Trade in Commodities and Business Cycle Volatility[1]

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Abstract

This paper studies the role of the patterns of production and international trade on the higher business cycle volatility of emerging economies. We study a multi-sector small open economy in which firms produce and trade commodities and manufactures. We estimate the model to match key cross-sectional differences across countries: emerging economies run trade surpluses in commodities and trade deficits in manufactures, while sectoral trade flows are balanced in developed economies. We find that these differences amplify the response of emerging economies to fluctuations in commodity prices. We show evidence consistent with these findings using cross-country data.

JEL Classification Codes: E32, F4, F41, F44

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1 Introduction

Emerging and developed economies differ systematically along both the cross-section and in their dynamics. On the one hand, business cycles in emerging economies are more volatile than in developed ones; Figure 1 shows the negative relationship between GDP per capita and the standard deviation of real GDP previously examined, for instance, by Acemoglu and Zilibotti (1997) and Koren and Tenreyro (2007).[1] On the other hand, a growing literature on structural transformation shows that emerging and developed economies specialize in the production of different types of goods; see Herrendorf et al. (2014) for an overview of this literature. In this paper, we show that cross-sectional differences between emerging and developed economies can account for a large share of the difference in business cycle volatility.

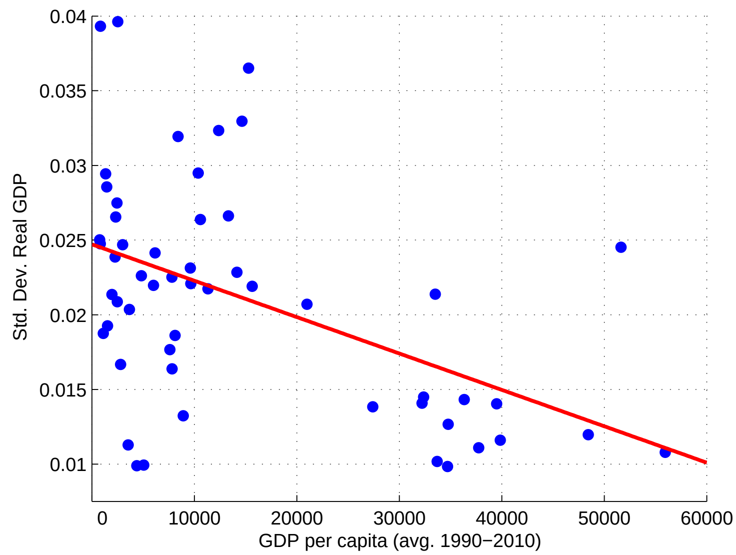
Our starting point is the observation that while emerging economies produce and export systematically different goods than their developed counterparts, these economies consume and import very similar types of goods. In particular, we document that commodities make up 71% of aggregate exports in the average emerging economy, while only 29% in the average developed economy. In contrast, commodities as a share of aggregate imports is very similar across these economies: 33% and 31%, respectively.

This paper shows that these systematic differences between emerging and developed economies affect their response to changes in the international relative prices of commodities and manufactures, amplifying business cycle volatility in emerging economies. For instance, consider an increase in the relative price of commodities. In emerging economies, this increases the value of production and exports, while reducing the relative price of goods imported by these economies, triggering an economic boom. In contrast, in developed economies, an increase in the value of production and exports is approximately offset by an increase in the value of imports and, thus, has a minimal impact on aggregate economic activity.

To investigate the role of this mechanism in accounting for the difference

[1]For details on the data and variables used in Figure 1, see Section 2.

Figure 1: Economic development and business cycle volatility



in business cycle volatility between emerging and developed economies, we model a multi-sector small open economy. The economy produces commodities, manufactures, and non-tradable goods. Firms trade commodities and manufactures internationally taking prices as given from the rest of the world. Aggregate fluctuations are driven by shocks to the productivity of all sectors as well as by shocks to the relative price of commodities.

First, we investigate analytically the role of differences in the types of goods produced and consumed across countries in the response of output to changes in international relative prices. We show that international price fluctuations impact the incentives to accumulate physical capital and supply labor insofar as the composition of the consumption price index is different from the production price index; this is the case in emerging economies. We also show that international relative price shocks affect aggregate output by leading to changes in aggregate total factor productivity (TFP). In contrast to Kehoe and Ruhl (2008), in our economy, changes in international relative prices can affect aggregate TFP through reallocation of production inputs across sectors.

Second, we quantitatively investigate the extent to which systematic cross-sectional differences between emerging and developed economies can account for the difference in business cycle volatility. To do so, we first estimate the model to account for salient cross-sectional and time-series features of developed economies. In particular, we parameterize the model to account for the share of commodities and manufactures in aggregate output as well as for sectoral trade imbalances in commodities and manufactures. Notice that the latter captures the differences in the shares of commodities and manufactures in aggregate exports and imports.

Our goal is to quantify the role of cross-sectional differences in accounting for the difference in aggregate volatility between emerging and developed economies. Thus, we contrast the implications of our estimated developed economy with a counter-factual emerging economy that differs from its developed counterpart only in the parameters related to its patterns of production and trade. We re-estimate these parameters such that the emerging economy matches the cross-sectional features of emerging economies mentioned above.

We find that cross-sectional differences in the patterns of production and trade can account for 52% of the difference in real GDP volatility between emerging and developed economies. In particular, given a developed economy parameterized to match the real GDP volatility in the data (equal to 1.39%), we find that our model implies that real GDP volatility in the counter-factual emerging economy is equal to 1.90% (vs. 2.37% in the data). Thus, we find that cross-sectional differences between developed and emerging economies have a significant impact on business cycle volatility in the emerging economy despite being subject to the same shock processes as its developed counterpart.

Third, we investigate which features of our model are most important in accounting for our findings. We begin by showing that the implied differences between developed and emerging economies are primarily accounted for by differences in their responses to international relative price shocks. Then, we show that sectoral trade imbalances are the key feature driving the larger response of the emerging economy to commodity price shocks: Aggregate volatility is significantly reduced when the emerging economy is recalibrated to match the smaller manufacturing trade imbalance of developed economies.

Fourth, we show that the key channels that account for the higher volatility of emerging economies in our model are also important in accounting for aggregate volatility in the data. In particular, we use cross-country data to document that sectoral trade imbalances are positively associated with aggregate real GDP volatility. Importantly, we find that this relationship is robust to controlling for the countries' level of economic development.

Finally, we examine whether the implications of our model are quantitatively consistent with this cross-country evidence. To do so, we re-estimate our model for each of the 55 countries in our cross-country dataset and contrast the implications for each country with its empirical counterpart. We show that, indeed, our model is quantitatively consistent with the cross-country empirical relationship between sectoral imbalances and aggregate volatility.

Our paper contributes to a growing literature that investigates the role of terms of trade shocks on business cycle fluctuations across countries. Earlier work by Mendoza (1995) and Kose (2002) showed that terms of trade shocks are an important source of business cycle volatility in emerging and developed economies. In contrast, Schmitt-Grohé and Uribe (2018) argue that these shocks only account for a small share of aggregate fluctuations in emerging economies. Recent work by Fernández et al. (2018) and Fernández et al. (2017) document that commodity price fluctuations account for a higher fraction of output volatility than terms of trade shocks, with heterogeneous effects across countries. Our paper shows that differences in the patterns of production and trade across countries can account for the heterogeneous response of aggregate fluctuations to commodity price shocks in emerging and developed economies, even if they are subject to the same shocks.[2]

A key feature of our mechanism is the differential response to international relative price shocks based on the economies' patterns of production and trade. In contrast to Kehoe and Ruhl (2008), we show that terms of trade shocks can

[2]Zeev et al. (2017), Shousha (2016), and Drechsel and Tenreyro (2017) also emphasize the importance of commodity price shocks on business cycle fluctuations.

impact real GDP by increasing capital and labor, as well as by increasing aggregate TFP through the reallocation of production across sectors.

Our paper is also related to studies that investigate complementary channels to account for business cycle fluctuations in emerging economies. On the one hand, Acemoglu and Zilibotti (1997), Koren and Tenreyro (2007), and Da-Rocha and Restuccia (2006), among others, study other channels that account for the higher volatility of emerging economies. On the other hand, Neumeyer and Perri (2005), Aguiar and Gopinath (2007), García-Cicco et al. (2010), Chang and Fernández (2013), Hevia (2014), and Comin et al. (2014) study channels that account for differences in economic fluctuations between emerging and developed economies along a broader set of business cycle moments. We contribute to these literatures by providing a novel and quantitatively important mechanism based on the mismatch between the types of goods that are produced and consumed in emerging economies.

The rest of the paper is structured as follows. In section 2, we document salient features of developed and emerging economies. In section 3, we set up our model. In section 4, we examine the mechanisms through which changes in international relative prices can affect real GDP in our model. In section 5, we calibrate the model, present our results and study the mechanism behind them. In section 6, we contrast the implications of our model with cross-country evidence. In section 7, we present the main conclusions of the paper.

2 Volatility, production, and trade in emerging economies

In this section, we document salient features of developed and emerging economies. First, we present a well-known empirical fact: Business cycles in emerging economies are more volatile than in developed ones. Then, we show that these two country groups also differ markedly along the cross-section: The production of commodities constitute a larger share of economic activity in emerging economies than the production of manufactures, while the opposite is true for developed economies. Moreover, we show that these economies also differ in the type of goods traded internationally: In emerging economies the compositions of exports and imports are quite different, while in developed economies the shares of commodities and manufactures are similar for exports and imports. In subsequent sections, we use a structural model to investigate the extent to which these cross-sectional differences between emerging and developed economies can account for the difference in business cycle volatility.

