yes	No	Yes	No
Firm-Country FE	No	Yes	No	Yes
Year FE	No	Yes	No	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 4: Firm-Level Samples

In summary, the main finding about the positive elasticity of price to uncertainty is both statistically and economically significant. For example, the uncertainty proxy for U.S textile sector increases about 80% from 2006 to 2007, and it suggests that the export price will increase by 1.152% (80% x 0.0144) due to uncertainty.

The impact of uncertainty on export volumn and revenue is tested as well. As predicted by the model, the elasticity of quantity to uncertainty is negative (see Table 5). The heterogeneous response in export volumn to uncertainty is included in Table 5, column (4) which displays the elasticity of export volumn to uncertainty is decreasing in productivity. This finding is consistent with the literature (see Sousa et al.,2016 working paper). However, no robust results for effects of uncertainty on export revenue are found.

VARIABLES (Y=Log Quantity)	(1)	(2)	(3)	(4)
Log Volatility	-0.0296*	-0.0115	-0.0455***	-0.0556***
	(0.0170)	(0.0173)	(0.0118)	(0.0190)
Log L1_TFP	0.0173***	0.0151***	0.00970**	0.0146***
	(0.00437)	(0.00447)	(0.00448)	(0.00446)
Log Tariff	-0.0445***	-0.0273***	-0.157***	-0.0443***
	(0.00679)	(0.00696)	(0.0176)	(0.00679)
Log Country-HS2 Import		0.302***		
		(0.00565)		
Log Volatility x Log L1_TFP				-0.0212***
				(0.00675)
Observations	1,595,649	1,517,371	1,595,649	1,595,649
R-squared	0.048	0.057	0.004	0.048
Number of Firm-Product(-Country)	412,645	397,018	890,863	412,645
Firm-Product FE	Yes	Yes	No	Yes
Country-Year FE	Yes	Yes	No	Yes
Firm-Product-Country FE	No	No	Yes	No
Year FE	No	No	Yes	No

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 5: Impact on Export Volume

4.2 Heterogeneity in Response to Uncertainty

Firms are heterogeneous in their productivity, size and ownership status, therefore may respond differently to uncertainty. For example, Sousa et al. (2016, working paper) show the most productive firms have higher elasticity of export value to uncertainty. In this section, the previous finding that uncertainty elasticity of price increases in productivity is confirmed using the rank of TFP followed by the exploration of firm heterogeneity in firm size and ownership status. The benchmark sample is used for the study of firm heterogeneity.

Percentile dummies of firm representative TFP[8], e.g., Bottom 50% is a time-variant dummy to indicate whether a firm's representative TFP belongs to the bottom 50% of the sample. The results reconfirm the previous finding that low productivity firms tend to have lower elasticity of price to uncertainty.

VARIABLES	(1)	(2)	(3)	(4)
Log Volatility	0.0229***	0.0145***	0.0155***	0.0156***
	(0.00635)	(0.00552)	(0.00505)	(0.00478)
Log L1_TFP	-0.00497***			
	(0.00185)			
Log Volatility x Log L1_TFP	0.00690***			
	(0.00236)			
Log Volatility x Bottom 75%		-0.00324		
		(0.00421)		
Log Volatility x Bottom 50%			-0.00652	
			(0.00397)	
Log Volatility x Bottom 25%				-0.0122***
				(0.00462)
Log Tariff	-0.00209	-0.000824	-0.000826	-0.000817
	(0.00189)	(0.00162)	(0.00162)	(0.00162)
Observations	1,595,649	2,287,091	2,287,091	2,287,091
R-squared	0.033	0.048	0.048	0.048
Number of firm_product	412,645	562,149	562,149	562,149
Firm-Product FE	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 6: Firm Heterogeneity in TFP

The correlation between product price and firm size has been studied

[8] The "representative TFP" is first calculated for each firm by averaging its estimated TFP over the sample period (2000-2007), then use this representative TFP to calculate those percentiles

in the literature. Kugler and Verhoogen (2013) show larger plants charge more for their outputs on average. Manova and Zhang (2012) suggest that exporters selling to more countries charge a higher price on average.

