The Business Cycle Volatility Puzzle

Emerging vs Developed Economies *

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Abstract

We study the drivers of the business cycle volatility differences between emerging and developed economies. We develop a multi-sector small open economy framework with heterogeneous firms and production linkages in which firms are subject to sectoral and firm-level TFP shocks, and international prices shocks. Using input-output sector-level data, firm-level micro data, and international trade data from various developed and emerging economies, we quantity the relevant model-based sufficient statistics. We find that differences in the sectoral composition and in the distribution of firms explain roughly half of the excessive business cycle volatility in emerging economies. Finally, we find that the contribution of international prices is sensitive to the households' preferences.

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1 Introduction

Emerging economies are characterized by higher business cycle volatility compared to developed ones (Acemoglu and Zilibotti, 1997). This higher output volatility is mirrored by even greater private consumption volatility (Neumeyer and Perri, 2005; Aguiar and Gopinath, 2007), affecting households' welfare in emerging economies. Identifying the sources of this excessive volatility is crucial to determine whether policy interventions can mitigate it or if it is an inherent aspect of the development process. In this paper, we study the drivers of the differences in aggregate output volatility between emerging and developed economies.

Extending Hulten (1978)'s theorem to a multi-sector small open economy with heterogenous firms and production linkages, we show that aggregate output volatility can be decomposed into four channels: aggregate, sectoral, firm-level, and international prices. Our findings reveal that disparities in the economic structure, such as the distribution of sectors and firms, can account for nearly half of the excessive volatility observed in emerging economies. On the other hand, the contribution of the international prices channel ranges from 0.2 percent to 16.2 percent, depending on the responsiveness of labor supply to changes in households' real income.

In our model, there is a set of goods that can be traded internationally (tradables) and a set of goods which are only consumed and produced domestically (nontradables). Both set of goods can be used for production (intermediate) and final consumption. Since the economy is small, the prices of tradable goods are assumed to be exogenous. Within each sector, firms produce a homogeneous good with a decreasing returns to scale technology that combines labor and intermediate inputs produced by other firms. Thus, there is an endogenous distribution of firms and the production across sectors is linked through the firms' use of intermediate inputs. Firms' productivity is exogenous and has three components: economy-wide (aggregate), sectoral and firm-specific. Last, there is a representative household who owns all the firms in the economy, supplies labor, and consumes tradable and nontradable goods.

We first show that the *fundamental* volatility (i.e., the volatility of aggregate output when aggregate labor supply is fixed), up to a first order approximation, can be explained only by aggregate, sectoral, and firm-level TFP shocks, as in a closed economy.[1] Furthermore, the relevance of each channel is determined by sufficient statistics. The aggregate channel depends on the volatility of the economy-wide TFP shocks and the total sales over GDP (aggregate Domar weight). The sectoral channel depends on the sector-level TFP shocks volatilities and the distribution of sectoral sales shares

[1] Our definition of fundamental volatility is similar to the one in Carvalho and Gabaix (2013).

(sectoral Domar weights). On the other hand, the firm-level channel depends on the firm-specific TFP shocks volatility and the concentration of firms' sales shares (firm-level Domar weights).

Next, we show that the volatility of aggregate output can also be explained by international prices shocks when households' labor supply is elastic. The relevance of the international prices channel depends on sufficient statistics – i.e., the volatility of international prices and the distribution of sectoral trade imbalances – and the parameters of the households' preferences that govern the strength of the substitution and income effects. Intuitively, if for example the economy is a net exporter of a tradable goods, and its price increases, the real income of households rises. This, in turn, leads to a change in aggregate labor supply if the income and substitution effects do not cancel each other out, consequently affecting aggregate output.

In our quantitative exercises, we first study how much of the differences in GDP volatility between emerging and developed economies can be explained by differences in the *fundamental* volatility. We compute the model-induced sufficient statistics using input-output production and firm-level data for 10 emerging and 19 developed economies. To isolate the contribution of the micro-composition of the economy, we assume that the volatility of sectoral and idiosyncratic TFP shocks is the same across emerging and developed economies. Therefore, the contribution of the sectoral and firm-level channels is solely determined by differences in the distribution of sales shares across sectors and firms. In our baseline estimates, we find that differences in the sectoral distribution of the economy explain as much as 43% of the excessive volatility in emerging economies and the firm-level channel explains 5%.

The relevance of the sectoral channel is explained by the significant contrast in the sectoral distribution between emerging and developed economies. Emerging economies concentrate 47% of their sales in high TFP volatility sectors, such as manufacturing and primary sectors, while developed economies concentrate only 30% of their sales in these sectors. This pattern is closely tied to the structural transformation process, which posits that as economies develop, economic activity shifts away from agriculture and manufacturing (which have high TFP volatility) towards services (which have low TFP volatility).[2] This suggests that almost half of the disparities in aggregate output volatility can be intrinsic to the development process.

On the other hand, in the firm-level channel, the relevant model-based sufficient statistic is the concentration of firm sales among top firms (Gabaix, 2011). Using firm-level data from several countries, we observe that sales by the largest firms in the econ-

[2] See Herrendorf, Rogerson and Ákos Valentinyi (2014) for a review of the literature.

omy are 41% more concentrated in emerging economies.[3] Despite this observation, differences in the distribution of firms can explain a small fraction (5%) of the excessive volatility in emerging economies. However, if we allow for firm-level TFP shocks to be moderately more volatile in emerging economies, we find that the contribution of this channel could be substantially higher.

Finally, we focus on the international transmission of shocks. When disparities exist between the consumption basket and production structure, shocks to the prices of tradable goods can affect households' real income. These disparities manfiest as trade imbalances at the level of individual goods or sectors. Crucially, any shifts in real income translate into changes in aggregate output only if labor supply is responsive. Using disaggregated international trade data, we document that emerging economies have higher sectoral trade imbalances than developed. Then, we estimate the contribution of the international prices channel for a range of different preferences parameters which are commonly used in the literature, and find that it can explain from 0.2% to 16.2% of the differences in GDP volatility between emerging and developed.

Related Literature and Contributions. The observation that emerging economies have a higher business cycle volatility than developed economies [see, for example, Lucas (1988, p4) and Acemoglu and Zilibotti (1997)] ignited a large body of work that studies potential explanations. First, many papers have focused on aggregate explanations such as more frequent or larger financial shocks [Neumeyer and Perri (2005), Uribe and Yue (2006), Calvo, Izquierdo and Talvi (2006), and others], more persistent TFP processes [Aguiar and Gopinath (2007)], procyclical fiscal and monetary policy [Vegh and Vuletin (2014)], more institutional instability [Mobarak (2005)], and higher exposure to commodity price shocks [see, for example, Kohn, Leibovici and Tretvoll (2021)]. Second, a smaller set of papers have focused on the role of sector-level shocks and sectoral differences across emerging and developed economies [see, for example, Da-Rocha and Restuccia (2006) and Koren and Tenreyro (2007)].[4] In our paper, we combine these different views – aggregate and micro explanations – in a unique theoretical framework. Our empirical contribution is to document that, in emerging economies, the sectoral sales tend to be more concentrated in the most volatile sectors, the firms' sales tend to be more concentrated in the largest firms, and disaggregated trade imbalances are larger.

[3] Concentration is measured as the square of the sum of the Domar weights (HHI index) of the Top 70 largest firms in the economy.

[4] Although it doesn't focus on differences between emerging and developed economies, Carvalho and Gabaix (2013) studies the role of sectoral composition in changes in volaility across time for the US and other developed economies.

Unlike previous studies on the excessive business volatility in emerging economies, we use model-induced sufficient statistics to quantify the contribution of each channel.[5] These statistics can be computed using input-output data, firm-level micro data, and international trade data from several emerging and developed economies. To derive the sufficient statistics, we extend Hulten (1978)'s theorem to a small open economy framework. Our analytical results are related to Baqaee and Farhi (2021). While they focus on a multiple economy setup, we focus on a small open economy setup with tradable (no market clearing, thus exogenous prices) and nontradable sectors (only domestic market clearing), a non-degenerate distribution of firms within a sector, and elastic labor supply.

