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Gabriela Contreras

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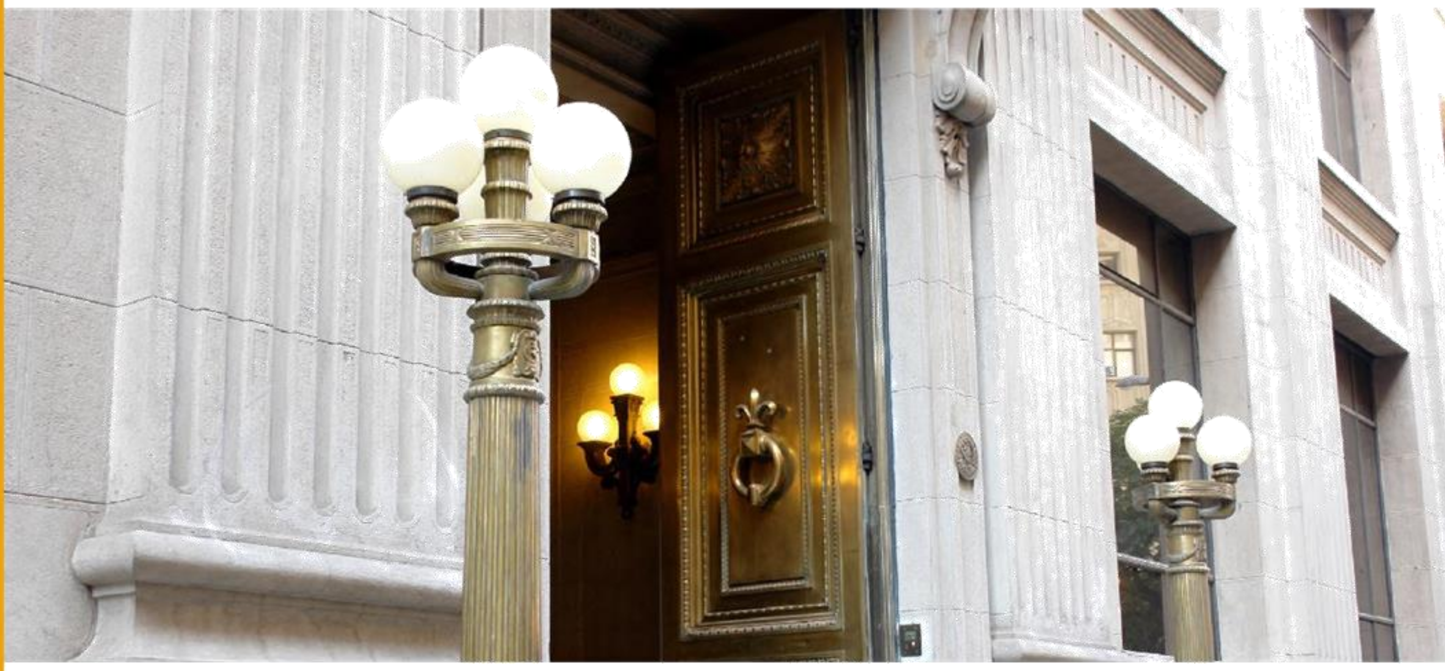

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Agustinas 1180, Santiago, Chile
Teléfono: (56-2) 3882475; Fax: (56-2) 38822311

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Hard Commodities Hit Harder: Global Financial Risk and Commodity Exporters*

Gabriela Contreras
Central Bank of Chile

Abstract
In this study, I investigate the response of commodity exporters to the global financial cycle and how it depends on the type of commodity exported. I first show that following an upsurge in global financial risk, the prices of hard commodities (such as energy, metals, and minerals) decline considerably more than soft commodities. Through a panel SVAR analysis, I compare the reactions of hard and soft commodity exporters to an unexpected increase in global financial risk. My findings reveal that hard commodity exporters experience a more significant decline in their commodity terms of trade, a higher increase in their country spread, and a more substantial reduction in output. I set up a small open economy model to explore the effects of global risk shocks on country spreads, depending on the type of commodities an economy exports. The results of this model suggest that global risk shocks are primarily transmitted through commodity prices, which means that hard commodity exporters are impacted more severely due to the composition of their exports.

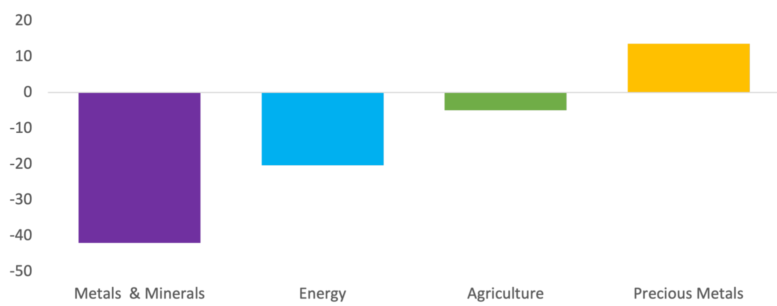
Resumen
En este estudio, investigo la respuesta de exportadores de commodities al ciclo financiero global y cómo depende del tipo de commodity exportado. Primero muestro que después de un aumento en el riesgo financiero global, los precios commodities duros (como energía, metales y minerales) disminuyen considerablemente más que los commodities blandos. A través de un análisis panel SVAR, comparo las reacciones de los exportadores de commodities duros y blandos ante un aumento inesperado en el riesgo financiero global. Mis hallazgos revelan que los exportadores de commodities duros experimentan una disminución más significativa en sus términos de intercambio, un mayor aumento en su riesgo país y una reducción más sustancial en el producto. Construyo un modelo de economía abierta para explorar los efectos de los shocks de riesgo global en el riesgo país, dependiendo del tipo de commodities que la economía exporta. Los resultados de este modelo sugieren que los shocks de riesgo global se transmiten principalmente a través de los precios de commodities, lo que significa que los exportadores de commodities duros se ven afectados más severamente debido a la composición de sus exportaciones.

* The views expressed are those of the author and do not necessarily represent the views of the Central Bank of Chile or its board members. Email: gcontreras@bcentral.cl

1 Introduction

The impact of global financial risk on business cycles in emerging economies is largely mediated by changes in country spreads (Neumeyer & Perri, 2005; Uribe & Yue, 2006; Akinci, 2013). Furthermore, there is evidence that fluctuations in commodity prices are a significant factor in driving business cycles in small emerging market economies and that these effects can be amplified through changes in sovereign spreads (Fernández et al., 2018; Drechsel & Tenreyro, 2018). However, we still lack a more thorough understanding of how the relationship between global financial risk and commodity prices depends on the production structure of each economy. This study aims to fill this gap by investigating how these factors interact and impact emerging economies based on their export basket composition.

Figure 1: Correlation between Different Commodity Prices and Global Financial Risk



Notes: Average correlation between global financial risk (proxied by the U.S. BAA corporate spread) and the annual increase in the real commodity price from 1990 to 2020. Additional information on the data used can be found in Section 2.2.

Commodity prices tend to rise and fall together (Fernández et al., 2018), however recent research suggests that capturing the transmission of global disturbances for emerging economies requires looking at multiple commodity prices (Fernández et al., 2017). In line with these findings, this paper documents that global financial risk affects different commodities in distinct ways, with hard commodities being hit harder.[1] While the price of energy, metals, and minerals (henceforth, hard commodities) is negatively correlated with global financial uncertainty, the rest of commodities

[1] The distinction between hard and soft commodities lies in their production process, with hard commodities being extracted or mined and soft commodities being agricultural products or livestock. Precious metals are typically considered hard commodities, but this paper excludes them from this group and adds them to soft commodities due to their status as a safe haven investment.

(henceforth, soft commodities) exhibit a negligible or even positive correlation (Figure 1).[2] [3] This evidence underscores the importance of understanding how the global financial cycle drives the business cycle of different commodity exporters.

Motivated by this evidence, this paper investigates the impact of the global financial cycle on commodity-exporting countries and how this response varies depending on the type of commodity being exported. First, I show empirical evidence that hard commodity exporters are hit harder in response to an unexpected increase in global financial risk. Then, using a small open economy model, I find that global risk shocks are primarily mediated by fluctuations in commodity prices instead of through borrowing costs. This suggests that hard commodity exporters are more vulnerable to global risk shocks due to the composition of their exports, which are typically more exposed to fluctuations in global risk.

The empirical estimation in the paper extends a previous study by Akinci (2013) by including commodity price shocks. In particular, the model includes an exogenous and an endogenous block. The first one is conformed by the global risk-free real interest rate, a proxy for global financial risk, and a measure of commodity terms of trade. The second is by a country spread and a number of domestic macroeconomic variables. I estimate the panel SVAR for two groups of emerging economies: hard and soft commodity exporters. To create these groups, I take a sample of 21 emerging countries and divide them based on the share of hard commodity exports. The estimation covers the period 1994-2019 at a quarterly frequency.

My empirical results show that after an increase in global financial risk, hard commodity exporters experience a more significant decline in their commodity terms of trade (30% larger) and a twice as large increase in their sovereign spread compared to soft commodity exporters. A year after the shock, consumption falls more than twice as much, and output drops 75% more in hard commodities exporters than in soft commodities exporters. Although my empirical results suggest that hard commodity exporters are hit harder, they do not allow me to disentangle the channels through which the global financial cycle is transmitted in each group of countries.

To answer this question, I set up a small open economy model that follows the one in Schmitt-Grohé & Uribe (2018). The model features three sectors (importables, exportables, and nontradables) with production, domestic absorption, capital, and labor in all three sectors. I assume gestation lags in the production of capital in the three sectors, external habit formation, and working-

[2]This finding is consistent with previous literature (Bilgin et al., 2018; Huang et al., 2021) and can be explained in part by the safe haven status of precious metals, particularly gold.

Prior research has shown that metal and oil markets are cointegrated with the global commodity index, whereas agriculture and gold markets do not tend to have long-run price equilibrium relationships with other commodity markets due to a cross-market liquidity interference effect (Ding & Zhang, 2020).

[3]During the global financial crisis, a period of heightened uncertainty, energy, metals, and minerals fell by around 50% in real terms between 2008Q3 and 2009Q1, whereas agriculture products and precious metals experienced a reduction of only 15% and 3%, respectively.

capital constraint that stipulates that firms in each sector must maintain a certain proportion of non-interest-bearing liquid assets relative to their wage bill. Lastly, I assume that the laws of motion of the exogenous variables and the country spread are the ones estimated in the SVAR, extending the limited information approach in Uribe & Yue (2006) by including the processes for global risk and commodity prices.

I estimate the model separately for each group of economies, matching the variance of domestic variables due to a global risk shock. The calibrated parameters capture the production structure of each set of economies. By doing so, the model is able to match both the targeted and untargeted moments, including the relative impact of external shocks on both groups. Notably, the model reproduces the finding that hard commodity exporters are more severely affected by a rise in global risk, even when both groups are calibrated to use the same parameters.

