New Terrain in International Trade

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Society for Economic Dynamics, Warsaw

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Map of the Terrain

- Starting Point: Ricardian Trade:
  - Multiple countries, with Jonathan Eaton (2002)
  - Counterfactuals, with Dekle and Eaton (2007, 2008)
- New Terrain: Intranational Trade and Labor Mobility
- New Terrain: Dynamics and Global Accounting

Navigational Tools

- Focus on two ideas/tools we've found useful:

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  2. Hat algebra to calibrate to data
- These ideas also prove useful navigating new terrain, as I'll show
- As in the world of Lucas (2009), they didn't come out of nowhere:
  1. Modeling idea: antecedent in McFadden and discrete choice models
  2. Calibration idea: antecedent in growth accounting and CGE modeling

Recent Contributions

- Bridging models: Arkolakis, Costinot and Rodríguez-Clare (ACR 2012)
- Estimating the trade elasticity: Simonovska and Waugh (2014)
- Quantitative analyis of NAFTA: Caliendo and Parro (2015)
- Quantitative analysis of trade wars and policy: Ossa (2014)
- Overview, coining "exact hat algebra": Costinot and Rodríguez-Clare (2014)

Simplest Ricardian Setting

- Endowments: L_i, for countries $i = 1, ..., N$
- Preferences: tradables share α, symmetric over $j \in [0, 1]$
- Technology: efficiency $z_i(j)$ (efficiency in services a_i will disappear)
- Labor perfectly mobile across sectors
- Iceberg trade costs (shipping to n from i) $d_{ni} \geq 1$ and $d_{ii} = 1$

I. Modeling Idea

- Summarize efficiencies with Fréchet distribution:

$$\Pr\left[z_i(j) \leq z\right] = e^{-T_i z^{-\theta}}$$

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- Most efficient producer of j has same distribution: $T = \sum_k T_k$

- Probability low-cost producer for n is from country i:

$$\pi_{ni} = \frac{T_i \left(w_i d_{ni}\right)^{-\theta}}{\sum_k T_k \left(w_k d_{nk}\right)^{-\theta}}$$

II. Calibration Idea

- Data on bilateral trade shares (of n's tradable spending imported from i):

$$\frac{X_{ni}}{\alpha X_n} = \boldsymbol{\pi_{ni}} = \frac{T_i \left(w_i d_{ni}\right)^{-\theta}}{\sum_{k=1}^{N} T_k \left(w_k d_{nk}\right)^{-\theta}}$$

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- Use them to calibrate T_i's and d_{ni}'s to calculate ...

- ... change in trade shares if wages are w_k' instead ($\hat{w}_k = w_k'/w_k$):

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- ... change in trade shares if wages are w'_k instead ($\hat{w}_k = w'_k / w_k$):

$$\pi'_{ni} = \frac{T_i \left(w_i \hat{w}_i d_{ni}\right)^{-\theta}}{\sum_{k=1}^{N} T_k \left(w_k \hat{w}_k d_{nk}\right)^{-\theta}} = \frac{\boldsymbol{\pi_{ni}} \left(\hat{w}_i\right)^{-\theta}}{\sum_{k=1}^{N} \boldsymbol{\pi_{nk}} \left(\hat{w}_k\right)^{-\theta}}$$

An ACR Detour

- Given wages w_k, home share is:

$$\frac{X_{ii}}{\alpha X_i} = \pi_{ii} = T_i \left(\frac{w_i}{p_i/\gamma} \right)^{-\theta}$$

- Why not invert it? (don't forget equation 15 in EK!)

$$\frac{w_i}{p_i} = \gamma \left(\frac{T_i}{\pi_{ii}} \right)^{1/\theta}$$

- Real wage relative to autarky:

$$\frac{W}{W^A} = (\pi_{ii})^{-\alpha/\theta}$$

Table 1: Welfare Relative to Autarky

Country	Basic Model	Multiple Sectors & Intermediates
Poland	1.05	1.51
USA	1.02	1.09

Calculations based on Costinot and Rodriguez-Clare (2014)

General Equilibrium

- Income: $Y_i = w_i L_i$

- Trade imbalances: $X_n = Y_n + D_n$

- Market clearing:

$$Y_i - (1 - \alpha)(Y_i + D_i) = \sum_n \pi_{ni} \alpha (Y_n + D_n)$$

- If $\alpha = 1$ and $d_{ni} = 1$ then D's drop out, otherwise affect specialization

Counterfactual Trade Balance

- Given data on $\boldsymbol{Y_i}$ and $\boldsymbol{\pi_{ni}}$, moving from our world ...