VARIABLES	(1) Destination	(2) Destination	(3) Destination	(4) Product	(5) Product	(6) Product
Log Volatility	0.0122***	0.0107***	0.00979***	0.0128***	0.0105***	0.00984***
	(0.00300)	(0.00294)	(0.00294)	(0.00318)	(0.00302)	(0.00295)
Log Volatility x Bottom 75%	-0.0130***			-0.00918***		
	(0.00282)			(0.00265)		
Log Volatility x Bottom 50%		-0.0220***			-0.00720**	
		(0.00409)			(0.00345)	
Log Volatility x Bottom 25%			-0.0141**			-0.0113**
			(0.00593)			(0.00562)
Log Tariff	0.000956	0.000959	0.000955	0.000960	0.000959	0.000958
	(0.00105)	(0.00105)	(0.00105)	(0.00105)	(0.00105)	(0.00105)
Observations	6,667,259	6,667,259	6,667,259	6,667,259	6,667,259	6,667,259
R-squared	0.036	0.036	0.036	0.036	0.036	0.036
Number of firm_product	2,094,273	2,094,273	2,094,273	2,094,273	2,094,273	2,094,273
Firm-Product FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 7: Firm Heterogeneity in Size

I use number of export destinations and number of products as the proxy for firm size. Tabel 7 suggests that firms export to less markets or export less products tend to absorb less uncertainty into their markup on average. Both the results of TFP and firm size suggest that low-performance exporters are less sensitive to uncertainty.

State-owned enterprises (SOEs) in China do not always make profit (utility) maximization choice (Hsieh and Klenow, 2009), and their export decisions may be intervened by the government as well. Therefore, ownership status might be a potential source of firm heterogeneity. Table 8 shows that SOEs have higher elasticity of price to uncertainty than non-SOEs, and the result is robust to alternative samples.

VARIABLES	(1) Main	(2) New	(3) Sample_3	(4) Sample_4
Log Volatility	0.0142**	0.0161***	0.00832	0.0146*
	(0.00565)	(0.00620)	(0.00858)	(0.00855)
Log L1_TFP	-0.00581***	-0.00508***	-0.00810**	-0.00807**
	(0.00182)	(0.00190)	(0.00347)	(0.00351)
SOE x Log Volatility	0.0605**	0.0685**	0.0900*	0.0908*
	(0.0289)	(0.0306)	(0.0479)	(0.0477)
Log Tariff	-0.00188	-0.00199	0.000755	0.00116
	(0.00190)	(0.00228)	(0.00293)	(0.00293)
Observations	1,568,102	1,103,079	387,915	405,963
R-squared	0.033	0.038	0.043	0.041
Number of Firm-Product	406,434	189,489	-	-
Number of Firm	-	-	34,647	35,236
Firm-Product FE	Yes	Yes	No	No
Country-Year FE	Yes	Yes	Yes	Yes
Firm FE	No	No	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 8: Firm Heterogeneity in Ownership

Our findings on firm heterogeneity consistently show that low perfomance firms have lower price to uncertainty elasticity, which is consistent with the model prediction that demand elasticity is lower for high-productivity firms.

4.3 Extensive Margin of Trade

We focus on the intensive margin of trade previously to display that firm pricing strategy is of great importance to understand the pattern of export prices. Now we investigate the impact of uncertainty on Chinese exporters' entry and re-entry decisions to country-sector-year triplets. Prediction 2 suggests that potential exporters may benefit from the softer competition envirionment created by uncertainty if the demand shock is not too severe (the ex post export price $p_{ij}(\omega)^* \geq 0$). In the case of a great negative demand shock, the impact of uncertainty on the probability of exporting is not captured by the model. The boost-entry effects of uncertainty has been found in the recent research, such as Sousa et al. (2016,working paper), which concludes that a rise in the industry-level expenditure uncertainty of the destination market increases the probability of exporting of low productivity firms if fixed trade costs are low enough.

The literature (see Campell and Cochrane, 1999) suggests that investors are less willing to take risk during a recession. Therefore, a potential entrant may demand higher risk premium during a recession which will increase the costs of importing. Exporters with high bargaining power may survive with a higher mark-up, but small exporters with low bargaining power are likely to be forced out.

