Trade in Commodities and Business Cycle Volatility: Online Appendix

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1 Data

This section describes the variables and data sources used throughout the paper.

1.1 Data sources

Our sources of data are:

- World Bank's World Development Indicators (WDI; The World Bank,, 2018)
- Penn World Table 9.0 (PWT; Feenstra et al. 2015)
- Federal Reserve Economic Data (FRED; Federal Reserve Bank of St. Louis, 2019)

1.2 Business cycle moments

The variables that we use in the paper to compute the business cycle moments are the following:

- Real GDP: GDP per capita in constant local currency units [WDI=NY.GDP.PCAP.KN]
- Net exports / GDP: Exports of goods and services (% of GDP) [WDI=NE.EXP.GNFS.ZS] – Imports of goods and services (% of GDP) [WDI=NE.IMP.GNFS.ZS]
- Consumption: Households and NPISHs final consumption expenditure (% of GDP) [WDI=NE.CON.PRVT.ZS] × Real GDP
- Investment: Gross fixed capital formation (% of GDP) [WDI=NE.GDI.FTOT.ZS] × Real GDP
- Employment: Number of persons engaged [PWT=EMP]
- Hours: Average annual hours worked by persons engaged [PWT=AVH] × Employment
- TFP: TFP at constant national prices [PWT=RWTFPNA]

All of these variables are expressed in per capita terms by dividing over:

- Population: Population, total [WDI=SP.POP.TOTL]

1.3 Cross-sectional moments

The variables that we use in the paper to compute the cross-sectional moments are the following:

Value-added variables

- Value added = Agriculture, forestry, and fishing, value added (current LCU) [WDI=NV.AGR.TOTL.CN] + Industry (including construction), value added (current LCU) [WDI=NV.IND.TOTL.CN] + Services, value added (current LCU) [WDI=NV.SRV.TOTL.CN]

- Share of manufactures in GDP: Manufacturing, value added (current LCU) [WDI=NV.IND.MANF.CN] / Value added

- Value added in commodities: Agriculture, forestry, and fishing, value added (current LCU) [WDI=NV.AGR.TOTL.CN] + Industry (including construction), value added (current LCU) [WDI=NV.IND.TOTL.CN] − Manufacturing, value added (current LCU) [WDI=NV.IND.MANF.CN]

- Share of commodities in GDP: Value added in commodities / Value added

- Share of non-tradables in GDP: Services, value added (current LCU) [WDI=NV.SRV.TOTL.CN] / Value added

Whenever feasible, we extend the data from the value added data from the WDI using data from the OECD's STAN Industrial database.

Sectoral and aggregate imbalances

- Exports of commodities (% of merchandise exports): Agricultural raw materials exports (% of merchandise exports) [WDI=TX.VAL.AGRI.ZS.UN] + Food exports (% of merchandise exports) [WDI=TX.VAL.FOOD.ZS.UN] + Fuel exports (% of merchandise exports) [TX.VAL.FUEL.ZS.UN] + Ores and metals exports (% of merchandise exports) [WDI=TX.VAL.MMTL.ZS.UN]

- Exports of manufactures (% of merchandise exports): Manufactures exports (% of merchandise exports) [WDI=TX.VAL.MANF.ZS.UN]

- Merchandise exports: Merchandise exports (current US$) [WDI=TX.VAL.MRCH.CD.WT]

- Imports of commodities (% of merchandise imports): Agricultural raw materials imports (% of merchandise imports) [WDI=TM.VAL.AGRI.ZS.UN] + Food imports (% of merchandise imports) [WDI=TM.VAL.FOOD.ZS.UN] + Fuel imports (% of merchandise imports) [TM.VAL.FUEL.ZS.UN] + Ores and metals imports (% of merchandise imports) [WDI=TM.VAL.MMTL.ZS.UN]

- Imports of manufactures (% of merchandise imports): Manufactures imports (% of merchandise imports) [WDI=TM.VAL.MANF.ZS.UN]

- Merchandise imports: Merchandise imports (current US$) [WDI=TM.VAL.MRCH.CD.WT]

- GDP: GDP (current US$) [WDI=NY.GDP.MKTP.CD]

- Net exports of commodities / GDP: [Exports of commodities (% of merchandise exports) × Merchandise exports – Imports of commodities (% of merchandise imports) × Merchandise imports] / GDP

- Net exports of manufactures / GDP: [Exports of manufactures (% of merchandise exports) × Merchandise exports – Imports of manufactures (% of merchandise imports) × Merchandise imports] / GDP

- Aggregate NX / GDP: (Merchandise exports - Merchandise imports) / GDP

1.4 International relative prices

- Relative price of commodities: Producer Price Index by Commodity for Intermediate Demand by Commodity Type: Unprocessed Goods for Intermediate Demand [FRED=WPSID62] / Producer Price Index by Commodity for Final Demand: Finished Goods Less Foods and Energy [FRED=WPSFD4131]

1.5 Other variables used

- Real GDP per capita (PPP): GDP per capita, PPP (constant 2011 international $) [WDI=NY.GDP.MKTP.PP.KD]

1.6 Country selection

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 25 years of consecutive annual observations for each of the business cycle variables that we examine in Section 2.1 of the paper. We also exclude any country with cross-sectional variables observed for less than 15 years. In addition, we exclude countries that transitioned from communism to market economies in the 1990s.[1] Finally, we drop the U.S. and China, since we study a small open economy throughout our quantitative analysis, and we drop countries with a population below 1 million. After applying these filters, our final sample consists of 56 emerging economies and 20 developed ones.[2]

[1] These countries are the former Soviet and Yugoslav Republics as well as members of the Warsaw Pact (except East Germany).

[2] Results are robust to dropping countries with values of the standard deviation of real GDP above 8.5%, which are outliers in our data. These countries are Iran, Rwanda, Yemen, and Zimbabwe.

2 Model

2.1 Equilibrium conditions

The equilibrium conditions consist of the first-order conditions of the households, as well as those corresponding to firms producing manufactures, commodities, non-tradables, tradable composite goods, and final goods. In addition, there are the laws of motion for bond holdings, capital, productivity shocks and the relative price of commodities, the production functions, and the market clearing conditions.

2.1.1 Households

The households' first-order conditions for consumption of the final good and for labor supply to each of the three sectors $x \in \{m, c, n\}$ are:

$$[C_t - \psi_u N_t^\nu]^{-\gamma} = \lambda_t p_t \tag{1}$$

$$\begin{aligned}\frac{w_{x,t}}{p_t} =& \nu\psi_u N_t^{\nu-1} \\ &+ \phi_N^X \frac{\partial g(N_{m,t})}{\partial N_{x,t}} \left\{ \left(g(N_{m,t}) - \frac{N_{m,t-1}}{N_{t-1}} \right) - \mathbb{E}_t \left[m_{t+1} \left(\frac{N_{m,t+1}}{N_{t+1}} - g(N_{m,t}) \right) \right] \right\} \\ &+ \phi_N^X \frac{\partial g(N_{c,t})}{\partial N_{x,t}} \left\{ \left(g(N_{c,t}) - \frac{N_{c,t-1}}{N_{t-1}} \right) - \mathbb{E}_t \left[m_{t+1} \left(\frac{N_{c,t+1}}{N_{t+1}} - g(N_{c,t}) \right) \right] \right\}\end{aligned} \tag{2}$$

where λ_t is the Lagrange multiplier on the household's budget constraint and $g(N_{x,t}) = N_{x,t}/N_t$.

The first-order condition with respect to the future capital stock in each sector delivers the standard equations for pricing the sectoral returns to capital in sector $x \in \{m, c, n\}$:

$$1 = \mathbb{E}_t \left[m_{t+1} r_{x,t+1}^K \right] \tag{3}$$

where the stochastic discount factor m_{t+1} is

$$m_{t+1} = \beta \left[\frac{C_{t+1} - \psi_u N_{t+1}^\nu}{C_t - \psi_u N_t^\nu} \right]^{-\gamma} \tag{4}$$

and $r^K_{x,t+1}$ is the return on capital investment in sector x given by

$$(5)\quad r^K_{x,t+1} = \left[\phi_K\left(\frac{K_{t+1}}{K_t}-1\right)+\phi^X_K\left(f(K_{m,t+1})-\frac{K_{m,t}}{K_t}\right)\frac{\partial f(K_{m,t+1})}{\partial K_{x,t+1}}+\right.$$
$$\left.\phi^X_K\left(f(K_{c,t+1})-\frac{K_{c,t}}{K_t}\right)\frac{\partial f(K_{c,t+1})}{\partial K_{x,t+1}}+1\right]^{-1}\left\{\frac{r_{x,t+1}}{p_{t+1}}+(1-\delta)+\frac{\phi_K}{2}\left(\left(\frac{K_{t+2}}{K_{t+1}}\right)^2-1\right)+\right.$$
$$\left.\phi^X_K\left(\frac{K_{m,t+2}}{K_{t+2}}-f(K_{m,t+1})\right)\frac{\partial f(K_{m,t+1})}{\partial K_{x,t+1}}+\phi^X_K\left(\frac{K_{c,t+2}}{K_{t+2}}-f(K_{c,t+1})\right)\frac{\partial f(K_{c,t+1})}{\partial K_{x,t+1}}\right\}$$

where $f(K_{x,t+1}) = K_{x,t+1}/K_{t+1}$.

