Quality, Variable Markups, and Welfare: A Quantitative General Equilibrium Analysis of Export Prices

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\textsuperscript{d}Pennsylvania State University, NBER and CESifo
Overview

Introduction

Rapid growth in quantitative general equilibrium trade models

  - Require few parameters
  - Key parameter is the "trade elasticity", the effect on import value of a change in ad-valorem trade costs
  - Limited use of price data (e.g. Jung, Simonovska, and Weinberger 2019)
Introduction

Fact: The same firm charges prices that can vary dramatically across countries.

Price variation reflects the interaction of

1. Heterogeneous trade costs
2. Pricing to market
3. Quality heterogeneity across firms

What does the literature miss by modeling only two of the three?
What We Do

We analyze a simple quantitative GE model with heterogeneous firms and endogenous price and quality choice that allows for

- **Rich Treatment of Trade costs**: our setting allows for trade costs that are both *ad-valorem* and *specific*

- **Variable Markups**: Non-homothetic preferences and firm heterogeneity generate price heterogeneity across firms.

- **Washington Apples Effects**: Demand for quality, *specific-trade* costs, and higher costs to producing quality generate quality provision differences across countries
We calibrate the model to moments from Chinese firm-level data and aggregate trade data
- show need for all three mechanisms to match data
- highlight the relationship between the nature of trade costs and quality and variable markups

We also consider the comparative static to show the differential effect of the shocks of reducing specific and iceberg trade costs on the pattern of prices across countries.
Connection to Literature


Road Map

- Stylized Facts
- Model
- Data and Quantification
- Comparative Static
- Conclusion
Stylized Facts

- **Selection**: more productive firms are more likely to export and export to a larger number of markets than less productive firms (e.g. Bernard and co-authors)

- **Selection**: More firms export to rich countries than to poor countries (e.g. Eaton, Kortum, and Kramarz, 2011)

- **Quality vs Markups**: More productive firms charge higher prices and earn greater revenues than less productive firms in any given market (e.g. Manova and Zhang 2012)

- **Quality vs Markups**: Within firms, prices charged in rich countries are higher than in poor countries (e.g. Fan Li and Yeaple, 2015)

- **Washington Apples Effect**: Higher priced goods tend to be shipped longer distances than lower priced goods (e.g. Hummels and Skiba, 2004).
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- **Washington Apples Effect**: Higher priced goods tend to be shipped longer distances than lower priced goods (e.g. Hummels and Skiba, 2004).
Stylized Fact 1: Export prices are higher in developed countries.

Table: Export Prices across Destination

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable: ( \ln(price) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \ln(p_{fhc}) )</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>GDP per capita (current in US dollar)</td>
<td>0.024***</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
</tr>
<tr>
<td>Population</td>
<td>0.008***</td>
</tr>
<tr>
<td></td>
<td>(0.001)</td>
</tr>
<tr>
<td>Distance</td>
<td>0.020***</td>
</tr>
<tr>
<td></td>
<td>(0.003)</td>
</tr>
<tr>
<td>Firm-Product Fixed Effect</td>
<td>yes</td>
</tr>
<tr>
<td>Product Fixed Effect</td>
<td>no</td>
</tr>
<tr>
<td>Observations</td>
<td>1,441,468</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.946</td>
</tr>
</tbody>
</table>

Notes: *** p < 0.01, ** p < 0.05, * p < 0.1. Robust standard errors corrected for clustering at the destination country level in parentheses. Robust standard errors corrected for clustering at the destination country level in parentheses. The dependent variable in specifications (1)-(2) is the (log) price at the firm-HS6-country level, and in specifications (3)-(4) is the (log) price at the HS6-country level. All regressions include a constant term.
Figure: Export prices increase with destination income

Note: GDP per capita in 2004 US dollar
Stylized Fact 2: A larger number of firms export to developed countries.