Then, I examine whether a global risk is transmitted through country spreads or commodity prices. When the country spread is assumed not to respond directly to variations in global financial risk, the variance of output, consumption, investment, and the trade-balance-to-output ratio explained by global financial risk shocks remain practically unchanged. However, when commodity prices are assumed not to respond directly to variations in global financial risk, the variance of the same variables explained by global financial risk shocks drops to nearly zero for both types of economies. These results suggest that commodity prices amplify the effect of global risk shocks, leading to a more significant impact on hard commodity exporters due to the composition of their exports, which are more exposed to global risk.

This paper contributes to the existing literature that investigates the impact of a global financial cycle on open economies, in which a deterioration of this cycle leads to an increase in market volatility and a rise in aggregate risk aversion (Miranda-Agrippino & Rey, 2020). This literature emphasizes the economic relevance of global risk on the business cycle of emerging economies (Matsumoto, 2011; Carrière-Swallow & Céspedes, 2013), as it is propagated through its impact on sovereign spreads (Akinci, 2013; Epstein et al., 2019). In contrast to the existing literature, my paper explores the interaction between these shocks and commodity prices, which have been shown to be a critical factor for many emerging economies. By considering this interaction, the paper offers new insights into how the global financial cycle and commodity prices jointly impact the business cycle of emerging economies.

My paper is also related to the strand of research that studies the impact of commodity price shocks as drivers of macroeconomic volatility in small open economies. Early studies by Mendoza (1995) and Kose (2002) suggest that terms of trade shocks play a crucial role in driving business cycle fluctuations, which was later empirically confirmed using commodity terms of trade as a measure and recognizing that country spreads amplify these shocks (Ben-Zeev et al., 2017; Fernández et al., 2018; Drechsel & Tenreyro, 2018). Also, Kohn et al. (2021) emphasize the importance of patterns of production and international trade in explaining the impact of commodity prices on the business cycles of emerging economies. Nonetheless, the literature has not yet examined the transmission of global risk shocks through commodity prices. My paper addresses this gap.

Recent developments point out that incorporating multiple commodity prices can better capture the significance of global disturbances for emerging economies (Fernández et al., 2017; Di Pace et al., 2020; Fernández et al., 2020). In line with this literature, my paper acknowledges the criticality of distinguishing between various commodity prices, particularly in their differential transmission of the global financial cycle.

The outline of this paper is as follows. Section 2 details the empirical analysis. Section 3 presents the theoretical model. Section 4 shows the model's results, particularly a counterfactual exercise where I study the transmission channels of the global financial risk shock. Section 5 concludes.

2 The Empirical Model

The empirical analysis aims to identify the impact of shocks on the world interest rate, global financial risk, commodity terms of trade, and country spreads on aggregate activity in two distinct groups of emerging economies. The first group, known as hard commodity exporters, has export baskets focused on energy, metals, and minerals. The second group, called soft commodity exporters, exports more agricultural products and precious metals. By comparing the response of the two groups of economies, the study reveals that the channel of transmission of global financial risk shocks differs depending on the type of commodity produced.

The empirical model modifies the specification in Akinci (2013) to include the commodity terms of trade. It takes the form of the following first-order panel VAR system

$$Ay_{i,t} = By_{i,t-1} + \epsilon_{i,t} \tag{1}$$

$$y_{i,t} = \left[\widehat{gdp}_{i,t}, \widehat{c}_{i,t}, \widehat{inv}_{i,t}, tby_{i,t}, \widehat{R}_t^{US}, \widehat{GR}_t, \widehat{ctot}_{i,t}, \widehat{R}_{i,t}\right]$$

$$\epsilon_{i,t} = \left[\epsilon_{i,t}^{gdp}, \epsilon_{i,t}^{c}, \epsilon_{i,t}^{inv}, \epsilon_{i,t}^{tby}, \epsilon_{t}^{RUS}, \epsilon_{t}^{GR}, \epsilon_{i,t}^{ctot}, \epsilon_{i,t}^{R}\right]$$

where i represents countries, t indicates time period in quarters, gdp denotes real gross domestic product, c denotes real consumption, inv denotes real gross domestic investment, tby denotes the trade-balance-to-output ratio, R^{US} denotes the gross real U.S. interest rate, GR is an indicator for global financial risk, $ctot$ is the country-specific commodity terms of trade, and R denotes the country-specific interest rate. In addition, a hat on gdp, c, inv, and $ctot$ indicates log deviations from a log-quadratic trend, while a hat on R^{US}, GR, and R denotes a logarithmic transformation. The trade-balance-to-GDP ratio, tby, is expressed in percentage points.

The term commodity terms of trade refers to a weighted average of four commodity prices, namely energy (p^o), metals and minerals (p^m), agricultural products (p^a), and precious metals (p^g). These prices are weighted by a constant share to determine the overall index. An alternative approach to the SVAR system described in equation (1) is to estimate the model by including the individual commodity prices separately.

$$y_{i,t} = \left[\widehat{gdp}_{i,t}, \widehat{c}_{i,t}, \widehat{inv}_{i,t}, tby_{i,t}, \widehat{R}_t^{US}, \widehat{GR}_t, \widehat{p}_t^o, \widehat{p}_t^m, \widehat{p}_t^a, \widehat{p}_t^g, \widehat{R}_{i,t}\right] \tag{2}$$

$$\epsilon_{i,t} = \left[\epsilon_{i,t}^{gdp}, \epsilon_{i,t}^{c}, \epsilon_{i,t}^{inv}, \epsilon_{i,t}^{tby}, \epsilon_t^{RUS}, \epsilon_t^{GR}, \epsilon_t^{o}, \epsilon_t^{m}, \epsilon_t^{a}, \epsilon_t^{g}, \epsilon_{i,t}^{R}\right]$$

2.1 Identification and Estimation Method

I use the least square estimator with country-specific dummies for each group of countries. The empirical model is identified by imposing restrictions on the matrix A such that it is lower triangular with unit diagonal elements. This means that each variable in the system can only be contemporaneously affected by other variables that appear earlier in the ordering. In this model, global financial variables (R^{US}, GR, $ctot$) are considered exogenous to the small emerging countries, and, thus, the matrix elements $A_{i,j}$ and $B_{i,j}$ are set to zero for $i = (5, 6, 7)$ and $j = (1, 2, 3, 4, 8)$ to reflect this.

The empirical model assumes, consistent with Akinci (2013), that variations in the real short-term interest rate in the US immediately affect both global financial risk and commodity prices. However, innovations in global risk or commodity prices do not have a contemporaneous impact on the gross real U.S. interest rate.

The identification strategy also assumes that financial markets can react quickly to news about the state of the business cycle in emerging economies, and, therefore, innovations in the world interest rate, global financial risk, commodity terms of trade, and domestic variables have a contemporaneous impact on the country spread, which is the last variable in the system. In contrast, innovations in global financial conditions and country spreads affect domestic real variables with a one-period lag.

2.2 Data

I estimate the SVAR system (1) by pooling quarterly data from 1993:Q4 to 2019:Q4 from two separate panels from a set of 21 emerging countries, listed in Table A.1. Data availability, particularly of a measure of country spread, guides the choice of countries and sample period. The two groups are separated according to the share of energy, metals, and minerals exports. The group of 10 that export relatively more of this type of product are denoted as hard commodity exporters and the rest as soft commodity exporters. As shown in Table A.2, the volatility of domestic variables is greater in hard commodity exporters than in soft commodity exporters, but this relationship is reversed when it comes to country spreads.

Real output, consumption, investment, exports, and imports are taken from IFS or the national statistics department of each country. The variable R^{US} is computed as the 3-month gross U.S. Treasury bill rate deflated using a measure of expected U.S. inflation[4]. GR is proxied by the U.S. BAA corporate spread, calculated as the difference between Moody's U.S. BAA corporate borrowing rate and the 20-year U.S. Treasury bond rate. I calculate the commodity terms of trade index *ctot* for each country following Ben-Zeev et al. (2017), as the weighted average of four World Bank's Pink Sheet indexes (energy, metals and minerals, agricultural products, and precious metals) deflated by the U.S. import price of manufactured goods from industrialized countries. The weights correspond to the 1995-2015 average of exports of the four commodity aggregations, obtained from the BACI-CEPII database.[5] The variable R_t is measured as the sum of J.P. Morgan's EMBI Global sovereign spread, taken from Bloomberg, and the U.S. real interest rate.

2.3 Estimation Results

2.3.1 Impulse Responses

Figures 2 and 3 show the impulse responses that result from a one standard deviation increase in the measure of global financial risk. The impact on the real prices of hard and soft commodities is analyzed, and the results are consistent with the simple correlations shown in Figure 1.

Figure 2 depicts the impact of global financial risk on two alternative estimates of commodity

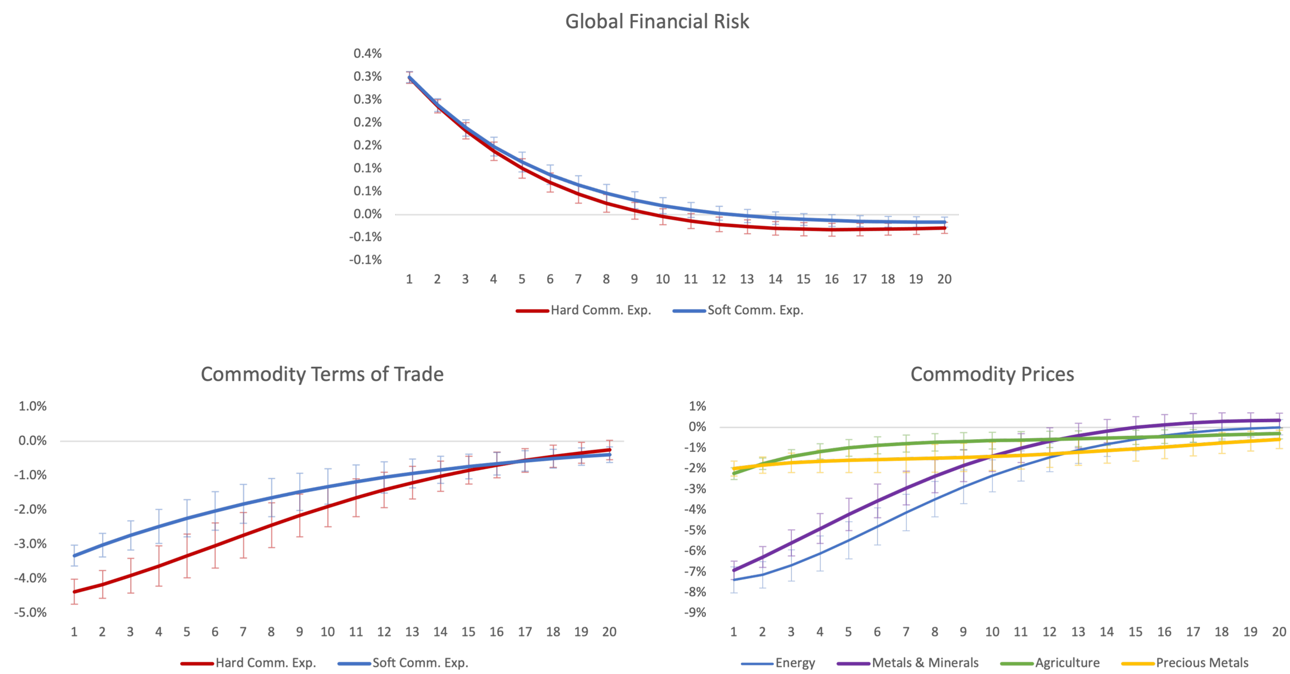
[4]This measure was introduced in Schmitt-Grohé & Uribe (2012). The quarterly gross real U.S. interest rate is calculated as $1 + R_t^{US} = (1 + i_t)E_t \frac{1}{1+\pi_{t+1}}$, where i_t denotes the 3-month U.S. Treasury bill rate and π_t is the U.S. CPI inflation. The term $E_t \frac{1}{1+\pi_{t+1}}$ is calculated as the fitted component of a regression of $1 + \pi_{t+1}$ onto a constant and two lags.

