Terms of Trade Volatility, Business Cycles and Default Risk in Emerging Economies[☆]

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PRELIMINARY DRAFT. PLEASE DO NOT CIRCULATE

Abstract

This paper examines the effects of terms of trade volatility shocks on emerging economies business cycles, distinguishing between common and country-specific innovations. We identify common and idiosyncratic terms of trade volatility shocks using the Particle Filter. A one-standard-deviation common volatility shock causes a fall in aggregate output and investment by 0.4% and 0.7% respectively, with domestic interest rates increasing by 0.4 percentage points. While common shocks account for 9% of output fluctuations, idiosyncratic shocks do not yield significant effects. The *default premium channel* is key for the transmission: increased terms of trade volatility raises default probabilities, leading to a tighter supply of credit. By incorporating this channel into an open economy model with stochastic volatility, we reproduce the empirical contractionary responses. Excluding the default premium channel leads to a counterfactual result—a negative relationship between volatility and interest rates—underscoring the importance of credit-supply behavior to understanding the effects of terms of trade volatility shifts.

Keywords: Terms of Trade Volatility; Emerging Economies; Business Cycles; Common Factors; Default Premium.
JEL Codes: E32, F41, F44.

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1 Introduction

Many emerging economies are characterized by their trade openness and reliance on the export of commodities and low-value-added goods. This dependence leaves them vulnerable to external shocks and commodity price fluctuations (Reinhart et al., 2016, Juvenal and Petrella, 2024). Consequently, a substantial body of literature has documented the relevance of terms of trade and commodity price variations for these economies.[1] For instance, Di Pace et al. (2025) find that commodity prices are a primary driver of domestic business cycles, with export and import price shocks jointly explaining up to 30% of output fluctuations. However, most of these studies have focused only on changes in the level of terms of trade. Volatility shifts of distinct macroeconomic series affect agents' decisions and lead to aggregate economic fluctuations, even when the levels remain unchanged (see, for example, Fernández-Villaverde et al., 2011). While previous works have documented an important role for interest rate volatility shocks, the evidence on the effects of terms of trade volatility remains scarce.

This paper examines the macroeconomic effects of terms of trade volatility in emerging economies, combining empirical evidence with theoretical predictions. We begin by identifying volatility shocks using a particle filter and incorporating these innovations into a VAR that considers a panel of emerging economies. The empirical results indicate that increases in terms of trade volatility reduce production, investment, and lead to a rise in the domestic interest rate. To interpret these findings, we built on a textbook RBC open economy model to analyze two transmission channels. On the one hand, greater uncertainty can strengthen precautionary motives, inducing agents to postpone consumption and investment decisions.[2] On the other hand, higher volatility can raise the likelihood that the country will be unable to meet its future debt obligations, thereby increasing the default premium embedded in the interest rate. This paper focuses on the second mechanism, which we demonstrate is essential for generating the positive interest

[1] See **?**, Ben Zeev et al. (2017), Fernández et al. (2017), Schmitt-Grohé and Uribe (2018), and **?**.

[2] Similar to the wait-and-see channel described in Bloom (2009), Bachmann and Bayer (2013), and Baker et al. (2024), in which agents postpone their investment decisions in environments of greater uncertainty.

rate response observed in the data, given that the precautionary savings channel alone yields a counterfactual interest rate decline.

Another contribution of the paper is to distinguish between common and idiosyncratic terms of trade volatility shocks. Episodes of heightened global uncertainty may simultaneously affect commodity-exporting economies, amplifying financial frictions through higher risk aversion and tighter external borrowing conditions. Identifying whether volatility shocks are common or country-specific is therefore crucial for understanding their aggregate consequences. Following the literature on the Global Financial Cycle and the Global Trade and Commodity Cycle,[3] we disentangle emerging economies terms of trade into common and idiosyncratic components to study the impact of their volatility fluctuations separately. The analysis shows that common volatility shocks play a disproportionately important role. They are more strongly correlated with default risk premiums and generate substantially larger macroeconomic effects, highlighting the relevance of systematic volatility on the business cycles in emerging economies.

To understand the relationship between terms of trade volatility and interest rates in emerging economies, we extend a simplified version of the default model of Arellano (2008) to study a two-period small open economy, in which a representative household has the possibility of defaulting on its debt obligations and interest payments, in an environment where it faces an exogenous and uncertain income path. Within this framework we demonstrate that a terms of trade volatility shock induces an increase in default probabilities. The higher risk of default leads creditors to demand higher interest rates, even assuming risk-neutral behavior. If we include the presence of risk-averse creditors, the channel is amplified and, for a volatility shock of equal magnitude, the pass-through to interest rates is greater. We also find that the pass-through is stronger as debt increases

[3]This literature documents the presence of common factors driving global movements in capital flows, commodity price indices, and global private liquidity. For instance, Fernández et al. (2018) identify a strong co-movement in the commodity prices exported by emerging economies, with a single common factor explaining nearly 78% of their variability. See Miranda-Agrippino and Rey (2022) for a comprehensive review on the Global Financial Cycle and the Global Trade and Commodity Cycle.

and as the penalties for default decrease. If the interest rate at which economies borrow responds to volatility, this could have consequences for emerging economies. Higher interest rates could trigger declines in investment and consumption due to substitution effects, and depress aggregate output as a result of lower capital accumulation. We call this transmission mechanism *default premium channel* and its introduction serves as a starting point for the rest of the paper.

To study empirically the effects of terms of trade volatility on emerging economies business cycles, we first identify the common and idiosyncratic components of each country's terms of trade with principal components, using monthly terms of trade data from 12 emerging countries for the period 1980-1 to 2019-12. We find a common factor that explains 41% of the sample variance, reflecting the existence of co-movement in the commodity-based terms of trade of emerging economies, whereas the idiosyncratic components are obtained as the part of the terms of trade that cannot be explained by the common factor. We then estimate the unobserved volatility of both total terms of trade and common and idiosyncratic components using a version of the particle filter described in Fernández-Villaverde and Rubio-Ramirez (2007). This filter has been used before in other contexts to estimate unobserved second moments and their innovations. For instance, both Fernández-Villaverde et al. (2011) and Fernández-Villaverde et al. (2015) rely on this methodology to obtain the volatility of interest rates and fiscal policy, respectively. As stated by Fernández-Villaverde and Rubio-Ramirez (2013), the filter allows us to obtain a series of shocks to the level (terms of trade), as well as to the second moment (terms of trade volatility).

We find that terms of trade volatility varies over time and that the processes for the common- and idiosyncratic components are not statistically different for the median country. Common terms of trade volatility increased during the mid-1980s and again in the commodity boom of the mid-2010s, while remaining relatively stable during the 1990s. It also increased significantly during the Great Recession. The average standard deviation of common level

shocks is about 0.34 percentage points. During the crisis, however, the standard deviation increased to approximately 2 percentage points, amplifying the size of common terms of trade level shocks throughout this period.

In line with the default premium channel, we find that terms of trade volatility components are positively correlated with default risk premiums (proxied by the EMBI spread) and with aggregate measures of volatility and financial tightening. Importantly, we document that common volatility is more related to default risk premiums than idiosyncratic volatility. One possible interpretation of this result is that creditors penalize systematic risk to a greater extent. Environments of greater global uncertainty could lead to increases in risk aversion levels and, consequently, to higher required premiums. If the default premium channel is more important in the face of common volatility than of idiosyncratic volatility, then common volatility shocks could have a more significant effect on the business cycles of emerging economies.

To test for the presence of heterogeneous effects induced by common and idiosyncratic shocks, we use the common- and idiosyncratic terms of trade volatilities and their shocks obtained with the particle filter to estimate a panel VAR with emerging economies macro data. The main macroeconomic variables of emerging economies react significantly to a one-standard deviation common terms of trade volatility shock. Output and investment decline by 0.4% and 0.7% respectively, and the domestic interest rate increases by 0.4 percentage points on impact, consistent with the default premium channel. In contrast, idiosyncratic volatility shocks do not have such a significant and important effect, with most responses lacking statistical significance. We conduct forecast error variance decompositions to confirm this finding. While common terms of trade volatility shocks explain about 9% of output fluctuations in emerging economies, idiosyncratic shocks only explain 0.3%. Therefore, even though terms of trade volatility shocks have a significant effect on emerging economies, the nature of the shock matters. Common shocks are more important and have a greater impact.

Finally, to understand further the effects of terms of trade volatility on the business

cycles of emerging economies, we augment the MXN model from Schmitt-Grohé and Uribe (2017) and Schmitt-Grohé and Uribe (2018) to include time-varying terms of trade volatility and working-capital constraints. We also introduce the default premium channel in a reduced-form fashion, allowing the interest rate to respond directly to changes in terms of trade volatility. This relationship is based on the findings of the simple two-period model and with this specification we can easily capture the direct link between volatility and default premiums. Here we do not distinguish between common and idiosyncratic components to focus exclusively on the transmission mechanisms of terms of trade volatility, with the emphasis put on the role played by the default premium channel.

We find that the model successfully captures the contractionary response observed in the data to terms of trade volatility shocks. The output decline is primarily driven by a contraction in the nontradable sector due to a real exchange rate depreciation, which causes a reallocation of labor towards the tradable sector. Additionally, we demonstrate that relying solely on the precautionary savings channel as the transmission mechanism yields a counterfactual interest rate result. Through this channel, when a positive terms of trade volatility shock occurs, households consume and invest less in order to reduce their net external debt and protect themselves from unfavorable future terms of trade realizations. If the interest rate is positively related to debt, then a decrease in net external debt results in a fall in the domestic interest rate instead of the positive response observed in the data. Including the default premium channel in the model ensures a positive interest rate response, resolving the counterfactual result. Therefore, rather than focusing exclusively on the demand-side of the credit market, we should also recognize and address the supply-side consequences of terms of trade volatility.

