Trade Adjustment and Productivity in Large Crises

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November, 2012

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

1. *Terms of Trade and Productivity*: Mendoza and Yue (2009), Kehoe and Ruhl (2008), Arkolakis, Costinot, and Rodriquez-Clare (2011), Feenstra, Mandel, Reinsdorf, and Slaughter (2009), Burstein and Cravino (2010)

2. *Imported Intermediate Inputs & Productivity*: Halpern, Koren and Szeidl (2009), Broda, Greenfield, and Weinstein (2006), Amiti and Konings (2007), Goldberg, Khandelwal, Pauvcnik, and Topalova (2009)

3. *Trade and Gains from Varieties*: Feenstra (1994), Broda and Weinstein (2006), Arkolakis et al. (2008)

4. *Misallocation, Intermediate Multiplier*: Hsieh and Klenow (2009), Jones (2010), Sandleris and Wright (2010)

Road Map

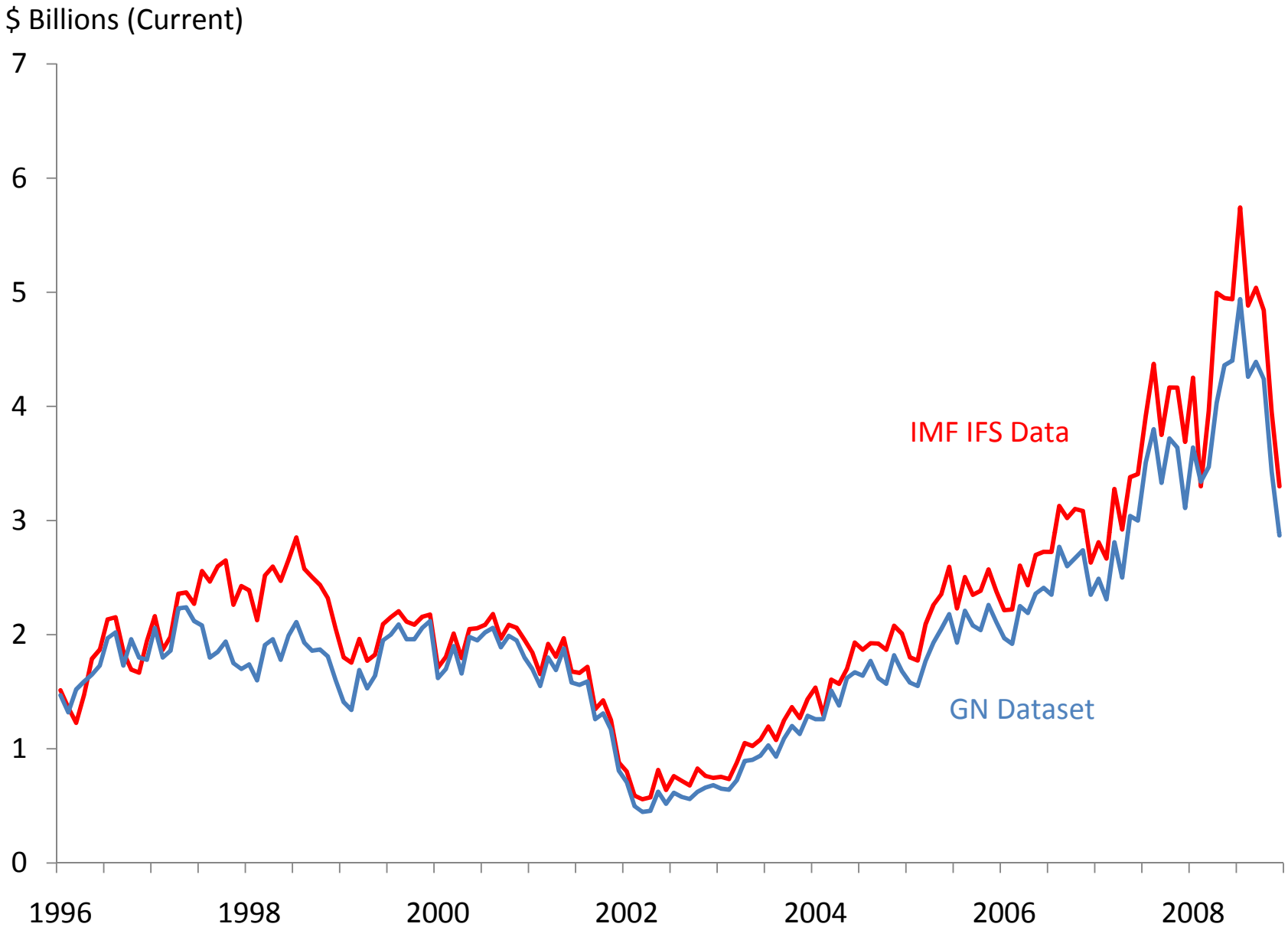
- Data Description
- Empirics: Firms Adjusted Imports Differently to Shock
- Simple Theory Replicates Empirical Features and Generates Decline in Productivity
- Simulation: These Channels Can Be Important Quantitatively

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

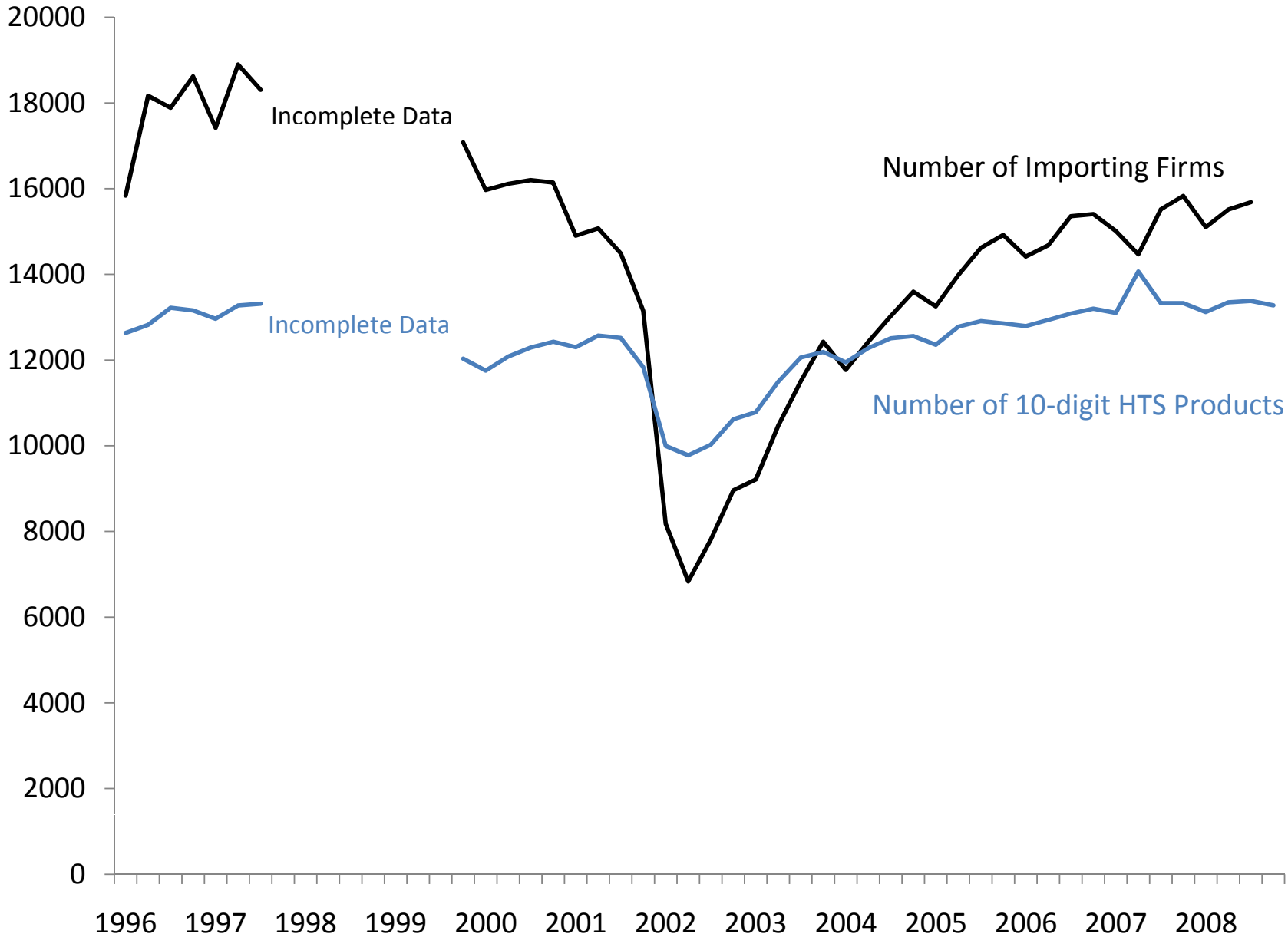
Argentina Constructed Multilateral Import Series



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 (Unweighted)