Table: Firm Mass across Destination

<table>
<thead>
<tr>
<th></th>
<th>Dependent Variable: $\ln(FirmNumber)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\ln(N_{hc})$ $\ln(N_c)$</td>
</tr>
<tr>
<td></td>
<td>(1) (2) (3) (4)</td>
</tr>
<tr>
<td>GDP per capita (current in US dollar)</td>
<td>0.236*** 0.296*** 0.687*** 0.767***</td>
</tr>
<tr>
<td></td>
<td>(0.042) (0.020) (0.070) (0.042)</td>
</tr>
<tr>
<td>Population</td>
<td>0.283*** 0.762***</td>
</tr>
<tr>
<td></td>
<td>(0.022) (0.039)</td>
</tr>
<tr>
<td>Distance</td>
<td>-0.453*** -0.178</td>
</tr>
<tr>
<td></td>
<td>(0.085) (0.154)</td>
</tr>
<tr>
<td>Country-level other Control</td>
<td>no yes no yes</td>
</tr>
<tr>
<td>Product Fixed Effect</td>
<td>yes yes no no</td>
</tr>
<tr>
<td>Observations</td>
<td>173,422 173,422 173 173</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.322 0.528 0.292 0.808</td>
</tr>
</tbody>
</table>

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors corrected for clustering at the destination country level in parentheses. The dependent variable in specifications (1)-(2) is the (log) firm number at the HS6-country level, and in specifications (3)-(4) is the (log) firm number at the destination country level. Country-level other controls include population and distance. All regressions include a constant term.
**Figure**: Firm Mass increases with destination income

Note: GDP per capita in 2004 US dollar
Stylized Fact 3: More productive firms charge higher export prices.

Table: Export Prices across Firm

<table>
<thead>
<tr>
<th>Dependent Variable: ln(price)</th>
<th>ln(p_{fhc})</th>
<th>ln(p_{fh})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>ln(TFP)</td>
<td>0.095***</td>
<td>0.050***</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>Firm-level Other Control</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Product-country Fixed Effect</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Product Fixed Effect</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Observations</td>
<td>504,813</td>
<td>504,627</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.775</td>
<td>0.779</td>
</tr>
</tbody>
</table>

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors corrected for clustering at the firm level in parentheses. The dependent variable in specifications (1)-(2) is the (log) price at the firm-HS6-country level, and in specifications (3)-(4) is the (log) price at the firm-HS6 level. Firm-level other controls include employment, capital-labor ratio, and wage. All regressions include a constant term.
Figure: Export prices increase with firm productivity

Note: Export Price in 2004 US dollar

Fan, Li, Xu & Yeaple (2020)
Road Map

- Stylized Facts
- **Model**
- Data and Quantification
- Comparative Static
- Conclusion
Countries and Endowments

- $I$ countries indexed by $i$ and $j$
- Country $i$ is endowed with measure $L_i$ of consumers
- Each consumer is endowed with one unit of labor that is mobile within a country but is not mobile across countries.
Preferences

Consumers have generalized CES preferences:

\[ U_j = \left[ \sum_i \int_{\omega \in \Omega_{ij}} \left( q_{ij}(\omega) x_{ij}^c(\omega) + \bar{x} \right) \frac{\sigma-1}{\sigma} \right]^{\frac{\sigma}{\sigma-1}}, \]

where

- \( j \): destination country; \( i \): source country;
- \( q_{ij}(\omega) \): quality of variety \( \omega \) produced in country \( i \) and sold in \( j \);
- \( x_{ij}^c(\omega) \): quantity consumed of variety \( \omega \) by a consumer in \( j \) and produced in \( i \);
- \( \sigma \) governs the elasticity of substitution across \( \omega \) and \( \bar{x} > 0 \) is a constant that creates a “choke price”
Demand

Utility maximization implies that the demand for variety $\omega$ in country $j$ is

$$x_{ij}(\omega) \equiv x_{ij}^c(\omega)L_j = \frac{L_j}{q_{ij}(\omega)} \left[ \frac{y_j + \bar{x}P_j}{P_{j\sigma}^{1-\sigma}} \left( \frac{p_{ij}(\omega)}{q_{ij}(\omega)} \right)^{-\sigma} - \bar{x} \right]$$

(1)

