Changing Global Input-Output Linkages and Demand Spillover

Wataru Miyamoto
U of Hong Kong

Thuy Lan Nguyen
SF Fed

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Changing IO Linkages

- World input-output structure has changed over time
  - Data: World Input-Ouput Table (1965-2011)
  - Changes in international trade
  - Changes in sectoral composition
- Question: To what extent does changing world input-output (IO) linkages affect international spillover of demand changes?
- Approach: Framework based on IO analysis

Main Findings

- Significant changes in the strength of transmission
  - Foreign value added increases about twice as much with 2011 IO linkages
- Key for transmission magnitude
  - IO linkages in both intermediate and final goods
  - Demand composition
- Implication: relevant for large literature
  - Time varying transmission
  - Demand composition matters (as opposed to aggregate analysis)

Related Literature

- Changing trade, input-output linkages and business cycles
  - Bonadio, Huo, Levchenko and Pandalai-Nayar (2023): comovement
  - Caselli et al. (2017 QJE), Miyamoto and Nguyen (2022): volatility
  - This paper: transmission of demand changes
- Demand spillover
  - Bems, Johnson and Yi (2010 IMFER, 2011 AERPP): demand spillover, global trade and Great Recession
  - This paper: transmission over time

Empirical Framework

			Intermediate Demand				Final Demand	
			US Sector 1	US Sector 2	ROW Sector 1	ROW Sector 2	US	ROW
Intermediate Inputs	US	Sector 1						
	US	Sector 2						
	ROW	Sector 1			**M**			F
	ROW	Sector 2						
Value Added					V			
Gross Output					Q			

- N countries and S sectors
- Final demand F is $NS \times 1$
- Intermediate inputs M is $NS \times NS$
- Value added and Gross output are $NS \times 1$

- Assumption based on input-output (IO) analysis
  - Production function is Leontief in its input
  - Focus on the propagation through IO linkages

Empirical Framework

- Demand side: Final demand is exogenous
- Gross output in each country i and sector s in each year:

$$Q(i,s) = \sum_{j=1}^{N} \sum_{k=1}^{S} m((i,s),(j,k)) + \sum_{j=1}^{N} f((i,s),j), \qquad (1)$$

$m((i,s),(j,k))$: intermediate goods from country j sector k

$f((i,s),j)$: final goods from country j

- In matrix form:

$$Q = M \times I_{NS} + \widetilde{F}$$

Empirical Framework

- Supply side
  - Assumption: Leontief production function
    - Very short run – Boehm, Flaeen, Pandalai-Nayar (2019)
- Fixed intermediate input share
  - Define A: matrix containing share of intermediate inputs used in each sector

$$A = M\bar{Q}^{-1},$$

where $\bar{Q}$ is a diagonalized matrix of Q.

- Fixed value added share: $v' = V'\bar{Q}^{-1}$
  - Value added is determined by

$$V = \bar{v}Q$$

where $\bar{v}$ is a diagonalized matrix of v.

Empirical Framework

- Equilibrium gross output is given by

$$Q = AQ + \tilde{F} \tag{2}$$

$$\Rightarrow Q = (I - A)^{-1}\tilde{F}. \tag{3}$$

- We focus on changes in value added, so

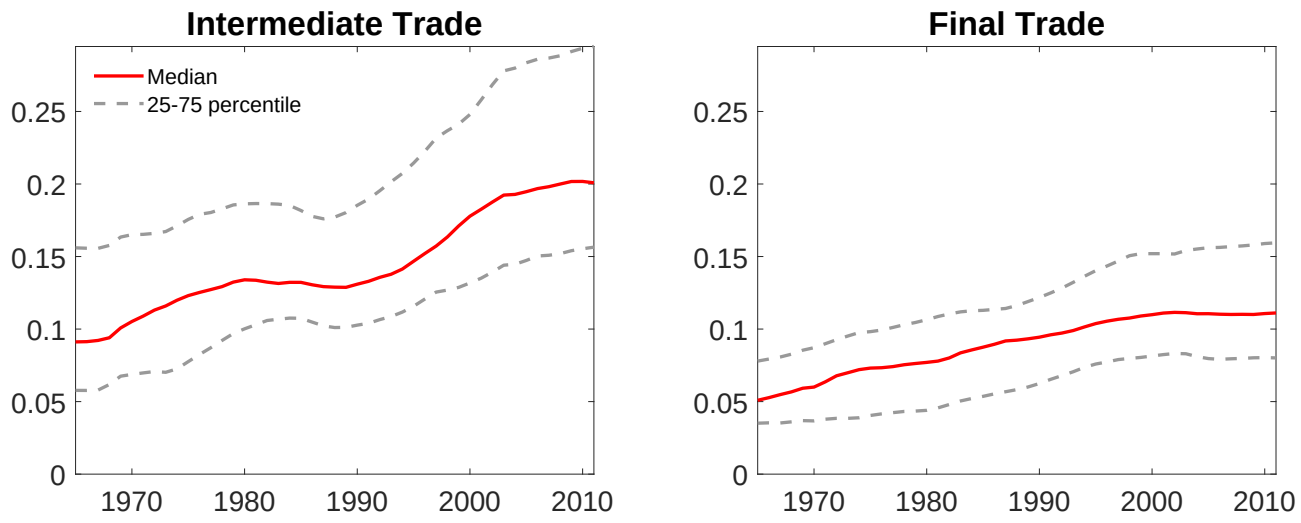
$$\Delta V = \bar{v}(I - A)^{-1}\Delta\tilde{F}.$$

- Notes:
  - Total value added change = total final demand change
  - We examine a unit change in $\tilde{F}$ to be comparable.
  - Short-run analysis

