International Linkages and the Changing Nature of International Business Cycles

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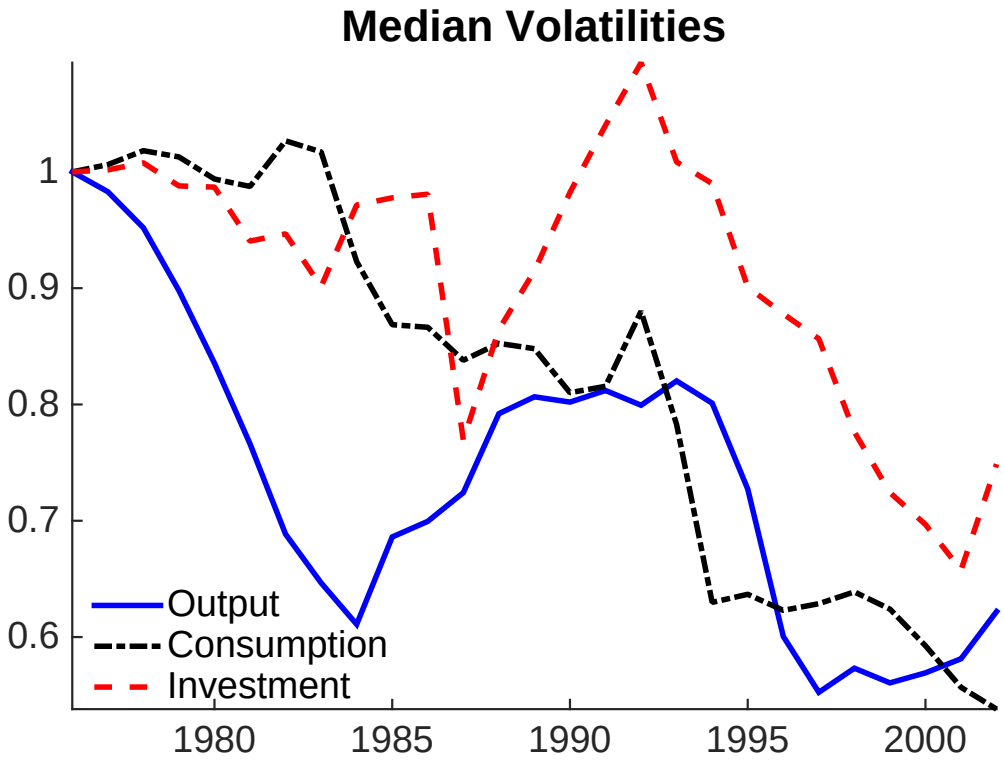
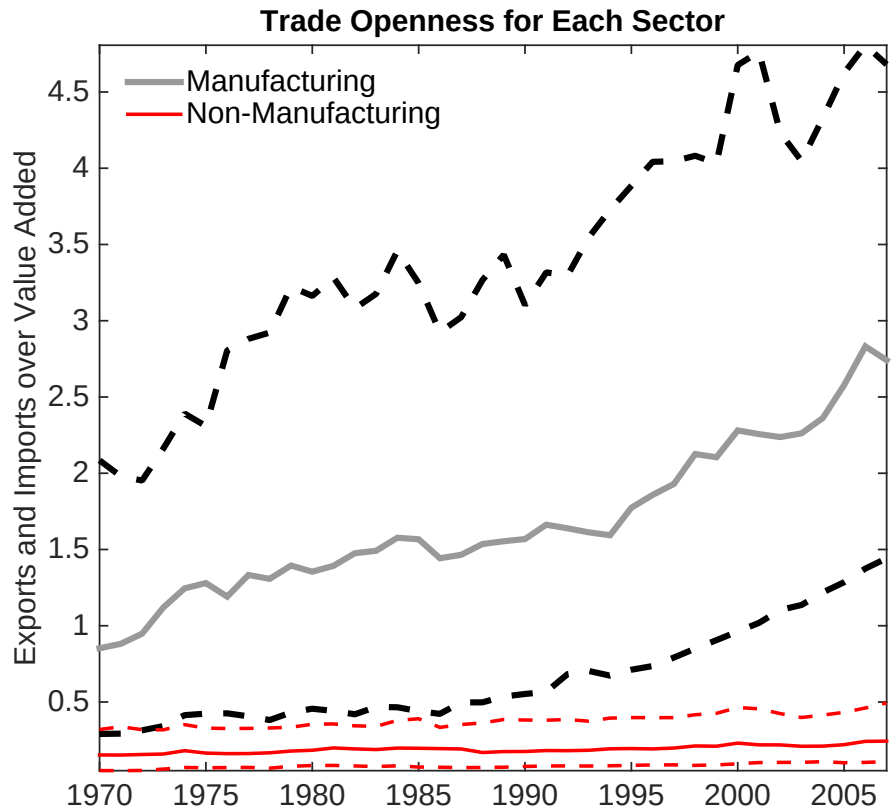
Changing Nature of Business Cycles



- The median 10-year rolling over standard deviations of the HP-filtered output, consumption and investment in 23 countries between 1970 and 2007.

