The Business Cycle Volatility Puzzle

emerging vs developed economies

Lucía Casal
Cornell

Rafael Guntin
NYU

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Motivation

- Emerging economies are characterized by higher business cycle volatility than developed ones
- Potential channels:
  1. Aggregate shocks
  2. International prices shocks
  3. Structural composition of the economy
     - sector-level
     - firm-level

Research question

How much each channel **contributes** to the differences in GDP volatility between emerging and developed economies?

What We Do

- Build multi-sector small open economy model with heterogeneous firms and production linkages.

- Decompose GDP volatility in four channels that depend on *sufficient statistics*:

    1. Macro: sum of total sales shares (*Domar weights*) and aggregate TFP volatility
    2. International prices: sectoral trade imbalances and volatility of international prices
    3. Sectoral: distribution of sectors' *Domar weights* and sector-level TFP volatility
    4. Granular: distribution of large firms' *Domar weights* and firm-level TFP volatility

- Conduct an accounting exercise using national accounts, input-output, international trade, and firm-level data for 10 emerging and 20 developed economies.

What We Find So Far

- GDP volatility in emerging economies is 2.4 times the volatility in developed

How much each channel contributes to the **difference** in GDP volatility?

1. Macro channel: 45%
2. International prices channel: 12%
3. Sectoral channel: 37%
4. Granular channel: 6%

Related Literature

1. Macro channel
    - on financial frictions and business cycle fluctuations in emerging economies
      Neumeyer Perri 2005; Uribe Yue 2006; Chang Fernandez 2013
    - on sudden stops in emerging economies
      Calvo Izquierdo Talvi 2006
    - on fiscal and monetary policy and the intensity and duration of crisis in LAC
      Vegh Vulletin 2014
    - on democracy and business cycle volatility
      Mobarak 2005
2. International prices channel
3. Sectoral channel
4. Granular channel

Related Literature

1. Macro channel

2. International prices channel

   - on the impact of terms-of-trade shocks on aggregate TFP
     Kehoe Ruhl, 2008

   - on how differences in trade patterns between emerging and developed economies explain differences in GDP volatility
     Leibovici Kohn Tretvoll, 2019

3. Sectoral channel

4. Granular channel

Related Literature

1. Macro
2. International prices
3. Sectoral channel
   - *Carvalho Gabaix, 2013* use Hulten theory to derive the aggregate volatility that is explained only by micro shocks and estimate it for 4 advanced economies
   - *Koren Tenreyro, 2007* decompose agg volatility in macro and micro component using factor model, and use it to explain vol diff between EM and DEV. However, it is "atheoretical" (Carvalho Gabaix 2013)
4. Granular channel

Related Literature

1. Macro
2. International prices
3. Sectoral channel
4. Granular channel
   - *Gabaix, 2011* on how fat-tailed distribution of firms leads to high aggregate volatility coming from idiosyncratic shocks. Application for US firms
   - *di Giovanni Levchenko, 2012* on how idiosyncratic shocks to large firms can explain differences in volatility between small and large countries.

Related Literature

1. Macro channel
2. International prices channel
3. Sectoral channel
4. Granular channel

- Our **contribution**
  - single framework that features the 4 channels
  - differences in GDP volatility between emerging and developed economies quantified using *sufficient statistics*

Outline

- Accounting framework
- Empirical application
- Discussion & Next steps

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- **Accounting framework**
- Empirical application
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Overview of the Model

- Multi-sector small open economy with heterogeneous firms and production linkages
  - SOE version of Hulten (1978)
  - Variation of Baqaee & Farhi (2018)

- **Decomposition** of GDP volatility in Macro, International prices, Sectoral and Granular channels.

Environment

- Sectors $s \in \mathcal{S} = \left\{ \underbrace{1, ..., S_{NT}}_{\mathcal{S}^{NT}}, \underbrace{S_{NT} + 1, ..., S_{NT} + S_T}_{\mathcal{S}^{T}} \right\}$.
- Denote $\mathcal{I}_s$ as the set of firms i in sector s.
- SOE takes tradable prices p_s with $s \in \mathcal{S}_T$ as exogenous.
- Production function for firm i in sector s is $\mathcal{A}_i F_s \left(L_i, \left\{ X_{i,j} \right\}_{j=1}^{S} \right)$
  - $\ln \mathcal{A}_i = a + a_s + a_i$ exogenous,
  - $F_s(.)$ decreasing returns to scale.