[5]CEPII builds this database from data directly reported by each country to the United Nations Statistical Division (Comtrade). They developed a procedure that reconciles the declarations of the exporter and the importer, which may be different from the original data.

prices. The bottom left figure illustrates the response of the commodity terms of trade (SVAR system (1)), while the bottom right figure shows the response of the four separate commodity prices (SVAR system (2)). The figures show that the real price of energy, metals, and minerals experiences a stronger negative response to an increase in global financial risk than the prices of soft commodities. The contraction in the real prices of hard commodities is about three times more significant than the contraction experienced by agricultural products and precious metals.

Furthermore, the analysis reveals that hard commodity exporters suffer a more severe decline in their commodity terms of trade compared to soft commodity exporters, experiencing an additional 1.1 percentage point reduction, which amounts to a 30% greater decline. These results indicate that the effect of global financial risk on commodity prices and terms of trade is contingent on the type of commodity being exported.

Figure 2: Estimated Impulse Responses to a Global Risk Shock

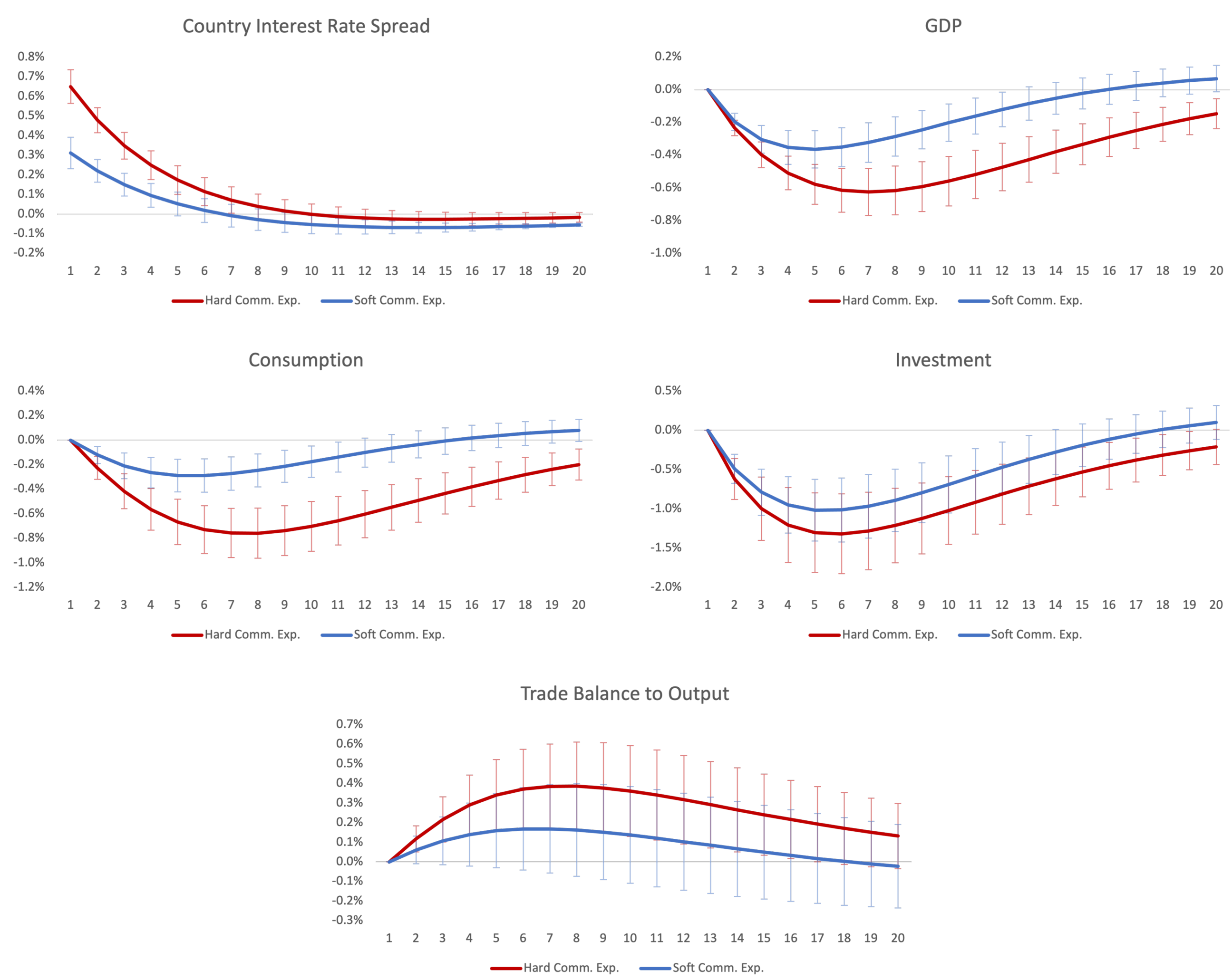


Notes: Impact of a one-standard-deviation shock on global financial risk (proxied by the U.S. BAA corporate spread). The bold lines represent the impulse responses of global financial risk, and two alternative estimates of commodity prices, with the 90% confidence intervals displayed in brackets. The bottom left figure illustrates the response of the commodity terms of trade, while the bottom right figure shows the response of the four separate commodity prices. The hard commodity exporters are depicted in red, and soft commodity exporters are in blue, except for the response of the four indexes, which are distinguished by commodity rather than country. Additional information on the identification strategy and data used can be found in Sections 2.1 and 2.2.

Figure 3 shows the impulse responses of domestic variables to a one standard deviation increase in a measure of global financial risk for two sets of countries: hard commodity exporters and soft commodity exporters. The results indicate that hard commodity exporters are hit harder by the shock. Specifically, the sovereign spread of hard commodity exporters increases twice as much as that of soft commodity exporters.

Moreover, the results suggest that the shock has a more significant impact on consumption and output in hard commodity exporters than in soft commodity exporters. A year after the shock, consumption falls more than twice as much (0.4 pp), and output drops 75% more (0.3 pp) in hard commodities exporters than in soft commodities exporters. These findings remain robust when using other global risk proxies (see Figure B.1) and when including a measure of global activity (see Figure B.2).

Figure 3: Estimated Impulse Responses to a Global Risk Shock



Notes: Bold lines depict the impulse responses to a one standard deviation shock to global financial risk (proxied by the U.S. BAA corporate spread), with the 90% confidence intervals shown in brackets. Hard commodity exporters are shown in red, while soft commodity exporters are in blue. Additional information on the identification strategy and data used can be found in Sections 2.1 and 2.2.

2.3.2 Variance Decomposition

Table 1 shows the variance decomposition of output at a horizon of five years, associated with business cycle fluctuations. Innovations in the global financial risk explain 25% of aggregate activity movements in hard commodity exporters, almost three times the share in countries with exports more concentrated in soft commodity exporters. In contrast, unanticipated movements in the commodity terms of trade account for a smaller share of output movements in hard commodity exporters.

Table 1: Forecast Error Variance Decomposition of Output

	Hard Comm. Exp.		Soft Comm. Exp.	
	CTOT	4 Prices	CTOT	4 Prices
U.S. Interest Rates	1	0	0	1
Global Risk	**25**	**19**	**8**	**6**
Commodity Terms of Trade	3	15	26	26
GDP	46	44	60	63
Consumption	3	3	2	2
Investment	18	18	1	1
Trade Balance to Output	2	0	1	0
Country Spread	3	1	3	2

Notes: Percentage of the variance of the 5-year ahead forecasting error of output. The first column shows the result using a panel of eleven soft commodity exporters, while the second column presents the results of a panel of 10 hard commodity exporters. Additional information on the identification strategy and data used can be found in Sections 2.1 and 2.2.

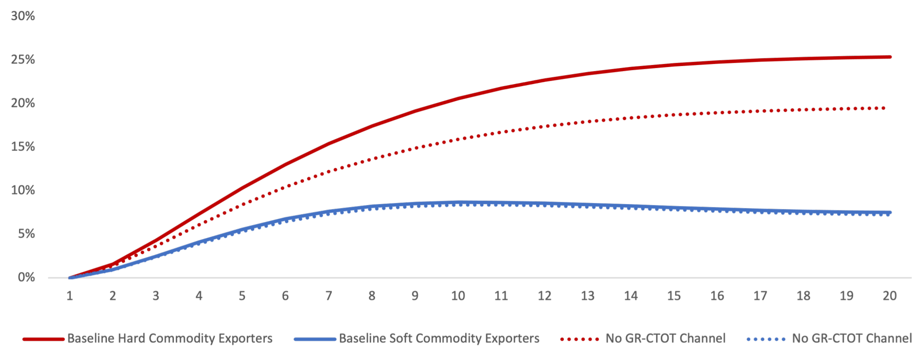
2.3.3 The Role of Commodity Terms of Trade in the Transmission of Global Risk

To disentangle the role of commodity prices in the transmission of global risk shocks, I compare the baseline estimation to a counterfactual scenario where commodity terms of trade do not directly depend on global financial risk. For this purpose, the commodity terms of trade equation in the SVAR system (1) is modified by setting to zero coefficients on GR_{t-i} for $t = 0, 1$ ($A_{7,6} = B_{7,6} = 0$). After estimating the modified SVAR system, I compute the impulse response functions and decompose their corresponding variances.

Figure 4 compares the variance decomposition of output at different horizons for both groups of countries, under the baseline and a counterfactual scenario. When I shut off the response of the commodity terms of trade to global financial risk, the variance of output explained by global risk is mostly unaffected for soft commodity exporters. In contrast, when commodity terms of trade do not directly depend on the global financial risk, the contribution of global financial risk in output variance falls for hard commodity exporters.

Although this empirical exercise does not allow me to disentangle properly the channels through which the global financial cycle is transmitted in each group of countries, I interpret the previous results as evidence that commodity prices have a role in propagating the response to global financial risk shock on the domestic economy of hard commodity exporters.