We use data from the World Development Indicators.[3] We restrict attention to annual data from 1970 to 2010. We classify countries into "Emerging" and "Developed" following Schmitt-Grohé and Uribe (2018): Countries with average, PPP-converted, GDP per capita lower than $25,000 in 2005 U.S. dollars are referred to as "Emerging," while the rest are referred to as "Developed"; averages are taken over the period from 1990 to 2009.

We restrict the set of countries that we study to ensure the availability of data along the dimensions of interest. First, we restrict attention to countries with at least 30 years of consecutive annual observations for each of the business cycle variables that we examine in section 2.1. We also exclude any country with cross-sectional variables observed for less than half of the years of our sample period. In addition, we drop the U.S. and China since we study a small open economy throughout our quantitative analysis; finally, we drop countries with a population below 1 million. After applying these filters, our final sample consists of 42 emerging economies and 13 developed ones.

2.1 Business cycles in emerging economies are more volatile

We begin by contrasting the volatility of business cycles between emerging and developed economies. To do so, we focus on annual real GDP fluctuations as our measure of business cycle volatility.

We construct real GDP by deflating nominal GDP with the GDP deflator. We restrict attention to seasonally adjusted series, and express real GDP in per capita terms. To identify fluctuations at business cycle frequencies using annual data, we follow Ravn and Uhlig (2002) and de-trend the data, applying the Hodrick-Prescott filter with smoothing parameter 6.25.[4]

[3] The data is publicly available at http://databank.worldbank.org/.

[4] All our findings are qualitatively robust to alternative de-trending schemes, such as applying the HP filter with smoothing parameter 100 or examining deviations of the data

Table 1: GDP volatility and type of goods produced and traded

	Developed Economies	Emerging Economies
GDP volatility (%)	1.39 (1.11, 1.43)	2.37 (1.93, 2.75)
Share of Commodities in GDP	0.14 (0.12, 0.15)	0.33 (0.25, 0.39)
Share of Manufactures in GDP	0.19 (0.16, 0.21)	0.16 (0.12, 0.20)
Share of Commodities in Aggregate Exports	0.29 (0.15, 0.41)	0.71 (0.52, 0.90)
Share of Commodities in Aggregate Imports	0.31 (0.24, 0.33)	0.33 (0.28, 0.40)
Net Exports of Manufactures / GDP	-0.01 (-0.03, 0.03)	-0.10 (-0.13, -0.05)
Net Exports of Commodities / GDP	-0.004 (-0.03, 0.01)	0.05 (-0.01, 0.11)
Aggregate Net Exports / GDP	-0.01 (-0.01, 0.02)	-0.05 (-0.10, -0.003)

Note: Averages computed for 42 emerging economies and 13 developed countries for the period 1970 to 2010, as described in the text. The values corresponding to the 25th and 75th percentiles, respectively, are in parenthesis.

The first row of Table 1 reports the average volatility of real GDP corresponding to each country group. As previously documented in the literature, we observe that economic activity in emerging economies is more volatile than in developed ones: The average standard deviation of real GDP is 1.39% in developed economies and 2.37% in emerging countries. Thus, we observe that emerging economies are 0.98 percentage points more volatile than developed ones on average (that is, real GDP is 71% more volatile in emerging countries).

2.2 Emerging economies specialize in commodity production

We now contrast the types of goods and services produced by emerging and developed economies. We partition the goods and services produced by these

around a log-quadratic trend.

countries (their GDP) into three groups: services, commodities and manufactured goods, where commodities consist of goods produced by the agricultural, mining, and fuel sectors.

The second and third rows of Table 1 report the average shares of commodities and manufactures in GDP, respectively, for each of these country groups. The remaining share consists of services. First, the total share of non-services goods is much higher in emerging than in developed economies (49% vs. 33 %). Second, the share of commodities is much larger in the emerging economies, about two thirds of total non-services, while only 42% of non-services output consists of commodities in developed economies.

2.3 Emerging economies exhibit sectoral trade imbalances

We now contrast the types of goods that emerging and developed economies trade internationally. To do so, we report the average shares of commodities in aggregate exports and aggregate imports, respectively, in the fourth and fifth rows of Table 1.[5]

On the one hand, we find that developed economies export and import very similar goods: On average, commodities make up 29% of aggregate exports and 31% of aggregate imports. In contrast, emerging economies export and import very different baskets of goods: On average, commodities make up 71% of aggregate exports but only 33% of aggregate imports.

In the sixth and seventh rows of Table 1, we show that the differences in the types of goods that developed and emerging economies trade internationally lead to differences in sectoral trade deficits across these countries. While imports and exports of manufactures are roughly identical, relative to GDP, in developed economies, there is a sizable mismatch between them in emerging countries. In particular, while emerging economies exhibit, on average, a manufacturing trade deficit equal to 10 % of GDP, the average manufacturing trade deficit is only 1 % in developed economies. In contrast, while emerging economies are net exporters of commodities, trade of these goods in developed

[5]Results look qualitatively similar when considering commodities excluding fuel.

economies is largely balanced, as documented in the seventh row of the table.

The final row of Table 1 reports the aggregate trade imbalances that follow from the sectoral trade patterns. While emerging economies exhibit an average aggregate trade deficit equal to 5% of GDP, the deficit is 1% in developed ones.[6]

3 Model

We study a small open economy model with three sectors that produce manufactures, commodities, and non-tradables. Manufactures and commodities can be traded internationally with the rest of the world. The economy is populated by a representative household, a representative producer of a tradable composite good, a representative producer of a final good, and representative producers of the three sectoral goods.

Time is discrete. Each period a random event s_t is realized, and $s^t = (s_0, s_1, \ldots, s_t)$ denotes the history of events up to and including period t. The probability in period 0 of a particular history of events is $\pi_t(s^t)$, and s_0 is given. In general, allocations in period t are functions of the history s^t and of initial values of the capital stock K_0 and asset holdings B_0, but for notational convenience we suppress this dependence.

3.1 Households

We consider an economy populated by a representative infinitely lived household that derives utility from consumption of final goods C_t and leisure $1-N_t$. The utility function is given by

$$U_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[C_t^{\alpha}(1-N_t)^{1-\alpha}\right]^{1-\gamma}}{1-\gamma}, \tag{1}$$

where α is the share of consumption in the consumption-leisure bundle, β is the discount factor, and γ is the coefficient of relative risk aversion. $\mathbb{E}_t[\cdot]$ denotes the expectation operator conditional on the information at time t.

The household accumulates the aggregate capital stock internally by in-

[6] If we considered all countries in the world, trade should be balanced for each type of good. This is not the case in our sample since we drop China and the U.S., among others.

vesting final goods subject to an aggregate capital adjustment cost. In addition, the household chooses how to allocate the aggregate capital stock across sectors subject to sectoral reallocation costs, which require the household to pay in order to change the share of capital supplied to each sector. The evolution of the aggregate capital stock is then given by the following law of motion:

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\phi_K}{2}\left(\frac{K_{t+1}}{K_t} - 1\right)^2 K_t - \frac{\phi_K^X}{2}\left(\frac{K_{m,t+1}}{K_{t+1}} - \frac{K_{m,t}}{K_t}\right)^2 - \frac{\phi_K^X}{2}\left(\frac{K_{c,t+1}}{K_{t+1}} - \frac{K_{c,t}}{K_t}\right)^2, \quad (2)$$

where I_t is aggregate investment, $K_{x,t} \geq 0$ is the capital stock in sector $x \in \{m, c, n\}$ at the beginning of period t, δ is the depreciation rate of the stock of capital, and changes to the aggregate capital stock entail a quadratic adjustment cost governed by $\phi > 0$. The parameter ϕ_K^X controls the cost of adjusting the share of capital used in the three sectors.[7]

Similarly, the household chooses the aggregate amount of labor to supply as well as the amount of labor supplied to each sector subject to reallocation costs. Every period the household can vary the sectoral labor shares, but there is a cost to reallocate labor resources across sectors.

The household has access to international financial markets where it can trade a non-contingent bond that delivers one unit of the tradable composite good next period. B_{t+1} is the quantity of such bonds and q_t is its internationally given price measured in units of the tradable composite good. To ensure the stationarity of bond holdings, we assume that the bond price is sensitive to the level of outstanding debt as in Schmitt-Grohé and Uribe (2003). Specifically, we assume that $\frac{1}{q_t} = 1 + r^* + \psi\left[e^{-\left(\tilde{B}_{t+1} - b\right)} - 1\right]$, where r^* is the world interest rate, $b \in \mathbb{R}$ is the steady-state level of bond holdings, $\psi > 0$ determines the elasticity of the interest rate to changes in the debt level, and $\tilde{B}_{t+1}$ denotes the aggregate per capita level of foreign debt.[8]

[7] Given there are three sectors in our economy, specifying sectoral reallocation costs as a function of changes in the share of commodities and manufactures is without loss of generality.

[8] Given the representative household assumption, $\tilde{B}_{t+1} = B_{t+1}$ in equilibrium. We also assume that $\beta = 1/(1 + r^*)$ to ensure the existence of a steady state.