The remaining first-order condition with respect to the choice of non-contingent bonds delivers the following expression for the bond price:

$$(6)\qquad q_t = \mathbb{E}_t\left[m_{t+1}\frac{p_{\tau,t+1}/p_{t+1}}{p_{\tau,t}/p_t}\right]$$

2.1.2 Firms

The final goods firm's first-order conditions with respect to the demand for the tradable composite good and non-tradable goods are given by:

$$(7)\qquad \frac{\partial G\left(X_{\tau,t},X_{n,t}\right)}{\partial X_{k,t}} = \frac{p_{k,t}}{p_t}$$

for $k\in\{\tau,n\}$.

The first-order conditions for the producer of the tradable composite good with respect to the demand for manufactured goods and commodities are for $i\in\{m,c\}$:

$$(8)\qquad \frac{\partial H\left(X_{m,t},X_{c,t}\right)}{\partial X_{i,t}} = \frac{p_{i,t}}{p_{\tau,t}}$$

In the manufacturing, commodity and non-tradable sectors, the firms' first-order conditions for labor and capital are for $x\in\{m,c,n\}$:

$$(9)\qquad w_{x,t} = (1-\theta_x)\mu_x p_{x,t}A_x Z_t\frac{\left(K^{\theta_x}_{x,t}N^{1-\theta_x}_{x,t}\right)^{\mu_x}}{N_{x,t}}$$

$$(10)\qquad r_{x,t} = \theta_x\mu_x p_{x,t}A_x Z_t\frac{\left(K^{\theta_x}_{x,t}N^{1-\theta_x}_{x,t}\right)^{\mu_x}}{K_{x,t}}$$

2.1.3 Remaining conditions

The remaining conditions necessary to solve the equilibrium are the laws of motion for capital, productivity, bonds, the bond price, and the relative price of commodities; and the market clearing conditions.

2.2 Labor and capital shares

The labor share in this economy is given by the total labor compensation relative to GDP. In nominal terms this ratio is:

$$LS_t = \frac{w_{m,t}N_{m,t} + w_{c,t}N_{c,t} + w_{n,t}N_{n,t}}{Y_{m,t} + p_{c,t}Y_{c,t} + p_{n,t}Y_{n,t}} \tag{11}$$

$$= \frac{(1-\theta_m)\mu_m Y_{m,t} + (1-\theta_c)\mu_c p_{c,t}Y_{c,t} + (1-\theta_n)\mu_n p_{n,t}Y_{n,t}}{Y_{m,t} + p_{c,t}Y_{c,t} + p_{n,t}Y_{n,t}} \tag{12}$$

If the capital and labor intensities are equal across sectors as well as the degree of decreasing returns to scale (so that $\theta_x = \theta$ and $\mu_x = \mu$ for $x \in m, c, n$), then the labor share is constant and given by $LS = (1-\theta)\mu$.

Similarly, the capital share is given by the total compensation going to capital relative to GDP:

$$KS_t = \frac{r_{m,t}K_{m,t} + r_{c,t}K_{c,t} + r_{n,t}K_{n,t}}{Y_{m,t} + p_{c,t}Y_{c,t} + p_{n,t}Y_{n,t}} \tag{13}$$

$$= \frac{\theta_m\mu_m Y_{m,t} + \theta_c\mu_c p_{c,t}Y_{c,t} + \theta_n\mu_n p_{n,t}Y_{n,t}}{Y_{m,t} + p_{c,t}Y_{c,t} + p_{n,t}Y_{n,t}} \tag{14}$$

Again, if the capital and labor intensities are equal across sectors as well as the degree of decreasing returns to scale, then the capital share is constant and given by $KS = \theta\mu$.

2.3 Real GDP and TFP

2.3.1 Real GDP

We compute real GDP in the model following the value-added approach. Following Kehoe and Ruhl (2008) and Schmitt-Grohe and Uribe (2018), we keep prices fixed at their steady-state levels. Thus, we have that real GDP in our model is given by:

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

where variables with an "ss" subscript are evaluated at their steady-state levels.

2.3.2 TFP

To derive aggregate TFP in our model, we begin by plugging the sectoral production functions into the above expression for real GDP:

$$\text{Real GDP}_t = \sum_{j\in\{m,c,n\}} p_{j,ss} A_j Z_t \left(K_{j,t}^{\theta_j} N_{j,t}^{1-\theta_j}\right)^{\mu_j}.$$

To obtain an analytical expression for aggregate TFP, we set $\theta_j = \theta$ and $\mu_j = \mu$ for all $j \in \{c, m, n\}$. Then, we multiply and divide by $K_t^{\theta\mu}$ and $N_t^{(1-\theta)\mu}$ to obtain:

$$\text{Real GDP}_t = Z_t \left[\sum_{j\in\{m,c,n\}} p_{j,ss} A_j \left(\frac{K_{j,t}}{K_t}\right)^{\theta\mu} \left(\frac{N_{j,t}}{N_t}\right)^{(1-\theta)\mu}\right] \times \left(K_t^{\theta} \times N_t^{1-\theta}\right)^{\mu}.$$

Aggregate TFP is then given by:

$$\text{TFP}_t = Z_t \left[\sum_{j\in\{m,c,n\}} p_{j,ss} A_j \left(\frac{K_{j,t}}{K_t}\right)^{\theta\mu} \left(\frac{N_{j,t}}{N_t}\right)^{(1-\theta)\mu}\right],$$

and real GDP is given by:

$$\text{Real GDP}_t = \text{TFP}_t \times \left(K_t^{\theta} \times N_t^{1-\theta}\right)^{\mu}.$$

That is, with this assumption on the production functions in the three sectors (all three use capital and labor with the same intensities and share the same rate of decreasing returns to scale, they only differ in their steady-state productivity), we can decompose measured TFP into an exogenous component driven by the productivity process and an endogenous component that is determined by the share of capital and labor that is allocated to each sector.

3 Additional Results

3.1 Commodity price correlations in the model and the data

Table 1 complements Table 5 in the paper and presents the correlations of commodity prices with real GDP, NX/GDP, consumption, investment, labor, and TFP, in the data and the model, for both developed and emerging economies.

	GDP	NX/GDP	C	I	N	TFP
			Emerging			
Data	0.11	-0.09	0.07	0.10	0.04	0.10
Model	0.24	-0.38	0.39	0.54	0.38	0.01
			Developed			
Data	0.10	-0.10	0.08	0.08	0.09	0.08
Model	0.11	-0.63	0.31	0.42	0.16	0.01

Table 1: Correlation with commodity prices

3.2 Cross-sectional features and business cycle volatility

3.2.1 Manufacturing NX/GDP

Table 2 presents the business cycle implications of two alternative parameterizations of our model, which we discuss in Section 5.4 of the paper. 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 the net exports of manufactures to GDP ratio featured by developed economies; and the remaining cross-sectional moments of emerging economies. All other parameters are kept unchanged at the values reported in the paper. 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 the sectoral trade imbalances of emerging economies, and the remaining cross-sectional moments of developed economies.

3.2.2 Manufacturing NX/GDP and non-tradable share

Table 3 presents results analogous to those in the previous subsection. The key difference is that the first two rows of each panel now contrast our estimated emerging economy with a counter-factual economy parameterized to target the net exports of manufactures to GDP ratio and share of non-tradables of developed economies. The bottom two rows of each panel report the results for the analogous exercise starting from our estimated developed economy.

