Specialization, Market Access and Real Income

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Trade shocks and real income

Question: How do foreign demand and supply shocks in different sectors affect real income?

Thought Experiment: Give initially identical economies different foreign shocks, then look at differences in (steady-state) real income.

- Structural quantitative modeling $\rightarrow$ model-specific answers
- Our approach
  - Minimal structure for measurement and interpretation
  - Otherwise, let the data speak!

What we do

- Estimate causal impact of foreign shocks in different sectors on real income
  - Sample of 127 countries and 5 decades (1965-2015)
- Along the way:
  1. Estimation approach based on first order approximation to a general small open economy with gravity
  2. Reduce dimensionality by clustering sectors by characteristics using machine learning techniques
     - 268 4-digit sectors $\rightarrow$ 6 clusters
  3. Identification with high-dimensional controls using Post-Lasso estimator of Belloni et al (2012)

What we find – estimates

- Impact of foreign shocks varies across sectors
- Foreign demand shocks:
  - Strongest positive effect in complex intermediates and capital goods (esp. in developing countries)
  - Other sectors – Ag, Mining, processed raw materials, consumer goods – small positive impact
- Foreign supply shocks:
  - Strongest positive effect in capital goods and consumer goods
  - Estimates large but imprecise

What we find – counterfactuals

- Both comparative advantage and geography significantly affect growth
- Comparative advantage:
  - Experiment: a uniform foreign demand shock to all countries and sectors
  - Growth elasticity ranges from close to 0 (Africa) to 0.4-0.5 in emerging markets such as HUN, SLV, MYS, TWN
- Geography:
  - Experiment: give each country shocks associated with another country's geographic position
  - Asia has benefited from positive foreign shocks, Europe has suffered

Model

- Small open economy H with K sectors (indexed k), J factors (indexed j), and N other countries (indexed n)
  - May have monopoly power and large in dom. market
- Rep. consumer with homothetic preferences $U(Q^C_{H,k})$
- Competitive producers perceive CRS technology
  - May be external effects
- Competitive input markets

Model

- Intra-sectoral export demand is CES:

$$\sum_{n \in N} p_{Hn,k} q_{Hn,k} = c_{H,k}^{1-\sigma_k} \cdot \underbrace{\sum_{n \in N} \tau_{Hn,k}^{1-\sigma_k} \cdot \frac{E_{n,k}}{P_{n,k}^{1-\sigma_k}}}_{FMA_{H,k}}$$

  where $E_{n,k}$ are foreign sectoral expenditures, $P_{n,k}$ are foreign price indices, and $\tau_{Hn,k}$ are iceberg trade costs

- $FMA_{H,k}$ = (External) "Firm Market Access"
  - Exogenous from Home's perspective (net of export taxes)
  - Summarizes relevant foreign demand
- Implies gravity equation at the sector-level
  - $E_{n,k}/P_{n,k}^{1-\sigma_k}$ as the importer effects
  - $c_{n,k}^{1-\sigma_k}$ as the exporter effects

Model

- Intra-sectoral import demand is also CES:

$$\sum_{n \in N} p_{nH,k} \cdot q_{nH,k} = \frac{E_{H,k}}{P_{H,k}^{1-\sigma_k}} \cdot \underbrace{\sum_{n \in N} \left(c_{n,k} \cdot \tau_{nH,k}\right)^{1-\sigma_k}}_{CMA_{H,k}}$$

- $CMA_{H,k}$ = (External) "Consumer Market Access"
  - Exogenous from Home's perspective (net of import tariffs)
  - Summarizes relevant foreign supply
- Factor market clearing + trade balance for equilibrium
  - Extension to factor accumulation, deficits
- Assume *unique* and *smooth* mapping from exogenous $(\{T_{H,k}\}, \{FMA_{H,k}\}, \{CMA_{H,k}\})$ to endogenous variables

First-order welfare approximation

Approximate real income growth following foreign shocks:

$$d \ln y \approx \sum_k \delta_k^{ex} \cdot [\lambda_k^{ex} d \ln FMA_k] + \sum_k \delta_k^{im} \cdot \left[\lambda_k^{im} d \ln CMA_k\right] + \epsilon$$

- λ_k^{ex} and λ_k^{im} are initial revenue/expenditure shares
- δ_k^{ex} and δ_k^{im} elasticities w.r.t. sector-specific foreign shocks
- ϵ contains domestic shocks

Interpreting the elasticities

- $\delta_k^{ex} = (1 - \sigma_k) \cdot d \ln y / d \ln \tau_k^{ex}$
  - τ_k^{ex} can be foreign tariffs or other export (non-revenue) trade barriers
- $\delta_k^{im} = (1 - \sigma_k) \cdot d \ln y / d \ln \tau_k^{im}$
  - τ_k^{ex} can be foreign export taxes or other import (non-revenue) trade barriers
- Similar interpretation for foreign productivity/demand shocks
- Subject of large academic and policy literature
- Income and market access literature, e.g. Redding and Venables (2004)

▸ Efficient ▸ Single Factor ▸ Spillovers

Estimating equation

General model-implied relationship:

$$d\ln y_{i,t} = \sum_k \delta^{ex}_{ik,t} \cdot \left[\lambda^{ex}_{ik,t} d\ln FMA_{ik,t}\right] + \sum_k \delta^{im}_{ik,t} \cdot \left[\lambda^{im}_{ik,t} d\ln CMA_{ik,t}\right] + \epsilon_{i,t}$$

Actual estimating equation:

$$d\ln y_{i,t} = \nu_t + \sum_{g\in G} \delta^{ex}_g \cdot [d\ln FMA_{ig,t}] + \sum_{g\in G} \delta^{im}_g \cdot [d\ln CMA_{ig,t}] + \mu_{i,t} + \epsilon_{i,t}$$

