Trade Adjustment and Productivity in Large Crises

Gita Gopinath
Harvard University
and NBER

Brent Neiman
University of Chicago
and NBER

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Motivation

- Large crises associated with collapse in dollar value of imports
  - Argentina (2000-2002): 69%
  - South Korea (1997-1998): 35%
  - Thailand (1997-1998): 32%

- Large measured TFP declines
  - Argentina: 12% (in manufacturing, Sandleris & Wright 2011)
  - South Korea: 7.1% (Meza & Quintin 2006)
  - Thailand: 15.1% (Meza & Quintin 2006)

- Little known about mechanics and costs of trade collapse
We do Three Things:

1. Use firm-level data to empirically characterize the mechanics of trade adjustment during the Argentine crisis of 2001/2002

2. Use model to evaluate channels though which collapse in imports impacts manufacturing productivity and welfare

3. We show in a numerical simulation:
   - These channels can be important quantitatively, and
   - Firm-level data moment are important in evaluating impact
Related Literatures


Road Map

- Data Description
- Empirics: Firms Adjusted Imports Differently to Shock
- Simple Theory Replicates Empirical Features and Generates Decline in Productivity
- Simulation: These Channels Can Be Important Quantitatively
Data Description

• Trade data collected by Argentine customs for 1996-2008
  • Includes: firm name, tax ID, date, quantity, weight, unit price, value, HTS, country, port, taxes, model # (sometimes), etc.
  • Imports purchased from The Datamyne (our focus)
  • Exports purchased from Nosis (lower quality, used less)

• Capital IQ Data base (Standard and Poors)
  • Match ≈2000 firms that make up 65% of imports.
  • Info on primary sector (10 categories) and industry (131)
  • Used to identify distributors or trading companies
  • Used (with RAs) to determine if MNC or not
First Empirical Result

1. Extensive margin at country level is not important (≈10%)

2. Within-firm (sub-) extensive margin is important (≈40%)

3. Pattern of trade adjustment varies with size

4. Assuming CES, dropped varieties imply 13% import price increase when using micro data, 0% using aggregate data
Extensive Margin (Weighted)

\[ \frac{\Delta v_t}{v_{t-1}} = \left( \sum_{i \in \psi_{t-1} \cap \psi_t} \frac{v_{i,t} - v_{i,t-1}}{v_{t-1}} \right) + \left( \sum_{i \in \psi_t, i \notin \psi_{t-1}} \frac{v_{i,t}}{v_{t-1}} - \sum_{i \in \psi_{t-1}, i \notin \psi_t} \frac{v_{i,t-1}}{v_{t-1}} \right), \]

where

\[ v_t = \text{Total FOB at period } t \]
\[ v_{i,t} = \text{Total FOB for CUIT/HTS } i \text{ at month } t \]
\[ \psi_t = \text{Set of CUIT/HTS } i \text{ with } v_{i,t} > 0. \]
Constant Panel of Importers (Benchmarked in 1999)
Product (HTS 10) Intensive/Extensive Margin (Quarterly)

- Intensive Margin
- Extensive Margin

- Pierce and Schott (2009) for U.S., 6 digit
Conventional Extensive Margin Not Important

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>% Intensive</th>
<th>% Extensive</th>
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<tr>
<td>Firm</td>
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<td>0.89</td>
<td>0.11</td>
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<tr>
<td>HTS 6</td>
<td>-69%</td>
<td>1.00</td>
<td>0.00</td>
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<td>HTS 10</td>
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<tr>
<td>HTS 10 X Cty</td>
<td>-69%</td>
<td>0.79</td>
<td>0.21</td>
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</table>

**Table:** Intensive and Extensive Margins, 2000-2002

- Top 5% of firms account for 85% of imports
- Top 5% of 6 digit account for 60% of imports
Second Empirical Result

1. Extensive margin at country level is not important (≈10%)

2. Within-firm (sub-) extensive margin is important (≈40%)

3. Pattern of trade adjustment varies with size

4. Assuming CES, dropped varieties imply 13% import price increase when using micro data, 0% using aggregate data
Within-Firm Extensive Margin (HTS10) is Large

Percent Growth

Sub-Intensive Margin

Extensive and Sub-Extensive Margin

Sub-Extensive Margin (Plus Extensive) is Important

<table>
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<tr>
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<th>Total</th>
<th>% Sub-Intensive</th>
<th>% Sub-Extensive</th>
<th>% Extensive</th>
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<tr>
<td>HTS 6</td>
<td>-69%</td>
<td>0.71</td>
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<td>HTS 10</td>
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<td>HTS 10 X Cty</td>
<td>-69%</td>
<td>0.44</td>
<td>0.45</td>
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</table>

**Table:** Sub-Intensive, Sub-Extensive, and Extensive Margins, 2000-2002
How is Sub-Extensive Big if Extensive is Small?