A. Parameters	A_m	η	η_τ	b	ψ_u
Emerging	0.890	0.396	0.471	0.984	0.401
... developed economy's Mfct NX/GDP	0.890	0.419	0.287	1.163	0.401
Developed	1.039	0.152	0.570	0.096	0.558
... emerging economy's Mfct NX/GDP	1.039	0.196	0.871	0.143	0.558
B. Cross-sectional moments	Y_m/GDP	Y_c/GDP	NX/GDP	NX_m/GDP	Time at work
Emerging	0.153	0.332	-0.067	-0.107	1/3
... developed economy's Mfct NX/GDP	0.153	0.332	-0.067	-0.005	0.36
Developed	0.188	0.146	-0.005	-0.005	1/3
... emerging economy's Mfct NX/GDP	0.188	0.146	-0.005	-0.107	0.37
C. Real GDP volatility					
Emerging	4.21				
... developed economy's Mfct NX/GDP	3.84				
Developed	2.26				
... emerging economy's Mfct NX/GDP	2.56				

Table 2: Aggregate volatility: Role of manufacturing NX/GDP

A. Parameters	A_m	η	η_τ	b	ψ_u
Emerging	0.890	0.396	0.471	0.984	0.401
... developed economy's Mfct NX/GDP and NT share	0.890	0.203	0.276	1.678	0.401
Developed	1.039	0.152	0.570	0.096	0.558
... emerging economy's Mfct NX/GDP and NT share	1.039	0.398	0.776	0.082	0.558
B. Cross-sectional moments	Y_m/GDP	Y_c/GDP	NX/GDP	NX_m/GDP	Time at work
Emerging	0.153	0.332	-0.067	-0.107	1/3
... developed economy's Mfct NX/GDP and NT share	0.105	0.228	-0.067	-0.005	0.50
Developed	0.188	0.146	-0.005	-0.005	1/3
... emerging economy's Mfct NX/GDP and NT share	0.273	0.212	-0.005	-0.107	0.25
C. Real GDP volatility					
Emerging	4.21				
... developed economy's Mfct NX/GDP and NT share	3.66				
Developed	2.26				
... emerging economy's Mfct NX/GDP and NT share	2.82				

Table 3: Aggregate volatility: Role of manufacturing NX/GDP and non-tradable Share

3.3 Impulse response functions

In this section, we present the impulse responses for real GDP, consumption, investment, net exports, and labor in response to the two shocks we have in our baseline model: A shock to the price of commodities (Figure 1) and a shock to aggregate productivity (Figure 2).

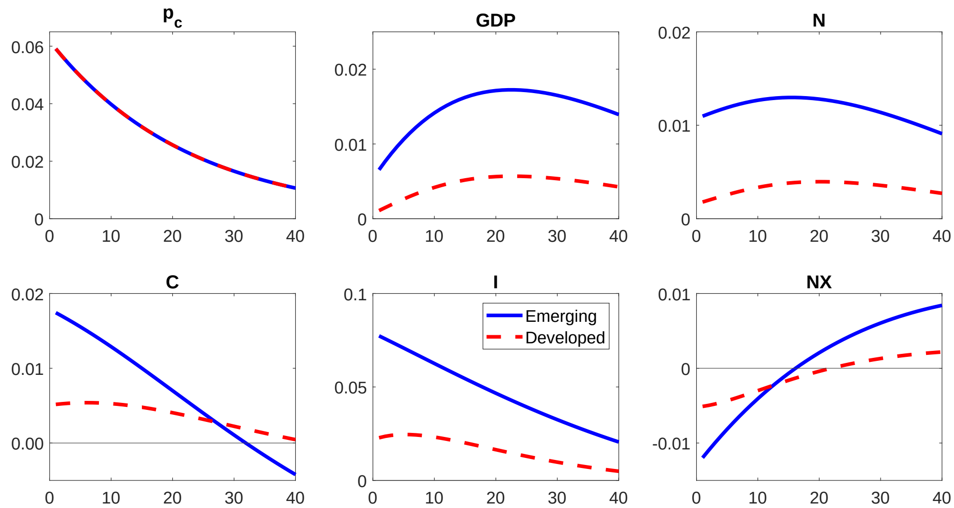

Figure 1: Commodity price shock

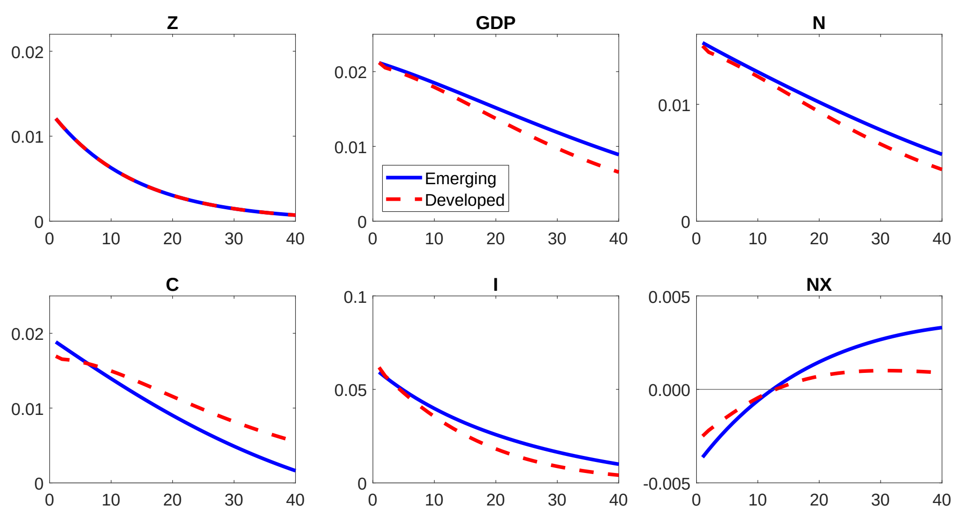

Figure 2: Productivity shock

3.4 Labor reallocation

3.4.1 Model vs. data

We gather data on labor across sectors, countries, and time to compare the implications of our model with evidence from the data (from World Bank's Development Indicators). The data is not perfect, as it is not available for all country-year pairs in our sample and, moreover, because the disaggregation across sectors is slightly different than in our paper. In our paper, we partition industries into commodities, manufactures, and non-tradables; in the World Bank data, industries are partitioned into agriculture, industry, and services. While services and non-tradables are roughly comparable, agriculture is a subset of commodities, as non-agriculture commodities belong to industry in this data.

	Std. dev. $\ln \frac{\text{Labor in commodities}}{\text{Total labor supply}}$	Std. dev. $\ln \frac{\text{Labor in manufacturing}}{\text{Total labor supply}}$
Emerging economies		
Data	0.142	0.118
Model	0.142	0.163
Model without sectoral labor adjustment costs	0.237	0.422
Model without sectoral adjustment costs	0.431	0.892
Developed economies		
Data	0.257	0.116
Model	0.181	0.133
Model without sectoral labor adjustment costs	0.261	0.276
Model without sectoral adjustment costs	0.574	0.585

Note: Due to data limitations, employment in "commodities" in the data measured as employment in "agriculture." Similarly, employment in "manufacturing" measured as employment in "industry." Data source: World Bank Development Indicators.

Table 4: Labor reallocation — Model vs. data

In Table 4 we compare the implications of our model for the volatility of labor reallocation with its empirical counterpart. In particular, we focus on the standard deviation of the log of the share of labor in commodities and manufactures (agriculture and industry in the data, respectively). The first two rows in the top and bottom panels of the table show that the implications of the model are close to their empirical counterpart, both in emerging and developed economies. The fit is particularly tight for emerging economies, but still close for developed economies.

The third and fourth rows of each panel show that sectoral adjustment costs play a key role in accounting for these findings. The third row of each panel reports the implied volatility of labor reallocation in a model with the same parameters as the baseline but without sectoral labor reallocation costs. The fourth row of each panel reports the implied volatility of labor reallocation in a model with the same parameters as the baseline but without sectoral labor and capital reallocation costs. We find that both emerging and developed economies feature a higher volatility of sectoral labor reallocation when labor or both sectoral reallocation costs are removed. Importantly, these implied volatilities are further from their empirical counterpart than our baseline economies.

3.4.2 Model without sectoral labor adjustment costs

To what extent do labor adjustment costs affect the results reported in the paper? To answer this question, we re-estimate the emerging economy under the constraint that $\phi_N^X = 0$. The estimation results are reported in Table 5. All targets are matched as well as in the baseline model.