Related Literature: The paper is related to three distinct yet interrelated strands of the literature. First, is associated with studies that analyze the properties and drivers of real business cycles in small open emerging economies. Mendoza (1995) finds that terms of trade shocks account for nearly half of output fluctuations in developing countries. Aguiar

and Gopinath (2007) conclude that shocks to trend growth are the primary source of fluctuations in emerging economies. Only by including both transitory and permanent productivity shocks one can characterize the business cycles of both emerging and developed small open economies. However, García-Cicco et al. (2010) find that an augmented model that incorporates shocks to the country premium and financial frictions does a better job explaining emerging economies business cycles. Similarly, both Neumeyer and Perri (2005) and Uribe and Yue (2006) observe that large fluctuations in country risk and international interest rates are deeply connected with large fluctuations in economic activity. A feature confirmed by Akinci (2013), who documents that country spread shocks explain about 15% of the business cycles in emerging economies. Fernández et al. (2017) and Drechsel and Tenreyro (2018) highlight the role of commodities and how commodity prices explain a significant fraction of output movements. Finally, Schmitt-Grohé and Uribe (2018) show that improvements in terms of trade lead to increases in output, investment, and consumption, but terms of trade innovations would explain less than 10% of business cycles. We contribute to this literature by providing insights and novel estimates on the importance of terms of trade volatility as a driver of real business cycles in small open emerging economies, distinguishing between common and idiosyncratic volatility.

Most closely related to this paper are a few studies that document the role and effects of terms of trade volatility on business cycles. Gómez-González and Rees (2013) empirically and theoretically analyze the effects of shocks to the volatility of terms of trade, concluding that they depress both investment and consumption through a precautionary savings channel. Pfeifer et al. (2012) develop a DSGE model to explore the effects stemming from terms of trade uncertainty. They find that uncertainty shocks are recessionary and attributable to firms in the non-tradable sector choosing higher markups over marginal costs to avoid being stuck with low prices when large terms of trade shocks realize. They estimate that terms of trade uncertainty can account for about one fifth of

Chilean output fluctuations at business cycle frequencies. Both Xia and Zhou (2022) and Xia and Zhou (2023) identify common terms of trade factors in the data and empirically study the effects of terms of trade volatility over the business cycles in emerging and developed economies. They conclude that common factors explain between 59%-73% of individual terms of trade variability, and that volatility shocks induce recessions. However, they do not address the underlying transmission mechanisms. Lastly, Monterroso and Vilán (2025) examine the consequences of terms of trade volatility shocks in a VAR setting, finding that they depress investment, output and aggregate consumption. Our main contribution to this literature revolves around understanding the role of the domestic interest rate as an additional transmission channel for terms of trade volatility shocks and characterizing its importance to explore the effects on emerging economies business cycles.

Finally, this paper also relates to an empirical literature that links terms of trade volatility to interest rates and financial conditions and their impact on long-term economic growth. Both Catao and Sutton (2002) and Hilscher and Nosbusch (2010) empirically document that terms of trade volatility is an important determinant and positively related to risk premiums and default probabilities in emerging economies. Blattman et al. (2007) find that countries with more volatile terms of trade grow less and that the transmission channel would be through foreign investment, via a reduction in capital inflows. Lee (2023) studies growth at the industry level in commodity-dependent economies, finding that volatility in terms of trade generates negative effects through credit channels. Higher volatility increases borrowing costs and limits the availability of loanable funds. Our contribution to this literature is twofold. First, we theoretically demonstrate the existence of a causal relationship between terms of trade volatility and required interest rates in a simple two-period model.[4] And second, we highlight the role of debt, risk aversion and default penalties in determining the strength of this relationship.

The rest of the paper is organized as follows. Section 2 develops a simple theoretical

[4]While there are some theoretical papers that analyze the link between macroeconomic volatility and default probabilities (see **???**), we focus specifically on terms of trade volatility.

framework that demonstrates the link between terms of trade volatility and interest rates. Section 3 describes the identification strategy used to obtain the common and idiosyncratic terms of trade factors, as well as the volatility series and their shocks. Section 4 illustrates the empirical impulse-responses and variance decompositions estimated with the VAR model. Section 5 introduces the RBC open economy model and their results. Finally, Section 6 concludes.

2 Theoretical Framework

To understand how terms of trade volatility can affect the credit supply and interest rates at which emerging economies borrow, we rely on a simplified version of the default model of Arellano (2008). Specifically, we follow and extend the exposition of Végh (2013) to study a two-period small open economy facing an exogenous and uncertain income path. First, we describe the household problem and define the conditions under which default could occur. Second, we describe the creditors' problem and derive the credit supply. Third, we analyze the supply response to a terms of trade volatility shock. And finally, we study the determinants of the pass-through of volatility to required interest rates.

Households: A representative household must choose a consumption path $\{C_1, C_2\}$, as well as a level of net external debt D_1, that matures in one period. This choice solves the following problem under uncertainty:[5]

$$\max_{\{C_1,C_2,D_1\}} U(C_1) + \beta \mathrm{E}(U(C_2)) \quad s.t.$$

$$[1] \quad C_1 = p_1 Y_1 + D_1$$

$$[2] \quad C_2 + (1+r)D_1 = p_2 Y_2$$

$$[3] \quad p_2 \sim U(p_{min}, p_{max})$$

$$[4] \quad C_1 \geq 0, C_2 \geq 0$$

[5]Throughout this paper, uncertainty and volatility will be treated in the same way.

where $U(C_t)$ is a strictly increasing and concave function, $\beta \in (0,1)$ is the subjective discount factor, Y_t is the endowment of exportable goods, and p_t is the relative price of exportable goods to importable goods (we assume that both debt and consumption are defined in terms of importable goods). We call this price the terms of trade. Finally, r corresponds to the interest rate.

Note that the terms of trade in the second period are stochastic and follow a uniform distribution $U(p_{min}, p_{max})$. Therefore, although the household knows the first period terms of trade, when making an optimal decision it faces uncertainty regarding the value of p_2. Since the focus of this work is on small open emerging economies, assuming an exogenous process for the terms of trade is natural and in line with the literature (see, for example, Schmitt-Grohé and Uribe, 2017; Schmitt-Grohé and Uribe, 2018). For the sake of simplicity and to ensure that the economy wishes to borrow in the first period, we will assume that $Y_1 = 0$ and $Y_2 = 1$. However, these assumptions do not affect our main results and conclusions.

Once the household has made the optimal choice regarding consumption and debt, in the second period it can choose between defaulting on the principal and interest payments, or repaying all its debts together with the accrued interest (when lending resources to the economy, creditors are aware of these possibilities). We refer to the first possibility as *default* and to the second as *commitment*. However, in the event of default, the household must pay a fraction $\phi \in (0,1]$ of its second-period income p_2.[6] This loss can be thought of as the application of direct sanctions or the loss of access to international markets. Under this scheme, the economy will only want to default if and only if its level of consumption in $t = 2$ under this alternative is greater than what it would obtain under commitment.

[6]Since $Y_2 = 1$, the income from the second period $p_2 Y_2$ is simply p_2.

Mathematically, it will want to default if:

$$\begin{aligned} & C_2^{ND} \leq C_2^D \\ \iff & p_2 - D_1(1+r) \leq (1-\phi)p_2 \\ \iff & D_1(1+r) \geq \phi p_2 \end{aligned}$$

where ND and D refer to commitment and default states respectively. In other words, the economy will choose to default if the following condition holds:

$$p_2 \leq \frac{D_1(1+r)}{\phi} \tag{1}$$

Therefore, given a level of debt and interest rate, the economy will prefer to default when the terms of trade are unfavorable. Specifically, since we know that p_2 follows a uniform distribution, we can compute the conditional default probability (π)[7] explicitly as:

$$\begin{aligned} & \pi = Pr\left(p_2 \leq \frac{D_1(1+r)}{\phi}\right) \\ \iff & \pi = \frac{D_1(1+r) - \phi p_{min}}{\phi(p_{max} - p_{min})} \end{aligned} \tag{2}$$

Note that π increases with both the level of debt and the interest rate, while it decreases as the income loss parameter (ϕ) rises.