The impact of uncertainty on firm exporting decisions is estimated by the following specification

$$y_{ijt}^{k} = \begin{cases} 0, & \text{if } y_{ijt}^{*k} \leq 0 \\ 1, & \text{if } y_{ijt}^{*k} > 0 \end{cases} \tag{23}$$

$$\begin{aligned} y_{ijt}^{*k} = &\beta_1 ln(UNC_{jt}^{k}) + \beta_2 Crisis \times ln(UNC_{jt}^{k}) \\ &+ \beta_x X_{jt}^{k} + \mu_{ijt} + \epsilon_{ipjt} \end{aligned} \tag{24}$$

where y_{ijt}^{*k} is the latent variable that determines whether a strictly positive export value is observerd. Given the likely effects of the supprime crisis on a firm's export decision (see Bricongne et al., 2012), a crisis dummy [9] interacted with the log uncertainty proxy is included in equation 24 to capture the time-varying risk-aversion.

We are interested in the probability of new entry ($y_{ijt}^{k} = 1|y_{ij,t-1}^{k} = 0$) and re-entry ($y_{ijt}^{k} = 1|y_{ij,t-1}^{k} = 1$)). The counterfactual scenario for new entry and re-entry regressions is thus ($y_{ijt}^{k} = 0|y_{ij,t-1}^{k} = 0$) and ($y_{ijt}^{k} = 0|y_{ij,t-1}^{k} = 1$)) respectively. These two probabilities are estimated by linear probability model and fixed effects (conditional) logit model separately.

[9] The crisis period is defined as 2007 to 2010.

VARIABLES	(1) New Entry	(2) New Entry	(3) Re-Entry	(4) Re-Entry
Log Volatility	0.00105	0.0397**	0.0151***	0.0400
	(0.000649)	(0.0183)	(0.00125)	(0.0316)
Crisis Dummy x Log Volatility	-0.0104***	-0.171***	-0.0582***	-0.225***
	(0.00153)	(0.0301)	(0.00393)	(0.0420)
Log Country-GICS Import	0.00331***	0.0996***	0.00620***	0.138***
	(0.000217)	(0.00515)	(0.000578)	(0.00721)
Observations	16,047,777	883,998	5,155,481	499,660
Estimation	LPM	FE Logit	LPM	FE Logit
Number of firm_des_year	11,715,350	321,322	3,897,309	183,453
Firm-Country-Year FE	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 9: Extensive Margin of Trade

Table 9 shows uncertainty has positive or little effects on a firm' entry or re-entry decision out of the recession, but negative effects during the subprime crisis. These findings are consistent with the competition effects hypothesis as sugguested by the model, and the time-varying risk-averson hypothesis documented in the literature. The probability of exporting increases in uncertainty if the negative demand shock is not too severe, but decreases in uncertainty if the economy is in a recession. In sum, low-productivity entrants benefit from a higher average price driven by moderate uncertainty, but are deterred by the high uncertainty during a recession.

The findings on the extensive margin of trade, especially how uncertainty influence a firm's export decision during the subprime crisis, reinforce our main finding that firm pricing strategy drives the increasing price index at economic downturns. As those low-productivity exporters charging higher prices leave the market at economic downturns, the extensive margin of trade will drag the aggregate price index down. Inclusion of firm turnovers in the sample therefore renders the effects of uncertainty on export prices likely to be underestimated.

4.4 Sector Level Results

We now investigate the impact of uncertainty on sector exports. Previous findings show that exporters respond to uncertainty heterogeneously based on their characteristics. Therefore, the impact of uncertainty on sector exports may be related to the distribution of exporters within a sector. A simple measure to summarize the firm distribution within a sector is the Herfindahl index. Sectors are defined at HS-6, HS-4, and HS-2 level respectively. At sector level, an estimation of unit price and export volumn will be less informative than that at firm-product level due to the existence of inconsistent unit across products. Therefore we focus on the estimation of the impact of uncertainty on sector exports.

$$\begin{aligned} ln(m_{jkt}) = \beta_1 ln(UNC_{jkt}) + \beta_2 ln(UNC_{jkt}) \times her_{jkt} \\ + \beta_x X^k_{jt} + \beta_z Z_{jt} + FE + \phi_t + \epsilon_{jkt} \end{aligned} \tag{25}$$

where m_{jkt} is sector exports, X_{jkt} is country-sector-level controls, and Z_{jt} is country-level controls.

