Uncertainty and Trade Elasticities

Erick Sager Olga A. Timoshenko

Federal Reserve Board George Washington University

December 21st, 2018

Motivation

- **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

▸ Countertactual

Motivation

- 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

What We Do

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

What We Do

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

What We Do

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

▸ Literature

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 Details
- Monopolistic competition
- Heterogeneous firms as in Melitz (2003)
- Idiosyncratic demand as in Jovanovic (1982), Timoshenko (2015)
- Exogenous entry as in Chaney (2008)

Firms and Heterogeneity

- 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 $g^{\theta}_{ijk}(.)$ with zero mean

Supply side:

- $\varphi_{ijk}(\omega)$ - idiosyncratic productivity level
- drawn from a distribution $g^{\varphi}_{ijk}(.)$
- henceforth denoted by φ

Information Structure

Under uncertainty

- φ 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, φ

Under complete information

- φ 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.*

Trade Elasticity

$$\frac{\partial \ln X_{ijk}}{\partial \ln \tau_{ij}} = \underbrace{(1-\epsilon_k)}_{\substack{\text{level of the} \\ \text{partial trade elasticity}}} \left(\underbrace{1}_{\substack{\text{intensive margin} \\ \text{contribution}}} + \underbrace{\gamma_{ijk}}_{\substack{\text{extensive margin} \\ \text{contribution}}} \right)$$

- 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
- $\gamma_{ijk} = \xi/(\epsilon_k - 1) - 1$
- $\partial \ln X_{ijk}/\partial \ln \tau_{ij} = -\xi$

Back to welfare theory

Trade Elasticity

- The extensive margin contribution to trade elasticity

$$\gamma_{ijk}(x^*) \equiv \frac{e^{x^*} g^x_{ijk}(x^*)}{\int_{x^*}^{+\infty} e^x g^x_{ijk}(x) dx} = \frac{h_{ijk}(x^*)}{1 - H_{ijk}(x^*)},$$

  where
  - x^* is the entry threshold
  - $g^x_{ijk}(.)$ is the distribution of the underlying decision-relevant heterogeneity
- A hazard rate associated with r.v. distributed according to

$$h_{ijk}(x^*) = \frac{e^{x^*} g^x_{ijk}(x^*)}{\int_{-\infty}^{+\infty} e^x g^x_{ijk}(x) dx} \quad (1)$$

- Role of information

x^* and $g(x)$ differ across information environments

Trade Elasticity

- The extensive margin contribution to trade elasticity

$$\gamma_{ijk}(x^*) \equiv \frac{e^{x^*} g^x_{ijk}(x^*)}{\int_{x^*}^{+\infty} e^x g^x_{ijk}(x) dx} = \frac{h_{ijk}(x^*)}{1 - H_{ijk}(x^*)}$$

Variable	Uncertainty	Complete Information
	productivity	profitability
x	$\phi = (1-\epsilon_k)\varphi$	$z = (1-\epsilon_k)\varphi + \theta$
$g^x_{ijk}(.)$	$g^{\phi}_{ijk}(.)$	$g^{z}_{ijk}(.)$

- Implications for
  1. Comparing trade elasticities
  2. Identifying trade elasticities from the data

▸ Trade Elast. Uncert. ▸ Trade Elast. Compl. Inf.

Trade Elasticity - Comparison

- The extensive margin contribution to trade elasticity

$$\gamma_{ijk}(x^*) \equiv \frac{e^{x^*} g^x_{ijk}(x^*)}{\int_{x^*}^{+\infty} e^x g^x_{ijk}(x) dx} = \frac{h_{ijk}(x^*)}{1 - H_{ijk}(x^*)}$$

Variable	Uncertainty	Complete Information
	productivity	profitability
x	$\phi = (1-\epsilon_k)\varphi$	$z = (1-\epsilon_k)\varphi + \theta$
$g^x_{ijk}(.)$	$g^\phi_{ijk}(.)$	$g^z_{ijk}(.)$

- z is a mean preserving spread of ϕ
- The hazard rate of a mean preserving spread is lower
  - $\forall x$ above some value

$$\gamma^{z,\text{complete info}}_{ijk}(x) < \gamma^{\phi,\text{uncertainty}}_{ijk}(x)$$

▸ Assumption 1

Trade Elasticity - Comparison

Implications for welfare

$$X_{ijk} = J_i \epsilon_k w_i f_{ijk} \frac{1}{\gamma_{ijk}(x^*)} g^x_{ijk}(x^*)$$