- ... to a world of $D' = 0$ implies wage changes satisfying:

$$Y_i' = \hat{w}_i \boldsymbol{Y_i} = \sum_n \pi'_{ni} \hat{w}_n \boldsymbol{Y_n}$$

$$\pi'_{ni} = \frac{\boldsymbol{\pi_{ni}} (\hat{w}_i)^{-\theta}}{\sum_{k=1}^{N} \boldsymbol{\pi_{nk}} (\hat{w}_k)^{-\theta}}$$

Table 2: Rebalancing Counterfactual

	CA deficit (% of GDP)	Counterfactual change from 2004 base			
		change in GDP			Real GDP
	2004	mobile	immobile	theta=1	theta=1
Germany	-3.8	1.03	1.08	1.19	1.01
Greece	5.0	0.96	0.90	0.82	0.97
USA	5.6	0.96	0.86	0.70	0.98

From Dekle, Eaton, and Kortum (2008)

Issues Raised by Counterfactual

- Modeling labor immobility
- Modeling trade deficits
- Modeling trade elasticities (short and long run)
- Modeling slow wage adjustment
- Explore first two issues in new terrain

New Terrain: Intranational Trade

Burst of Activity

- Allen and Arkolakis (2014); Ahlfedlt, Redding, Sturm, and Wolf (2015)
- Ramondo, Rodríguez-Clare, and Saborio (2014)
- Redding (2015); Monte, Redding, and Rossi-Hansberg (2015)
- Tombe and Zhu (2015); Fajgelbaum, Suárez-Serrato, and Zidar (2015)
- Follow: Caliendo, Dvorkin, and Parro (CDP 2015)

New Elements

- Ricardian model: but locations i within and between countries
- Cost of moving from n to i is τ_{ni} (can be prohibitive)
- Dynamic discrete choice as in Artuç and McLaren (2010)
- Amenity draws $a_{i,t}(\omega)$ distributed Fréchet (ϵ)

CDP Model

- Let $V_{n,t}$ be the value of residing in location n at date t:

$$V_{n,t} = \ln(w_{n,t}/p_{n,t}) + E\left[\max_i \left\{\rho V_{i,t+1} + \ln a_{i,t+1}(\omega) - \ln \tau_{ni}\right\}\right]$$

- Migration shares (of individuals in n relocating to i), letting $u_{i,t} = e^{V_{i,t}}$:

$$\mu_{ni,t+1} = \frac{\left(\left(u_{i,t+1}\right)^{\rho} / \tau_{ni}\right)^{\epsilon}}{\sum_k \left(\left(u_{k,t+1}\right)^{\rho} / \tau_{nk}\right)^{\epsilon}}$$

- State variables $L_{i,t}$ evolve according to these migration shares

Counterfactuals

- Counterfactual: dynamic response to a new path, such as $\left\{\hat{T}_{i,t+1}\right\}$
- ("hat" now means temporal change, $\hat{x}_{t+1} = x_{t+1}/x_t$)
- Condition on data $\boldsymbol{Y_{i,t}}$, $\boldsymbol{L_{i,t}}$, $\boldsymbol{\pi_{ni,t}}$, and $\boldsymbol{\mu_{ni,t}}$ for initial period only ...
- ... leaving only three parameters! θ, ϵ, and ρ
- Perfect foresight: initial $\hat{u}_{n,t}$'s get you on path to the steady state of...

$$\left(\hat{u}_{n,t}\right)^{\epsilon} = \sum_{i} \boldsymbol{\mu_{ni,t}} \left(\hat{T}_{i,t+1}/\hat{\pi}_{ii,t+1}\right)^{\epsilon/\theta} \left(\hat{u}_{i,t+1}\right)^{\rho\epsilon}$$

$$\mu_{ni,t+1} = \frac{\boldsymbol{\mu_{ni,t}} \left(\hat{u}_{i,t+1}\right)^{\rho\epsilon}}{\sum_{k} \boldsymbol{\mu_{nk,t}} \left(\hat{u}_{k,t+1}\right)^{\rho\epsilon}}$$