Our result that international prices shocks are neutral, i.e., they don't affect domestic aggregate output, when labor supply is inelastic is related to other results by, for example, Kehoe and Ruhl (2008), Burstein and Cravino (2015), and Baqaee and Farhi (2021). We highlight the importance of households' preferences, particularly the responsiveness of labor supply to changes in real income, in quantifying the impact of international price shocks on excessive output volatility in emerging economies.[6]

Lastly, to our knowledge, this is the first paper that studies how the differences in the distribution of firms between emerging and developed economies can account for the excessive volatility of output in emerging economies. Gabaix (2011) and di Giovanni and Levchenko (2012) also study the role of firm-level shocks, but focus in developed economies and in the differences between large and small countries, respectively.

Organization. The rest of the paper is organized as follows: Section 2 describes the theoretical model and main proposition, Section 3 includes the main quantitative applications and empirical patterns, and Section 4 concludes.

2 Theoretical Framework

We develop a multi-sector small open economy model with heterogeneous firms and production linkages. We use the model to decompose volatility of GDP in aggregate, sectoral, firm-level, and international prices channel.

[5] E.g., Koren and Tenreyro (2007) uses an atheoretical approach to study the role of the economic structure. In spite of this, our main findings regarding the economic structure are in line with theirs.

[6] Several papers in the literature that studies the transmission of commodity price shocks to domestic output in open economies [see, for example, Shousha (2016); Drechsel and Tenreyro (2018); Kohn *et al.* (2021)] use GHH preferences, which we show they could significantly amplify their transmission by muting the income effects.

2.1 Environment

In the economy, there is a discrete number of sectors $s \in \mathcal{S}$ where $\mathcal{S}$ can be partitioned into a sub-set of nontradable sectors $\mathcal{S}^{NT}$ which can only be sold domestically and a sub-set of tradable sectors $\mathcal{S}^{T}$ which can be sold domestically and internationally, then

$$\mathcal{S} = \left\{ \underbrace{1, ..., S_{NT}}_{\mathcal{S}^{NT}}, \underbrace{S_{NT}+1, ..., S_T + S_{NT}}_{\mathcal{S}^{T}} \right\},$$

where $S_{NT} + S_{NT} = N$ is the total number of sectors. The economy is relatively small and open, so tradable prices, p_s with $s \in \mathcal{S}^T$, are exogenous. On the other hand, the nontradable prices, p_s with $s \in \mathcal{S}^{NT}$, are determined in general equilibrium. Within each sector $s \in \mathcal{S}$ there is an arbitrary finite number of heterogeneous firms $i \in \mathcal{I}_s$. The set of all firms in the economy is

$$\mathcal{I} = \left\{ \underbrace{1, 2, ..., I_1}_{\mathcal{I}_1}, \underbrace{I_1+1, ..., I_2 + I_1}_{\mathcal{I}_2}, ..., \underbrace{\sum_{s=1}^{N-1} I_s + 1, ..., \sum_{s=1}^{N} I_s}_{\mathcal{I}_N} \right\},$$

where $I = \sum_s^N I_s$ is the total number of firms. Firms are linked through their production – i.e., firms buy intermediate goods from other firms – and act competitively. The economy is also populated by a representative household who owns all the firms, consumes, and supplies labor to the firms. We next describe the firm and household problem, and the market clearing conditions and aggregates.

2.1.1 Firms

Each firm i in sector s produces an homogenous good s, and chooses labor and intermediate inputs to maximize its profits, taking the price of the good produced, wages and prices of intermediate inputs as given. Then the problem of firm i in sector s is

$$\pi_i = \max_{L_i, \mathbf{X}_i} p_s y_i - w L_i - \mathbf{p}\mathbf{X}_i^{'}, \tag{1}$$

where y_i is the output produced by firm i, L_i is labor demanded by firm i at wage w, and $\mathbf{X}_i = \begin{bmatrix} X_{i,1} & \cdots & X_{i,s} & \cdots & X_{i,N} \end{bmatrix}$ are the intermediate inputs demanded by firm i at prices $\mathbf{p} = \begin{bmatrix} p_1 & \cdots & p_s & \cdots & p_N \end{bmatrix}$, where $X_{i,j}$ denotes firm i's demand of sector j intermediate good. The production function of firm i in sector s is

$$y_i = \mathcal{A}_i F_s \left(L_i, \mathbf{X}_i \right),$$

where $\mathcal{A}_i = \exp(a + \tilde{a}_s + a_i)$ is an exogenous productivity shifter composed by aggregate productivity $A = e^a$, sectoral productivity $\tilde{A}_s = e^{\tilde{a}_s}$ and firm-level idiosyncratic productivity $A_i = e^{a_i}$ components. Crucially, the function $F_s(.)$ exhibits decreasing returns to scale, then firms can be heterogeneous within sector [see Hopenhayn (1992)].

2.1.2 Households

The representative household consumes tradable and nontradable goods, supplies labor to firms, and owns all the firms in the economy. The household maximizes her utility

$$\max_{\mathbf{C},L} \frac{\mathcal{C}(\mathbf{C})^{1-\sigma}}{1-\sigma} - \frac{L^{1+\frac{1}{\psi}}}{1+\frac{1}{\psi}},$$

subject to the budget constraint

$$\mathbf{p}\mathbf{C}^{'} + B^{*} \leq wL + \sum_{i\in\mathcal{I}} \pi_i, \tag{2}$$

where σ is the relative risk aversion parameter and ψ the labor-supply elasticity, $\mathcal{C}(.)$ is an homogeneous degree one aggregator over consumption choices $\{C_s\}_{s=1}^{N}$ with $\mathbf{C} = \begin{bmatrix} C_1 & \cdots & C_s & \cdots & C_N \end{bmatrix}$, L the aggregate labor supply choice, $\mathbf{p}' \in \mathcal{R}_{+}^{N}$ consumption goods' prices, and B^* the exogenous net transfers to the rest of the world [similar to Baqaee and Farhi (2021)]. Household's earnings are the sum of labor income wL and firms' profits $\sum_{i\in\mathcal{I}} \pi_i$. Since firms have a decreasing returns to scale technology, profits are weakly positive, i.e., $\pi_i \geq 0 \;\; \forall i \in \mathcal{I}$.

2.1.3 Market Clearing and Aggregation

Market clearing. First, the total amount of labor demanded by all the firms in the economy has to equate the labor supplied by the representative household:

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

Next, for each nontradable sector the goods produced the firms within sector s has to equate the households' and all firms' demand of sector s good:

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

Finally, there is an aggregate external resource constraint such that the sum of production across all tradable sectors net of aggregate consumption of these sectors and aggregate demand of intermediate inputs from these sectors equals aggregate net exports in the small open economy:

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

Gross domestic product. The gross domestic product (GDP) in this economy is given by aggregate production net of the use of intermediate inputs. Combining equation this with the nontradable sector's market clearing conditions (4) and using the assumptions that the $\mathcal{C}(.)$ is homogeneous of degree 1 and aggregate price index is the numeraire good, we can express the economy's GDP ($\tilde{Y}$) as

$$\tilde{Y} = \mathbf{p}\mathbf{C}^{'} + B^{*} = wL + \sum_{i \in \mathcal{I}} \pi_i = \mathcal{C}\left(\mathbf{C}\right) + B^{*} \tag{6}$$

which means that, different from a closed economy setup, in our small open economy GDP differs from welfare by the exogenous net exports.[7] Notice that $\tilde{Y}$ is the GDP deflated by the CPI index $P = P_{\mathcal{C}} = 1$ which is the numeraire and denote GDP deflated by the production price index $P_{\mathcal{Y}}$ as $Y = \frac{P_{\mathcal{C}}}{P_{\mathcal{Y}}} \tilde{Y}$. In Lemma 1, we show analytically what determines the difference between the CPI inflation and the production price index.

2.2 Competitive Equilibrium

In this section we define the competitive equilibrium for this economy.

Definition 1. *A competitive equilibrium is an allocation* $\left\{ \{\mathbf{X}_i\}_{i \in \mathcal{I}}, \mathbf{C}, \{L_i\}_{i \in \mathcal{I}}, L \right\}$ *with exogenous productivity shifter* $\mathcal{A}_i = A\tilde{A}_s A_i$*, tradable prices* $\mathbf{p}^T$*, 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 nontradable goods and labor markets clear.*

Importantly, the economy is efficient so the competitive equilibrium allocations coincide with the allocations of the planner's problem.