Household Problem

A representative household solves the following static problem

$$\max_{\mathbf{C}} U\left(\{C_s\}_{s=1}^{S}\right)$$

subject to

$$\sum_{s\in\mathcal{S}} P_s C_s + B^* \leq w \sum_{s\in\mathcal{S}} \sum_{i\in\mathcal{I}_s} L_i + \sum_{s\in\mathcal{S}} \sum_{i\in\mathcal{I}_s} \pi_i \tag{1}$$

- Utility function U homogeneous degree one.
- B^* are exogenous *net* transfers to the rest of the world.
- HH provide one unit of labor inelastically.

Firms Problem

Each firm i in sector s produces an homogenous good s, and choose inputs to max profits taking prices as given:

$$\pi_i = \max_{L_i, \{X_{i,j}\}_{j \in \mathcal{S}}} p_s y_i - w L_i - \sum_{j \in \mathcal{S}} p_j X_{i,j}. \tag{2}$$

- $y_i = \mathcal{A}_i F_s \left(L_i, \{X_{i,j}\}_{j=1}^{S} \right)$.
- $\ln \mathcal{A}_i = a + a_s + a_i$ exogenous.
- F_s has decreasing returns to scale.
- $X_{i,j}$ denotes the intermediate inputs that firm i sources from sector j.

Market clearing & Aggregation

- Labor market clearing

$$\sum_{j \in \mathcal{S}} \sum_{i \in \mathcal{I}_j} L_i = 1. \tag{3}$$

- Non-tradable sectors market clearing. For $s \in \mathcal{S}_{NT}$

$$\sum_{i \in \mathcal{I}_s} y_i = C_s + \sum_{j \in \mathcal{S}} \sum_{i \in \mathcal{I}_j} X_{i,s}. \tag{4}$$

- Aggregate tradable resource constraint

$$\sum_{s \in \mathcal{S}^T} p_s \left(\sum_{i \in \mathcal{I}_s} y_i - C_s - \sum_{j \in \mathcal{S}} \sum_{i \in \mathcal{I}_j} X_{i,s} \right) = B^*. \tag{5}$$

firm in NT sector

firm in T sector

Competitive Equilibrium

A competitive equilibrium is an allocation $\left\{\{\mathbf{x}_i\}_{i=1}^{S}, \mathbf{c}, \mathbf{l}\right\}$ with exogenous productivity shifter $\mathcal{A}_i = A A_s A_i$, tradable prices $\mathbf{p}^T$, aggregate net exports B^*, and prices $\{\mathbf{p}, w\}$ such that

- firms take as given prices $\mathbf{p}$ and w (including tradables and non-tradables) and maximize their profits,
- households take prices $\mathbf{p}$, w and B^* as given and maximize their utility,
- non-tradable goods and labor markets clear.

Domar Weigths & Trade Imbalances

- GDP in this economy: $\mathrm{GDP} = \mathrm{GNI} + B^{*} = \sum_{s \in \mathcal{S}} p_s \left(\sum_{i \in \mathcal{I}_s} y_i - \sum_{j \in \mathcal{S}} \sum_{i \in \mathcal{I}_j} X_{i,s} \right)$

- Define the sales share in GDP or *Domar weight* of firm $i \in \mathcal{I}_s$ as

$$\lambda_i \equiv \frac{p_s y_i}{Y}.$$

  - $Y = \mathrm{GDP}$
  - property: $\sum_{i \in \mathcal{I}_s} \lambda_i \geq 1$

- Define sector $s \in \mathcal{S}_T$ trade imbalance as

$$B_s \equiv \frac{p_s \left(\sum_{i \in \mathcal{I}_s} y_i - C_s - \sum_{j \in \mathcal{S}} \sum_{i \in \mathcal{I}_j} X_{i,s} \right)}{Y}.$$

Business Cycle Volatility Accounting 1/2

Proposition (Augmented Hulten Theorem)

The first order response of output $Y(B^*, \mathbf{p}^T, A, A_s, A_i)$ *to changes in* $A, A_s, A_i, B^*, \mathbf{p}^T$ *is*

$$\partial \log Y(B^*, \mathbf{p}^T, A, A_s, A_i) = \left(\sum_{s \in \mathcal{S}} \sum_{i \in \mathcal{I}_s} \lambda_i \right) \partial a + \sum_{s \in \mathcal{S}} \left(\sum_{i \in \mathcal{I}_s} \lambda_i \right) \partial a_s + \sum_{s \in \mathcal{S}} \sum_{i \in \mathcal{I}_s} \lambda_i \partial a_i + \sum_{s \in \mathcal{S}_T} B_s \partial p_s. \tag{6}$$