Data

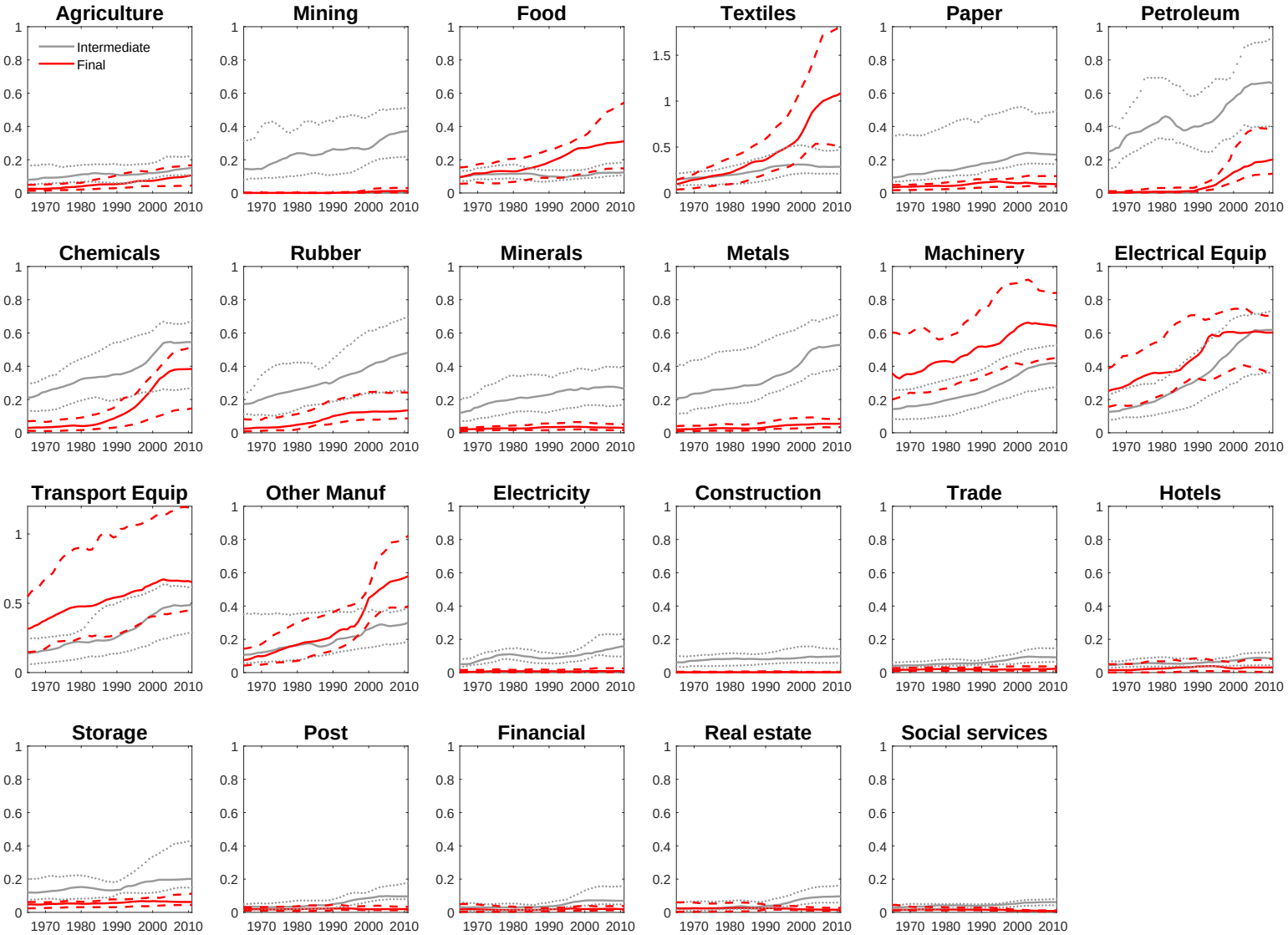
- Historical world input output tables: 1965-2000
- Combined with recent world input output database: 1995-2011
- Final data:
  - 23 countries + Rest-of-the-World (ROW): Australia, Austria, Belgium, Brazil, Canada, China, Germany, Denmark, Spain, Finland, France, the United Kingdom, Greece, India, Ireland, Italy, Japan, Korea, Mexico, the Netherlands, Portugal, Sweden, and the United States.
  - 23 sectors
- Take 10 year moving average to eliminate business cycle effect

Intermediate and Final Trade as a Share of Gross Output between 1965 and 2011



- Trade is defined as total exports and imports

Trade differences across sectors



Aggregate Economy Analysis

- One sector economy: aggregate all sectors
- Multiplier: \$1 increase in final demand of home country i
  - Demand for domestic and foreign goods
- Foreign: sum of responses of all other countries $j \neq i$
- Repeat for world IO structure at each year t

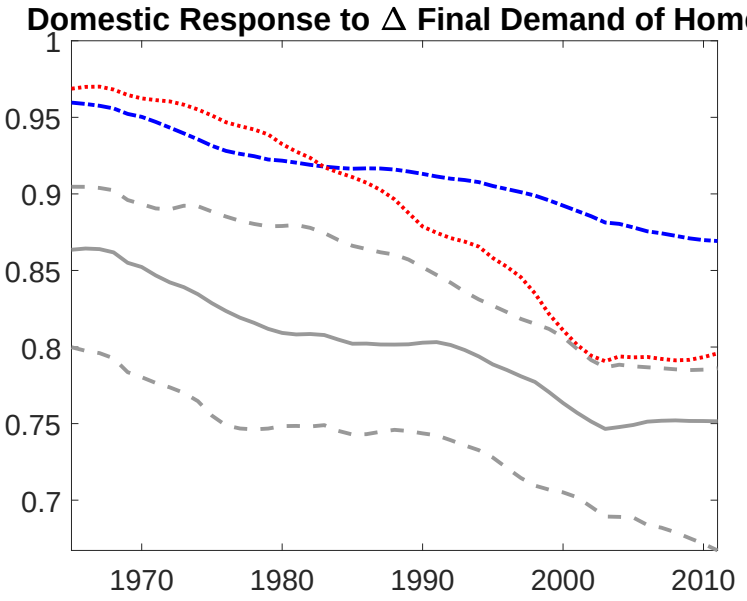
Proportional change in final demand

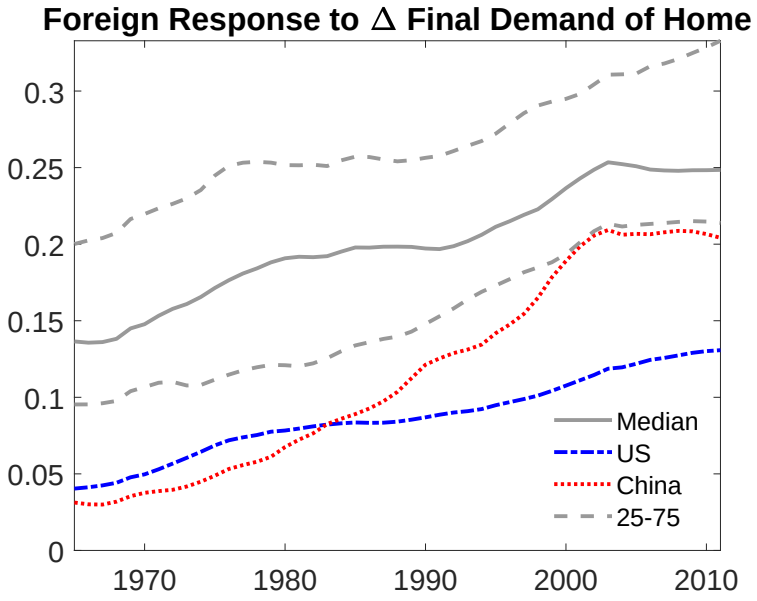
- Restriction on final demand

		Intermediate		Final demand		Gross Output
		US	ROW	US	ROW	
Intermediate	US			\$ x		
	ROW			\$ y		
Gross output						

- $\Delta x + \Delta y = 1$
- $\Delta x = x/(x+y)$ and $\Delta y = y/(x+y)$
- x and y are proportional, based on shares in final demand in IO table at time t