- $K \approx 260 \rightarrow G = 6$ clusters (4 manuf, 1 ag, 1 mining)
- Interpretation: best constrained approximation to conditional expectation function

Identification

- In the error term:
  - $d \ln T_{ik,t}$, other shocks to fundamentals
  - Initial conditions
- OLS identifies δ_g's only under restrictive assumptions
  - Error function of, e.g. λ^{ex}, λ^{im}
  - Unclear which way bias goes
- Key idea: use initial trade shares, etc. to control for initial fundamentals via invertibility

Identification

- General trade model approximately satisfies

$$d \ln y_{i,t} = \nu_t + \sum_{g \in G} \delta_g^{ex} \cdot [d \ln FMA_{ig,t}] + \sum_{g \in G} \delta_g^{im} \cdot [d \ln CMA_{ig,t}] + \boldsymbol{\eta} \mathbf{w}_{i,t} + \tilde{\epsilon}_{i,t},$$

  where $\mathbf{w}_{i,t}$ is a high-dimensional vectors of (functions of) initial period variables

- Assumption: $\boldsymbol{\eta}$ is *approximately sparse*

- Double Selection Post-LASSO Estimator identifies δ_g's (Belloni et al., 2012)

  - Run LASSO regression of dependent variable and each treatment on $\mathbf{w}_{i,t}$
  - Take $\bar{\mathbf{z}}_{i,t}$ to be union of selected variables
  - Run OLS on treatments and $\bar{\mathbf{z}}_{i,t}$ to identify δ_g
  - Standard inference valid

Summary of empirical procedure

1. Leave-one-out gravity equation estimation with PPML to recover the foreign component of $FMA_{ik,t}$ and $CMA_{ik,t}$ by country for 268 sectors

2. Clustering algorithm to group manufacturing sectors into 4 clusters

3. Construct $d \ln FMA_{ig,t}$ and $d \ln CMA_{ig,t}$

4. LASSO of $d \ln y_{i,t}$, $d \ln FMA_{ig,t}$ and $d \ln CMA_{ig,t}$ on $\mathbf{w}_{i,t}$ to get $\bar{\mathbf{z}}_{it}$

5. OLS regression of $d \ln y_{i,t}$ on $d \ln FMA_{ig,t}$ and $d \ln CMA_{ig,t}$ and $\bar{\mathbf{z}}_{it}$ to get δ_g^{ex} and δ_g^{im}

Data

- Growth: PWT 9.0
- Trade: COMTRADE
- Gravity: CEPII
- Final sample: 127 countries, 268 NAICS industries, 5 decades from 1965 to 2015 (10 year intervals)
- Industry characteristics :

Industry Characteristics	Data Source
Investment sales share	1997 I-O standard make and use table
Intermediates using share	1997 I-O standard make and use table
Intermediates sales share	1997 I-O standard make and use table
4-Firm concentration ratios	2002 Economic Census
Skilled worker share	2000 American Community Survey
Capital intensity	NBER-CES Manuf. Industry Database
Contract intensity of inputs	Nunn (2007)

Why Cluster?

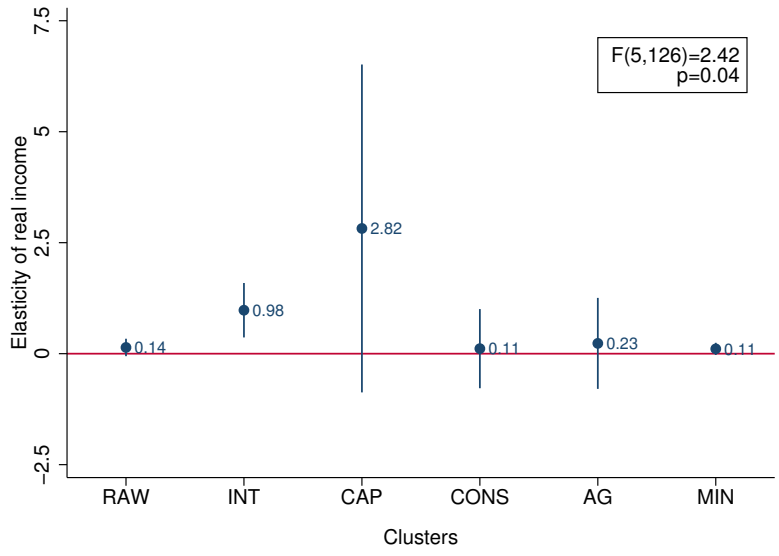
- In practice, want to choose clusters to
  - Minimize intra-cluster heterogeneity in effects
  - Get some sense for what factors drive variation in effects
- Conventional classification schemes (probably) do not further these goals
- Statistical methods to cluster using outcomes as well, but no standard errors...
- Use K-means clustering algorithm