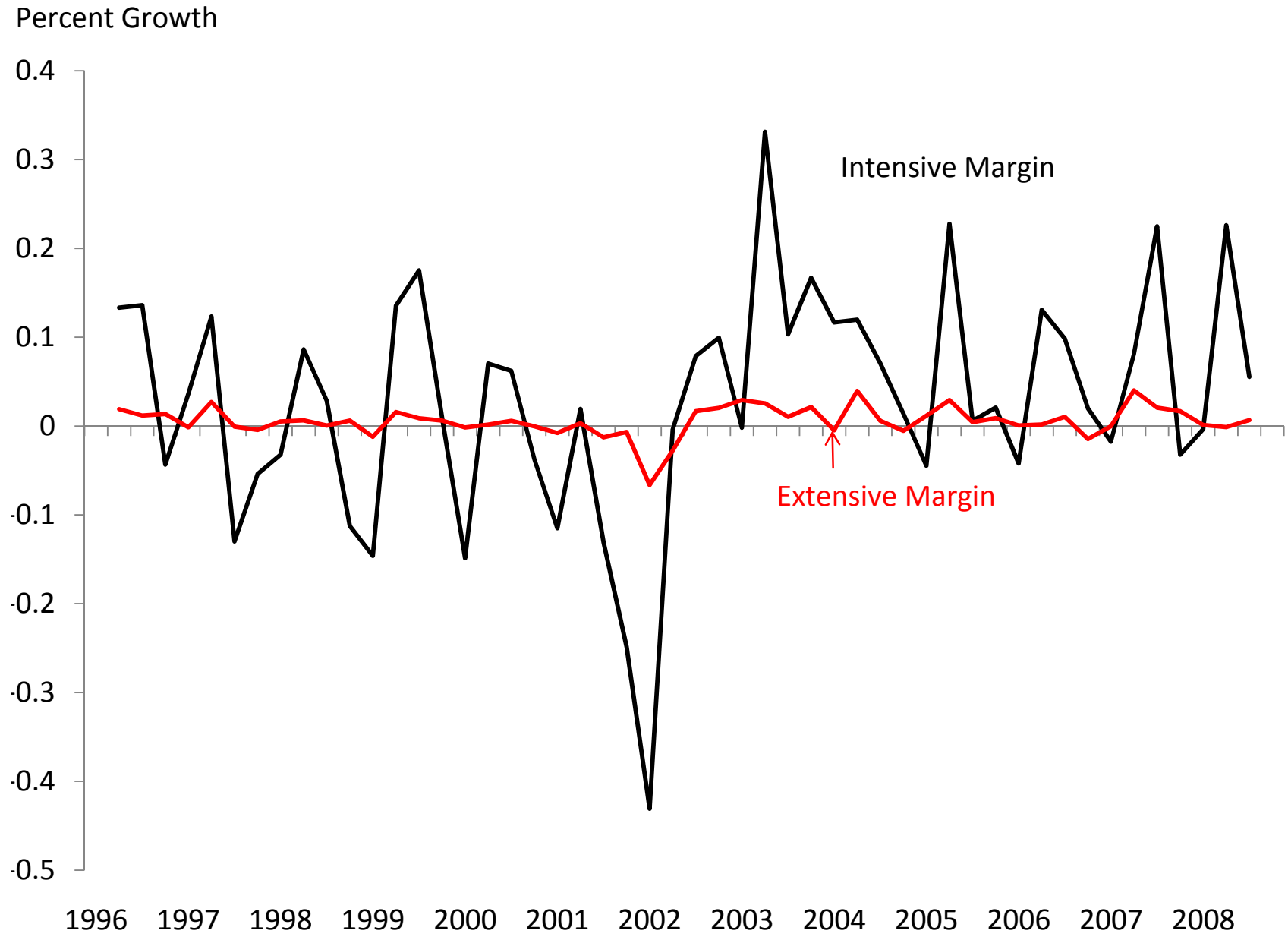
Extensive Margin (Weighted)

$$\frac{\Delta v_t}{v_{t-1}} = \underbrace{\left(\sum_{i \in \Psi_{t-1} \cap \Psi_t} \frac{v_{i,t} - v_{i,t-1}}{v_{t-1}} \right)}_{\text{Intensive Margin}} + \underbrace{\left(\sum_{i \in \Psi_t, i \notin \Psi_{t-1}} \frac{v_{i,t}}{v_{t-1}} - \sum_{i \in \Psi_{t-1}, i \notin \Psi_t} \frac{v_{i,t-1}}{v_{t-1}} \right)}_{\text{Extensive Margin}},$$

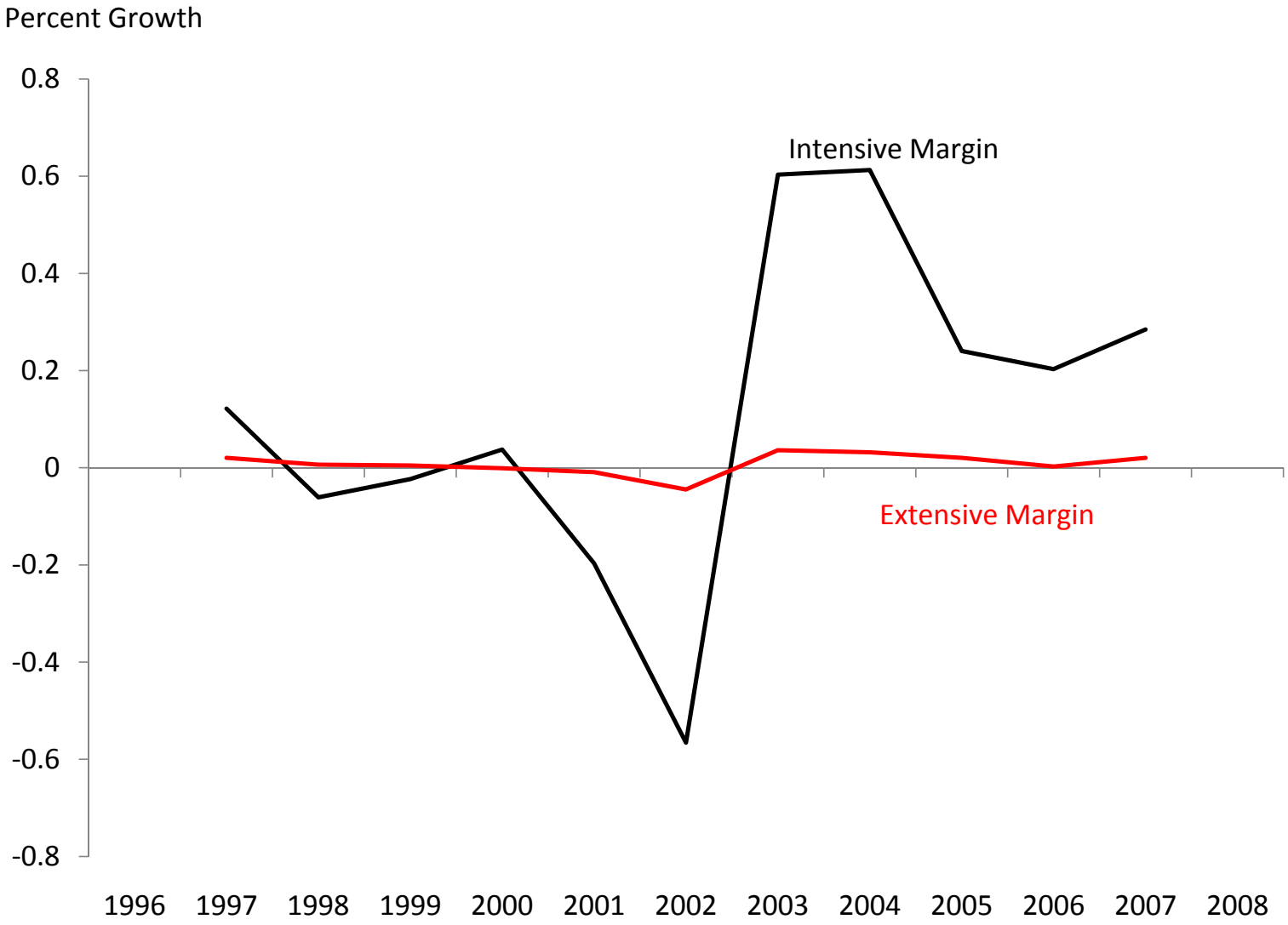
where

$$\begin{aligned} v_t &= \text{Total FOB at period } t \\ v_{i,t} &= \text{Total FOB for CUIT/HTS } i \text{ at month } t \\ \Psi_t &= \text{Set of CUIT/HTS } i \text{ with } v_{i,t} > 0. \end{aligned}$$

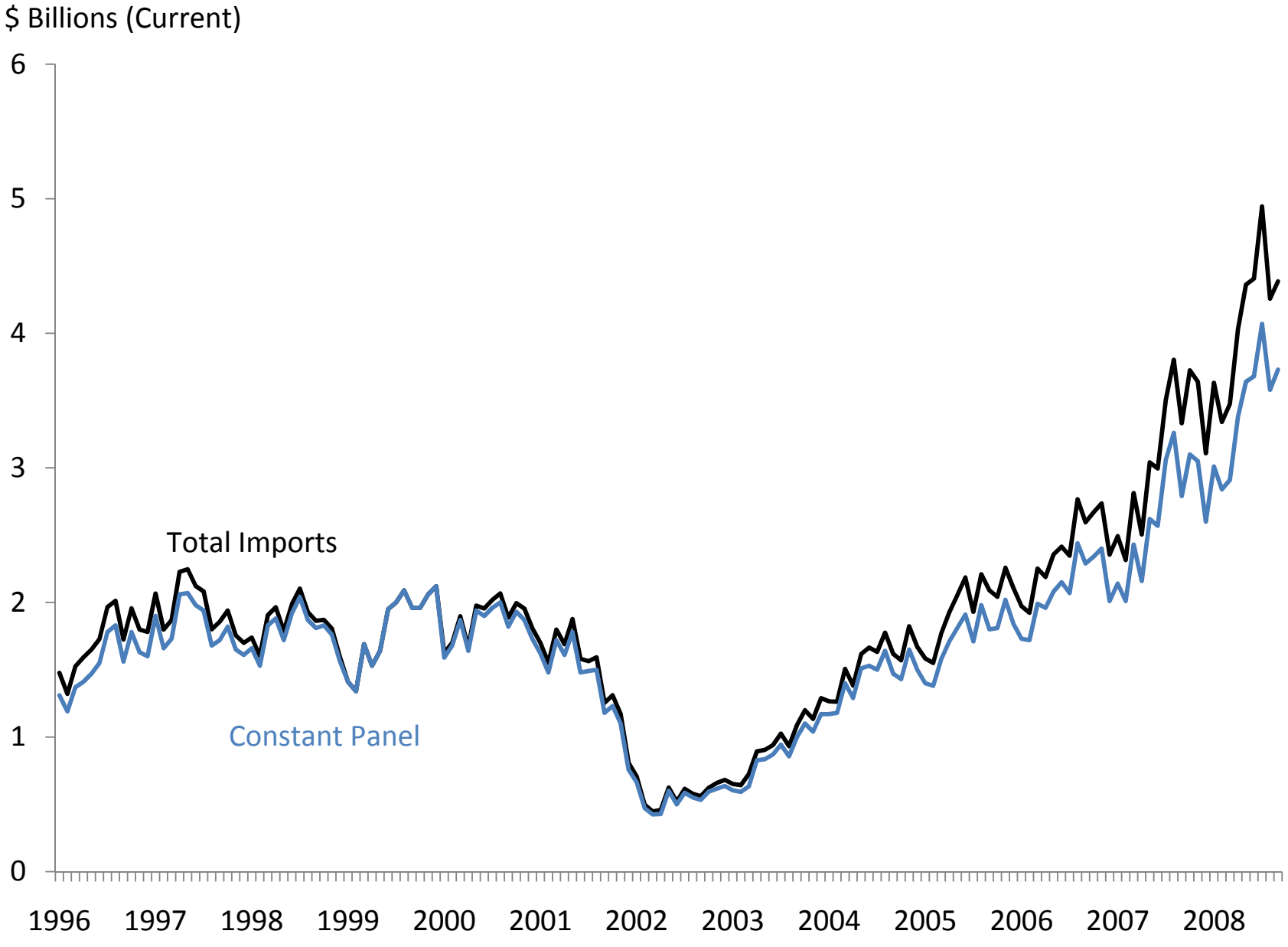
Firm Intensive/Extensive Margin (Quarterly)



