The Business Cycle Volatility Puzzle
emerging vs developed economies

Lucía Casal
Cornell

Rafael Guntin
University of Rochester

Preliminary slides

August 2022

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 19 developed economies.

What We Find So Far

- GDP volatility in emerging economies is 3.1 times the volatility in developed

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

Channel		**Contribution** benchmark	correlated shocks
Macro		12%	37 %
International Prices		0%	1%
Micro	Sectoral	83%	57%
	Granular	5%	5%
Int. Prices and Sectoral interaction		-	0.3%

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
- Application
- Discussion & Next steps

Outline

- **Accounting framework**
- Application
- Discussion & Next steps

Environment

- Sectors $\mathcal{S} = \left\{ \underbrace{1, ..., S_{NT}}_{\mathcal{S}^{NT}}, \underbrace{S_{NT} + 1, ..., S_T + S_{NT}}_{\mathcal{S}^{T}} \right\}$.
- Denote $\mathcal{I}_s$ as the set of heterogeneous firms i within 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 $\mathcal{A}_i F_s \left(L_i, \mathbf{X}_i \right)$
  - $\mathbf{X}_i = \left[\begin{array}{ccccc} X_{i,1} & \cdots & X_{i,s} & \cdots & X_{i,N} \end{array} \right]$ intermediate inputs,
  - $\ln \mathcal{A}_i = a + a_s + a_i$ exogenous,
  - $F_s(.)$ decreasing returns to scale.

Household Problem

A representative household solves the following static problem

$$\max_{\mathbf{C}} U(\mathbf{C})$$

subject to

$$\mathbf{p}\mathbf{C}' + B^* \leq w + \sum_{i \in \mathcal{I}} \pi_i, \tag{1}$$

- $\mathbf{C} = \begin{bmatrix} C_1 & \cdots & C_s & \cdots & C_N \end{bmatrix}$
- 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:

$$\pi_i = \max_{L_i, \mathbf{X}_i} p_s y_i - wL_i - \mathbf{p}\mathbf{X}_i', \tag{2}$$

- $y_i = \mathcal{A}_i F_s (L_i, \mathbf{X}_i)$.
- $\mathbf{X}_i = \begin{bmatrix} X_{i,1} & \cdots & X_{i,s} & \cdots & X_{i,N} \end{bmatrix}$; $\mathbf{p} = \begin{bmatrix} p_1 & \cdots & p_s & \cdots & p_N \end{bmatrix}$.
- $\ln \mathcal{A}_i = a + a_s + a_i$ exogenous.
- F_s has decreasing returns to scale.

Market clearing & Aggregation

- Labor market clearing

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

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

$$\sum_{i \in \mathcal{I}_s} y_i = C_s + \sum_{i \in \mathcal{I}} X_{i,s} \qquad \text{if } \; s \in \mathcal{S}^{NT}. \tag{4}$$

- Aggregate tradable resource constraint

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

firm in NT sector

firm in T sector

Competitive Equilibrium

Definition

A competitive equilibrium is an allocation $\{\{\mathbf{X}_i\}_{i\in\mathcal{I}}, \mathbf{C}, \{L_i\}_{i\in\mathcal{I}}\}$ with exogenous productivity shifter $\mathcal{A}_i = A\tilde{A}_s A_i$, tradable prices $\mathbf{p}^\mathsf{T}$, aggregate net exports B^*, and prices $\{\mathbf{p}, w\}$ such that

- given prices $\mathbf{p}$ and w, firms maximize their profits,
- given $\mathbf{p}$, w and B^*, the representative household maximizes her utility,
- the non-tradable goods and labor markets clear.

Domar Weigths & Trade Imbalances

- $GDP = U(\mathbf{C}) + B^* = \sum_{s \in \mathcal{S}} p_s \left(\sum_{i \in \mathcal{I}_s} y_i - \sum_{i \in \mathcal{I}} X_{i,s} \right).$

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

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

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

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

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

Business Cycle Volatility Accounting 1/2

Proposition (Augmented Hulten Theorem)

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

$$d\log Y(B^*, \mathbf{p}^T, A, \tilde{A}_s, A_i) = \Lambda da + \sum_{s\in\mathcal{S}} \Lambda_s d\tilde{a}_s + \sum_{i\in\mathcal{I}} \lambda_i da_i + \sum_{s\in\mathcal{S}_T} b_s d\log p_s. \tag{6}$$