VARIABLES	(1) HS-6	(2) HS-6	(3) HS-4	(4) HS-4	(5) HS-2	(6) HS-2
Log Volatility	-3.709***	-9.333***	-2.164***	-7.281***	-0.840***	-4.007***
	(0.132)	(0.874)	(0.163)	(0.619)	(0.211)	(0.336)
Herfindahl index x Log Volatility	0.445***	1.113***	0.277***	0.914***	0.138***	0.595***
	(0.0161)	(0.102)	(0.0215)	(0.0779)	(0.0344)	(0.0525)
log_tariff_1	-0.128***	0.0637				
	(0.0142)	(0.0562)				
Log RGDP	0.807***	1.068*	0.916***	1.131*	1.017***	1.264***
	(0.00715)	(0.585)	(0.0114)	(0.594)	(0.0246)	(0.408)
log_tariffhs4_1			-0.139***	0.107*		
			(0.0243)	(0.0541)		
Log Tariff (HS-2)					-0.260***	-0.0541
					(0.0478)	(0.0504)
Observations	408,758	408,758	133,600	133,600	17,426	17,426
R-squared	0.229	0.068	0.299	0.094	0.418	0.120
Sector FE	Yes	No	Yes	No	Yes	No
Country FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Sectors	4,177	-	951	-	75	
Number of Countries	-	42	-	42	-	42

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 10: Sector Exports I

Table 10 displays that uncertainty has a negative impact on sector exports, and the effect is weaker in the sectors whose exports are concentrated on a few high-performance exporters. We further investigate the time-varying elasticity of sector exports to uncertainty.

VARIABLES	(1) HS-6	(2) HS-6	(3) HS-4	(4) HS-4	(5) HS-2	(6) HS-2
Log Volatility	0.136***	0.135*	0.222***	0.201*	0.321***	0.374*
	(0.0264)	(0.0741)	(0.0447)	(0.106)	(0.105)	(0.221)
Crisis x Log Volatility	-0.319***	-0.440**	-0.508***	-0.683**	-0.535***	-0.629
	(0.0486)	(0.205)	(0.0853)	(0.258)	(0.190)	(0.419)
Log Tariff (HS-6)	-0.133***	0.0720				
	(0.0140)	(0.0566)				
Log RGDP	0.813***	0.978	0.921***	1.000	1.020***	1.253***
	(0.00710)	(0.625)	(0.0113)	(0.651)	(0.0246)	(0.416)
Log Tariff (HS-4)			-0.147***	0.115**		
			(0.0239)	(0.0550)		
Log Tariff (HS-2)					-0.268***	-0.0499
					(0.0469)	(0.0517)
Observations	408,758	408,758	133,600	133,600	17,426	17,426
R-squared	0.227	0.057	0.299	0.083	0.418	0.111
Sector FE	Yes	No	Yes	No	Yes	No
Country FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Sectors	4,177	-	951	-	75	-
Number of Countries	-	42	-	42	-	42

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 11: Sector Exports II

Table 11 shows that the time-varying sector elasticity is consistent with my estimation of the extensive margin. Sector exports increase as the probability of exporting goes up with uncertainty out of the recession, the opposite happens when it is in a recession. On the other hand, little evidence is found to support a negative impact of uncertainty on firm or firm-product exports (see Appendix). Therefore, the change in sector exports is likely driven by the extensive margin. When the economy is at business cycle troughs, sector exports decrease in uncertainty, due to the exit of low productivity firms; when the economy is on its growth path, sector exports increase in uncertainty, due to the new entrants.