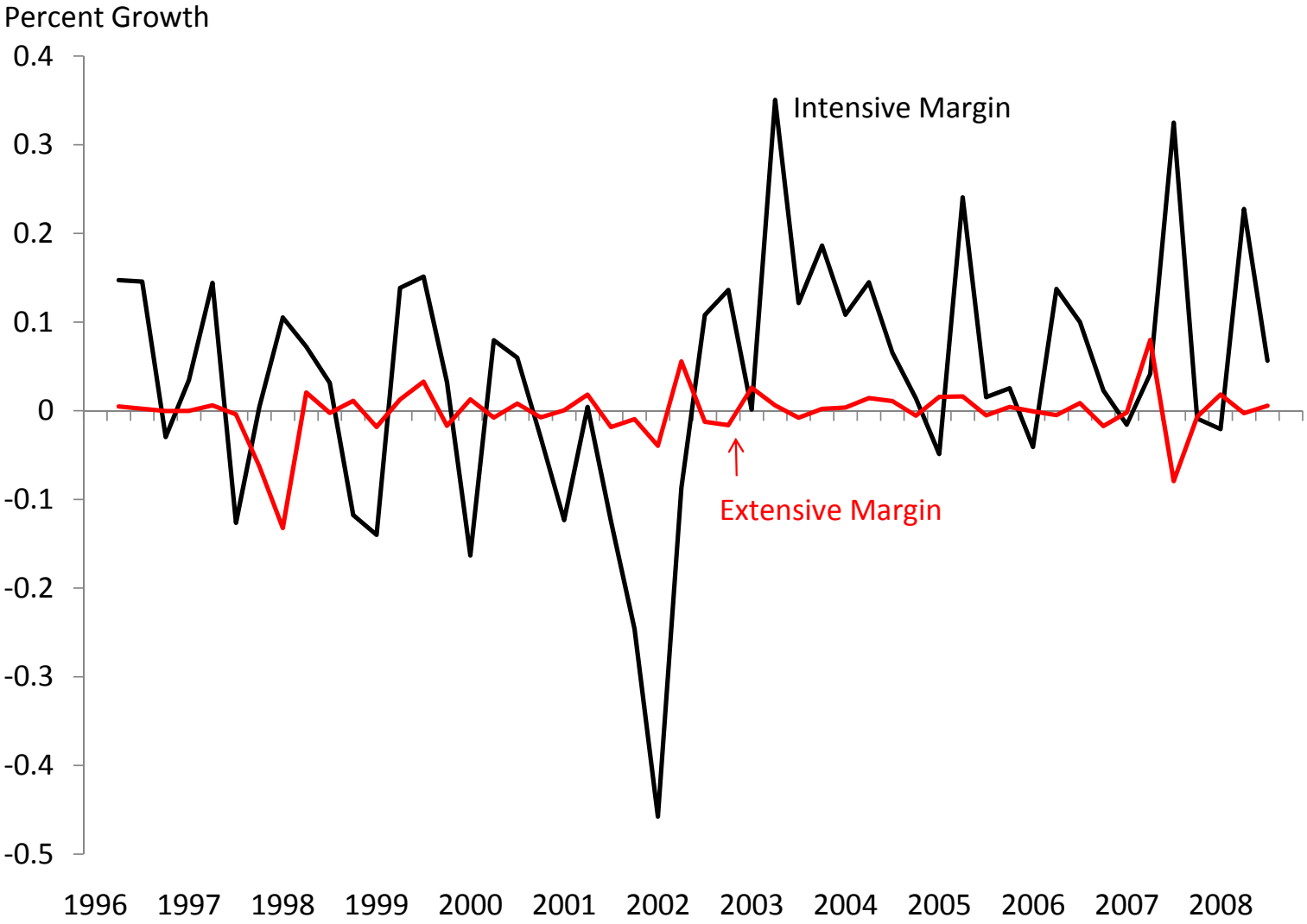
Firm Intensive/Extensive Margin (Annual)



Constant Panel of Importers (Benchmarked in 1999)

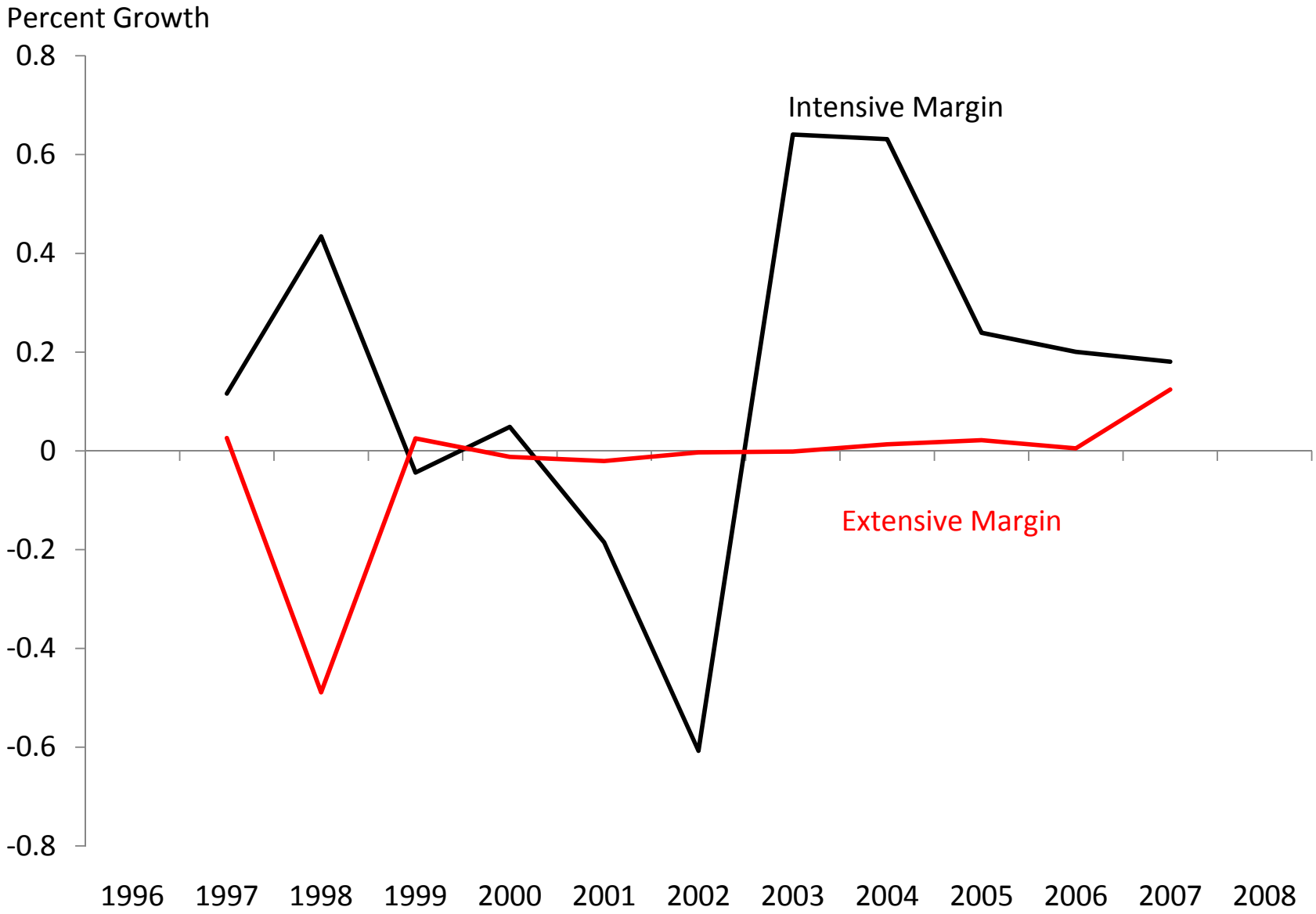


Product (HTS 10) Intensive/Extensive Margin (Quarterly)



- HTS revisions in 1997, May 2002, May 2007
- Pierce and Schott (2009) for U.S., 6 digit

Product (HTS 10) Intensive/Extensive Margin (Annual)



Conventional Extensive Margin Not Important

	Total	% Intensive	% Extensive
Firm	-69%	0.89	0.11
HTS 6	-69%	1.00	0.00
HTS 10	-69%	0.92	0.08
HTS 6 X Cty	-69%	0.91	0.09
HTS 10 X Cty	-69%	0.79	0.21