Supply: Assume that on the fund supply side, there is a risk-neutral creditor in a perfectly competitive market. This creditor must decide whether to invest in a risk-free asset to obtain a return of r^* or lend funds to the economy in exchange for a rate of r, taking into account that the economy may not repay the loan. The following non-arbitrage

[7] Conditional on the level of debt and interest rate.

condition is therefore satisfied in equilibrium:

$$\begin{aligned} & 1 + r^* = (1 - \pi)(1 + r) + \pi 0 \\ \iff & 1 + r^* = \left(1 - \frac{D_1(1 + r) - \phi p_{min}}{\phi(p_{max} - p_{min})}\right)(1 + r) \end{aligned}$$

Let $s \equiv p_{max} - p_{min}$ be the range of p_2, which determines the variance of the second-period terms of trade. Then, we can rewrite the non-arbitrage condition as a quadratic equation that implicitly describes the supply curve of debt faced by the economy:

$$D_1(1 + r)^2 - \phi(p_{min} + s)(1 + r) + \phi s(1 + r^*) = 0$$

The solution for this equation is given by:

$$r^s = \begin{cases} r^*, & \text{if } D_1 \leq 0 \\ \frac{\phi(s + p_{min}) - \sqrt{\phi^2(p_{min} + s)^2 - 4D_1\phi s(1 + r^*)}}{2D_1} - 1, & \text{if } 0 < D_1 \leq D_{max} \end{cases}$$

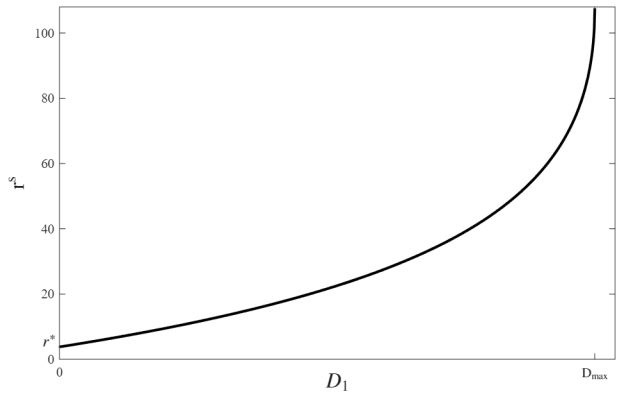
where r^s is the interest rate required by creditors and $D_{max} = \frac{\phi(p_{min} + s)^2}{4s(1 + r^*)}$ corresponds to the maximum debt for which there exists an interest rate that induces creditors to lend. For debt amounts above that level, the default probability is so high that no creditor would be willing to lend at any interest rate.

To illustrate the supply curve behavior, assume the following parameterization:[8] $p_{min} = 0.025, p_{max} = 12, \phi = 0.4, r^* = 4\%$. Figure 1 shows how required interest rates depend on the amount of external debt demanded by the economy. As the level of debt increases, the probability of default rises, leading to higher interest rates required by creditors.

Volatility Shock: Within this framework, we will analyze the effect of a shock to the volatility of the terms of trade on the supply of credit in this economy. Consider a mean-

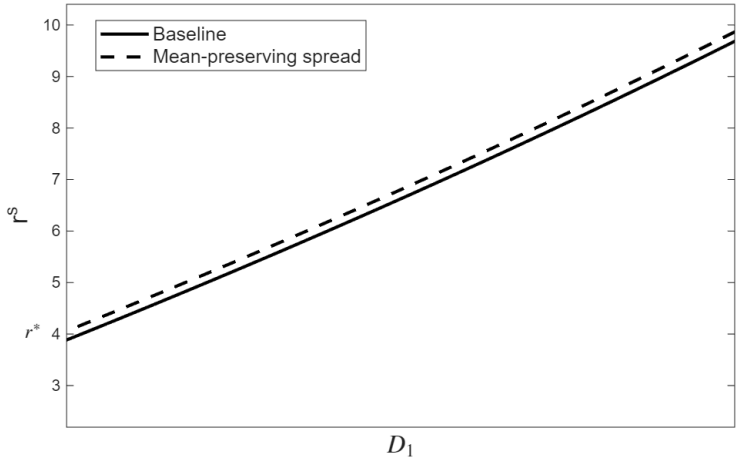
[8]Since this is not a quantitative model, the chosen parameterization is not very relevant. Reasonable values suffice to develop the intuition and mechanisms that are the purpose of this section.

Figure 1 Credit Supply Curve



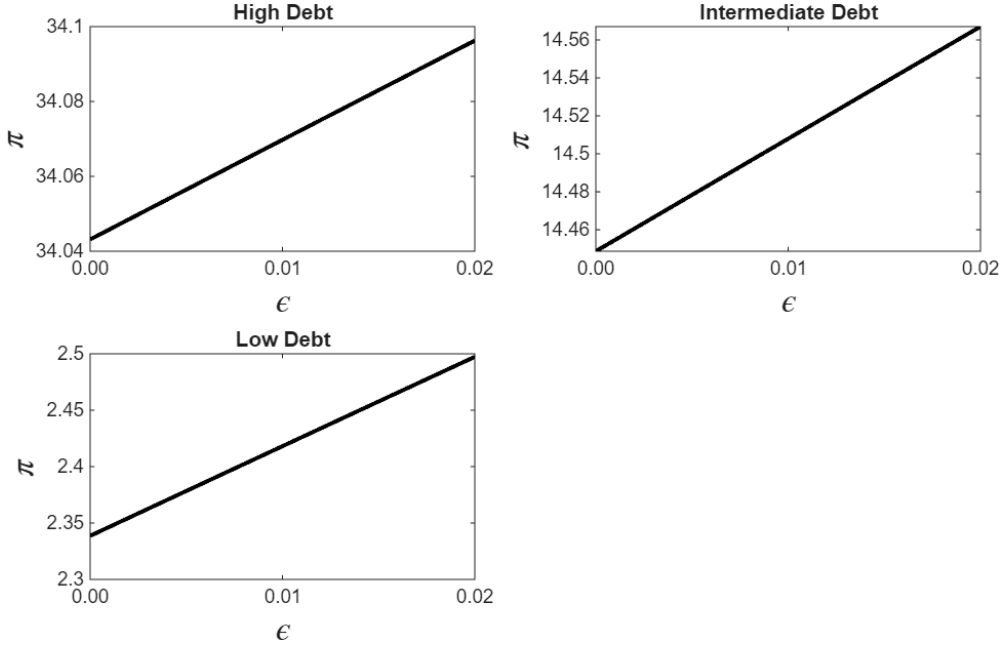
preserving spread in the model such that the variance of p_2 increases, but its expected value remains unchanged. This can be rationalized as an increase in p_{max} and a decrease in p_{min} by the same amount ϵ. For instance, assuming a value for $\epsilon = 0.02$, we are able to obtain a new credit supply curve. Figure 2 illustrates that under a mean-preserving spread, creditors demand higher interest rates for the same amount of borrowed debt. In other words, we observe a contraction of the credit supply curve. Even though creditors are risk-neutral, the supply of funds is declining because mean-preserving spreads are increasing the default probability. Indeed, Figure 3 shows that, regardless of the level of debt, there is a positive relationship between terms of trade volatility and default probabilities.[9]

Figure 2 Mean-preserving Spread



[9]One could argue that the effects are quantitatively small. While we acknowledge this concern, the primary objective of this straightforward framework is to cultivate an intuitive understanding of the relationship between terms of trade volatility and credit supply. Later in the paper, we present empirical estimates about the effect of terms of trade volatility on interest rates.

Figure 3 Default probability as a function of mean-preserving spreads



Formally, let us analyze the change in default probabilities when the economy faces mean-preserving spreads:

$$\pi = \frac{D_1(1+r) - \phi(p_{min} - \epsilon)}{\phi(p_{max} + \epsilon - (p_{min} - \epsilon))} = \frac{D_1(1+r) - \phi p_{min} + \phi\epsilon}{\phi(p_{max} - p_{min}) + 2\phi\epsilon}$$

Taking the derivative with respect to ϵ and evaluating at $\epsilon = 0$ yields:

$$\left.\frac{\partial \pi}{\partial \epsilon}\right|_{\epsilon=0} = \frac{\phi(p_{max} - p_{min}) - 2(D_1(1+r) - \phi p_{min})}{\phi(p_{max} - p_{min})^2}$$

The numerator governs the sign of the derivative (recall that $\phi > 0$), which means that the positive relationship between π and ϵ depends on whether the following is true:

$$\begin{aligned} & \phi(p_{max} - p_{min}) - 2(D_1(1+r) - \phi p_{min}) > 0 \\ \iff & \frac{p_{max} + p_{min}}{2} > \frac{D_1(1+r)}{\phi} \\ \iff & \mathrm{E}(p_2) > \frac{D_1(1+r)}{\phi} \end{aligned} \tag{3}$$

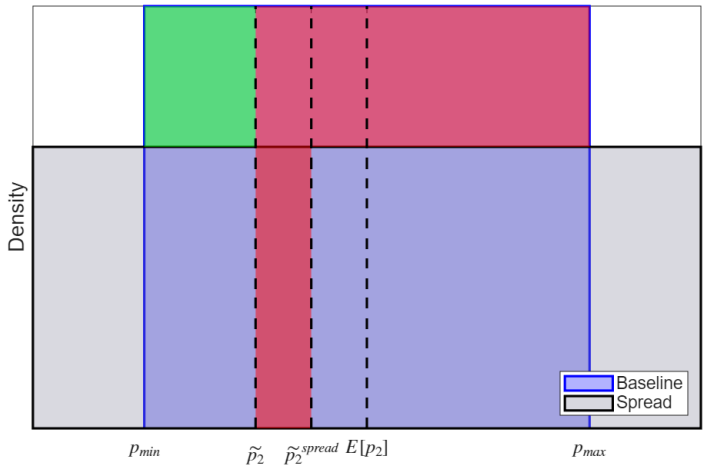
This condition is very similar to what we obtained in equation (1). That expression showed us the set of values for p_2 for which the economy decides to default. Therefore, based on (3), we observe a positive relationship between mean-preserving spreads and default probabilities if the economy chooses commitment when p_2 takes its expected value. Note that condition (3) only needs to be true for the combinations of (D_1, r) that lie on the credit supply curve. The rest of the combinations are not observed in equilibrium and therefore do not determine the effects of terms of trade volatility shocks.