K-means description

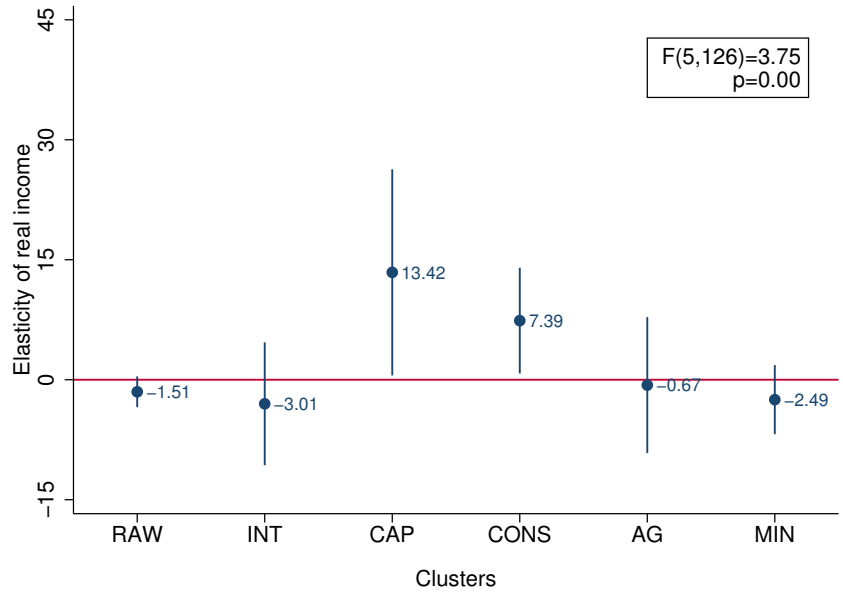
Clusters

	cluster					
	1	2	3	4	Mean	Std. Dev.
Inv. Share	0.00	0.05	0.52	0.04	0.13	0.22
Int. Using	0.78	0.58	0.65	0.66	0.66	0.16
Int. Sales	0.84	0.70	0.27	0.28	0.57	0.31
Conc. Ratio	0.47	0.27	0.38	0.56	0.40	0.21
Sk. Share	0.32	0.28	0.35	0.36	0.32	0.13
Cap. Int.	0.68	0.55	0.54	0.70	0.61	0.10
Con. Int.	0.26	0.56	0.73	0.52	0.51	0.22
Num of ind.	60	84	47	42		
Trade share	0.33	0.26	0.23	0.11		
Label	Raw Materials Processing	Complex Intermediates	Capital Goods	Consumer Goods		
Abbreviation	RAW	INT	CAP	CONS		

Results: Post-Double-LASSO



Foreign Demand Shocks



Foreign Supply Shocks

▸ Tuning ▸ 5 clusters ▸ Meas.Error ▸ Drop Large ▸ Drop Contig.

Two counterfactuals

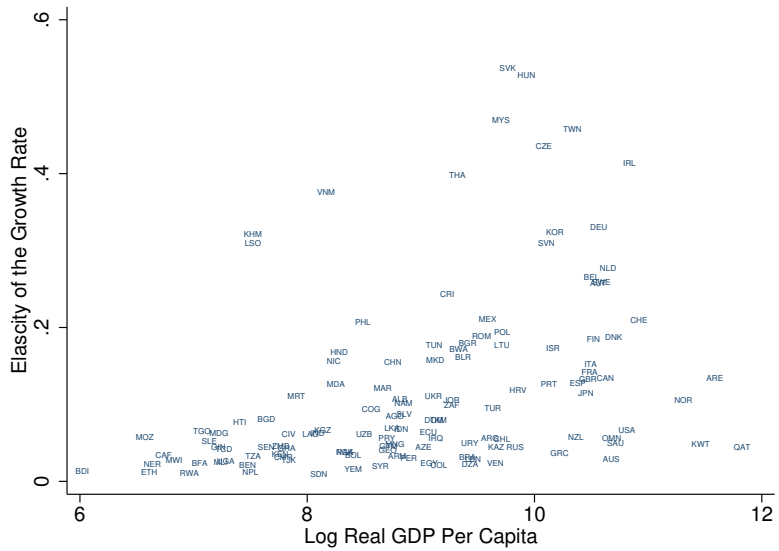
1. "Comparative advantage:"
   - A uniform increase in all FMA, CMA
   - Growth elasticity country-specific:

$$\frac{d \ln y_{i,t}}{d \ln FMA} = \sum_{g \in G} \widehat{\delta}_g^{ex} \sum_{k \in G} \lambda_{ik,t}^{ex},$$

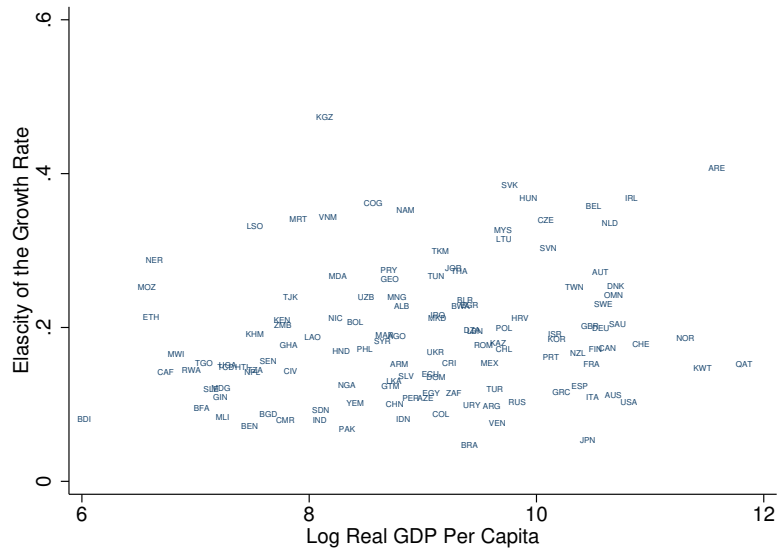
$$\frac{d \ln y_{i,t}}{d \ln CMA} = \sum_{g \in G} \widehat{\delta}_g^{im} \sum_{k \in G} \lambda_{ik,t}^{im}.$$

2. "Geography":
   - Construct synthetic FMA, CMA by combining im/exporter FE's with alternative geographical positions
   - Given the worldwide vector of supply/demand shocks, how different growth would be if country A moved to geographic position of country B?