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

- $\gamma^{z,\text{compl. inf.}}_{ijk} < \gamma^{\phi,\text{uncert.}}_{ijk} \rightarrow |\frac{\partial \ln X_{ijk}}{\partial \ln \tau_{ij}}|^{z,\text{compl. inf.}}_{ijk} < |\frac{\partial \ln X_{ijk}}{\partial \ln \tau_{ij}}|^{\phi,\text{uncert.}}_{ijk}$
- $X^{z,\text{compl. inf.}}_{ijk} > X^{\phi,\text{uncert.}}_{ijk} \rightarrow \pi^{z,\text{compl. inf.}}_{ii,k} < \pi^{\phi,\text{uncert.}}_{ii,k}$

- Welfare gains from trade are smaller under uncertainty

▸ Trade elasticity theory ▸ Countertactual

Trade Elasticity - Identification

2. Identifying trade elasticities from the data

Variable	Uncertainty	Complete Information
	productivity	profitability
x	$\phi = (1-\epsilon_k)\varphi$	$z = (1-\epsilon_k)\varphi + \theta$
$g^x_{ijk}(.)$	$g^{\phi}_{ijk}(.)$	$g^{z}_{ijk}(.)$
q_{ijk}	$B^q_{ijk} \cdot e^{\epsilon_k \varphi}$	$B^{q,CI}_{ijk} \cdot e^{\epsilon_k \varphi + \theta_{ijk}}$
r_{ijk}	$B^r_{ijk} e^{(\epsilon_k - 1)\varphi + \frac{\theta_{ijk}}{\epsilon_k}}$	$B^{r,CI}_{ijk} e^{(\epsilon_k - 1)\varphi + \theta_{ijk}}$

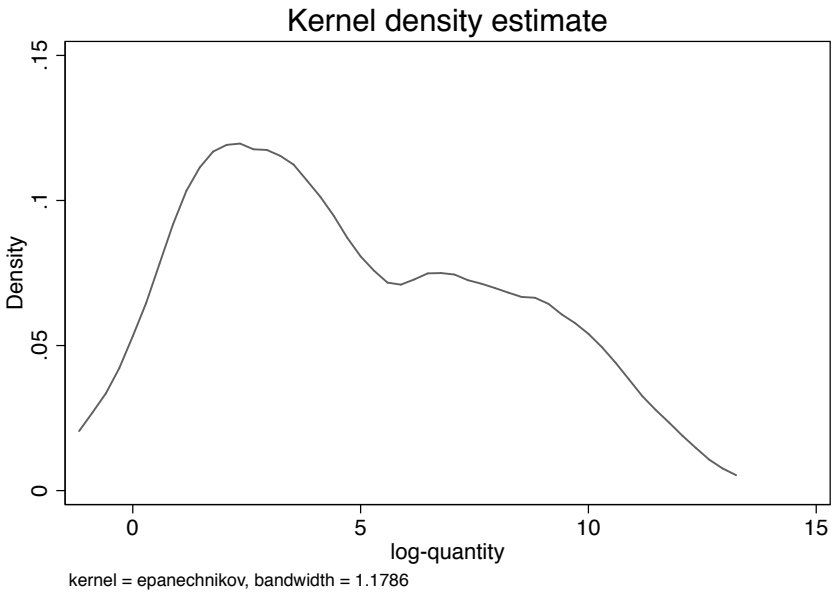
- Uncertainty: ▸ Details
  - Productivity identifies trade elasticity
  - Productivity is contained in the export quantity data
- Complete information: ▸ Details
  - Profitability identifies trade elasticity
  - Profitability is contained in the export sales data

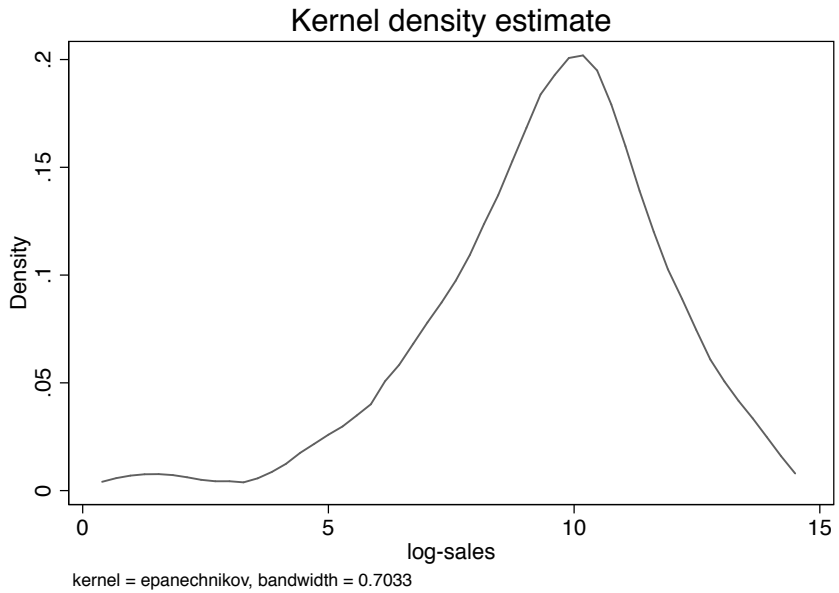
Data

- 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

▸ Sample Properties

An example





Statistic	Log-quantity	Log-sales
Standard Deviation	4.85	9.45
Kelly Skew	0.27	-0.13
Average-to-Minimum	5,300	23,100