- $P_j = \sum_i \int_{\omega \in \Omega_{ij}} \frac{p_{ij}(\omega)}{q_{ij}(\omega)} d\omega$ and $P_{j\sigma} = \left\{ \sum_i \int_{\omega \in \Omega_{ij}} \left( \frac{p_{ij}(\omega)}{q_{ij}(\omega)} \right)^{1-\sigma} d\omega \right\}^{\frac{1}{1-\sigma}}$

are aggregate price index

- Define the quality-adjusted price $\tilde{p}_{ij}(\omega) \equiv \frac{p_{ij}(\omega)}{q_{ij}(\omega)}$;

- $\tilde{p}_j^* \equiv \left( \frac{y_j + \bar{x}P_j}{\bar{x}P_{j\sigma}^{1-\sigma}} \right)^{\frac{1}{\sigma}}$

- Demand could be simplified as:

$$x_{ij}(\omega) = \frac{\bar{x}L_j}{q_{ij}(\omega)} \left[ \left( \frac{\tilde{p}_{ij}(\omega)}{\tilde{p}_j^*} \right)^{-\sigma} - 1 \right]$$

(2)
Optimal Pricing Decision

- Firm’s pricing decision solves:

\[
\max_{p_{ij}(\omega)} \left[ p_{ij}(\omega) - c_{ij}(\omega) \right] x_{ij}(\omega)
\]

\[
\Leftrightarrow \max_{\tilde{p}_{ij}(\omega)} \tilde{x} L_j \left[ \tilde{p}_{ij}(\omega) - \tilde{c}_{ij}(\omega) \right] \left[ \left( \frac{\tilde{p}_{ij}(\omega)}{\tilde{p}_j^*} \right)^{-\sigma} - 1 \right]
\]

- Optimal pricing decision is the solution to:

\[
\sigma \frac{\tilde{c}_{ij}(\omega)}{\tilde{p}_j^*} = \left( \frac{\tilde{p}_{ij}(\omega)}{\tilde{p}_j^*} \right)^{\sigma+1} + (\sigma - 1) \left( \frac{\tilde{p}_{ij}(\omega)}{\tilde{p}_j^*} \right) \quad (3)
\]

- \(\tilde{p}_{ij}(\omega)\) is a function of \(\tilde{c}_{ij}(\omega)\). According to envelope theorem, maximizing firm’s profit is equivalent to minimizing \(\tilde{c}_{ij}(\omega) = \frac{c_{ij}(\omega)}{q_{ij}(\omega)}\)
Quality and Production

- Productivity $\varphi$ is heterogeneous and follows Pareto distribution
  \[ G_i(\varphi) = 1 - b_i \varphi^{-\theta} \]

- Production of quality follows Feenstra and Romalis (2014)
  \[ q_{ij} = (\varphi l_{ij})^{\frac{1}{\eta}} \]

- Firm’s quality-adjusted marginal cost is
  \[
  \tilde{c}_{ij} \equiv \frac{c_{ij}(\varphi, \varepsilon)}{q_{ij}} = \frac{\left( T_{ij} w_i + \frac{w_i \tau_{ij}}{\varphi} q_{ij}^{\eta} \right) \varepsilon}{q_{ij}}
  \]

where $\tau_{ij}$ is ad valorem trade cost and $T_{ij}$ is a specific transportation cost from country $i$ to country $j$. Following Eaton, Kortum and Kramarz (2011), we assume that each firm draws a cost shock $\varepsilon$, with $\log \varepsilon \sim N(0, \sigma_\varepsilon)$ that is heterogeneous across firms and across destinations.
Optimal Quality Decision

- Firm chooses quality to minimize quality-adjusted marginal cost $\tilde{c}_{ij}$

$$\min_{q_{ij}} \tilde{c}_{ij}$$

- Positive relationship b/w productivity and quality

$$q_{ij} (\varphi, \varepsilon) = \left( \frac{T_{ij} \varphi}{(\eta - 1) \tau_{ij}} \right)^{\frac{1}{\eta}}, \quad (4)$$

- Negative relationship b/w productivity and quality-adjusted marginal cost

$$\tilde{c}_{ij} (\varphi, \varepsilon) = \gamma \frac{w_i \delta_{ij} \varepsilon}{\varphi^{\frac{1}{\eta}}}$$

where $\gamma$ is a constant and $\delta_{ij} = (T_{ij})^{1-\frac{1}{\eta}} (\tau_{ij})^{\frac{1}{\eta}}$ is average trade cost.
Equilibrium Productivity Cutoff