2.3 Business Cycle Volatility

Before stating the main proposition, it is useful to define the relevant *domar weights* in this economy. The domar weight of firm $i \in \mathcal{I}_s$ is the sales share of firm i in GDP ($\tilde{Y}$) and denoted by λ_i, i.e., $\lambda_i \equiv \frac{p_s y_i}{\tilde{Y}}$. Then, it follows that the sectoral domar weight for a sector s is $\Lambda_s \equiv \sum_{i \in \mathcal{I}_s} \lambda_i$ and the aggregate domar weight is $\Lambda \equiv \sum_{i \in \mathcal{I}} \lambda_i$.

Proposition 1. *The first order response of output* $Y(.)$ *to changes in* $\{A, \tilde{A}_s, A_i, \mathbf{p}^T\}$ *is*

$$d\log Y = \vartheta \left[\Lambda da + \sum_{s \in \mathcal{S}} \Lambda_s d\tilde{a}_s + \sum_{i \in \mathcal{I}} \lambda_i da_i \right] + (\vartheta - 1) \sum_{s \in S^T} b_s d\log p_s \tag{7}$$

[7] Define the expenditure function of the household as $e(p, \mathcal{C}) = \sum_s p_s C_s$. Since $\mathcal{C}$ is homogeneous of degree 1, we have $e(p, \mathcal{C}) = \mathcal{C}e(p)$. Normalize the unit cost of consumption $e(p) = 1$ to obtain $\sum_i p_s C_s = \mathcal{C}$, [see, for example, Baqaee and Farhi (2021)].

where $\vartheta = \left(\frac{1+\psi}{1+\psi\sigma(1-b^*)}\right)$ *and* $b^* = \frac{B^*}{Y-B^*}$. *Moreover, if firm-level shocks are uncorrelated and their volatility is the same for all firms, sectoral shocks can be correlated across sectors, and international price shocks can be correlated across tradable goods, then the variance of GDP growth (in log differences) is*

$$Var\,(d\log Y) = \underbrace{\vartheta^2\Lambda^2\sigma_A^2}_{aggregate} + \underbrace{\vartheta^2\mathbf{\Lambda}'\Omega_{\tilde{A}}\mathbf{\Lambda}}_{sectoral} + \underbrace{\vartheta^2\lambda'\lambda\,\sigma_{A_i}^2}_{firm\text{-}level} + \underbrace{(1-\vartheta)^2\,\mathbf{b}'\Omega_{\mathbf{p}^T}\mathbf{b}}_{int.\ prices} \tag{8}$$

where σ_A^2 *is the variance of common (aggregate) TFP shocks,* $\mathbf{\Lambda}$ *is the vector of sector-level Domar weights,* $\Omega_{\tilde{A}}$ *is the covariance matrix of sectoral TFP shocks,* λ *is the vector of firm-level Domar weights,* σ_{A_i} *is the variance of firm-level shocks,* $\mathbf{b}$ *vector of sectoral trade imbalances, and* $\Omega_{\mathbf{p}^T}$ *the covariance matrix of international prices shocks. The variance terms are computed for log changes. The fundamental volatility of* Y *is defined for parameter values such that* $\vartheta = 1$. *The proof is in Appendix A.*

In Proposition 1, we extend the Hulten theorem to a small open economy with tradable and non-tradable sectors, firm-level heterogeneity, and elastic aggregate labor supply. To a first order, GDP growth and its volatility can be decomposed into four distinctive channels which depend on observable sufficient statistics and parameters of the household's utility function.

The first channel is the aggregate channel, whose impact depends on the volatility of the aggregate TFP shocks and the sum of all firms Domar weights (aggregate sales share). The second and third terms correspond to the channels related to the micro-structure of the economy at the sector- and firm-level, respectively. The sectoral channel depends on the variance and covariance matrix of sector-level shocks, and the vector of sectoral Domar weights. The firm-level channel depends on the volatility of firm-level shocks and the Herfindahl index of the firm's sale share. The aggregate, sector-, and firm-level channels are scaled by the parameter ϑ which is determined by parameters of the household preferences and the aggregate trade balance. If $\vartheta > 1$ (<1) then shocks are amplified (dampen) by changes in the labor supply. Last, the international prices depends on the variance and covariance matrix of tradable prices shocks and the vector of sectoral trade balances, but is scaled by $(1-\vartheta)$.

Furthermore, we show that the *fundamental* volatility (Carvalho and Gabaix, 2013) of aggregate output doesn't depend on international prices shocks. For values of $\{b^*, \sigma, \psi\}$ such that $\vartheta = 1$ we recover the standard closed economy version of Hulten (1978)'s Theorem. To a first order, as in a closed economy setup, solely the TFP shocks (aggregate, sector-, and firm-level shocks) matter for aggregate output fluctuations, and the Domar weights summarize their importance. The neutrality of international price shocks is related to results in Kehoe and Ruhl (2008), Burstein and Cravino (2015), and Baqaee and Farhi (2021). For international price shocks to matter, we need that the aggregate labor supply is elastic ($\psi \neq 0$) and that the income and substitution effect don't fully cancel each other out.[8] Intuitively, when there is a trade imbalance on sector $b_s \neq 0$, a change in p_s changes the real income of the households, since the CPI index changes relative to the GDP deflator (see Lemma 1). If the supply of labor is elastic, and the income and substitution effects are different, then L responds to the change in real income, which ultimately changes aggregate output.[9]

3 Quantitative Applications

It is well documented that emerging economies have a significantly higher aggregate output volatility than advanced economies (see, for example, Acemoglu and Zilibotti (1997)). In this section, using input-output, firm-level micro data and trade data from several emerging and advanced economies we quantify decomposition (8) and estimate how much each channel contributes to explain the differences in aggregate output volatility between emerging and developed economies. In the first part, we focus on estimating the contribution of the *fundamental* volatility, i.e., that explained by differences in the distribution of sectors and the distribution of firms. Second, we study the role of international transmission and discuss how sensitive are our results to different assumptions regarding households' preferences.

3.1 Data Description

Sample We start by empirically defining emerging and developed economies and tradable and nontradable sectors. For the definition of the country groups, we follow Kohn *et al.* (2021), and define developed economies as those members of OECD with average PPP adjusted GDP per capita higher than \$25,000, and emerging economies as those countries with average PPP adjusted GDP per capita lower than \$25,000.[10] We follow the standard in the literature and define tradable sectors as those belonging to the commodities and manufacturing categories, and nontradable sectors as those belonging to services. After combining all the data sources for each of the four channels (described below) we end up with a sample of 10 emerging and 19 developed economies.[11]

[8]In our setup, substitution and income fully cancel if there are log-preferences ($\sigma = 1$) and a balanced aggregate trade balance ($b^* = 0$).

[9]International price shocks could also explain aggregate output fluctuations through higher order moments, such as reallocation. But, for example, Kohn *et al.* (2021) find are the reallocation channel is the least relevant in their quantitative exercises. In our baselines theorem, the reallocation channel is muted since we focus on the first order approximation.

[10]Following Kohn *et al.* (2021) we exclude from the sample large open economies such as China and US and ex-communist countries.

[11]See the list of countries and sectors in Appendix B.2.

Data Sources and Data Moments We compute the business cyclce volatility of each country as the variance of the cyclical component of GDP, using data from the World Development Indicators (WDI) for the period 1970-2016. [12] In our sample, the median emerging economy has 2.2 times the business cycle volatility of the median developed economy. We combine data from several sources to compute the sufficient statistics to quantify each channel's contribution. For the sectoral channel, we use the OECD input-output tables to compute the sectoral Domar weights vector $\mathbf{\Lambda}_c$ for 36 (tradable and nontradable) sectors for each country. To compute the sectoral TFP covariance matrix $\Omega_{\tilde{A}}$ we use sector-level TFP estimates from Jorgenson, Ho and Stiroh (2005) from which we substract the commonly correlated component across sectors.[13] We assume that volatility of TFP is the same for same sectors across countries, and equal to the one in US. This assumption allows us to focus on differences in sectoral composition while using the best estimates possible for long-run sectoral TFP volatility. For the firm-level channel, we use data from Worldscope –which covers more than 90% of publicly held firms market cap internationally– to compute the Domar weights of the largest 70 firms λ_c for each country.[14] The advantage of Worldscope dataset is that it allows us to compute firm-level Domar weights using sales by domestic subsidiaries. We use the baseline estimates from Gabaix (2011) to compute the firm-level TFP volatility $\sigma^2_{A_i}$, which we assume common across firms in both emerging and developed economies, and equal to the one in US. Last, for the international prices channel, we use data from OECD to compute sectoral trade balances $\mathbf{b}$ and international sector-level price data from Groningen Growth and Development Centre to compute the volatility of tradable prices $\Omega^T_{\mathbf{p}}$.