Methodology - Uncertainty

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

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

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

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

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

Methodology - Uncertainty

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

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

- A strictly monotone function with a unique solution

Step 3: Take ϵ_k from Soderbery (2015)

Complete Information

- Same steps, log-export sales data Details

Elasticity Estimates

Result 1: *Under demand uncertainty, the trade elasticity is larger relative to the complete information environment.*

Table: Trade elasticity estimates.

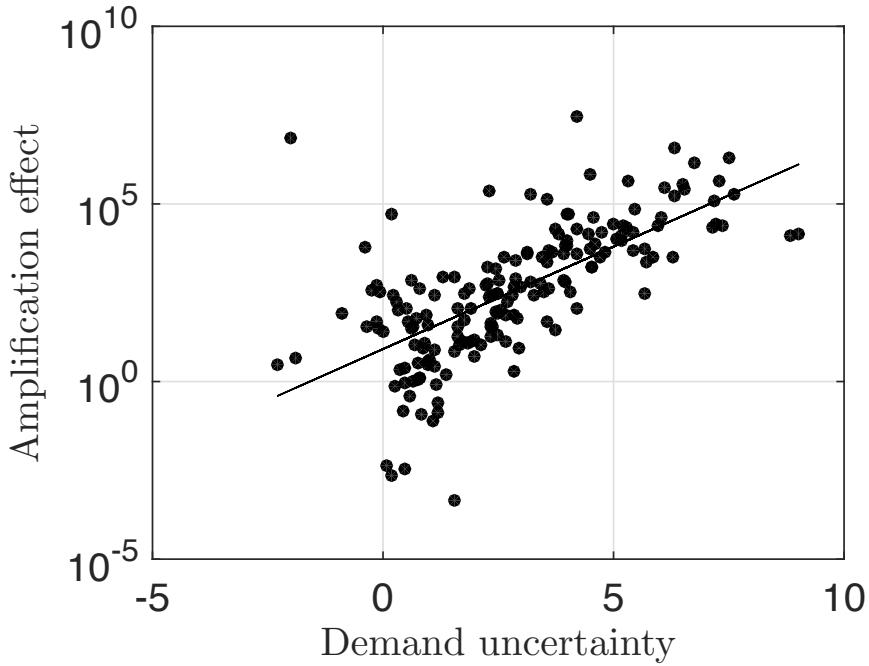
	Extensive Margin Elasticity		Partial Trade Elasticity, η_{ijk}	
Measure	Mean	Std. Dev.	Mean	Std. Dev.
Panel A: Estimates of trade elasticity				
Quantity based[a]	0.07	0.34	3.38	3.64
Sales based	0.003	0.02	3.54	3.76
Panel B: Amplification effect				
Amplification effect[b]	$2.8 \cdot 10^5$	$1.6 \cdot 10^6$	1.07	0.34

[b] 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?

Elasticity Estimates

Result 2: *The difference in the trade elasticity estimates between environments with demand uncertainty and complete information is larger in more uncertain economies.*



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.