Figure 4: Forecast Error Variance Decomposition of Output explained by Global Risk



Notes: Solid lines depict the k-quarter ahead forecasting error variance percentage explained by a global financial risk shock (proxied by the U.S. BAA corporate spread). Dashed lines show the percentage of the variance of the k-quarter ahead forecasting error explained by global financial risk shocks when the commodity terms of trade are assumed not to respond directly to variations in the global financial risk. Hard commodity exporters are shown in red, while soft commodity exporters are in blue. Additional information on the identification strategy and data used can be found in Sections 2.1 and 2.2.

3 The Model

The empirical analysis of the section does not allow us to ascertain if the differences obtained between the two groups of countries are driven by differences in their production structure or by the nature of the commodity they export. This is especially important given that, on average, commodities account for a higher share in the export basket of countries referred to as hard commodity exporters (69% versus 28% in soft commodity exporters, as shown in column 3 of Table A.1). To separate the role played by the type of commodity a country exports from the part played by its production structure, I set up a small open economy model that delivers similar results as the empirical evidence when I feed in the panel SVAR estimation of the country spread process. I use this model to investigate the transmission channels of global financial shocks and the interaction with the type of commodity produced by the emerging economy and also to perform counterfactual exercises.

My model is a standard real business cycle model for a small open economy, which incorporates elements from both Schmitt-Grohé & Uribe (2018) and Uribe & Yue (2006). The model includes three sectors: an importable sector (m), an exportable sector (x), and a nontradable sector (n), as seen in the MXN model from Schmitt-Grohé & Uribe (2018). The presence of importables and exportables allows the terms of trade to have an impact, while nontradables act as a buffer, limiting the effects of changes in the terms of trade. Each sector has its own production, domestic absorption, and sector-specific factors of production, so moving capital and labor across sectors may involve costs. Tradables (t sector) are produced using importables and exportables, while nontradables and tradables are utilized as inputs for final consumption and investment goods.

In addition to these features, I have also adapted five elements from the one-sector model in Uribe & Yue (2006). First, like in the empirical model, households make consumption and labor supply decisions before the realization of external shocks and the country spread in each period. Second, external habit formation is included in the preferences to prevent excessive contraction in consumption in response to external shocks. Third, firms in all three sectors face a working-capital-in-advance constraint, which allows for a direct supply-side effect of changes in the cost of borrowing in international financial markets. Fourth, to avoid excessive volatility in investment, the process of capital accumulation in each sector involves adjustment costs in the form of gestation lags and convex costs. Lastly, I assume that the laws of motion of the exogenous variables and the country spread are the ones estimated in the SVAR, extending the limited information approach by including the processes for global risk and commodity prices.

3.1 Households

The model economy is populated by a large number of infinitely lived households with preferences described by the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[c_t - \theta \tilde{c}_{t-1} - \frac{(h_t^m)^\omega}{\omega} - \frac{(h_t^x)^\omega}{\omega} - \frac{(h_t^n)^\omega}{\omega}\right]^{1-\sigma} - 1}{1-\sigma} \tag{3}$$

where c_t denotes consumption in period t, $\tilde{c}_{t-1}$ denotes the cross-sectional average level of consumption in period $t-1$, h_t^m, h_t^x, and h_t^n denote hours worked in the importable, exportable, and nontradable sectors, respectively. The sector-specific hours worked enter as separate arguments in the utility function, allowing for imperfect substitutability of labor across different activities. Households take as given the process for $\tilde{c}_{t-1}$. The parameter $\beta \in (0,1)$ is the subjective discount factor, $\theta \geqslant 0$ measures the degree of external habit formation, $\sigma > 0$ represents the inverse of the intertemporal elasticity of substitution, and $\frac{1}{\omega-1}$ is the labor supply elasticity with $\omega > 0$.

Households have access to two types of capital: sector-specific physical capital, entirely owned by domestic residents, and internationally traded bonds. They have three sources of income: wages, capital rents, and interest income from their financial assets, and are subject to the sequential budget constraint

$$c_t + \sum_{j=\{m,x,n\}} i_t^j + d_t = \frac{d_{t+1} - \Psi(d_{t+1})}{1+r_t} + \sum_{j=\{m,x,n\}} [w_t^j h_t^j + u_t^j k_t^j] \tag{4}$$

where i_t^j, k_t^j, w_t^j, and u_t^j denote, respectively, gross investment, the capital stock, the real wage, and the rental rate of capital in sector j for $j = \{m, x, n\}$, with the superscripts m, x, and n denoting the sector producing respectively, importable, exportable, and nontraded goods. The variable d_t denotes the stock of debt due in period t, and r_t is the interest rate on debt held from period t to $t+1$. Consumption, investment, wages, rental rates, debt, and foreign asset capital adjustment costs are measured in units of final goods.

The function $\Psi(\cdot)$ captures the foreign asset adjustment costs, introduced to eliminate the familiar unit root built in the dynamics of standard formulations of the small open economy model (Schmitt-Grohé & Uribe, 2003). This function takes the form

$$\Psi(d - \bar{d}) = \frac{\psi}{2}(d - \bar{d})^2$$

where $\phi_j > 0$ are parameters for $j = \{m, x, n\}$.

For the firm's problem will be useful to analyze the following decentralization of debt adjustment cost: Suppose that financial transactions between domestic and foreign residents require the intermediation by a continuum of competitive domestic banks with a measure of one. These banks capture funds, d_{t+1}, from foreign investors at the country rate r_t and lend them to domestic agents at the rate r_t^d incurring in operational costs $\Psi(d_{t+1})$, obtaining profits of $(1+r_t^d)[d_{t+1} - \Psi(d_{t+1})] - (1+r_t)d_{t+1}$, which are distributed to domestic households in a lump sum manner. Taking r_t^d and r_t as given, banks choose the volume of intermediation, d_{t+1}, that satisfies the first-order condition

$$1 + r_t^d = \frac{1+r_t}{1 - \Psi'(d_{t+1})} \tag{5}$$

revealing that the interest rate charged to domestic residents and the shadow interest rate faced by domestic agents in the centralized problem are the same.

The process of capital accumulation in each sector exhibits gestation lags and convex costs for installing new capital goods. It takes four consecutive periods of investing 1/4 units of goods to produce one unit of capital good. Let $s_{i,t}^j$ denote the number of investment projects in sector j started in period $t - i$ for $j = \{m, x, n\}$ and $i = \{0, 1, 2, 3\}$. Sector j gross investment in period t, denoted i_t^j, is given by

$$i_t^j = \frac{1}{4}\sum_{i=0}^{3} s_{i,t}^j \tag{6}$$

where the evolution of $s_{i,t}^j$ is given by

$$s_{i+1,t+1}^j = s_{i,t}^j \tag{7}$$

$j = \{m, x, n\}$ and $i = \{0, 1, 2\}$. The law of motion for physical capital in sector j is given by

$$k_{t+1}^j = (1-\delta)k_t^j + k_t^j \Phi\left(\frac{s_{3,t}^j}{k_t^j}\right) \tag{8}$$

where $\delta \in (0,1)$ is the rate of depreciation of physical capital (constant across sectors), and $\Phi(\cdot)$ represents adjustment costs, introduced to prevent excessive investment volatility in response to changes in the interest rate faced by the country in international markets. The capital adjustment costs function takes the form

$$\Phi\left(\frac{s_{3,t}^j}{k_t^j}\right) = \left[\frac{s_{3,t}^j}{k_t^j} - \frac{\phi_j}{2}\left(\frac{s_{3,t}^j}{k_t^j} - \delta\right)^2\right]$$

where $\phi_j > 0$ are parameters for $j = \{m, x, n\}$. This function satisfies $\Phi(\delta) = \delta$ and $\Phi'(\delta) = 1$ to ensure that there are no adjustment costs in the steady state.

In period t, the household chooses c_{t+1}, h_{t+1}^j, $s_{i,t+1}^j$, and d_{t+1} for $j = \{m, x, n\}$ and $i = \{0, 1, 2, 3\}$ to maximize the utility function (3) subject to the budget constraint (4). The laws of motion of investment projects and capital (equations (6)-(8)), and a borrowing constraint of the form

$$\lim_{k\to\infty} E_t \frac{d_{t+k+1}}{\Pi_{s=0}^{k}(1+r_{t+s})} \leqslant 0 \tag{9}$$

that prevents Ponzi schemes. Households take as given the processes $\left\{\tilde{c}_{t-1}, r_t, w_t^j, u_t^j\right\}_{t=0}^{\infty}$ as well as c_0, h_0^j, k_0^j, r_{-1}, d_{-1}, and $s_{i,0}^j$ for $j = \{m, x, n\}$ and $i = \{0, 1, 2, 3\}$.

3.2 Production of Final Goods

The final good is produced using a composite of tradable and nontradable goods as intermediate inputs. Their profits are given by

$$B(a_t^\tau, a_t^n) - p_t^\tau a_t^\tau - p_t^n a_t^n \tag{10}$$

where $B(a_t^\tau, a_t^n)$ denotes the quantity of final goods produced, whose price is taken to be numeraire; a_t^j and p_t^j represent, respectively, the domestic absorption and the relative price in terms of units of the final good of the tradable composite and nontradables for $j = \tau, n$. The aggregator function $B(\cdot, \cdot)$ takes the CES form

$$B(a_t^\tau, a_t^n) = [\chi_\tau (a_t^\tau)^{1-\frac{1}{\mu_{\tau n}}} + (1-\chi_\tau)(a_t^n)^{1-\frac{1}{\mu_{\tau n}}}]^{\frac{1}{1-\frac{1}{\mu_{\tau n}}}}$$

where $\chi_\tau \in (0,1)$ represents the share parameter, and $\mu_{\tau n} > 0$ represents the intratemporal elasticity of substitution between tradable and nontradable absorption.

3.3 Production of the Tradable Composite Good

The tradable composite good is produced using importable and exportable goods as intermediate inputs, with the technology

$$a_t^\tau = A(a_t^m, a_t^x) \tag{11}$$

where a_t^m and a_t^x denote the domestic absorptions of importables and exportables, respectively, and the aggregator $A(\cdot, \cdot)$ represents the production of the tradable composite good, that takes the CES form

$$A(a_t^m, a_t^x) = [\chi_m (a_t^m)^{1-\frac{1}{\mu_{mx}}} + (1-\chi_m)(a_t^x)^{1-\frac{1}{\mu_{mx}}}]^{\frac{1}{1-\frac{1}{\mu_{mx}}}}$$

where $\chi_m \in (0,1)$ represents the share parameter, and $\mu_{mx} > 0$ represents the intratemporal elasticity of substitution between exportable and importable absorption.

Profits of producers of tradable goods are given by

$$p_t^\tau A(a_t^m, a_t^x) - p_t^m a_t^m - p_t^x a_t^x \tag{12}$$

3.4 Production of Importable, Exportable, and Nontradable Goods

The production of importable, exportable, and nontradable goods takes the form of Cobb-Douglas technologies, using capital and labor as inputs

$$y_t^j = F^j(k_t^j, h_t^j) = A^j \left(k^j\right)^{\alpha j} \left(h^j\right)^{1-\alpha j} \tag{13}$$

where $A^j > 0$, and $\alpha_j \in (0,1)$ is the capital elasticity to output y_t^j in sector $j = \{m, x, n\}$.