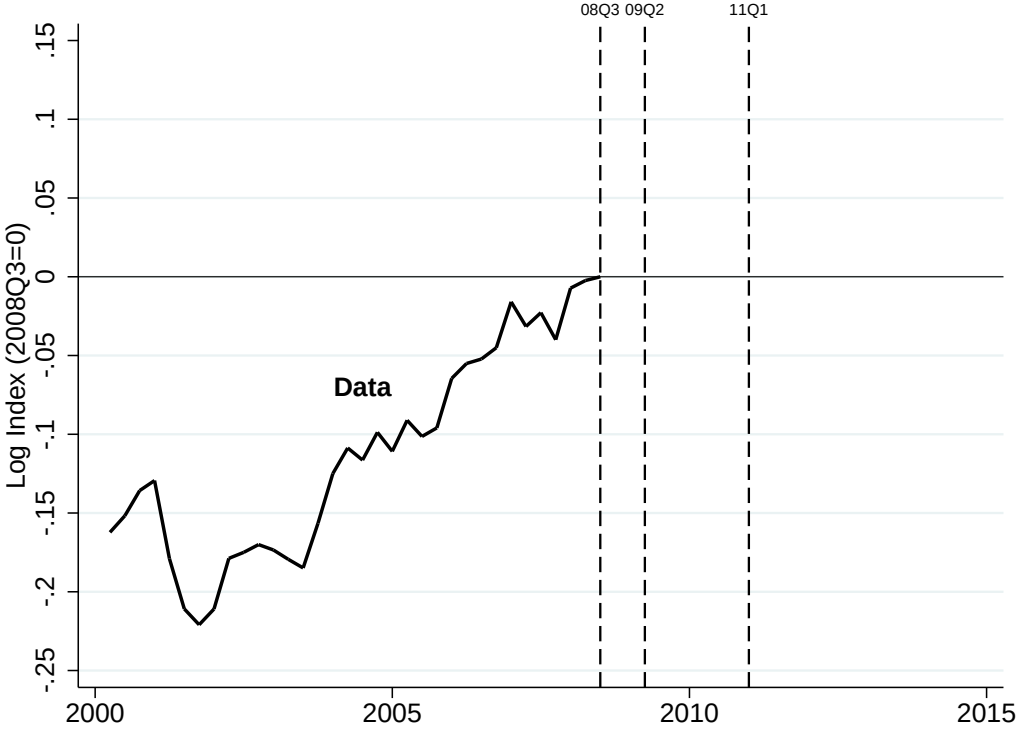
$$L_{n,t+1} = \sum_{i} \mu_{in,t+1} \boldsymbol{L_{i,t}}$$

$$\pi_{ni,t+1} = \frac{\boldsymbol{\pi_{ni,t}} \hat{T}_{i,t+1} \left(\hat{w}_{i,t+1}\right)^{-\theta}}{\sum_{k=1}^{N} \boldsymbol{\pi_{nk,t}} \hat{T}_{k,t+1} \left(\hat{w}_{k,t+1}\right)^{-\theta}},$$

$$\hat{w}_{i,t+1} \hat{L}_{i,t+1} \boldsymbol{Y_{i,t}} = \sum_{n} \pi_{ni,t+1} \hat{w}_{n,t+1} \hat{L}_{n,t+1} \boldsymbol{Y_{n,t}},$$

New Terrain: Dynamics

What happend to world trade? ...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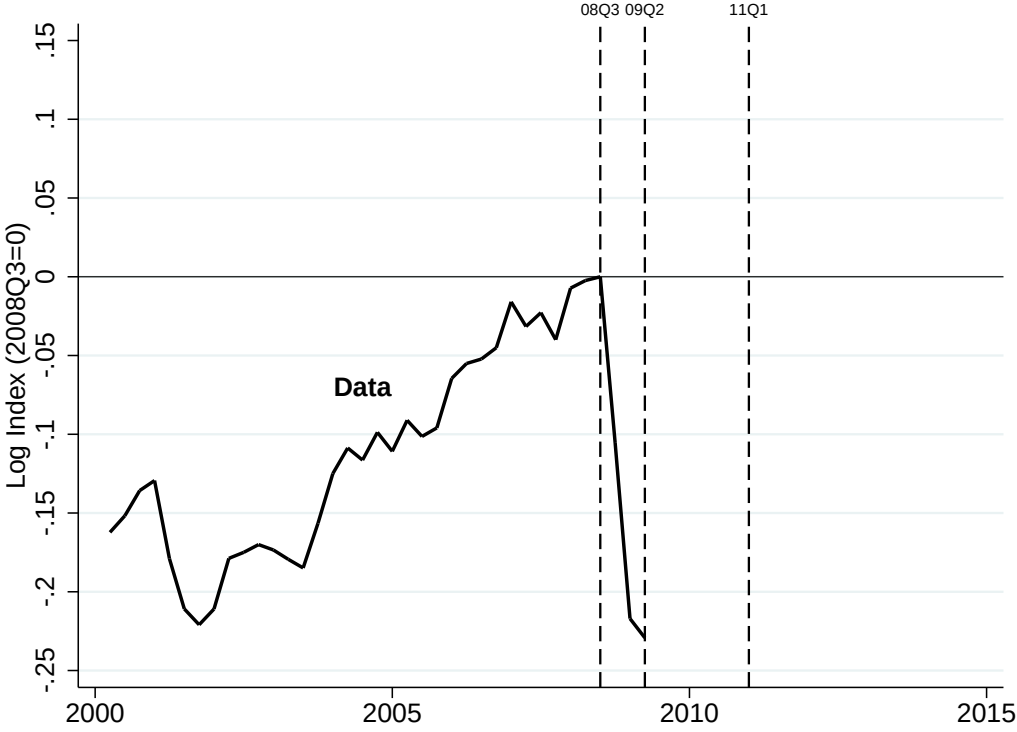
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Contributions