3.2 The Role of the Fundamental Volatility

In this section, we study how much of the differences in output volatility between emerging and developed economies can be accounted by differences in the fundamental volatility. We focus on the contribution of differences in the sectoral- and firm-level distribution across emerging and developed economies.

To isolate the contribution of the micro-structure of the economy we use the decomposition (8) and assume: (i) fundamental volatility (i.e., $\vartheta = 1$ such that labor supply unresponsive to real income changes), (ii) sector-level covariance matrix is the same

[12]Consistent with the theoretical framework, we compute the cyclical component as the variance of GDP log-differences.

[13]To do so, we substract the year fixed-effects from the sectoral TFP series. See Appendix B.

[14]As studied by Gabaix (2011), if there is a fat-tailed distribution of firms' sale shares in the economy, when it comes to the firm-level channel, what matters for the impact of firms' idiosyncratic shocks on aggregate volatility is how concentrated are sales among the largest firms in the economy.

across countries, (iii) firm-level volatility is the same across countries, and (iv) the sum of domar weights for non-top firms tends to zero.[15] These assumptions imply that the contribution of the sectoral and firm-level channels are explained *only* by differences in the micro-structure of the economy, and not by intrinsic differences in sector- and firm-level volatility across countries.[16] Then, the difference in output volatility between emerging and developed economies is

$$\begin{aligned}\operatorname{Var}(d\log Y_{\text{EM}}) - \operatorname{Var}(d\log Y_{\text{DEV}}) = \\ \underbrace{\boldsymbol{\Lambda}_{\text{EM}}^{'}\Omega_{\tilde{A}}\boldsymbol{\Lambda}_{\text{EM}} - \boldsymbol{\Lambda}_{\text{DEV}}^{'}\Omega_{\tilde{A}}\boldsymbol{\Lambda}_{\text{DEV}}}_{\text{sectoral distribution}} + \underbrace{\left[\left(\lambda'\lambda\right)_{\text{EM}}^{\text{top}} - \left(\lambda'\lambda\right)_{\text{DEV}}^{\text{top}}\right]\sigma_{A_i}^2}_{\text{firm-level distribution}} \\ + \underbrace{\Lambda_{\text{EM}}^2\sigma_{A,\text{EM}}^2 - \Lambda_{\text{DEV}}^2\sigma_{A,\text{DEV}}^2}_{\text{residual aggregate}}. \end{aligned} \tag{9}$$

Decomposition (9) shows that aggregate output volatility can be expressed in terms of sufficient statistics that can be taken directly from the data: differences in the distribution of domar weights across sectors and differences in the herfindahl index of firm-level domar weights. Table 1 reports our main findings. The differences in the distribution of sectors and firms can explain much as 48% (43% sectoral and 5% firm-level) of the excessive aggregate output volatility in emerging economies. Next, we study and discuss in detail what determines the contribution of each channel.

Table 1: *Volatility Accounting: Emerging vs Developed Economies*

	Contribution		
	Sectoral	Firm-level	Aggregate
Baseline (median)	0.43	0.05	0.52
[P25,P75]	[0.10,0.63]	[-0.01,0.05]	[0.91,0.32]

Note: the contributions of each channel are estimated using equation (9). Further details about the data and the computation in the text. 'P25' refers to the result for the exercise using the 25th percentile of the distribution of sectoral and firm-level Domar weights and GDP volatility. 'P75' refers to the result for the exercise using the 75th percentile of the distribution of sectoral and firm-level Domar weights and GDP volatility.

[15]Figure C.2 shows that both, in emerging and developed economies, the cumulative sum of squared Domar weights (the sufficient statistic for the firm-level channel) becomes flat when roughly more than 15 to 20 firms are included.

[16]We don't rule out that differences in intrinsic volatility may exist and be relevant. See next subsection's discussion.

3.2.1 Sectoral channel

Pattern 1. *Sectoral domar weights in emerging economies are concentrated in highly volatile sectors (i.e., manufacturing and agriculture), whereas in developed economies they are concentrated in the least volatile sectors (i.e., services).*

Table 2 Panel (a) summarizes the distribution of sectoral Domar weigths in sectors that belong to the highest and lowest quartiles of sectoral volatility for emerging and developed economies. The sum of Domar weights across the most volatile sectors for the median emerging economy is 0.62 compared to 0.38 in developed economies, and the sum of Domar weights among the least volatile sectors is 0.70 in the median emerging economy vs 0.89 in the median developed economy.

Table 2: *Sectoral and firm distribution*

	Sum of Domar weights	
	Emerging	Developed
(a) Sector volatility		
Most volatile sectors	0.62	0.38
	(0.46,0.68)	(0.32,0.40)
Least volatile sectors	0.70	0.89
	(0.62,0.78)	(0.77,0.93)
(b) Firms concentration		
Top firms	0.48	0.36
	(0.24,0.55)	(0.29,0.49)

Source: World Development Indicators (WDI), Jorgenson *et al.* (2005) dataset, and Worldscope firm-level data.
Note: Panel (a) shows the sum of the Domar weights across sector's volatility for the median emerging and developed economies. 'Most volatile sectors' refer to the sectors belonging to the highest quartile in volatility, 'Least volatile sectors' refer to the sectors belonging to the lowest quartile in volatility. Panel (b) shows the sum of the Domar weights for Top firms in the economy for the median emerging and developed economies. Top firms are the 70 largest firms in terms of sales. We report in parentheses the values corresponding to the 25th and 75th percentiles.

Relation with Structural Transformation. We analyze which specific sectors are driving such a substantial contribution of the sectoral channel. As shown in the first three columns of Table 3, emerging economies tend to have relatively more sales shares in agriculture and manufacturing, which are the most volatile sectors. On the other hand, developed economies concentrate relatively more sales in services, a low volatile sector. These patterns are consistent with the process of structural transformation, widely studied in the macro-development literature, which suggests that as countries develop, they transition their production away from agriculture and manufacturing and towards services. We conduct a counterfactual analysis to quantify the relative importance of each sector in explaining the excessive volatility observed in emerging economies. The results can be found in the fourth column of Figure 3. If differences in sectoral Domar weigths came only from agriculture, the sectoral channel would explain 46% of GDP volatility differences. If they came only from manufacturing, the sectoral channel would contribute 53%. Lastly, if the only differences came from services, the sectoral channel would yield a negative contribution of -46%, implying that this sector plays a pivotal role in explaining output volatility in developed economies but not in emerging economies.

Table 3: *Sectoral channel decomposition*

	Domar W		Volatility	Contribution
	EM	DEV	(std)	to differences
Agriculture	0.21	0.05	0.10	46%
Manufacturing	0.62	0.42	0.08	53%
Services	1.00	1.32	0.06	-46%

Source: authors' calculations based on World Development Indicators (WDI) and Jorgenson *et al.* (2005) dataset.
Note: the first column shows the sectoral Domar weights for the median emerging (EM) and developed (DEV) developed; the second column shows the sectoral TFP volatility; and the third column shows the contribution of the sectoral channel (net of cross-sector correlations) in the counterfactual scenario in which the sale shares for all sectors but the one under analysis are the same in emerging and developed economies.