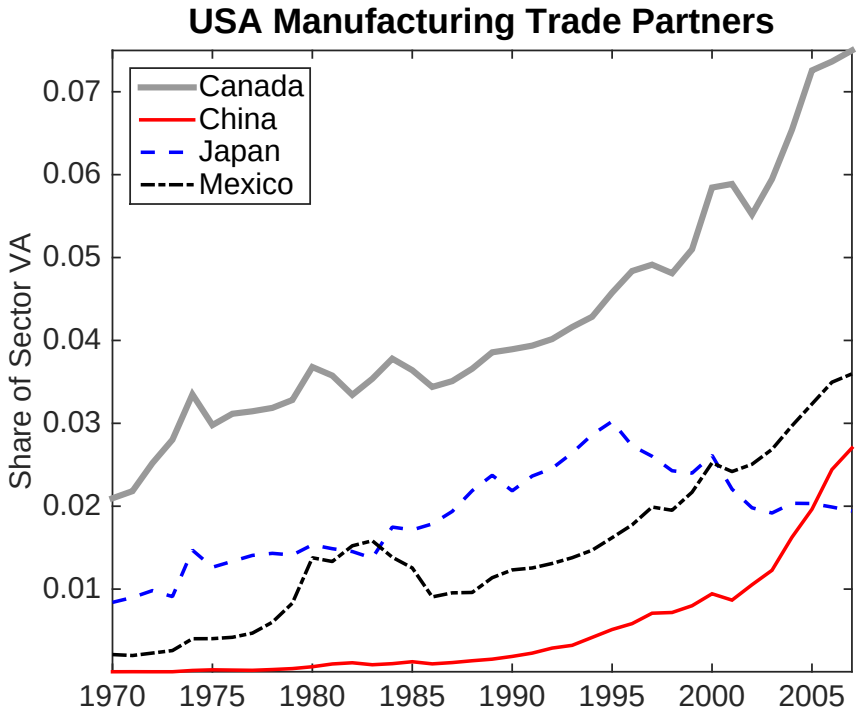
International Linkages

- Change in total trade shares: Increase in openness in most countries
  - Total trade over VA in manufacturing increased from 80% in 1970 to nearly 250% in 2007 at median.



International Linkages

- Change in trade partners
  - Example: US trades more with China and Mexico than with Japan in 2007



Our Paper

- Question: To what extent does change in international input-output linkages affect business cycles in different countries?

- Approach: Build a 24-country 2-sector augmented IRBC model
  - Match with World IO table changes from 1970–2007
  - Decompose total effects of World IO table changes into several channels

Our Paper

- Answer:
  - Changes in international input-output linkages explain 15% of drop in output volatilities at median in the baseline
    - Compare to about 40% in the data
  - The effects are heterogeneous across countries
  - International linkages tend to stabilize domestic volatilities but more risk from foreign shocks
  - Estimates depend on degrees and mechanism of transmission in the model

Related Literature

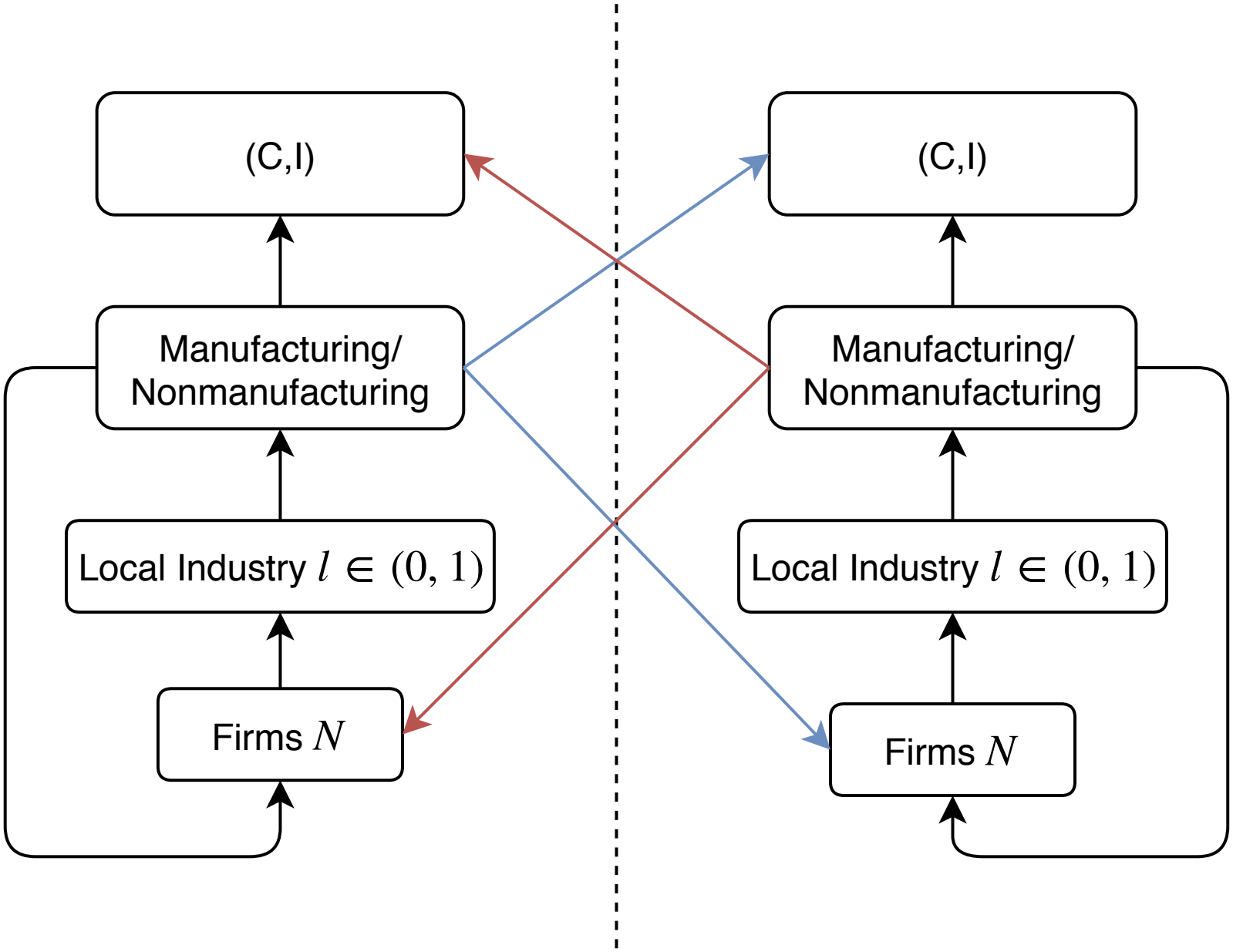
- Accounting volatility changes using network structure
  - Foerster et al. (2011), Moro (2012), Carvalho and Gabaix (2013), Atalay (2017)
- Trade, Diversification, and Volatilities
  - di Giovanni and Levchenko (2009), Caselli et al. (2017)
- International Business Cycle Comovement
  - BKK (1992), Kose and Yi (2002), Burstein et al. (2008), Johnson (2013), Davis and Huang (2011), Liao and Santacreu (2015), Nosal et al. (2015), Miyamoto and Nguyen (2017), de Soyres (2018)
- Role of intermediate good trade
  - Burstein et al. (2008), di Giovanni and Levchenko (2010), Bems et al. (2015)