- Alessandria, Kaboski, and Midrigan (2010, 2011)
- Fitzgerald (2012)
- Mutreja, Ravikumar, and Sposi (2014)
- Kehoe and Ruhl (2014)
- Follow: Eaton, Kortum, Neiman, and Romalis (EKNR 2015)

New Elements

- Ricardian trade, country as unit of observation, discrete time
- Factors of production: L_i fixed (share β) and $K_{i,t}$ evolving
- Tradeable goods invested to build capital (efficiency of invest $\chi_{i,t}$):

$$K_{i,t+1} = \chi_{i,t} \left(I_{i,t}\right)^{\eta} \left(K_{i,t}\right)^{1-\eta} - (1-\delta)K_{i,t}$$

- Nontradable goods consumed to max log preferences (shocks $\phi_{i,t}$)
- Solved by a global social planner (weights ω_i), complete markets

EKNR Relationships

- Consumption spending: $X^C_{i,t} = \omega_i \phi_{i,t}$
- Investment spending: $X^I_{i,t} = p_{i,t} I_{i,t}$
- Value of GDP: $Y_{i,t} = X^C_{i,t} + \sum_n \pi_{ni,t} X^I_{n,t}$
- Payments to labor: $w_{i,t} L_i = \beta Y_{i,t}$
- Payments to capital: $r_{i,t} K_{i,t} = (1 - \beta) Y_{i,t}$
- Bilateral trade equations unchanged ...

- Investment Euler equation:
  - cost of building one more unit of capital

$$\frac{p_{i,t}}{\eta \chi_{i,t}} \left(\frac{I_{i,t}}{K_{i,t}} \right)^{1-\eta}$$

  - equals benefit

$$\rho \left(r_{i,t+1} + \frac{(1-\eta) p_{i,t+1} I_{i,t+1}}{\eta K_{i,t+1}} + \frac{(1-\delta) p_{i,t+1}}{\eta \chi_{i,t+1}} \left(\frac{I_{i,t+1}}{K_{i,t+1}} \right)^{1-\eta} \right)$$

- Trade deficit:

$$D_{i,t} = X^I_{i,t} - \sum_n \pi_{ni,t} X^I_{n,t} = X^C_{i,t} + X^I_{i,t} - Y_{i,t}$$

Computing a Perfect Foresight Path

- Shocks paths: $\left\{\hat{d}_{ni,t+1}\right\}$, $\left\{\hat{T}_{i,t+1}\right\}$, $\left\{\hat{\phi}_{i,t+1}\right\}$, $\left\{\hat{\chi}_{i,t+1}\right\}$, eventually 1

- Condition on initial data $\boldsymbol{Y_{i,t}}$, $\boldsymbol{X^{C}_{i,t}}$, $\boldsymbol{X^{I}_{i,t}}$, and $\boldsymbol{\pi_{ni,t}}$

- Initial $\hat{K}_{i,t+1}$'s get you on perfect-foresight path to steady state of:

- change in consumption spending: $\hat{X}^{C}_{i,t} = \hat{\phi}_{i,t}$

- price change equation: $\hat{p}_{i,t+1} = \hat{w}^{\beta}_{i,t+1}\hat{r}^{1-\beta}_{i,t+1}\left(\hat{\pi}_{ii,t+1}/\hat{T}_{i,t+1}\right)^{1/\theta}$ ...

- trade share evolution:

$$\pi_{ni,t+1} = \frac{\boldsymbol{\pi_{ni,t}} \hat{T}_{i,t+1} \left(\hat{w}_{i,t+1}^{\beta} \hat{r}_{i,t+1}^{1-\beta} \hat{d}_{ni,t+1} \right)^{-\theta}}{\sum_{k=1}^{N} \boldsymbol{\pi_{nk,t}} \hat{T}_{k,t+1} \left(\hat{w}_{k,t+1}^{\beta} \hat{r}_{k,t+1}^{1-\beta} \hat{d}_{nk,t+1} \right)^{-\theta}}$$

- GDP changes, wage changes, and rental rate changes

- Euler equation to solve for change in investment spending

- Update change in capital with

$$\hat{K}_{i,t+2} - (1-\delta) = \hat{\chi}_{i,t+1} \left(\frac{\hat{X}_{i,t+1}^{I}}{\hat{p}_{i,t+1} \hat{K}_{i,t+1}} \right)^{\eta} \left(\hat{K}_{i,t+1} - (1-\delta) \right)$$

The Algorithm

- Starting from 2012:Q4, shocks fixed thereafter, solve for $\hat{K}$'s
- Work backwards using data to form paths for the $\hat{K}_{i,t+1}$
- Using capital paths (in changes) back out shocks during data period
- Intertemporal preference shock is easy: $\hat{\phi}_{i,t} = \hat{X}^C_{i,t}$
- Other three are a bit deeper!