The household chooses the amount of consumption along with the aforementioned choices to maximize (1) subject to the capital evolution equation and budget constraint, given initial values of the capital stock K_0 and asset holdings B_0. The budget constraint is given by

$$p_t C_t + p_t I_t + p_{\tau,t} q_t B_{t+1} + p_t \sum_{x \in \{m,c\}} \frac{\phi_N^X}{2} \left(\frac{N_{x,t}}{N_t} - \frac{N_{x,t-1}}{N_{t-1}} \right)^2$$
$$= \sum_{x \in \{m,c,n\}} w_{x,t} N_{x,t} + \sum_{x \in \{m,c,n\}} r_{x,t} K_{x,t} + \Pi_t + p_{\tau,t} B_t, \tag{3}$$

where $N_{x,t} \in [0,1]$ is the fraction of time spent working in sector $x \in \{m, c, n\}$. In sector x, the wage and the rental rate of capital are respectively $w_{x,t}$ and $r_{x,t}$. Π_t denotes the total profits transferred to the household from the ownership of all domestic firms, p_t is the price of the final good used for consumption and investment, and $p_{\tau,t}$ is the price of the tradable composite good. ϕ_N^X controls the cost of adjusting the share of labor employed in the three sectors.

3.2 Firms

There are five types of goods produced in the economy: final goods, a tradable composite good, manufactures, commodities, and non-tradable goods. The tradable composite combines manufactures and commodities, while final goods are a composite good that combines tradable and non-tradable goods. Each good is produced by a representative firm. In this section we describe these firms and the stochastic processes for productivity and prices.

3.2.1 Production of final goods

A representative firm produces final goods using a constant elasticity of substitution (CES) production function. To do so, it uses a tradable composite good and non-tradable goods as inputs. The demands for these goods are denoted by $X_{\tau,t}$ and $X_{n,t}$, respectively, and the production function is given by

$$G\left(X_{\tau,t}, X_{n,t}\right) = \left[\eta X_{\tau,t}^{\frac{\sigma-1}{\sigma}} + (1-\eta) X_{n,t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \tag{4}$$

where σ is the elasticity of substitution between the two inputs,[9] and η determines the relative weight of tradable and non-tradable goods.

The representative final goods producer takes the prices of the two inputs as given and solves the following problem:

$$\max_{X_{\tau,t},X_{n,t}\geq 0} p_t G\left(X_{\tau,t}, X_{n,t}\right) - p_{\tau,t}X_{\tau,t} - p_{n,t}X_{n,t}, \tag{5}$$

where $p_{n,t}$ is the price of non-tradable goods. The solution to the final goods producers' problem determines the price level p_t, which is given by $p_t = \left[\eta^\sigma p_{\tau,t}^{1-\sigma} + (1-\eta)^\sigma p_{n,t}^{1-\sigma}\right]^{\frac{1}{1-\sigma}}$.

3.2.2 Production of tradable composite

A representative firm produces a tradable composite by combining manufactures and commodities purchased from domestic or international markets using a CES production function. The demands for these goods are denoted by $X_{m,t}$ and $X_{c,t}$, respectively, and the production function is given by

$$H\left(X_{m,t}, X_{c,t}\right) \ = \left[\eta_\tau X_{m,t}^{\frac{\sigma_\tau - 1}{\sigma_\tau}} + (1-\eta_\tau)X_{c,t}^{\frac{\sigma_\tau - 1}{\sigma_\tau}}\right]^{\frac{\sigma_\tau}{\sigma_\tau - 1}}, \tag{6}$$

where σ_τ is the elasticity of substitution between the two inputs[10] and η_τ determines the relative weight of manufactures and commodities.

The representative producer takes the prices of the two inputs as given and solves the following problem:

$$\max_{X_{m,t},X_{p,t}\geq 0} p_{\tau,t} H\left(X_{m,t}, X_{c,t}\right) - p_{m,t}X_{m,t} - p_{c,t}X_{c,t}, \tag{7}$$

where $p_{i,t}$ is the price of input $i \in \{m, c\}$. The solution to the problem for the producer of the tradable composite good determines the price of that good $p_{\tau,t}$, which is given by $p_{\tau,t} = \left[\eta_\tau^{\sigma_\tau} p_{m,t}^{1-\sigma_\tau} + (1-\eta_\tau)^{\sigma_\tau} p_{c,t}^{1-\sigma_\tau}\right]^{\frac{1}{1-\sigma_\tau}}$.

[9] For $\sigma = 1$, the final goods production function is Cobb-Douglas.

[10] For $\sigma_\tau = 1$, the production function for the tradable composite good is Cobb-Douglas.

3.2.3 Production of manufactures, commodities, and non-tradables

In each sector $x \in \{m, c, n\}$, a representative firm produces sector-specific goods using capital and labor with a decreasing returns to scale production technology.[11] For sector $x \in \{m, c, n\}$ the amount $Y_{x,t}$ produced is given by

$$Y_{x,t} = A_x Z_t \left(K_{x,t}^{\theta_x} N_{x,t}^{1-\theta_x} \right)^{\mu_x}, \tag{8}$$

where Z_t is a time-varying Hicks-neutral level of productivity that affects all sectors, A_x is a sector-specific and time-invariant level of productivity, $\theta_x \in [0, 1]$ controls the share of capital in production, and $\mu_x \in (0, 1)$ determines the degree of decreasing returns to scale.

The representative firms take the prices of their output and factor inputs as given and maximize profits by solving

$$\max_{N_{x,t}, K_{x,t} \geq 0} \pi_{x,t} = p_{x,t} Y_{x,t} - w_{x,t} N_{x,t} - r_{x,t} K_{x,t}. \tag{9}$$

The total amount of profits transferred to the households are then given by $\Pi_t = \pi_{m,t} + \pi_{c,t} + \pi_{n,t}$.

3.2.4 Productivity

The process for the time-varying level of productivity Z_t is given by

$$\log Z_t = \rho_z \log Z_{t-1} + \varepsilon_{z,t}, \tag{10}$$

where ρ_z denotes the persistence of productivity and $\varepsilon_{z,t} \sim N(0, \sigma_z^2)$.

3.2.5 Prices

We choose the price of manufactured goods to be the numeraire and set $p_{m,t} = 1$. The small open economy trades manufactures and commodities in international markets and takes the relative price of commodities $p_{c,t}$ as

[11] We assume that firms operate decreasing returns to scale technologies to ensure that, in equilibrium, output is nonzero in all sectors for any combination of sectoral prices.

given exogenously. The process for this relative price is given by

$$\log p_{c,t} = \rho_c \log p_{c,t-1} + \varepsilon_{c,t}, \tag{11}$$

where ρ_c is the persistence of shocks to the relative price, and $\varepsilon_{c,t} \sim N(0, \sigma_c^2)$.

3.2.6 Market clearing conditions

Market clearing in the manufacturing and commodity goods sectors requires that the amount of goods purchased by the producer of the tradable composite good equals the sum of domestic production and net imports of these goods. We let $M_{i,t}$ be the net amount imported in sector $i \in \{m, c\}$. $M_{i,t} > 0$ (< 0) implies that goods are imported (exported). The market clearing condition in sector i is then given by

$$X_{i,t} = Y_{i,t} + M_{i,t}. \tag{12}$$

For the non-tradable goods, tradable composite good, and final goods, demand has to equal domestic production:

$$X_{n,t} = Y_{n,t} \tag{13}$$

$$X_{\tau,t} = H\left(X_{m,t}, X_{c,t}\right) \tag{14}$$

$$C_t + I_t + \sum_{x\in\{m,c\}} \frac{\phi_N^X}{2}\left(\frac{N_{x,t}}{N_t} - \frac{N_{x,t-1}}{N_{t-1}}\right)^2 = G\left(X_{\tau,t}, X_{n,t}\right). \tag{15}$$

Finally, market clearing in the capital and labor markets requires that the amount of capital and labor supplied by the household equals the total demand by the producers of manufactures, commodities, and non-tradable goods:

$$K_t = \sum_{x\in\{m,c,n\}} K_{x,t} \tag{16}$$

$$N_t = \sum_{x\in\{m,c,n\}} N_{x,t}. \tag{17}$$

3.3 Definition of equilibrium

Given the law of motion for productivity shocks in equation (10), the international interest rate r_t^*, and the process for the relative prices of commodities $p_{c,t}$, an equilibrium of this economy consists of a set of aggregate allocations C_t, I_t, N_t, K_t, B_t, $X_{\tau,t}$, and NX_t; a set of sectoral allocations for $x \in \{m, c, n\}$, $N_{x,t}$, $K_{x,t}$, $X_{x,t}$, $Y_{x,t}$, and for $i \in \{m, c\}$, $M_{i,t}$; and prices q_t, p_t, $p_{\tau,t}$, $p_{n,t}$ $w_{x,t}$, and $r_{x,t}$ for $x \in \{m, c, n\}$ such that (i) given prices, the households' allocations solve the households' problem; (ii) given prices, the allocations of producers of manufactured goods, commodities, and non-tradable goods solve the producers' respective problems; (iii) given prices, the tradable composite goods producers' allocations solve the tradable composite goods producers' problem; (iv) given prices, the final goods producers' allocations solve the final goods producers' problem; and (v) markets clear.