Assuming that the exogenous shocks are uncorrelated then it follows that the variance of GDP growth (in log differences) is

$$Var\left(d\log Y\right) = \underbrace{\Lambda^2\sigma_A^2}_{macro} + \underbrace{\sum_{s\in\mathcal{S}} \Lambda_s^2\sigma_{\tilde{A}_s}^2}_{sector} + \underbrace{\sum_{i\in\mathcal{I}} \lambda_i^2\sigma_{A_i}^2}_{granular} + \underbrace{\sum_{s\in\mathcal{S}_T} b_s^2\sigma_{p_s}^2}_{int.\ prices}, \tag{7}$$

where $\log A_i \equiv a_i$*,* $\log\tilde{A}_s \equiv \tilde{a}_s$*,* $\log A \equiv a$.

Business Cycle Volatility Accounting 2/3

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

$$\begin{aligned}
Var\left(d\log Y_{EM}\right) - Var\left(d\log Y_{DEV}\right) = & \underbrace{\Lambda_{EM}^{2}\sigma_{A,EM}^{2} - \Lambda_{DEV}^{2}\sigma_{A,DEV}^{2}}_{\text{macro}} \\
& + \underbrace{\sum_{s\in\mathcal{S}}\Lambda_{s,EM}^{2}\sigma_{\tilde{A}_s,EM}^{2} - \sum_{s\in\mathcal{S}}\Lambda_{s,DEV}^{2}\sigma_{\tilde{A}_s,DEV}^{2}}_{\text{sectoral}} \\
& + \underbrace{\sum_{i\in\mathcal{I}^{EM}}\lambda_{i,EM}^{2}\sigma_{A_i,EM}^{2} - \sum_{i\in\mathcal{I}^{DEV}}\lambda_{i,DEV}^{2}\sigma_{A_i,DEV}^{2}}_{\text{granular}} \\
& + \underbrace{\sum_{s\in\mathcal{S}_T}\left(b_{s,EM}^{2} - b_{s,DEV}^{2}\right)\sigma_{p_s}^{2}}_{\text{international prices}}. \qquad (8)
\end{aligned}$$

sectoral and granular

Business Cycle Volatility Accounting 3/3

Corollary (Proposition 1 with Correlated Shocks)

When allowing for correlation across sectors, firms and prices, and, additionally, between prices and sectoral TFP, equation (7) becomes:

$$Var\left(d\log Y\right) = \underbrace{\boldsymbol{\Lambda}'\Omega_{\tilde{A}}\boldsymbol{\Lambda}}_{\text{sectoral}} + \underbrace{\mathbf{b}'\Omega_{p^{T}}\mathbf{b}}_{\text{international prices}} + \underbrace{\mathbf{b}'D\left(\Omega_{(p^{T},\tilde{A})}\right)\boldsymbol{\Lambda}}_{\text{international prices and sectors}} + \underbrace{\lambda'\Omega_{A}\lambda}_{\text{granular}} + \underbrace{\Lambda^{2}\sigma^{2}_{A}}_{\text{aggregate}}, \tag{9}$$

where

- $\boldsymbol{\Lambda}$ *vector of sectoral Domar weights,*
- $\Omega_{\tilde{A}}$ *cov matrix for sectoral TFP (log) change,*
- $\mathbf{b}$ *vector of trade balances,*
- $\Omega_{p^{T}}$ *cov matrix for (log) changes of international prices,*
- $D\left(\Omega_{(p^{T},\tilde{A})}\right)$ *diagonal of cov matrix btw changes in sectoral TFP and changes in int. prices.*

Outline

- Accounting framework
- **Application**
- Discussion & Next steps

Business Cycle Volatility

$$\underbrace{Var\left(\partial \log Y_{EM}\right)}_{0.11\%} - \underbrace{Var\left(\partial \log Y_{DEV}\right)}_{0.04\%} = 0.07\%$$

- 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

cross-country detail

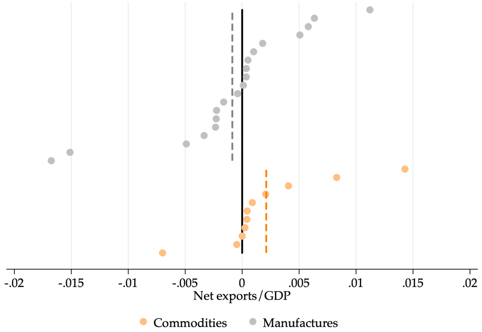
Channels' Data Sources

	International Prices	Sectoral	Macro	Granular
Sufficient statistic	$b^2_{s,c}$	$\Lambda^2_{s,c}$	Λ^2_c	$\lambda^2_{i,c}$
Data source	COMTRADE	OECD		Worldscope
Volatility	$\sigma^2_{p_s}$	$\sigma^2_{\tilde{A}_s}$	$\sigma^2_{A_c}$	$\sigma^2_{A_i}$
Data source	Jorgenson et al. (2005)		Residual	Gabaix(2011)

