**Uncertainty**: a firm’s information about the firm’s idiosyncratic supply and demand shocks in markets

**Trade Elasticity**: the elasticity of trade flows with respect to variable trade costs

**Question**: What is the effect of uncertainty on trade elasticities and the gains from trade?
Motivation

- Arkolakis, Costinot, Rodriguez-Clare (2012)

\[
\ln(\text{Welfare}) \propto \frac{1}{\text{Trade Elasticity}} \ln(\text{Dom. Trade Share})
\]

Inverse relationship between Trade Elasticity and Welfare gains from trade.

- The gains from trade are largely derived from models with complete information
  - Arkolakis, Costinot, Rodriguez-Clare, 2012; Melitz, Redding, 2015

- Estimates of trade elasticities are obtained from models with complete information
  - Eaton, Kortum, 2002; Simonovska, Waugh, 2014; Caliendo, Parro, 2015
Models with firm-level uncertainty match salient patterns of empirically observed firm behavior

- Conditional age and size dependence of firm growth rates
  - Arkolakis, Papageorgiou, Timoshenko, 2018
- The decline in product turnover within firms over time
  - Timoshenko, 2015
- The dynamics of firms’ input and output prices
  - Bastos, Dias, Timoshenko, 2017

The implications of models with uncertainty for measurements of trade elasticity and welfare are not yet well understood

Exactly what we do in this paper
1. Take an economic environment that encompasses

- Supply and demand side heterogeneity
  - Firms are heterogeneous according to
    - Productivity (Melitz, 2003)
    - Demand (Timoshenko, 2015)

- Two information environments
  - Information sets prior to export decisions
    - Uncertainty: only observe productivity
    - Complete information: observe both productivity and demand
2. Derive implications for elasticities, trade, and welfare

We show that under uncertainty
- Trade is more elastic
- Trade flow is lower
- Welfare gains from trade are lower

3. Derive identification strategy for trade elasticities

We show that
- Uncertainty: export quantity data identify trade elasticities
- Complete Information: export sales data identify trade elasticities
4. Quantify the effect of uncertainty on trade elasticities

- Use Brazilian export data from 1990-2001
- Adapt Bas, Mayer and Thoenig (2017) structural estimation approach to an environment with uncertainty

We find

- Trade elasticities are on average 7% larger under uncertainty
- The gap increases when demand is more uncertain

5. Quantify the resulting welfare wedge

- Complete information overstated welfare gains from trade by 1% to 12% from a 10% decline in variable trade costs.
- The wedge increases when demand is more uncertain
Economic Environment

- Static economy
- $N$ countries
  - $i$ - an origin country
  - $j$ - a destination country
- $K$ sectors
  - $k$ - a sector
- Differentiated varieties
- Nested constant elasticity of substitution preferences
- Monopolistic competition
- Heterogeneous firms as in Melitz (2003)
- Exogenous entry as in Chaney (2008)
A firm can supply one variety in each sector
Firms are heterogeneous in supply and demand side parameters

Demand side:
- $\theta_{ijk}(\omega)$ - idiosyncratic demand level
- drawn from a distribution $g_{ijk}(\cdot)$ with zero mean

Supply side:
- $\varphi_{ijk}(\omega)$ - idiosyncratic productivity level
- drawn from a distribution $g_{ijk}(\cdot)$
- henceforth denoted by $\varphi$
Under uncertainty

- $\varphi$ is always observed by firms
- $\theta_{ijk}(\omega)$ is not observed by firms at the time of making decisions
- Firms make their decisions based on observed productivity, $\varphi$

Under complete information

- $\varphi$ is always observed by firms
- $\theta_{ijk}(\omega)$ is always observed by firms
- Firms make their decisions based on observed profitability

$$z_{ijk} \equiv (\epsilon_k - 1)\varphi + \theta_{ijk}$$

- Profitability is a mean preserving spread of productivity.
Theoretical Framework