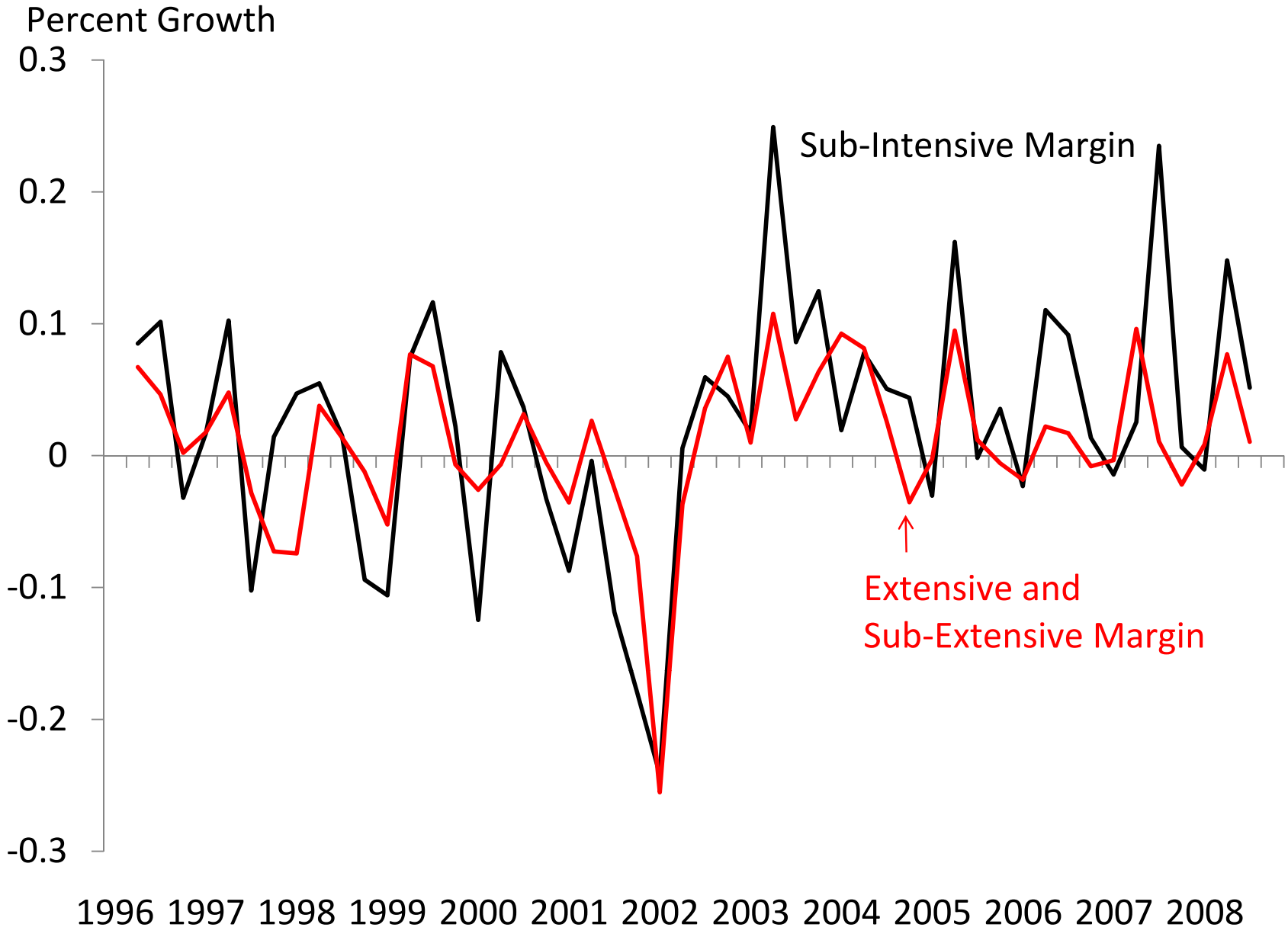
Table: Intensive and Extensive Margins, 2000-2002

- 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



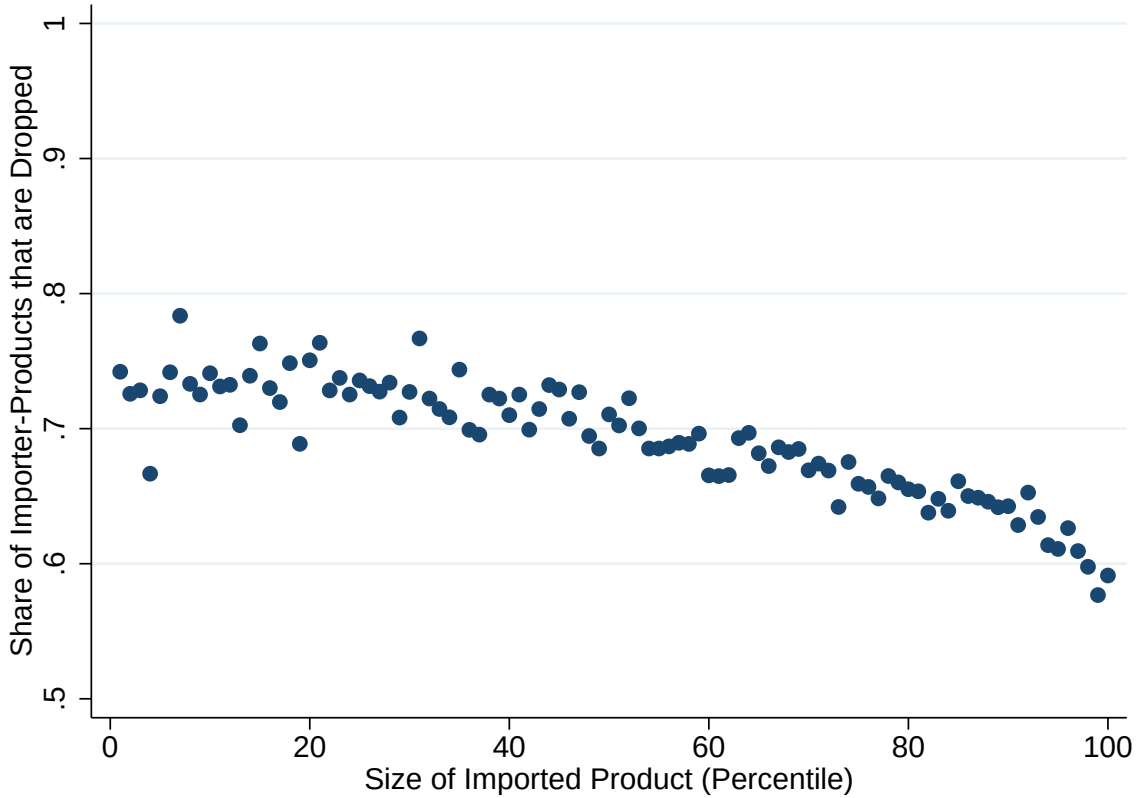
Sub-Extensive Margin (Plus Extensive) is Important

	Total	% Sub-Intensive	% Sub-Extensive	% Extensive
HTS 6	-69%	0.71	0.18	0.11
HTS 10	-69%	0.56	0.33	0.11
HTS 6 X Cty	-69%	0.54	0.35	0.11
HTS 10 X Cty	-69%	0.44	0.45	0.11

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

How is Sub-Extensive Big if Extensive is Small?

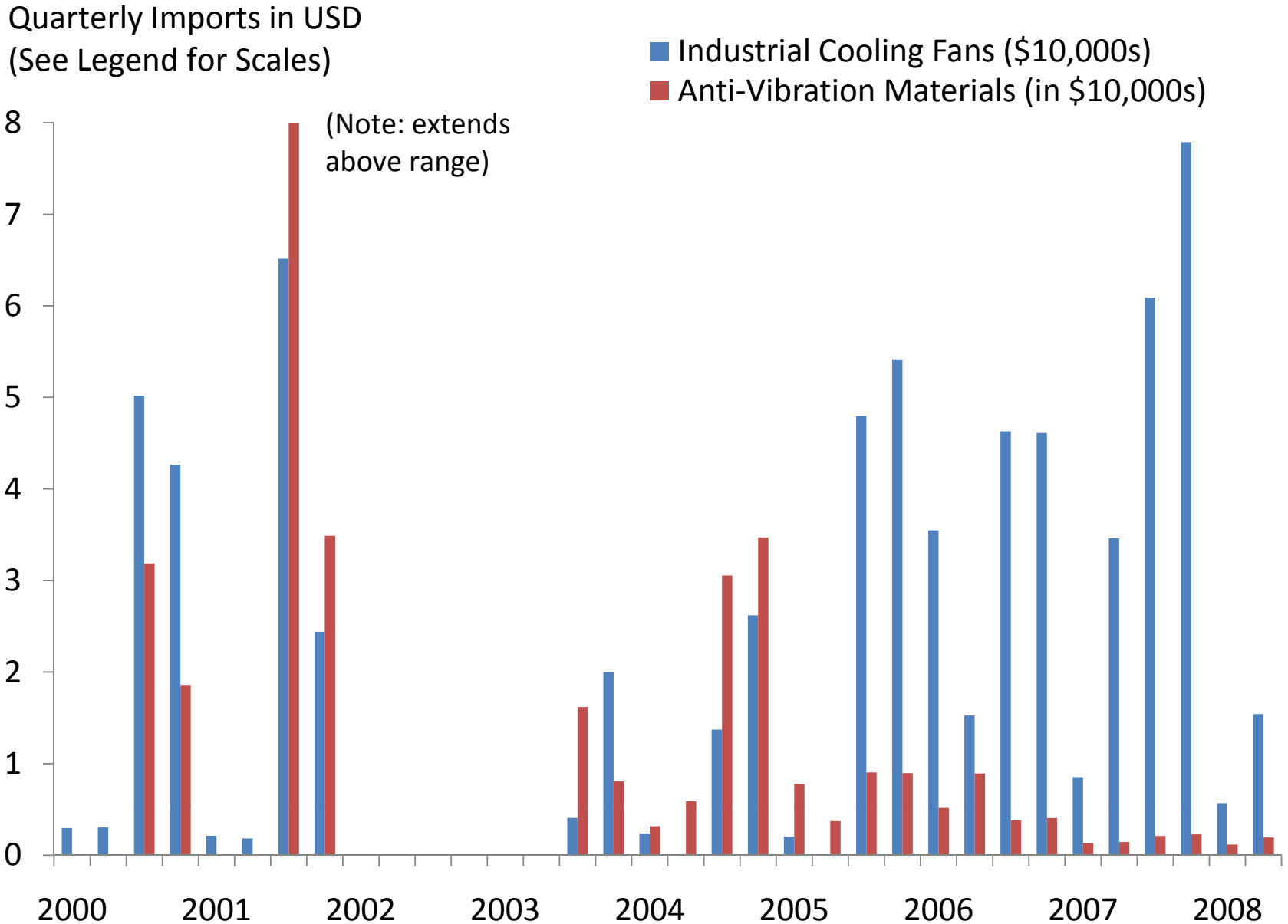
1. Firms drop a product that other firms continue to import



