INTERNATIONAL LINKAGES AND THE
CHANGING NATURE OF INTERNATIONAL
BUSINESS CYCLES

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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

- Trade, Diversification, and Volatilities
  - di Giovanni and Levchenko (2009), Caselli et al. (2017)

- International Business Cycle Comovement

- 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

(C,I)

Manufacturing/Nonmanufacturing

Local Industry \( l \in (0, 1) \)

Firms \( N \)

(C,I)

Manufacturing/Nonmanufacturing

Local Industry \( l \in (0, 1) \)

Firms \( N \)
Final and Intermediate Goods Production

- Final good firms produce consumption goods:

  \[ C(i) = \left( \sum_{s=1}^{S} \left( \omega_{CF}(s,i) \right) \right)^{\frac{1}{\gamma_F}} \left( f_C(s,i) \right)^{\frac{\gamma_F-1}{\gamma_F}} \]

  \[ f_C(s,i) = \left( \sum_{j=1}^{I} \left( \omega_{Cf}\left((j,s),i\right) \right) \right)^{\frac{1}{\gamma_f}} \left( f\left((j,s),i\right) \right)^{\frac{\gamma_f-1}{\gamma_f}} \]

- 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 $l \in [0,1]$

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

- Raw sector output is given by:

$$Q(i,s) = \left[ \int_0^1 L(i,s|l) \frac{\gamma_Q^{-1}}{\gamma_Q} dl \right]^{\frac{\gamma_Q}{\gamma_Q-1}}$$
Production technology for each firm $f$:

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

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:

\[
C_t(i) + p^I_t(i)I_t(i) + \mathbb{E}_t \epsilon_t(i) r_{t,t+1} B_{t+1}(i) \leq W_t(i) H_t(i) + R^k_t(i) (u_t(i) K_t(i)) + \epsilon_t(i) B_t(i)
\]

Capital accumulation:

\[
K_{t+1}(i) \leq (1 - \delta(u_t(i))) K_t(i) + I_t(i) \left(1 - S \left(\frac{I_t(i)}{I_{t-1}(i)}\right)\right)
\]
RELATIONSHIP BETWEEN INTERNATIONAL LINKAGES AND OUTPUT VOLATILITY

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

![Graph showing relationship between international linkages and output volatility]
### Calibration

Common parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.96</td>
<td>Discount factor</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.36</td>
<td>Labor share parameter</td>
</tr>
<tr>
<td>$\delta$</td>
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<td>Depreciation rate</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>2</td>
<td>Inverse of IES</td>
</tr>
<tr>
<td>$\nu$</td>
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<td>Inverse of Frisch labor supply</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>0.1</td>
<td>Wealth effect parameter</td>
</tr>
<tr>
<td>$\frac{\delta''_u}{\delta'_u} u$</td>
<td>0.05</td>
<td>Inverse utilization elasticity</td>
</tr>
<tr>
<td>$\gamma_F$</td>
<td>1</td>
<td>ES between sectoral goods</td>
</tr>
<tr>
<td>$\gamma_f$</td>
<td>1</td>
<td>ES between home and foreign goods</td>
</tr>
<tr>
<td>$\epsilon_{markup}$</td>
<td>0.12</td>
<td>Elasticity of markup</td>
</tr>
<tr>
<td>$s$</td>
<td>0.1</td>
<td>Investment adjustment cost</td>
</tr>
<tr>
<td>$\rho_A$</td>
<td>0</td>
<td>Shock persistence</td>
</tr>
</tbody>
</table>
Calibration

Calibrate productivity shock standard deviations

- Let $\omega$ be the vector of steady state parameters that include all share and size parameters in IO table

- Calibrate $\omega$: 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

<table>
<thead>
<tr>
<th></th>
<th>CA s1</th>
<th>CA s2</th>
<th>US s1</th>
<th>US s2</th>
<th>CA final</th>
<th>US final</th>
<th>GO</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
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<tr>
<td>s1</td>
<td>$M_{11}$</td>
<td>$M_{12}$</td>
<td>$M_{13}$</td>
<td>$M_{14}$</td>
<td>$F_{11}$</td>
<td>$F_{12}$</td>
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<tr>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>$V_{1}$</td>
<td>$V_{2}$</td>
<td>$V_{3}$</td>
<td>$V_{4}$</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>GO</td>
<td>$Q_{1}$</td>
<td>$Q_{2}$</td>
<td>$Q_{3}$</td>
<td>$Q_{4}$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 $\omega(\text{year})$ to be the steady state for each year
- Calibrate $\omega(\text{year})$ 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 $\tilde{WIOT}$ 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 $\omega(\text{year})$ using $\tilde{WIOT}$ and solve model

- Effects = $\sum_{h=0}^{T} \left( Y_{1970+h+1} - Y_{1970+h} \right)$
**Experiment 3: Relative Sectoral Size**

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

- Construct hypothetical $\tilde{WIOT}$ 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 $WIOT$ and solve model

- Effects = $\sum_{h=0}^{T} \left( \tilde{\sigma}_{1970+h+1}^{Y} - \sigma_{1970+h}^{Y} \right)$
World IO changes & Changing Volatilities

Total

International Linkage

Sector Size

Model: Median
25-75
10-90
Data: Median

1980 1990 2000

1980 1990 2000

1980 1990 2000

1980 1990 2000

1980 1990 2000

1980 1990 2000
**World IO changes & Changing Output Volatilities: Heterogeneity**

**Canada**

**US**

**Mexico**

![Graphs showing changes in output volatilities over time for Canada, US, and Mexico.](image-url)
Inspecting Mechanism

Baseline

RBC

Confidence Shock

Low Elasticity

Correlated Shock

Baseline
Robustness
Baseline 25-75
Robustness 25-75
**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

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

(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**

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

SD of VA: Country 1

Size of Sector2/Sector1
RELATIVE SECTOR SIZES

GO Shares of Manufacturing Sector

- Median
- Canada
- US
- Mexico
- 25-75% percentile

OTHER VARIABLES

C : Total

C : International Linkage

C : Sector Size

I : Total

I : International Linkage

I : Sector Size

Median

25-75

10-90