Parameter	Value	Target moment	Data	Model
		Time-series targets		
σ_z	0.010	Std. dev. real GDP	4.23	4.22
ρ_z	0.978	Autocorrelation real GDP	0.55	0.70
ϕ_K	7.118	Std. dev. investment / Std. dev. real GDP	3.90	3.89
ϕ_K^X ($\phi_N^X = 0$)	459.87	Std. dev. share of manufactures in GDP	0.20	0.34
η_{GDP}	-0.061	Corr(NX/GDP,GDP)	-0.20	-0.22
		Std. dev. consumption / Std. dev. real GDP	1.34	1.30
		Std. dev. NX/GDP	3.44	3.44
		Cross-sectional targets		
A_m	0.890	Avg. share of manufactures in GDP	0.152	0.153
η	0.396	Avg. share of commodities in GDP	0.332	0.332
η_τ	0.471	Avg. manufactures NX/GDP	-0.107	-0.107
b	0.984	Avg. aggregate NX/GDP	-0.067	-0.067
ψ_u	0.401	Share of labor endowment used to work	—	1/3

Table 5: Estimated parameters — No labor adjustment costs

We explore the implications of this alternative parameterization of the model in Table 6. We find that when this alternative emerging economy is recalibrated to match the cross-sectional patterns of production and trade featured by developed economies, the standard deviation of real GDP is reduced from 4.22 to 3.77 (vs. 3.63 in the baseline economy examined in the paper). Thus, the cross-sectional patterns of production and trade account for 23% of the volatility gap observed in the data (vs. 29% in the baseline economy examined in the paper). Thus, sectoral labor adjustment costs amplify the impact of differences in the patterns of production and trade on aggregate volatility.

	Std. dev. real GDP
Emerging economy without sectoral labor adjustment costs	4.22
. . . with avg. developed economy's structure of production and trade	3.77
Data	4.23
Emerging economy baseline	4.21

Table 6: Real GDP Volatility — No labor adjustment costs

3.5 Correlated processes for prices and productivity

In the baseline calibration, our approach is to first estimate the process for the relative price of commodities in the data and then estimate other parameters separately for an average developed and an average emerging economy. In this way we impose that both of these small open economies face the same process for commodity prices in international markets. As the process is estimated independently of the two countries, the correlation with the shocks to productivity is assumed to be zero. To test the importance of this assumption for our results, we have conducted a series of exercises in which we allow for prices and productivity to be correlated. We describe these exercises below.

In the first exercise ("Full calibration"), we include the parameters of the commodity price process in the simulated method of moments (SMM) estimation for each economy.[3] The additional parameters to be estimated are the persistence and the conditional standard deviation of the price process, and the correlation between shocks to the relative price and shocks to productivity. The extra moments to include are the autocorrelation and standard deviation of the relative price of commodities in the data, and the correlation between this series and real GDP.

In the second exercise ("Correlation only"), we keep the estimated values of the persistence and the conditional standard deviation of the relative price process for each country. Then, in the SMM, we only include the correlation between the shocks to the relative price of commodities and productivity as an extra parameter to calibrate. The only additional moment is then the correlation between the relative price of commodities and real GDP in the data. Thus, in this exercise, we maintain the assumption that both emerging and developed countries face the same process for commodity prices in international markets, but allow their productivity processes to differ in the correlation with those prices.

Tables 7 and 8 show the calibrations that result in both of these exercises for the emerging and the developed economies, respectively. For both economies, the persistence of the commodity price process is similar whether it is estimated separately only using data on commodity prices or in the SMM. In contrast, we estimate a more volatile process for both economies when the commodity price process is included in the SMM. Along with the more volatile price process, we estimate a higher sectoral adjustment cost to dampen the degree of sectoral reallocation. Finally, the estimated correlation between commodity prices and productivity is close to zero for the developed economy, but slightly negative for the emerging economy.

Table 9 reports the implications of our model under these alternative parameterizations for the role of the cross-sectional patterns of production and trade on aggregate volatility differences.

- In the "Full calibration" exercise, we find that estimating a more volatile commodity price process implies that more of the overall variance is accounted for by commodity price shocks. The difference between the share of the overall variance accounted for by commodity prices in the emerging and developed economies is also larger than in the baseline calibration. As shown in Table 7 and

[3] Note that changing the process for the relative price of commodities does not affect the steady state of the model. Hence, the parameters that are calibrated to steady-state moments are not affected in the exercises discussed here.

Table 7: Alternative calibrations of the commodity price process - Emerging economy

Parameter	Baseline	Full calib.	Corr. only	Target moment	Data	Baseline	Full calib.	Corr. only
σ_z	0.012	0.012	0.012	Std. dev. real GDP	4.23	4.21	4.22	4.21
ρ_z	0.93	0.95	0.95	Aut. real GDP	0.55	0.64	0.65	0.66
ϕ_K	7.67	7.59	7.34	Std. dev. I/real GDP	3.90	3.89	3.89	3.88
$\phi_K^X = \phi_N^X$	99.2	133.4	91.7	Std. dev. share Manf/GDP	0.20	0.27	0.29	0.28
η_{GDP}	-0.084	-0.079	-0.083	Corr(NX/GDP, GDP)	-0.20	-0.21	-0.20	-0.22
				Std. dev. C / Std. dev. GDP	1.34	1.28	1.29	1.28
				Std. dev. NX/GDP	3.44	3.45	3.45	3.45
σ_{p_c}	***0.059***	0.078	***0.059***	Std. dev. commodity price	21.2		21.2	
ρ_{p_c}	***0.96***	0.95	***0.96***	Aut. commodity prices	0.85		0.81	
$\text{corr}(\varepsilon_z, \varepsilon_{p_c})$	***0***	-0.23	-0.14	Corr(com. price, GDP)	0.11		0.15	0.16

Table 8: Alternative calibrations of the commodity price process - Developed economy

Parameter	Baseline	Full calib.	Corr. only	Target moment	Data	Baseline	Full calib.	Corr. only
σ_z	0.0074	0.0071	0.0074	Std. dev. real GDP	2.25	2.26	2.26	2.26
ρ_z	0.91	0.92	0.91	Aut. real GDP	0.58	0.59	0.60	0.59
ϕ_K	2.60	1.74	2.58	Std. dev. I/real GDP	3.30	3.30	3.30	3.30
$\phi_K^X = \phi_N^X$	75.6	150.6	73.1	Std. dev. share Manf/GDP	0.19	0.19	0.20	0.20
η_{GDP}	-0.06	-0.05	-0.06	Corr(NX/GDP, GDP)	-0.28	-0.26	-0.24	-0.26
				Std. dev. C / Std. dev. GDP	0.96	0.99	1.00	0.98
				Std. dev. NX/GDP	1.39	1.38	1.37	1.38
σ_{p_c}	***0.059***	0.073	***0.059***	Std. dev. commodity price	21.2		21.2	
ρ_{p_c}	***0.96***	0.96	***0.96***	Aut. commodity prices	0.85		0.83	
$\text{corr}(\varepsilon_z, \varepsilon_{p_c})$	***0***	-0.008	-0.003	Corr(com. price, GDP)	0.10		0.12	0.10

Table 8, part of this larger difference between the two economies follows from a higher conditional standard deviation estimated for the emerging economy. In the developed economy, the role of the cross-sectional patterns of production and trade on aggregate volatility are also larger than in the baseline. But in the emerging economy, we find a slightly smaller impact of cross-sectional differences in trade and production on aggregate volatility.

- In the "Correlation only" exercise, on the other hand, the two countries face an international price process with the same persistence and conditional standard deviation. In the developed economy, we estimate a correlation close to zero, so the results of this exercise are virtually identical to those of our baseline. In the emerging economy, the negative correlation between commodity prices and productivity slightly reduces the impact of cross-sectional differences in trade and production on aggregate volatility. In addition, the variance decomposition indicates that commodity prices account for an equally large share of the variance as in the baseline. This latter result is not very surprising, as the estimated negative correlation does not matter when shutting off the productivity shocks, but it does highlight that including the correlation does not materially affect the calibration of the other parameters.

Table 9: Results with alternative calibrations of the commodity price process

	Baseline	Full calib.	Correlation only
Emerging economy	4.21	4.22	4.21
Share of variance accounted for by commodity price shocks	26.2	33.9	26.3
With developed economy's structure of production and trade			
Real GDP volatility	3.63	3.75	3.70
Share of volatility gap explained	29.9	23.6	26.2
Developed economy	2.26	2.26	2.26
Share of variance accounted for by commodity price shocks	10.7	11.9	10.7
With emerging economy's structure of production and trade			
Real GDP volatility	3.03	3.21	3.03
Share of volatility gap explained	39.7	48.7	39.5

3.6 Countries with Sectoral Trade Deficits

We examine the sensitivity of the empirical results reported in the paper to restricting attention to countries with sectoral trade deficits. We have thus re-estimated the empirical analysis presented in the paper for these countries. In particular, we restrict attention to countries featuring sectoral trade deficits, on average, in manufacturing (i.e. countries with avg. NX of Manufactures / GDP < 0). We present these results in Table 10. We find that all the results presented in the paper are quantitatively and qualitatively robust to restricting attention to countries with sectoral trade deficits.