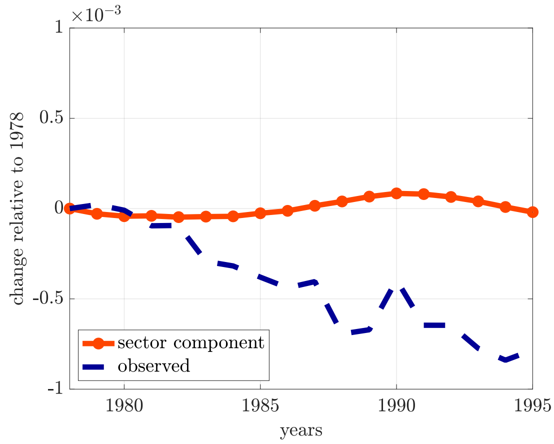
Time-Series Analysis. Next, we study the volatility differences between emerging and developed economies over time, and quantify the contribution of the sectoral channel in explaining the time-series. We document a significant reduction in output volatility in both emerging and developed economies during the period between 1978 and 1995. Notably, this decline is more pronounced in emerging economies.[17]

We employ our theoretical framework from Section 2 to investigate the impact of changes in the sectoral structure of both developed and emerging economies on this *relative* reduction in output volatility in emerging economies. In calculating the time series of the sectoral channel, we allow the Domar weights ($\Lambda_{sc,t}$) to vary over time, while keeping the covariance matrix of the sectoral TFP shocks ($\Omega_{\tilde{A}}$) fixed. We find that the sectoral channel alone cannot account for the relative decrease in output volatility in emerging economies, as illustrated in Figure 1. This suggests the presence of additional factors influencing these trends, such as improvements in macroeconomic policy

[17] In Appendix C.1, we use different samples to check for robustness and find that the decline in output volatility is robust across both groups of economies, and the relatively larger decline in emerging economies is robust but weaker. We focus on this period due to data availability.

management in emerging markets.[18]

Figure 1: *Output volatility and Sectoral Channel changes*



Notes: figure shows the change of the sectoral channel $\left(\Lambda'_{\text{EM},t}\Omega_{\tilde{A}}\Lambda_{\text{EM},t} - \Lambda'_{\text{DEV},t}\Omega_{\tilde{A}}\Lambda_{\text{DEV},t}\right)$ and the observed $(\sigma^2_{\text{EM},t} - \sigma^2_{\text{DEV},t})$ relative to base year 1978.

The Relevance of Correlated Sectoral Shocks Alternatively, we assume that sectoral TFP shocks are uncorrelated, and find that the sectoral channel explains 83% of the excessive output volatility in emerging economies. Thus, the sectoral channel's contribution is significantly smaller if we take into account that sector-level TFP shocks can be correlated across sectors.

3.2.2 Firm-level channel

Pattern 2. *Firm-level Domar weights within the largest firms are more concentrated in emerging than developed economies.*

This pattern drives the contribution of the firm-level channel. Through the lens of our model, a higher concentration of sales in fewer large firms implies that shocks that hit large firms, given the same firm-level shocks volatility, would have a higher impact on emerging economies aggregate volatility than on developed. Using firm-level data from Worldscope, we analyze how concentrated are the sales shares across the largest firms in the economy. The dataset allows us to separate sales by domestic subsidiaries (the relevant ones for our theory) from foreign ones. Table 2 Panel (b) shows that sales within the largest firms are more concentrated in emerging economies, with the sum of Domar weights of the top 70 firms being 0.48 in emerging economies vs 0.36 in developed ones.

[18] Additionally, we document a surge in the significance of the service sector for both emerging and developed economies, which may be a key driver of the substantial decrease in output volatility observed in both types of economies, a phenomenon previously noted by Carvalho and Gabaix (2013) for the United States and other developed economies.

Intrinsic Volatility Differences Aggregate output in emerging economies could be more volatile because firms idiosyncratic shocks are more volatile in emerging economies. We cannot measure directly the differences in firm-level volatility, then we assume that the residual portion of the excessive volatility comes only from *intrinsic* differences in firm-level volatility (i.e., we assume the aggregate channel is 0). In this exercise, we find that the idiosyncratic volatility of firms in emerging economies are 2 times and 31% higher than in developed economies with correlated and uncorrelated shocks, respectively. This suggests that the firm-level channel may be much more relevant if firms are moderately more volatile in emerging economies.[19]

3.3 International Prices Transmission

In this section, we focus on the role of the international prices channel in explaining the output volatility differences in emerging and developed economies, and how sensitive it is to different assumptions regarding the household's preferences. We show in Proposition 1 that for international prices to transmit to aggregate output fluctuations, we need that there are trade imbalances across sectors and the labor supply is responsive to real income fluctuations.

The sectoral trade imbalances reflect that the consumption basket and production structure are different. Shocks to international prices of sectors with trade imbalances will change households' real income. For example, if there is an increase in a good which is produced domestically but consumed abroad (i.e., exported) then the household's real income increases since the production price index increases more than the consumer price index. Importantly, shifts in real income, to a first order, translate into changes in aggregate output only if labor supply is responsive (or more formally, if the income and substitution effect don't cancel each other out).

Using disaggregated trade data from COMTRADE (see Appendix C.3), we first document the trade imbalances across emerging and developed economies. Figure C.3 shows the sectoral trade imbalances for 20 tradable sectors for the median emerging and developed economies. We observe that trade imbalances are much larger in emerging economies. In addition, as Kohn *et al.* (2021) observe, while emerging economies are net exporter of commodities and net importers of manufactures, developed economies are roughly balanced in both sector categories.

To estimate the contribution of international prices to the excessive output volatility in emerging economies we compute $\mathbf{p}^T$ and $\Omega_{\mathbf{p}^T}$ using sectoral prices data and construct the vector of observed trade imbalances for emerging $\mathbf{b}_{EM}$ and developed $\mathbf{b}_{DEV}$.

[19] This number is comparable to previous findings that use firm-level data. See, for example, Kochen (2023) estimates for a set of high- and middle-income European economies.

Using equation (8) for emerging and developed economies, we define the contribution of the international prices channel as

$$(1-\vartheta)^2 \frac{\left[\mathbf{b}'_{EM}\Omega_{\mathbf{p}^T}\mathbf{b}_{EM} - \mathbf{b}'_{DEV}\Omega_{\mathbf{p}^T}\mathbf{b}_{DEV}\right]}{\mathrm{Var}\left(\mathrm{d}\log Y_{\mathrm{EM}}\right) - \mathrm{Var}\left(\mathrm{d}\log Y_{\mathrm{DEV}}\right)}. \tag{10}$$

In Table 4, we compute the contribution for various values of ψ and σ, recall $\vartheta \equiv \left(\frac{1+\psi}{1+\psi\sigma(1-b^*)}\right)$. We find that the contribution of the international prices channel ranges from 0.2% to 16.2%. These results suggest that preferences such as GHH ($\sigma = 0$), which are commonly used in the literature, by muting the income effect can amplify significantly the transmission of commodity prices shocks to aggregate GDP fluctuations through real income changes.

Table 4: *International Prices Channel*

Parameters				
σ	2	2	0	0
ψ	2	4	2	4
Contribution	0.2%	0.2%	4.0%	16.2%

Note: contributions are estimated using equation (10) with trade data from COMTRADE and sectoral price data from Jorgenson *et al.* (2005). We assume $b^* = -0.02$ for both country categories. Further details in Appendix C.3.

4 Conclusion

In this paper, we study why emerging economies are more volatile than developed economies through the lens of a small open economy general equilibrium model with production linkages, tradable and nontradable sectors, heterogeneous firms within each sector, and elastic aggregate labor supply.

Our main proposition shows that in this comprehensive economy, aggregate output can fluctuate through four channels – aggregate, sectoral, firm-level, and international prices – which depend on observable sufficient statistics and a parameter that summarizes the responsiveness of labor to changes in labor income. Using microdata (sector- and firm-level data) from several countries we find that difference in the sectoral and firm distribution between emerging and developed economies can explain around half of the greater output volatility in emerging economies. On the other hand, we find that the international prices channel relevance depends on the household's preferences.

The paper remains silent on why the micro-structure of the economy (distribution of sectors and firms) differs between emerging and developed economies. Whether differences are driven by heterogeneity in natural endowments, skills distribution, market structure, or inefficiencies, would have different normative implications. We leave these interesting research avenues for future work.

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Online Appendix

"The Business Cycle Volatility Puzzle: Emerging vs Developed Economies" by Lucia Casal and Rafael Guntin

A Theory Appendix

A.1 Proof of Lemma 1

Lemma 1. *If we assume shocks to* $\{A, \tilde{A}_s, A_i, \mathbf{p}^T\}$ *we have that the GDP deflator is*

$$d\log P_{\mathcal{Y}} = \sum_{s\in\mathcal{S}^T} b_s d\log p_s. \tag{11}$$

where b_s *is the trade balance of sector* s.