Assuming that all exogenous shocks are uncorrelated then it follows that the variance of GDP growth is

$$Var\left(\partial \log Y(B^*, \mathbf{p}^T, A, A_s, A_i)\right) = \underbrace{\left(\sum_{s \in \mathcal{S}} \sum_{i \in \mathcal{I}_s} \lambda_i \right)^2 \sigma_A^2}_{\textit{macro}} + \underbrace{\sum_{s \in \mathcal{S}} \left(\sum_{i \in \mathcal{I}_s} \lambda_i \right)^2 \sigma_{A_s}^2}_{\textit{sector}} + \underbrace{\sum_{s \in \mathcal{S}} \sum_{i \in \mathcal{I}_s} \lambda_i^2 \sigma_{A_i}^2}_{\textit{granular}} + \underbrace{\sum_{s \in \mathcal{S}_T} B_s^2 \sigma_{p_s}^2}_{\textit{int. prices}}, \tag{7}$$

where $logA_i \equiv a_i$, $logA_s \equiv a_s$, $logA \equiv a$.

Business Cycle Volatility Accounting 2/2

We can express equation (7) in terms of BC volatility differences between EM and DEV economies:

$$
\begin{aligned}
Var\left(\partial \log Y_{EM}\right) - Var\left(\partial \log Y_{DEV}\right) \quad = \quad & \underbrace{\left[\left(\sum_{s\in\mathcal{S}}\sum_{i\in\mathcal{I}_s}\lambda_{i,EM}\right)^2 \sigma^2_{A,EM} - \left(\sum_{s\in\mathcal{S}}\sum_{i\in\mathcal{I}_s}\lambda_{i,DEV}\right)^2 \sigma^2_{A,DEV}\right]}_{\text{macro}} \\
+ \quad & \underbrace{\left[\sum_{s\in\mathcal{S}}\left(\sum_{i\in\mathcal{I}_s}\lambda_{i,EM}\right)^2 \sigma^2_{A_s} - \sum_{s\in\mathcal{S}}\left(\sum_{i\in\mathcal{I}_s}\lambda_{i,DEV}\right)^2 \sigma^2_{A_s}\right]}_{\text{sectoral}} \\
+ \quad & \underbrace{\left[\sum_{s\in\mathcal{S}}\sum_{i\in\mathcal{I}_s}\lambda^2_{i,EM}\sigma^2_{A_i} - \sum_{s\in\mathcal{S}}\sum_{i\in\mathcal{I}_s}\lambda^2_{i,DEV}\sigma^2_{A_i}\right]}_{\text{granular}} \\
+ \quad & \underbrace{\left[\sum_{s\in\mathcal{S}_T} B^2_{s,EM}\sigma^2_{p_s} - \sum_{s\in\mathcal{S}_T} B^2_{s,DEV}\sigma^2_{p_s}\right]}_{\text{international prices}} \qquad (8)
\end{aligned}
$$

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- Accounting framework
- **Empirical application**
- Discussion & Next steps

Business Cycle Volatility

$$\underbrace{Var\left(\partial \log Y_{EM}\right)}_{0.12\%} - \underbrace{Var\left(\partial \log Y_{DEV}\right)}_{0.05\%} = 0.07\%$$

- Country classification:
  - developed: members of OECD with avg. PPP adjusted GDP per cap $>$ \$25,000
  - emerging: avg. PPP adjusted GDP per cap $<$ \$25,000
- Data source: World Development Indicators (WDI)
  - estimate cyclical component of GDP and compute variance
  - 1970-2016

Channels' Data Sources

	Int.prices	**Sectoral**	**Macro**	**Granular**
Suff. statistic	$B^2_{s,c}$	$\left(\sum_{i \in \mathcal{I}_s} \lambda_{i,c}\right)^2$	$\left(\sum_{s \in \mathcal{S}} \sum_{i \in \mathcal{I}_s} \lambda_{i,}\right)^2$	$\lambda^2_{i,c}$
Data source	OECD IO tables 20 sectors	OECD IO tables 36 sectors		Worldscope Large firms
Volatility	$\sigma^2_{p_s}$	$\sigma^2_{A_s}$	σ^2_{A}	$\sigma^2_{A_i}$
Data source	WIOT SEA EM&DEV	Jorgensen(2005) US	Residual	Gabaix(2011) US