Each production process is subject to the following working-capital constraint that requires firms to hold non-interest-bearing assets to finance a fraction $\eta \geqslant 0$ of the wage bill each period, assumed constant across sectors

$$M_t^j \geqslant \eta w_t^j h_t^j$$

where M_t^j denotes the amount of working capital the representative firm holds, $j = \{m, x, n\}$ in period t.

Firms in sector j choose k_t^j, h_t^j, m_t^j and d_{t+1}^j to maximize the present discounted value of distributed dividends

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ p_t^j y_t^j - u_t^j k_t^j - w_t^j h_t^j - (M_t^j - M_{t-1}^j) + \frac{d_{t+1}^j}{1 + r_t^d} - d_t^j \right\} \tag{14}$$

where r_t^d denotes the interest rate at which the firms can borrow in period t and is given by (5).

3.5 Equilibrium

As all households consume identical quantities in equilibrium, individual consumption equals average consumption across households

$$c_t = \tilde{c}_t \tag{15}$$

In equilibrium, the demand for final goods must equal its supply

$$c_t + i_t^m + i_t^x + i_t^n = B(a_t^\tau, a_t^n) \tag{16}$$

The demand for nontradables must equal the production of nontradables

$$a_t^n = y_t^n \tag{17}$$

Imports, denoted m_t and measured in terms of final goods, are given by the difference between the domestic absorption of importables and output in the importable sector

$$m_t = p_t^m (a_t^m - y_t^m) \tag{18}$$

Similarly, exports, denoted x_t and also measured in terms of final goods, are defined as the difference between output in the exportable sector and the domestic absorption of exportables

$$x_t = p_t^x (y_t^x - a_t^x) \tag{19}$$

Combining (4), (16), (17), (18), (19), and taking into account that firms in (10), (12), and (14) make zero profits at all times, yields the following expression linking the growth rate of external debt to interest payments and the trade balance

$$\frac{d_{t+1} - \Psi(d_{t+1})}{1 + r_t} = d_t + m_t - x_t \tag{20}$$

The commodity terms of trade are defined as the relative price of exportable goods in terms of importable goods

$$ctot_t = \frac{p_t^x}{p_t^m} \tag{21}$$

I utilize the limited information method employed by Uribe & Yue (2006) to close the model. This method has the advantage of allowing me to evaluate the plausibility of identified external shocks without introducing any shocks into the model beyond those relevant to the effects of interest. Thus, all that is needed to close the model is to add a law of motion for the world interest rate, r_t^*, the commodity terms of trade, $ctot_t$, the global risk shock, gr_t, and the country interest rate, r_t. I use for each country the estimate of the bottom four equations of the SVAR system (1).

4 Results of the Model

4.1 Calibration

The model has 23 structural parameters: β, σ, θ, ω, δ, ψ, η, A^m, A^x, A^n, α_m, α_x, α_n, ϕ_m, ϕ_x, ϕ_n, χ_m, χ_τ, μ_{mx}, $\mu_{\tau n}$, $\bar{d}$, $\bar{r^*}$, $\bar{r}$. Table 2 lists 13 preassigned parameters and their source.

Table 2: Preassigned Parameters

Parameter	Description	Value	Source
σ	IES	2.00	Mendoza (1991)
ω	Frish Elasticity	1.46	Mendoza (1991)
δ	Depreciation Rate	0.10	Mendoza (1991)
α_m	Capital Share of M Production	0.50	CBCh (2017)
α_x	Capital Share of X Production	0.50	CBCh (2017)
α_n	Capital Share of N Production	0.25	Schmitt-Grohé & Uribe (2018)
μ_{mx}	IES between X-M absorption	1.00	Schmitt-Grohé & Uribe (2018)
$\mu_{\tau n}$	IES between T-NT absorption	0.50	Schmitt-Grohé & Uribe (2018)
$\bar{r^*}$	World Interest Rate	0.04	Uribe & Yue (2006)
$\bar{r} - \bar{r^*}$	Country Spread	0.07	Uribe & Yue (2006)
β	Discount Rate	0.97	Schmitt-Grohé & Uribe (2018)
A^m	Importables Productivity	1.00	Normalization
A^n	Non-tradables Productivity	1.00	Normalization

Note: For the model to be consistent with the empirical exercise, δ,r^*, and $\bar{r}$ are divided by four to express them in quarterly terms. Bars denote steady-state values.

Four parameters, A^x, χ_m, χ_τ, and $\bar{d}$, are determined by the following moment restrictions taken from the data, keeping it constant for both groups of countries.

$$s_{tb} = \frac{x - m}{p^m y^m + p^x y^x + p^n y^n} = 0.01$$

$$s_x = \frac{x}{p^m y^m + p^x y^x + p^n y^n} = 0.19$$

$$s_{ym} = \frac{p^m y^m}{p^m y^m + p^x y^x + p^n y^n} = 0.25$$

$$s_{yn} = \frac{p^n y^n}{p^m y^m + p^x y^x + p^n y^n} = 0.50$$

where s_{tb} is the average trade-balance-to-GDP ratio, s_x is the average exports share in GDP, s_{ym} is the average share of the importable sector in GDP, and s_{yn} is the average share of the nontradable sector in GDP.

The remaining six parameters, θ, ψ, η, ϕ_m, ϕ_x, ϕ_n do not appear in the steady-state equilibrium conditions. To simplify the calibration process, I assume that ϕ_m, ϕ_x, and ϕ_n are equal, leaving me with four parameters to estimate. Following Uribe & Yue (2006), I manually calibrate these parameters to match the moments from the data and implied by the theoretical model for the five variables in the SVAR system (1) that are endogenous. Specifically, I minimize the difference between the estimated and theoretical variance of output, consumption, investment, trade-balance-to-GDP, and the country spread in response to a global risk shock over a 5-year period following the shock. Table 3 shows the calibrated parameters for the two country groups.

Table 3: Calibrated Parameters

Parameter	Description	Hard Commodity Exporter	Soft Commodity Exporter
θ	Habit parameter	0.06	0.06
η	Working capital constraint	0.63	0.001
ϕ	Capital adjustment cost	33.0	9.6
ψ	Foreign asset adjustment cost	0.026	0.008

4.2 Theoretical and Estimated Impulse Responses

The model calibrated using the parameters from the previous section performs well in fitting the data, as shown in Table 4. Specifically, the model accurately reproduces the variance of output in response to a global risk shock for hard commodity exporters, while slightly overestimating the variance for soft commodity exporters. However, it effectively captures the higher variance observed in the hard commodity exporters. The model also overestimates the variance of consumption and the trade-balance-to-GDP, but similarly to the case of output, it successfully captures the discrepancy between the two groups of countries. Finally, the model perfectly matches the variance of investment in both hard and soft commodity-exporting countries.

Table 4: Standard Deviation due to a Global Risk Shock

	Hard Commodity Exporter		Soft Commodity Exporter	
	Data	Model	Data	Model
Country Spread	0.9	1.0	0.5	0.5
Output	1.9	1.9	0.9	1.2
Consumption	2.4	3.8	0.7	2.3
Investment	3.9	3.9	2.7	2.7
Trade Balance	1.2	1.8	0.5	1.1

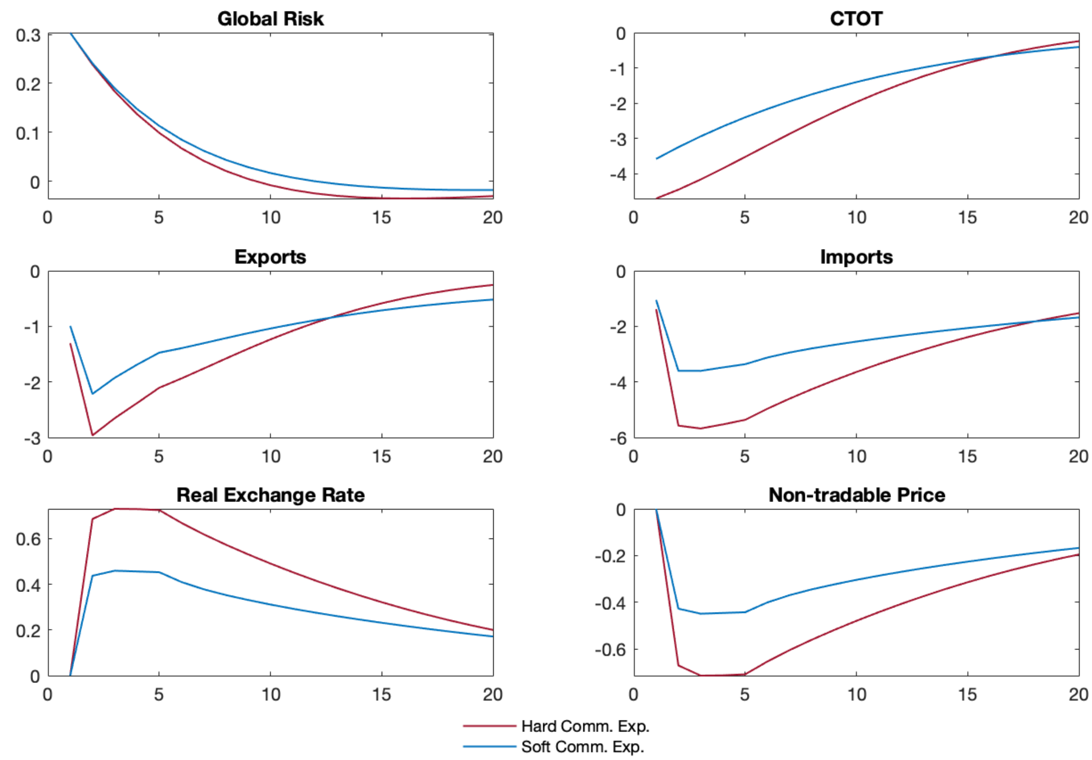
Note: The table compares the difference between the estimated and theoretical standard deviation of output, consumption, investment, trade-balance-to-GDP, and the country spread in response to a global risk shock over a 5-year period following the shock.

Figures 5 and 6 depict the impulse response functions resulting from a one standard deviation increase in global financial risk, as indicated by the theoretical model for both hard and soft commodity exporters. In both groups, there is a decline in commodity terms of trade and an increase in country spread, which leads to a contraction in output, investment, consumption, imports, and exports. Additionally, the decline in imports exceeds the decline in exports, improving the trade balance.

Figure 5 reveals that commodity terms of trade deteriorate, particularly for hard commodity exporters, a result that is directly derived from the SVAR. In terms of exports and imports, hard commodity exporters experience a larger decline than soft commodity exporters, with imports suffering a more significant reduction. Consequently, the trade balance for hard commodity exporters improves more than that of soft commodity exporters. The real exchange rate, measured by the price of tradables[6], depreciates more for hard commodity exporters. As a result, the price of nontradables falls more for hard commodity exporters than for soft commodity exporters.