Counterfactual 1: Comparative advantage



Foreign Demand Shock



Foreign Supply Shock

Counterfactual 2: Geography

Figure: Difference Relative to Median Geographic Location

Region	1975	1985	1995	2005	2015
East Asia & Pacific	0.45 *[0.16, 0.60]* 10	0.55 *[0.23,0.68]* 14	0.12 *[-0.12,0.27]* 14	0.78 *[0.43,2.14]* 14	0.80 *[0.30,1.92]* 14
Eastern Europe & Central Asia	0.00 *[-0.01,0.00]* 2	-0.39 *[-0.72,-0.22]* 6	0.09 *[0.04,0.33]* 6	-0.12 *[-0.32,0.23]* 24	-0.28 *[-0.74,-0.02]* 24
Latin America & Caribbean	-0.25 *[-0.39,0.02]* 18	-0.14 *[-0.27,0.03]* 18	0.00 *[-0.19,0.24]* 18	-0.07 *[-0.15,0.06]* 18	-0.11 *[-0.39,-0.07]* 18
Middle East & North Africa	0.01 *[-0.02,0.11]* 7	-0.09 *[-0.63,0.12]* 14	-0.02 *[-0.17,0.14]* 14	-0.05 *[-0.30,0.12]* 15	0.21 *[-0.08,0.45]* 15
South Asia	0.03 *[-0.01,0.16]* 4	0.07 *[0.04,0.20]* 5	0.06 *[0.01,0.07]* 5	0.04 *[-0.01,0.22]* 5	0.34 *[0.31,0.37]* 5
Sub-Saharan Africa	-0.04 *[-0.20,0.05]* 28	0.07 *[-0.01,0.23]* 30	-0.22 *[-0.43,-0.11]* 30	0.13 *[0.06,0.37]* 30	0.23 *[0.04,0.35]* 33
West Europe/North America	-0.06 *[-0.23,0.04]* 18	-0.88 *[-1.39,-0.54]* 18	0.58 *[0.34,1.03]* 18	-0.39 *[-1.13,-0.12]* 18	-0.88 *[-1.55,-0.63]* 18

Taking stock

- New approach to identify growth effects of foreign shocks
  - Theoretical foundation
  - Dimensionality reduction
  - Identification of average effects with post-double LASSO
- Foreign shocks have heterogeneous impact across sectors
  - Especially big for complex intermediates, capital goods
- Both comparative advantage and geography have economically significant impacts on real income growth

Efficient benchmark

- Elasticities:

$$\delta_k^{ex} = \frac{1}{\sigma_k}, \quad \delta_k^{im} = \frac{1}{\sigma_k - 1}$$

  - Intuition: low $\sigma_k \rightarrow$ high margin, low quantity
- SOE competitive equilibrium not typically efficient
  - Terms of trade effects
  - Network structure of inputs
  - Production externalities
  - Long run factor supply

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Single factor economy with no spillovers

- Elasticities:

$$\delta_k^{ex} = \kappa$$

$$\delta_k^{im} = \left(\frac{1}{\sigma_k - 1} - \kappa \theta_k^d \right)$$

$$\kappa = \frac{\sum_{k \in K} \lambda_k^{im}}{1 - \sum_{k' \in K} \left[\lambda_{k'}^d + (1 - \sigma_{k'}) \left(\lambda_{k'}^d (1 - \theta_{k'}^d) + \lambda_{k'}^{ex} \right) \right]}$$

  - export elasticity is constant across industries
  - κ captures the overall importance of trade to the economy and the distribution of sales across foreign and domestic customers and their covariance with the trade elasticities

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Single factor economy with industry spillovers

- Elasticities:

$$\delta_k^{ex} = \kappa \cdot \frac{1}{1-\gamma_k(\sigma_k-1)}$$

$$\delta_k^{im} = \left(\frac{1}{\sigma_k-1}\right)$$

$$\kappa = \frac{1}{1-\sum_{k'\in K}\frac{(1+\gamma_{k'})(1-\sigma_{k'})}{1-\gamma_{k'}(\sigma_{k'}-1)}\lambda_{k'}^{ex}}$$

  - under zero domestic sales
  - demand shocks to sectors with larger productivity spillovers generate higher income growth
  - amplified by σ_k

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K-means clustering

- m sectors, characteristics $x^{(i)} \in \mathbb{R}^n$, $i = 1, \ldots, m$
- Assign the m sectors $\rightarrow$ G clusters

1. Initialize cluster centroids $\mu_1, \mu_2, \ldots, \mu_G$ for each cluster.
2. Assign each sector $x^{(i)}$ to closest cluster centroids. The cluster assignment is $c(i) \in \{1, 2, \ldots, G\}$,

$$c(i) = \underset{g \in \{1,\ldots,G\}}{\operatorname{argmin}} ||x^{(i)} - \mu_g||^2.$$

3. Replace cluster centroid μ_g by the coordinate-wise average of all points (sectors) in the gth cluster,

$$\hat{\mu}_g = \frac{\sum_{i=1}^{m} \mathbf{1}(c(i) = g) \cdot x^{(i)}}{\sum_{i=1}^{m} \mathbf{1}(c(i) = g)}.$$