Model Overview

- 24-country, 2-sector augmented International Real Business Cycle Model
  - To capture the input-output linkages within and across countries and generate endogenous transmission of shocks across countries

- Additional Features
  - Intermediate goods trade across countries and sectors
  - Variable capacity utilization
  - Variable markup generated by firms' entry and exit
  - Investment adjustment cost

Production Overview



Final and Intermediate Goods Production

- Final good firms produce consumption goods:

$$C(i) = \left[\sum_{s=1}^{S} \left(\omega_{CF}(s,i)\right)^{\frac{1}{\gamma_F}} \underbrace{\left(f_C(s,i)\right)^{\frac{\gamma_F - 1}{\gamma_F}}}_{\text{sectoral final composite good}} \right]^{\frac{\gamma_F}{\gamma_F - 1}}$$

$$f_C(s,i) = \left[\sum_{j=1}^{I} \left(\omega_{Cf}((j,s),i)\right)^{\frac{1}{\gamma_f}} \underbrace{\left(f((j,s),i)\right)^{\frac{\gamma_f - 1}{\gamma_f}}}_{\text{shipment from country } j \text{ to } i} \right]^{\frac{\gamma_f}{\gamma_f - 1}}$$

- Similar for Investment $I(i)$ and Intermediate goods $M(i)$

Raw Output Production

Firms have market power, modeled by firms' entry and exit (Jaimovich and Floetotto (2008 JME))

Variable markup: depending on states of business cycles, high in slumps and low in booms

- Each local industry has a limited number of firms
- Local output $L(i,s|l)$ where $l \in [0,1]$

$$L(i,s|l) = N_f (i,s|l)^{-\frac{1}{\gamma_L - 1}} \left[\sum_{k=1}^{N_f} q(i,s|l,f)^{\frac{\gamma_L - 1}{\gamma_L}} \right]^{\frac{\gamma_L}{\gamma_L - 1}}$$

- Raw sector output is given by:

$$Q(i,s) = \left[\int_0^1 L(i,s|l)^{\frac{\gamma_Q - 1}{\gamma_Q}} dl \right]^{\frac{\gamma_Q}{\gamma_Q - 1}}$$

Raw Output Production

- Production technology for each firm f:

$$q(i,s|l,f) = \left[\begin{array}{c} \omega_q(i,s)^{\frac{1}{\gamma_q}} \left(A(i,s) K(i,s|l,f)^{\alpha} H(i,s|l,f)^{1-\alpha} \right)^{\frac{\gamma_q - 1}{\gamma_q}} \\ + \left(1 - \omega_q(i,s)\right)^{\frac{1}{\gamma_q}} \left(M(i,s|l,f) \right)^{\frac{\gamma_q - 1}{\gamma_q}} \end{array} \right]^{\frac{\gamma_q}{\gamma_q - 1}} - \phi(i,s)$$

- Productivity process:

$$\ln A_t(i,s) = \rho_A \ln A_{t-1}(i,s) + e_t^A(i,s)$$

HOUSEHOLDS

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C(i), H(i))$$

subject to budget constraint:

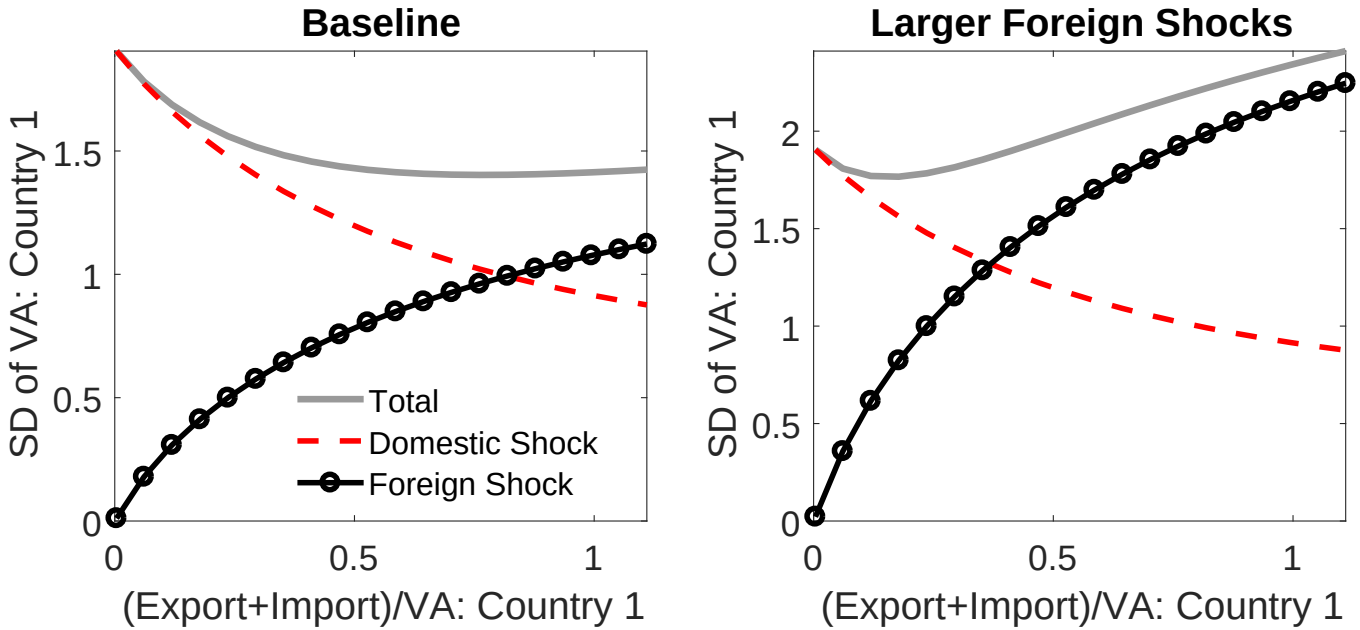
$$C_t(i) + p_t^I(i) I_t(i) + \mathbb{E}_t \varepsilon_t(i) r_{t,t+1} B_{t+1}(i) \leq$$
$$W_t(i) H_t(i) + R_t^k(i) \left(u_t(i) K_t(i)\right) + \varepsilon_t(i) B_t(i)$$