4 Mechanism

In this section, we investigate the channels through which international relative prices affect real GDP in our model. To do so, we begin by describing our measurement of real GDP and defining a measure of TFP. We then discuss a special case that shows that our measure of TFP can be decomposed into an exogenous component driven by the process in equation (10) and an endogenous component driven by the reallocation of resources across sectors. Finally, we investigate the impact of changes in international relative prices on factors of production and aggregate productivity.

4.1 Real GDP

Real GDP is defined as the ratio between nominal GDP and the GDP deflator: Real $\text{GDP}_t = \frac{\text{GDP}_t}{P_t^{\text{GDP}}}$, where GDP_t is given by $p_{m,t}Y_{m,t}+p_{c,t}Y_{c,t}+p_{n,t}Y_{n,t}$ following the value-added approach.

To derive an expression for real GDP consistent with its empirical counterpart, we restrict attention to the GDP deflator as measured by statistical agencies. In particular, we follow the approach of the World Bank's Development Indicators (our source of data throughout the paper) and compute the

GDP deflator as a Paasche index, defined as the ratio between GDP measured at current prices relative to GDP measured at base-year prices:

$$P_t^{\text{GDP}} = \frac{p_{m,t}Y_{m,t} + p_{c,t}Y_{c,t} + p_{n,t}Y_{n,t}}{p_{m,ss}Y_{m,t} + p_{c,ss}Y_{c,t} + p_{n,ss}Y_{n,t}},$$

where we define base-year prices to be given by their values in the deterministic steady state, denoted with the ss subscript.

Combining the expressions above, we have that real GDP is given by

$$\text{Real GDP}_t = p_{m,ss}Y_{m,t} + p_{c,ss}Y_{c,t} + p_{n,ss}Y_{n,t}. \tag{18}$$

Finally, we define a measure of TFP by expressing real GDP as a function of the aggregate capital stock and labor supply:

$$\text{Real GDP}_t = \text{TFP}_t K_t^{KS} N_t^{LS}, \tag{19}$$

where K_t denotes the aggregate stock of physical capital, N_t denotes the aggregate supply of labor, and KS and LS are, respectively, the capital and labor shares in the deterministic steady state.[12]

Under certain restrictions on the parameters, we can obtain a simple analytic expression for TFP. In particular, if we impose that the capital intensity $\theta_x = \theta$ and the degree of returns to scale $\mu_x = \mu$ are the same across sectors, then the aggregate capital and labor shares are constant and equal to the shares in each sector. The steady-state values in equation (19) are then given by $KS = \theta\mu$ and $LS = (1-\theta)\mu$. In this case we can use the equations for real GDP and TFP and the sectoral production functions to express TFP as

[12] In particular, we define $KS = \frac{r_{m,ss}K_{m,ss}+r_{c,ss}K_{c,ss}+r_{n,ss}K_{n,ss}}{Y_{m,ss}+p_{c,ss}Y_{c,ss}+p_{n,ss}Y_{n,ss}}$ and $LS = \frac{w_{m,ss}N_{m,ss}+w_{c,ss}N_{c,ss}+w_{n,ss}N_{n,ss}}{Y_{m,ss}+p_{c,ss}Y_{c,ss}+p_{n,ss}Y_{n,ss}}$.

$$
\begin{aligned}
\mathrm{TFP}_t = Z_t \Bigg[& p_{m,ss} A_m \left(\frac{K_{m,t}}{K_t}\right)^{KS} \left(\frac{N_{m,t}}{N_t}\right)^{LS} \\
& + p_{c,ss} A_c \left(\frac{K_{c,t}}{K_t}\right)^{KS} \left(\frac{N_{c,t}}{N_t}\right)^{LS} + p_{n,ss} A_n \left(\frac{K_{n,t}}{K_t}\right)^{KS} \left(\frac{N_{n,t}}{N_t}\right)^{LS} \Bigg].
\end{aligned}
\tag{20}
$$

That is, in this case, real GDP in our economy can be represented as an aggregate production function that uses aggregate capital and labor as its inputs, where TFP can be decomposed into an exogenous component Z_t and an endogenous component that depends on the shares of aggregate labor and capital allocated to each sector. Reallocation of resources across sectors thus affects measured TFP through this endogenous component. As a result, our economy features five alternative sources of real GDP fluctuations: (*i*) changes in the aggregate stock of physical capital, (*ii*) changes in the aggregate supply of labor, (*iii*) changes in the allocation of physical capital across sectors, (*iv*) changes in the allocation of labor across sectors, and (*v*) changes in exogenous productivity. While (*i*) and (*ii*) affect real GDP through the factors of production, (*iii*)-(*v*) affect it through TFP.[13]

4.2 International Relative Prices and Factors of Production

The expressions above show that changes in international relative prices may affect real GDP through two broad channels: either by affecting the factors of production or aggregate productivity. In this subsection, we show that the extent to which changes in international relative prices affect capital and labor depends on the degree to which they impact the production price index (PPI) relative to the consumption price index (CPI). To simplify the exposition, here we restrict attention to economies that operate under international financial autarky and we ignore the sectoral reallocation cost on labor.

[13]In our baseline calibration, we impose that the degree of returns to scale is the same across sectors but we allow the capital intensities to differ. Therefore, the decomposition in equation (20) does not hold but it is still the case that sectoral reallocation of resources affects measured TFP.

Plugging the profits of sectoral producers into the household's budget constraint and using the results above, we have that $C_t + I_t = \frac{P_t^{\text{PPI}}}{P_t^{\text{CPI}}} \times \text{Real GDP}_t$, where P_t^{PPI} denotes the PPI given by the GDP deflator P_t^{GDP}, defined above, and P_t^{CPI} denotes the consumption (and investment) price index p_t faced by households.

This expression shows that the mapping between real GDP and aggregate consumption and investment depends on the relative prices of production and consumption baskets. In particular, the relative price between goods produced and consumed regulates the extent to which output can be used to accumulate physical capital as well as the returns to supplying additional units of labor.

To illustrate these effects, consider the response of two counter-factual economies to a persistent increase in the price of commodities $p_{c,t}$. The first economy only produces commodities but consumes commodities, manufactures and non-tradables. In this economy, the relationship above boils down to

$$C_t + I_t = \frac{p_{c,t}}{P_t^{\text{CPI}}} \times \text{Real GDP}_t.$$

Thus, in this economy, an increase in the price of commodities $p_{c,t}$ triggers an increase in the price of production relative to consumption. Therefore, with a higher price of commodities, every unit produced can be transformed into physical capital and consumption at a higher rate, increasing the incentives to accumulate capital and supply labor.

The second economy only produces and consumes commodities. In this economy, the relationship above boils down to $C_t + I_t = \text{Real GDP}_t$. Thus, in this economy, changes in the price of commodities have no impact on equilibrium allocations. In contrast to the first economy, an increase in the price of commodities now increases the value of the production and consumption baskets by equal amounts; thus, the rate at which output may be transformed into consumption or investment goods remains unchanged.

We conclude that the relative compositions of consumption and production baskets play a fundamental role in the extent to which changes in international relative prices may affect capital accumulation and labor supply. Thus, in the following sections we examine the quantitative impact of international relative prices on real GDP, using data to discipline the relative compositions of the consumption and production baskets.

4.3 International Relative Prices and Aggregate Productivity

We now examine the impact of changes in international relative prices on aggregate TFP. In equation (20), changes in international prices may only affect aggregate TFP insofar as they trigger changes in the share of capital and labor that is allocated across sectors. Thus, we now investigate the extent to which changes in international relative prices may lead to reallocation of production inputs across sectors.

To do so, we consider the response of two counter-factual economies to a persistent increase in the price of commodities $p_{c,t}$. The first economy produces non-tradables, commodities, and manufactures. In this economy, an increase in the price of commodities increases the returns to selling commodities relative to non-tradables or manufactures; thus, it triggers a reallocation of production inputs towards this sector. This response of the economy leads to a change in aggregate TFP, as implied by equation (20).

The second economy specializes in the production of commodities, and produces no non-tradables or manufactures. In this economy, aggregate TFP is given by $\text{TFP}_t = Z_t$. Thus, changes in international relative prices have no impact on aggregate TFP in this one-sector economy.

We conclude that the impact of international price movements on aggregate TFP depends crucially on the extent to which these trigger a reallocation of production inputs across sectors. Thus, in the following sections, we discipline the impact of international relative prices on aggregate TFP by estimating sectoral reallocation costs to capture the degree of cross-sectoral reallocation observed in the data.

In contrast to Kehoe and Ruhl (2008), we find that changes in the terms of trade may impact aggregate TFP as long as they are associated with the reallocation of production inputs across sectors. Thus, the distinguishing feature of our analysis is the existence of multiple sectors across which economic activity may reallocate in response to shocks. As we show above, in a one-sector version of our model, we find that terms-of-trade shocks do not impact aggregate TFP, as previously documented by Kehoe and Ruhl (2008).

5 Quantitative Analysis

Following our discussion in the previous section, differences in the sectoral composition of production and trade between developed and emerging economies may affect how aggregate output responds to changes in international relative prices through two channels. First, the aggregate supply of capital and labor may respond to changes in the relative price between goods consumed and produced (Section 4.2). Second, aggregate TFP may respond to changes in the distribution of capital and labor across sectors (Section 4.3). In this section, we investigate the extent to which differences in the sectoral composition of production and trade can account for the higher business cycle volatility of emerging economies observed in the data.