In Appendix 7.1 we demonstrate that $p_{min} > 0$ is a sufficient condition for $\mathrm{E}(p_2) > \frac{D_1(1+r)}{\phi}$ to hold. In other words, if p_2 takes its expected value and $p_{min} > 0$, then the economy prefers to commit at every equilibrium combination of (D_1, r). Since p_{min} is a relative price, $p_{min} > 0$ holds at all times. Consequently, condition (3) is satisfied and we are able to identify a positive relationship between terms of trade volatility and the interest rates required by creditors. We refer to this relationship as the **default premium channel**. Intuitively, condition (3) tells us that in order to rule out default as the expected conditional outcome, creditors restrict their offers to contracts that encourage the economy to commit when the terms of trade take their expected value. They demand a combination of (D_1, r) to ensure commitment as the expected outcome given this combination. Therefore, in equilibrium we never observe that $\mathrm{E}(p_2) < \frac{D_1(1+r)}{\phi}$.

It is not obvious why default probabilities increase in the presence of mean-preserving spreads. To facilitate the analysis, let us examine the distributions of p_2 before and after the shock. Figure 4 shows the original distribution (outlined in blue) and the new distribution (outlined in grey/black). Note that the expected value of p_2 does not change with the spread and that a new element, $\tilde{p_2}$, is shown. This value represents the threshold of p_2 at which the economy defaults when $D_1 = D_{max}$. Therefore, for any value of p_2 above that threshold, the economy commits with certainty. Anything that ensures commitment is highly desirable for the creditor. Consequently, the entire mass of probabilities to the right of the threshold leaves the creditor in a better situation. Note that under the new distribution, the entire

red area at the top is lost, and in addition, as the threshold moves to the right, due to the mean-preserving spread,[10] the red area between the thresholds is also lost. The only compensation lies in the green area, representing scenarios in which default could occur, so its elimination leaves the creditor better off. Overall, the mass of probability to the right of the baseline threshold lost under the new distribution is greater than the mass gained. Now it is less likely that commitment will occur with certainty. Hence, the unconditional default probability increases, which explains why creditors demand higher interest rates for the same amount of borrowed debt, even when they are risk-neutral.

Figure 4 Distribution of second-period terms of trade (p_2)

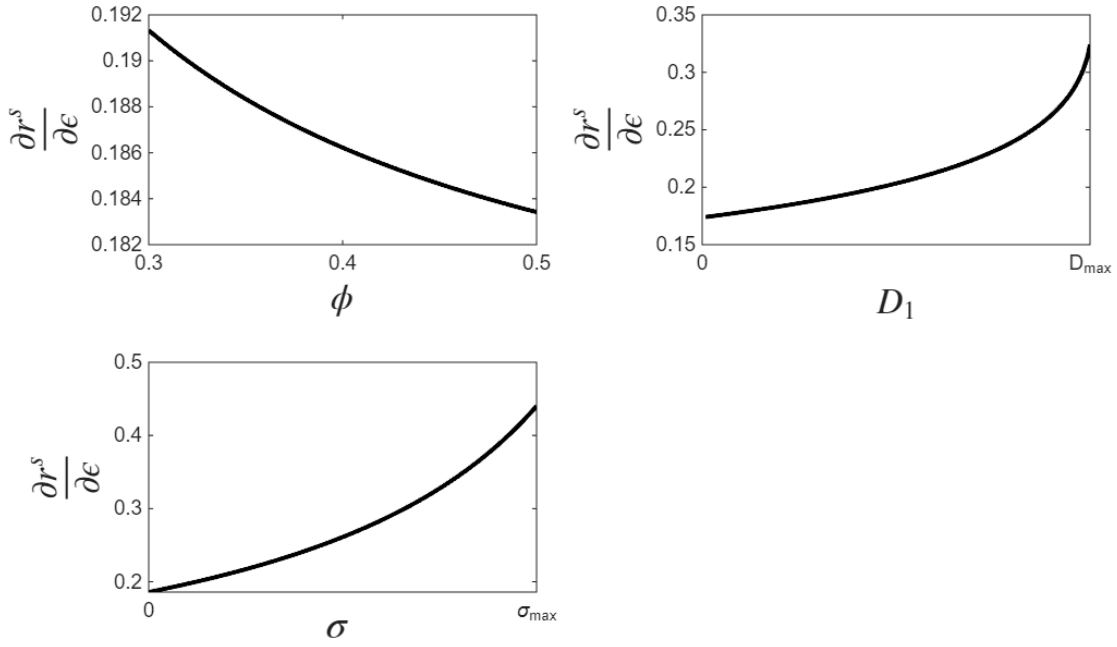


We should emphasize that the existence of the default premium channel does not depend on the choice of the uniform as the terms of trade distribution. In Appendix 7.2 we show that when assuming a log-normal distribution for the terms of trade with the same expected value and variance as the uniform, we also observe a contraction in credit supply in the event of a mean-preserving spread. Therefore, the conclusions and insights obtained so far are robust to the choice of distribution. We opted for a uniform distribution due to its simplicity, as this facilitates mathematical derivation and enables us to obtain closed forms, allowing us to focus primarily on the intuition and mechanisms.

[10] Appendix 7.1 shows that $\tilde{p_2}(D_{max}) = \frac{p_{max}}{2}$, which means that as p_{max} increases under mean-preserving spreads, the threshold also increases. However, note that if $p_{min} > 0$, then the expected terms of trade $\mathrm{E}(p_2) = \frac{p_{min}+p_{max}}{2}$ is always greater than the threshold. This result is endogenously caused by creditors to induce commitment as the expected outcome.

Determinants: Finally, Figure 5 illustrate the elements that determine the default premium channel, i.e. the elements that cause the credit supply response to vary in the event of a terms of trade volatility shock. The results show that, as debt increases and the penalty for default decreases, the impact of volatility shocks on the rate required by creditors increases. This is because high values of D_1 and low values of ϕ increase the default probability, as shown in equation (2). Consequently, economies with relatively high levels of debt and low penalties for default should be more vulnerable to terms of trade volatility shocks. Additionally, until now we have assumed that creditors are risk-neutral. However, it is important to analyze how the level of risk aversion affects the impact of terms of trade volatility on interest rates. Therefore, we also study how the default premium channel depends on the level of aversion, as measured by the coefficient σ of a CRRA (Constant Relative Risk Aversion) utility function that we assume for creditors. The bottom panel of Figure 5 demonstrates that as creditors become more risk-averse, the greater the pass-through of volatility to required interest rates. Since terms of trade volatility shocks make payoffs riskier, risk-averse creditors demand higher compensation to satisfy the desired level of debt in the economy.

Figure 5 Determinants of the default premium channel



With this simple model we illustrated how a terms of trade volatility shock increases the default probability and decreases the credit supply. In Appendix 7.3, we show how a terms of trade level shock takes place in the model. Negative shocks to the level also generate increases in the default probability and contractions in supply. Although shocks to the level and volatility generate similar effects, in this model we demonstrate that volatility alone can generate greater financial constraints. In the following sections, we therefore proceed to study the effects of terms of trade volatility on the business cycles of emerging economies, distinguishing between common and idiosyncratic volatility, and recognizing the default premium channel as one of the channels through which volatility shocks are transmitted.

3 Identification

Given the theoretical relationship found between terms of trade volatility and interest rates, and our interest in differentiating between common and idiosyncratic components, in this section we describe how we isolate a common factor in commodity-based terms of trade from emerging economies, how we identify terms of trade volatility and its innovations, and we carry out a brief descriptive exercise of the default premium channel. The section is divided as follows. First, we decompose each country's terms of trade into common and idiosyncratic factors, describing the data to be used, the methodology, and the results. Second, we estimate the volatility of the terms of trade components of emerging economies, describing our identification strategy and the estimated results. And third, to study the existence of the default premium channel in the data, as a first approximation we analyze the relationships between our estimated volatility measures and financial variables.

3.1 Principal Components

To identify the common factor of the terms of trade of emerging economies, we follow the approach taken by Fernández et al. (2018), who identify the common factor of the main export prices of emerging economies through Principal Component Analysis. Once the common factor has been recovered, we will refer to the part of each country's terms of trade not explained by the common factor as the idiosyncratic component.

Data: The terms of trade data we use comes from the International Monetary Fund (IMF) Commodity Terms of Trade database.[11] We work with data from 12 emerging economies,[12] based mostly on the sample studied by Fernández et al. (2018). They classify economies as emerging if they have observations from JP Morgan's EMBI spread, which leaves them with a sample of 61 countries. However, due to data availability, they study in detail a reduced sample of 13 economies. The data frequency is monthly and covers the period from 1980-1 to 2019-12. Finally, given that stationary series are required to perform the PCA, each country's terms of trade was log-quadratic detrended. Otherwise, when working with non-stationary series, the PCA results could be spurious, overestimating the importance of the common factor.

Methodology: Let tot_{it} be the terms of trade for country i in period t. Following the exposition in Ludvigson and Ng (2009), a factor model for $i = 1, ..., N$ and $t = 1, ..., T$ is defined as:

$$tot_{it} = \lambda_i' f_t + e_{it} \tag{4}$$

Here, λ_i represents the factor loadings, which correspond to the vector of weights that country i places on the common factor f_t. The term e_{it} refers to the idiosyncratic component

[11] Specifically, we look at terms of trade based exclusively on commodities using the Commodity Net Export Price Index, Individual Commodities Weighted by Ratio of Net Exports to GDP, Recent, Rolling Weights, Index series.

[12] Argentina, Brazil, Bulgaria, Chile, Colombia, Ecuador, Indonesia, Malaysia, Mexico, Peru, South Africa, and Venezuela.

of the terms of trade. Both the common factor, f_t, and the idiosyncratic components, e_{it}, can follow dynamic processes. Additionally, the idiosyncratic dynamics of e_{it} may be cross-sectionally correlated.