4. Iterate on steps 2 and 3 until convergence.

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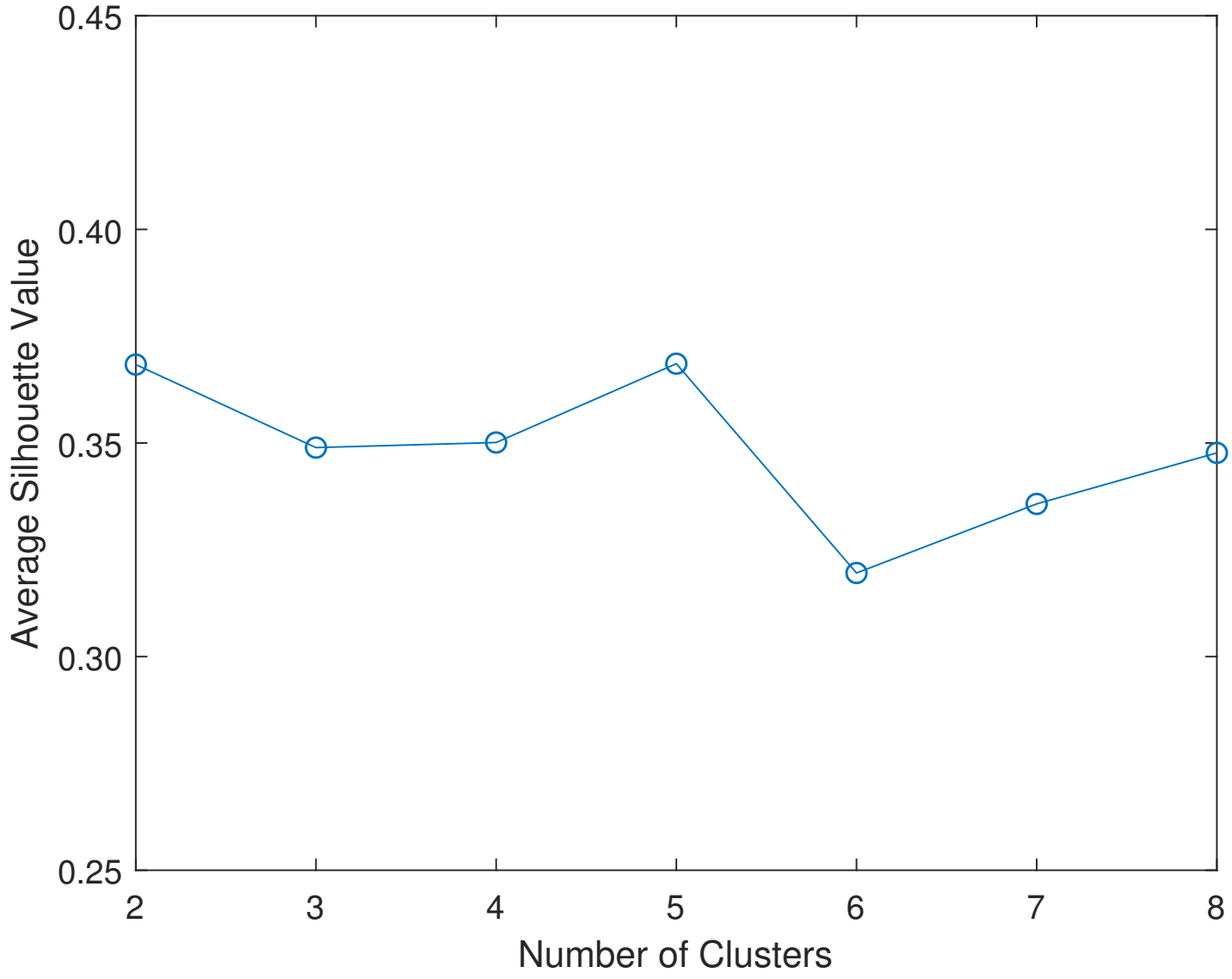
Silhouette



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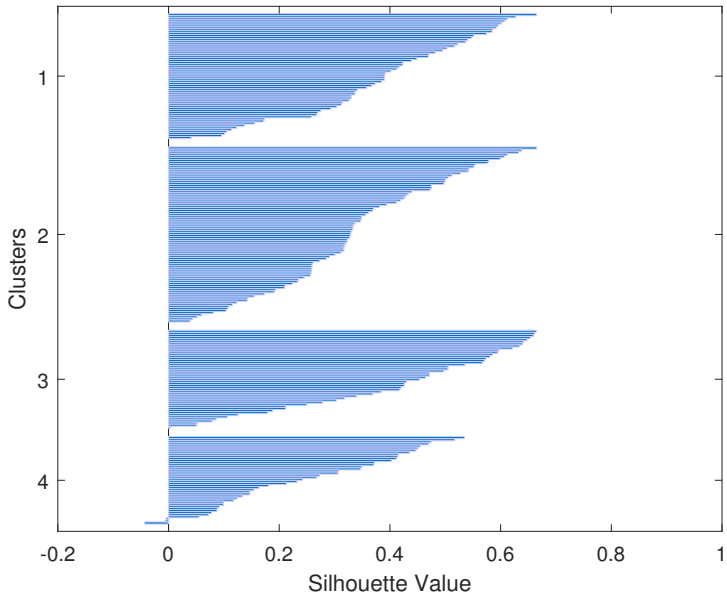
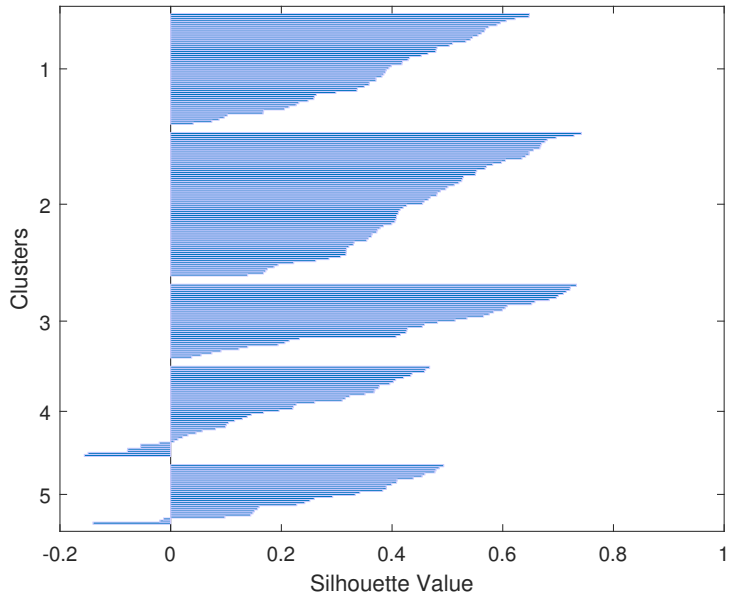
Silhouette