To do so, we consider the model presented in Section 3 and estimate it to match salient features of developed economies. We contrast the implications of this economy with those of an emerging economy designed to isolate the impact of cross-sectoral differences in the composition of production and trade on business cycle volatility. In particular, we consider a counter-factual emerging economy that only differs from the developed economy in the parameters that control the cross-sectoral patterns of production and trade.

Unless otherwise specified, the data used to parameterize the model corresponds to the data sources described in Section 2. In particular, we classify countries as "Developed" or "Emerging" following Schmitt-Grohé and Uribe (2018) and identify the relevant moments by computing the averages across countries in these groups; see Section 2 for more details.

5.1 Developed economy

To parameterize the developed economy, we partition the parameter space into three groups. The first group consists of predetermined parameters set to standard values from the literature. The second group consists of the parameters that control the stochastic process for international relative prices, which are externally estimated. Finally, the third group is estimated jointly via simulated method of moments (SMM) to match salient features of the data.

5.1.1 Predetermined parameters

Panel A of Table 2 shows the set of predetermined parameters. These include the preference parameters, borrowing costs in international financial markets, and most of the technology parameters in the production functions for sectoral and final goods. A period in the model represents a quarter. We set the preference parameters as in Aguiar and Gopinath (2007), so the discount factor β is 0.98, risk aversion γ is 2, and the consumption share in the utility function α is 0.36. It follows that the world interest rate r^* that is consistent with a steady-state equilibrium is 2%. The parameter ψ that controls the debt elasticity of the interest rate is set to 0.001.[14]

We set the elasticity of substitution σ_τ between commodities and manufactures in the production of tradable goods to 1.5, as in Backus et al. (1994). Similarly, we set the elasticity of substitution σ between tradable and non-tradable goods to 1.5. Based on Aguiar and Gopinath (2007) and Midrigan and Xu (2014), we set θ_x to 0.32 and μ_x to 0.85 for $x \in \{m, c\}$. For non-tradable goods, instead, we assume that $\theta_n = 0$, so that these goods only use labor, but we keep fixed the degree of decreasing returns to scale $\mu_n = 0.85$.[15] The capital depreciation rate δ is set to 0.05. Finally, we normalize the steady-state productivity in the production of commodities and non-tradable goods A_c and A_n, respectively, to 1.

[14] We set this parameter to a sufficiently low value to ensure the stationarity of the model without affecting its implications for business cycles.

[15] Non-tradable goods are more labor intensive as in Schmitt-Grohé and Uribe (2018).

Table 2: Developed economy

A. Predetermined parameters

	Value	Source		Value	Source
β	0.98	Aguiar and Gopinath (2007)	ψ	0.001	See section 5.1.1
α	0.36	Aguiar and Gopinath (2007)	r^*	0.02	$1/\beta - 1$
γ	2	Aguiar and Gopinath (2007)	σ	1.5	Backus et al. (1994)
σ_τ	1.5	Backus et al. (1994)	$\theta_m = \theta_c$	0.32	See section 5.1.1
θ_n	0	See section 5.1.1	μ	0.85	See section 5.1.1
δ	0.05	Aguiar and Gopinath (2007)	A_c	1	Normalization
A_n	1	Normalization			

B. Price process

Parameter	Value
ρ_c	0.953
σ_c	0.060

C. Jointly estimated parameters

Parameter	Value	Target moment	Data	Model
C1. Time-series targets				
ρ_z	0.403	Autocorrelation real GDP	0.25	0.25
σ_z	0.012	Std. dev. real GDP	1.39	1.39
ϕ_K	2.553	Std. dev. investment / Std. dev. real GDP	4.28	4.28
$\phi_K^X = \phi_N^X$	31.178	Std. dev. share of manufactures in GDP	0.136	0.136
C2. Cross-sectional targets				
A_m	1.045	Avg. share of manufactures in GDP	0.188	0.188
η	0.426	Avg. share of commodities in GDP	0.140	0.140
η_τ	0.556	Avg. manufactures NX/GDP	-0.009	-0.009
b	0.134	Avg. aggregate NX / GDP	-0.01	-0.01

5.1.2 Price process

As described in Section 3, we let the price of manufacturing goods be the numeraire and specify a stochastic process to determine the evolution of commodity prices $p_{c,t}$. Then, we use data on the price of commodities relative to the price of manufactures to estimate this process.

To do so, we follow Gubler and Hertweck (2013) and use data from the "Producer Price Index - Commodity Classification" published by the Bureau of Labor Statistics. For commodity prices, we use the "PPI by Commodity for Crude Materials for Further Processing" index; as they discuss in detail, this index captures much of the variation in commodity prices of alternative indexes and is available for a longer time period.[16] For the price of manufactured goods we use the "PPI by Commodity for Finished Goods Less Food & Energy" index. This index is only available starting in 1974, so we estimate the parameters in equation (11) using data from the first quarter of 1974 to the last quarter of 2010.

We estimate this process externally via ordinary least squares (OLS). Panel B of Table 2 reports our estimates. The estimated process for the relative price of commodities features a high persistence, with ρ_c estimated at 0.953, and a high standard deviation σ_c of 0.060.

5.1.3 Jointly estimated parameters

Finally, panel C of Table 2 reports the parameters estimated jointly via SMM.

Time-series targets Panel C1 of Table 2 presents the parameters used to target salient features of business cycles in developed economies. The parameters that we choose are the persistence ρ_z and the standard deviation σ_z of the productivity process in equation (10), as well as the sectoral and aggregate adjustment costs ϕ_N^X, ϕ_K^X, and ϕ_K. The table reports the estimated parameters along with the target and model-implied moments at an annual frequency; we annualize the simulated series from our quarterly model before computing the corresponding moments.[17]

The parameters of the productivity process allow us to discipline the dynamics of real GDP in the developed economy; in particular, we choose them to target the volatility and autocorrelation of real GDP. Therefore, our parametrization of the developed economy will feature business cycles that

[16] In addition, Gubler and Hertweck (2013) point out that this index is also used by Hanson (2004) and Sims and Zha (2006).

[17] We solve the model using perturbation methods to compute the second-order approximation of the model around its deterministic steady state. We compute 100 simulations of 164 quarters, simulating 1164 quarters starting at the steady state and then dropping the initial 1000 quarters. Moments are computed as the average across each of the simulations.

are as volatile as those in the data. In the next subsections, we contrast this developed economy with an emerging economy whose real GDP volatility is an untargeted outcome that is informative about the role of cross-sectoral differences in trade and production in accounting for the difference in business cycle volatility between emerging and developed economies.

The aggregate capital adjustment cost ϕ_K allows us to discipline the volatility of aggregate investment relative to real GDP. We do so to discipline the extent to which investment in our economy may respond to changes in the relative prices of consumption and production goods, a potentially important channel through which changes in international relative prices may affect aggregate output (Section 4.2).

Finally, the sectoral adjustment costs ϕ_N^X and ϕ_K^X allow us to discipline the degree of cross-sectoral reallocation of production inputs and, thus, output featured by the economy in response to aggregate shocks. Given the limited availability of time-series data on sectoral inputs across countries, we assume that $\phi_N^X = \phi_K^X$ and choose them to match the standard deviation of the share of manufacturing output in aggregate GDP. These sectoral adjustment costs allow us to discipline the degree of cross-sectoral reallocation featured in the developed economy and, thus, the extent to which international price movements affect aggregate TFP (Section 4.3).

Cross-sectional targets We complete the parameterization of the developed economy by choosing the four remaining parameters, A_m, η, η_τ, and b, to match salient cross-sectional features of developed economies; see Panel C2 of Table 2 for the parameter values as well as for the empirical and model-implied moments.

In particular, we choose these four parameters such that the steady state of the economy matches four key cross-sectional features of developed economies reported in Table 1: (*i*) the average share of commodities in aggregate GDP, (*ii*) the average share of manufactures in aggregate GDP, (*iii*) the average net exports of manufactures relative to GDP, and (*iv*) the average aggregate net exports to GDP ratio.

As can be seen in Table 2, these four parameters allow us to match the four targets exactly. Intuitively, the productivity of the manufacturing sector A_m allows us to discipline the share of manufactures in aggregate GDP. Similarly, the share of non-tradables in the production of final goods η allows us to match the share of commodities (and, thus, non-tradables) in aggregate GDP.

Given the pattern of production implied by these parameters, the remaining two parameters allow us to discipline the sectoral and aggregate trade imbalances of the economy. First, the share of manufactures in the production of tradable goods η_τ controls the relationship between domestic demand and domestic production of manufactures; or, in other words, the sectoral trade imbalance in manufactures. Second, the steady-state level of bond holdings controls the magnitude of aggregate trade imbalances that the economy needs to run to sustain such a financial position.

5.2 Emerging economy

Our main exercise consists of contrasting the implications of the developed economy, described in the previous section, with their counterparts for an emerging economy.

Given our goal to investigate the extent to which differences in the sectoral composition of production and trade between developed and emerging economies can account for the higher business cycle volatility of emerging economies, we consider a counter-factual emerging economy. In particular, we consider an emerging economy that only differs from the developed economy in the parameters used to discipline the cross-sectional moments reported in Panel C2 of Table 2. All other parameters are identical to those described in Table 2 for the developed economy.

Table 3 shows the corresponding parameters and moments for the emerging economy. As in the data, the emerging economy has a higher share of commodity production in aggregate GDP, has a lower share of production of manufactures relative to GDP, and runs a larger aggregate trade deficit due to a larger trade deficit in the manufactured goods sector.