Capital accumulation:

$$K_{t+1}(i) \leq \left(1 - \delta(u_t(i))\right) K_t(i) + I_t(i) \left(1 - S\left(\frac{I_t(i)}{I_{t-1}(i)}\right)\right)$$

Relationship between international linkages and output volatility

- 2 country 2 sector model: Canada and the US
- Varies trade shares in manufacturing sector



CALIBRATION

Common parameters:

Parameter	Value	
β	0.96	Discount factor
α	0.36	Labor share parameter
δ	0.1	Depreciation rate
σ	2	Inverse of IES
ν	1	Inverse of Frisch labor supply
κ	0.1	Wealth effect parameter
$\frac{\delta_u''}{\delta_u'}u$	0.05	Inverse utilization elasticity
γ_F	1	ES between sectoral goods
γ_f	1	ES between home and foreign goods
ϵ_{markup}	0.12	Elasticity of markup
s	0.1	Investment adjustment cost
ρ_A	0	Shock persistence

CALIBRATION

Calibrate productivity shock standard deviations

- Let ω be the vector of steady state parameters that include all share and size parameters in IO table
- Calibrate ω: Average of World IO table (1984–1993)
  - Midpoint of the sample
  - Average to eliminate the effects of business cycles
- Match the standard deviations of sectoral value added in each country

$$\sigma_{data} VA(i,s) = \sigma_{model} VA(i,s)$$

DECOMPOSITION: WORLD IO TABLE

TABLE: General World IO table

		CA s1	CA s2	US s1	US s2	CA final	US final	GO
CA	s1	M_{11}	M_{12}	M_{13}	M_{14}	F_{11}	F_{12}	Q_1
CA	s2	M_{21}	M_{22}	M_{23}	M_{24}	F_{21}	F_{22}	Q_2
US	s1	M_{31}	M_{32}	M_{33}	M_{34}	F_{31}	F_{32}	Q_3
US	s2	M_{41}	M_{42}	M_{43}	M_{44}	F_{41}	F_{42}	Q_4
VA		V_1	V_2	V_3	V_4			
GO		Q_1	Q_2	Q_3	Q_4			

Notes: M is $IS \times IS$, V is $IS \times 1$, Q is $IS \times 1$ and F is $IS \times I$.

EXPERIMENT 1: WORLD IO TABLE CHANGE

- Fix shock processes
- We solve the model corresponding to each year
- Denote $\omega(year)$ to be the steady state for each year
- Calibrate $\omega(year)$ using rolling mean WIOT and solve model
  - Mean of WIOT 1985-1995 $\rightarrow \omega(1990) \rightarrow \sigma^{Y}_{1990}$
  - Mean of WIOT 1986-1996 $\rightarrow \omega(1991) \rightarrow \sigma^{Y}_{1991}$
- Effects = $\sum_{h=0}^{T} \left(\sigma^{Y}_{1970+h+1} - \sigma^{Y}_{1970+h}\right)$

EXPERIMENT 2: INTERNATIONAL LINKAGES

Goal: Isolate changes due to openness from others such as sectoral compositions of inputs, sector sizes

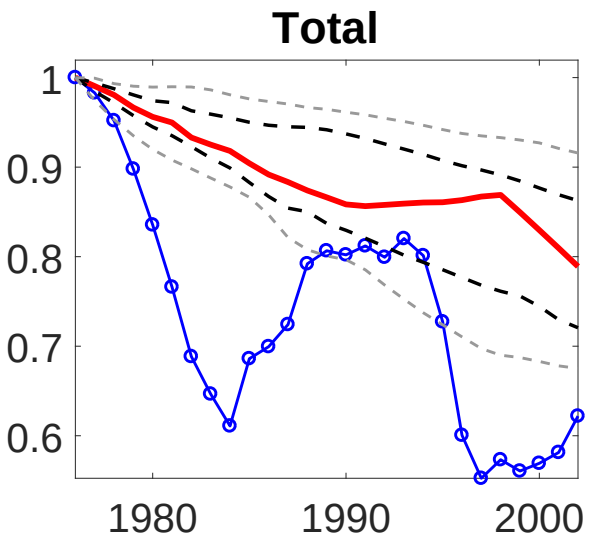
- Construct hypothetical $\widetilde{WIOT}$ at each year T
  - Calculate shares of M and VA in GO by column
  - Fix VA shares and sectoral shares at time T-1
  - Update foreign relative to domestic intermediate shares within sector
  - Update final demand: foreign relative to domestic shares
- Calibrate $\omega(year)$ using $\widetilde{WIOT}$ and solve model
- Effects = $\sum_{h=0}^{T} \left(\widetilde{\sigma}^{Y}_{1970+h+1} - \sigma^{Y}_{1970+h} \right)$