Dependent variable: Std. dev. real GDP					
	(1)	(2)	(3)	(4)	(5)
NX of manufactures / GDP	0.33		0.30	0.32	0.28
	(0.003)		(0.013)	(0.012)	(0.038)
Share of commodities in GDP					0.55
					(0.135)
Share of manufactures in GDP					0.15
					(0.282)
Share of non-tradables in GDP				-0.45	
				(0.044)	
Aggregate NX/GDP					-0.07
					(0.700)
GDP per capita (log)		-0.18	-0.07	0.24	0.28
		(0.121)	(0.559)	(0.224)	(0.344)
R-squared	0.11	0.03	0.11	0.22	0.20
# of Obs	66	66	66	66	66

Notes: a) beta coefficients reported, b) all regressions inclue an intercept, c) p-values in parentheses based on robust standard errors

Table 10: Cross-country evidence — Countries with sectoral trade deficits

3.7 Excluding crises episodes

Are the volatility differences between emerging and developed economies mainly driven by crisis episodes, or are they salient features of the data extending beyond such episodes? To answer this question we use a dataset that identifies crisis episodes across countries collected by Carmen Reinhart, Ken Rogoff, Christoph Trebesch, and Vincent Reinhart.[4] These data identify banking crisis dates for 70 countries from 1960 until today, as well as exchange rate crises, stock market crises, sovereign debt crises, systemtic crises, and inflation crises.

We recompute the volatility of real GDP as constructed in the paper exclude country-year observations in which there was any kind of crisis. The results are reported in Table 11. As would be expected, we find that excluding crisis episodes reduces the volatility of real GDP in both developed and emerging economies, but the volatility difference between them is only mildly reduced: the percentual volatility difference decreases from 87.9% to 83.5% once we exclude crises episodes (similarly, the percentage point difference in volatility decreases from 2.0% to 1.7%). We conclude that our analysis is robust to excluding crisis episodes.

	Std. Dev. real GDP (%)	
	Baseline data	Data excluding crisis years
Developed	2.25%	2.01%
Emerging	4.23%	3.70%
Percent difference	87.9%	83.5%
Percentage point difference	2.0%	1.7%

Table 11: Real GDP volatility — Crisis episodes

[4]The data is available for download from https://www.hbs.edu/behavioral-finance-and-financial-stability/data/Pages/global.aspx.

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3.8 Country size

We evaluated the importance of country size by recomputing the regression results presented in the paper but now weighting observations according to country size. The results are reported in Table 12. We find that the results discussed in the paper are robust when assigning higher weight to bigger countries, which runs contrary to the idea that bigger countries might be more diversified and thus have lower real GDP volatility.

Dependent variable: Std. dev. real GDP		
	Baseline	Weight by population
NX of manufactures / GDP	0.28	0.51
	(0.025)	(0.000)
Share of commodities in GDP	0.59	0.55
	(0.110)	(0.099)
Share of manufactures in GDP	0.14	0.05
	(0.306)	(0.747)
Share of non-tradables in GDP		
Aggregate NX/GDP	-0.06	0.20
	(0.697)	(0.035)
GDP per capita (log)	0.27	0.42
	(0.381)	(0.202)
R-squared	0.24	0.42
# of Obs	76	76

Notes: a) beta coefficients reported, b) all regressions inclue an intercept, c) p-values in parentheses based on robust standard errors

Table 12: Cross-country evidence — Country size

3.9 Country-by-country calibration

Tables 13 and 14 report the country-specific parameters estimated in Section 6.2 of the paper which underlie the exercises conducted in that section.

		Target Moments			*Calibrated Parameters*			
Country	NX/GDP	Manuf.NX/GDP	Comm./GDP	Manuf./GDP	A_m	b	η_τ	η
Albania	-0.247	-0.163	0.394	0.073	0.777	3.510	0.331	0.515
Argentina	0.027	-0.044	0.180	0.207	1.022	-0.706	0.698	0.196
Australia	-0.010	-0.091	0.211	0.142	0.943	0.157	0.645	0.174
Austria	-0.038	-0.004	0.142	0.208	1.059	0.614	0.545	0.198
Bangladesh	-0.068	-0.015	0.330	0.156	0.894	1.131	0.309	0.415
Belgium	0.011	0.063	0.117	0.208	1.090	-0.223	0.463	0.134
Benin	-0.116	-0.120	0.373	0.133	0.857	1.600	0.407	0.472
Bolivia	-0.005	-0.163	0.313	0.153	0.898	0.082	0.672	0.324
Brazil	0.008	-0.012	0.195	0.229	1.025	-0.162	0.580	0.252
Burkina Faso	-0.127	-0.131	0.416	0.127	0.837	1.675	0.385	0.543
Cameroon	-0.025	-0.110	0.350	0.148	0.879	0.360	0.494	0.379
Canada	0.015	-0.048	0.182	0.165	0.985	-0.268	0.641	0.152
Central African Republic	-0.020	-0.043	0.573	0.080	0.744	0.372	0.182	0.699
Chile	0.009	-0.122	0.260	0.185	0.950	-0.187	0.705	0.289
Colombia	-0.011	-0.074	0.295	0.185	0.933	0.170	0.529	0.341
Congo, Rep.	0.216	-0.168	0.570	0.061	0.716	-2.890	0.552	0.389
Costa Rica	-0.088	-0.163	0.212	0.196	0.988	1.880	0.723	0.328
Cote d'Ivoire	0.091	-0.118	0.348	0.136	0.868	-1.738	0.646	0.256
Denmark	0.003	-0.021	0.128	0.165	1.038	-0.072	0.641	0.111
Dominican Republic	-0.098	-0.091	0.245	0.197	0.968	1.608	0.534	0.363
Ecuador	0.008	-0.126	0.293	0.180	0.929	-0.149	0.659	0.323
El Salvador	-0.122	-0.128	0.267	0.190	0.950	1.890	0.550	0.404
Finland	0.015	0.040	0.163	0.237	1.058	-0.234	0.512	0.214
France	-0.013	0.007	0.123	0.167	1.047	0.276	0.526	0.116
Germany	0.042	0.081	0.091	0.229	1.148	-0.948	0.531	0.111
Ghana	-0.068	-0.191	0.522	0.088	0.766	0.815	0.413	0.610
Greece	-0.119	-0.090	0.177	0.133	0.958	1.748	0.520	0.206
Guatemala	-0.083	-0.119	0.272	0.167	0.929	1.354	0.548	0.341
Honduras	-0.077	-0.228	0.298	0.174	0.922	1.424	0.732	0.413
India	-0.031	-0.002	0.408	0.182	0.886	0.471	0.296	0.570
Indonesia	0.062	-0.047	0.369	0.230	0.931	-0.839	0.515	0.491
Iran, Islamic Rep.	0.033	-0.104	0.382	0.127	0.847	-0.502	0.484	0.343
Ireland	0.090	0.071	0.126	0.233	1.097	-1.967	0.603	0.113
Israel	-0.115	-0.053	0.092	0.157	1.084	2.272	0.578	0.152