Table 3: Emerging economy

Parameter	Value	Target moment	Data	Model
A_m	0.900	Avg. share of manufactures in GDP	0.165	0.165
η	0.574	Avg. share of commodities in GDP	0.334	0.334
η_τ	0.492	Avg. manufactures NX/GDP	-0.103	-0.103
b	0.562	Avg. aggregate NX / GDP	-0.050	-0.050

5.3 Results

We now investigate the extent to which differences in the cross-sectional pattern of production and trade between developed and emerging economies account for the higher business cycle volatility of emerging economies. To do so, we simulate 100 quarterly real GDP series for 164 periods for the developed and emerging economies described in the previous subsections. We annualize each of the series and compute the volatility of real GDP for each; finally, we compute the average real GDP volatility across all series for the developed and emerging economies respectively.[18]

Table 4 reports the volatility of real GDP implied by our model for our parametrizations of the developed and emerging economies, as well as their empirical counterparts. The first row of the table shows that real GDP in our estimated developed economy matches exactly the volatility of real GDP observed in the data. This is by construction, given that the parameters that govern the stochastic process for aggregate productivity are chosen to match the volatility and autocorrelation of real GDP in this economy.

The second row of Table 4 contrasts the business cycle volatility implied by our counter-factual emerging economy with its empirical counterpart. We find real GDP volatility in our emerging economy is equal to 1.90% (vs. 2.37% in the data). That is, our model implies that differences in the cross-sectional pattern of production and trade can account for 52% of the business cycle volatility gap between emerging and developed economies.

[18]To ensure the comparability of results across economies, we use the same sequences of shocks to simulate each of the economies.

Table 4: Real GDP Volatility (%)

	Data	Model
Developed	1.39	1.39
Emerging	2.37	1.90

In other words, these findings show that if developed and emerging economies were identical except for their cross-sectional pattern of production and trade, then real GDP volatility in the latter would be 0.51 percentage points higher than in the former.

These differences result despite the fact that both economies face the same aggregate productivity and international relative price shocks. Therefore, we interpret these findings as evidence that the cross-sectional pattern of production and trade plays an important role in accounting for the difference in business cycle volatility between emerging and developed economies.

In the rest of this section, we investigate the key channels that account for this finding. In the following section, we investigate the extent to which cross-sectional differences across individual countries — rather than country aggregates — account for country-by-country differences in business cycles observed in the data.

5.4 Additional business cycle moments

Given the higher business cycle volatility implied by cross-sectional differences between developed and emerging economies, we now investigate the extent to which these differences also affect additional business cycle moments. To do so, we contrast the volatility, correlation with GDP, and autocorrelation of the following variables for the developed and emerging economies: real GDP, the net exports to GDP ratio, consumption, investment, labor, and TFP.

Panel A of Table 5 reports the volatility of these variables. We find that real GDP and the net exports to GDP ratio are considerably more volatile in the emerging economy. However, no clear pattern emerges on the volatility of the rest of the variables relative to GDP: While consumption and labor are both more volatile in the emerging economy, investment and TFP are relatively more volatile in the developed economy. Importantly, these differences do not appear to be quantitatively or economically very significant.

As shown in Panel B of the table, the cyclicality of these variables is also fairly similar across the two economies, with the exception that measured TFP is less procyclical in the emerging country. Our model does not generate the countercyclicality of net exports over GDP in either economy.

Table 5: Additional Business Cycle Moments

	Std. dev. (%)		Std. dev. relative to GDP			
A. Volatility						
	GDP	NX/GDP	C	I	N	TFP
Developed	1.39	0.94	0.56	4.28	0.51	0.66
Emerging	1.90	1.92	0.66	3.76	0.74	0.47
B. Correlation with GDP						
	GDP	NX/GDP	C	I	N	TFP
Developed	1.00	0.83	0.79	0.84	0.88	0.91
Emerging	1.00	0.90	0.59	0.81	0.91	0.70
C. Autocorrelation						
	GDP	NX/GDP	C	I	N	TFP
Developed	0.25	0.65	0.36	0.30	0.51	0.11
Emerging	0.46	0.76	0.66	0.53	0.68	0.11

Note: For net exports we compute the standard deviation of NX/GDP. For other variables X we compute the standard deviation of log(X) and divide by the standard deviation of log(GDP).

Finally, Panel C shows that the exposure of the emerging economy to the persistent process for the relative price of commodities translates into relatively more persistent business cycles in that economy. The resulting autocorrelation of GDP, the net exports to GDP ratio, consumption, investment, and labor are all higher than in the developed economy.

We conclude that, while the cross-sectional differences between developed and emerging economies appear to significantly account for the higher business cycle volatility of emerging economies, these differences do not generate systematically different business cycle dynamics along other dimensions.

5.5 What accounts for the higher volatility of emerging economies?

We now investigate the mechanism that underlies the higher volatility of business cycles in emerging economies. To do so, we first study the response of the developed and emerging economies to productivity and commodity price shocks. Then, we investigate the specific cross-sectional differences between these economies that account for our findings.

5.5.1 Do emerging economies respond differently to shocks?

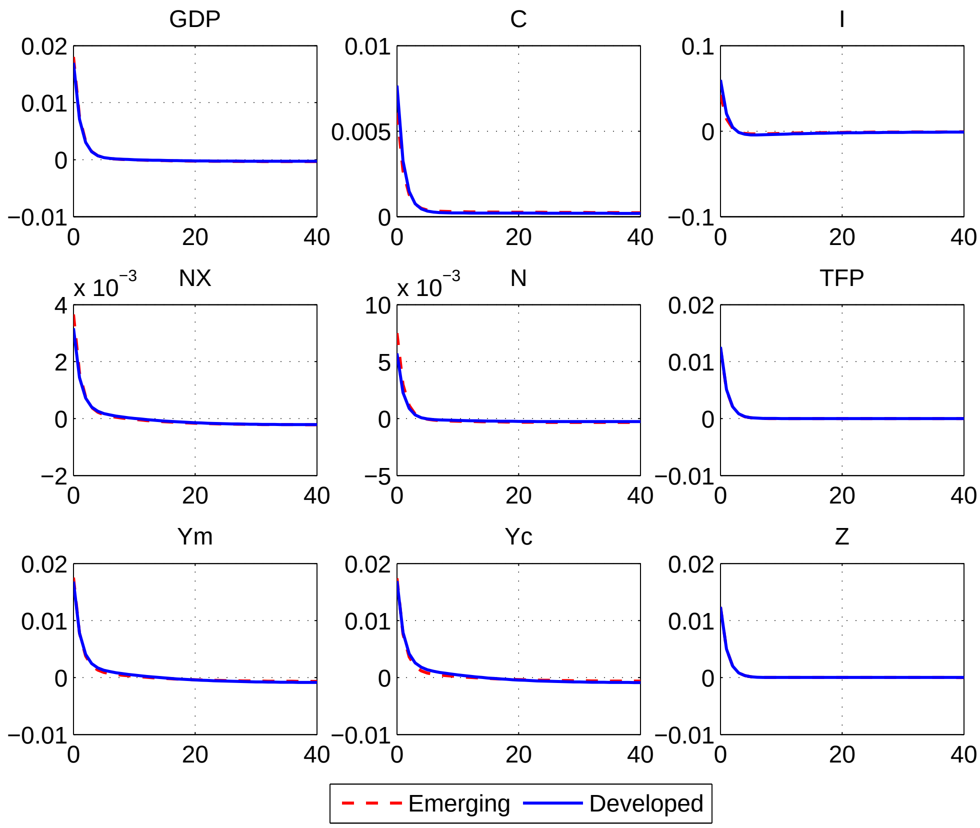
Our first step to understanding the channels that account for the higher volatility of business cycles in emerging economies is to identify whether this difference is primarily driven by each country's response to a particular shock. In particular, is it indeed the case that emerging economies respond differently to international price shocks than developed economies?

To answer this question, we compute impulse response functions of key aggregate variables in the developed and emerging economies to the two shocks: (*i*) a positive aggregate productivity shock and (*ii*) a positive shock to the relative price of commodities. Specifically, Figures 2 and 3 plot the response to one-time one-standard-deviation orthogonal shocks to productivity and the relative price of commodities, respectively. The dynamics of the shocked variables are plotted in the bottom-right panel of each of the figures.

Figure 2 shows that the responses of the economies to an aggregate productivity shock is consistent with earlier findings in the literature. An aggregate productivity shock leads to an increase in output, consumption, and investment. There is also an increase in labor that further increases these responses. Finally, output increases symmetrically across sectors, and measured TFP increases.