[6]Some assumptions are needed to obtain that the real exchange rate, defined as the ratio of the foreign consumer price index to the domestic consumer price index, $RER_t = \varepsilon_t P_t^*/P_t$, equals to the price of tradables, $p_t^\tau = P_t^\tau/P_t$, where ε_t denotes the nominal exchange rate, measured as the domestic currency price of a unit of foreign currency, P_t^* denotes the foreign price of consumption, and P_t the domestic price of consumption. Firstly, we must assume that the law of one price holds for both importables and exportables and that the technology used to aggregate these into tradables is consistent across countries. This leads to the equation $\varepsilon_t P_t^{\tau *} = P_t^\tau$. Additionally, we must assume that the terms of trade for a small open economy do not impact the relative price of tradables in terms of consumption goods in the rest of the world. This assumption can be expressed as a constant $P_t^{/} P_t^\tau$ ratio, which can be normalized to unity without loss of generality.

Figure 5: Theoretical Impulse Responses to a Global Risk Shock

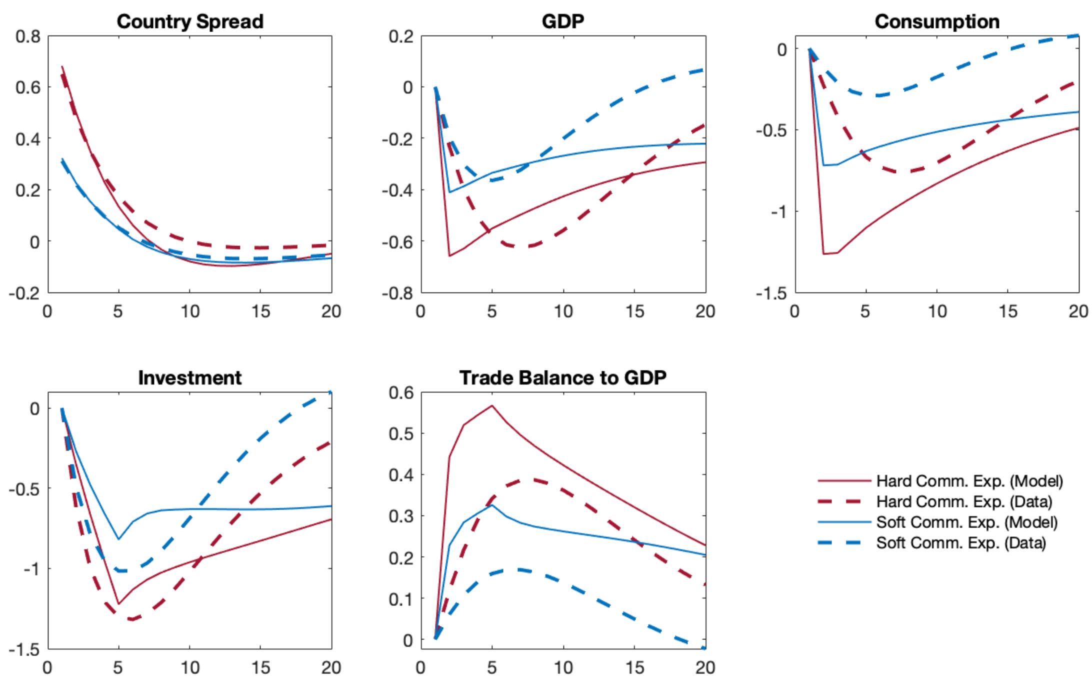


Notes: Theoretical impulse responses to a one standard deviation shock to global financial risk (proxied by the U.S. BAA corporate spread), with hard commodity exporters shown in red and soft commodity exporters in blue. The responses of commodity terms of trade, exports, imports, real exchange rate, and nontradable price are expressed as a percent deviation from their respective log-quadratic trends. The response of global financial risk is expressed as annualized percentage points.

Figure 6 compares the predicted response of country spreads, output, consumption, investment, and the trade balance to GDP ratio, as generated by the model, to those generated by the empirical model presented in the SVAR. The figures reveal that the deterioration in global risk and the significant reduction in commodity terms of trade result in a more than twofold increase in country spreads for the first group of economies (0.7 percentage points versus 0.3 percentage points, respectively). It is important to note that while the impact response of the country spread is the same in the model as in the data due to the use of SVAR estimation and the law of motion of external variables, this may not hold true for future periods as the dynamics of the country spread also depend on the evolution of other endogenous domestic variables. Nonetheless, it is observed that the model's predicted evolution of the country spread for both groups of countries closely follows that of the data.

Figure 6 is particularly noteworthy since it demonstrates that despite having the same calibration for the production structure (same moments s_{tb}, s_x, s_{ym}, and s_{yn}), the model effectively captures the difference in responses to a global financial risk shock between hard and soft commodity exporters. By incorporating the law of motion of country spread and of the external variables of the SVAR system (1), the model can generate more substantial contractions in output, consumption, and investment in the first group of countries. This finding lends support to the hypothesis that the prices of hard commodities magnify global financial risk shocks in emerging economies that rely on their exports by affecting their country spreads.

Figure 6: Theoretical and Estimated Impulse Responses to a Global Risk Shock



Notes: Impulse responses to a one standard deviation shock to global financial risk (proxied by the U.S. BAA corporate spread), with solid lines depicting the responses in the model and dashed lines showing the responses in the data. Hard commodity exporters are shown in red, while soft commodity exporters are in blue. The output, consumption, and investment responses are expressed as a percent deviation from their respective log-quadratic trends. The responses of the trade-balance-to-GDP and the country spread are expressed in annualized percentage points.

4.3 Variance Decomposition

Table 5 presents a comparison between the estimated and theoretical variance of output following a global risk shock, a commodity terms of trade shock, and a world interest rate shock over a 5-year period. The near-perfect match in the case of the variance of output due to a global risk shock is a construction of the calibration, as it is one of the targets. However, the model's responses to the other shocks are not targeted, indicating that the model matches the relative significance of external shocks for both groups of countries.

Table 5: Variance of Output due to External Shocks

	Hard Commodity Exporters		Soft Commodity Exporters	
	Data	Model	Data	Model
Global Risk	25	25	8	13
Commodity Terms of Trade	3	16	26	23
World Interest Rate	1	1	0	0
External Shocks	28	42	34	37

Notes: Estimated and theoretical variance of output resulting from a global risk shock (proxied by the U.S. BAA corporate spread), a commodity terms of trade shock, and a world interest rate shock over a 5-year period. Since these are the only shocks in the model, the model columns indicate the variance predicted by the model conditional on each shock, while the denominator represents the unconditional variance suggested by the SVAR model. All shares are expressed as percentages.

4.4 Transmission Channels of Global Financial Risk

My model allows me to investigate different scenarios to isolate the transmission of the shock of interest through different variables of the model. Figure 7 illustrates the response of the country spread and output to a global risk shock under four counterfactual scenarios.

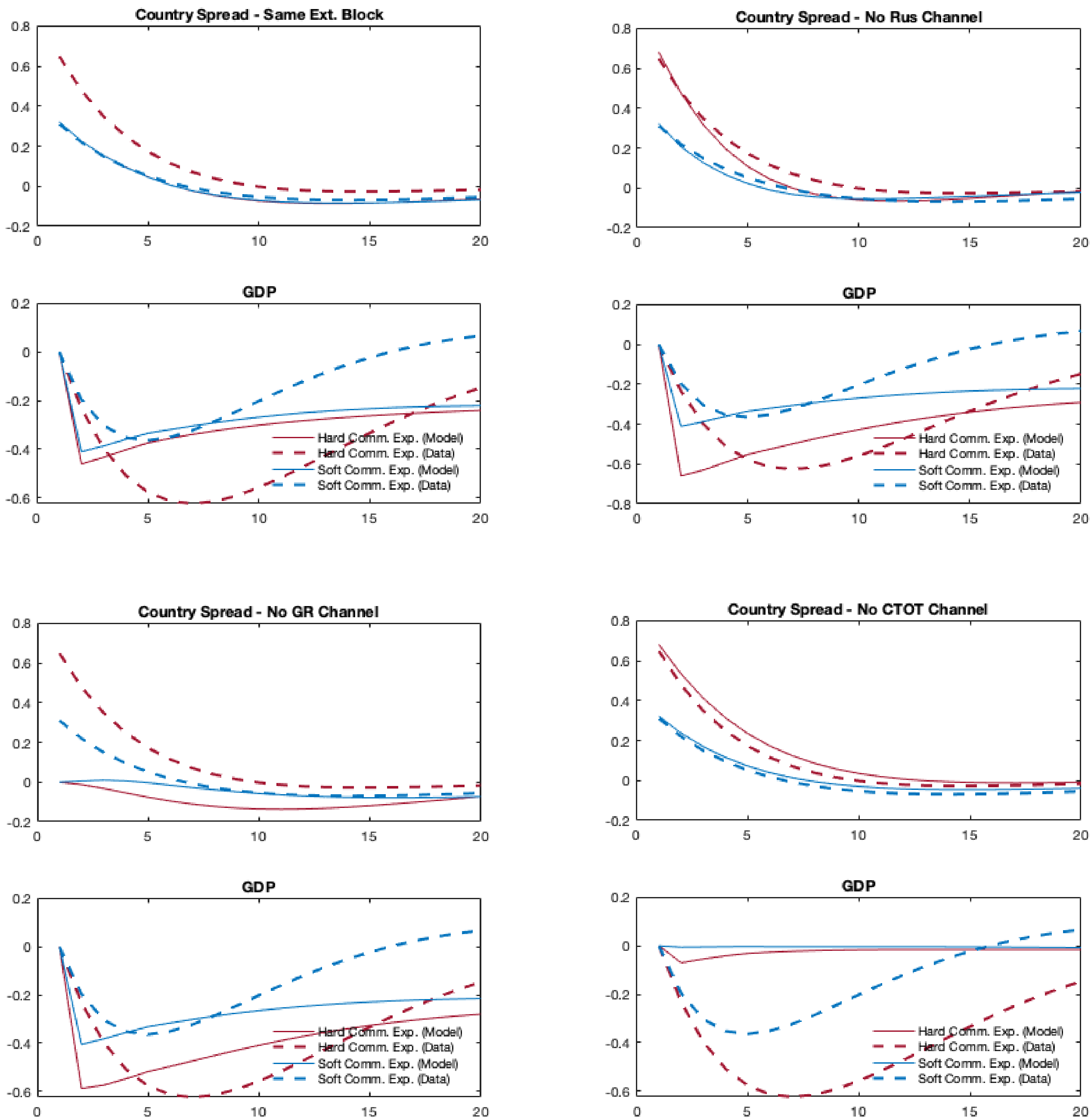
In the first scenario, both hard and soft commodity exporters are modeled with the same law of motion for the country spread and external variables. The response of output is almost identical for both types of countries, indicating that the main difference between them arises from the external block and the law of motion of the country interest rate, rather than differences in the calibration.

The second scenario, which assumes a constant world interest rate, has no significant effect on the response of domestic variables, as shown by comparing columns 2 and 4 of Table 6. Therefore, global risk shocks are not transmitted through the reaction of the world interest rate.