Table 13: Country-by-country calibration

	Target Moments				*Calibrated Parameters*			
Country	NX/GDP	Manuf.NX/GDP	Comm./GDP	Manuf./GDP	A_m	b	η_τ	η
Italy	-0.006	0.045	0.130	0.214	1.077	0.099	0.481	0.166
Jamaica	-0.210	-0.109	0.205	0.100	0.898	4.070	0.406	0.265
Japan	0.012	0.065	0.125	0.253	1.112	-0.204	0.516	0.194
Jordan	-0.369	-0.217	0.173	0.149	0.978	6.199	0.530	0.406
Kenya	-0.104	-0.131	0.385	0.118	0.838	1.427	0.411	0.457
Korea, Rep.	-0.009	0.087	0.201	0.266	1.043	0.175	0.376	0.340
Lebanon	-0.349	-0.196	0.150	0.106	0.949	6.594	0.500	0.310
Madagascar	-0.093	-0.104	0.319	0.117	0.861	1.476	0.418	0.342
Malaysia	0.089	-0.066	0.278	0.256	0.988	-1.768	0.725	0.370
Mexico	-0.006	-0.032	0.219	0.194	0.982	0.129	0.539	0.243
Morocco	-0.116	-0.080	0.255	0.199	0.963	1.814	0.491	0.394
Namibia	-0.156	-0.196	0.294	0.116	0.870	2.435	0.552	0.355
Nepal	-0.175	-0.113	0.551	0.068	0.730	2.897	0.228	0.720
Netherlands	0.020	-0.008	0.146	0.167	1.021	-0.405	0.599	0.114
New Zealand	-0.008	-0.118	0.177	0.193	1.013	0.170	0.822	0.230
Niger	-0.100	-0.129	0.509	0.061	0.727	1.446	0.283	0.582
Nigeria	0.123	-0.146	0.362	0.136	0.864	-2.692	0.750	0.266
Norway	0.055	-0.092	0.264	0.126	0.895	-0.908	0.651	0.164
Pakistan	-0.067	-0.016	0.349	0.156	0.886	1.101	0.301	0.450
Panama	-0.192	-0.206	0.166	0.138	0.973	4.381	0.692	0.269
Paraguay	-0.113	-0.242	0.390	0.136	0.854	1.518	0.592	0.502
Peru	0.015	-0.079	0.267	0.181	0.943	-0.291	0.601	0.273
Philippines	-0.056	-0.036	0.302	0.239	0.965	0.797	0.460	0.491
Portugal	-0.106	-0.045	0.128	0.152	1.026	2.733	0.509	0.169
Rwanda	-0.167	-0.155	0.486	0.099	0.787	2.203	0.337	0.642
Senegal	-0.143	-0.103	0.263	0.145	0.914	2.331	0.450	0.345
South Africa	-0.042	-0.074	0.211	0.198	0.990	0.834	0.604	0.272
Spain	-0.050	-0.016	0.170	0.178	1.007	0.766	0.487	0.200
Sri Lanka	-0.096	-0.084	0.323	0.169	0.908	1.397	0.431	0.436
Sudan	-0.054	-0.103	0.480	0.074	0.755	0.793	0.292	0.517
Sweden	0.023	0.039	0.128	0.213	1.079	-0.445	0.547	0.141
Switzerland	0.003	0.032	0.093	0.197	1.120	-0.065	0.574	0.110
Tanzania	-0.117	-0.112	0.487	0.079	0.761	1.713	0.279	0.588
Thailand	-0.030	-0.043	0.187	0.284	1.065	0.579	0.653	0.371
Togo	-0.177	-0.175	0.483	0.081	0.765	2.309	0.345	0.615
Turkey	-0.061	-0.041	0.277	0.198	0.951	0.965	0.446	0.383
Uganda	-0.142	-0.138	0.495	0.076	0.756	1.981	0.300	0.610
United Kingdom	-0.037	-0.011	0.131	0.166	1.036	0.694	0.531	0.138
Uruguay	-0.023	-0.059	0.190	0.194	1.003	0.510	0.620	0.225
Venezuela, RB	0.091	-0.115	0.375	0.163	0.882	-1.466	0.621	0.347
Yemen, Rep.	-0.033	-0.151	0.704	0.117	0.764	0.535	0.314	0.914
Zimbabwe	-0.047	-0.120	0.271	0.187	0.945	0.795	0.609	0.345

Table 14: Country-by-country calibration (Cont.)

3.10 Developed commodity exporters

An implication of our model is that developed economies that are also commodity exporters and feature high sectoral trade imbalances (e.g. Australia, Canada, New Zealand and Norway), should have higher GDP volatility than similar economies that are not commodity exporters or have sectoral balanced trade. In this section, we examine the implications of our model for these countries. To do so, we re-estimate the model to match salient features of business cycles across these economies, as well as their cross-sectional patterns of production and trade. In particular, we follow the same estimation strategy as in the paper but target the average moments across these four countries. Table 15 shows that the model can largely account for salient features of Australia, Canada, New Zealand, and Norway. Table 16

Parameter	Value	Target moment	Data	Model
		Time-series targets		
σ_z	0.004	Std. dev. real GDP	1.96	1.96
ρ_z	0.999	Autocorrelation real GDP	0.61	0.68
ϕ_K	0.093	Std. dev. investment / Std. dev. real GDP	3.70	3.70
$\phi_K^X = \phi_N^X$	0.000	Std. dev. share of manufactures in GDP	0.29	0.64
η_{GDP}	-0.007	Corr(NX/GDP,GDP)	-0.22	-0.21
		Std. dev. consumption / Std. dev. real GDP	1.24	1.25
		Std. dev. NX/GDP	1.91	1.36
		Cross-sectional targets		
A_m	0.959	Avg. share of manufactures in GDP	0.16	0.16
η	0.177	Avg. share of commodities in GDP	0.21	0.21
η_τ	0.693	Avg. manufactures NX/GDP	-0.087	-0.087
b	-0.237	Avg. aggregate NX/GDP	0.013	0.013
ψ_u	0.541	Share of labor endowment used to work	—	1/3

Table 15: Estimated Parameters — Australia, Canada, New Zealand, Norway

shows that Australia, Canada, New Zealand, and Norway would be, on average, 14% less volatile if they had the structure of production and trade of an average developed economy. Therefore, our mechanism is weaker for these countries than it is for the average emerging economy. This is not surprising since these countries are only similar to the average emerging economy along some of the cross-sectional features that we focus on. They have similar sectoral trade imbalances and a commodity sector that is larger than the manufacturing sector, but the size of the nontradable sector in these economies is more similar to the average developed economy. In a variance decomposition, we find that commodity price shocks account for a much higher share of real GDP volatility in these four economies, than in the average developed economy. This share is much closer to its respective value for the average emerging economy as shown in Table 17. This is partly due to the fact that the calibrated productivity process for these countries has a low volatility to match the low standard deviation of real GDP in these countries. Thus, commodity prices play an important role in accounting for the business cycles of these developed

	Std. dev. Real GDP
Australia, Canada, New Zealand, Norway	1.96
... with avg. developed economy's structure of production and trade	1.69

Table 16: Real GDP Volatility — Australia, Canada, New Zealand, Norway

commodity exporters. In contrast to the implications of the model, the data shows that Australia,

Parameter	Commodity price shocks
Australia, Canada, New Zealand, Norway	25.5%
Emerging economy	26.2%
Developed economy	10.7%

Table 17: Real GDP variance decomposition — Australia, Canada, New Zealand, Norway

Canada, New Zealand, and Norway are less volatile than the average developed economy (1.96% vs. 2.25%). Therefore, the implications of the model suggest that:

1. The lower empirical volatility of countries like Australia, Canada, New Zealand, and Norway are likely to be accounted for by other factors than the channels investigated in this paper. Moreover, our model implies that if these countries featured lower sectoral trade imbalances, then their business cycle volatility would be even lower than observed in the data.

2. Commodity price shocks do play a bigger role in these economies than in the average developed economy. Yet, there are other factors that lead these economies to be less rather than more volatile than the average developed economy.

We then contrast the implications of the model with evidence from the data. To do so, we restrict attention to developed economies, which already feature low overall levels of business cycle volatility. We ask: Is it indeed the case that differences in sectoral trade imbalances are associated with differences in business cycle volatility even across low-volatility economies such as developed countries?

Our first attempt to answer this question consists of recomputing some of the regressions presented in the paper, but now restricting attention to developed economies and, thus, excluding a control for GDP per capita. The results are presented in the first two columns of Table 18. We find that there is no systematic relationship between business cycle volatility and sectoral trade imbalances or any of the other variables that characterize the structure of production and trade.

Dependent variable: Std. dev. real GDP				
	(1)	(2)	(3)	(4)
NX of manufactures / GDP	0.23	0.20	0.59	0.62
	(0.287)	(0.455)	(0.092)	(0.071)
Share of commodities in GDP		0.20		0.57
		(0.517)		(0.049)
Share of manufactures in GDP		0.37		0.16
		(0.220)		(0.588)
Aggregate NX/GDP		-0.19		-0.04
		(0.663)		(0.912)
Sovereign stabilization fund dummy			-0.55	-0.91
			(0.079)	(0.050)
R-squared	0.05	0.12	0.23	0.35
# of Obs	20	20	20	20

Notes: a) beta coefficients reported, b) all regressions include an intercept, c) p-values in parentheses based on robust standard errors

Table 18: Cross-country evidence — Developed countries

We then ask: To what extent is the lack of a relationship between aggregate volatility and the structure of production and trade accounted for by differences in policies across developed economies? To answer this question, we focus on the role of sovereign stabilization funds in commodity-producing developed economies. These funds are aimed at accumulating assets when commodity prices are high, to serve as a buffer when commodity prices are low. Following Mohaddes and Raissi (2017), we find that in our data only Australia, New Zealand, and Norway are commodity producers with sovereign stabilization funds. Then, we re-estimate the regressions presented in the first two columns of Table 18, but we include a dummy variable equal to one for countries with a sovereign wealth fund. These results are reported in columns (3) and (4) of Table 18.

In contrast to the findings discussed above and consistent with the results reported in the paper, we now find that sectoral imbalances and the share of commodities in GDP are both economically and statistically significant. Moreover, we find that the sovereign stabilization fund dummy is also economically and statistically significant, implying that sovereign wealth funds are associated with lower real GDP volatility.