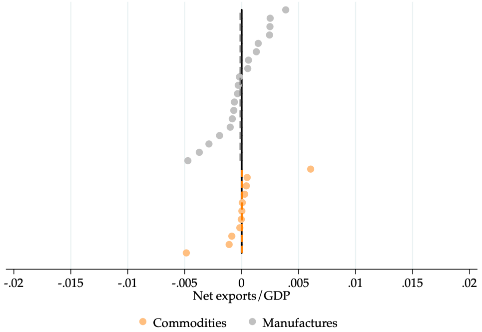
International Prices Channel

Sectoral trade imbalances (as % of GDP)

(a) *Emerging*



(b) *Developed*



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.

sectoral detail

granular detail

What We Find So Far

- GDP volatility in emerging economies is 3.1 times the volatility in developed

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

Channel		**Contribution** benchmark	correlated shocks
Macro		12%	37 %
International Prices		0%	1%
Micro	Sectoral	83%	57%
	Granular	5%	5%
Int. Prices and Sectoral interaction		-	0.3%

Outline

- Accounting framework
- Application
- **Discussion & Next steps**

Discussion & Next Steps

1. Next exercises:
   - Focus on sectoral and granular channels.
   - Intrinsic volatility differences.
   - International prices and exchange rate shocks.
2. 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):

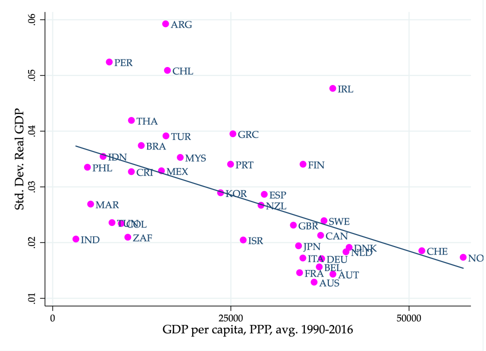
- Closed economy
  - changes in w,
  - changes in p_s for $s \in \mathcal{S}_{NT}$.
- Small open economy (*Farhi Baqaee 2019*):
  - changes in w,
  - no changes in p_s for $s \in \mathcal{S}_T$ since exogenous,
  - changes in p_s for $s \in \mathcal{S}_{NT}$.

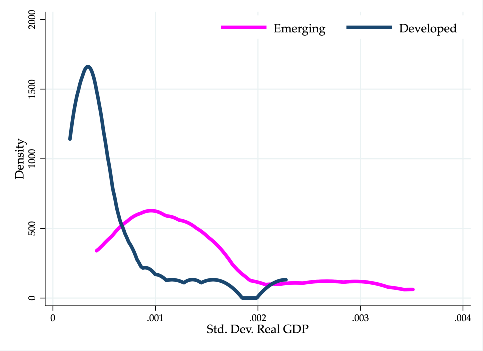
In both cases *Domar Weight* is sufficient statistic, but underlying forces differ.