In the third scenario, the country spread does not react directly to changes in the global risk, but only through the effect, this shock has on the rest of the variables of the model. Although the country spread remains almost constant under this counterfactual, the reaction of output is basically the same as in the baseline, as it is shown by comparing columns 2 and 5 of Table 6. Thus, it can be concluded that the global risk shock is not transmitted directly through the reaction of the country spread.

In the final scenario, commodity prices are assumed not to respond directly to variations in global financial risk. The results are extreme: the variance of output explained by global financial risk shocks drops to nearly zero for both types of economies. These results suggest that commodity prices amplify the effect of global risk shocks, leading to a more significant impact on hard commodity exporters due to the composition of their exports, which are more exposed to global risk.

Figure 7: Impulse Responses of the Country Spread and Output to a Global Risk Shock under Different Counterfactual Scenarios



Notes: Impulse responses to a one standard deviation shock to global financial risk (proxied by the U.S. BAA corporate spread), with solid lines depicting the responses in the model and dashed lines showing the responses in the data. Hard commodity exporters are shown in red, while soft commodity exporters are in blue. The response of output is expressed as a percent deviation from its log-quadratic trends, while the responses of the country spread are expressed in annualized percentage points.

Table 6: Standard Deviation of Output due to Global Risk Shock
under Different Counterfactual Scenarios

	Data	Baseline Model	Same Ext. Block	No Rus Channel	No GR Channel	No CTOT Channel
Hard Comm. Exporter	1.9	1.9	1.4	1.9	1.8	0.1
Soft Comm. Exporter	0.9	1.2	1.2	1.2	1.2	0.02
Difference	1.0	0.7	0.1	0.7	0.6	0.1

Notes: Estimated and theoretical variance of output resulting from a global risk shock, a commodity terms of trade shock, and a world interest rate shock over a 5-year period. Since these are the only shocks in the model, the model columns indicate the variance predicted by the model conditional on each shock, while the denominator represents the unconditional variance suggested by the SVAR model. All shares are expressed as percentages.

5 Conclusions

This paper examines how the global financial cycle affects commodity-exporting countries and whether the impact differs depending on the type of commodity being exported. My empirical model shows that hard commodity exporters are more severely affected by unexpected increases in global financial risk than soft commodity exporters. Specifically, hard commodity exporters experience a more significant decline in their commodity terms of trade, a larger increase in their sovereign spread, and a more substantial reduction in consumption and output compared to soft commodity exporters. However, it is unclear which channels transmit the global financial cycle in each group of countries.

To address this, the paper builds a small open economy model and finds that commodity prices play a critical role in amplifying the effect of global risk shocks. When commodity prices are assumed not to respond directly to changes in global financial risk, the variance of output, consumption, investment, and the trade-balance-to-output ratio explained by global financial risk shocks drops significantly for both types of economies. However, assuming that country spread does not respond directly to global risk shocks does not change the variance of the same variables explained by these shocks. These results suggest that policymakers should pay close attention to the vulnerabilities of hard commodity-exporting countries to global financial risk shocks.

Appendix

A Sample of Countries

Table A.1: Classification of emerging commodity exporters

	Share of Exports of Goods			Commodity Terms of Trade		
	Energy, Metals & Minerals	Agriculture & Precious Metals	Commodity Exports	Standard Deviation	Correlation with Output	Serial Correlation
Hard Comm. Exp.	**38**	**31**	**69**	**16**	**59**	**90**
Russia	68	13	81	18	68	85
Chile	52	35	87	14	51	88
Colombia	51	25	76	16	32	85
Ecuador	44	48	92	13	25	85
Peru	44	41	85	17	72	94
Belarus	36	22	58	13	24	86
Indonesia	31	25	56	14	45	84
South Africa	26	36	62	15	69	93
Bulgaria	24	19	43	20	72	94
Brazil	19	38	57	17	83	95
Soft Comm. Exp.	**8**	**21**	**29**	**14**	**13**	**92**
Croatia	16	19	34	14	7	90
Argentina	13	56	69	9	50	81
Mexico	12	8	20	21	-33	94
Guatemala	8	53	62	4	-11	65
Poland	8	14	22	18	26	95
Turkey	6	15	21	13	42	91
Philippines	6	10	16	11	7	86
Thailand	5	22	27	15	43	94
El Salvador	4	27	31	9	17	81
Hungary	4	11	14	10	16	82
Costa Rica	1	39	40	3	43	62

Notes: Hard (soft) commodity exporters refer to countries that export relatively more (less) energy, metals, and minerals. Additional information on the data used can be found in Section 2.2.

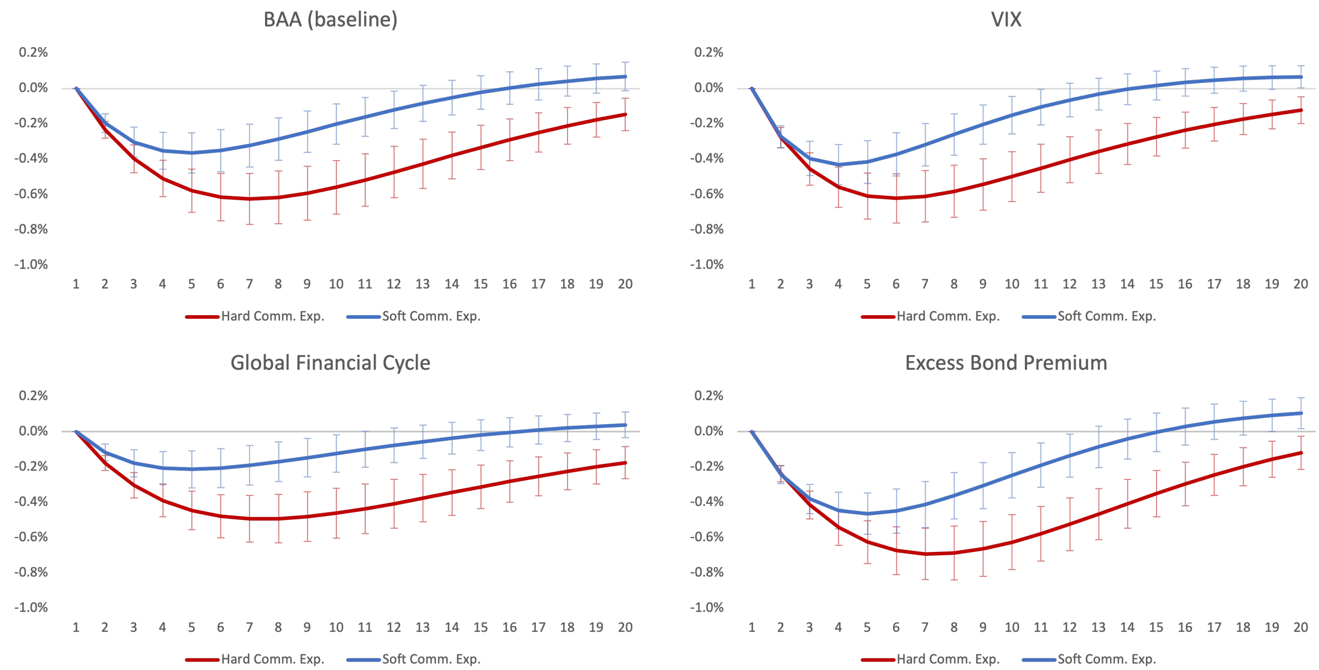
Table A.2: Business Cycle Moments

	Output	Investment	Consumption	Trade balance	Country Spread
Standard Deviations	σ_y	σ_i/σ_y	σ_c/σ_y	σ_{tby}/σ_y	σ_r
Hard Commodity Exporters	3.9	3.6	1.3	1.2	3.6
Soft Commodity Exporters	3.2	3.3	1.1	1.1	3.8
Correlations with Output					
Hard Commodity Exporters	100.0	47.3	71.3	-14.1	-4.6
Soft Commodity Exporters	100.0	84.2	82.9	-32.5	-8.2
Serial Correlations					
Hard Commodity Exporters	93.2	71.7	84.1	88.2	88.2
Soft Commodity Exporters	89.1	87.9	80.9	87.0	89.6

Notes: Additional information on the data used can be found in Section 2.2.

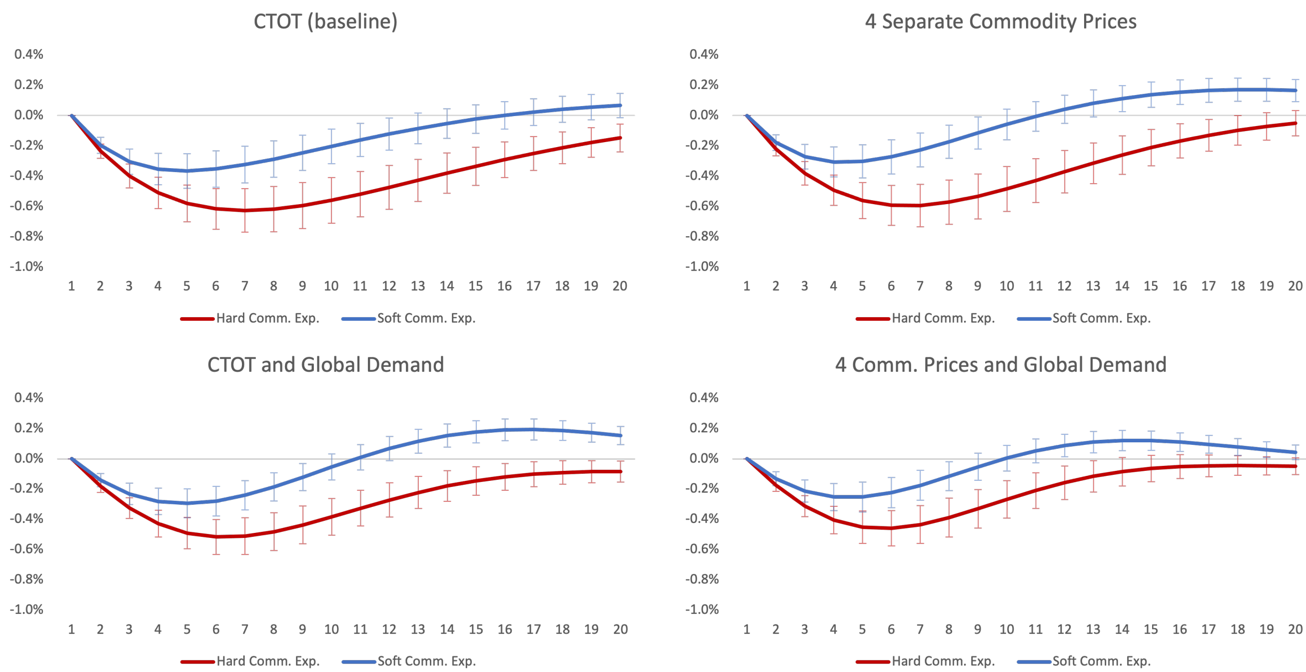
B Panel SVAR Robustness

Figure B.1: Response of Output due to a Global Risk Shock
using Different Measures of Global Financial Risk



Notes: The impulse responses of output (measured in percent deviation from its log-quadratic trend) to a one standard deviation shock to global financial risk are depicted by bold lines, with the 90% confidence intervals shown in brackets. Hard commodity exporters are shown in red, while soft commodity exporters are in blue. The alternative measures of global risk are U.S. BAA corporate spread (measured as the difference between Moody's U.S. BAA corporate borrowing rate and the 20-year U.S. Treasury bond rate), VIX (Chicago Board Options Exchange's CBOE Volatility Index), Global Financial Cycle (a measure of the global financial cycle proposed by Miranda-Agrippino & Rey (2020)), and Excess Bond Premium (measured presented by Gilchrist & Zakrajsek (2012)). Additional information on the identification strategy and data used can be found in Sections 2.1 and 2.2.