Backing out Shocks

- Trade Frictions:

$$\hat{d}_{ni,t+1} = \left(\frac{\hat{\pi}_{ni,t+1}}{\hat{\pi}_{ii,t+1}}\right)\frac{\hat{p}_{n,t+1}}{\hat{p}_{i,t+1}}$$

- Productivity :

$$\hat{T}_{i,t+1} = \hat{\pi}_{ii,t+1}\left(\left(\hat{w}_{i,t+1}\right)^{\beta}\left(\hat{r}_{i,t+1}\right)^{1-\beta}/\hat{p}_{i,t+1}\right)^{\theta}$$

- Efficiency of investment:

$$\hat{\chi}_{i,t+1} = \left(\frac{\hat{X}^{I}_{i,t+1}}{\hat{p}_{i,t+1}\hat{K}_{i,t+1}}\right)^{-\eta}\frac{\hat{K}_{i,t+2}-(1-\delta)}{\hat{K}_{i,t+1}-(1-\delta)}$$

Counterfactuals for Accounting

- Perfect foresight path, given the shocks we back out, reproduces the data
- Assess contributions: compute with only a single set of shocks
- Breaks the Euler equation at the date when new future becomes apparent
- If a shock can explain the data on its own, its important
- Global analog of Chari, Kehoe, and McGratten (2007)