5 Conclusion

In this paper, we present both theoretical and empirical evidence to explain the countercyclical prices in international trade. Firms are typically assumed to have perfect information when they make production decisions in trade literature. However, recent research such as Panousi and Papanikolaou (2012) provides evidence that risk aversion is an important factor influencing a manager's decisions under uncertainty. By assuming risk-aversion exporters, uncertainty is shown to play an important role in firm-level export decisions.

Using Chinese firm-level data, this paper explores the implication of uncertainty on the intensive margin and extensive margin of trade. The empirics mainly show 1) a firm's pricing strategy under uncertainty, the intensive margin, drives the countercyclical export prices. The extensive margin, on the other hand, tends to generate procyclical aggregate price during the subprime crisis; 2) high-performance or state-owned firms have higher elasiticity of price to uncertainty; 3) uncertainty negatively influencs sector exports mainly through the extensive margin.

References

[1] Ackerberg, D., Caves, K., and Frazer, G. Structural identification of production functions. *working paper* (2006).

[2] Amiti, M., and Khandelwal, A. K. Import competition and quality upgrading. *Review of Economics and Statistics 95*, 2 (2013), 476–490.

[3] Amiti, M., and Konings, J. Trade liberalization, intermediate inputs, and productivity: Evidence from indonesia. *The American Economic Review 97*, 5 (2007), 1611–1638.

[4] Antoniades, A. Heterogeneous firms, quality, and trade. *Journal of International Economics 95*, 2 (2015), 263–273.

[5] Bachmann, R., Elstner, S., and Sims, E. R. Uncertainty and economic activity: Evidence from business survey data. *American Economic Journal: Macroeconomics 5*, 2 (2013), 217–249.

[6] Banker, R. D., Byzalov, D., and Plehn-Dujowich, J. M. Demand uncertainty and cost behavior. *The Accounting Review 89*, 3 (2013), 839–865.

[7] Berman, N., Martin, P., and Mayer, T. How do different exporters react to exchange rate changes? *The Quarterly Journal of Economics 127*, 1 (2012), 437–492.

[8] Berman, N., Rebeyrol, V., and Vicard, V. Demand learning and firm dynamics: evidence from exporters.

[9] Bloom, N. Fluctuations in uncertainty. *The Journal of Economic Perspectives 28*, 2 (2014), 153–175.

[10] Blundell, R., and Bond, S. Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics 87*, 1 (1998), 115–143.

[11] Bricongne, J.-C., Fontagné, L., Gaulier, G., Taglioni, D., and Vicard, V. Firms and the global crisis: French exports in the turmoil. *Journal of international Economics 87*, 1 (2012), 134–146.

[12] Campbell, J. Y., and Cochrane, J. H. By force of habit: A consumption-based explanation of aggregate stock market behavior. *Journal of political Economy 107*, 2 (1999), 205–251.

[13] Carballo, J. Global sourcing under uncertainty. *University of Maryland, mineograph* (2014).

[14] Comin, D. A., and Philippon, T. The rise in firm-level volatility: Causes and consequences. In *NBER Macroeconomics Annual 2005, Volume 20*. MIT Press, 2006, pp. 167–228.

[15] Creusen, H., Lejour, A., et al. Uncertainty and the export decisions of dutch firms. Tech. rep., FIW, 2011.

[16] Crozet, M., Head, K., and Mayer, T. Quality sorting and trade: Firm-level evidence for french wine. *The Review of Economic Studies 79*, 2 (2012), 609–644.

[17] Davis, S. J., and Kahn, J. A. Interpreting the great moderation: changes in the volatility of economic activity at the macro and micro levels. *The Journal of Economic Perspectives 22*, 4 (2008), 155–180.

[18] De Loecker, J., and Warzynski, F. Markups and firm-level export status. *The American Economic Review 102*, 6 (2012), 2437–2471.

[19] Di Comite, F., Thisse, J.-F., and Vandenbussche, H. Verti-zontal differentiation in export markets. *Journal of International Economics 93*, 1 (2014), 50–66.

[20] Dyer, J., Furr, N., and Lefrandt, C. The industries plagued by the most uncertainty. *Harvard Business Review, digital article 11* (2014).

[21] Esposito, F. Risk diversification and international trade.