Intuitively, f_t determines the portion of each country's terms of trade that is common to all countries. The idiosyncratic component, e_{it}, corresponds to the fraction of the terms of trade that cannot be explained by this common factor. We estimate equation (4) using PCA, and we only consider the first principal component, as our objective is to decompose each country's terms of trade into two distinct parts: a common component and an idiosyncratic component. We describe in more detail the PCA methodology in Appendix 7.4.

Factors: Since we will be working with national account series in the following sections, we average the common and idiosyncratic factors obtained through PCA at quarterly frequency. Figure 6 illustrates the dynamics of the common factor f_t (in blue), together with the terms of trade series for each country. This factor explains around 41%[13] of the sample variance,[14] reflecting the existence of a co-movement in the commodity-based terms of trade of emerging economies. As robustness exercises, (i) we estimated the common factor using terms of trade data from an extended sample of 49 emerging countries, and (ii) by examining export price indices[15] instead of terms of trade. For the latter, we analyzed the baseline sample of 12 economies and the expanded sample of 49 countries. In all cases, we obtained a common factor that was very similar to the factor obtained using the sample of 12 countries and terms of trade data, with contemporaneous correlations of at least 0.89. In Appendix 7.6, we show all the common factors under the different samples and definitions.

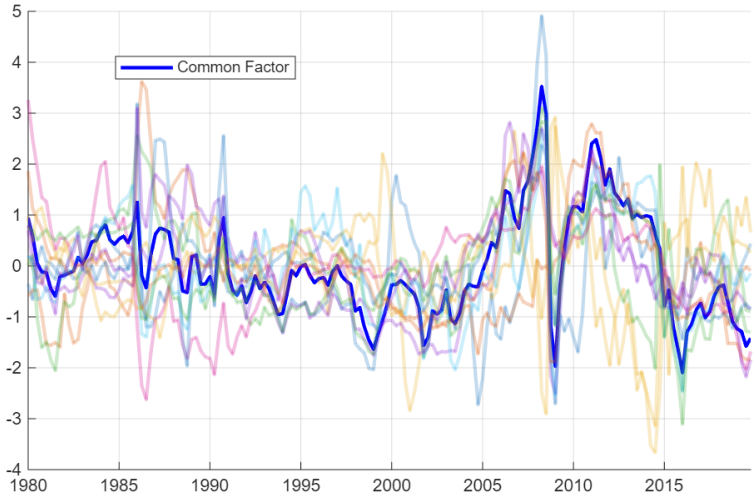
The commodity-based terms of trade common factor correctly identifies the deterioration of prices during the Asian financial crisis of the late 1990s, the sharp decline during the

[13] This figure is lower than the 59% found by Xia and Zhou (2023). However, their analysis considers not only emerging economies but also advanced ones.

[14] Appendix 7.5 reports the proportion of each country's variance that is explained by the common factor.

[15] The series used in this case are obtained from the same source as the terms of trade data, and correspond to Commodity Export Price Index, Individual Commodities Weighted by Ratio of Exports to GDP, Recent, Rolling Weights, Index.

Figure 6 Common factor of EMEs terms of trade (blue) along with each terms of trade series



Great Recession, and the sustained decrease between 2012 and 2015. It also captures the commodity boom of the early 2000s, which was generated in part by the significant increase in demand for raw materials from China. And finally, the common factor identifies the rapid recovery of emerging economies' terms of trade after the 2008–2009 crisis. Therefore, our estimated common factor is consistent with the overall behavior of commodities and the terms of trade in emerging economies.

As mentioned in Section 2 and shown in Appendix 7.3, terms of trade level shocks affect the capacity of emerging economies to repay their external debt. Negative shocks increase the default probability and the rates required by creditors. Therefore, using the EMBI spread as a proxy for emerging economies default risk premiums, we study the correlation between the common/idiosyncratic terms of trade factors with the EMBI spread of each country. One would expect that the higher the level, the lower the premium required, and vice-versa. Indeed, Table 1 shows the median contemporaneous correlations between the series, confirming a negative relationship between default risk premiums and terms of trade components. However, the common factor appears to be more related to the EMBI spread, in comparison to the idiosyncratic factor.

Note: Total refers to terms of trade without separating between common and idiosyncratic factors.

The results obtained are consistent with the predictions of the theoretical framework and also with the empirical literature. For instance, Fernández et al. (2018), Boehm et al.

Table 1 Cross-country median correlations between EMBI spreads and commodity based terms of trade components

Terms of Trade	EMBI Spread
Common Factor	-0.35
Idiosyncratic Factor	-0.17
Total	-0.32

(2021), and Drechsel and Tenreyro (2018) identify negative relationships between interest rates and commodity prices. Similarly, Bastourre et al. (2012) examine common factors in commodity prices and emerging market spreads, finding that commodity prices are among the most significant determinants of sovereign spreads in commodity-exporting countries.

Using the factors obtained in this section, we proceed to estimate the volatility and first- and second-moment shocks to the terms of trade for both the common and idiosyncratic components.

3.2 Particle Filter

We use a particle filter to estimate the volatility of the components of each country's terms of trade (see Fernández-Villaverde and Rubio-Ramirez, 2007 for a general and detailed description of this type of filter). This tool allows us to estimate nonlinear models, separately identify shocks to the level and volatility (Fernández-Villaverde and Rubio-Ramirez, 2013), and has been used previously to estimate time-varying volatility in macroeconomic series in other contexts (see Fernández-Villaverde et al., 2011, 2015).

Structure: To estimate the terms of trade volatility at the country level, we must first distinguish between the common factor f_t, which is a single time series for the entire group, and each country's common component ω_{it}. Following the notation from equation (4), let $x_{it} = \{\omega_{it}, e_{it}\}$ be the terms of trade decomposition for a given country i. We define ω_{it} as the portion of country i's terms of trade attributable to the common factor, satisfying $\omega_{it} = \lambda_i' f_t$. While f_t is one series, ω_{it} is a country-specific series because the factor loading λ_i measures each economy's exposure to the common factor. Since we are interested in separating each

country's terms of trade into common and idiosyncratic components, we focus on ω_{it} rather than f_t. Assume that each component $x_{it} = \{\omega_{it}, e_{it}\}$ follows an autoregressive process as:[16]

$$x_t - x = \rho_x(x_{t-1} - x) + exp(\sigma_t^x)\epsilon_t^x, \qquad \epsilon_t^x \sim N(0,1) \tag{5}$$

where x is the unconditional mean of x_t, ρ_x is the persistence of the process, $exp(\sigma_t^x)$ is the time-varying volatility of the component, and ϵ_t^x is a terms of trade component level shock.

We model a law of motion for the log-volatility σ_t^x:

$$\sigma_t^x = \alpha_x + \rho_{\sigma^x}\sigma_{t-1}^x + \eta_x\nu_t^x, \qquad \nu_t^x \sim N(0,1) \tag{6}$$

where ρ_{σ^x} corresponds to the log-volatility's persistence, ν_t^x is a terms of trade component volatility shock, and η_x determines the standard deviation of a terms of trade component volatility shock.

In order to estimate the processes and identify the shocks, we require the following parameterization:

$$\begin{aligned}
\alpha_x &\equiv (1 - \rho_{\sigma^x})\pi_x \\
\rho_{\sigma^x} &\equiv \frac{exp(\overline{\rho}_{\sigma^x})}{exp(\overline{\rho}_{\sigma^x}) + 1} \\
\eta_x &\equiv (1 - \rho_{\sigma^x}^2)^{1/2} exp(\overline{\eta_x})
\end{aligned}$$

Under this structure, the average standard deviation of a level shock is given by $exp(\pi_x)$.

Estimation: Using the Liu and West (2001) version of the particle filter, we simultaneously estimate for each country the unobserved state σ_t^x and the parameters ρ_x, π_x, $\overline{\rho}_{\sigma^x}$, and $\overline{\eta_x}$. We use 100,000 particles, and as priors we follow Roch et al. (2025),

[16] We omit the subscript i to ease notation.

choosing $U(0,1)$ distributions for both ρ_x and $\overline{\rho}_{\sigma^x}$, a $U(-3,0)$ distribution for $\overline{\eta_x}$, and a normal distribution for π_x with a variance of 0.2 and a mean equal to the log-standard deviation of the OLS estimated residuals of (5). With the resulting estimations of σ_t^x and the parameters, we identify the level and volatility shocks as the innovations to the processes (5) and (6) respectively. We run the particle filter on the common terms of trade component ω_{it} and on the idiosyncratic terms of trade component e_{it} of the 12 economies separately.

Results: Table 2 reports the median estimates for the parameters, along with the 95% probability intervals. To avoid overwhelming the analysis by showing the results for the 12 economies separately, we choose to display the cross-country median estimates. In other words, we first estimate the particle filter for every country, both for the common and idiosyncratic parts of its terms of trade, and then we report the results as the cross-country medians of the estimated parameters. We report the country-specific estimates in Appendix 7.7.

Table 2 Median parameter estimates

Component	ρ_x	π_x	$\overline{\rho}_{\sigma^x}$	$\overline{\eta_x}$
Common	0.91 $[0.85, 0.98]$	-5.68 $[-5.83, -5.51]$	0.76 $[0.26, 1.24]$	-0.62 $[-1.00, -0.25]$
Idiosyncratic	0.89 $[0.81, 0.96]$	-5.48 $[-5.67, -5.27]$	0.75 $[0.21, 1.27]$	-0.70 $[-1.09, -0.36]$

Note: We report in brackets the 95% probability intervals associated to each estimation. Each row displays the cross-country median estimates obtained with the particle filter.