Spillover of $1 increase in demand in one-sector





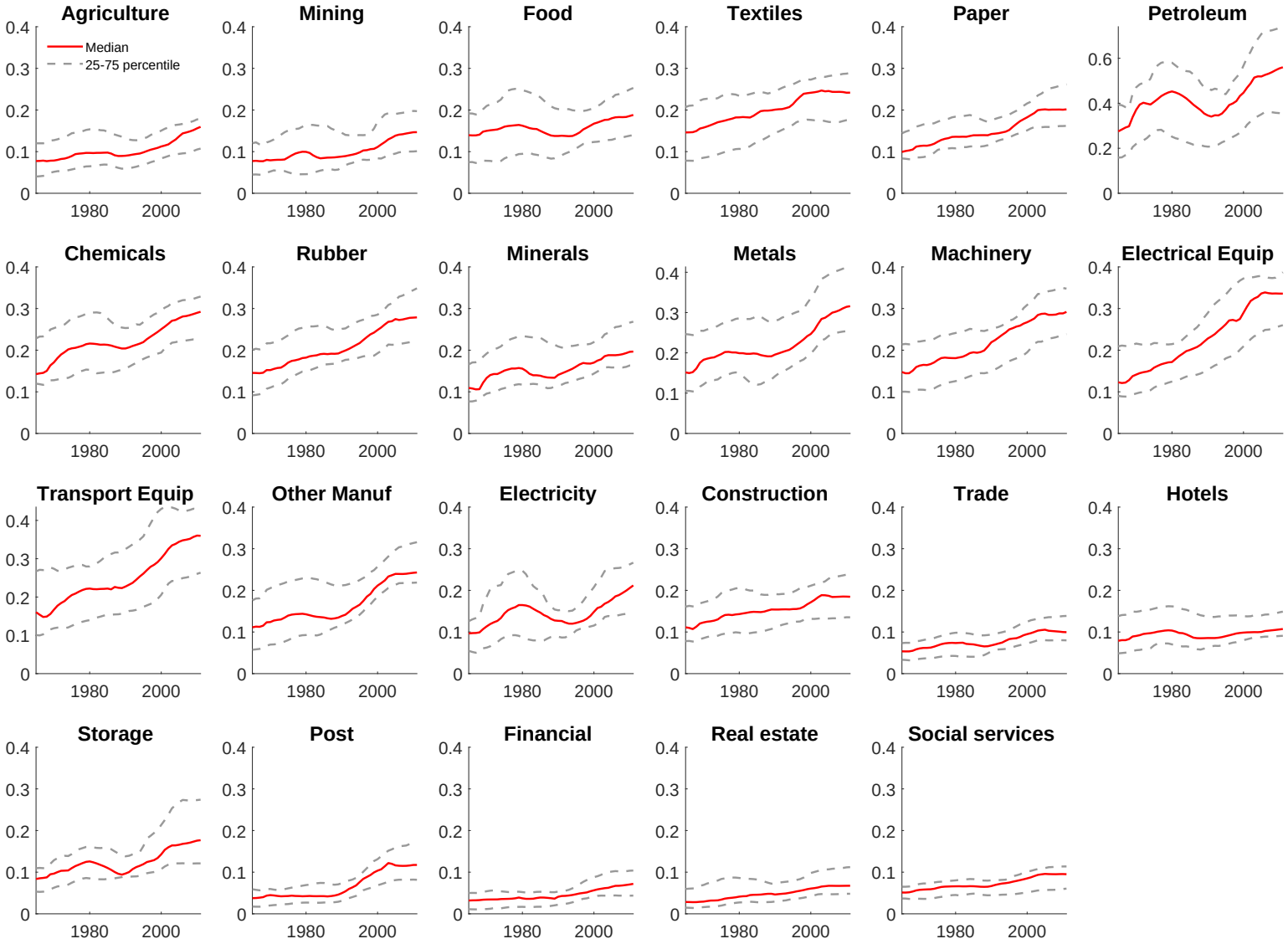
- Median response of foreign value added
  - First 5 years: $ 0.14
  - Last 5 years: $ 0.25

Multi-sector Analysis: Sector-specific demand

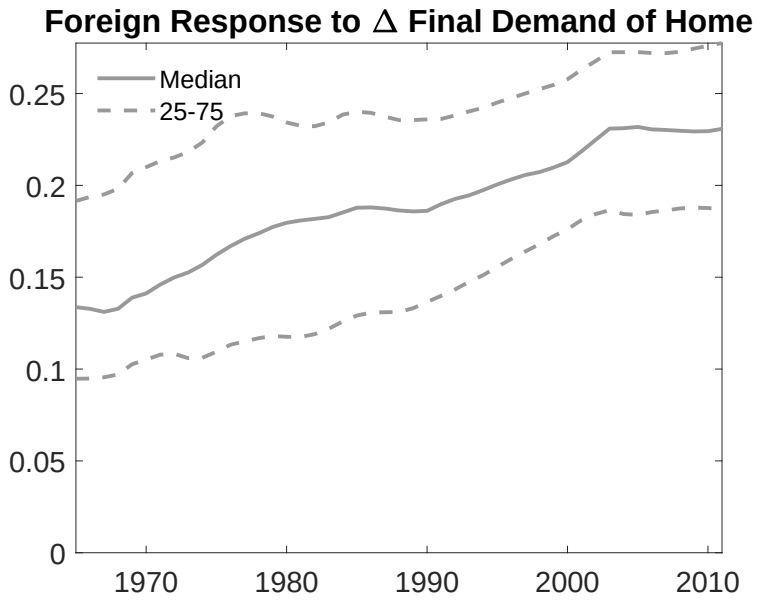
- Demand for each sector in each country increases by $1

			Intermediate				Final Demand	
			US Sector 1	US Sector 2	ROW Sector 1	ROW Sector 2	US	ROW
Intermediate	US	Sector 1					$ 1	
	US	Sector 2						
	ROW	Sector 1						
	ROW	Sector 2						
Value added								
Gross output								

SECTOR-SPECIFIC DEMAND



Spillover of $1 increase in demand in multi-sector

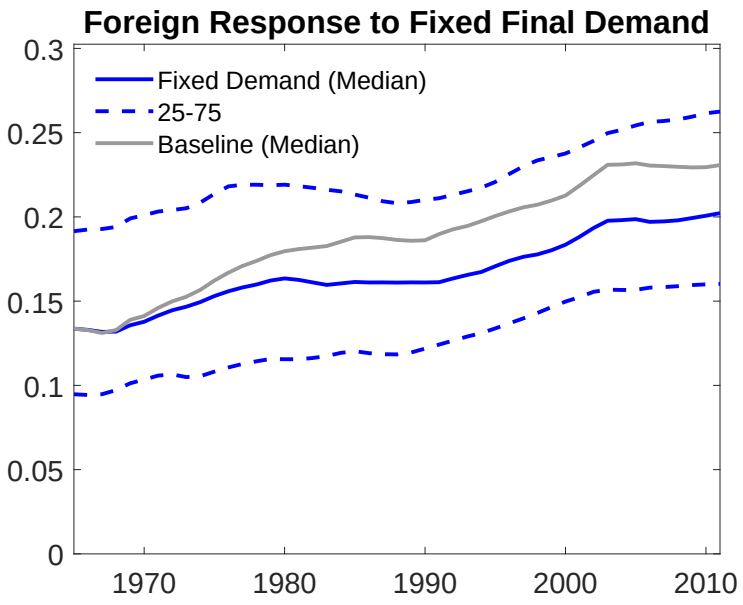


- Demand of home for both domestic and foreign final goods change proportionally
  - First 5 years: $ 0.13
  - Last 5 years: $ 0.23

Spillover of $1 increase in demand in multi-sector

- Fixing composition of $1 increase in final demand at initial year

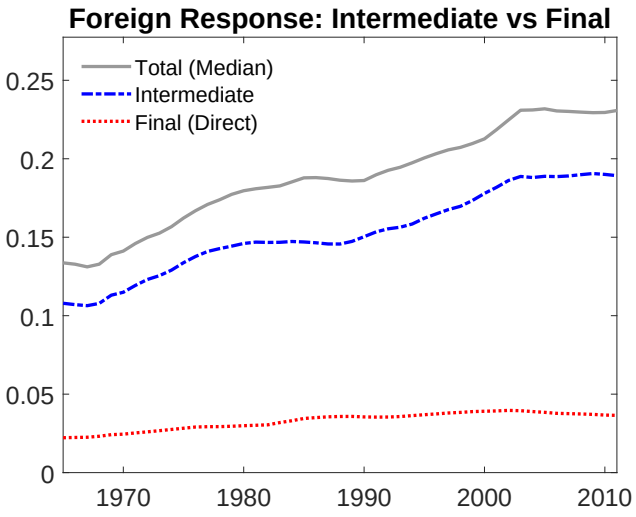
$$\Delta V = \bar{v}(I - A)^{-1}\Delta\tilde{F}_{1965}$$