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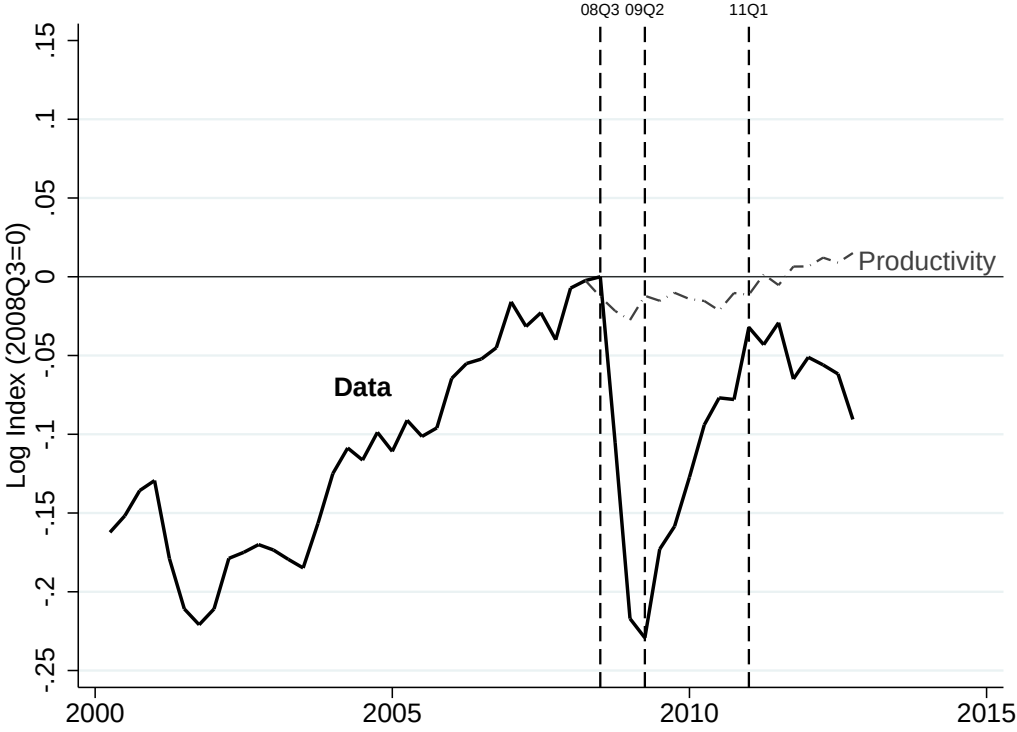
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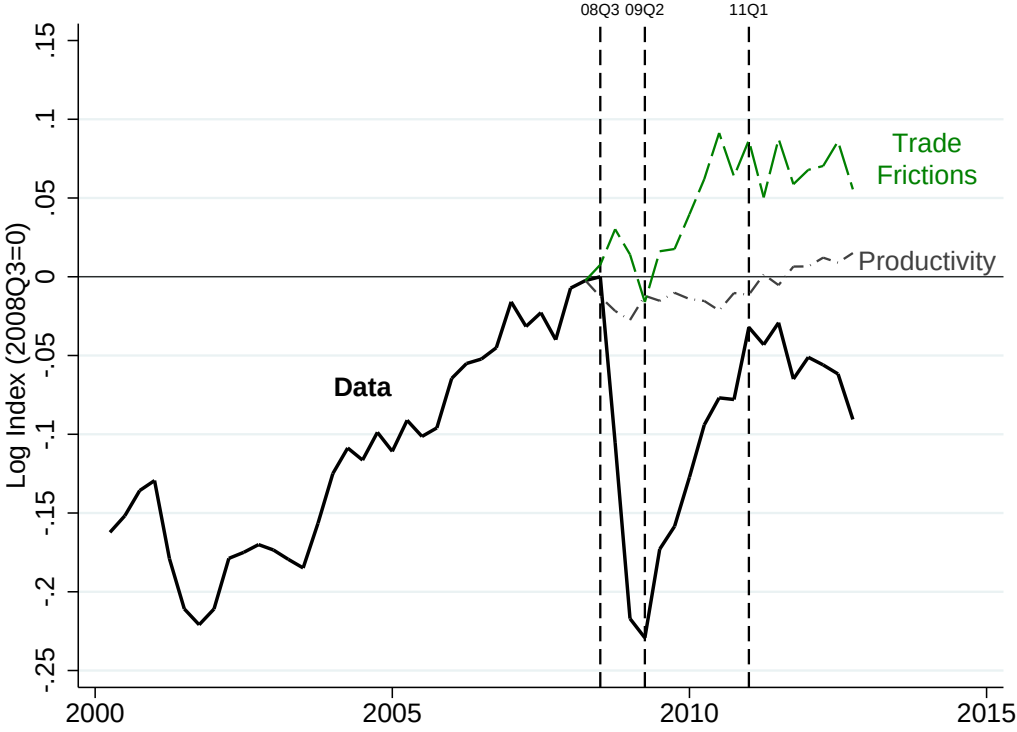
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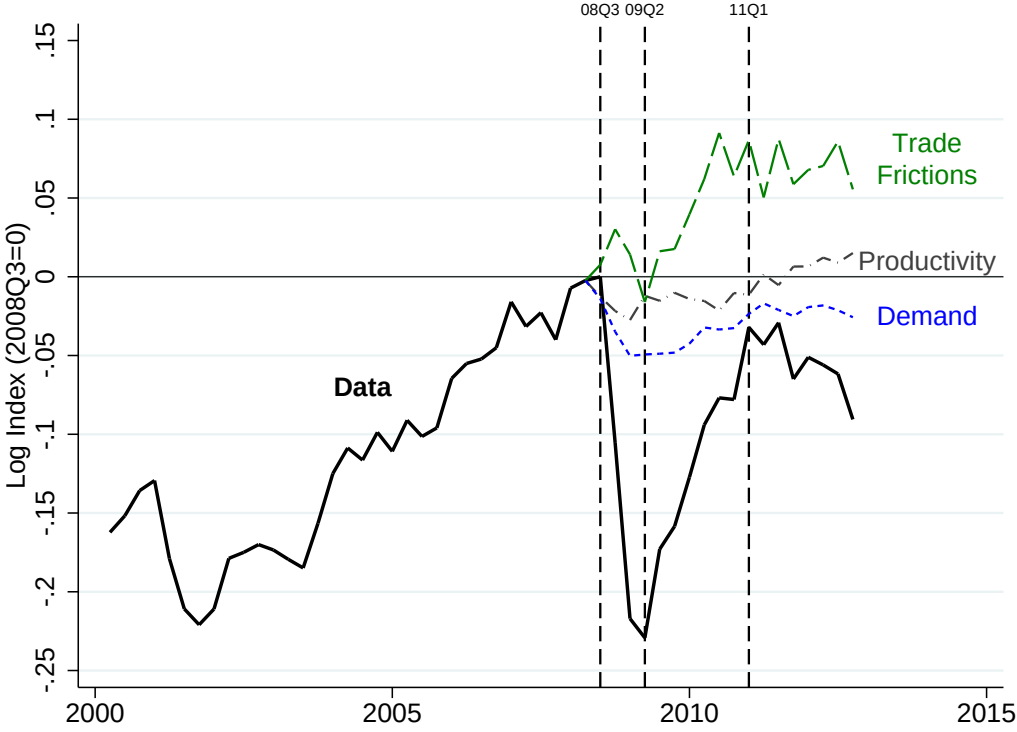