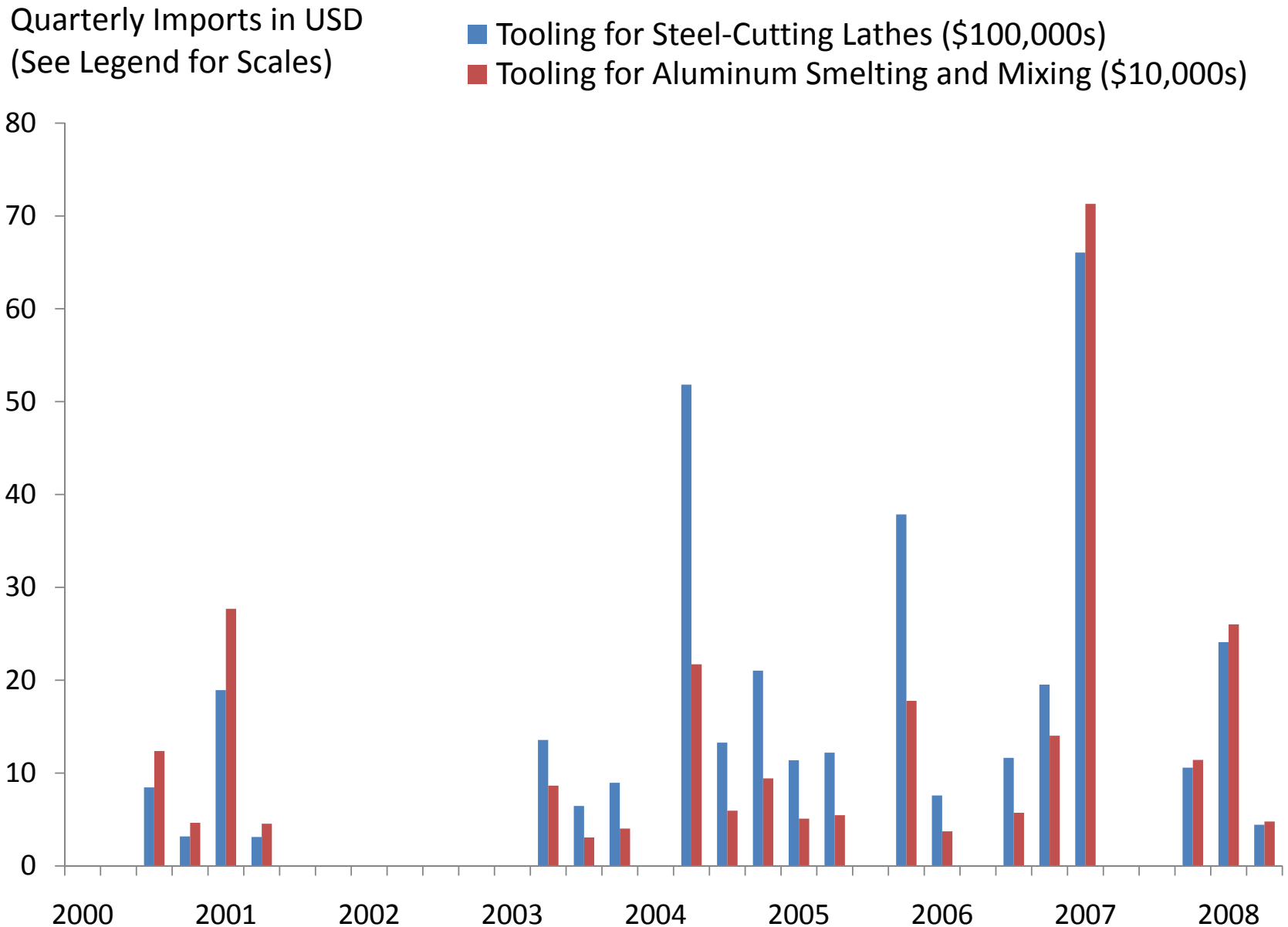
2. Firms drop some imported products but not others

Products in the 25th/50th/75th percentiles had initial import values of $30,000/$165,000/$800,000.

BGH, Argentine Manufacturer (#25 Importer)



Siderca, Argentine Building Products Firm (#22 Importer)



Third Empirical Result

1. Extensive margin at **country level is not** important (≈10%)
2. **Within-firm** (sub-) extensive margin is important (≈40%)
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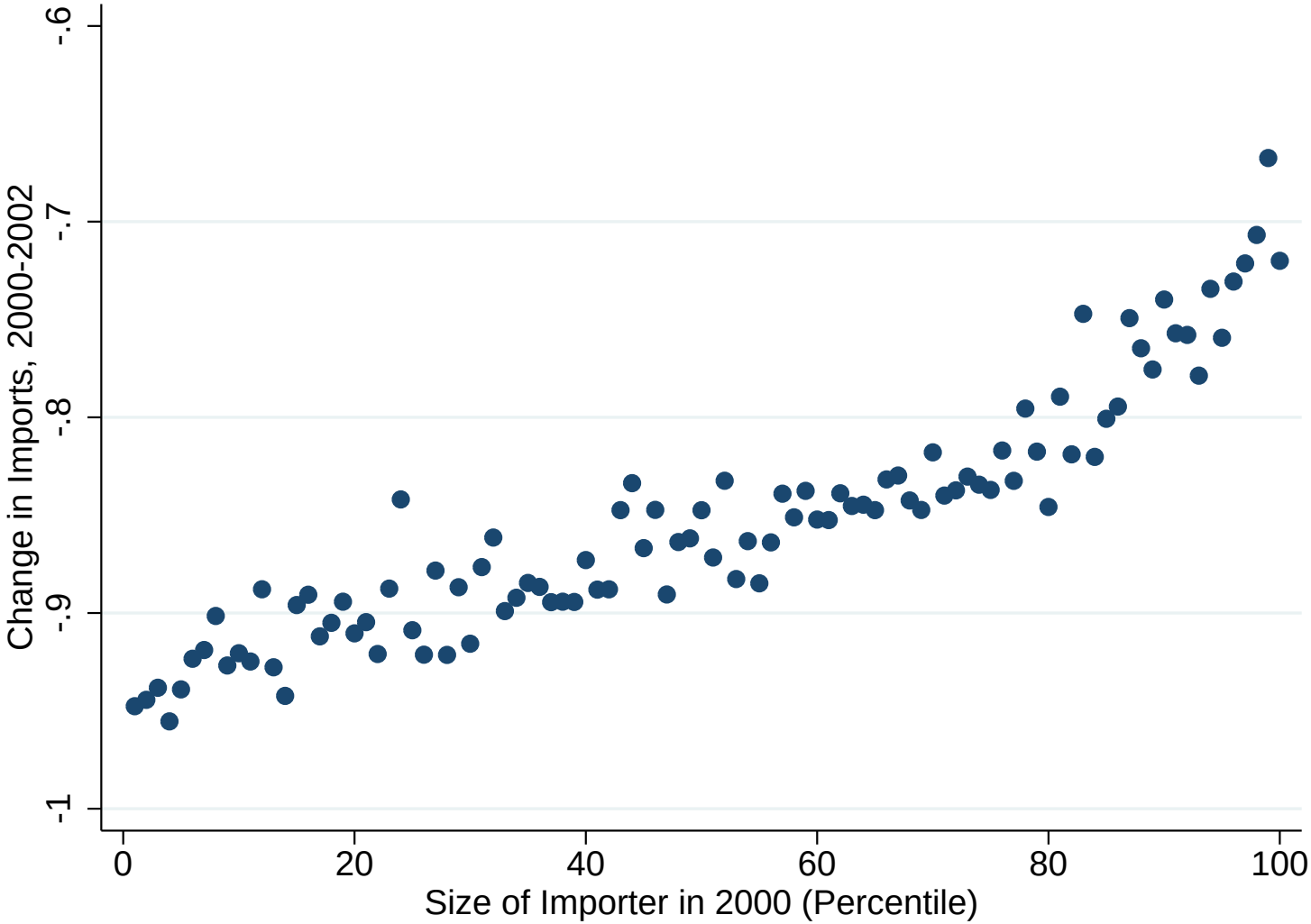
Importer Size and Trade Adjustment