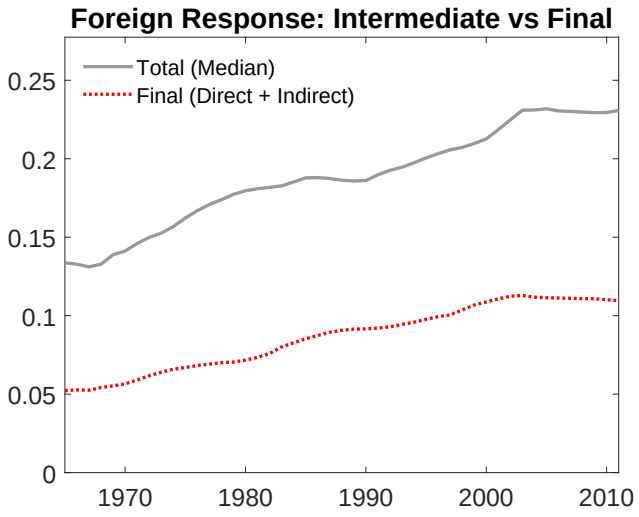


Intermediate and Final Goods Trade Channels

- Two decompositions for the final goods trade
  - (1) Direct effect of final goods trade
  - (2) Direct + indirect effects of final goods trade
  - Intermediate goods trade channel as residuals

$$
\begin{aligned}
\Delta V &= \bar{v}(I-A)^{-1}\Delta\tilde{F} \\
&= \bar{v}(I-A)^{-1}(\Delta\tilde{F}_{foreign} + \Delta\tilde{F}_{domestic}) \\
&= \bar{v}(I + A + A^2 + \ldots)(\Delta\tilde{F}_{foreign} + \Delta\tilde{F}_{domestic})
\end{aligned}
$$





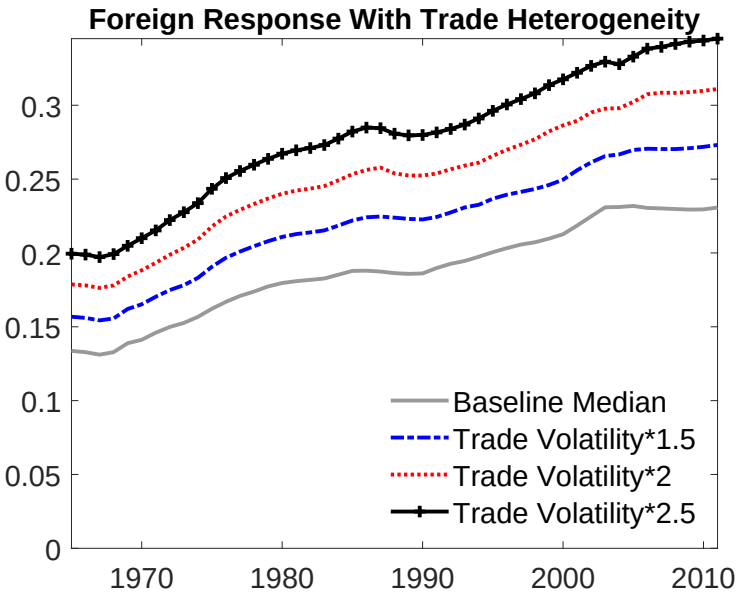
The importance of Trade Linkages and Demand Composition

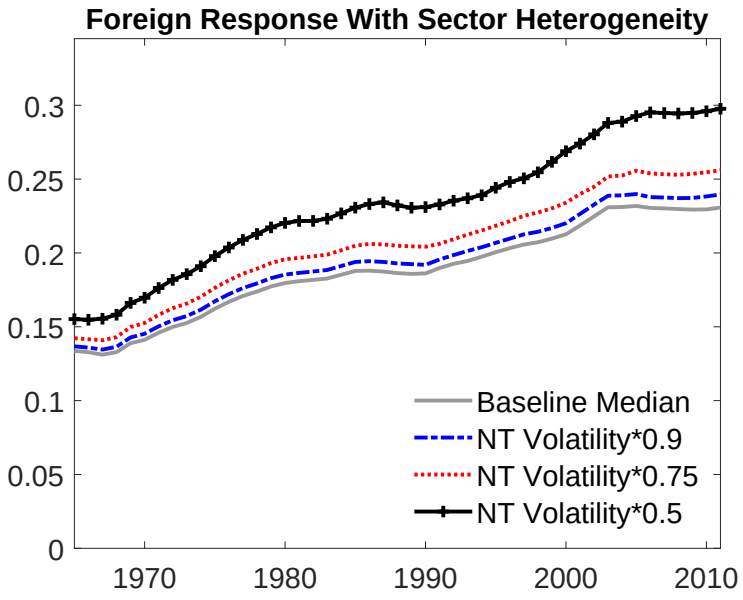
- So far, proportional changes in final demand components
- Counterfactuals for demand composition to account for:
  1. Within the same sector: demand for foreign goods is more volatile than demand for domestic goods
  2. Volatilities of final demand are different across sectors

$$\Delta V = \bar{v}(I - A)^{-1}\Delta\tilde{F}$$

$$\Delta\tilde{F} = \Delta F_{US} = [US_1, US_2, ROW_1, ROW_2]'$$

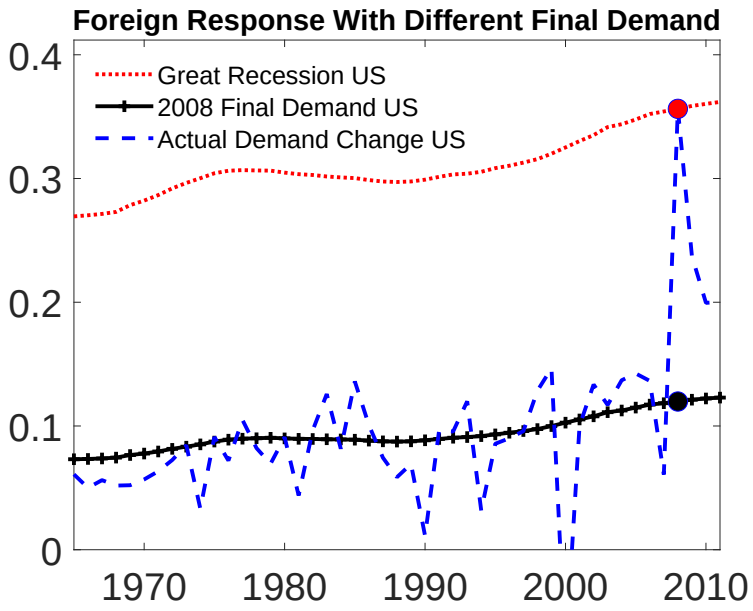
The importance of Trade Linkages and Demand Composition