These results suggest that differences in policies across developed economies are likely to be important in accounting for differences in business cycle volatility. Moreover, we find evidence consistent with the importance of the channels investigated in the paper after controlling for the presence of sovereign stabilization funds. Thus, consistent with the implications of the model, we conclude that differences in the structure of production and trade across developed economies are also important for understanding differences in business cycle volatility among them.

4 Sensitivity analysis

4.1 Elasticity of substitution between tradable and nontradable goods

In our baseline calibration, we set the elasticity of substitution between tradable and nontradable goods, σ, to 0.5. The weight on the tradable composite good in the CES aggregator, η, is among the parameters calibrated in the steady-state calibration of the model. Tables 19 and 20 show the alternative calibrations that result if we instead choose higher values for σ for the emerging and the developed economy respectivley.

Table 19: Alternative values for σ - Emerging economy

Parameter	$\sigma = 0.5$ *(Baseline)*	$\sigma = 1$	$\sigma = 1.5$	Target moment	Data	$\sigma = 0.5$ *(Baseline)*	$\sigma = 1$	$\sigma = 1.5$
				Time-series targets				
σ_z	0.012	0.012	0.011	Std. dev. real GDP	4.23	4.21	4.21	4.22
ρ_z	0.93	0.95	0.96	Aut. real GDP	0.55	0.64	0.66	0.67
ϕ_K	7.67	8.40	8.57	Std. dev. I/real GDP	3.90	3.89	3.88	3.88
$\phi_K^X = \phi_N^X$	99.2	91.2	86.5	Std. dev. share Manf/GDP	0.20	0.27	0.24	0.22
η_{GDP}	-0.084	-0.076	-0.073	Corr(NX/GDP, GDP)	-0.20	-0.21	-0.21	-0.20
				Std. dev. C / Std. dev. GDP	1.34	1.28	1.29	1.30
				Std. dev. NX/GDP	3.44	3.45	3.44	3.45
				Cross-sectional targets				
A_m	0.89	0.89	0.89	Avg. share manf. in GDP	0.15	0.15	0.15	0.15
η	**0.40**	**0.52**	**0.56**	Avg. share com. in GDP	0.33	0.33	0.33	0.33
η_τ	0.47	0.47	0.47	Avg. manf. NX/GDP	-0.11	-0.11	-0.11	-0.11
b	0.98	0.97	0.97	Avg. aggregate NX/GDP	-0.07	-0.07	-0.07	-0.07
ψ_u	0.40	0.39	0.38	SS share of work/time	—	1/3	1/3	1/3

For both economies, increasing σ has a similar effect. The main change is that the calibrated value of η increases. With more substitutability between tradable and nontradable goods, more weight is placed on the tradable composite good to ensure that the size of the nontradable sector remains the same in the steady state of the model. The calibrated productivity difference between sectors and the parameters of the CES aggregator for the tradable composite goods are unchanged, and the result is that the model matches the same steady-state moments for the higher values of σ.

Table 21 shows the impact of the different calibrated values on our results. The variance decompositions show that with greater substitutability between traded and nontraded goods, the relative price of commodities can account for a bit less of the variance of real GDP than in our baseline. The difference is not large however, and the main results still hold with a value of $\sigma = 1.5$. An economy with the emerging market structure of production and trade has a higher standard deviation of real GDP, and commodity price shocks account for more of the variance in the emerging economy.

Table 20: Alternative values for σ - Developed economy

Parameter	$\sigma = 0.5$ (Baseline)	$\sigma = 1$	$\sigma = 1.5$	Target moment	Data	$\sigma = 0.5$ (Baseline)	$\sigma = 1$	$\sigma = 1.5$
				Time-series targets				
σ_z	0.0074	0.0071	0.0069	Std. dev. real GDP	2.25	2.26	2.26	2.26
ρ_z	0.91	0.93	0.94	Aut. real GDP	0.58	0.59	0.61	0.62
ϕ_K	2.60	3.39	3.80	Std. dev. I/real GDP	3.30	3.30	3.29	3.30
$\phi_K^X = \phi_N^X$	75.6	52.0	44.4	Std. dev. share Manf/GDP	0.19	0.19	0.19	0.19
η_{GDP}	-0.06	-0.05	-0.05	Corr(NX/GDP, GDP)	-0.28	-0.26	-0.26	-0.25
				Std. dev. C / Std. dev. GDP	0.96	0.99	0.98	0.99
				Std. dev. NX/GDP	1.39	1.38	1.38	1.38
				Cross-sectional targets				
A_m	1.04	1.04	1.04	Avg. share manf. in GDP	0.19	0.19	0.19	0.19
η	**0.15**	**0.34**	**0.42**	Avg. share Com. in GDP	0.15	0.15	0.15	0.15
η_τ	0.57	0.57	0.57	Avg. manf. NX/GDP	-0.005	-0.005	-0.005	-0.005
b	0.096	0.09	0.09	Avg. aggregate NX/GDP	-0.005	-0.005	-0.005	-0.005
ψ_u	0.56	0.49	0.46	SS share of work/time	—	1/3	1/3	1/3

Table 21: Results with alternative values of σ

	$\sigma = 0.5$ (Baseline)	$\sigma = 1$	$\sigma = 1.5$
Emerging economy	4.21	4.21	4.22
Share of variance accounted for by commodity price shocks	26.1	22.1	20.8
With developed economy's structure of production and trade			
Real GDP volatility	3.63	3.72	3.77
Share of volatility gap explained	29.7	25.1	22.6
Developed economy	2.26	2.26	2.26
Share of variance accounted for by commodity price shocks	10.7	10.4	10.4
With emerging economy's structure of production and trade			
Real GDP volatility	3.03	2.90	2.83
Share of volatility gap explained	39.5	32.8	29.2

4.2 Elasticity of substitution between manufactures and commodities

In our baseline calibration we set the elasticity of substitution between commodities and manufactures in the production of the tradable good, σ_τ, to 1.0. Tables 22 and 23 show the alternative calibrations that result if we choose different values for σ_τ for the emerging and the developed economy respectively.

Reducing σ_τ has the opposite impact on the calibrated value of η_τ in the two economies. In the emerging economy, decreasing σ_τ leads to a decrease in η_τ. In the baseline calibration for the emerging economy, the manufacturing sector is smaller and the steady-state productivity is lower than in the commodity sector. When manufactured goods and commodities become more complementary in the production of the tradable composite good, demand for manufactured goods (the smaller sector) would go up unless a smaller weight was placed on those goods in the aggregation. Therefore, η_τ has to decrease to match the same steady-state moments. In the developed economy, the manufacturing sector is larger and the steady-state productivity is higher than in the commodity sector, so the logic is reversed and a decrease in σ_τ leads to an increase in the calibrated value of η_τ to match the same demand for commodities when the two sectors are complements. Increasing σ_τ and hence, increaseing the substitutability of manufactures and commodities has the opposite effect on η_τ in both economies.

Table 24 shows the impact of the different calibrated values on our results. Our results are virtually unchanged for both the emerging and the developed economy when η_τ is recalibrated to match the same steady-state moments as in the baseline case. The choice we make for the predetermined parameter σ_τ is, therefore, not crucial in driving our key results.

Table 22: Alternative values for σ_τ - Emerging economy

Parameter	$\sigma_\tau = 0.5$	$\sigma_\tau = 1$ *(Baseline)*	$\sigma_\tau = 1.5$	Target moment	Data	$\sigma_\tau = 0.5$	$\sigma_\tau = 1$ *(Baseline)*	$\sigma_\tau = 1.5$
				Time-series targets				
σ_z	0.012	0.012	0.012	Std. dev. real GDP	4.23	4.21	4.21	4.21
ρ_z	0.94	0.93	0.92	Aut. real GDP	0.55	0.64	0.64	0.63
ϕ_K	7.87	7.67	7.44	Std. dev. I/real GDP	3.90	3.89	3.89	3.89
$\phi_K^X = \phi_N^X$	103.6	99.2	95.4	Std. dev. share Manf/GDP	0.20	0.27	0.27	0.27
η_{GDP}	-0.084	-0.084	-0.083	Corr(NX/GDP, GDP)	-0.20	-0.20	-0.21	-0.21
				Std. dev. C / Std. dev. GDP	1.34	1.28	1.28	1.28
				Std. dev. NX/GDP	3.44	3.45	3.45	3.45
				Cross-sectional targets				
A_m	0.89	0.89	0.89	Avg. share manf. in GDP	0.15	0.15	0.15	0.15
η	0.40	0.40	0.40	Avg. share com. in GDP	0.33	0.33	0.33	0.33
η_τ	**0.44**	**0.47**	**0.48**	Avg. manf. NX/GDP	-0.11	-0.11	-0.11	-0.11
b	0.99	0.98	0.98	Avg. aggregate NX/GDP	-0.07	-0.07	-0.07	-0.07
ψ_u	0.40	0.40	0.40	SS share of work/time	—	1/3	1/3	1/3