4 Clusters



5 Clusters

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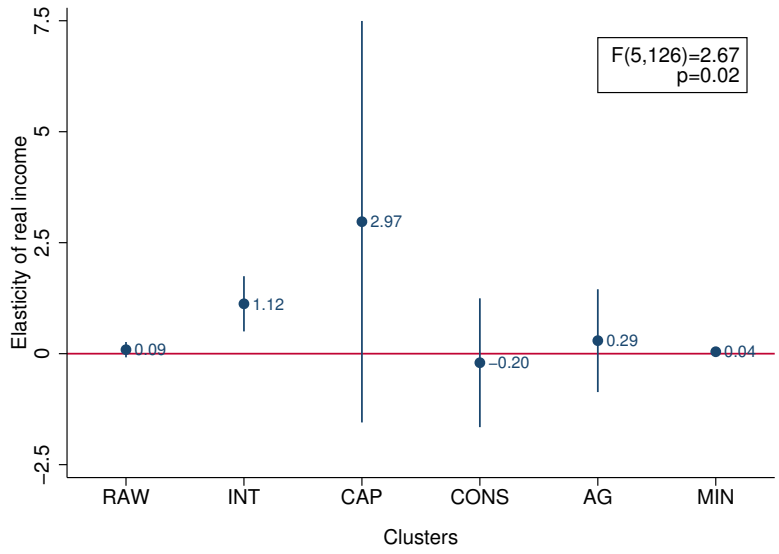
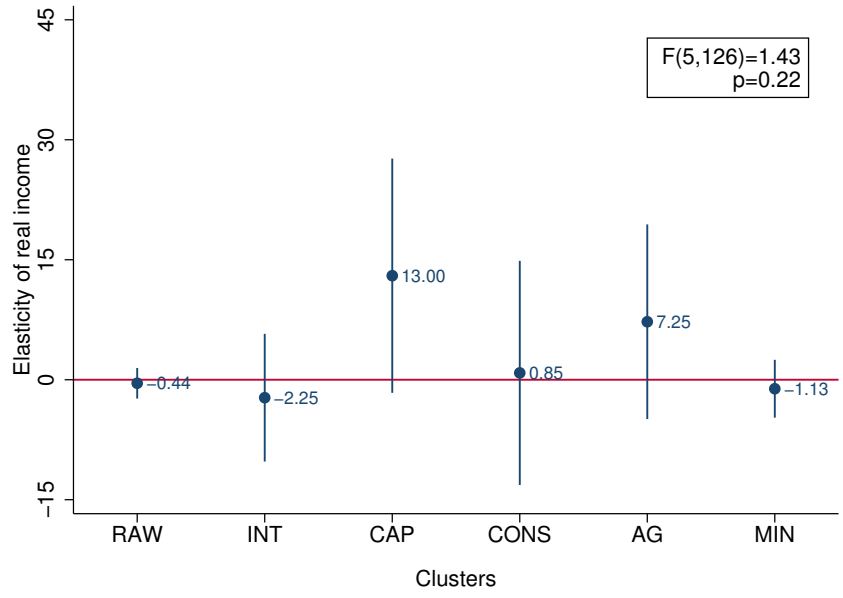
Results: Decreased tuning



Foreign Demand Shocks



Foreign Supply Shocks

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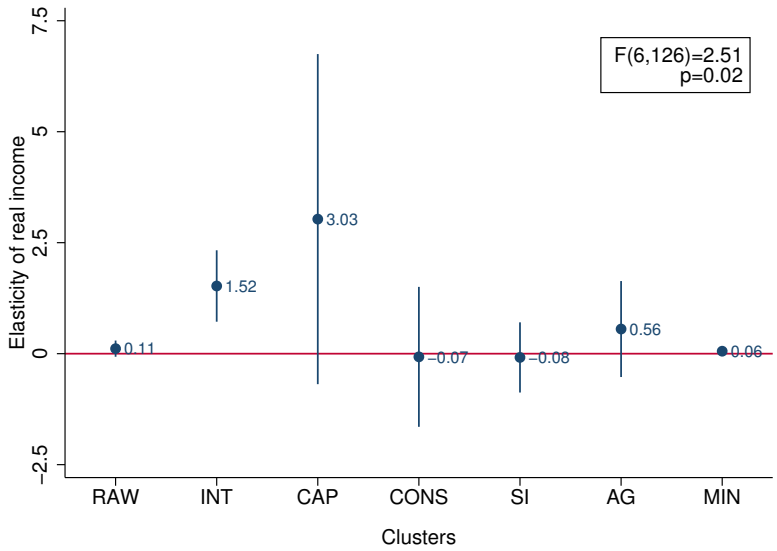
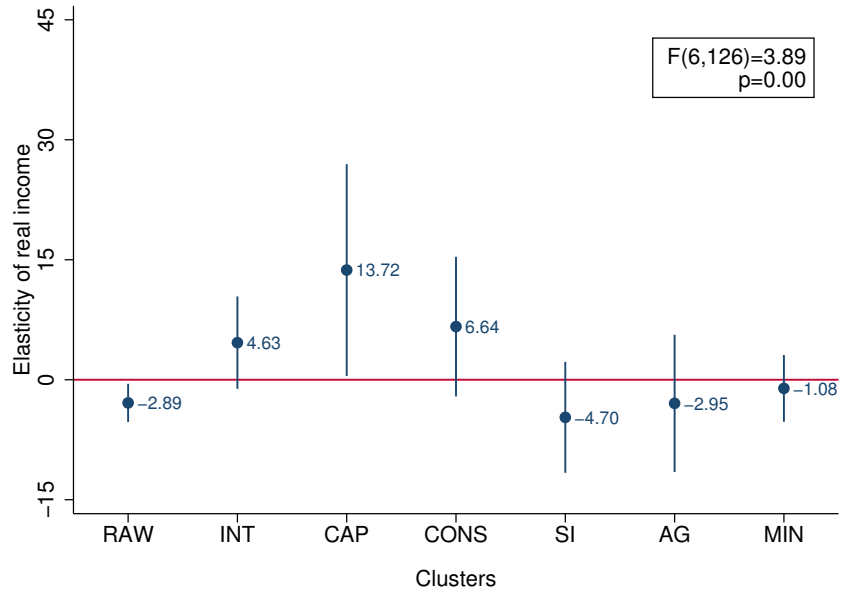
Results: 5 clusters