- To sell in market $j$, $\tilde{p}_{ij}(\varphi, \varepsilon) \leq \tilde{p}_j^*$. Otherwise, the demand by consumers is zero.
- At the cut-off, we have:
  $$\tilde{p}_{ij}(\varphi, \varepsilon) = \tilde{c}_{ij}(\varphi, \varepsilon) = \tilde{p}_j^*$$
- Equilibrium productivity cutoff $\varphi_{ij}^*$:
  $$\varphi_{ij}^* = \gamma^n \left( (T_{ij})^{\eta-1} \tau_{ij} \right) \left( \frac{w_i}{\tilde{p}_j^*} \right)^{\eta} \varepsilon^{\eta} \tag{5}$$
  Where trade cost.
Closing the Model

- **Free entry**: pay $f$ in local labor get variety draw with productivity $\varphi$
- The exporting firm mass from $i$ to $j$ endogenously determined

- Labor market is perfectly competitive

- Countries are on their budget constraint (trade balances):

\[
\sum_j X_{ij} = \sum_j X_{ji}
\]
Quantitative Implications

- More productive firms
  - charge higher prices and higher quality adjusted markups
  - earn larger sales revenue

- Consumers in richer countries
  - Pay higher import prices
  - Enjoy greater access to variety
Road Map

- Stylized Facts
- Model
- Data and Quantification
- Comparative Static
- Conclusion
Data

- Customs’ transaction-level trade data
  - Price and sales data on Firm×HS6×Destination
- Firm level production data from National Bureau of Statistics of China
  - Firm level productivity estimation
- CEPIII data
  - Country level macro variables
  - Gravity variables
- Global Trade Analysis Project (GTAP)
  - Industry level output
  - Bilateral trade flows
Three Steps

(1) Estimate two sets of the parameters of the model:
   - $\Theta_1$: $\eta$, the inverse of quality scope, $\theta$, productivity shape, $\sigma$ and $\sigma_\varepsilon$;
   - All endogeneous macro variables:
     \[
     \Theta_2 = \left\{ \left\{ w_j, P_j, P_j, fJ_i, T_i^{\eta-1}r_{ij}, b_i, N_j \right\}_{i=1}^I \right\}_{j=1}^J
     \]

(2) Simulate the model using the estimated parameter set $\Theta_1$ and $\Theta_2$.
(3) Generate pseudo-Chinese exporters that is comparable with the custom data and analyze the model fit by comparing the real data and model generated one.
Parameterization: Identification of $\Theta_1$

$$\log\left(\frac{\lambda_{ij}}{\lambda_{ji}}\right) = \log \left[ J_i b_i w_i^{-\theta \eta} \right] - \log \left[ J_i b_i \left( T_{ij}^{\eta - 1} \tau_{jj} w_j^{-\eta} w_i^{-\theta \eta} \right)^{\theta} \right] - \theta (\eta - 1) \log T_{ij} - \theta \log \tau_{ij}$$

- **Estimation of $\theta$.**
  - Following Caliendo and Parro (2015) and Arkolakis et al. (2017b);
  - estimate $\theta$ from the coefficient on tariffs in a gravity equation.

- Use a set of gravity variables to proxy for $T_{ij}$ and for $\tau_{ij}$.
  - Following Waugh (2010) and Jung, Simonovska and Weinberger (2019);
  - Assume that specific and ad valorem trade costs are related to observables.
  - Note that with an estimate $\theta$, it’s possible to back out the aggregate trade cost $T_{ij}^{\eta - 1} \tau_{ij}$
Parameterization: Identification of $\Theta_1$ (cont.)

- Bilateral trade share $\lambda_{ij}$ is constructed based on the method in Ossa (2014)
- Gravity variables $dist_{ij}$ and other variables (e.g., common language, common currency) are taken from CEPII dataset;
- Tariff data is from WITS
  - The average tariff rate for all HS6 sectors of each destination is used to represent $tar_{ij}$
  - Let $tar_{ij} = 1$ if both $i$ and $j$ belongs to EU, NAFTA, ASEAN members countries.