▸ Definition

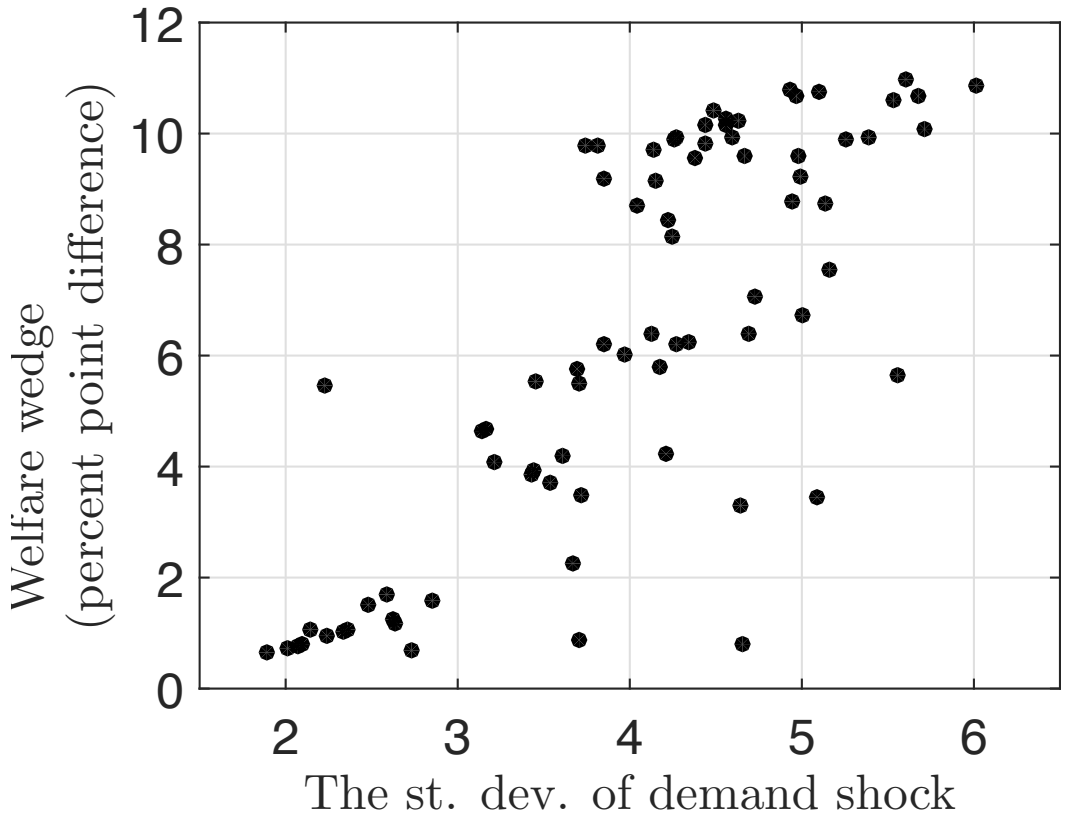
Counterfactual Simulations

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

Welfare Simulation

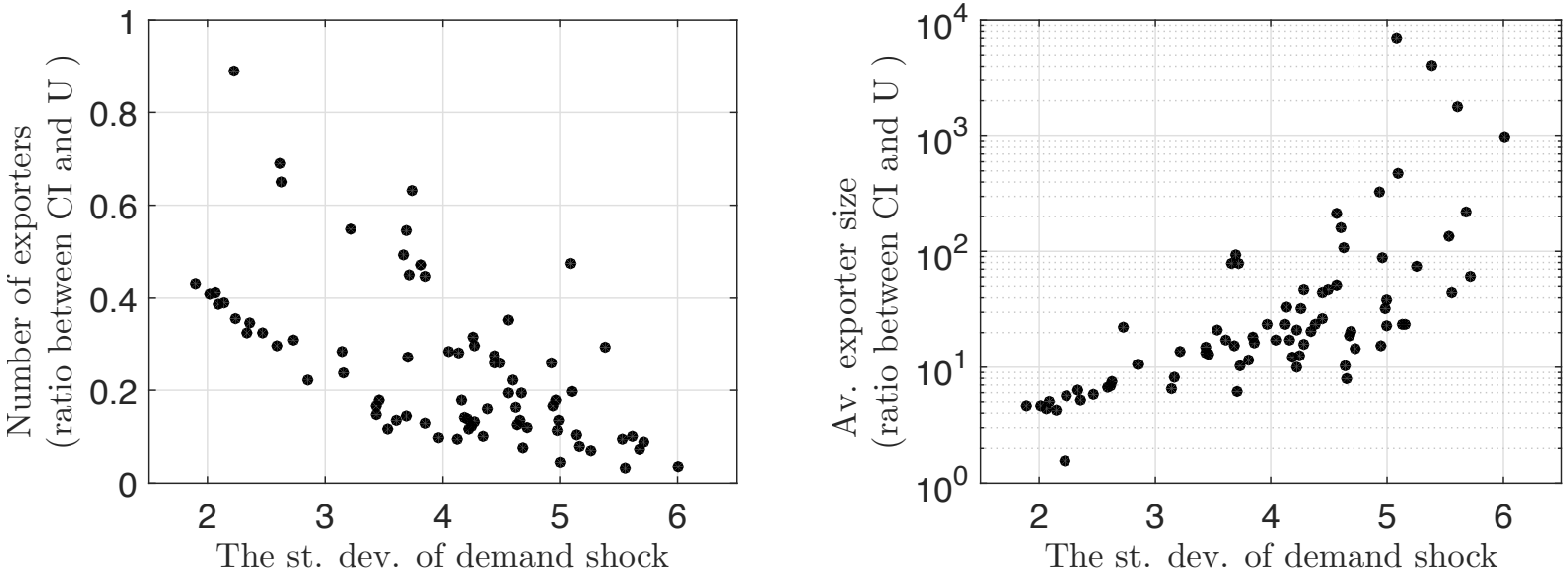
Figure: The welfare wedge from a 10% decline in variable trade costs.



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 Simulation

Figure: Conterfactual 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

▸ ACR equation ▸ Total trade flow

Conclusion 1/2

- 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

Conclusion 2/2

- 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