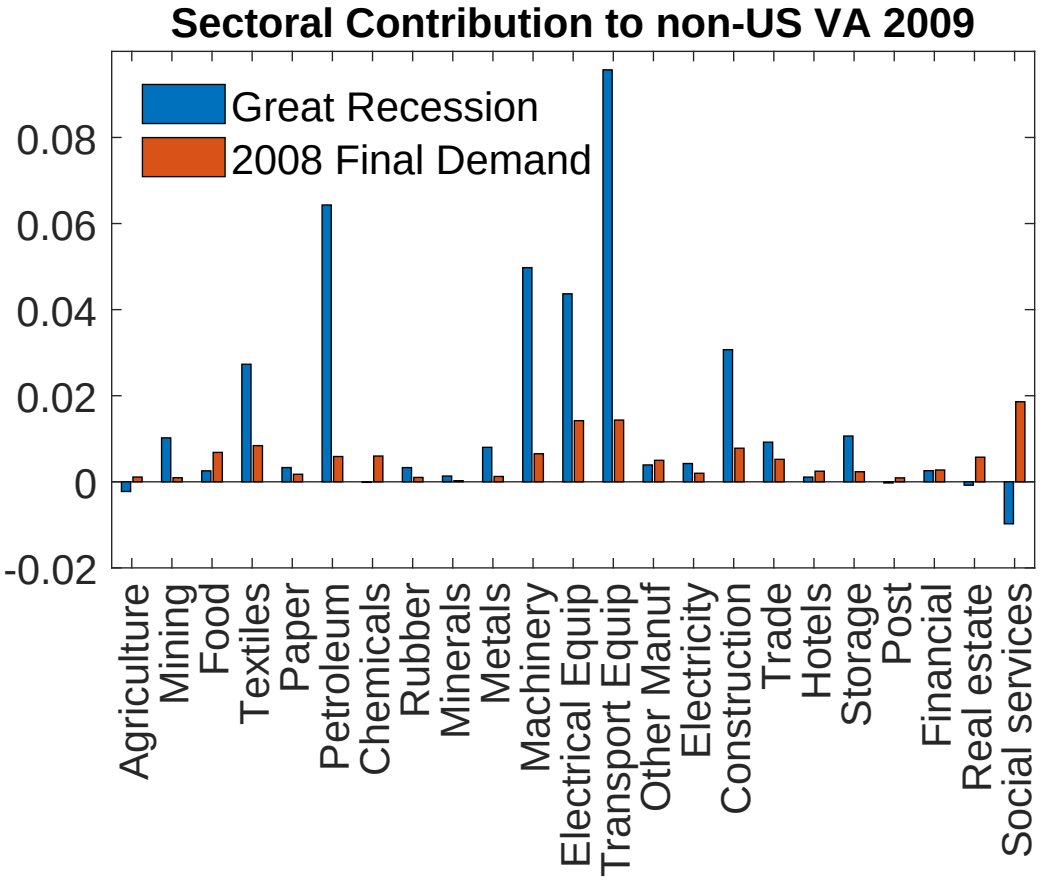
IO linkages over time and Demand composition: Great Recession

- $\Delta\tilde{F}$ is US final demand change between 2008 and 2009
  - 0.36 in 2009
  - US final demand in 2008 with proportional change: 0.12



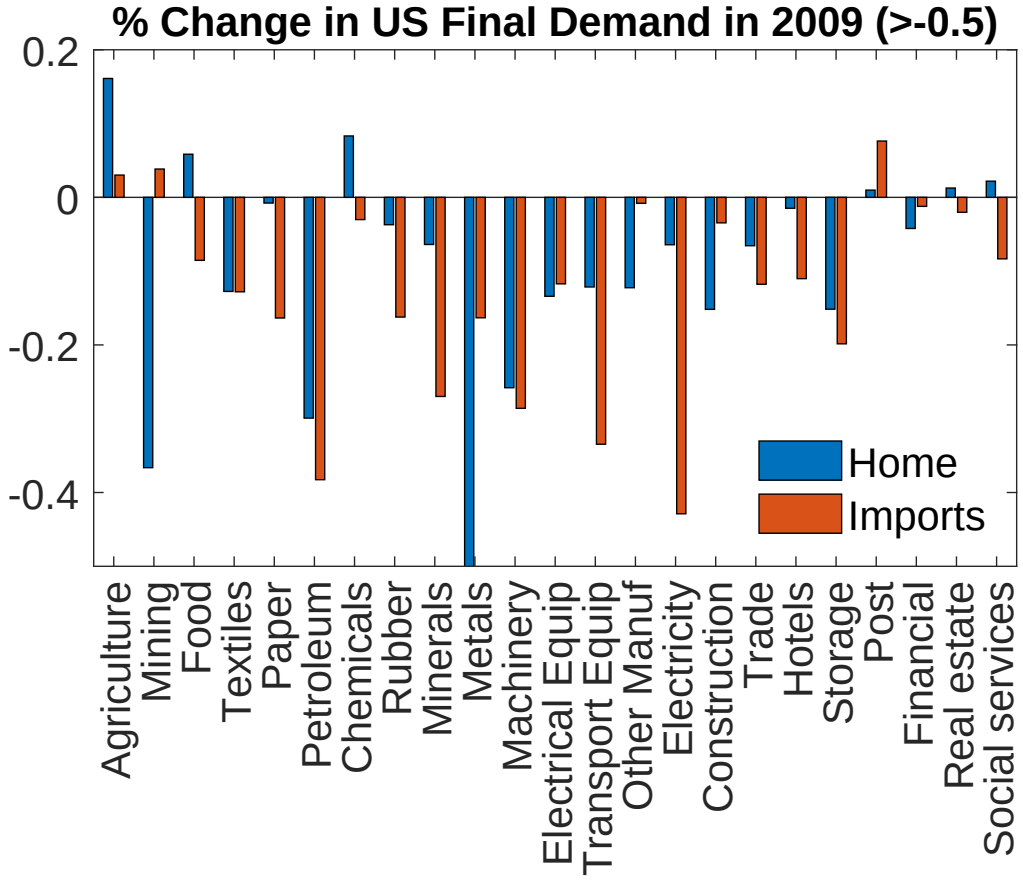
IO linkages over time and Demand composition: Great Recession

- Contribution of each sectoral final demand



IO linkages over time and Demand composition: Great Recession

- Changes in US sectoral final demand in 2009

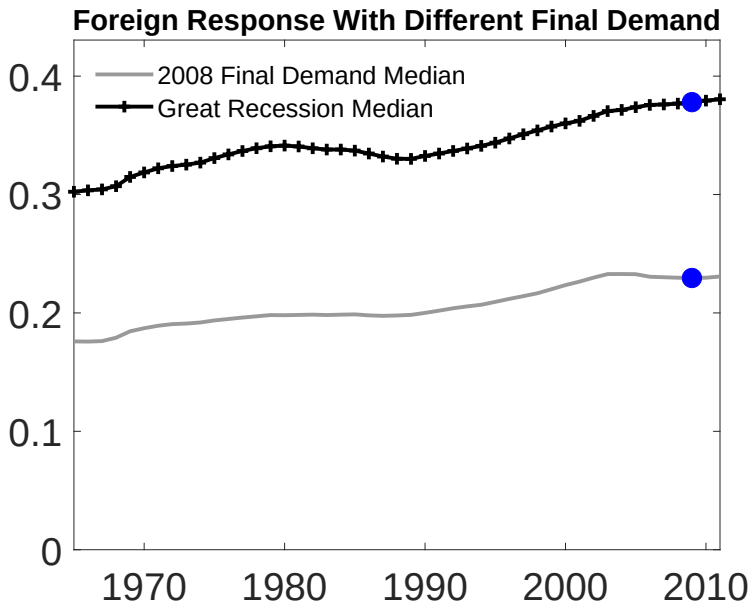


Conclusion

- Transmission has changed
  - Transmission tends to be larger due to world IO structure changes
- Transmission depends on which sector is hit by a shock
- Analysis assuming stable relationship over time and a single sector may not capture important dimensions of transmission
  - Need to pay attention to structural changes and demand composition in a multi-sector model