### Summary Statistics of Gravity Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\log(\lambda_{ij}/\lambda_{jj})$</td>
<td>-5.221</td>
<td>1.842</td>
<td>-10.491</td>
<td>0</td>
<td>1296</td>
</tr>
<tr>
<td>$\log(tar_{ij})$</td>
<td>0.066</td>
<td>0.067</td>
<td>0</td>
<td>0.264</td>
<td>1296</td>
</tr>
<tr>
<td>$\log(dist_{ij})$</td>
<td>8.432</td>
<td>1.059</td>
<td>2.258</td>
<td>9.811</td>
<td>1296</td>
</tr>
</tbody>
</table>

Fan, Li, Xu & Yeaple (2020)  
Quality, Variable Markups & Welfare: A Quantitative GE Analysis of Export Prices
Parameterization: Identification of $\Theta_1$ (cont.)

**Table: Estimation of Gravity Equation**

<table>
<thead>
<tr>
<th>Dependent variable: $\log (\lambda_{ij}/\lambda_{jj})$</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\log (\text{tar}_{ij})$</td>
<td>-6.097***</td>
</tr>
<tr>
<td></td>
<td>(0.795)</td>
</tr>
<tr>
<td>$\log (\text{dist}_{ij})$</td>
<td>-0.765***</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
</tr>
<tr>
<td>Common language</td>
<td>0.349***</td>
</tr>
<tr>
<td></td>
<td>(0.071)</td>
</tr>
<tr>
<td>Common currency</td>
<td>0.165*</td>
</tr>
<tr>
<td></td>
<td>(0.086)</td>
</tr>
<tr>
<td>Same country Dummy</td>
<td>2.658***</td>
</tr>
<tr>
<td></td>
<td>(0.139)</td>
</tr>
<tr>
<td>Importer Fixed Effects</td>
<td>YES</td>
</tr>
<tr>
<td>Exporter Fixed Effects</td>
<td>YES</td>
</tr>
<tr>
<td>Observations</td>
<td>1,296</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.988</td>
</tr>
</tbody>
</table>

Notes: Standard errors in parentheses.

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Parameterization: Identification of $\Theta_1$ (cont)

Estimating the remaining coefficients: $\sigma_\varepsilon$, $\sigma$, $\eta$ using Chinese firm-level trade data

- Simulated method of moments to identify $\sigma_\varepsilon$, $\sigma$, $\eta$
  - Standard deviation of observed (not quality adjusted) log price (demeaned by industry and country)
  - Standard deviation of log sales
  - Correlation between log prices and log sales.

- Define $\xi = (\varphi/\varphi_{ij}^*)^{\frac{1}{\eta}}$, we could obtain:

\[
\log p_{ij} (\xi, \varepsilon) = \log \left( \frac{\tilde{p}_{ij} (\xi))}{\tilde{p}_j^*} \right) + \log (\varepsilon) + \log (\xi) + \log \left( \frac{\eta}{\eta - 1} T_{ij}w_i \right)
\]

\[
\log r_{ij} (\xi) = \log \left( \frac{\tilde{p}_{ij} (\xi))}{\tilde{p}_j^*} \right) + \log \left( \left( \frac{\tilde{p}_{ij} (\xi))}{\tilde{p}_j^*} \right)^{-\sigma} - 1 \right) + \log (\bar{x}L_j)
\]
In summary, estimation strategy could be summarized as follows:

- First, calibrate $\sigma$ to target the standard deviation of the log of export sales.
- Second, choose $\sigma_\varepsilon$ to target the standard deviation of the log of export price.
- Third, the correlation between log-sale and log-price helps to identify $\eta \theta$.
  - Note that the distribution of $\xi$ is governed by the value of $\eta \theta$.
  - And a higher $\xi$ implies a higher price and also a higher sales.
### Table: Calibration of $\Theta_1$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>symbol</th>
<th>value (Exact ID)</th>
<th>value (Over ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>elasticity of substitution</td>
<td>$\sigma$</td>
<td>4.8179</td>
<td>5.4819</td>
</tr>
<tr>
<td>std. dev. of cost shock</td>
<td>$\sigma_\varepsilon$</td>
<td>0.6004</td>
<td>0.7599</td>
</tr>
<tr>
<td>inverse of quality scope</td>
<td>$\eta$</td>
<td>1.7111</td>
<td>1.2193</td>
</tr>
<tr>
<td>trade elasticity w.r.t. tariff</td>
<td>$\theta$</td>
<td>6.0973</td>
<td>6.0973</td>
</tr>
</tbody>
</table>
Identification: Solving for $\Theta_2$