1. Firms drop a product that other firms continue to import

2. Firms drop some imported products but not others

Products in the 25th/50th/75th percentiles had initial import values of $30,000/$165,000/$800,000.
BGH, Argentine Manufacturer (#25 Importer)

Quarterly Imports in USD
(See Legend for Scales)

(Note: extends above range)

Industrial Cooling Fans ($10,000s)
Anti-Vibration Materials (in $10,000s)
Siderca, Argentine Building Products Firm (#22 Importer)

Quarterly Imports in USD (See Legend for Scales)

- Tooling for Steel-Cutting Lathes ($100,000s)
- Tooling for Aluminum Smelting and Mixing ($10,000s)
Third Empirical Result

1. Extensive margin at **country level is not** important (≈10%)

2. **Within-firm** (sub-) extensive margin is important (≈40%)

3. Pattern of trade adjustment **varies with size**

4. Assuming CES, **dropped varieties** imply 13% import price increase when using micro data, 0% using aggregate data
Holds in regression with 10 sector and MNC dummies

Firms in the 25th/50th/75th percentiles had initial annual import volumes of about $50,000/$210,000/$770,000.
Importer Size and Trade Adjustment

- Smaller firms more likely to adjust with extensive margin, largest firms with sub-intensive margin

Firms in the 25th/50th/75th percentiles had initial annual import volumes of about $50,000/$210,000/$770,000.
Fourth Empirical Result

1. Extensive margin at country level is not important ($\approx 10\%$)

2. Within-firm (sub-) extensive margin is important ($\approx 40\%$)

3. Pattern of trade adjustment varies with size

4. Assuming CES, dropped varieties imply 13\% import price increase when using micro data, 0\% using aggregate data
Implication of Dropped Varieties for CES Unit Cost

- Assuming inputs are combined CES, the impact of changing varieties on unit cost of import bundle is (Feenstra 1994):

  \[
  F = \left( \frac{\sum_{\omega_t} v_{i,t} / \sum_{\omega_{t-1} \cap \omega_t} v_{i,t}}{\sum_{\omega_{t-1}} v_{i,t-1} / \sum_{\omega_{t-1} \cap \omega_t} v_{i,t-1}} \right)^{(\varepsilon-1)/\varepsilon}
  \]

- If economy drops import varieties, generates additional impact on cost of production above standard ToT measure

- If firms drop different import varieties, cost of production and market shares change differentially among continuing traders (even with common shock)
Varieties and Unit Cost: Aggregate vs. Firm-Level

- Measured comparing 2000-2002
- Elasticity equal to 4

<table>
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<th>Percentiles Included:</th>
<th>$F_i$ all</th>
<th>Weighted Average of $F_i$</th>
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<td>(5,95)</td>
<td>(20,80)</td>
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<td>1.087</td>
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<td>HTS 6 X Country</td>
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<td>1.004</td>
<td>1.176</td>
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<tr>
<td>Simple Average</td>
<td>1.002</td>
<td>1.134</td>
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</tbody>
</table>

Broda & Weinstein (2006), HTS 10-digit X country, mean/median elasticity of 2.9/8.2
Concern 1: Firms Can Still Use Inputs They Don’t Import

1. Distributors: Share ranges from 3%-8%, declines during crisis

2. Inventories (Alessandria, Midrigan, and Kaboski 2010):
   - Classify HTS6 sectors by inventory/sales ratio (from corresponding U.S. sector in 2000).

   - In simulation, we consider case where all imports dropped like the low inventory intensity goods (53% compared to 73%).
Concern 2: Less Varieties Are Produced?

Time Dummies (Number, SA)
Regressions Run with Firm-Fixed Effects

Export Varieties

Import Varieties

Import Varieties Less Export Varieties
How Empirical Results Motivate the Model/Calculations

- Empirical Finding 1: We’ll ignore firm entry/exit into trading behavior

- Empirical Finding 2: Changing market shares, heterogeneity, and sub-extensive margin all matter.