Proof. Changes in CPI can be defined as

$$\mathrm{d}\ln P = \sum_{s\in\mathcal{S}} \frac{p_s C_s}{\sum_{s\in\mathcal{S}} p_s C_s} \mathrm{d}\log p_s,$$

which can be split in different sectors as

$$\mathrm{d}\ln P = \sum_{s\in\mathcal{S}^T} \frac{p_s C_s}{\sum_{s\in\mathcal{S}} p_s C_s} \mathrm{d}\log p_s, + \sum_{s\in\mathcal{S}^{NT}} \frac{p_s C_s}{\sum_{s\in\mathcal{S}} p_s C_s} \mathrm{d}\log p_s. \tag{12}$$

By definition, the nominal GDP is

$$\tilde{\mathcal{Y}} = \sum_{s\in\mathcal{S}} p_s \left(y_s - X_s\right)$$

where $X_s = \sum_{i\in\mathcal{I}} X_{i,s}$ and $y_s = \sum_{i\in\mathcal{I}_s} y_i$ aggregated to the sector-level. Notice that nominal GDP and GDP deflated by CPI are the same since the CPI is normalized to 1 (i.e., $\mathrm{d}\ln P = 0$). Furthermore, we can use the CPI definition (12) and scale it by the ratio of total expenditure to GDP, such that

$$\frac{\sum_{s\in\mathcal{S}} p_s C_s}{\tilde{\mathcal{Y}}} \mathrm{d}\ln P = \sum_{s\in\mathcal{S}^T} \frac{p_s C_s}{\tilde{\mathcal{Y}}} \mathrm{d}\log p_s + \sum_{s\in\mathcal{S}^{NT}} \frac{p_s C_s}{\tilde{\mathcal{Y}}} \mathrm{d}\log p_s. \tag{13}$$

The GDP deflator can be defined as

$$\mathrm{d}\log P_{\mathcal{Y}} = \sum_{s\in S} \frac{p_s \left(y_s - X_s\right)}{\tilde{\mathcal{Y}}} \mathrm{d}\log p_s,$$

then using the non-tradable market clearing $y_s = C_s + X_s$, we can rewrite the GDP deflator as

$$\mathrm{d}\log P_{\mathcal{Y}} = \sum_{s\in\mathcal{S}^{NT}} \frac{p_s C_s}{\tilde{\mathcal{Y}}} \mathrm{d}\log p_s + \sum_{s\in\mathcal{S}^T} \frac{p_s \left(y_s - X_s\right)}{\tilde{\mathcal{Y}}} \mathrm{d}\log p_s$$

then substituing with CPI expression we have

$$\mathrm{d}\log P_{\mathcal{Y}} = \frac{\sum_{s\in\mathcal{S}} p_s C_s}{\tilde{\mathcal{Y}}}\mathrm{d}\log P - \sum_{s\in\mathcal{S}^T} \frac{p_s C_s}{\tilde{\mathcal{Y}}}\mathrm{d}\log p_s + \sum_{s\in\mathcal{S}^T} \frac{p_s\left(y_s - X_s\right)}{\tilde{\mathcal{Y}}}\mathrm{d}\log p_s$$

using the fact that $\mathrm{d}\log P = 0$ and $b_s \equiv \frac{(y_s - X_s - C_s)}{\tilde{\mathcal{Y}}}$ then the GDP deflator is

$$\mathrm{d}\log P_{\mathcal{Y}} = \sum_{s\in\mathcal{S}^T} b_s \mathrm{d}\log p_s. \tag{14}$$

□

We owe the proof of Lemma 1 to Alvaro Silva.

A.2 Proof of Proposition 1

Using the firm's optimal choices and market clearing conditions in the non-tradable sector and labor markets, we can write the aggregate production function as

$$\tilde{\mathcal{Y}}\left(\mathcal{A}, \mathbf{p}^T, L\right) = H\left(\mathcal{A}, \mathbf{p}^T, L\right) L.$$

Assumption 1. *We assume that the aggregate production function satisfies the following assumption*

$$\frac{\partial H\left(\mathcal{A}, \mathbf{p}^T, L\right)}{\partial L} \to 0 \tag{15}$$

This assumption assures that aggregate labor endowment doesn't affect the allocations across firms, therefore aggregate TFP, in equilibrium.

Proof of Proposition 1. The economy is efficient then to show the SOC Hulten Theorem setup the planner's problem. The planner maximizes household utility subject to the market clearing for every nontradable good, labor market clearing and the aggregate resource constraint. To solve the problem we, first, solve the planner's problem with L fixed and then find L to determine the response of aggregate output.

Planner's problem

Using the aggregation properties, given L, the planner solves the following problem

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

$$+\mu^T\left[\sum_{s\in\mathcal{S}^T} p_s\left(\sum_{i\in\mathcal{I}_s}\mathcal{A}_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)-C_s-\sum_{j\in\mathcal{S}}\sum_{i\in\mathcal{I}_j}X_{i,s}\right)-B^*\right]$$

where $\mathcal{A}_i = A\tilde{A}_sA_i$ if the TFP shifter, μ_s is the lagrange multiplier on the market clearing condition of nontradable sector $s\in\mathcal{S}^T$, λ is the multiplier on the labor supply constraint, and μ^T the mutiplier on the tradable sectors aggregate resource constraint. Notice that $\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)/P_{\mathcal{Y}} = \mathcal{Y}(A,\tilde{A}_s,A_i,\mathbf{p}^T)$ where $\tilde{\mathcal{Y}}$ is the nominal GDP (or deflated by CPI), $P_{\mathcal{Y}}$ is the GDP deflator , and $\mathcal{Y}$ is the real GDP deflated by the GDP deflator. Finally, the net external balance are B^* and the tradable sectors prices are $\mathbf{p}^T$.

Optimal conditions

First the envelope conditions for A, $\tilde{A}_s$, A_i,and p_s for $s\in\mathcal{S}^T$:

$$\begin{aligned}
\frac{\partial\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)}{\partial A} &= \sum_{s\in\mathcal{S}^{NT}}\mu_s\sum_{i\in\mathcal{I}_s}\tilde{A}_sA_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)+\mu^T\sum_{s\in\mathcal{S}^T}p_s\sum_{i\in\mathcal{I}_s}\tilde{A}_sA_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)\\
\frac{\partial\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)}{\partial \tilde{A}_s} &= \mathbf{1}_{s\in\mathcal{S}^{NT}}\mu_s\sum_{i\in\mathcal{I}_s}AA_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)+\mathbf{1}_{s\in\mathcal{S}^T}\mu^Tp_s\sum_{i\in\mathcal{I}_s}AA_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)\\
\frac{\partial\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)}{\partial A_i} &= \mathbf{1}_{s\in\mathcal{S}^{NT}}\mu_sA\tilde{A}_sF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)+\mathbf{1}_{s\in\mathcal{S}^T}\mu^Tp_sA\tilde{A}_sF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)\\
\frac{\partial\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)}{\partial p_s} &= \mu^T\left(A\tilde{A}_sA_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)-C_s-\sum_{j\in\mathcal{S}}\sum_{i\in\mathcal{I}_j}X_{i,s}\right)
\end{aligned}$$

The FOC with respect to consumption are

$$\frac{\partial\mathcal{C}\left(\{C_s\}_{s=1}^S\right)}{\partial C_s} = \mathbf{1}_{\mathbf{s}\in\mathcal{S}^{\mathbf{NT}}}\mu_s+\mathbf{1}_{s\in\mathcal{S}^T}\mu^Tp_s$$

From the descentralized problem of the household the optimal conditions are

$$\frac{\partial\mathcal{C}\left(\{C_s\}_{s=1}^S\right)}{\partial C_s} = p_s$$

which implies that $\mu^T=1$ and $\mu_s=p_s$. Then replacing in the envelope conditions of the planner's problem:

$$\begin{aligned}
\frac{\partial\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)}{\partial A} &= \sum_{s\in\mathcal{S}}p_s\sum_{i\in\mathcal{I}_s}\tilde{A}_sA_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)\\
\frac{\partial\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)}{\partial \tilde{A}_s} &= p_s\sum_{i\in\mathcal{I}_s}AA_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)\\
\frac{\partial\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)}{\partial A_{is}} &= p_sA\tilde{A}_sF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)\\
\frac{\partial\tilde{\mathcal{Y}}(A,\tilde{A}_s,A_i,\mathbf{p}^T)}{\partial p_s} &= A\tilde{A}_sA_iF_s\left(L_i,\{X_{i,j}\}_{j=1}^S\right)-C_s-\sum_{j\in\mathcal{S}}\sum_{i\in\mathcal{I}_j}X_{i,s}
\end{aligned}$$