- Solve wage $w_i$ for each country, using labor market clearing condition:

  $$w_i L_i = \sum_j X_{ij} = \sum_j \lambda_{ij} w_j L_j$$

- Recover $b_j$, using the importer fixed effect from the gravity estimation:

  $$S_j = \log \left[ (fJ_j) b_j w_j^{-\eta\theta} \right]$$

- Solve total firm mass $N_j$:

  $$N_j = \frac{(\eta - 1)^{\frac{\eta - 1}{\eta}}}{\eta \bar{x} [\beta \sigma - \beta]} \left( T_{ij}^{\eta - 1} \tau_{ij} \right)^{-\frac{1}{\eta}} \frac{w_j}{w_i} \left( \frac{\kappa J_i b_i}{N_{ij}} \right)^{\frac{1}{\eta\theta}}$$
Model Simulation

Following Eaton, Kortum, Karmaz (2011) and Jung, Simonovska and Weinberger (2019):

- First, define $u = b_c \varphi^{-\theta}$ where $b_c$ corresponds for China’s productivity;
- Then write the conditional productivity entry cutoff in terms of $u$.
- Define
  \[ \tilde{u} \equiv \frac{u}{u^*_c(\varepsilon)} \sim U[0, 1] \]

Now, we can simulate the model in the next four steps:

**Step 1** Draw $1 \times 10^6 \tilde{u}$ and $1 \times 10^6 \tilde{\varepsilon}$.
- make the transformation $\varepsilon = \exp(\sigma_{\varepsilon} \tilde{\varepsilon})$ to obtain the simulated specific trade cost shocks.
- for each draw of $\tilde{u}$, construct then entry hurdles $u^*_c^{max}$ for each country.

**Step 2** For each $\tilde{u}$, compute $u^*_c^{max} = \max_{j \neq \text{China}} \left\{ u^*_c(\varepsilon) \right\}$. And then construct $u = u^*_c^{max} \tilde{u}$ using the draw of $\tilde{u}$ in step 1.
Step 3

For each $u$, the export status $\delta_{cj}$ can be given by

$$
\delta_{cj} (u) = \begin{cases} 
1, & \text{if } u \leq u^*_c (\tilde{\epsilon}) \\
0, & \text{otherwise}
\end{cases}
$$

Step 4

Recover firm level variables.

- Firm-level productivity.
- Exporter-destination quality.
- Firm-level prices that are not adjusted for quality:

$$
\tilde{p}_{ij} (u, \epsilon) = \frac{\tilde{p}_{ij} (u, \epsilon)}{\tilde{p}_j^*} \tilde{p}_j^* q_{ij} (u, \epsilon)
$$

- Firm sales.
Model Fit: Price-Sales Relationship
### Model Fit: Non-Targeted Moments