For the median country, the estimated parameters for the common and idiosyncratic processes are not statistically different. We observed a high persistence in both the common component (0.91) and the idiosyncratic component (0.89) of the terms of trade.[17] The estimated volatility of both components presents practically the same median persistence, reaching a value of $\frac{exp(0.76)}{exp(0.76)+1} \approx 0.68$ (however this parameter is identified less

[17]Recall that we are currently working with quarterly series. In the previous section we averaged the monthly components to a quarterly frequency to match the frequency of the national accounts data that we will use in the following sections.

precisely than the others). The average standard deviation of the shocks to the common and idiosyncratic terms of trade is approximately $100 \times exp(-5.68) \approx 0.34$ percentage points and $100 \times exp(-5.48) \approx 0.42$ percentage points respectively. The median estimate for $\overline{\eta_x}$ implies that a positive one-standard-deviation common volatility shock ν_t^{ω} increases the common level shock standard deviation to about 0.51 percentage points $(100exp(-5.68 + (1 - 0.68^2)^{(1/2)}exp(-0.62)))$, whereas a positive one-standard-deviation idiosyncratic volatility shock ν_t^{e} increases the idiosyncratic level shock standard deviation to about 0.6 percentage points $(100exp(-5.48 + (1 - 0.68^2)^{(1/2)}exp(-0.70)))$.

Figure 7 illustrates the estimated common terms of trade volatility, along with the 95% probability interval.[18] Similarly to Gómez-González and Rees (2013) and Xia and Zhou (2023), we find evidence that terms of trade volatility varies over time. The standard deviation of common level shocks increased during the mid-1980s and again in the mid-2010s, while remaining relatively stable during the 1990s. Most striking is the significant increase in common terms of trade volatility during the Great Recession. Recall that the average standard deviation of common shocks is only 0.34 percentage points.[19] During the crisis, however, the standard deviation increased to approximately 2 percentage points, amplifying the size of common terms of trade level shocks throughout this period.

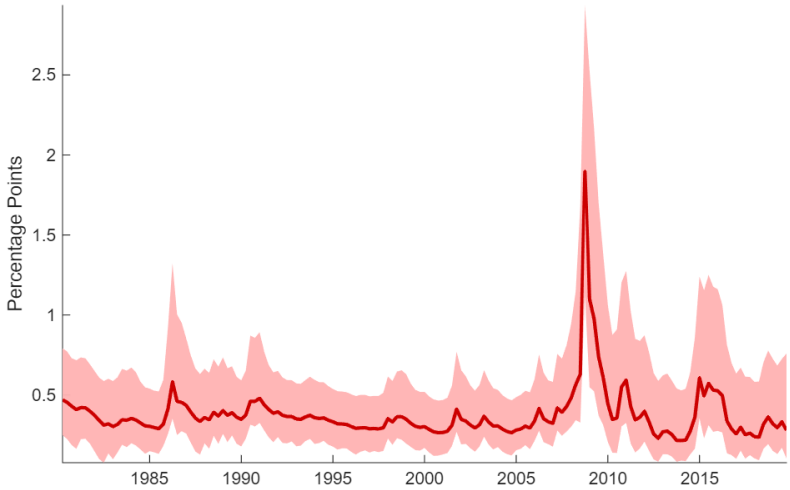
According to the theoretical framework analyzed in Section 2, volatility affects the default probability in economies facing uncertain terms of trade. Terms of trade volatility increases can deteriorate the capacity of emerging economies to repay their debt and accrued interests, negatively affecting their ability to borrow and increasing the risk premiums and interest rates required by creditors. The following sections empirically examine this positive relationship between terms of trade volatility and default risk premiums/interest rates predicted by the theoretical framework. We study this possibility using both simple descriptive statistics

[18] To graphically illustrate the series, we use the smoother from Godsill et al. (2004). However, for the rest of the paper we use the raw estimates obtained with the particle filter.

[19] Di Pace et al. (2025) highlight that excluding the contribution of manufacturing to both export and import prices overstates their volatility and results in less volatile terms of trade. Therefore, since we are working with commodity-based terms of trade, our estimated volatility should be comparatively lower than that estimated for a broader definition of terms of trade.

and vector autoregressive models augmented with the shocks and time-varying volatilities estimated in this section, with the latter also allowing us to estimate the effects of terms of trade volatility on emerging economies business cycles.

Figure 7 Common Terms of Trade Volatility



Note: The figure displays the smoothed median common terms of trade volatility $(100 \times exp(\sigma_t^{\omega}))$*, along with the 95% probability interval obtained with the particle filter.*

3.3 Descriptive Analysis

To analyze the relationship between volatility and default risk premiums, we first examine the contemporary correlation between the estimated terms of trade volatility and the EMBI spread for each economy, similar to what we did in Section 3.1 for the terms of trade level analysis. The first column of Table 3 confirms a positive relationship between terms of trade volatility and default risk premiums. The median correlations of the EMBI Spread with common and idiosyncratic terms of trade volatility are 0.3 and 0.1 respectively. These correlations differ statistically at a 5% significance level, implying that default risk premiums are more related to common volatility than idiosyncratic volatility (we found in previous sections that this feature also holds for common/idiosyncratic terms of trade level). These findings are consistent with the theoretical framework, which identified volatility as a determinant of default probabilities and required interest rates, and with the conclusions of Catao and Sutton (2002) and Hilscher and Nosbusch (2010).

Terms of trade volatility could be influenced by movements in levels of uncertainty and global volatility. For this reason, in Table 3 we also analyze the correlation of terms of trade volatility with the Federal Reserve Bank of St. Louis' VIX index (VIX) and with the estimated volatility of the Global Financial Cycle (GFC Vol). We estimate the latter by applying the same particle filter methodology (described in Section 3.2) to the Global Financial Cycle Factor found by Miranda-Agrippino and Rey (2020). We interpret this and the VIX series as proxies for global financial volatility and uncertainty. We find positive relationships between estimated terms of trade volatility and measures of financial volatility, with common terms of trade volatility again being most strongly related to the global series.

Table 3 Cross-country median correlations between commodity based terms of trade/volatility components with EMBI Spreads and global financial measures

Component	EMBI Spread	VIX	GFC Vol	NFCI	FSI
Common Terms of Trade	-0.35	-0.15	0.08	0.05	-0.10
Idiosyncratic Terms of Trade	-0.17	0.08	0.09	0.07	0.09
Total Terms of Trade	-0.32	-0.07	0.11	0.08	0.00
Common Volatility	0.30	0.47	0.54	0.39	0.69
Idiosyncratic Volatility	0.10	0.20	0.17	0.26	0.32
Total Volatility	0.17	0.26	0.29	0.31	0.43

Note: Total Terms of Trade (Volatility) refers to terms of trade (volatility) without separating between common and idiosyncratic. VIX corresponds to the VIXCLS series obtained from the Federal Reserve Bank of St. Louis. GFC Vol is the estimated volatility of the Global Financial Cycle Factor from Miranda-Agrippino and Rey (2020). NFCI is the Chicago Fed National Financial Conditions Index and FSI is the St. Louis Fed Financial Stress Index. Both obtained from the Federal Reserve Bank of St. Louis database.

If volatility causes credit supply to contract and interest rates to rise, we could expect environments of greater terms of trade volatility, especially of the common component, to coincide with scenarios of tighter financial conditions. Indeed, the last two columns of Table 3 show that estimated volatilities correlate positively with both the Chicago Fed National Financial Conditions Index (NFCI) and the St. Louis Fed Financial Stress Index (FSI),[20] implying that scenarios of higher volatility coincide with environments of greater financial

[20]Both series were obtained from the Federal Reserve Bank of St. Louis database.

constraints. Common volatility has a correlation of 0.69 and 0.32 with the NFCI and FSI respectively, showing that common volatility may effectively capture some global volatility events.

In this section, we found that terms of trade volatility is indeed positively related to default risk premiums in emerging economies and to aggregate measures of volatility and financial tightening. Additionally, we documented that common volatility is more strongly related to country-specific EMBI spreads than idiosyncratic volatility. One possible interpretation of this result is that creditors penalize systematic risk to a greater extent. Environments of greater global uncertainty could lead to increases in risk aversion levels and, consequently, to higher required premiums. If the default premium channel is more important in the face of common volatility than of idiosyncratic volatility, then common volatility shocks could have a more significant effect on the business cycles of emerging economies. In the following section, we explore this possibility and study the relationship between volatility and the interest rates faced by these countries in greater detail.

4 VAR Model

In this section, we empirically study vector autoregressive models (VAR) to analyze the qualitative and quantitative effects of terms of trade volatility shocks on the business cycles of emerging economies, using the volatility measures and shocks estimated in the previous section. First, we describe the data to be used in the empirical strategy. Second, we present the VAR model. And third, we analyze the Impulse Response Functions (IRFs) and Forecast Error Variance Decompositions (FEVD) in response to a terms of trade volatility shock, distinguishing between common and idiosyncratic shocks.