[22] Fan, H., Lai, E. L.-C., and Li, Y. A. Credit constraints, quality, and export prices: Theory and evidence from china. *Journal of Comparative Economics 43*, 2 (2015), 390–416.

[23] Fan, H., Li, Y. A., and Yeaple, S. R. Trade liberalization, quality, and export prices. *Review of Economics and Statistics 97*, 5 (2015), 1033–1051.

[24] Gilchrist, S., Schoenle, R., Sim, J., and Zakrajsek, E. Inflation dynamics during the financial crisis.

[25] Gilchrist, S., and Zakrajsek, E. Customer markets and financial frictions: Implications for inflation dynamics. In *Prepared for Inflation*

Dynamics and Monetary Policy, 2015 Jackson Hole Symposium, August (2015), vol. 11.

[26] Handley, K. Exporting under trade policy uncertainty: Theory and evidence. *Journal of international Economics 94*, 1 (2014), 50–66.

[27] Handley, K., and Limão, N. Policy uncertainty, trade and welfare: Theory and evidence for china and the us. Tech. rep., National Bureau of Economic Research, 2013.

[28] Harrigan, J., Ma, X., and Shlychkov, V. Export prices of us firms. *Journal of International Economics 97*, 1 (2015), 100–111.

[29] Harris, R., and Moffat, J. Plant-level determinants of total factor productivity in great britain, 1997-2006.

[30] Hornok, C., and Muraközy, B. Markup and productivity of exporters and importers.

[31] Johnson, R. C. Trade and prices with heterogeneous firms. *Journal of International Economics 86*, 1 (2012), 43–56.

[32] Kee, H. L., and Tang, H. Domestic value added in exports: Theory and firm evidence from china. *The American Economic Review 106*, 6 (2016), 1402–36.

[33] Kneller, R., and Yu, Z. Quality selection, sectoral heterogeneity and chinese exports. *Review of International Economics* (2016).

[34] Knight, F. H. Risk uncertainty and profit.

[35] Kugler, M., and Verhoogen, E. Prices, plant size, and product quality. *The Review of Economic Studies 79*, 1 (2011), 307–339.

[36] Levinsohn, J., and Petrin, A. Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies 70*, 2 (2003), 317–341.

[37] Li, H., Ma, H., and Xu, Y. How do exchange rate movements affect chinese exports?a firm-level investigation. *Journal of International Economics 97*, 1 (2015), 148–161.

[38] Manova, K., and Zhang, Z. Export prices across firms and destinations. *The Quarterly Journal of Economics 127*, 1 (2012), 379–436.

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

[40] Melitz, M. J., and Ottaviano, G. I. Market size, trade, and productivity. *The review of economic studies 75*, 1 (2008), 295–316.

[41] Nguyen, D. X. Demand uncertainty: Exporting delays and exporting failures. *Journal of International Economics 86*, 2 (2012), 336–344.

[42] Novy, D., and Taylor, A. M. Trade and uncertainty. Tech. rep., National Bureau of Economic Research, 2014.

[43] OLLEY, G. S., and PAKES, A. The dynamics of productivity in the telecommunications equipment industry. *Econometrica 64*, 6 (1996), 1263–1297.

[44] Panousi, V., and Papanikolaou, D. Investment, idiosyncratic risk, and ownership. *The Journal of Finance 67*, 3 (2012), 1113–1148.

[45] Ramondo, N., Rappoport, V., and Ruhl, K. J. The proximity-concentration tradeoff under uncertainty. *The Review of Economic Studies* (2013), rdt018.

[46] Roberts, M. J., Xu, D. Y., Fan, X., and Zhang, S. A structural model of demand, cost, and export market selection for chinese footwear producers. *NBER Working Paper Series* (2012), 17725.

[47] Van Beveren, I. Total factor productivity estimation: A practical review. *Journal of economic surveys 26*, 1 (2012), 98–128.

[48] Viaene, J.-M., and Zilcha, I. The behavior of competitive exporting firms under multiple uncertainty. *International Economic Review* (1998), 591–609.

[49] Yu, M. Processing trade, tariff reductions and firm productivity: evidence from chinese firms. *The Economic Journal 125*, 585 (2015), 943–988.