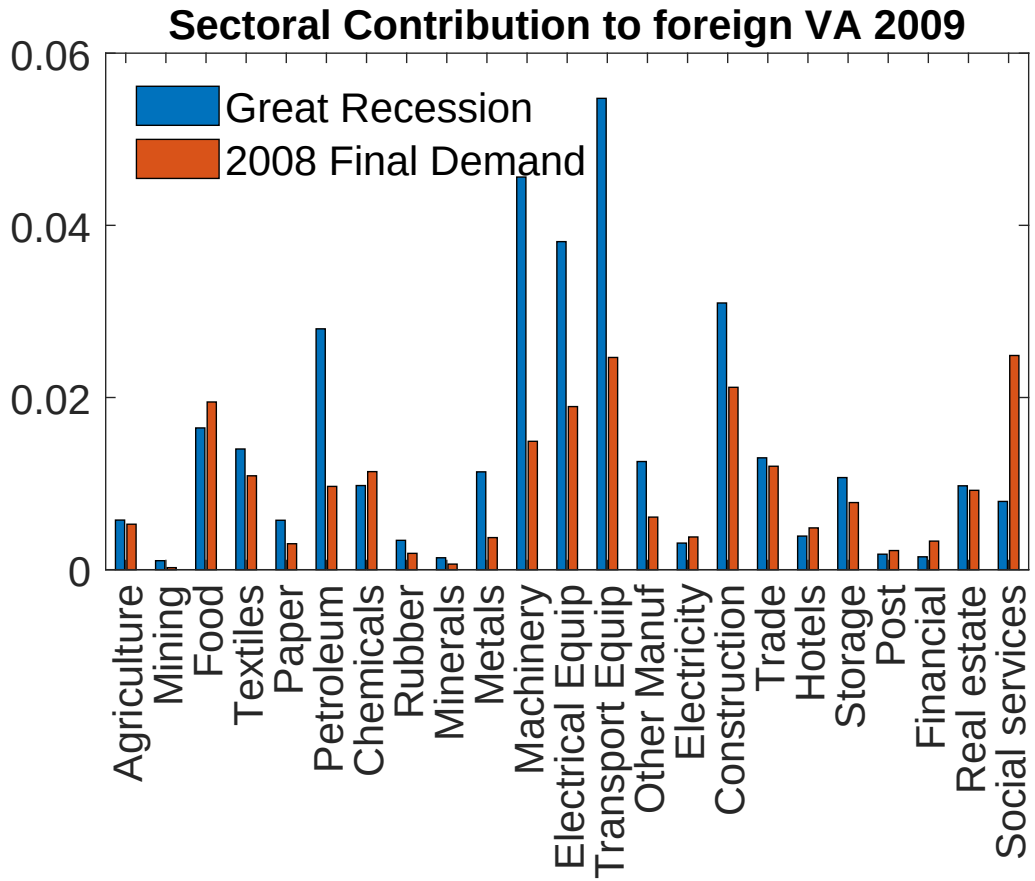
Appendix: IO linkages over time and Demand composition: Great Recession

- $\Delta\tilde{F}$ is final demand 2009 - 2008
  - 0.38 in 2009 (median)
  - 2008 final demand with proportional change: 0.23 (median)



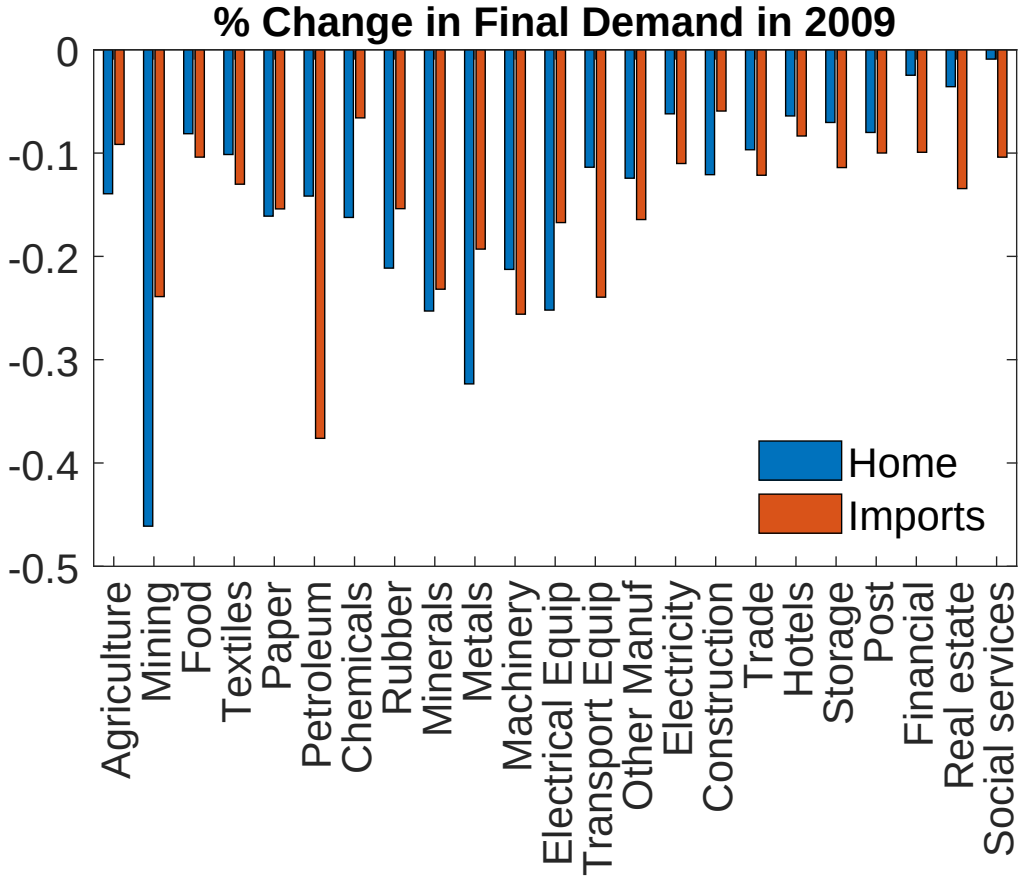
Appendix: IO linkages over time and Demand composition: Great Recession

- Contribution of each sectoral final demand (median)