4.1 Data

We use country-specific macroeconomics series from the IMF International Financial Statistics (IFS) database. Specifically, we consider the seasonally adjusted quarterly series of Nominal Gross Domestic Product (GDP), Nominal Gross Fixed Capital Formation (investment), and Nominal Trade Balance. Each was deflated using the GDP deflator. Output and investment were log-quadratically detrended, while the trade balance was deflated by the exponent of the output trend and subsequently removed from its quadratic trend, similar to the transformations performed by Schmitt-Grohé and Uribe (2017). We compute a series representing domestic interest rates as the sum of the 10-year U.S. interest rate and the domestic spread, measured by the J.P. Morgan's Emerging Market Bond Index (EMBI). Since the literature has found evidence that global financial conditions significantly determine the transmission of external shocks to emerging economies (Akinci, 2013), we also include in the VAR U.S. BAA Corporate Spread data obtained from the Federal Reserve Bank of St. Louis (BAA10Y). Finally, according to Catao and Sutton (2002), terms of trade volatility could affect the ability of economies to repay their debt through the real exchange rate (RER). RER depreciations may affect debt servicing capacity and hence sovereign risk. For that reason, we include country-specific real exchange rates series obtained from the Bank for International Settlements (BIS). These series were also log-quadratically detrended.

4.2 Model

Similar to Gómez-González and Rees (2013) and Roch et al. (2025), we model a VAR system containing both endogenous and exogenous blocks of the form:

$$Y_{i,t} = F_i + C(L)Y_{i,t-1} + B(L)\nu_{i,t} + \epsilon_{i,t} \tag{7}$$

where $Y_{i,t}$ is the vector of endogenous variables for country i, $\nu_{i,t}$ denotes the vector of

terms of trade level- and volatility shocks for country i, both for the common and idiosyncratic components, $B(L)$ quantifies the effects of these shocks on the endogenous block of variables, F_i is a matrix that controls for fixed effects at the country level, and $\epsilon_{i,t}$ is a vector of innovations with white noise processes.

Under this specification, the endogenous block $Y_{i,t}$ is made up of both domestic series (GDP, investment, trade balance, domestic interest rate and real exchange rate) and external series (BAA spread, terms of trade level,[21] common terms of trade volatility, and idiosyncratic terms of trade volatility). In addition, we impose certain restrictions on the dynamics of the model. Since the BAA spread is an international variable, we impose that it does not react to the domestic variables of emerging countries. Similarly, given that in Section 3.2 we assume that the level and volatility of the terms of trade follow independent and exogenous processes, we impose a restriction in the VAR that these series only respond to their own shocks and lags.

We estimate equation (7) as a pool VAR with quarterly data from 10 emerging economies,[22] using the Least Square Dummy Variable (LSDV) estimator, between the period 1995-1 and 2019-4,[23] assuming that $C(L)$ and $B(L)$ do not vary between countries. We consider four lags for domestic variables and one lag for external series, to maintain consistency with the processes in Section 3.2.[24] The total number of observations is 799. Since we recover both level- and volatility shocks in the particle filter, we do not need to impose additional restrictions in the VAR.

[21] To avoid losing precision by including too many variables in the system, we do not distinguish between the common and idiosyncratic components of the terms of trade level, but rather include the total directly. However, we do distinguish between common and idiosyncratic terms of trade volatility.

[22] Same country selection as in Section 3.1, but we exclude Bulgaria from the analysis for being an outlier in investment dynamics and Venezuela due to a lack of available data. Therefore, the pool VAR includes data from Argentina, Brazil, Chile, Colombia, Ecuador, Indonesia, Malaysia, Mexico, Peru, and South Africa.

[23] We use a different sample period for the VAR than for the principal component analysis and particle filter because EMBI spread observations begin in the 1990s.

[24] As robustness exercises, we also study the VAR with (i) four lags for all variables, (ii) following an information criterion (IC) that delivered a more parsimonious number of lags (two). In either case, the main results and conclusions remain unchanged.

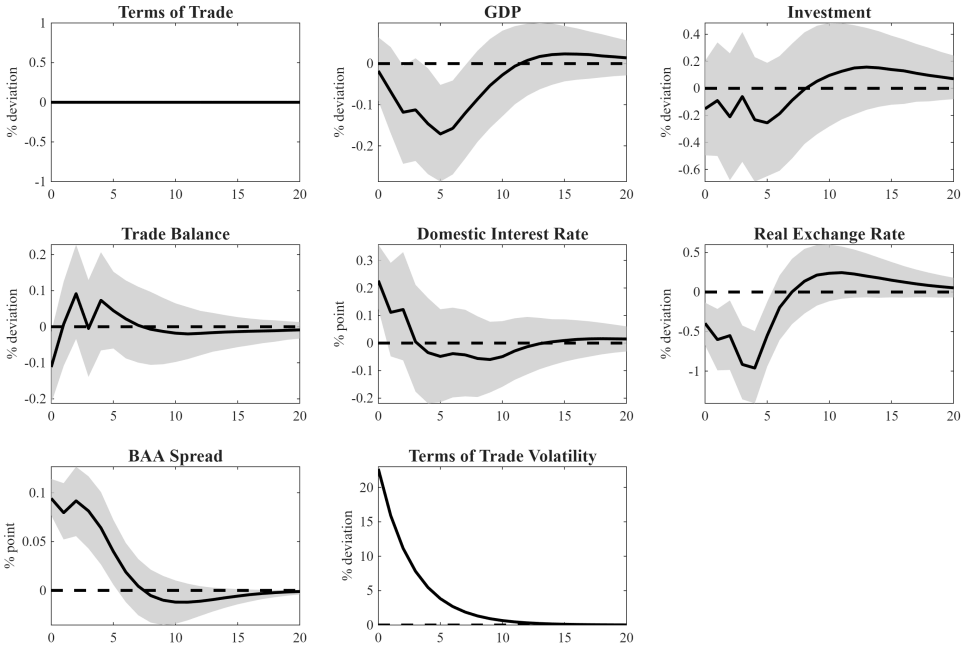
4.3 Impulse-Responses

To understand the effects of volatility, we first study the impulse-response functions to a one-standard-deviation terms of trade volatility shock, without distinguishing between common and idiosyncratic components. We set the horizon for the responses at 20 quarters. Figure 8 shows that terms of trade volatility causes a lagged decline in GDP of 0.2% and falls —albeit not significant ones— in investment and the trade balance. Volatility also generates a 1% depreciation in the real exchange rate and a 0.1 percentage point increase in the BAA spread, indicating the existence of tighter financial conditions. More importantly, as predicted by the model in Section 2, terms of trade volatility causes a 0.2 percentage point increase in interest rates, empirically validating the existence of a default premium channel. The recessionary effect of volatility could be caused both by a precautionary savings channel and by the increase in interest rates required by the market. In Appendix 7.3 we theoretically demonstrated that negative terms of trade level shocks should also generate an increase in interest rates and produce recessionary outcomes. Therefore, in Appendix 7.8, we estimate the impulse-responses against a one-standard-deviation negative terms of trade level shock. Similarly to terms of trade volatility shocks, level shocks produce interest rate increases, as well as falls in GDP and investment, and real exchange rate depreciations. Hence, as predicted in Section 2, both level and volatility shocks can independently generate higher risk premiums.

We now proceed to estimate the effects of volatility, distinguishing between common and idiosyncratic shocks. As shown in Figure 9, the main macroeconomic variables of emerging economies react significantly to a common terms of trade volatility shock. Output and investment fall by 0.4% and 0.7% respectively. The trade balance improves by 0.2%, the real exchange rate depreciates by 1%, and the BAA spread increases by around 0.2 percentage points. Similarly, the domestic interest rate increases by 0.4 percentage points on impact, in line with the default premium channel.

In contrast, Figure 10 shows that idiosyncratic volatility shocks do not have such a

Figure 8 Impulse-responses for a one-standard-deviation terms of trade volatility shock



Note: 90% confidence bands in light-grey computed through 1,000 bootstrap replications.

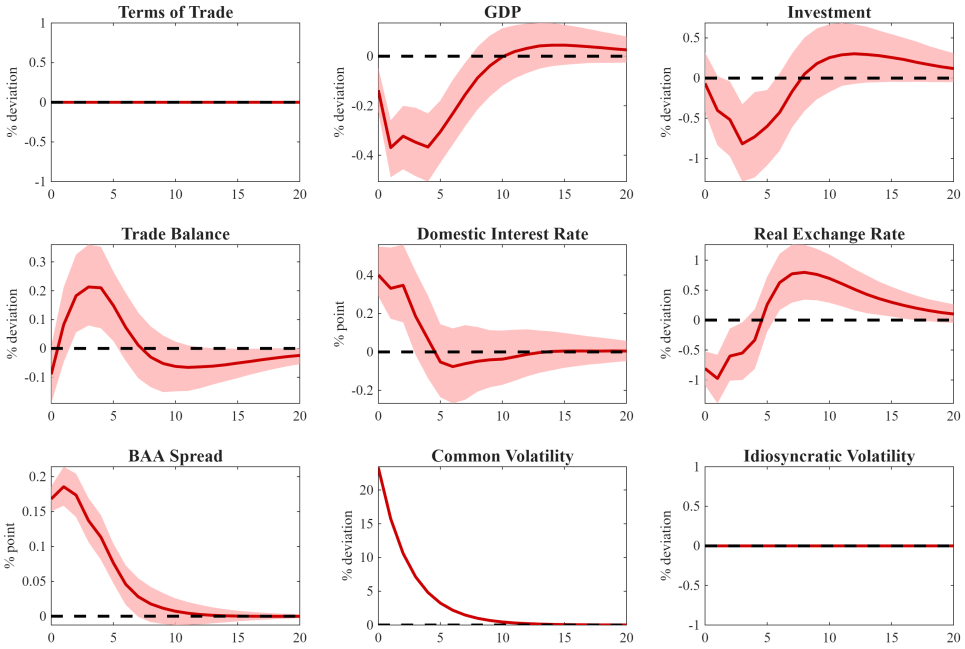
significant and important effect, with most responses being not statistically significant.[25] Only the depreciation of the real exchange rate and the deterioration of the trade balance are statistically different from zero. Therefore, we can conclude that common shocks are the ones driving the effects of total volatility shocks, shown in Figure 8. Idiosyncratic shocks do not have significant effects,[26] and in the following section, when analyzing variance decompositions, we formally evaluate the relevance of each component for explaining emerging economies business cycles. The finding that the effects of common shocks are more significant is consistent with Section 3.3, where we found that country-specific EMBI spreads are more related to common volatility than to idiosyncratic volatility.