Trade Elasticity

\[ \frac{\partial \ln X_{ijk}}{\partial \ln \tau_{ij}} = \frac{(1 - \varepsilon_k)}{1 - \varepsilon_k} \]

level of the partial trade elasticity

\[ \frac{1}{\text{intensive margin contribution}} + \gamma_{ijk} \]

extensive margin contribution

- The extensive margin contribution to trade elasticity

Krugman (1980)
- All firms are identical
- No selection
- \( \gamma_{ijk} = 0 \)

Chaney (2008)
- Firm productivity is distributed according to Pareto distribution
- \( \gamma_{ijk} = \frac{\xi}{(\varepsilon_k - 1)} - 1 \)
- \( \frac{\partial \ln X_{ijk}}{\partial \ln \tau_{ij}} = -\xi \)
The extensive margin contribution to trade elasticity

\[ \gamma_{ijk}(x^*) \equiv \frac{e^{x^*}g_{ijk}^x(x^*)}{\int_{x^*}^{+\infty} e^x g_{ijk}^x(x) dx} = \frac{h_{ijk}(x^*)}{1 - H_{ijk}(x^*)}, \]

where

- \( x^* \) is the entry threshold
- \( g_{ijk}^x(.) \) is the distribution of the underlying decision-relevant heterogeneity

A hazard rate associated with r.v. distributed according to

\[ h_{ijk}(x^*) = \frac{e^{x^*}g_{ijk}^x(x^*)}{\int_{-\infty}^{+\infty} e^x g_{ijk}^x(x) dx} \]  \hspace{1cm} (1)

Role of information

\( x^* \) and \( g(x) \) differ across information environments
Theoretical Framework

Trade Elasticity

- The extensive margin contribution to trade elasticity

\[
\gamma_{ijk}(x^*) \equiv \frac{e^{x^*} g_{ijk}^x(x^*)}{\int_{x^*}^{+\infty} e^x g_{ijk}^x(x) \, dx} = \frac{h_{ijk}(x^*)}{1 - H_{ijk}(x^*)}
\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncertainty</th>
<th>Complete Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>productivity</td>
<td>$z = (1 - \epsilon_k) \varphi + \theta$</td>
</tr>
<tr>
<td>$g_{ijk}(.)$</td>
<td>$\phi = (1 - \epsilon_k) \varphi$</td>
<td>$g_{ijk}(.)$</td>
</tr>
</tbody>
</table>

- Implications for
  1. Comparing trade elasticities
  2. Identifying trade elasticities from the data
The extensive margin contribution to trade elasticity

\[ \gamma_{ijk}(x^*) \equiv \frac{e^{x^*} g_{ijk}^x(x^*)}{\int_{x^*}^{+\infty} e^{x} g_{ijk}^x(x) dx} = \frac{h_{ijk}(x^*)}{1 - H_{ijk}(x^*)} \]

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<tr>
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<th>Complete Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>productivity</td>
<td>profitability</td>
</tr>
<tr>
<td>( g_{ijk}^x(.) )</td>
<td>( \phi = (1 - \epsilon_k)\varphi )</td>
<td>( z = (1 - \epsilon_k)\varphi + \theta )</td>
</tr>
<tr>
<td>( g_{ijk}^\phi(.) )</td>
<td>( g_{ijk}^z(.) )</td>
<td></td>
</tr>
</tbody>
</table>

- \( z \) is a mean preserving spread of \( \phi \)
- The hazard rate of a mean preserving spread is lower
  - \( \forall x \) above some value

\[ \gamma_{ijk}^{z,\text{complete info}}(x) < \gamma_{ijk}^{\phi,\text{uncertainty}}(x) \]
Implications for welfare

\[
X_{ijk} = J_i \varepsilon_k w_i f_{ijk} \frac{1}{\gamma_{ijk}(x^*)} g_{ijk}(x^*)
\]

\[
\ln(W_i) \propto \sum_{k=1}^{K} \frac{\mu_k}{\partial \ln X_{ijk}} \ln \left( \frac{\pi_{ii,k}}{L_{ik}} \right)^{-1}
\]