Table 23: Alternative values for σ_τ - Developed economy

Parameter	$\sigma_\tau = 0.5$	$\sigma_\tau = 1$ *(Baseline)*	$\sigma_\tau = 1.5$	Target moment	Data	$\sigma_\tau = 0.5$	$\sigma_\tau = 1$ *(Baseline)*	$\sigma_\tau = 1.5$
				Time-series targets				
σ_z	0.0074	0.0074	0.0074	Std. dev. real GDP	2.25	2.26	2.26	2.26
ρ_z	0.91	0.91	0.91	Aut. real GDP	0.58	0.59	0.59	0.59
ϕ_K	2.76	2.60	2.44	Std. dev. I/real GDP	3.30	3.30	3.30	3.30
$\phi_K^X = \phi_N^X$	75.5	75.6	77.4	Std. dev. share Manf/GDP	0.19	0.20	0.19	0.19
η_{GDP}	-0.061	-0.06	-0.059	Corr(NX/GDP, GDP)	-0.28	-0.26	-0.26	-0.26
				Std. dev. C / Std. dev. GDP	0.96	0.98	0.99	0.99
				Std. dev. NX/GDP	1.39	1.38	1.38	1.38
				Cross-sectional targets				
A_m	1.04	1.04	1.04	Avg. share manf. in GDP	0.19	0.19	0.19	0.19
η	0.15	0.15	0.15	Avg. share com. in GDP	0.15	0.15	0.15	0.15
η_τ	**0.64**	**0.57**	**0.55**	Avg. manf. NX/GDP	-0.005	-0.005	-0.005	-0.005
b	0.10	0.096	0.10	Avg. aggregate NX/GDP	-0.005	-0.005	-0.005	-0.005
ψ_u	0.56	0.56	0.56	SS share of work/time	—	1/3	1/3	1/3

Table 24: Results with alternative values of σ_τ

	$\sigma_\tau = 0.5$	$\sigma_\tau = 1$ *(Baseline)*	$\sigma_\tau = 1.5$
Emerging economy	4.21	4.21	4.21
Share of variance accounted for by commodity price shocks	25.4	26.1	27.1
With developed economy's structure of production and trade			
Real GDP volatility	3.62	3.63	3.63
Share of volatility gap explained	30.3	29.7	29.7
Developed economy	2.26	2.26	2.26
Share of variance accounted for by commodity price shocks	10.4	10.7	11.0
With emerging economy's structure of production and trade			
Real GDP volatility	3.03	3.03	3.03
Share of volatility gap explained	39.5	39.5	39.5

4.3 Capital share in non-tradables

In our baseline calibration, we follow Schmitt-Grohe and Uribe (2018) and set the capital share in non-tradables, θ_n, to 0.25, a lower value than the one we set for the capital share in tradable sectores, $\theta_c = \theta_m$ =0.35. Tables 25 and 26 show the alternative calibrations that result if we choose different values for θ_n for the emerging and the developed economy, respectively. In particular, we consider a case in which non-tradables are produced using only labor (θ_n=0), and a case in which non-tradables are produced with the same share of capital as tradables with $\theta_n = \theta_c = \theta_m$ =0.32.

Table 27 shows the impact of the different calibrated values on our results. As can be seen in this table, our main quantitative results still hold under these alternative assumptions.

Table 25: Alternative values for θ_n - Emerging economy

Parameter	$\theta_n = 0$, $\theta_c = 0.35$, $\theta_m = 0.35$	$\theta_n = 0.25$, $\theta_c = 0.35$, $\theta_m = 0.35$	$\theta_n = 0.32$, $\theta_c = 0.32$, $\theta_m = 0.32$	Target moment	Data	$\theta_n = 0$, $\theta_c = 0.35$, $\theta_m = 0.35$	$\theta_n = 0.25$, $\theta_c = 0.35$, $\theta_m = 0.35$	$\theta_n = 0.32$, $\theta_c = 0.32$, $\theta_m = 0.32$
				Time-series targets				
σ_z	0.016	0.012	0.011	Std. dev. real GDP	4.23	4.28	4.21	4.20
ρ_z	0.82	0.93	0.96	Aut. real GDP	0.55	0.46	0.64	0.69
ϕ_K	8.44	7.67	7.56	Std. dev. I/real GDP	3.90	3.92	3.89	3.87
$\phi_K^X = \phi_N^X$	14.9	99.2	87.6	Std. dev. share Manf/GDP	0.20	0.37	0.27	0.29
η_{GDP}	-0.091	-0.084	-0.080	Corr(NX/GDP, GDP)	-0.20	-0.19	-0.21	-0.19
				Std. dev. C / Std. dev. GDP	1.34	1.50	1.28	1.25
				Std. dev. NX/GDP	3.44	3.38	3.45	3.46
				Cross-sectional targets				
A_m	0.89	0.89	0.89	Avg. share manf. in GDP	0.15	0.15	0.15	0.15
η	0.37	0.40	0.38	Avg. share com. in GDP	0.33	0.33	0.33	0.33
η_τ	0.47	0.47	0.47	Avg. manf. NX/GDP	-0.11	-0.11	-0.11	-0.11
b	0.88	0.98	0.99	Avg. aggregate NX/GDP	-0.07	-0.07	-0.07	-0.07
ψ_u	0.45	0.40	0.41	SS share of work/time	—	1/3	1/3	1/3

Table 26: Alternative values for θ_n - Developed economy

Parameter	$\theta_n = 0$ $\theta_c = 0.35$ $\theta_m = 0.35$	$\theta_n = 0.25$ $\theta_c = 0.35$ $\theta_m = 0.35$	$\theta_n = 0.32$ $\theta_c = 0.32$ $\theta_m = 0.32$	Target moment	Data	$\theta_n = 0$ $\theta_c = 0.35$ $\theta_m = 0.35$	$\theta_n = 0.25$ $\theta_c = 0.35$ $\theta_m = 0.35$	$\theta_n = 0.32$ $\theta_c = 0.32$ $\theta_m = 0.32$
				Time-series targets				
σ_z	0.0057	0.0074	0.0072	Std. dev. real GDP	2.25	2.42	2.26	2.25
ρ_z	0.995	0.91	0.93	Aut. real GDP	0.58	0.58	0.59	0.63
ϕ_K	1.04	2.60	2.25	Std. dev. I/real GDP	3.30	3.33	3.30	3.29
$\phi_K^X = \phi_N^X$	200.8	75.6	129.0	Std. dev. share Manf/GDP	0.19	0.20	0.19	0.18
η_{GDP}	-0.042	-0.06	-0.060	Corr(NX/GDP, GDP)	-0.28	-0.45	-0.26	-0.27
				Std. dev. C / Std. dev. GDP	0.96	1.44	0.99	0.95
				Std. dev. NX/GDP	1.39	1.15	1.38	1.40
				Cross-sectional targets				
A_m	1.04	1.04	1.04	Avg. share manf. in GDP	0.19	0.19	0.19	0.19
η	0.15	0.15	0.14	Avg. share com. in GDP	0.15	0.15	0.15	0.15
η_τ	0.57	0.57	0.57	Avg. manf. NX/GDP	-0.005	-0.005	-0.005	-0.005
b	0.08	0.096	0.10	Avg. aggregate NX/GDP	-0.005	-0.005	-0.005	-0.005
ψ_u	0.61	0.56	0.59	SS share of work/time	—	1/3	1/3	1/3

Table 27: Results with alternative values of θ_n

	$\theta_n = 0$ $\theta_c = 0.35$ $\theta_m = 0.35$	$\theta_n = 0.25$ $\theta_c = 0.35$ $\theta_m = 0.35$	$\theta_n = 0.32$ $\theta_c = 0.32$ $\theta_m = 0.32$
Emerging economy	4.28	4.21	4.20
Share of variance accounted for by commodity price shocks	29.9	26.1	21.2
With developed economy's structure of production and trade			
Real GDP volatility	3.97	3.63	3.53
Share of volatility gap explained	16.7	29.7	34.9
Developed economy	2.42	2.26	2.25
Share of variance accounted for by commodity price shocks	3.0	10.7	11.0
With emerging economy's structure of production and trade			
Real GDP volatility	3.14	3.03	3.07
Share of volatility gap explained	38.7	38.9	41.5

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