Importantly, notice that aggregate variables corresponding to the developed and emerging economies respond in exactly the same way to the aggregate productivity shock. Given the process for productivity is the same in the two economies, this finding shows that the response to fluctuations in aggregate productivity is not affected by the cross-sectional differences between

Figure 2: One-Standard-Deviation Productivity Shock

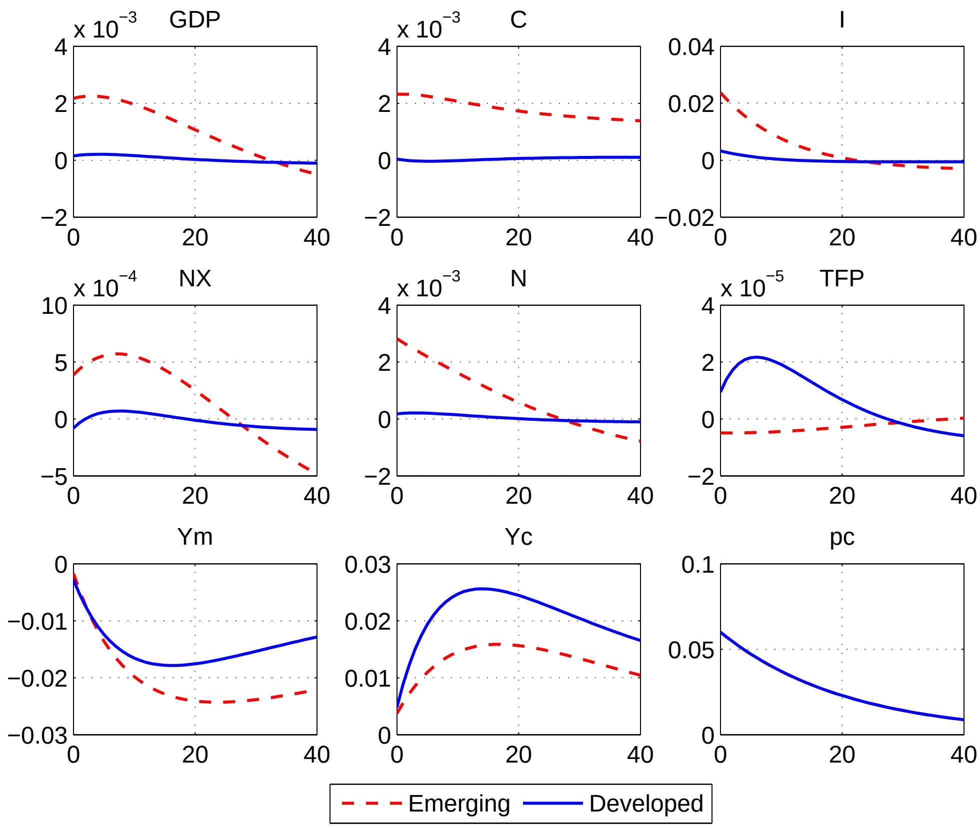


our model economies. Hence, any difference in the business cycle volatility of these economies is not driven by shocks to aggregate productivity.

Instead, these findings suggest that the higher business cycle volatility of the emerging economy is accounted for by the economy's differential response to aggregate commodity price shocks. Figure 3 shows that this is indeed the case: Shocks to the relative price of commodities have a substantial impact on key aggregate variables of the emerging economy, but a significantly lower impact on the developed economy.

First, note that in both economies an increase in the relative price of commodities leads to a sectoral reallocation of production: production of commodities increases, while production of manufactures decreases. Second, and most important, note that this reallocation of production is accompanied by very different responses across the two economies. In the emerging economy, there is a significant increase of output, consumption, investment, and labor. In contrast, aggregate variables in the developed economy remain largely unchanged.

Figure 3: One-Standard-Deviation Commodity Price Shock



Following our discussion in Section 4, this suggests that international relative price shocks have a bigger impact on the relative price between goods produced and consumed in the emerging economy than in the developed one and, thus, a bigger impact on aggregate output. In the next subsection we investigate the key features of the cross-sectional pattern of production and trade of the emerging economy that account for these findings.

Our conjecture, which is confirmed in the next subsection, is that shocks to the relative price of commodities have a very different impact on economic aggregates in the presence or absence of sectoral trade imbalances. In the emerging economy, which features significant sectoral trade imbalances, a positive shock to the relative price of commodities increases the price of the good that is exported and decreases the price of the good that is imported. These changes have a positive wealth effect, which increases the relative price between goods produced and consumed, increasing economic activity. In contrast, in the developed economy, where sectoral trade is balanced, an increase in the relative price of commodities does not have a wealth effect, as the positive impact of an increase in the value of domestically produced commodities is almost exactly offset by the increase in the price paid to consume commodities.

5.5.2 What accounts for the larger response of emerging economies to international relative price shocks?

In the preceding analysis, the emerging and developed economies are identical except for the four parameters presented in Panel C2 of Table 2 and in Table 3, which are calibrated to match the four cross-sectional moments also described in those tables. In this section, we investigate which of the differences between the emerging and developed economies are most important in accounting for the higher volatility of the former. To do so, we contrast the business cycle volatility implied by our calibrated economies with counter-factual ones that abstract from some of the cross-sectional differences between them.

We begin by restricting attention to the role played by sectoral trade imbalances. Table 6 presents the business cycle implications of two alternative parameterizations of our model. The top two rows of each panel contrast our benchmark emerging economy ("Emerging") with a counter-factual emerging economy without sectoral trade imbalances ("Emerging balanced"). The latter is an economy parameterized to target (*i*) the net exports of manufactures to GDP ratio featured by developed economies and (*ii*) the remaining cross-sectional moments of emerging economies. All other parameters are kept unchanged at the values reported in Table 2. The bottom two rows of each panel contrast our benchmark developed economy ("Developed") with a counter-factual developed economy with sectoral trade imbalances ("Developed imbalanced"); the latter is parameterized to target (i) the sectoral trade imbalances of emerging economies and (ii) the remaining cross-sectional moments of developed economies.

Table 6: Sectoral Trade Imbalances and Aggregate Volatility

A. Parameters	A_m	η	η_τ	b
Emerging	0.900	0.574	0.492	0.562
Emerging balanced	0.900	0.569	0.375	0.594
Developed	1.045	0.426	0.556	0.134
Developed imbalanced	1.045	0.407	0.771	0.169
B. Cross-sectional moments	Y_m/GDP	Y_c/GDP	NX/GDP	NX_m/GDP
Emerging	0.165	0.334	-0.050	-0.103
Emerging balanced	0.165	0.334	-0.050	-0.009
Developed	0.188	0.140	-0.010	-0.009
Developed imbalanced	0.188	0.140	-0.010	-0.103
C. Real GDP volatility				
Emerging	1.90			
Emerging balanced	1.55			
Developed	1.39			
Developed imbalanced	2.17			

Panels A and B report the parameters and target moments corresponding to each of the economies. We observe that the key parameter that controls the degree of sectoral imbalances in these economies is η_τ, which captures the share of manufactures in the production of tradable goods. First, we find that the primary difference between the "Emerging balanced" economy and our benchmark emerging economy is a lower value of η_τ in the former (0.375 vs. 0.492). Similarly, we find that the primary difference between the "Developed imbalanced" economy and our developed benchmark is a higher value of η_τ (0.771 vs. 0.556).

Panel C of Table 6 presents the volatility of real GDP corresponding to each of these economies. First, we observe that real GDP volatility in the "Emerging balanced" economy is substantially lower than our benchmark emerging economy; accounting for solely 16.32% of the observed volatility gap between emerging and developed economies (instead of 52% in the benchmark emerging economy). Second, we observe that real GDP volatility in the "Developed imbalanced" economy is substantially higher than in our benchmark developed economy (2.17 vs. 1.39). These findings show that differences in sectoral trade imbalances play a fundamental role in accounting for the higher volatility of emerging economies.

In the Online Appendix we examine the role each of the other cross-sectional moments used to calibrate our developed and emerging economies plays in accounting for our findings. To do so, we conduct quantitative exercises analogous to those conducted in this section. We find that none of the remaining cross-sectional targets has a significant impact on aggregate volatility. See the Online Appendix for details.

6 Country-By-Country Analysis

The quantitative analysis conducted in the previous section shows that cross-sectoral differences in the pattern of production and trade between emerging and developed economies can account for a significant fraction of the higher volatility of emerging economies. One implication of this finding is that such a relationship should hold not only across country aggregates (i.e., emerging vs. developed economies) but also across individual countries. In particular, countries with more unbalanced sectoral trade flows (i.e., with a larger trade deficit in manufactures) should exhibit more volatile output. In this section, we investigate whether this is indeed the case in the data. Then, we contrast the empirical relationship observed in the data with its model counterpart.

6.1 Empirical Evidence

We begin by investigating whether the systematic relationship between aggregate volatility and the cross-sectoral pattern of trade and production implied by our model indeed holds in the data. To do so, we use the cross-country panel dataset described in Section 2 to examine the empirical relationship between real GDP volatility and the key cross-sectional moments that characterize the pattern of trade and production in our model.

The analysis in Section 5.5.2 shows that sectoral trade imbalances are a key feature of emerging economies in accounting for the higher volatility in those economies: emerging economies are net exporters of commodities and net importers of manufactures, making them more vulnerable to changes in international relative prices. In contrast, sectoral trade flows are considerably more balanced in developed economies, shielding them from international relative price shocks.

We evaluate the extent to which this relationship holds in the data by estimating an OLS regression between real GDP volatility and sectoral imbalances, as characterized by the absolute value of the manufacturing net exports to GDP ratio.[19] We report the regression estimates in the first column of Table 7. The estimated relationship between sectoral trade imbalances and aggregate volatility across countries is positive and statistically significant at the 1% level. Moreover, this relationship is also economically significant: The beta coefficients reported show that a one-standard-deviation change in the manufacturing net exports to GDP ratio is associated with a 0.36-standard-deviation change in real GDP volatility.