**Table: Data Targets and Simulation Results**

<table>
<thead>
<tr>
<th>moment</th>
<th>data</th>
<th>model (Exact ID)</th>
<th>model (Over ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: targeted moments</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>std(log(sale))</td>
<td>1.3916</td>
<td>1.3916</td>
<td>1.4935</td>
</tr>
<tr>
<td>std(log(price))</td>
<td>0.6017</td>
<td>0.6017</td>
<td>0.7613</td>
</tr>
<tr>
<td>corr(log(sale), log(price))</td>
<td>0.0543</td>
<td>0.0543</td>
<td>0.0541</td>
</tr>
<tr>
<td>trade elasticity w.r.t. tariff</td>
<td>6.0973</td>
<td>6.0973</td>
<td>6.0973</td>
</tr>
<tr>
<td>log(sales) 90-10</td>
<td>4.1551</td>
<td>-</td>
<td>1.9511</td>
</tr>
<tr>
<td>log(price) 90-10</td>
<td>2.0297</td>
<td>-</td>
<td>3.6124</td>
</tr>
<tr>
<td>log(sales) 90-50</td>
<td>2.0369</td>
<td>-</td>
<td>0.9752</td>
</tr>
<tr>
<td>log(price) 90-50</td>
<td>1.0451</td>
<td>-</td>
<td>1.6070</td>
</tr>
<tr>
<td>log(sales) 99-90</td>
<td>1.3814</td>
<td>-</td>
<td>0.7954</td>
</tr>
<tr>
<td>log(price) 99-90</td>
<td>1.3242</td>
<td>-</td>
<td>1.4837</td>
</tr>
<tr>
<td><strong>Panel B: non-targeted moments</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>exporter domestic sales advantage</td>
<td>1.7152</td>
<td>2.0831</td>
<td>3.3971</td>
</tr>
<tr>
<td>firm frac. with exp. intensity (0.00, 0.10]</td>
<td>38.2064</td>
<td>27.2619</td>
<td>64.4882</td>
</tr>
<tr>
<td>firm frac. with exp. intensity (0.10, 0.50]</td>
<td>35.5425</td>
<td>72.5898</td>
<td>35.5118</td>
</tr>
<tr>
<td>firm frac. with exp. intensity (0.50, 1.00]</td>
<td>26.2511</td>
<td>0.1483</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

**Notes:** The targeted moments are constructed from customs data, which covers the universe of all exporters and importers. The non-targeted moments are constructed from the merged sample based on customs data and Chinese Manufacturing Survey data provided by NBSC (National Bureau of Statistics of China), because we need both exporters and non-exporters in the non-targeted moments to check exporter domestic sales advantage, and we also need total sales information from the NBSC data to compute export intensity.

- Model has trouble fitting the thick tails
- Fitting dispersion in prices across markets limits dispersion in sales across firms
Model Fit: Price-Wage and Entrant-Wage Relationship

Panel A (model)

Panel B (data)

Panel C (model)

Panel D (data)

Panel E (model)

Panel F (data)

Notes: In the top two panels, we normalize each exporter's price by its price at USA (log ($p_{CHN,j}$($\phi, \varepsilon$)) / $p_{CHN,US}$($\phi, \varepsilon$))). We then calculate the average destination price as the mean of this normalized price across firms on each destination. For the bottom two panels, we calculate the average destination price as the simple average of log price for all exporters on that destination. For the model, $w_j$ is the model predicted wage rate; for the data, $w_j$ is the 2004 destination GDP per capita in CEPII. For consistency with our empirical exercise, we control for log destination population, and log distance for both the data and the model. Since the model does not have an exact counterpart for distance, we thus use $T_{ij}$ as a proxy.
Welfare Discussion

- Change in welfare associated with small trade shock
  \[ d \ln W_j = - \left( 1 - \frac{\rho}{1 + \eta \theta} \right) \frac{d \ln \lambda_{jj}}{\eta \theta}, \]

  where \( \rho \) is the average markup elasticity that depends on \( \eta \theta \)

- Sufficient-statistic type formula reminiscent of Arkolakis et al. (2019), with \( \eta \theta \) being the trade elasticity
Road Map

- Stylized Facts
- Model
- Data and Quantification
- Comparative Static
- Conclusion
Consider a 5% *increase* in trade costs between country i and j as measured by $T_{ij}^{\eta-1} \tau_{ij}$.

By construction, whether these shocks are specific or ad-valorem has no impact on the size of the gains from trade.

They do, however, have big implications for the observed change in local import prices.
We use the same firm productivity draw ($\varphi$) and cost shock draw ($\varepsilon$) in the benchmark simulation.

$$\hat{p}_j^* = \frac{\hat{w}_j}{\sum_i \lambda_{ij} (\hat{\varphi}_{ij}^*)}^{-\theta}$$

$$\hat{\varphi}_{ij}^* = \hat{T}_{ij}^{-1} \hat{\tau}_{ij} (\hat{w}_i)^\eta (\hat{p}_j^*)^{-\eta}$$

$$\left(p_{CHN,j}(\varphi, \varepsilon)\right)' = \left(\frac{\tilde{p}_{CHN,j}(\varphi, \varepsilon)}{\tilde{p}_j^*}\right)' (\tilde{p}_j^*)' (q_{CHN,j}(\varphi, \varepsilon))'$$
Specific trade costs, quality ↑; ad-valorem trade costs, quality ↓.