International Prices Channel

	Emerging	Developed
Commodities trade imbalance	0.03 (-0.02,0.07)	0.00 (-0.04,0.03)
Manufacturing trade imbalance	-0.05 (-0.08,-0.04)	-0.005 (-0.05,0.04)
Commodities price volatility	0.16	0.16
Manufacturing price volatility	0.11	0.11

Note: in parentheses we report values corresponding to the 25th and 75th pct.

Sectoral & Granular Channels

	Emerging	Developed
Sum of Domar weigths of least volatile sectors	0.62 (0.57,0.68)	0.74 (0.71,0.78)
Sum of Domar weigths of most volatile sectors	0.51 (0.44,0.59)	0.35 (0.29,0.39)
Sum of Domar weigths of top 70 largest firms	0.48 (0.24,0.55)	0.36 (0.29,0.49)

Note: in parentheses we report the values corresponding to the 25th and 75th pct.

cross-country detail

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Discussion & Next Steps

1. Theoretical correlation between shocks (e.g., is A_i a function of p_i?)
2. Measurement error in sectoral idiosyncratic TFPs (is A_s measured in the data $A_s\mathcal{A}$?)
3. Next exercises:
   - compute firms' idiosyncratic TFP for EM and DEV.
   - compute relevant moments for small firms.
4. Relevant extensions:
   - Second order moments (i.e., changes in Domar weights and trade imbalances)
   - Inefficient economies (markups, labor reallocation costs, etc)

Extra Slides

Mechanisms behind sectoral and granular channels

Impact of changes in A_i (granular) or A_s (sectoral):

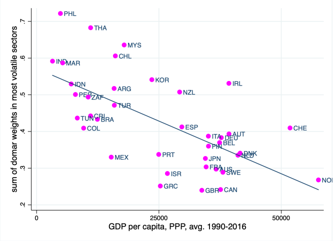
- Closed economy
  - changes in w,
  - changes in p_s for $s \in \mathcal{S}_{NT}$.
- Small open economy *(Farhi Baqaee 2019)*:
  - changes in w,
  - no changes in p_s for $s \in \mathcal{S}_T$ since exogenous,
  - changes in p_s for $s \in \mathcal{S}_{NT}$.

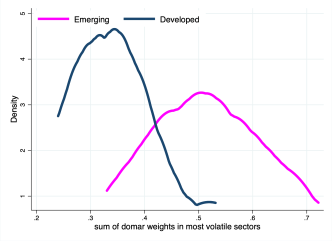
In both cases *Domar Weight* is sufficient statistic, but underlying forces differ.