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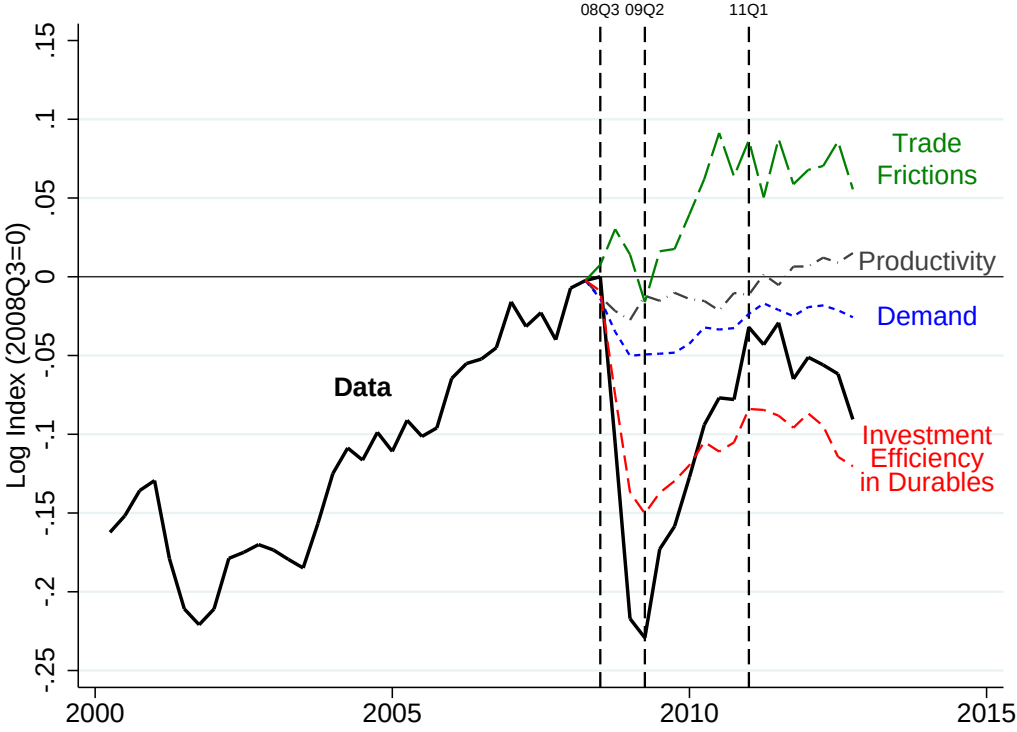
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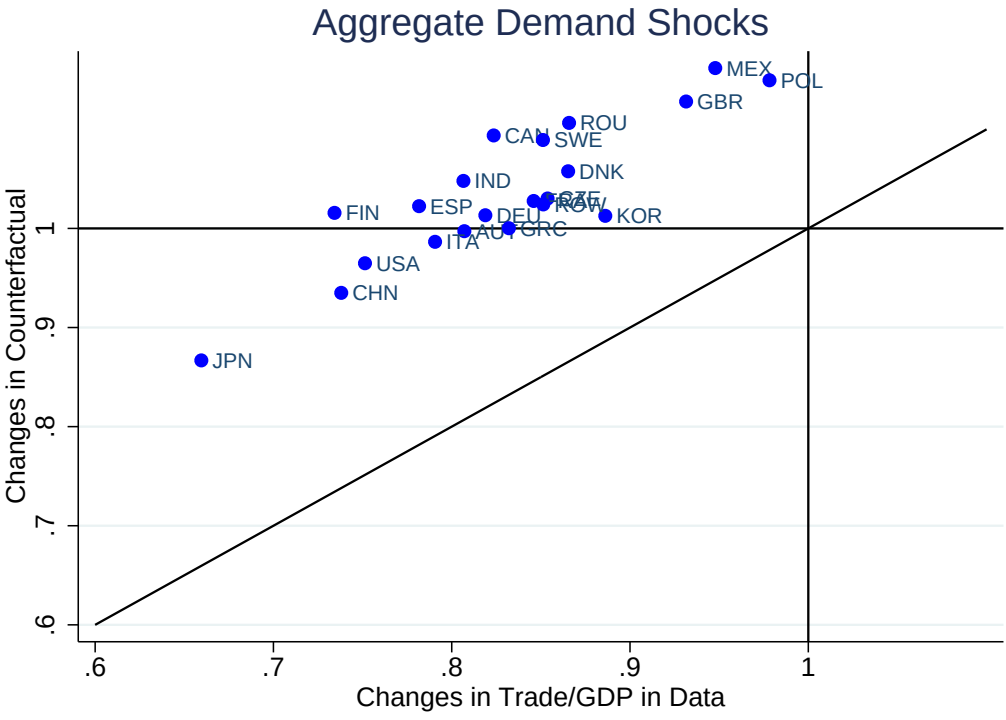
Investment Efficiency in Durables