Figure B.2: Response of Output due to a Global Risk Shock including Separate Commodity Prices and Global Demand



Notes: The impulse responses of output (measured in percent deviation from its log-quadratic trend) to a one standard deviation shock to global financial risk (proxied by the U.S. BAA corporate spread) are depicted by bold lines, with the 90% confidence intervals shown in brackets. Hard commodity exporters are shown in red, while soft commodity exporters are in blue. Global activity is calculated as the PPP weighted average of log-quadratic deviations of real GDP of forty advanced and emerging economies. Additional information on the identification strategy and data used can be found in Sections 2.1 and 2.2.

C Consumers Optimality Conditions

The Lagrangian associated with the household's optimization problem can be written as

$$
\begin{aligned}
\mathcal{L} =& E_0 \sum_{t=0}^{\infty} \beta^t \Bigg\{ U(c_t - \theta \tilde{c}_{t-1}, h_t^m, h_t^x, h_t^n) \\
&+ \lambda_t \left[\frac{d_{t+1} - \Psi(d_{t+1})}{1 + r_t} - d_t + \sum_{j=\{m,x,n\}} \left(w_t^j h_t^j + u_t^j k_t^j - \frac{1}{4} \sum_{i=0}^{3} s_{i,t}^j \right) - c_t \right] \\
&+ \lambda_t \sum_{j=\{m,x,n\}} \sum_{i=0}^{2} \nu_{it}^j \left(s_{i,t}^j - s_{i+1,t+1}^j \right) + \lambda_t \sum_{j=\{m,x,n\}} q_t^j \left[(1-\delta) k_t^j + k_t^j \Phi \left(\frac{s_{3,t}^j}{k_t^j} \right) - k_{t+1}^j \right] \Bigg\}
\end{aligned}
$$

where $\beta^t \lambda_t$, $\beta^t \lambda_t \nu_{it}^j$, and $\beta^t \lambda_t q_t^j$ are the Lagrange multipliers associated with constraints (4), (7), and (8), respectively. The optimality conditions associated with the household's problem are (4), (7), (8), and (9) holding with equality, and

$$E_t \lambda_{t+1} = U_c(c_{t+1} - \theta \tilde{c}_t, h_{t+1}^m, h_{t+1}^x, h_{t+1}^n) \tag{C.1}$$

$$E_t \left[w_{t+1}^j \lambda_{t+1} \right] = -U_{h^j}(c_{t+1} - \theta \tilde{c}_t, h_{t+1}^m, h_{t+1}^x, h_{t+1}^n) \tag{C.2}$$

$$\lambda_t (1 - \Psi'(d_{t+1})) = \beta (1 + r_t) E_t \lambda_{t+1} \tag{C.3}$$

$$E_t \lambda_{t+1} \nu_{0t+1}^j = \frac{1}{4} E_t \lambda_{t+1} \tag{C.4}$$

$$\beta E_t \lambda_{t+1} \nu_{1t+1}^j = \frac{\beta}{4} E_t \lambda_{t+1} + \lambda_t \nu_{0t}^j \tag{C.5}$$

$$\beta E_t \lambda_{t+1} \nu_{2t+1}^j = \frac{\beta}{4} E_t \lambda_{t+1} + \lambda_t \nu_{1t}^j \tag{C.6}$$

$$\beta E_t \left[\lambda_{t+1} q_{t+1}^j \Phi' \left(\frac{s_{3,t+1}^j}{k_{t+1}^j} \right) \right] = \frac{\beta}{4} E_t \lambda_{t+1} + \lambda_t \nu_{2t}^j \tag{C.7}$$

$$\lambda_t q_t^j = \beta E_t \left\{ \lambda_{t+1} q_{t+1}^j \left[1 - \delta + \Phi \left(\frac{s_{3,t+1}^j}{k_{t+1}^j} \right) - \frac{s_{3,t+1}^j}{k_{t+1}^j} \Phi' \left(\frac{s_{3,t+1}^j}{k_{t+1}^j} \right) \right] + \lambda_{t+1} u_{t+1}^j \right\} \tag{C.8}$$

D Profit Maximization in the Production of Final, Tradable, and Nontradable Goods

Producers of final goods behave competitively. The profit maximization conditions provide the domestic demand functions for the tradable composite goods and for nontradables.

$$B_1(a_t^\tau, a_t^n) = p_t^\tau \tag{D.1}$$

$$B_2(a_t^\tau, a_t^n) = p_t^n \tag{D.2}$$

Producers of tradable goods behave competitively in the intermediate and final goods markets. Profit maximization generates the domestic demand functions for importable and exportable goods.

$$p_t^\tau A_1(a_t^m, a_t^x n) = p_t^m \tag{D.3}$$

$$p_t^\tau A_2(a_t^m, a_t^x) = p_t^x \tag{D.4}$$

All firms that produce importable, exportable, and nontradable goods are assumed to behave competitively in product and factor markets, their optimality condition yields

$$p_t^j F_1^j(k_t^j, h_t^j) = u_t^j \tag{D.5}$$

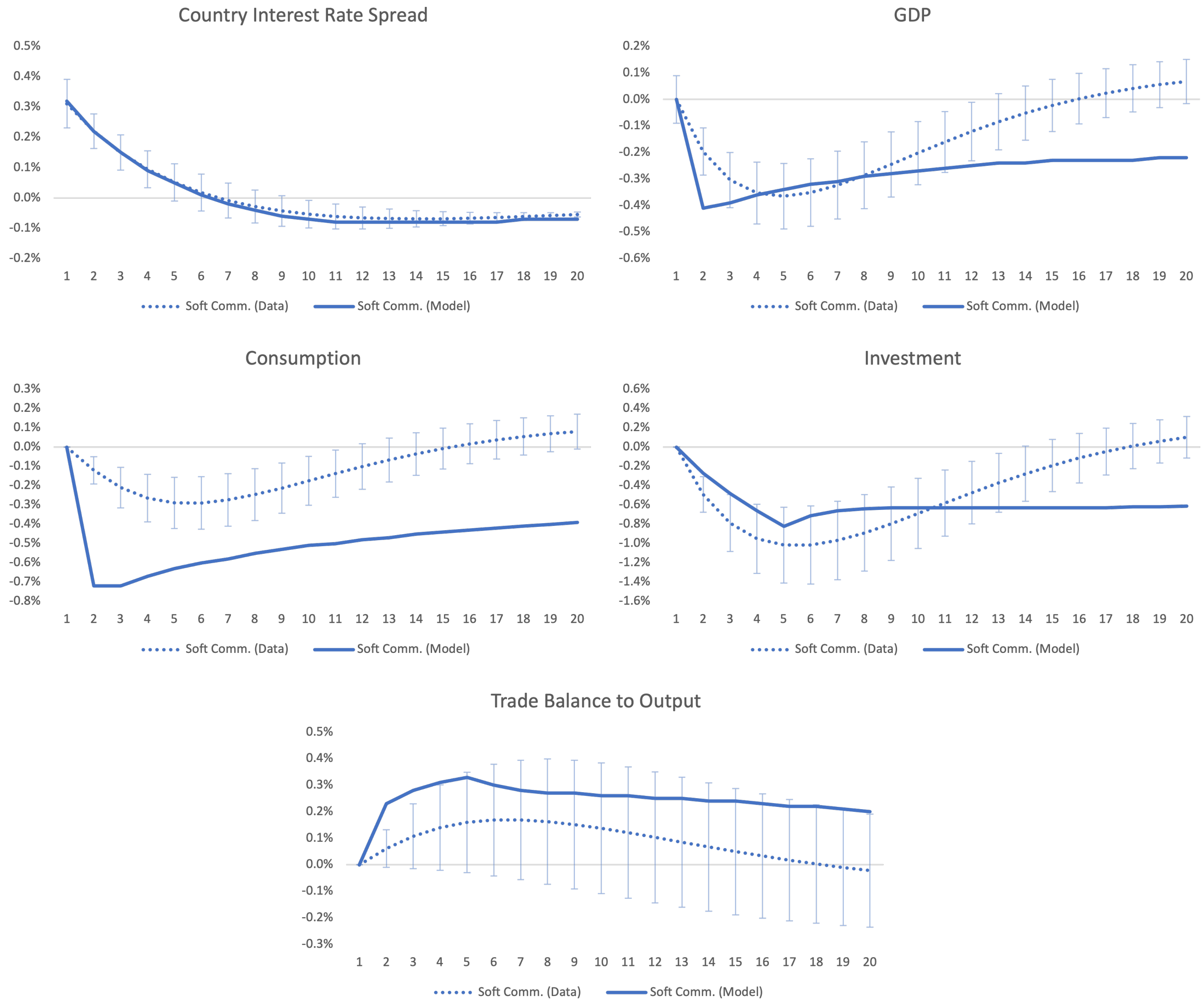
$$p_t^j F_2^j(k_t^j, h_t^j) = w_t^j \left[1 + \eta \left(\frac{r_t^d}{1 + r_t^d}\right)\right] \tag{D.6}$$

E Other Model Results

Figure E.1: Theoretical and Estimated Impulse Responses to a Global Risk Shock for Hard Commodity Exporters

Notes: Impulse responses to a one standard deviation shock to global financial risk (proxied by the U.S. BAA corporate spread), with solid lines depicting the responses in the model and dashed lines showing the responses in the data. Hard commodity exporters are shown in red, while soft commodity exporters are in blue. The output, consumption, and investment responses are expressed as a percent deviation from their respective log-quadratic trends. The responses of the trade-balance-to-GDP and the country spread are expressed in annualized percentage points.

Figure E.2: Theoretical and Estimated Impulse Responses to a Global Risk Shock for Soft Commodity Exporters



Notes: Impulse responses to a one standard deviation shock to global financial risk (proxied by the U.S. BAA corporate spread), with solid lines depicting the responses in the model and dashed lines showing the responses in the data. Hard commodity exporters are shown in red, while soft commodity exporters are in blue. The output, consumption, and investment responses are expressed as a percent deviation from their respective log-quadratic trends. The responses of the trade-balance-to-GDP and the country spread are expressed in annualized percentage points.

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