Price changes amplified for $T$ but dampened for $\tau$. 

Fan, Li, Xu & Yeaple (2020)
Quality, Variable Markups & Welfare: A Quantitative GE Analysis of Export Prices
### Prices and Trade Shocks (cont.)

**Table:** Effects of $T$ and $\tau$ on prices, markups, and sales distribution (% change)

<table>
<thead>
<tr>
<th></th>
<th>CAN</th>
<th>DEU</th>
<th>FRA</th>
<th>GBR</th>
<th>JPN</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: $T$ shock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean(log(prices))</td>
<td>5.86</td>
<td>5.77</td>
<td>5.75</td>
<td>5.80</td>
<td>5.67</td>
<td>5.70</td>
</tr>
<tr>
<td><strong>Panel B: $\tau$ shock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean(log(prices))</td>
<td>-1.00</td>
<td>-1.09</td>
<td>-1.11</td>
<td>-1.06</td>
<td>-1.19</td>
<td>-1.16</td>
</tr>
<tr>
<td><strong>Panel C: common responses to $T$ and $\tau$ shocks</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>std(log(prices))</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>log(prices) 99-50</td>
<td>-0.02</td>
<td>0.01</td>
<td>-0.04</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>mean(log(markups))</td>
<td>-1.00</td>
<td>-1.09</td>
<td>-1.11</td>
<td>-1.06</td>
<td>-1.19</td>
<td>-1.16</td>
</tr>
<tr>
<td>std(log(markups))</td>
<td>2.59</td>
<td>2.85</td>
<td>2.91</td>
<td>2.76</td>
<td>3.12</td>
<td>3.03</td>
</tr>
<tr>
<td>log(markups) 99-50</td>
<td>2.81</td>
<td>3.11</td>
<td>3.18</td>
<td>3.00</td>
<td>3.40</td>
<td>3.30</td>
</tr>
<tr>
<td>mean(log(sales))</td>
<td>-78.04</td>
<td>-80.06</td>
<td>-80.36</td>
<td>-78.92</td>
<td>-87.62</td>
<td>-85.28</td>
</tr>
<tr>
<td>std(log(sales))</td>
<td>70.57</td>
<td>72.18</td>
<td>71.12</td>
<td>71.04</td>
<td>78.74</td>
<td>75.33</td>
</tr>
<tr>
<td>log(sales) 99-50</td>
<td>20.61</td>
<td>21.63</td>
<td>21.60</td>
<td>21.00</td>
<td>23.67</td>
<td>22.99</td>
</tr>
<tr>
<td>corr(log(prices), log(sales))</td>
<td>-10.50</td>
<td>-21.35</td>
<td>-29.09</td>
<td>-15.61</td>
<td>-11.84</td>
<td>-18.10</td>
</tr>
<tr>
<td>corr(log(prices), log(markups))</td>
<td>2.04</td>
<td>3.73</td>
<td>4.86</td>
<td>2.67</td>
<td>3.03</td>
<td>2.89</td>
</tr>
<tr>
<td>corr(log(markups), log(sales))</td>
<td>-16.32</td>
<td>-16.21</td>
<td>-15.31</td>
<td>-15.85</td>
<td>-18.02</td>
<td>-16.59</td>
</tr>
</tbody>
</table>
Conclusion

- “Washington Apples” mechanism first order important to fit the facts.
- Document three stylized facts using disaggregated Chinese customs data regarding export prices across firms and destinations.
- Build a model containing three mechanisms that contribute to price dispersion across firms and countries.
- Calibrate the model and simulate to show the quantitative prediction of the model.
- Comparative statics show the importance of specific trade costs on prices changes.
Thank you!
Backup Slide

Model Fit: A Check on the Solution of the Model

Panel A
Panel B
Panel C
Panel D