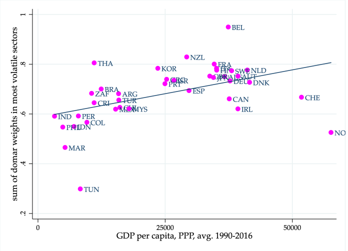
back

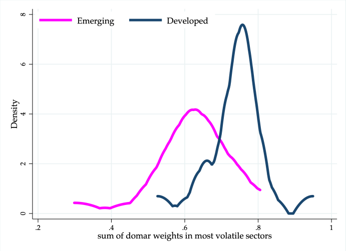
planner's problem

Micro channel: cross-country patterns



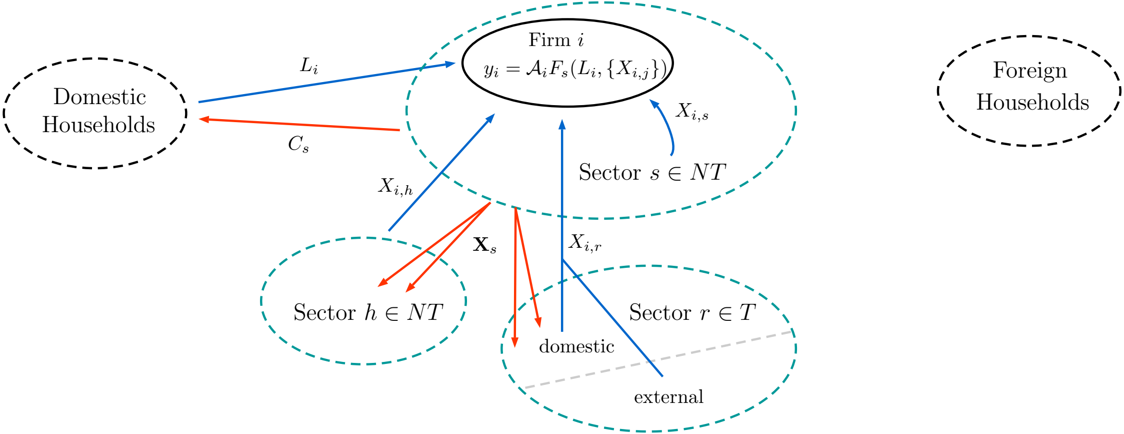






back

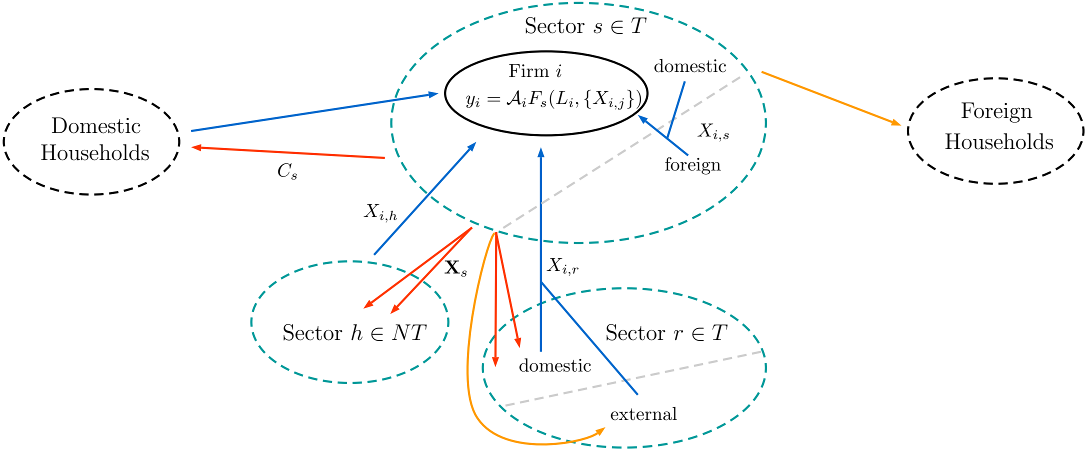
The problem of a firm in the non-tradable sector



$$\sum_{i \in s} \mathcal{A}_i F_s(L_i, \{X_{i,j}\}) = C_s + \sum_{j \in \mathcal{S}} \sum_{h \in \mathcal{I}_j} X_{h,s}$$

back

The problem of a firm in the tradable sector



$$\sum_{i \in s} \mathcal{A}_i F_s(L_i, \{X_{i,j}\}) = C_s + \sum_{j \in \mathcal{S}} \sum_{h \in \mathcal{I}_j} X_{h,s} + B_s$$

back

Planner's Problem

$$
\begin{aligned}
\mathcal{Y}(\mathcal{A}_i, B^*, \mathbf{p}^T) = \max_{\{X_{i,s}\}, L_i, C_s} & \, U\left(\{C_s\}_{s=1}^{S}\right) + B^* \\
& + \sum_{s \in \mathcal{S}^{NT}} \mu_s \left[\sum_{i \in \mathcal{I}_s} \mathcal{A}_i F_s\left(L_i, \{X_{i,j}\}_{j=1}^{S}\right) - C_s - \sum_{j \in \mathcal{S}} \sum_{i \in \mathcal{I}_j} X_{i,s} \right] \\
& + \lambda \left(1 - \sum_{j \in \mathcal{S}} \sum_{i \in \mathcal{I}_j} L_i \right) \\
& + \mu^T \left[\sum_{s \in \mathcal{S}^T} p_s \left(\sum_{i \in \mathcal{I}_s} \mathcal{A}_i F_s\left(L_i, \{X_{i,j}\}_{j=1}^{S}\right) - C_s - \sum_{j \in \mathcal{S}} \sum_{i \in \mathcal{I}_j} X_{i,s} \right) - B^* \right]
\end{aligned}
$$

back