- Empirical Finding 3: A per-variety fixed cost generates non-homotheticity that correlates with size.

- Empirical Finding 4: A (loose) calibration target
Basic Idea in the Model

- Without frictions, firms desire same share of imported inputs
- Fixed costs + het tech = varying deviations from this share
- Larger firms have lower unit costs of production.
- Shock amplified due to round-about production (Jones 2010)
- Joint dist of (exogenous) technologies and (endogenous) import shares matters for productivity
Production Function

- Each domestic manufacturing firm $i$ produces a unique variety:

$$Y_i = A_i(K_i^\alpha L_i^{1-\alpha})^{1-\mu} X_i^\mu$$

- $X_i$ combines a continuum of domestic and foreign inputs:

$$X_i = [Z_i^\rho + M_i^\rho]^{\frac{1}{\rho}}$$

$$Z_i = \left[ \int z_{ij}^\theta \, dj \right]^{\frac{1}{\theta}}$$

$$M_i = \left[ \int_{k \in \Omega_i} (b m_{ik})^\theta \, dk \right]^{\frac{1}{\theta}}$$

- $\Omega_i$ is set of inputs imported by firm $i$
- $b \geq 1$ captures higher import quality
- $\frac{1}{1-\rho}$: elasticity between imported and domestic inputs.
- $\frac{1}{1-\theta}$: elasticity within imported and domestic inputs.
Demand

• Final good $G$ is formed by aggregating all the $g_i$:

\[ G = \left[ \int_i g_i^\theta \, di \right]^{\frac{1}{\theta}}, \]

where $1/(1 - \theta)$ is elasticity of substitution.

• Firm’s output includes final and intermediate demand:

\[ Y_i = g_i + z_i \]
\[ = g_i + \int_j z_{ji} \, dj. \]
Firm’s Problem (1/3)

- Firm’s marginal cost depends on technology and input price:

\[ C_i = \frac{1}{\mu^\mu (1 - \mu)^{1 - \mu}} \frac{P_V^{1 - \mu} P_X^{\mu}}{A_i}, \]

where \( P_V = \alpha^{-\alpha} (1 - \alpha)^{-(1 - \alpha)} r^\alpha w^{1 - \alpha} \)

- All price indices dual to CES: \( P_G, P_X, P_Z, \) and \( P_{M_i} \)

- All imported varieties have same cost, \( p_m, \) so:

\[ P_{M_i} = \frac{p_m}{b} |\Omega_i|^{\frac{\theta - 1}{\theta}} \]
Firm’s Problem (2/3)

- Total demand for good $Y_i$ is then:

$$Y_i = \left( \frac{p_i}{P_G} \right)^{\frac{1}{\theta-1}} G + \int_j \left( \frac{p_i}{P_{X_j}} \right)^{\frac{1}{\theta-1}} X_j \, dj,$$

- Firm $i$’s operating profits are then:

$$\pi_i = \frac{1 - \theta}{\theta} C_i Y_i$$
Firm’s Problem (3/3)

- Importers pay entry and per-variety (convex) fixed cost:

\[ F(\Omega_i) = f|\Omega_i|^\lambda \]

where \( f, \lambda > 0 \).

- Hence, firm \( i \) chooses:

\[ \Omega_i = \arg \max_{\Omega_i} \{ \Pi_i - wF(|\Omega_i|) \}, \]

- \( \Omega_i \) is increasing in \( A_i \) as long as \( \lambda \) is sufficiently high. SOC

\[ \frac{\rho(1-\theta)}{\theta(1-\rho)} - \lambda + \left( \frac{\rho}{1-\rho} - \frac{\mu \theta}{1-\theta} \right) \frac{(\theta-1)}{\theta} \left( P_{M_i}/P_X \right)^{\frac{\rho}{\rho-1}} < 0 \]
Numerical Simulation

• Partial Equilibrium

• Consumers Demand: Buy manufacturing final good $G$ and $C_n$:

\[ C = \left[ \omega G^n + (1 - \omega) C_N^n \right]^{1/\eta}, \]

where $C$ and $P_N$ are fixed exogenously

• We consider increase in $p_m$

• Equilibrium is \( \{p_i, \Omega_i\} \) given price indices, demand, etc.
Algorithm