- \( \gamma_{ijk}^{z, \text{compl. inf.}} < \gamma_{ijk}^{\phi, \text{uncert.}} \) \( \rightarrow \) \( |\partial \ln X_{ijk} / \partial \ln \tau_{ij}|^{z, \text{compl. inf.}} < |\partial \ln X_{ijk} / \partial \ln \tau_{ij}|^{\phi, \text{uncert.}} \)

- \( X_{ijk}^{z, \text{compl. inf.}} > X_{ijk}^{\phi, \text{uncert.}} \) \( \rightarrow \) \( \pi_{ii,k}^{z, \text{compl. inf.}} < \pi_{ii,k}^{\phi, \text{uncert.}} \)

Welfare gains from trade are smaller under uncertainty.
### 2. Identifying trade elasticities from the data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Uncertainty</th>
<th>Complete Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x$</td>
<td>productivity</td>
<td>$z = (1 - \epsilon_k)\phi + \theta$</td>
</tr>
<tr>
<td>$g_{ijk}(.)$</td>
<td>$\phi = (1 - \epsilon_k)\phi$</td>
<td>$g_{ijk}(.)$</td>
</tr>
<tr>
<td>$q_{ijk}$</td>
<td>$B_{ijk}^q \cdot e^{\epsilon_k \phi}$</td>
<td>$B_{ijk}^{q,CI} \cdot e^{\epsilon_k \phi + \theta_{ijk}}$</td>
</tr>
<tr>
<td>$r_{ijk}$</td>
<td>$B_{ijk}^r e^{(\epsilon_k - 1)\phi + \frac{\theta_{ijk}}{\epsilon_k}}$</td>
<td>$B_{ijk}^{r,CI} e^{(\epsilon_k - 1)\phi + \theta_{ijk}}$</td>
</tr>
</tbody>
</table>

- **Uncertainty:**
  - Productivity identifies trade elasticity
  - **Productivity** is contained in the export quantity data

- **Complete information:**
  - Profitability identifies trade elasticity
  - **Profitability** is contained in the export sales data
Brazilian customs declarations collected by SECEX (Secretaria de Comercio Exterior)

Variables: export value and export quantity (weight) at the firm-product-destination-year level

Time period: 1997-2000

An observation: a distribution of log-quantity or log-sales across exporters in a given destination-year-HS6 triplet

190 destination-year-sector observations
An example

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Log-quantity</th>
<th>Log-sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Deviation</td>
<td>4.85</td>
<td>9.45</td>
</tr>
<tr>
<td>Kelly Skew</td>
<td>0.27</td>
<td>-0.13</td>
</tr>
<tr>
<td>Average-to-Minimum</td>
<td>5,300</td>
<td>23,100</td>
</tr>
</tbody>
</table>

Kernel density estimate

kernel = epanechnikov, bandwidth = 1.1786

kernel = epanechnikov, bandwidth = 0.7033
Methodology - Uncertainty

Step 1: Recover $g_{ijk}(.)$ from the empirical distribution of the log-export quantity

- Estimate parameters of $g_{ijk}(.)$ using a GMM procedure

$$\min_{(\mu, \sigma^2, \lambda_L, \lambda_R)} \sum_{i=1}^{N_P} \left( q^\text{data}_i - q_i(.) \right)^2$$

- $N_P$ - the number of percentiles (1st through 99th)
- $q^\text{data}_i$ - the $i$-th percentile of the empirical quantity distribution
- $q_i(.)$ - the model implied $i$-th quantity percentile

- $g_{ijk}(.) \sim$ Double EMG $(\mu, \sigma, \lambda_R, \lambda_L)$
- Defined as a convolution (sum) of a Normal and a Double Exponential distributions