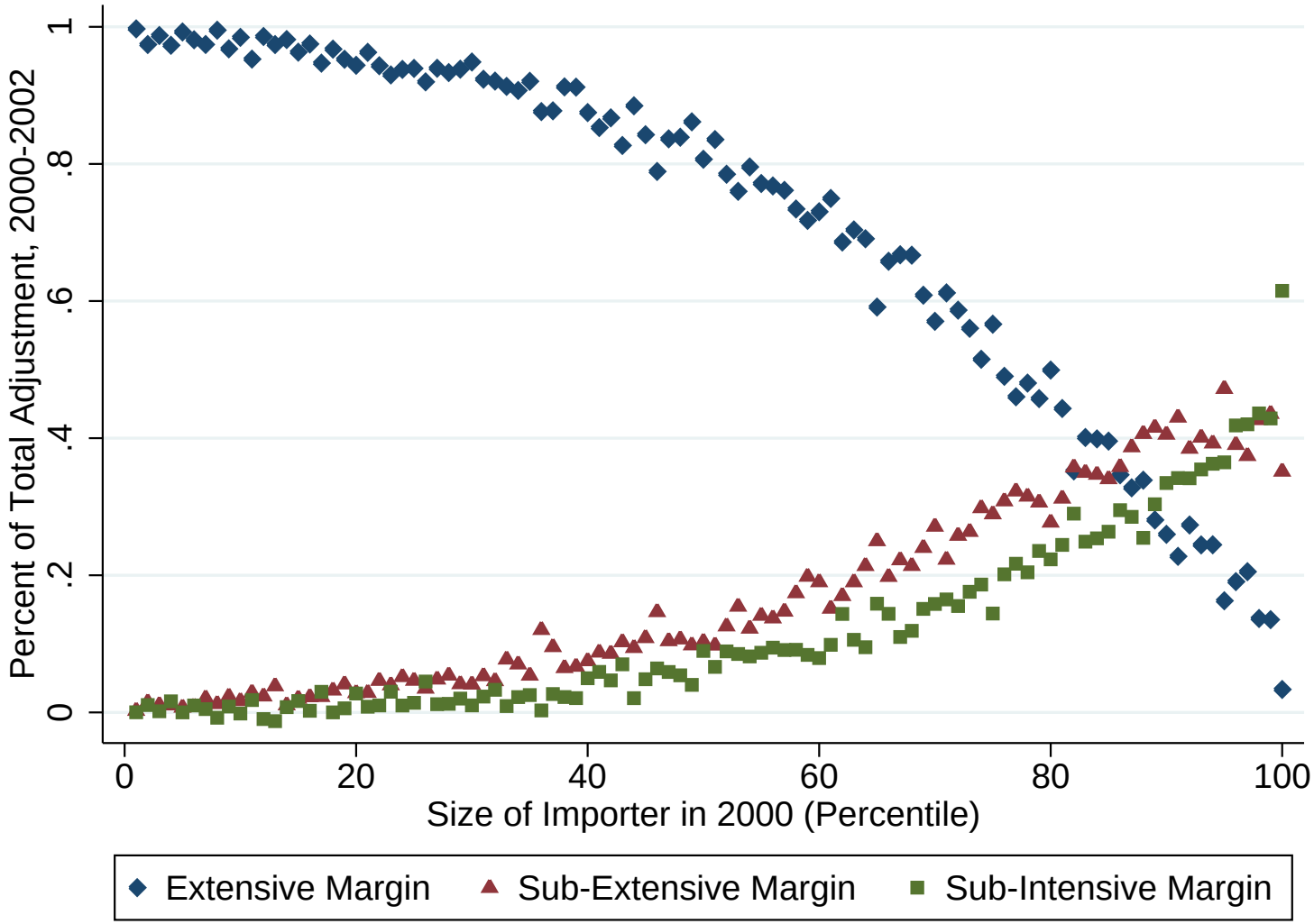


- Holds in regression with 10 sector and MNC dummies

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



Fourth 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

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):

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

- 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

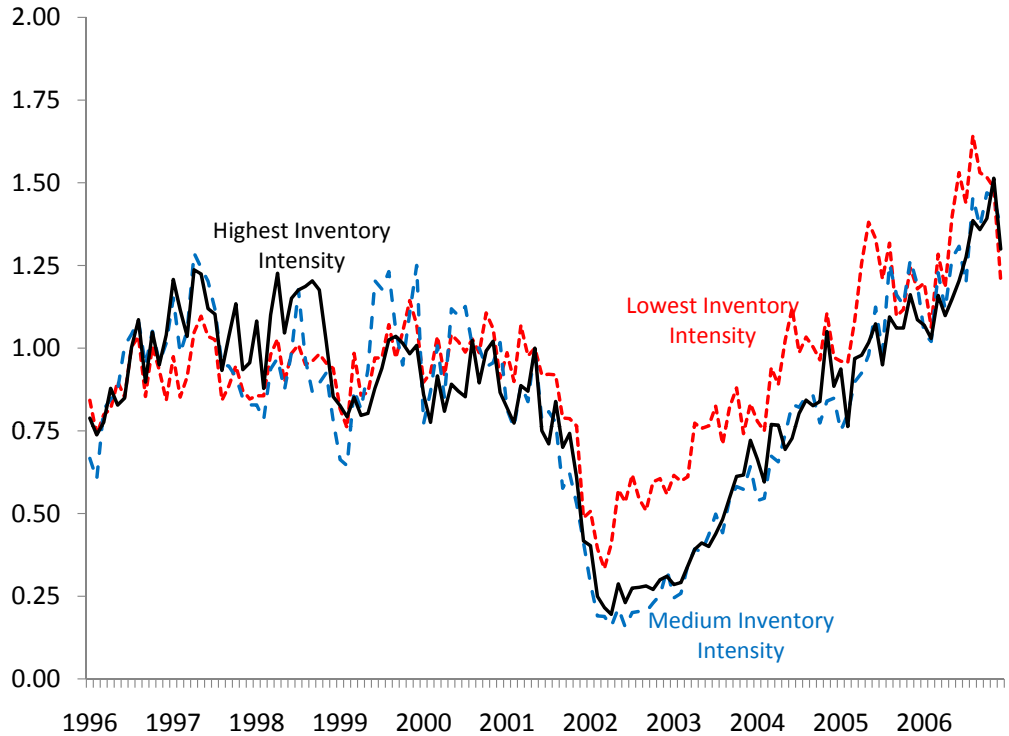
- Measured comparing 2000-2002
- Elasticity equal to 4

$\varepsilon = 0.75$	$\mathbb{F}$	Weighted Average of $\mathbb{F}_i$		
Percentiles Included:	all	all	(5,95)	(20,80)
HTS 6	1.000	1.087	1.046	1.034
HTS 10	0.992	1.110	1.068	1.060
HTS 6 X Country	1.012	1.163	1.099	1.063
HTS 10 X Country	1.004	1.176	1.096	1.097
Simple Average	1.002	1.134	1.077	1.064

Broda & Weinstein (2006), HTS 10-digit X country, mean/median elasticity of 2.9/8.2

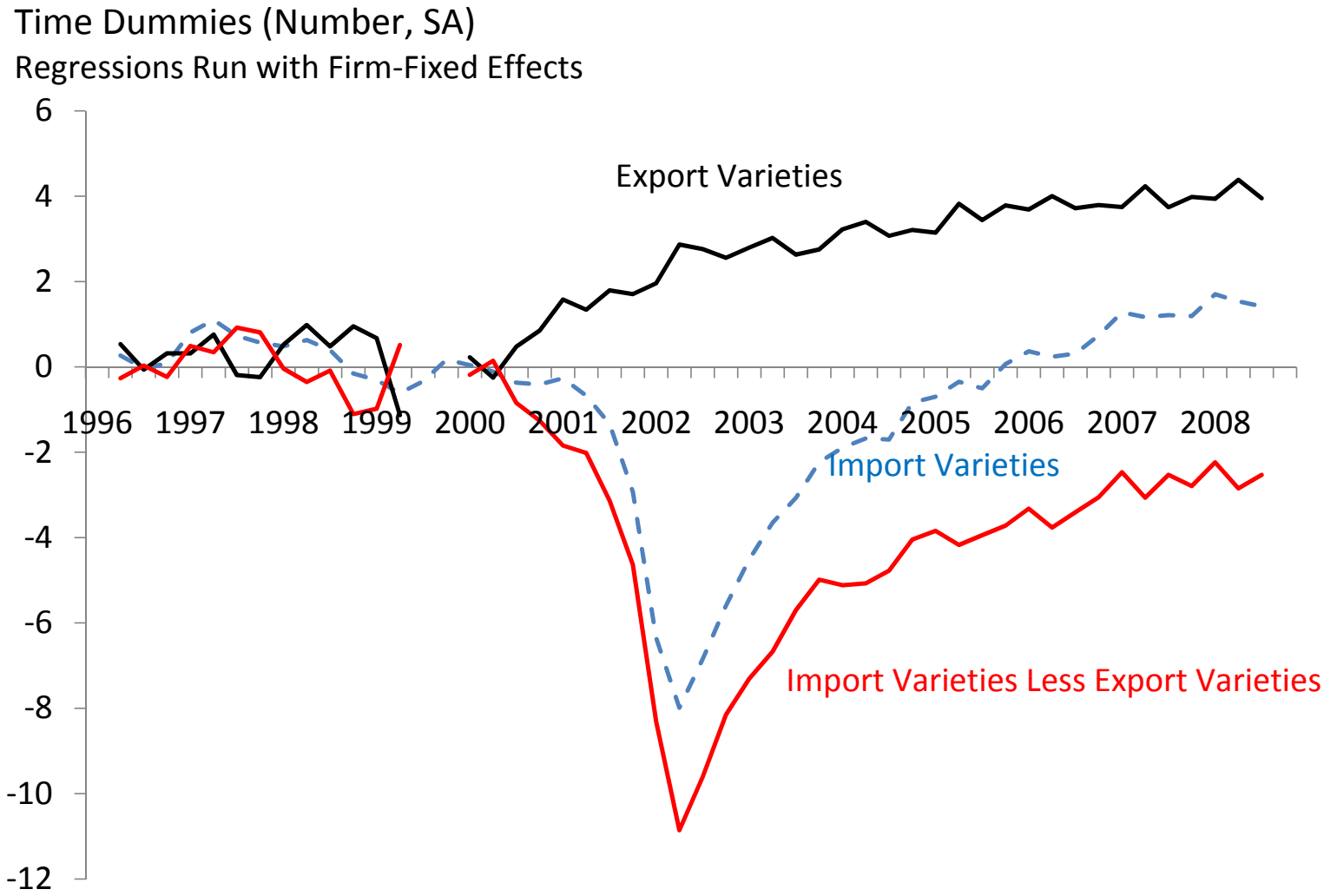
Concern 1: Firms Can Still Use Inputs They Don't Import

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?



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 fixe 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:

$$\begin{aligned} X_i &= \left[Z_i^{\rho} + M_i^{\rho}\right]^{\frac{1}{\rho}} \\ Z_i &= \left[\int_j z_{ij}^{\theta} dj\right]^{\frac{1}{\theta}} \\ M_i &= \left[\int_{k \in \Omega_i} (bm_{ik})^{\theta} \, dk\right]^{\frac{1}{\theta}} \end{aligned}$$

- Ω_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:

$$\begin{aligned} Y_i &= g_i + z_i \\ &= g_i + \int_j z_{ji} dj. \end{aligned}$$

Firm's Problem (1/3)

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

$$C_i = \frac{1}{\mu^{\mu}(1-\mu)^{1-\mu}} \frac{P_V^{1-\mu} P_{X_i}^{\mu}}{A_i},$$

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

$$\begin{aligned} P_{X_i} &= \left[P_Z^{\frac{\rho}{\rho-1}} + P_{M_i}^{\frac{\rho}{\rho-1}} \right]^{\frac{\rho-1}{\rho}} && \text{if firm } i \text{ imports} \\ &= P_Z && \text{if firm } i \text{ does not import.} \end{aligned}$$

- All price indices dual to CES: P_G, P_{X_i}, 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:

$$\Omega_i = \arg\max_{\Omega_i} \left\{ \Pi_i - wF(|\Omega_i|) \right\},$$

- Ω_i is increasing in A_i as long as λ is sufficiently high. SOC $\frac{\rho(1-\theta)}{\theta(1-\rho)} - \lambda + \left(\frac{\rho}{1-\rho} - \frac{\mu\theta}{1-\theta} \right) \frac{(\theta-1)}{\theta} \left(P_{M_i}/P_{X_i} \right)^{\frac{\rho}{\rho-1}} < 0$