- Firms take $P^1_Z$ ($= P^1_G$) as given
- Iterate the system:
  \[
  p^1_i = \frac{1}{A_i} \frac{P^1 - \mu}{V} \mu \frac{P^1 - \mu}{(1 - \mu)^1 - \mu} \left[ (P^1_Z)^{\theta - 1} + \left( \frac{p_m}{b} |\Omega^1_i| \right) \frac{\rho}{\rho - 1} \right] \]

\[
  P^1_Z = \left( \int_i \left( p^1_i \right)^{\frac{\theta}{\theta - 1}} \mathrm{d}i \right)^{\frac{\theta - 1}{\theta}},
\]

for all $i$ until $\{ p^1_i \}$ consistent with $P^1_Z$ and $\{ \Omega^1_i \}$.

- Generates $\{ p^2_i, \Omega^2_i \}$ and $\{ P^2_Z, P^2_G \}$
- Repeat until $\{ p^j_i, \Omega^j_i \} = \{ p^{j-1}_i, \Omega^{j-1}_i \}$
# Calibration Parameters

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<tr>
<th>θ</th>
<th>ρ</th>
<th>b</th>
<th>μ</th>
<th>α</th>
<th>λ</th>
<th>f</th>
<th>η</th>
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<td>0.75</td>
<td>0.75</td>
<td>1</td>
<td>2/3</td>
<td>1/3</td>
<td>2</td>
<td>0.0075</td>
<td>0.8</td>
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<th>w</th>
<th>r</th>
<th>C</th>
<th>$P_N$</th>
<th>$ω$</th>
<th>$p_{m}^{pre}$</th>
<th>$\hat{p}_m$</th>
<th>$γ^{pre}$</th>
<th>$γ^{post}$</th>
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<td>50</td>
<td>50</td>
<td>$1 \times 10^8$</td>
<td>1</td>
<td>0.2</td>
<td>1.74</td>
<td>1.155</td>
<td>0.83</td>
<td>0.89</td>
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</tbody>
</table>

## Share of Total Imports

![Share of Total Imports Graph](image)

- **Import CDF from Data (solid)**
- **Import CDF from Simulation (dashed)**
Baseline Simulation Results

• Empirical Finding 1: Matched by assumption

• Empirical Finding 2:
  • Data: Sub-extensive and sub-intensive account for 45 for 44%
  • Model: Sub-extensive and sub-intensive account for 47 and 53%

• Empirical Finding 4:
  • Data: Trade-weighted impact of dropped varieties on marginal cost ranged from 6-13%
  • Model: Equals 8.8%
Baseline Simulation Results

- We generate earlier patterns seen with size (Finding 3)
- This is a function of parameters: $\frac{\rho}{1 - \rho} > \frac{\mu \theta}{1 - \theta}$

![Graph showing the relationship between log initial import spending and percent change in import spending. The graph is a scatter plot with a trend line. The x-axis represents log initial import spending, ranging from 2 to 14. The y-axis represents percent change in import spending, ranging from -0.60 to -0.40.]
Baseline Simulation Results

- We generate earlier patterns seen with size (Finding 3)
- This is a function of parameters: \( \frac{\rho}{1 - \rho} > \frac{\mu \theta}{1 - \theta} \)
What Does All this Mean for Productivity and Welfare?

- Follow Basu and Fernald (2002), Basu et al. (2011) and Sandleris and Wright (2011) who derive in response to a one-time unanticipated fully transitory shock.

- We ignore changes in interest rates and asset prices and therefore arrive at this formula in our environment:

\[
\Delta \ln W_t \approx \left( \Delta \ln Y_t^{VA} - s_L \Delta \ln L_t - s_K \Delta \ln K_t \right) - s_M \Delta \ln P_t^M \\
\approx \Delta \ln PR - s_M \Delta \ln P_M
\]

- \( s_L \) and \( s_K \) are shares in value added and need not sum to one
What Does All this Mean for Productivity and Welfare?

- All firms face same input prices, therefore:
\[
\Delta \ln PR = \sum_i \omega_i \Delta \ln PR_i
\]
where \(\omega_i\) is \(i\)'s share in value added.