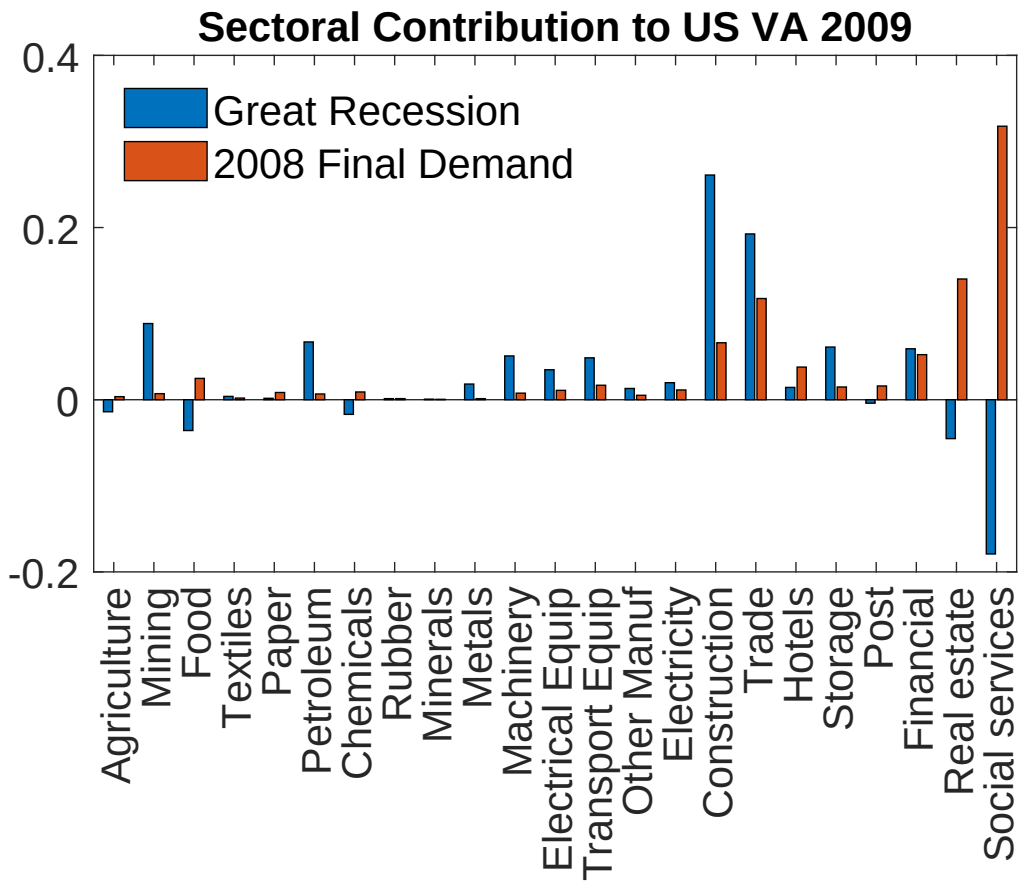
Appendix: IO linkages over time and Demand composition: Great Recession

- Changes in sectoral final demand in 2009 (median)



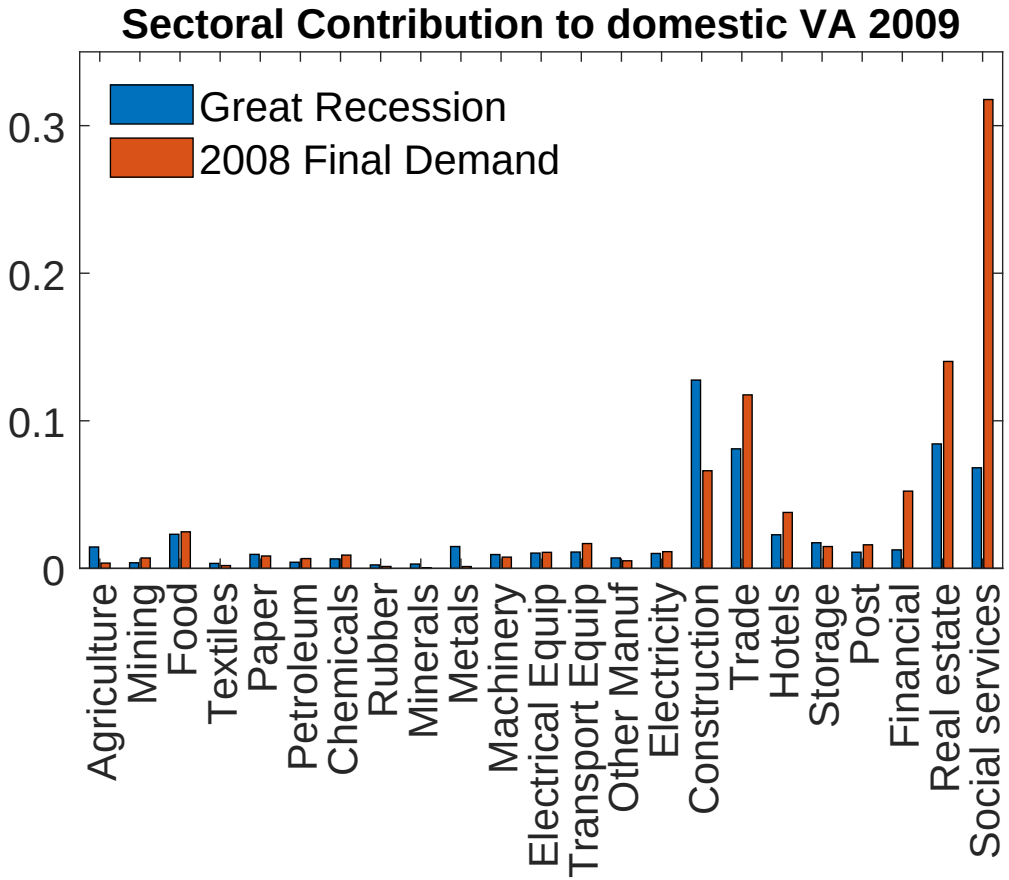
Appendix: IO linkages over time and Demand composition: Great Recession

- Contribution of each sectoral final demand to home VA



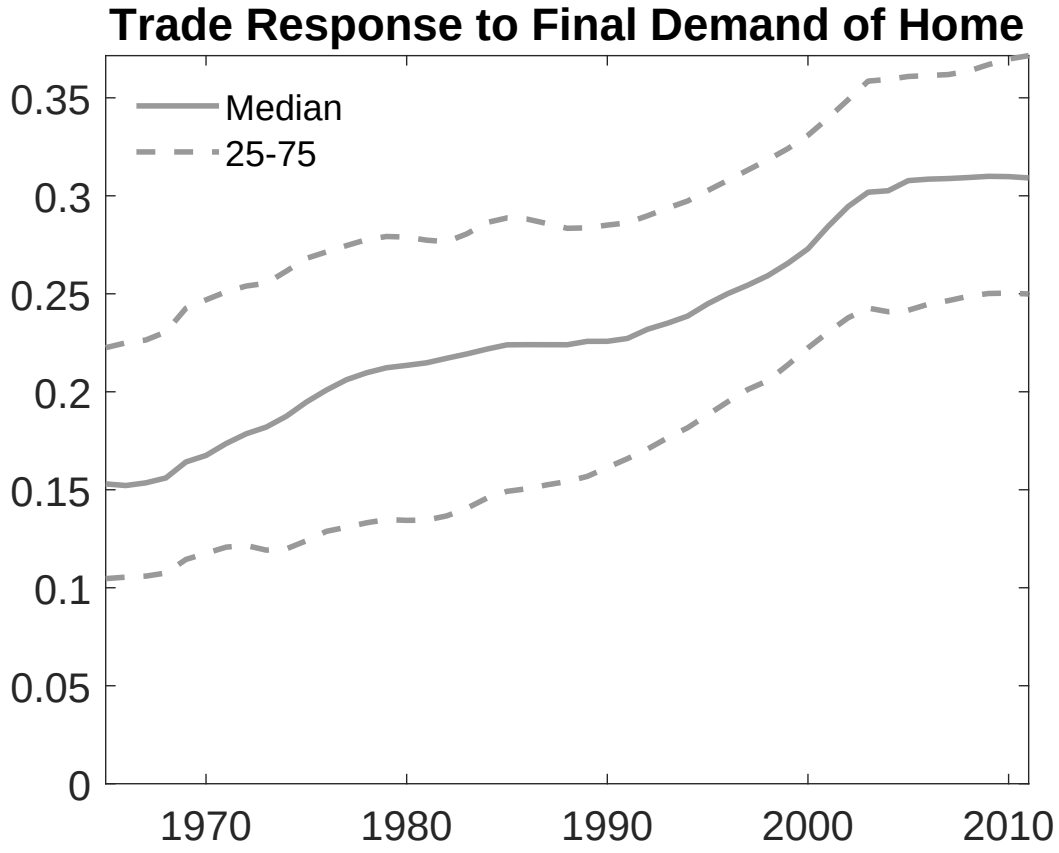
Appendix: IO linkages over time and Demand composition: Great Recession