Numerical Simulation

- Partial Equilibrium
- Consumers Demand: Buy manufacturing final good G and C_n:

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

  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_Z^1 $(= P_G^1)$ as given
- Iterate the system:

$$p_i^1 = \frac{1}{A_i}\frac{1}{\theta}\frac{P_V^{1-\mu}}{\mu^\mu(1-\mu)^{1-\mu}}\left[\left(P_Z^1\right)^{\frac{\theta-1}{\theta}} + \left(\frac{p_m}{b}\left|\Omega_i^1\right|^{\frac{\theta-1}{\theta}}\right)^{\frac{\rho}{\rho-1}}\right]^{\mu\frac{\rho-1}{\rho}}$$

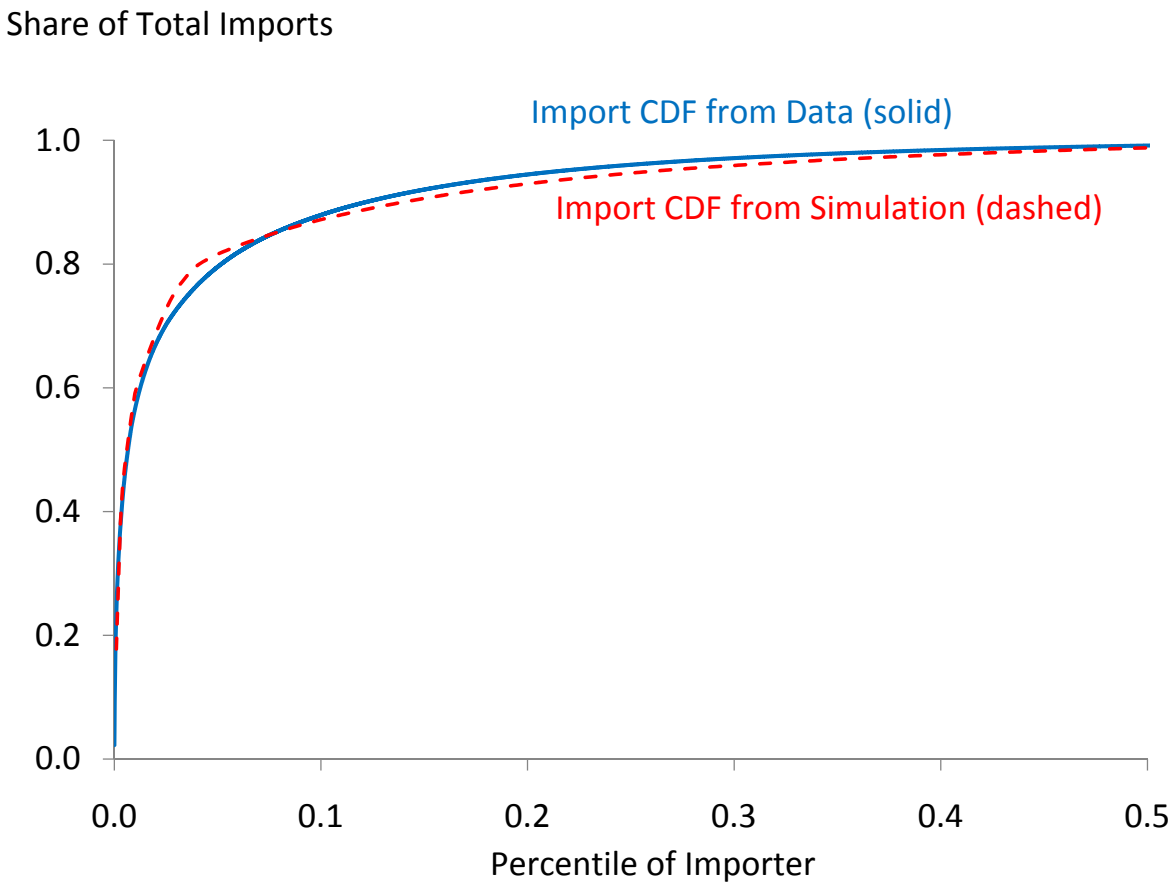
$$P_Z^1 = \left(\int_i \left(p_i^1\right)^{\frac{\theta}{\theta-1}} di\right)^{\frac{\theta-1}{\theta}},$$

  for all i until $\left\{p_i^1\right\}$ consistent with P_Z^1 and $\left\{\Omega_i^1\right\}$.

- Generates $\left\{p_i^2, \Omega_i^2\right\}$ and $\left\{P_Z^2, P_G^2\right\}$
- Repeat until $\left\{p_i^j, \Omega_i^j\right\} = \left\{p_i^{j-1}, \Omega_i^{j-1}\right\}$

Calibration Parameters

θ	ρ	b	μ	α	λ	f	η	
0.75	0.75	1	$2/3$	$1/3$	2	0.0075	0.8	
w	r	C	P_N	ω	p_m^{pre}	$\widehat{p}_m$	γ^{pre}	γ^{post}
50	50	$1x10^8$	1	0.2	1.74	1.155	0.83	0.89

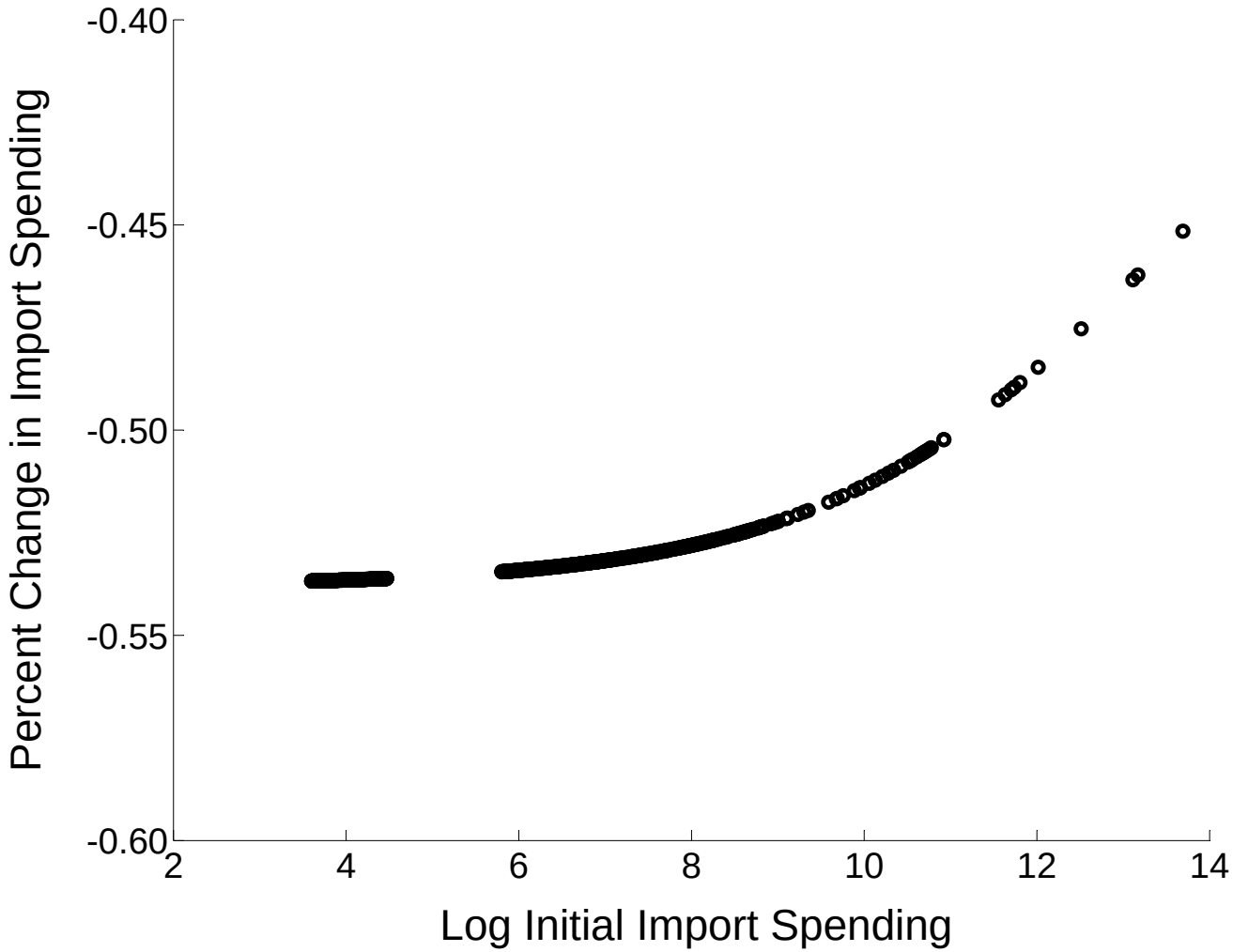


Baseline Simulation Results

- 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 patters seen with size (Finding 3)
- This is function of parameters: $\rho/(1-\rho) > \mu\theta/(1-\theta)$