While this evidence shows that sectoral trade imbalances are indeed associated with higher business cycle volatility, this relationship might be accounted for by the positive relationship between economic development and aggregate volatility for reasons other than sectoral trade imbalances. In the second column of Table 7, we evaluate the extent to which this is the case. We find that sectoral trade imbalances remain statistically and economically significant even after controlling for countries' GDP per capita. This evidence shows that, while more developed economies feature lower output volatility on average, sectoral trade imbalances are positively associated with higher business cycle volatility conditional on a country's level of economic development.

Finally, in the third column of Table 7, we examine whether any of the additional cross-sectional moments used to estimate our model are also associated

[19] In the model, it is the magnitude of sectoral trade imbalances that matter for volatility, not their sign. Therefore, we focus on the absolute value of sectoral trade imbalances in the regressions.

Table 7: Cross-Country Evidence

Dependent variable: Std. dev. real GDP	(1)	(2)	(3)
(Abs) NX manufactures / GDP	0.36	0.23	0.25
	(0.01)	(0.09)	(0.10)
Share of Commodities in GDP			0.24
			(0.41)
Share of Manufactures in GDP			0.18
			(0.33)
Aggregate NX/GDP			-0.01
			(0.95)
GDP per capita (log)		-0.32	-0.21
		(0.02)	(0.42)
$\overline{R}^2$	0.11	0.18	0.15
# of Obs	55	55	55

Notes: a) "Abs" denotes the absolute value. b) The beta coefficients are all normalized. c) Regressions all include an intercept. d) The numbers in parenthesis are p-values.

with real GDP volatility. We find that the relationship between sectoral trade imbalances and business cycle volatility is statistically and economically robust to controlling for these variables. In contrast, the relationship between GDP per capita and aggregate volatility is statistically insignificant when the extra controls are added. These findings suggest that the additional cross-sectional moments may be enough to capture the residual relationship between development and volatility after controlling for sectoral imbalances. Note, however, that these moments are also not statistically significant; the small number of observations prevents us from having sufficient statistical power to disentangle the extent to which this is the case.

6.2 Quantitative Analysis

The previous subsection shows that the key channels that account for the higher volatility of emerging economies in our model are also systematically associated with higher business cycle volatility in cross-country data. We now investigate the implications of our model for the volatility of real GDP in each of the 55 countries used to estimate the regression in Table 7.

To do so, we re-estimate our model for each of the 55 countries in the cross-country dataset described in Section 2. Our approach to estimating each of these economies is analogous to the strategy we pursue to compute the implications of our model for emerging economies, as described in Section 5.2. In particular, we assume that each of these economies only differs from our parameterization of the developed economy in the parameters used to discipline the cross-sectional moments reported in Panel C2 of Table 2. Then, for each of the 55 economies in our dataset, we estimate the parameters A_m, η, η_τ, and b to match (*i*) the share of manufactures in GDP, (*ii*) the share of commodities in GDP, (*iii*) the manufacturing net exports to GDP ratio, and (*iv*) the aggregate net exports to GDP ratio.[20]

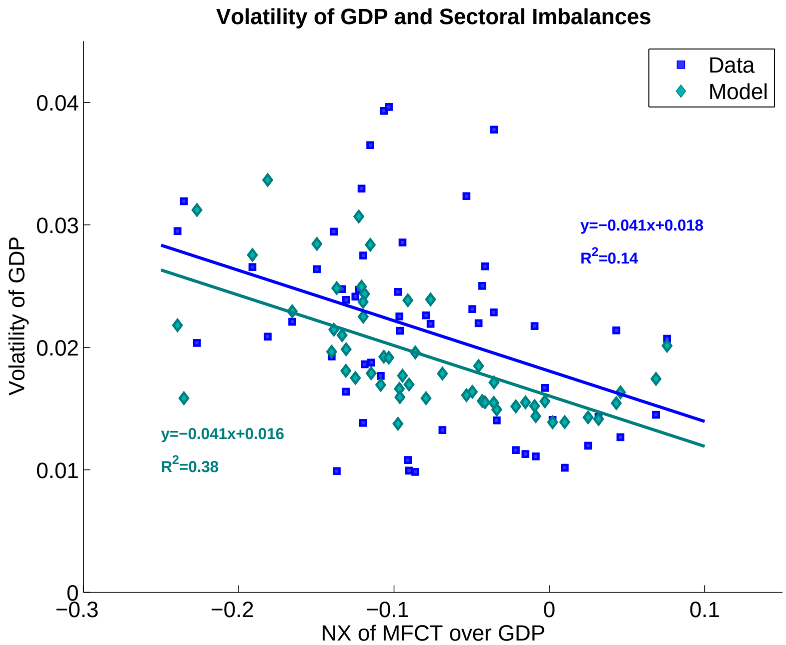
We contrast the implications of our 55 calibrated small open economies with their empirical counterparts along two dimensions. First, we examine the implications for the relationship between sectoral trade imbalances and real GDP volatility. To do so, in Figure 4 we use diamonds to represent the manufacturing net exports to GDP ratio and real GDP volatilities implied by our model for each of the countries, and we use squares to represent their empirical counterparts.

We observe that both the data and the model imply a negative relationship between sectoral trade imbalances and aggregate volatility: Real GDP volatility decreases systematically as the manufacturing net exports to GDP ratio approaches zero. Moreover, we find that the relationship between sectoral imbalances and real GDP volatility implied by our model is quantitatively consistent with the empirical relationship between them: An increase in the manufacturing net exports to GDP ratio from -0.1 to 0.0 is associated with a 0.41% decrease in real GDP volatility both in the model and the data. We interpret this finding as evidence of the success of our model in capturing the average relationship between sectoral imbalances and aggregate volatility observed in the data.

While the evidence presented in Figure 4 shows that the model and the

[20]See the Online Appendix for the country-specific parameters.

Figure 4

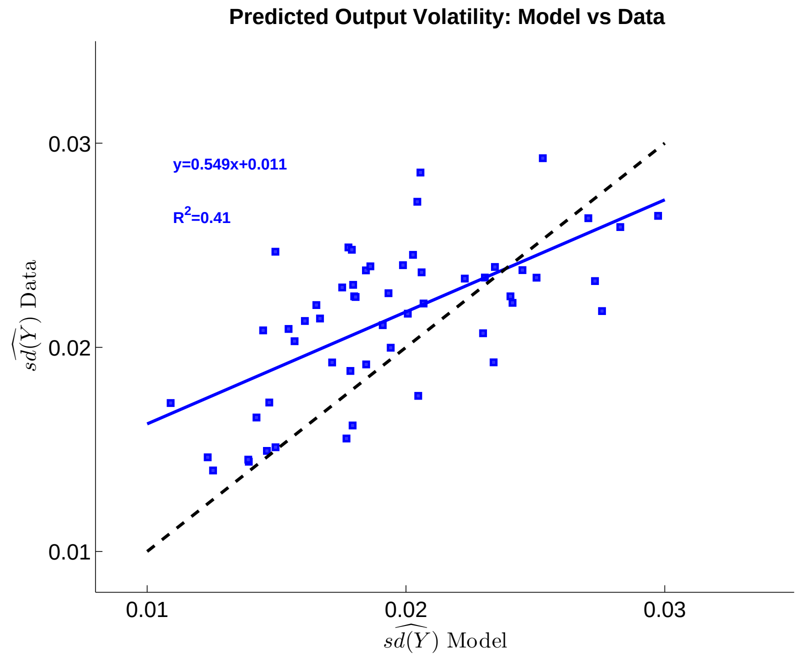


data feature a very similar relationship between sectoral trade imbalances and aggregate volatility *on average*, it begs the question about whether this relationship holds on a country-by-country basis. Thus, we now investigate the extent to which our model captures the empirical relationship between the four cross-sectional moments and real GDP volatility on a country-by-country basis.

To answer this question, we construct model-implied and empirical measures of predicted real GDP volatility given the four cross-sectional moments used to calibrate our model. To do so, we first regress real GDP volatility on the four cross-sectional variables that characterize each of our economies, using real and simulated data separately. Then, we use the estimated regressions to compute predicted real GDP volatilities for each country given their cross-sectional moments. Finally, we contrast the empirical and model-implied predicted real GDP volatilities for each country.

Figure 5 plots the empirical and model-implied predicted real GDP volatilities for each of the 55 countries in our sample. We find that there is a strong

Figure 5



systematic positive relationship between the aggregate volatilities predicted by our model and the empirical predicted volatilities. In particular, we find that our model accounts for 41% of the variation in predicted real GDP volatility from a regression using our four cross-sectional target moments. We interpret this as evidence of the success of our model in accounting for the empirical cross-country relationship between the patterns of trade and production and aggregate real GDP volatility.

7 Conclusion

In this paper, we investigate the extent to which salient cross-sectional differences between emerging and developed economies can account for the higher business cycle volatility in emerging economies. Our starting point is the observation that while emerging economies produce and export systematically different goods than their developed counterparts, these economies consume and import very similar types of goods.

We use a multi-sector small open economy model to show that these systematic differences between emerging and developed economies can affect their response to changes in international relative prices, amplifying business cycle volatility in emerging economies. We find that cross-sectional differences in the pattern of production and trade between developed and emerging economies can account for 52% of the difference in business cycle volatility.

Our findings show that the impact of terms of trade shocks on business cycle fluctuations depends on the economies' pattern of production and trade. In particular, emerging economies are more exposed to terms of trade shocks given that they run significant sectoral trade imbalances, with large trade surpluses in commodities and large deficits in manufactures.

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