Foreign Demand Shocks



Foreign Supply Shocks

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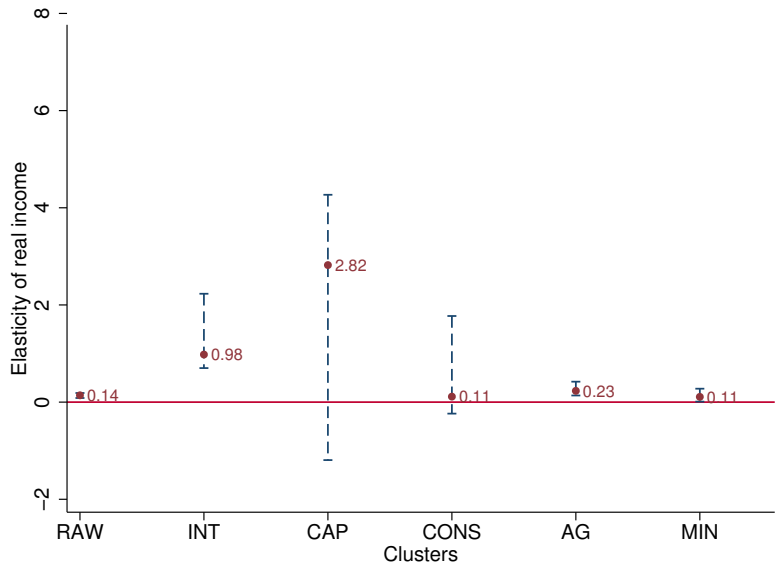
Results: Cluster measurement error simulation



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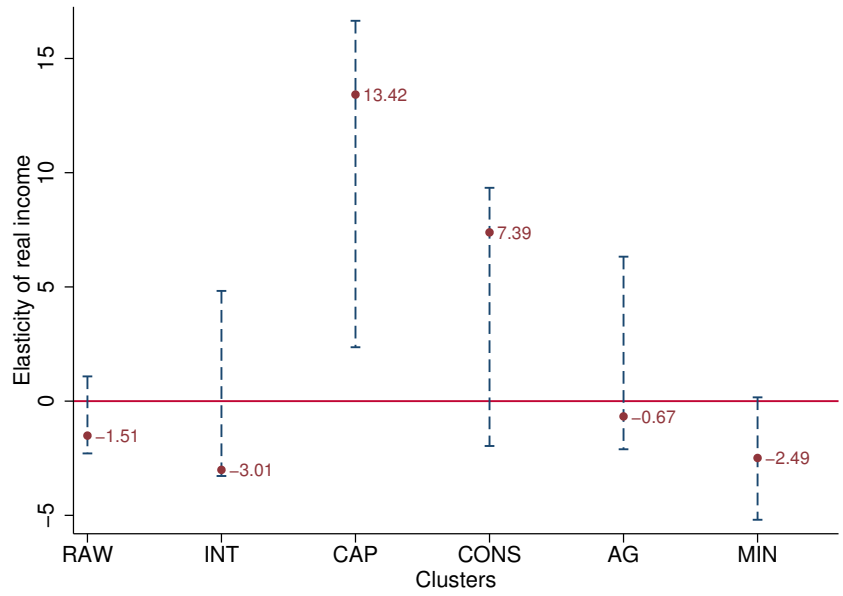