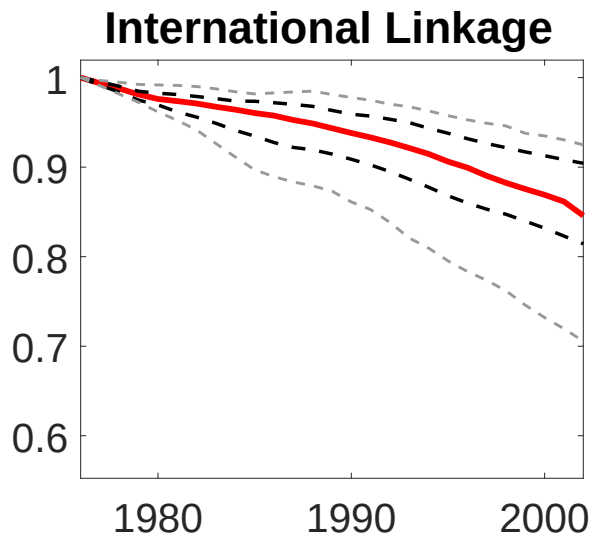
EXPERIMENT 3: RELATIVE SECTORAL SIZE

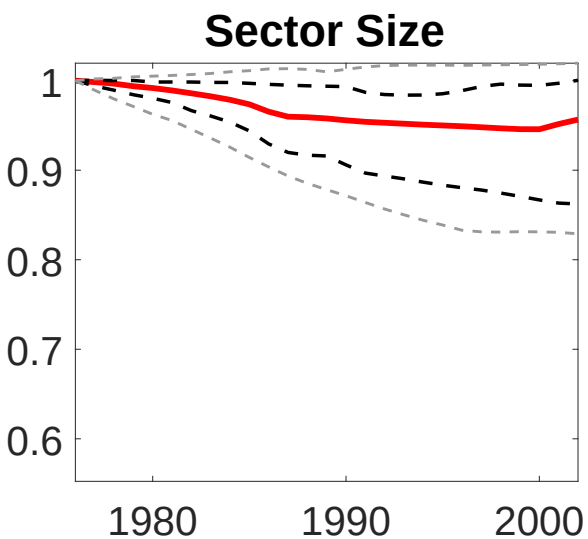
Goal: Isolate changes due to sector size from others such as sectoral compositions of inputs, country sizes

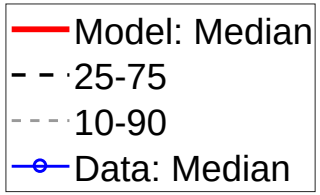
- Construct hypothetical $\widetilde{WIOT}$ at each year T
  - Only update relative sector sizes
  - Calculate new final demands from constraint of WIOT
    - Keep foreign to domestic shares of final demand at T-1
- Calibrate $\omega(year)$ using $\widetilde{WIOT}$ and solve model
- Effects = $\sum_{h=0}^{T} \left(\widetilde{\sigma}^{Y}_{1970+h+1} - \sigma^{Y}_{1970+h} \right)$