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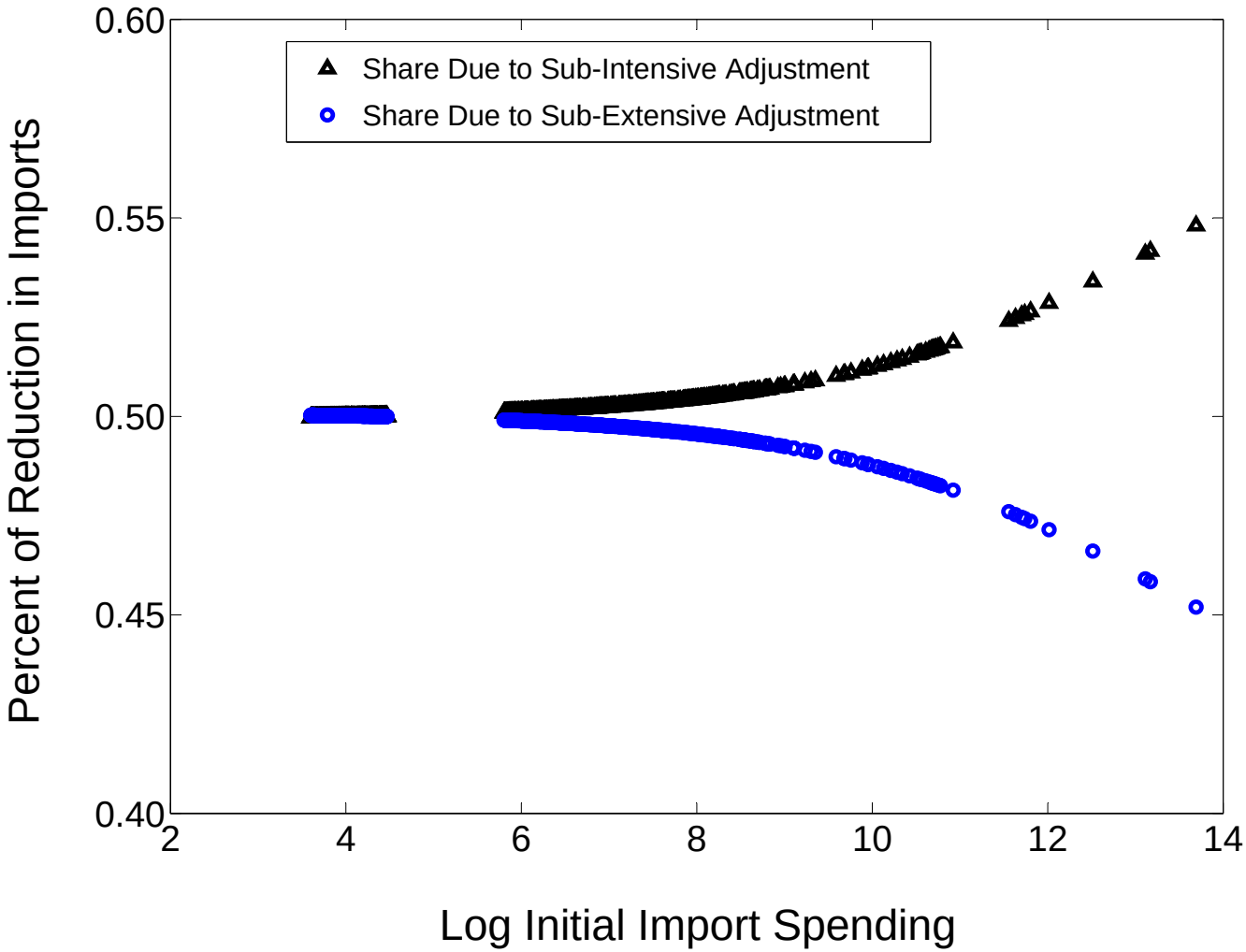


What Does All this Mean for Productivity and Welfare?

- 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:

$$\begin{aligned} \Delta \ln W_t &\approx \left(\Delta \ln Y_t^{VA} - s_L \Delta \ln L_t - s_K \Delta \ln K_t \right) - s_M \Delta \ln P_t^M \\ &\approx \Delta \ln \mathbf{PR} - s_M \Delta \ln P_M \end{aligned}$$

- 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:

$$\Delta \ln \mathbf{PR} = \sum_i \omega_i \Delta \ln \mathbf{PR}_i$$

where ω_i is i's share in value added.

- Applying Basu/Fernald to our model, we get:

$$\begin{aligned}\Delta \ln \mathbf{PR}_i &= \frac{(1-\theta)}{\theta(1-\mu)}\left[\Delta \ln V_i + \frac{\mu\theta}{1-\mu\theta}\left(\Delta \ln X_i - \Delta \ln Y_i\right)\right] \\ &\quad -\frac{(1-\mu\theta)}{\theta\,(1-\mu)} s_{L_i}\left(1-\omega_{L_{p,i}}\right)\Delta \ln L_{f,i} + \Delta \ln A_i/(1-\mu)\end{aligned}$$

and

$$\Delta \ln V_i \equiv s_{K_i}\Delta \ln K_i + s_{L_i}\Delta \ln L_i$$

- Consider relationship with:
  - Kohli (2004) and Kehoe and Ruhl (2008)
  - Arkolakis, Costinot, and Rodrigues Clare (2011)

What Does All this Mean for Productivity and Welfare?

- Define γ_i as firm i's input spending on domestic goods and aggregating across firms in our model:

$$\begin{aligned}\Delta \ln \mathbf{PR} &= \frac{\mu}{1-\mu}\frac{1-\theta}{\theta\mu}\Delta \ln V \\ &+\frac{\mu}{1-\mu}\left[\left(\frac{1-\theta}{1-\mu\theta}-\frac{1-\gamma}{1-\mu}\right)\frac{\theta-1}{\theta}\sum_i \omega_i \Delta \ln \omega_i\right] \\ &+\frac{\mu}{1-\mu}\left[\frac{1-\rho}{\rho}\left(\frac{\theta(1-\mu)}{1-\mu\theta}+\frac{\mu(1-\gamma)}{1-\mu}\right)\sum_i \omega_i \Delta \ln \gamma_i\right] \\ &-\frac{\mu}{1-\mu}(1-\gamma)\Delta \ln p_m\end{aligned}$$

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

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

Productivity Results

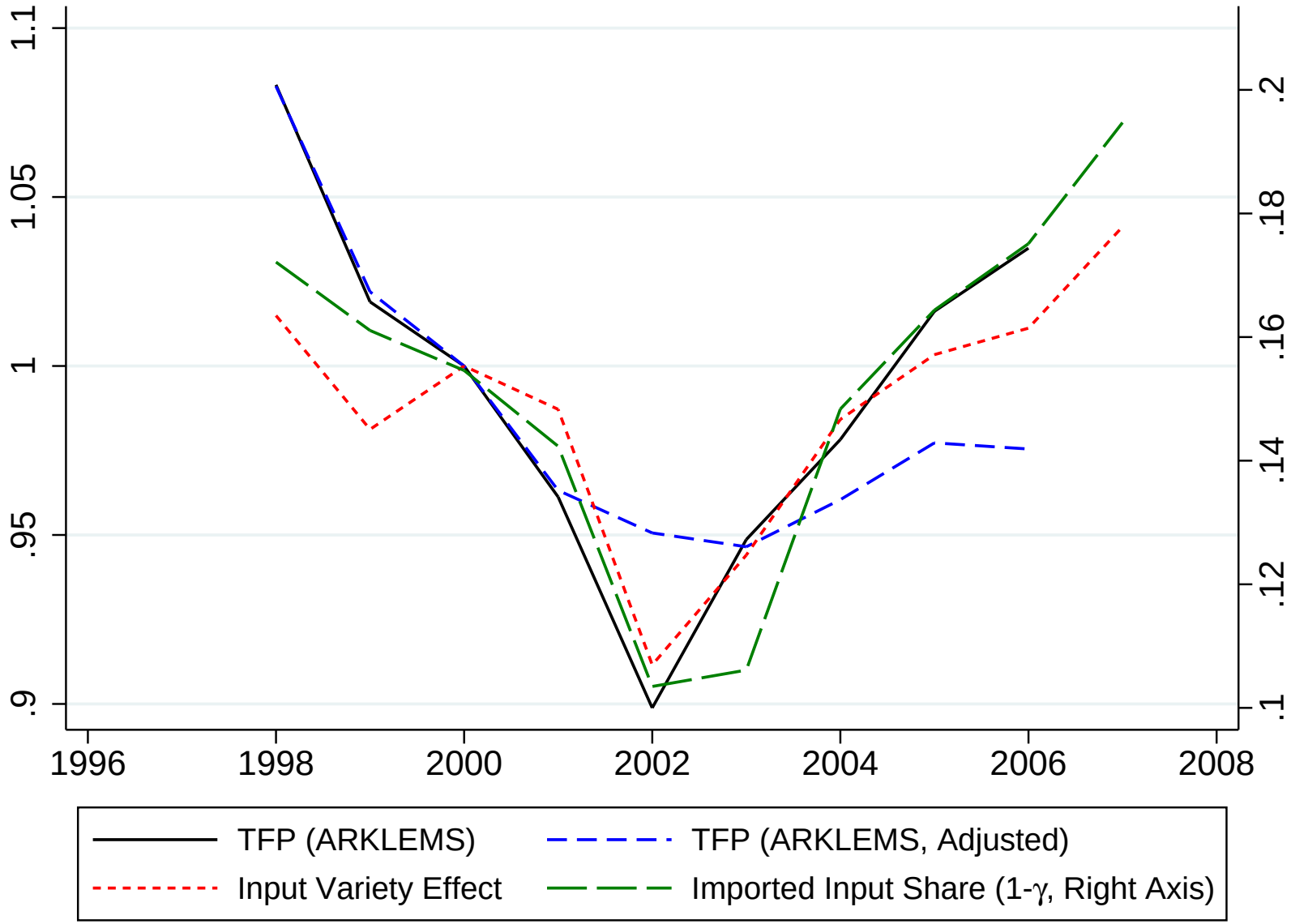
		$\Delta \ln \mathbf{PR}$	$\Delta \ln \widetilde{\mathbf{PR}}$	$\Delta \ln \mathbf{W}$
(1)	Benchmark	-0.051	-0.062	-0.086
(2)	No Fixed Costs, Same $\Delta \ln p_m$	-0.041	-0.041	-0.065
(3)	No Fixed Costs, Same $\Delta \ln \gamma$	-0.058	-0.058	-0.095

- Standard Solow Residual: -0.030

Alternative Simulation Results

		$\Delta \ln \mathbf{PR}$	$\Delta \ln \widetilde{\mathbf{PR}}$	$\Delta \ln \mathbf{W}$
(1)	Benchmark	-0.051	-0.062	-0.086
(4)	Adjusting For Inventories	-0.022	-0.034	-0.037
(5)	No Capital Goods	-0.031	-0.048	-0.052
(6)	No Round-About Production, Same $\Delta \ln p_m$	-0.024	-0.037	-0.050
(8)	$\rho = 0.50$	-0.151	-0.163	-0.223
(9)	$\theta = 0.90$	-0.032	-0.034	-0.062
(10)	$\rho = 0.50$, $\theta = 0.90$	-0.142	-0.145	-0.198

The Decline and Recovery in Argentina



Conclusion

- Large crises associated with declines in intermediate input imports and measured TFP
- Empircal 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.