- Applying Basu/Fernald to our model, we get:
\[
\Delta \ln PR_i = \frac{(1 - \theta)}{\theta (1 - \mu)} \left[ \Delta \ln V_i + \frac{\mu \theta}{1 - \mu \theta} (\Delta \ln X_i - \Delta \ln Y_i) \right]
- \frac{(1 - \mu \theta)}{\theta (1 - \mu)} s_{L_i} (1 - \omega_{L_{p,i}}) \Delta \ln L_{f,i} + \Delta \ln A_i / (1 - \mu)
\]
and
\[
\Delta \ln V_i \equiv s_{K_i} \Delta \ln K_i + s_{L_i} \Delta \ln L_i
\]

- Consider relationship with:
  - Arkolakis, Costinot, and Rodrigues Clare (2011)
What Does All this Mean for Productivity and Welfare?

• Define $\gamma_i$ as firm $i$’s input spending on domestic goods and aggregating across firms in our model:

$$\Delta \ln PR = \frac{\mu}{1 - \mu} \frac{1 - \theta}{\theta \mu} \Delta \ln V$$

$$+ \frac{\mu}{1 - \mu} \left[ \left( \frac{1 - \theta}{1 - \mu \theta} - \frac{1 - \gamma}{1 - \mu} \right) \frac{\theta - 1}{\theta} \sum_i \omega_i \Delta \ln \omega_i \right]$$

$$+ \frac{\mu}{1 - \mu} \left[ \frac{1 - \rho}{\rho} \left( \frac{\theta (1 - \mu)}{1 - \mu \theta} + \frac{\mu (1 - \gamma)}{1 - \mu} \right) \sum_i \omega_i \Delta \ln \gamma_i \right]$$

$$- \frac{\mu}{1 - \mu} (1 - \gamma) \Delta \ln p_m$$

• Compare to case with no fixed costs and no heterogeneity:

$$\Delta \ln PR = \frac{\mu}{1 - \mu} \left( \frac{1 - \theta}{\theta \mu} \Delta \ln V - \frac{1 - \rho}{\rho} \frac{1 - \theta}{1 - \mu \theta} \Delta \ln \gamma \right)$$
## Productivity Results

<table>
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<th>Scenario</th>
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<th>$\Delta \ln \tilde{PR}$</th>
<th>$\Delta \ln W$</th>
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<td>(1) Benchmark</td>
<td>-0.051</td>
<td>-0.062</td>
<td>-0.086</td>
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<tr>
<td>(2) No Fixed Costs, Same $\Delta \ln p_m$</td>
<td>-0.041</td>
<td>-0.041</td>
<td>-0.065</td>
</tr>
<tr>
<td>(3) No Fixed Costs, Same $\Delta \ln \gamma$</td>
<td>-0.058</td>
<td>-0.058</td>
<td>-0.095</td>
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</table>

- **Standard Solow Residual:** -0.030
## Alternative Simulation Results

<table>
<thead>
<tr>
<th>Case Description</th>
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<th>$\Delta \ln \tilde{PR}$</th>
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<td>Benchmark</td>
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<td>Adjusting For Inventories</td>
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<td>-0.034</td>
<td>-0.037</td>
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<tr>
<td>No Capital Goods</td>
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<td>-0.048</td>
<td>-0.052</td>
</tr>
<tr>
<td>No Round-About Production, Same $\Delta \ln p_m$</td>
<td>-0.024</td>
<td>-0.037</td>
<td>-0.050</td>
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<tr>
<td>$\rho = 0.50$</td>
<td>-0.151</td>
<td>-0.163</td>
<td>-0.223</td>
</tr>
<tr>
<td>$\theta = 0.90$</td>
<td>-0.032</td>
<td>-0.034</td>
<td>-0.062</td>
</tr>
<tr>
<td>$\rho = 0.50, \theta = 0.90$</td>
<td>-0.142</td>
<td>-0.145</td>
<td>-0.198</td>
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</table>
The Decline and Recovery in Argentina

- TFP (ARKLEMS)
- TFP (ARKLEMS, Adjusted)
- Input Variety Effect
- Imported Input Share (1-g, Right Axis)
Conclusion

• Large crises associated with declines in intermediate input imports and measured TFP

• Empirical characterization of trade adjustment

• Measured TFP impact can be sizeable (25 – 40%)

• No one shock can explain all of the TFP decline. Input trade channel can be an important factor.