World IO changes & Changing Volatilities

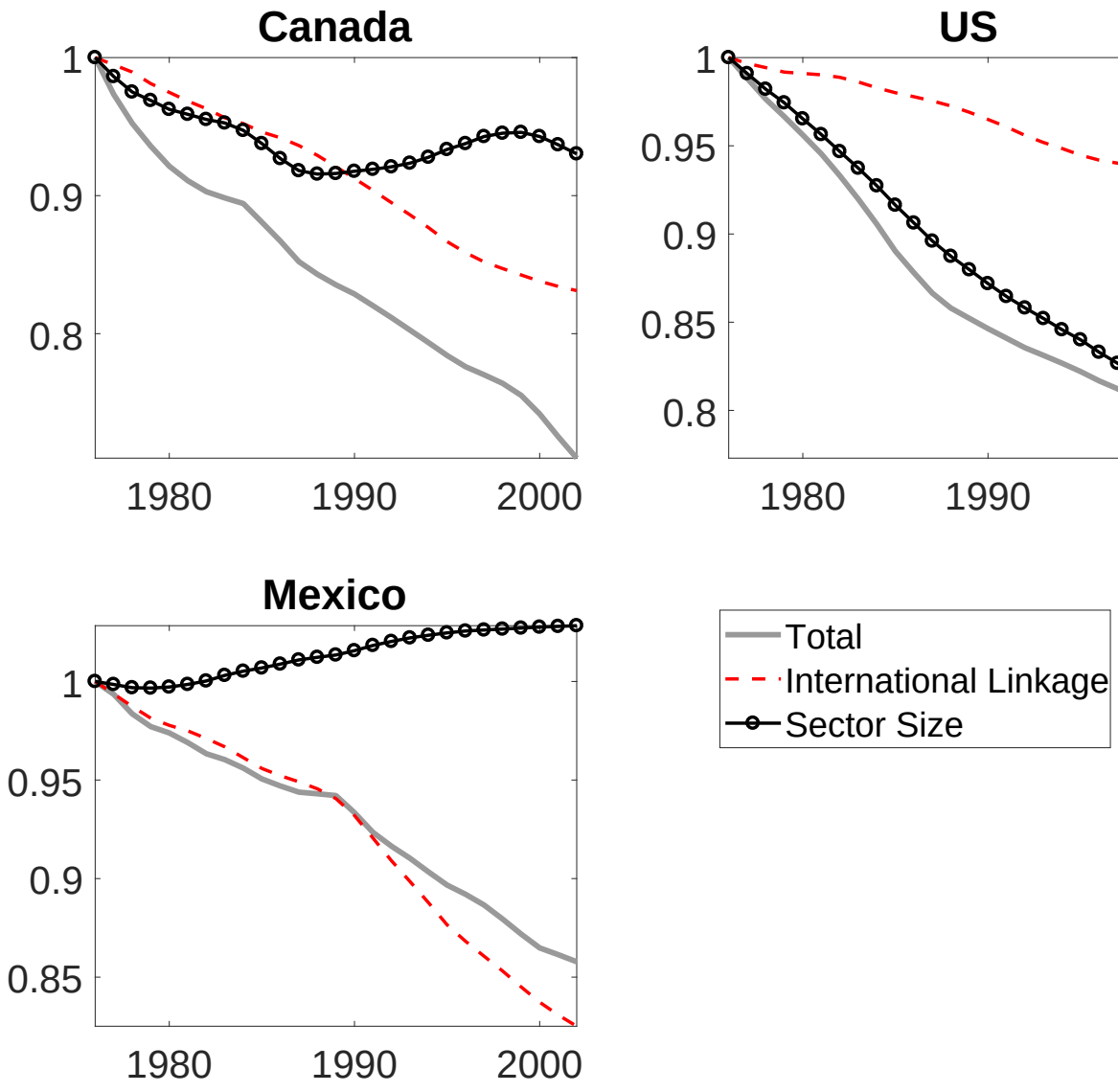




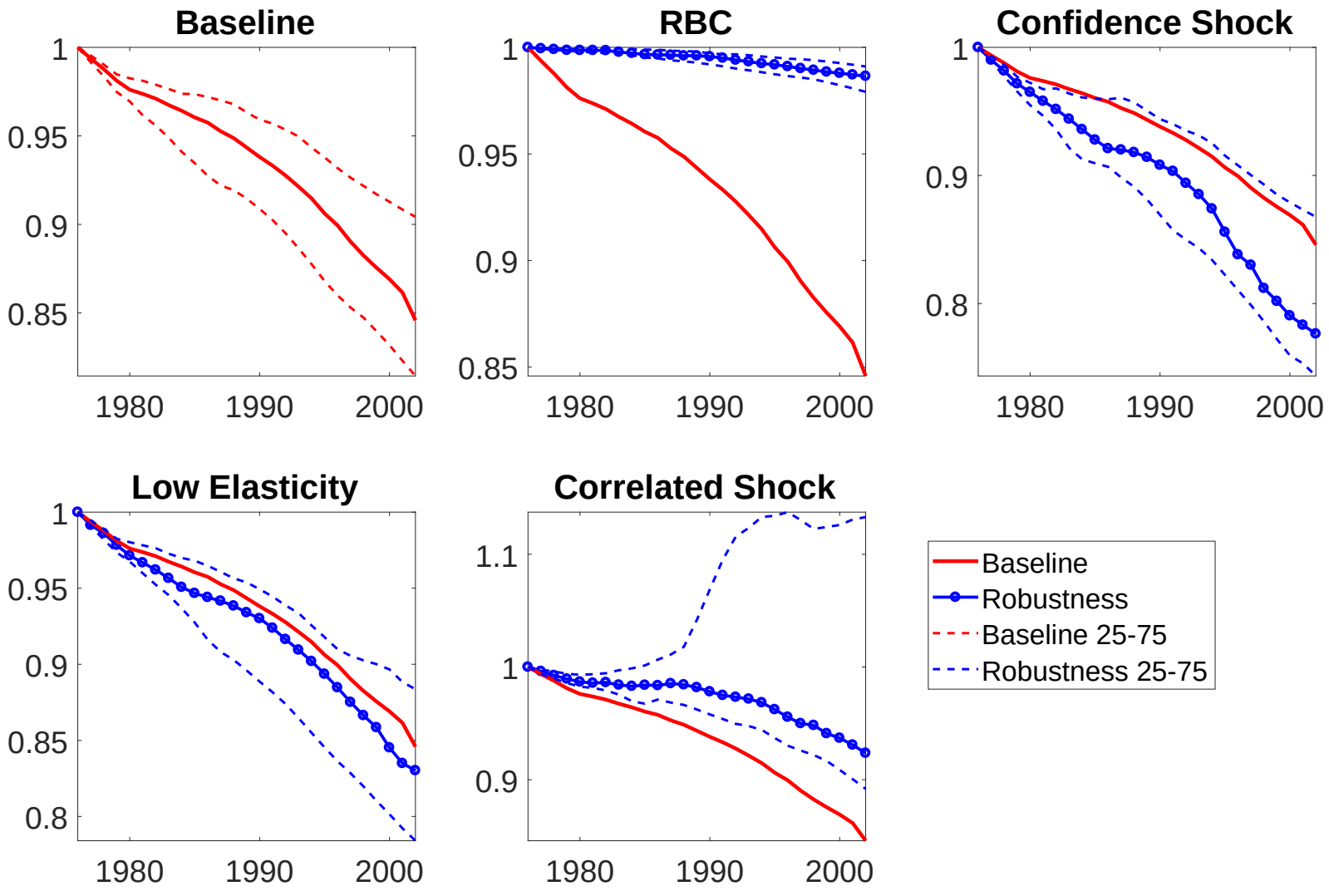




World IO changes & Changing Output Volatilities: Heterogeneity



Inspecting Mechanism



Potential Risk: Cross-Country Value Added Multipliers

- How much do shocks in one country affect other countries over time?
- Define Cross-country value added multipliers