back

planner's problem

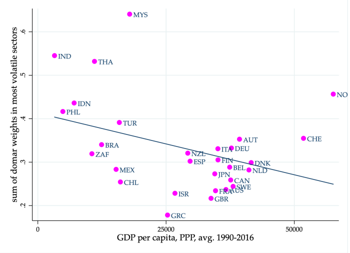
Micro channel: cross-country patterns

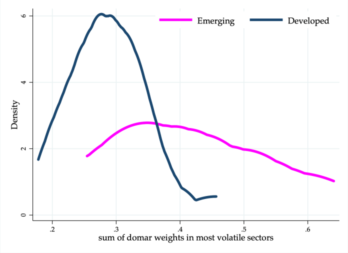


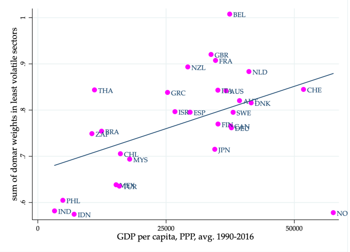


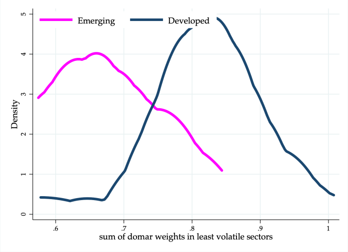
back

Micro channel: cross-country patterns





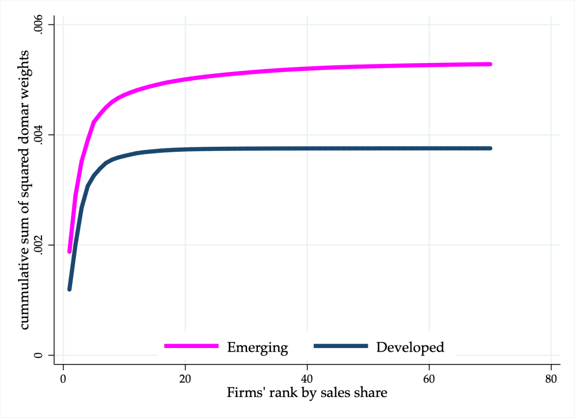




back

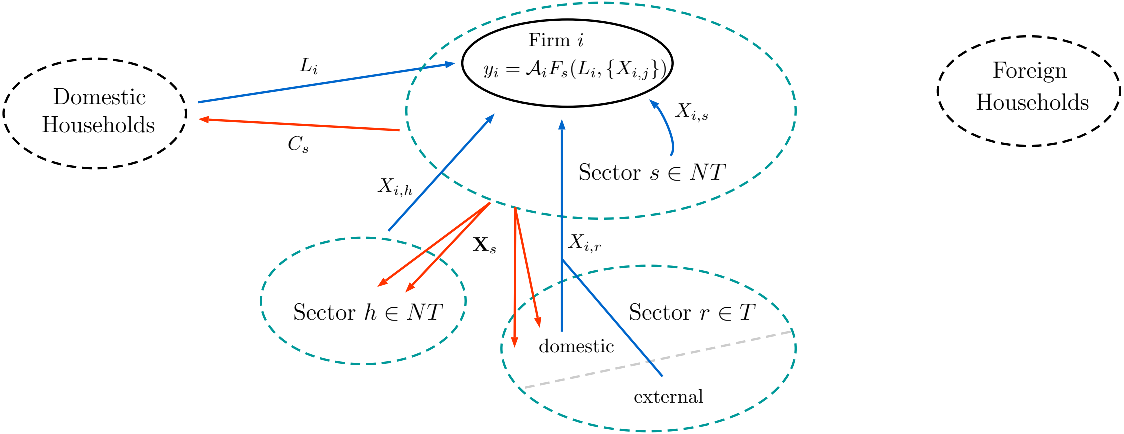
Micro channel: cross-country patterns

Firm distribution differences across the development spectrum



back

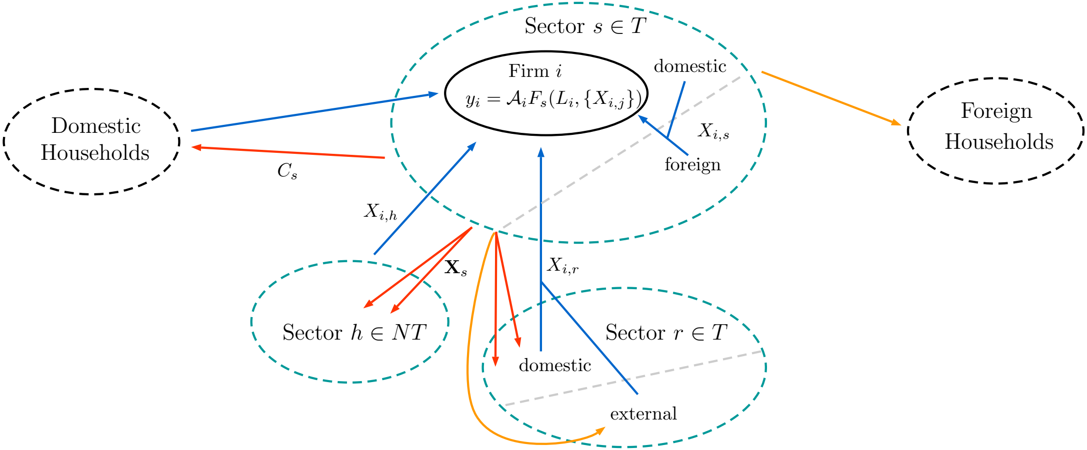
The problem of a firm in the non-tradable sector



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

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