Details
Step 2: Given $g_{ijk}(.)$, recover the scaled productivity threshold $\varphi_{ijk}^*$ by matching the model-implied average-to-minimum ratio to that in our quantity data

$$\text{Average-to-Minimum Ratio} = e^{-\varphi_{ijk}^*} \int_{\tilde{\varphi}_{ijk}^*}^{+\infty} \frac{e^{\varphi} g_{ijk}(\varphi)}{\text{Prob}_{ijk}(\varphi > \tilde{\varphi}_{ijk}^*)} d\varphi.$$ 

- A strictly monotone function with a unique solution

Step 3: Take $\varepsilon_k$ from Soderbery (2015)

Complete Information
- Same steps, log-export sales data
Result 1: Under demand uncertainty, the trade elasticity is larger relative to the complete information environment.

Table: Trade elasticity estimates.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Extensive Margin Elasticity</th>
<th>Partial Trade Elasticity, $\eta_{ijk}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Dev.</td>
</tr>
<tr>
<td><strong>Panel A: Estimates of trade elasticity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity based(^a)</td>
<td>0.07</td>
<td>0.34</td>
</tr>
<tr>
<td>Sales based</td>
<td>0.003</td>
<td>0.02</td>
</tr>
</tbody>
</table>

| **Panel B: Amplification effect** |             |                        |             |            |
| Amplification effect\(^b\) | 2.8 $\cdot$ 10\(^5\) | 1.6 $\cdot$ 10\(^6\) | 1.07       | 0.34       |

\(^a\) The amplification effect is computed as the ratio of the quantity based relative to the sales based estimate of trade elasticity. The summary statistics are reported across 175 destination-year-industry observations for which the elasticity is defined in terms of both quantity and sales based measures.

- How does the amplification effect depend on the magnitude of demand uncertainty?
Result 2: *The difference in the trade elasticity estimates between environments with demand uncertainty and complete information is larger in more uncertain economies.*

![Graph showing the relationship between amplification effect and demand uncertainty.](image)

Notes: Each dot corresponds to a destination-year-industry observation. The solid line is an OLS best fit line. The amplification effect is defined as the ratio of the extensive margin elasticity estimates between the quantity based and the sales based measures. Demand uncertainty is defined as the difference in the variance of log-sales and log-quantity.
Quantify errors in the measurement of the welfare gains from trade arising solely from changes in the information environment

- Calibrate a model with uncertainty to match
  - The estimated trade elasticity
  - Variance of log-export quantity and sales
  - Average value of export quantity and sales
- Hold structural parameters at their calibrated values
- Simulate trade liberalization
  - uncertainty
  - complete information
- Compare predicted changes in welfare
**Figure:** The welfare wedge from a 10% decline in variable trade costs.

Notes: The figure depicts the percentage point difference in the estimates of the welfare gains from trade from a 10% decline in variable trade costs between a model with complete information and a model with uncertainty. Each dot is a separate observation and represents a simulation result for that observation.
Welfare Implications

Welfare Simulation

Figure: Counterfactual export entry and average exporter size.

- Uncertainty lowers the gains from trade because it dampens the forces that lead to selection of firms into export markets
  - Uncertainty: more entry of smaller firms $\rightarrow$ smaller total trade flow
  - Compl. inf.: less entry of larger firms $\rightarrow$ larger total trade flow
We explore the implications of demand uncertainty for the partial trade elasticity and grains from trade.

The information available to firms at the time of making export decisions determines how responsive their decisions are to changes in variable trade costs.

Uncertainty $\rightarrow$ larger partial trade elasticity $\rightarrow$ lower welfare gains relative to complete information.

Identification of the partial trade elasticity:
- Uncertainty: quantity data
- Complete information: sales data
Quantitative results

- Under demand uncertainty the partial trade elasticity is larger relative to the complete information economy by 7% on average
- Complete information overstated welfare gains from trade by 1% to 12% from a 10% decline in variable trade costs

In countries or industries in which exporters face high demand uncertainty models with complete information

- Understate the true magnitude of extensive margin adjustments
- Overstate the welfare gains from trade