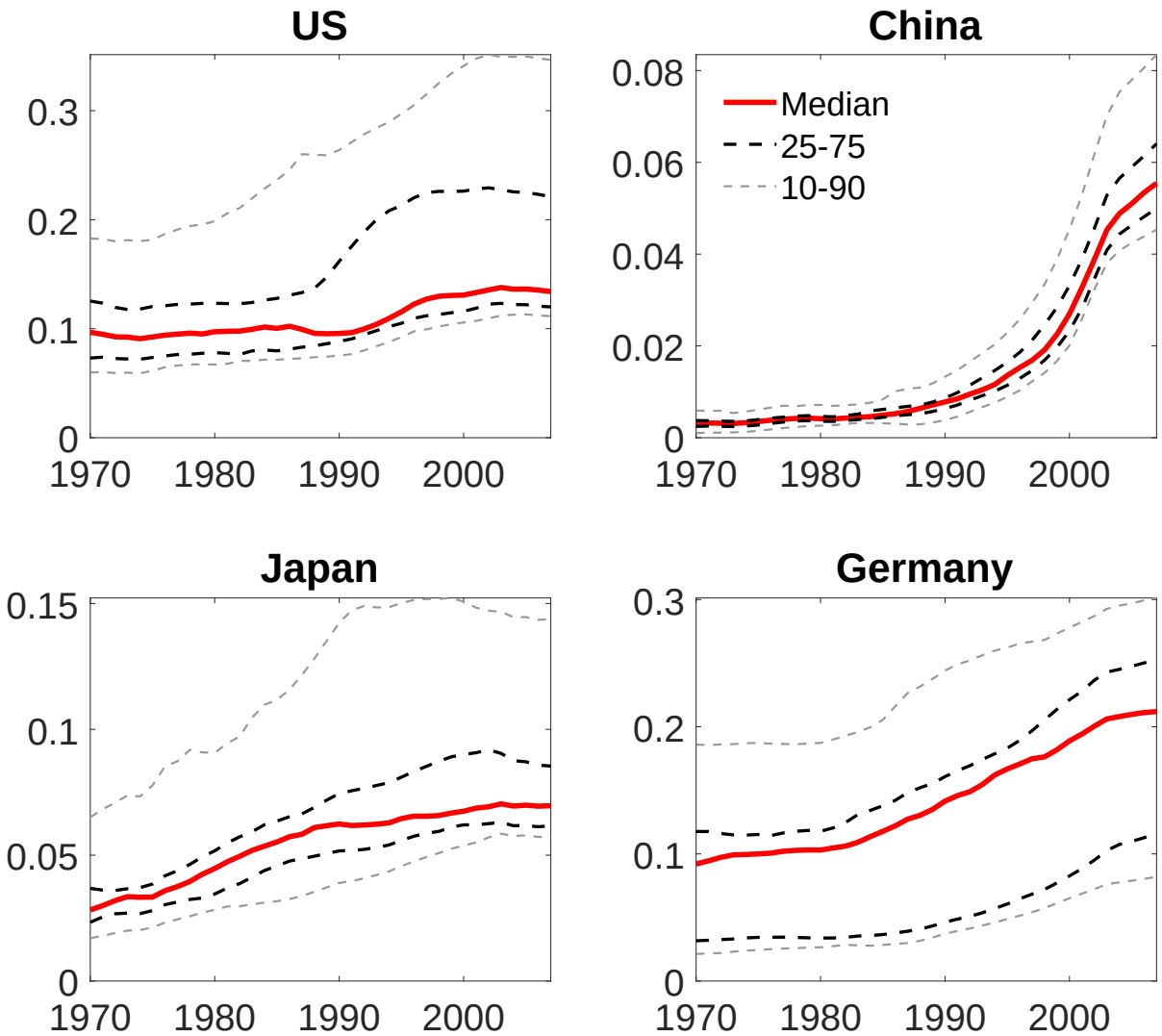
$$M_{US}^{H} = \frac{\sum_{h=1}^{H} \frac{\partial VA_{X,h}}{\partial A_{US,1}}}{\sum_{h=1}^{H} \frac{\partial VA_{US,h}}{\partial A_{US,1}}} \tag{1}$$

with X as other countries in the sample

  - Over H years, if US output goes up by 1%, Country X's output goes up by M%
  - Account for *only* degree of transmission of shocks across countries over time