The Cross-Country Dimension


Aggregate Demand Shocks
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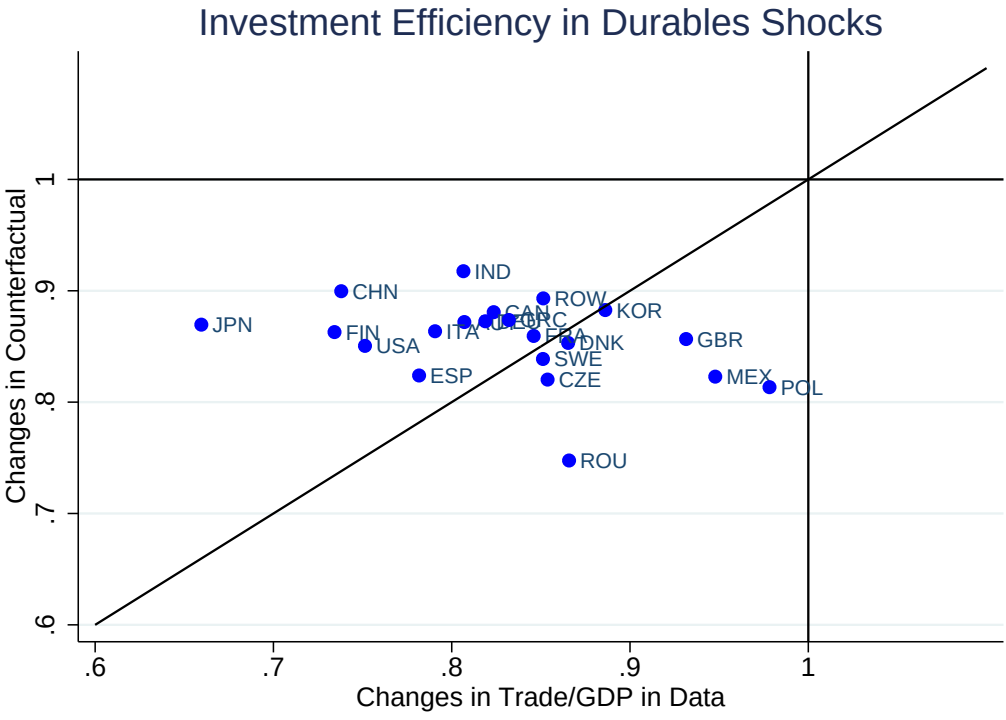
Changes in Trade/GDP in Data


Investment Efficiency in Durables Shocks
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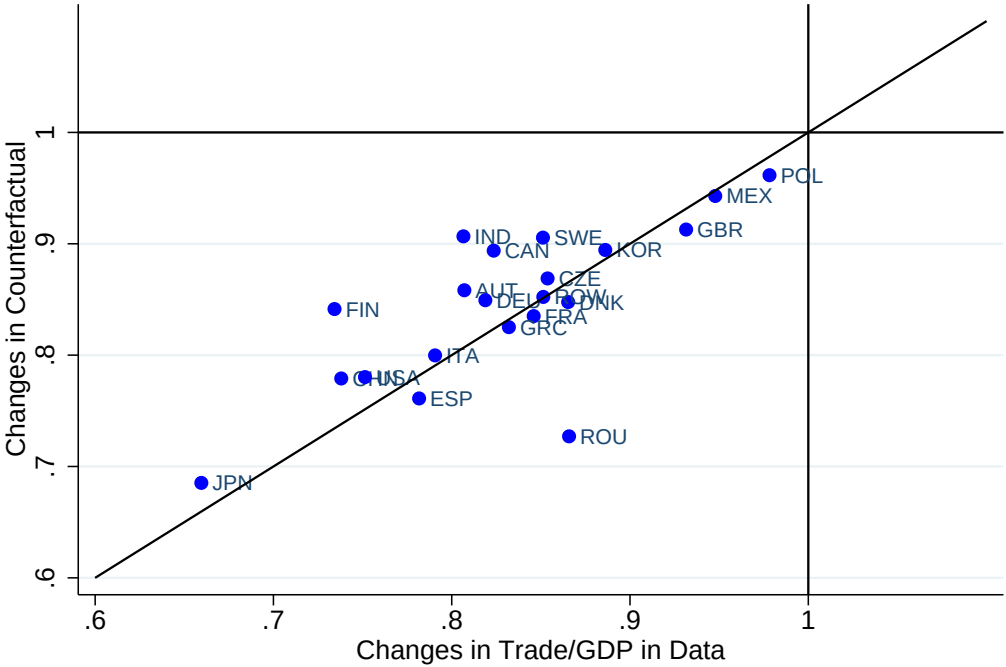
All Demand and Investment Efficiency Shocks



Conclusion