Rearranging terms and defining the Domar weight of firm $i \in \mathcal{I}_s$ as

$$\lambda_i \equiv \frac{p_s A \tilde{A}_s A_i F_s\left(L_i, \{X_{i,j}\}_{j=1}^S\right)}{\tilde{\mathcal{Y}}}$$

then we have:

$$\frac{\partial \tilde{\mathcal{Y}}(A, \tilde{A}_s, A_i, \mathbf{p}^T)/\tilde{\mathcal{Y}}}{\partial A/A} = \frac{\sum_{s\in\mathcal{S}} p_s \sum_{i\in\mathcal{I}_s} A\tilde{A}_s A_i F_s\left(L_i, \{X_{i,j}\}_{j=1}^S\right)}{\tilde{\mathcal{Y}}} = \sum_{s\in\mathcal{S}}\sum_{i\in\mathcal{I}_s}\lambda_i$$

$$\frac{\partial \tilde{\mathcal{Y}}(A, \tilde{A}_s, A_i, \mathbf{p}^T)/\tilde{\mathcal{Y}}}{\partial \tilde{A}_s/\tilde{A}_s} = \frac{p_s \sum_{i\in\mathcal{I}_s} A\tilde{A}_s A_i F_s\left(L_i, \{X_{i,j}\}_{j=1}^S\right)}{\tilde{\mathcal{Y}}} = \sum_{i\in\mathcal{I}_s}\lambda_i$$

$$\frac{\partial \tilde{\mathcal{Y}}(A, \tilde{A}_s, A_i, \mathbf{p}^T)/\tilde{\mathcal{Y}}}{\partial A_i/A_i} = \frac{p_s A\tilde{A}_s A_i F_s\left(L_i, \{X_{i,j}\}_{j=1}^S\right)}{\tilde{\mathcal{Y}}} = \lambda_i$$

$$\frac{\partial \tilde{\mathcal{Y}}(A, \tilde{A}_s, A_i, \mathbf{p}^T)/\tilde{\mathcal{Y}}}{\partial p_s/p_s} = \frac{p_s\left(A\tilde{A}_s A_i F_s\left(L_i, \{X_{i,j}\}_{j=1}^S\right) - C_s - \sum_{j\in\mathcal{S}}\sum_{i\in\mathcal{I}_j} X_{i,s}\right)}{\tilde{\mathcal{Y}}} \equiv b_s$$

The first order response of output, fixed L, to changes to shocks $\{A, \tilde{A}_s, A_i, \mathbf{p}^T\}$ is

$$\partial \log \tilde{\mathcal{Y}}(A, \tilde{A}_s, A_i, \mathbf{p}^T) = \sum_{s\in\mathcal{S}}\sum_{i\in\mathcal{I}_s}\lambda_i \partial a + \sum_{s\in\mathcal{S}}\sum_{i\in\mathcal{I}_s}\lambda_i \partial \tilde{a}_s + \sum_{s\in\mathcal{S}}\sum_{i\in\mathcal{I}_s}\lambda_i \partial a_i + \sum_{s\in\mathcal{S}} b_s \partial \log p_s. \tag{16}$$

Equation 16 is a standard version of Hulten theorem, where L inelastic and GDP is deflated by the CPI.[20] Using the properties of the aggregate production function and for L fixed, we know that $\mathrm{d}\log \tilde{Y} = \mathrm{d}\log H$.

Elastic L Supply

Using Assumption 1 we solve for the L choice problem, such that

$$\max_L \frac{(HL - B^*)^{1-\sigma}}{1-\sigma} - \frac{L^{1+\frac{1}{\psi}}}{1+\frac{1}{\psi}}$$

then the optimality condition is

$$H\left(\tilde{Y} - B^*\right)^{-\sigma} = L^{\frac{1}{\psi}}$$
$$\rightarrow H^{\psi+1}\left(\tilde{Y} - B^*\right)^{-\psi\sigma} = \tilde{Y}$$

Next, taking logs

$$\log \tilde{Y} = (1+\psi)\log H - \psi\sigma \log\left(\tilde{Y} - B^*\right)$$

[20] In a previous version of the theorem we consider shocks to B^*, but they don't affect real output when aggregate labor supply is inelastic. This result is consistent with the results by Burstein and Cravino (2015); Baqaee and Farhi (2021).

and then taking differences and using log-linearization[21]

$$\partial \log \tilde{Y} = \left(\frac{1+\psi}{1+\psi\sigma\left(1-b^*\right)} \right) \partial \log H$$

where $b^* = \frac{B_0^*}{Y_0 - B_0^*}$.

Extended SOE Hulten Theorem

Using Lemma 1, we deflate $\tilde{Y}$ by the GDP deflator and using equation 16, then it follows that

$$\begin{aligned} \partial \log Y = & \left(\frac{1+\psi}{1+\psi\sigma\left(1-b^*\right)} \right) \left[\Lambda \partial a + \sum_{s \in \mathcal{S}} \Lambda_s \partial a_s + \sum_{i \in \mathcal{I}} \lambda_i \partial a_i \right] \\ & + \psi \left(\frac{1-\sigma\left(1-b^*\right)}{1+\psi\sigma\left(1-b^*\right)} \right) \sum_{s \in S^T} b_s \partial \log p_s. \end{aligned}$$

□

B Data Appendix

In this Appendix, we explain the data sources, measurement and sampling used.

B.1 Data Sources by Channel

Business Cycle (GDP) Volatility. We use the GDP in constant LCU series from World Development Indicators (WDI) for the period 1970-2016 to compute the volatility of GDP for each country.

Sectoral Channel. Given the lack of long time series of sectoral productivity across countries, we assume sectoral volatilities to be the same across developed and emerging economies. We use the dataset from Jorgenson *et al.* (2005) to construct the sector-level TFP series. To remove the common component of TFP growth we run the following regression

$$\text{dlog}(A_{st}) = \alpha_t + \text{dlog}(\tilde{A}_{st}),$$

where $\mathrm{d}x_t = x_t - x_{t-1}$, A_{st} are the observed sectoral TFPs, α_t time (year) FE, and the residual $\text{dlog}(\tilde{A}_{st})$ is the sectoral TFP used in the estimation of the covariance matrices. We construct a crosswalk from the 77 sectors in Jorgenson *et al.* (2005) to compute the average sectoral volatility for each of the 36 OECD sectors.

[21] Log approx for $\log\left(\tilde{Y} - B^*\right) - \log\left(\tilde{Y}_0 - B_0^*\right) = \frac{\tilde{Y} - \tilde{Y}_0}{\tilde{Y}_0 - B_0^*}$ then $\mathrm{d}\log\left(\tilde{Y} - B^*\right) = \left(\frac{\tilde{Y}_0}{\tilde{Y}_0 - B_0^*}\right) \mathrm{d}\log \tilde{Y}$. Due to Inada conditions we know $\tilde{Y} - B^* > 0$.

We use the OECD input output tables to estimate the sectoral Domar weights for emerging and developed economies. For each sector we compute the share of gross output on aggregate value added (GDP), for both tradable and nontradable sectors (36 sectors in total).

To compute the long-run changes in Domar weights — in the time-series exercise — we use historical input-output data from WIOD, which covers the period 1965 to 2000. Domar weights are calculated using 11-year window, where the reference year is the 6th year (i.e., median year of the window).

Firm-level Channel. We use the Worldscope dataset to compute the firm's Domar weights λ_i. Worldscope contains financial statements of up to 90,000 public companies in both emerging and developed economies. The main advantage of Worldscope is that it covers both emerging and developed economies and distinguishes between domestic and foreign sales for each company, where domestic sales are sales done by establishments located in the country. Domestic sales are computed as 1 minus the share of foreign sales (`1-ITEM8731`) times total sales in USD (`ITEM7240`). Finally, the Domar weight is computed as the domestic sales over GDP from WDI in current USD.

Table B.1: Sample Selection: Worldscope

Criteria	drop	sample
Year $\geq$ 2000	341,292	1,223,875
Missing sales data	223,855	1,000,020
Domestic sales data	269,761	730,259
Duplicates	177,576	552,683
Irregular foreign sales shares (<0%, >100%)	177,576	373,542
Top 70 firms per country-year	250,203	123,339
Country sample	36,522	86,817

Table B.1 shows our sample selection criteria in Worldscope.