MULTIPLIERS OVER TIME

$\omega(year)$ based on entire World IO Table change

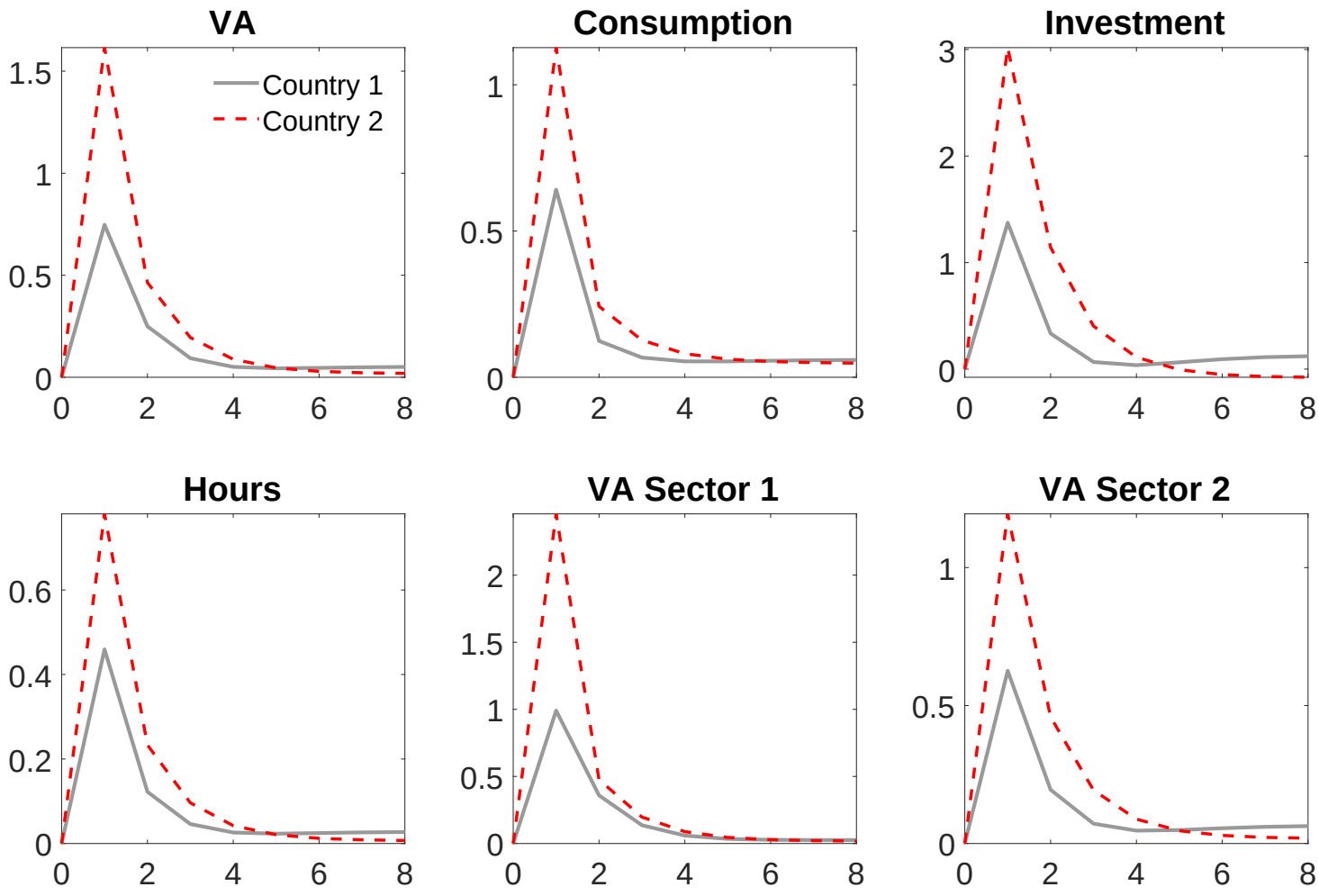


Conclusion

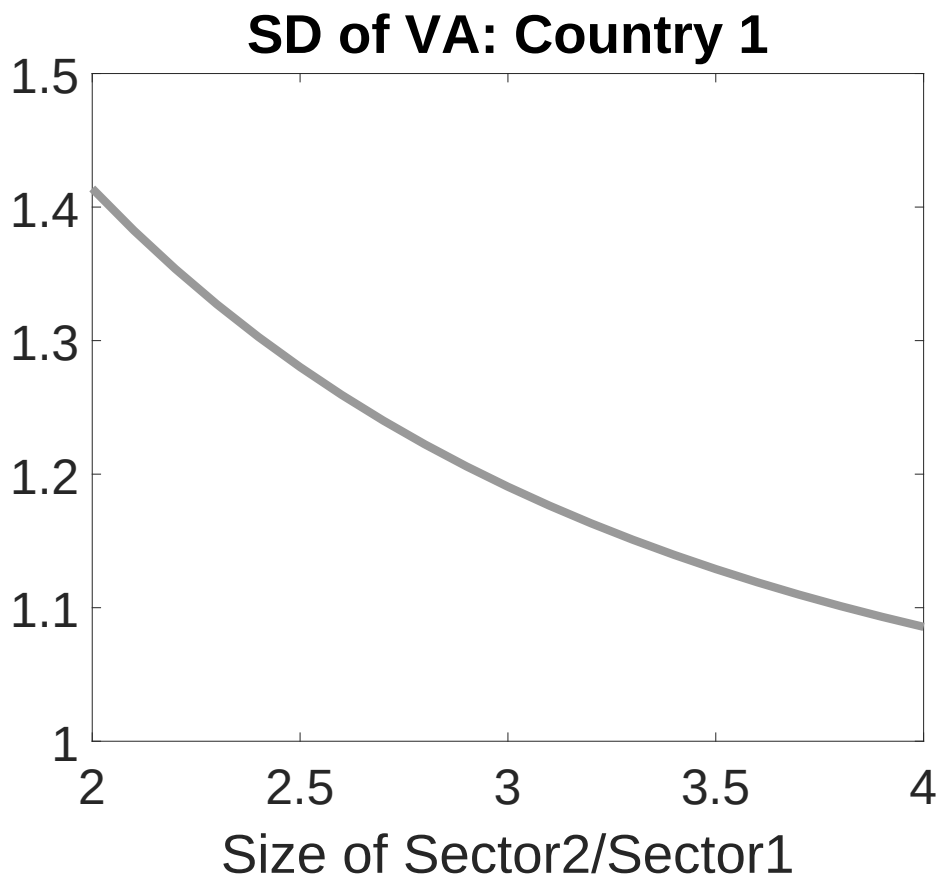
- Our model implies that international linkages explain a sizable change in aggregate volatilities
- Effects are heterogeneous across countries
- Increase in potential risk

EXTRA SLIDES

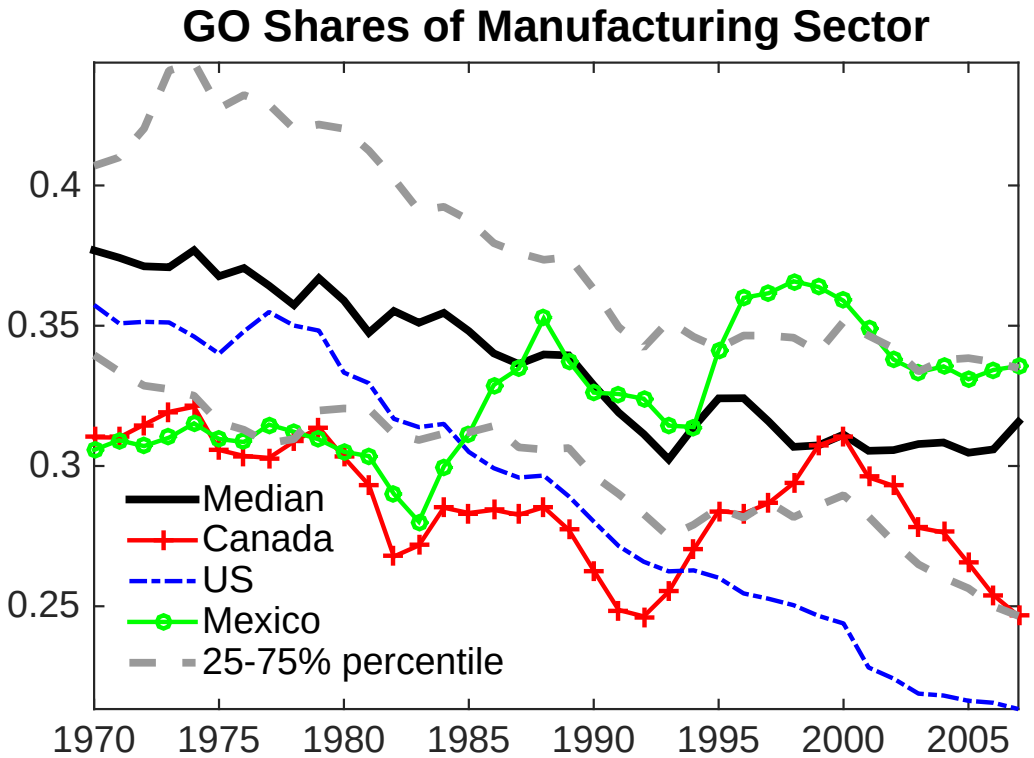
TWO-COUNTRY TWO-SECTOR MODEL



RELATIONSHIP BETWEEN RELATIVE SECTOR SIZE AND OUTPUT VOLATILITY



Relative Sector Sizes



Other Variables