- Contribution of each sectoral final demand to home VA (median)

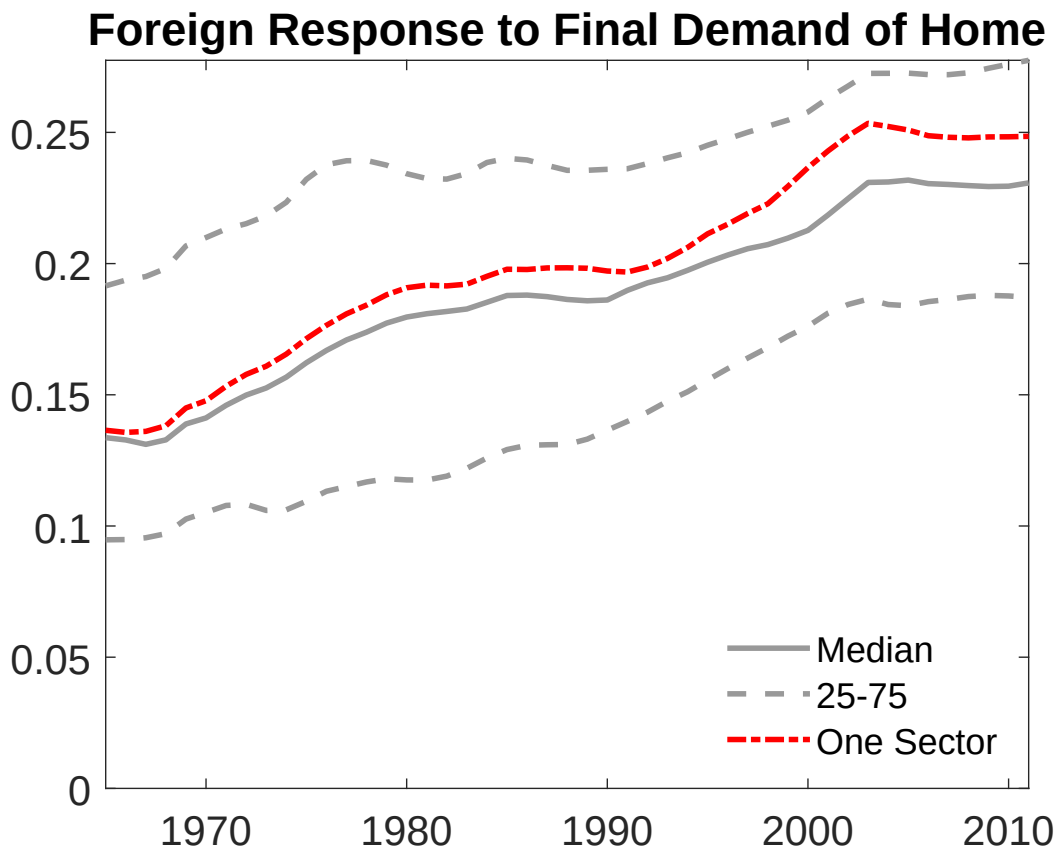


Appendix: Spillover of $1 increase in demand in multi-sector

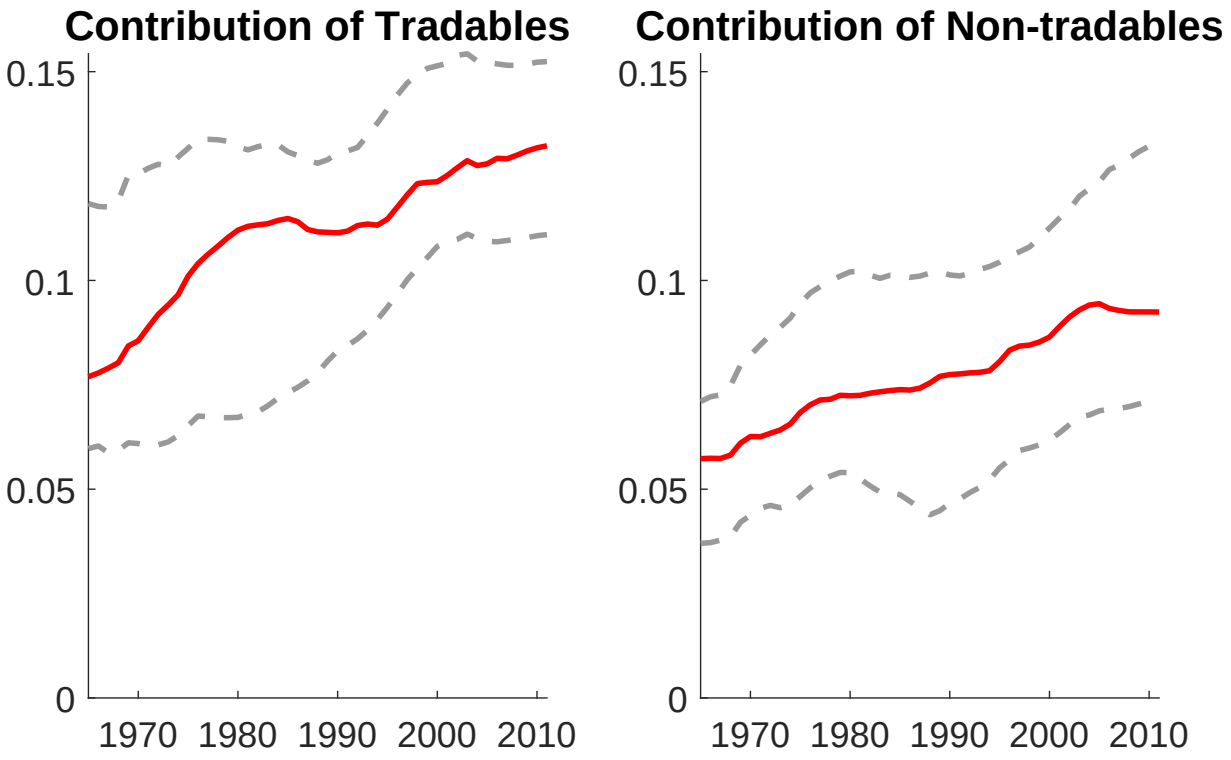
- Demand of home for both domestic and foreign final goods change proportionally
- Response of total imports in the world



Appendix: Multi-Sector vs. One-Sector



Appendix: Contribution of Tradables and Non-Tradables in Multi-Sector



- Contribution of tradables and non-tradables

$$\Delta V = \bar{v}(I - A)^{-1}\Delta\tilde{F}$$
$$= \bar{v}(I - A)^{-1}(\Delta\tilde{F}_{tradables} + \Delta\tilde{F}_{nontradables})$$