B.2 Countries and Sectors

Table B.2: Countries in the Baseline Sample

Emerging	Developed
Brazil	Australia
Chile	Austria
Indonesia	Belgium
India	Canada
Mexico	Denmark
Malaysia	Finland
Philippines	France
Thailand	Greece
Turkey	Germany
South Africa	Ireland
	Israel
	Italy
	Japan
	Netherlands
	Norway
	Spain
	Sweden
	Switzerland
	United Kingdom

Table B.3: Tradable and Nontradable OECD Sectors

Tradables	Nontradables
Mining and ext.of energy prod	Electricity, gas, water supply
Coke and refined petroleum products	Other business sector services
Machinery and equipment	Financial and insurance activities
Other transport equipment	Wholesale and retail trade; repair of motor vehicles
Motor vehicles, trailers and semi-trailers	Public admin. and defence; compulsory social security
Chemicals and pharmaceutical products	Publishing, audiovisual and broadcasting activities
Electrical equipment	Real estate activities
Textiles, wearing apparel, leather and related products	Construction
Fabricated metal products	Telecommunications
Basic metals	Arts, entertainment, recreation and other service activities
Mining support service activities	Transportation and storage
Other non-metallic mineral products	Human health and social work
Rubber and plastic products	Accommodation and food services
Other manufacturing	Education
Computer, electronic and optical products	IT and other information services
Wood products	
Paper products and printing	
Agriculture, forestry and fishing	
Mining and ext.of non-energy prod	

C Additional Exercises

In this section, we provide further detail of the additional exercises.

C.1 Structural Transformation and Business Cycle Volatility

We describe the sample used in the exercise that uses historical input-output data from WIOD.

Table C.1: Countries in the Long-Run Sample

Emerging	Developed
Brazil	Australia
India	Austria
Korea	Belgium
Mexico	Canada
Portugal	Denmark
	Finland
	France
	Germany
	Greece
	Ireland
	Italy
	Japan
	Netherlands
	Spain
	Sweden
	United Kingdom

Next, we perform a robustness check for different sample selections of the evolution of the relative volatility of emerging economies.

Table C.2: Changes in Volatility Differences: Sample Robustness

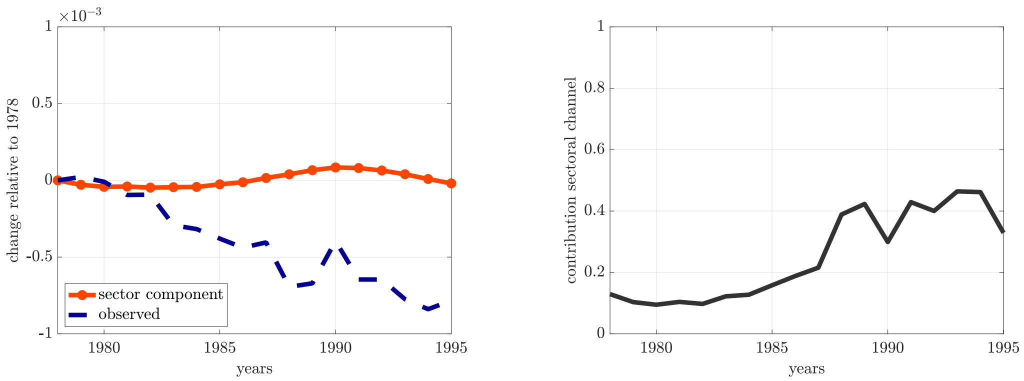
	sample		
	baseline	long-run	large*
$\left(\sigma^2_{\text{EM},1978} - \sigma^2_{\text{DEV},1978}\right)$	1.20	0.74	0.97
$\left(\sigma^2_{\text{EM},1995} - \sigma^2_{\text{DEV},1995}\right)$	0.41	0.60	0.59
$\Delta_{1978-1995}$	-0.79	-0.15	-0.38

Source: authors' calculations using WIOD and WDI data. Notes: volatility terms are expressed in 10^{-3} units.
*baseline sample in Kohn *et al.* (2021)

Finally, we compute the exercise using the theoretical framework. We compare the changes in relative volatility driven only by the sectoral channel and the observed decline, and we compute the contribution of the channel in explaining the level of the excessive volatility in emerging economies.

Figure C.1: Sectoral Channel and Relative Decline in Volatility

(a) *Output volatility and Sectoral Channel changes* **(b)** *Contribution to volatility differences*

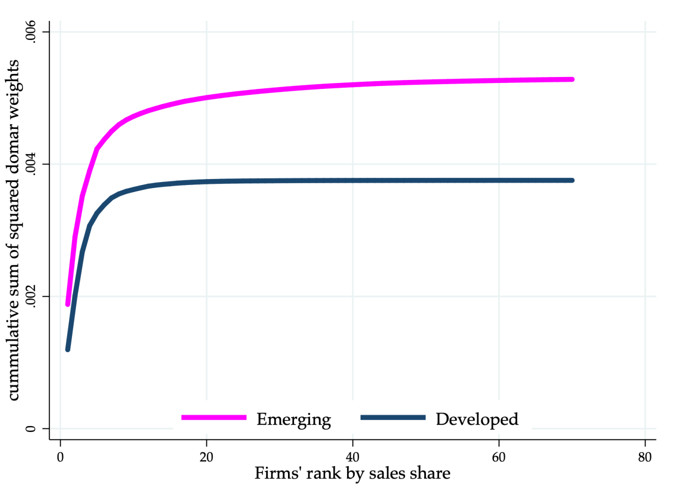


Notes: panel (a) shows the change of the sectoral channel $\left(\boldsymbol{\Lambda}'_{\mathbf{EM,t}}\Omega_{\tilde{A}}\boldsymbol{\Lambda}_{\mathbf{EM,t}} - \boldsymbol{\Lambda}'_{\mathbf{DEV,t}}\Omega_{\tilde{A}}\boldsymbol{\Lambda}_{\mathbf{DEV,t}}\right)$ and the observed $(\sigma^2_{\mathrm{EM},t} - \sigma^2_{\mathrm{DEV},t})$ relative to base year 1978. Panel (b) shows the evolution of the contribution of the sectoral channel to the volatility differences between emerging and developed economies.

C.2 Firm Distribution

Figure C.2 shows that the sum of the squared Domar from the Top 1 to Top 70 firms by sales of their domestic establishments. The sum become flat after a low number of firms.

Figure C.2: *Cummulative sum of squared Domar weights*



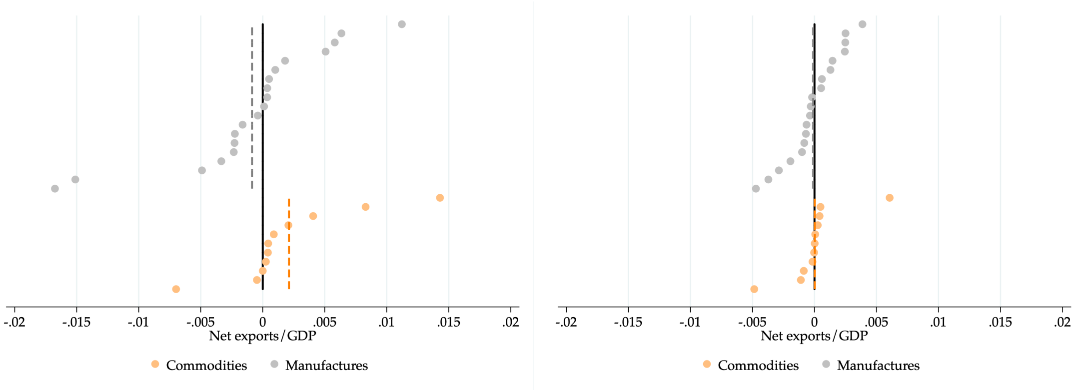
Source: Worldscope firm-level data.
Note: the figure shows the cummulative sum of squared Domar weights from the Top 1 to Top 70 firms in terms of sales by domestic establishments.

C.3 International Prices Data

We use international trade sector-country data from COMTRADE to compute the country-sector trade imbalances b_s. Trade imbalances b_s are defined as a sector s exports minus imports as a share of GDP. We construct the series consistent with the OECD tradable sectors. We use data from U.S. sector-level prices from Jorgenson *et al.* (2005) to compute the volatility of tradable sectors prices. We deflate the time series by US CPI. The main advantage of using this dataset is that it is consistent with our sector-level TFP estimates.

Figure C.3: Sectoral trade imbalances (as % of GDP)

(a) *Emerging economies* **(b)** *Developed economies*



Source: authors' calculations based on COMTRADE.
Note: orange and gray dashed lines represent averages within commodities and manufactures' sectors respectively. Within each broad category, sectors are ordered by their net trade balance.