Foreign Supply Shocks

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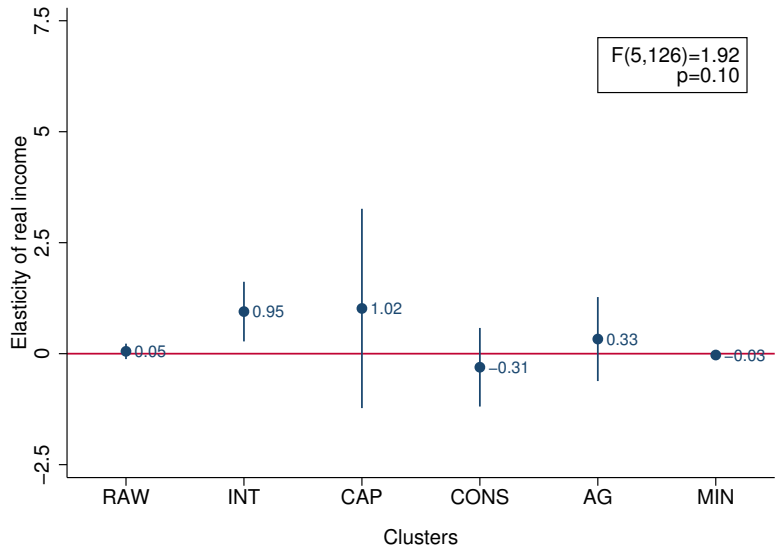
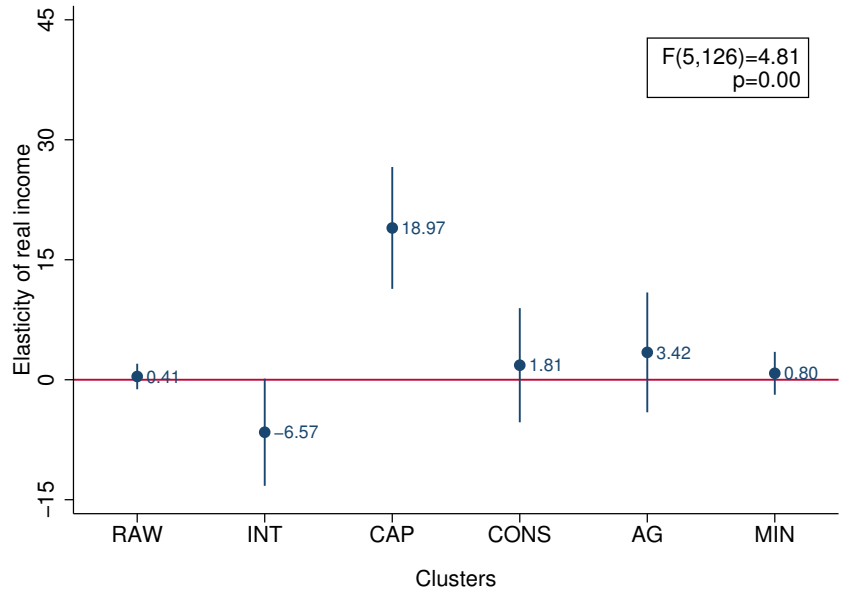
Results: Dropping large trading partners



Foreign Demand Shocks



Foreign Supply Shocks

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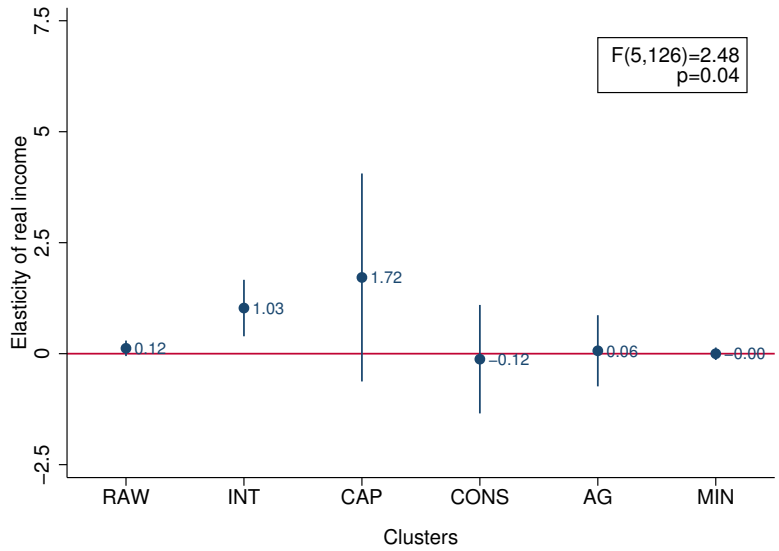
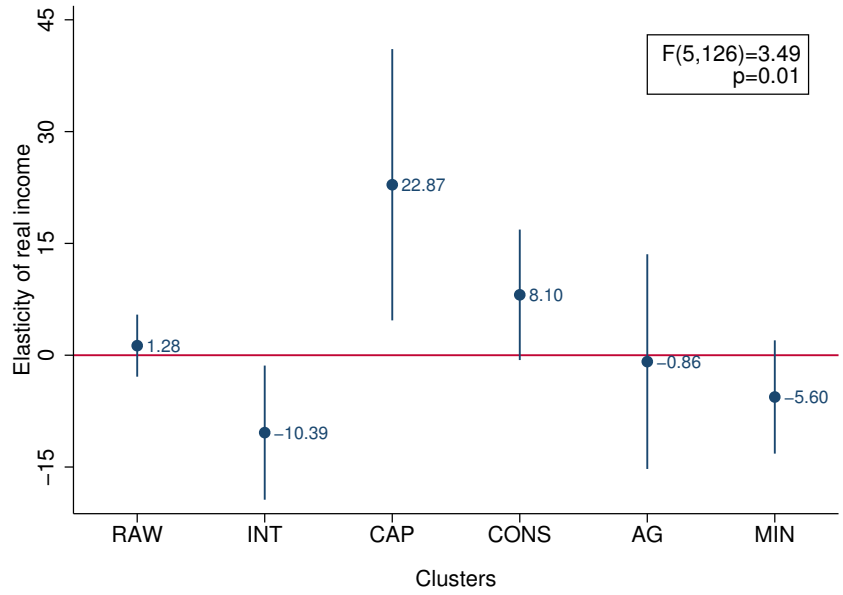
Results: Dropping contiguous countries



Foreign Demand Shocks



Foreign Supply Shocks

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