There is a possibility that the estimated terms of trade volatility is essentially capturing

[25]The response of the domestic interest rate could be driven by changes in the US interest rate and/or movements of the EMBI spread. To demonstrate that EMBI spreads are reacting to the shocks, in Appendix 7.9 we show the impulse-responses when the EMBI spread is included directly into the VAR. As expected, EMBI spreads increase under total and common terms of trade volatility shocks while remaining constant under idiosyncratic ones. Therefore, the responses of the domestic interest rate shown in the main text are mainly driven by the EMBI spread responses.

[26]**?** arrives to the same conclusion but for terms of trade level shocks. While a positive terms of trade global shock produces a 0.2% real output expansion, idiosyncratic shocks only expand production by 0.02%.

Figure 9 Impulse-responses for a one-standard-deviation common terms of trade volatility shock

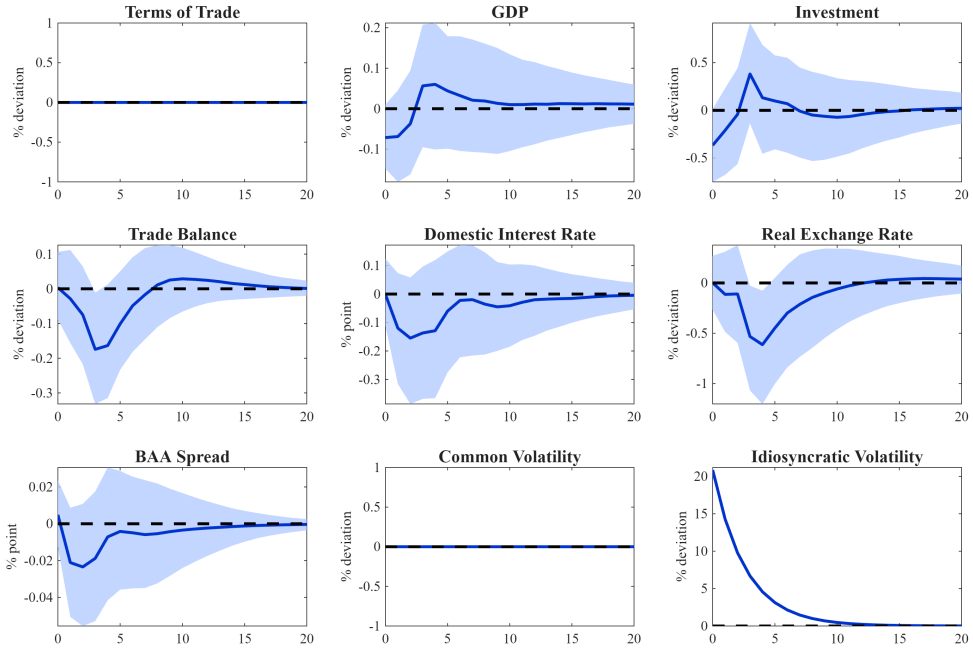


Note: 90% confidence bands in light-red computed through 1,000 bootstrap replications.

the same type of volatility captured by the VIX Index or other aggregate uncertainty series. We decided to include the BAA spread in the VAR to control for aggregate conditions, addressing this concern and demonstrating that the results are robust to the inclusion of this type of variable. Furthermore, as an additional robustness exercise, we replaced the BAA spread in the system with the VIX index to explicitly control for a global volatility series. The results obtained, reported in Appendix 7.10, are identical to those in Figures (9) and (10), validating our results and conclusions. Table 3 already showed that, although the estimated measures of terms of trade volatility correlated positively with measures of global volatility, the correlations were far from unitary values, indicating that terms of trade have their own volatility, distinct from that of other macroeconomic series.

Finally, we estimate the impulse-responses of figures (9) and (10) under Local Projections (Jordà, 2005), testing the validity of our results under an alternative econometric strategy. In Appendix 7.11, we show the effects of common- and idiosyncratic terms of trade volatility shocks on the main macroeconomic variables of emerging economies, using Local Projections, following the same restrictions and specifications as the

Figure 10 Impulse-responses for a one-standard-deviation idiosyncratic terms of trade volatility shock



Note: 90% confidence bands in light-blue computed through 1,000 bootstrap replications.

VAR. Both qualitatively and quantitatively, the results obtained are in line with the VAR estimates. Common shocks generate significant effects, while idiosyncratic shocks have a low impact. Therefore, our conclusions remain robust to alternative econometric methodologies.

4.4 Variance Decompositions

To understand the relevance of terms of trade volatility shocks in explaining business cycles in emerging economies, we analyze the forecast-error variance decompositions (FEVDs) in response to one-standard-deviation shocks. First, we examine the FEVDs in response to a total volatility shock. Then, we analyze the FEVDs separately distinguishing between common and idiosyncratic shocks.

Table 4 Share of variances explained by terms of trade volatility shocks

Volatility Shock	GDP	INV	TB	R	RER	BAA
Common Volatility	8.7	2.0	2.7	3.8	4.2	30.8
Idiosyncratic Volatility	0.3	0.4	1.2	0.7	1.2	0.3
Total Volatility	1.6	0.2	0.4	0.8	3.4	7.4

Note: Total Volatility refers to the share of variances explained by total terms of trade volatility shocks, without distinguishing between common and idiosyncratic volatility.

We find that terms of trade volatility shocks explain a small proportion of macroeconomic dynamics in emerging economies. Table 4 shows that volatility explains only 1.6% of output fluctuations, 0.2% of investment, 0.4% of the trade balance and 0.8% of interest rates. The explained variances of the real exchange rate and the BAA spread are slightly higher, reaching 3.4% and 7.4% respectively. Therefore, this evidence would indicate that, although terms of trade volatility shocks have significant effects, they do not explain a significant portion of emerging economies dynamics.

However, when we break down volatility shocks into common and idiosyncratic shocks, we obtain similar heterogeneous results to those found in the impulse-response analysis. The low variability explained by terms of trade volatility shocks is mainly due to the virtually nil relevance of idiosyncratic shocks. Common shocks, on the other hand, explain a larger fraction of business cycles in emerging economies. Common terms of trade volatility shocks explain 8.7% of output, 2% of investment, 2.7% of the trade balance, 3.8% of interest rates, and 4.2% of the real exchange rate. Similarly, common shocks account for nearly one-third of BAA spread variations, due to common terms of trade volatility partly capturing events of uncertainty and aggregate volatility. In Section 4.3, we found evidence of the default premium channel, with interest rates responding positively to terms of trade volatility. However, Table 4 illustrates that these shocks explain only 3.8% of the interest rate variance,

indicating that terms of trade volatility is not one of the most important determinants of domestic interest rates. In any case, the empirical exercises show that terms of trade volatility shocks have a significant effect on emerging economies, with common shocks having the greatest impact and importance.[27] In the following section, we develop an RBC open economy model that incorporates the default premium channel in a reduced-form fashion. Our goal is to replicate the empirical evidence and explain why this channel should be included when analyzing terms of trade volatility shocks.

5 Open Economy Model

In this section we study an extension of the MXN model from Schmitt-Grohé and Uribe (2017) and Schmitt-Grohé and Uribe (2018) to understand further the effects of terms of trade volatility on the business cycles of emerging economies. The economy consists of households that consume final goods and provide sector-specific labor and capital. Households can also borrow from the rest of the world to finance their spending. On the production side, there are five perfectly competitive sectors: importable, exportable, nontradable, tradable, and final. The importable, exportable, and nontradable sectors require capital and labor as productive inputs, and each firm is subject to working capital constraints. Tradable firms combine exportable and importable goods into a tradable composite good. Finally, the final goods sector combines the tradable and nontradable goods into a composite final good that is acquired and consumed by households. The economy faces exogenous terms of trade shocks and we augment the model to allow for the existence of time-varying volatility, along with the introduction of the default premium channel.

Since in Section 3.2 we found that the differences between the processes of common and

[27] Evidence shows that focusing on a single price (such as the terms of trade) underestimates the significance and effects of external shocks (see, for example, Fernández et al., 2017 and Di Pace et al., 2025). Therefore, we recognize that incorporating export and import prices separately into the analysis, or by using a group of individual prices instead of the terms of trade, may increase the importance and explained variance of external volatility shocks on the business cycles of emerging economies.

idiosyncratic terms of trade were not statistically significant (see Table 2), in this section we focus on the role of terms of trade volatility, without distinguishing between components, which also allow us to focus our attention on the default premium channel. The rest of the section is organized as follows. First, we introduce the problem of households and firms. Second, we describe the stochastic processes and the competitive equilibrium. Third, we present our calibration strategy. And fourth, we present the model results and its main conclusions.

5.1 Environment

Households: Assume that the economy is populated by a large number of identical households with preferences described by the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{[c_t - G(h_t^m, h_t^x, h_t^n)]^{1-\sigma} - 1}{1-\sigma},$$

with

$$G(h_t^m, h_t^x, h_t^n) = \frac{(h_t^m)^{\kappa_m}}{\kappa_m} + \frac{(h_t^x)^{\kappa_x}}{\kappa_x} + \frac{(h_t^n)^{\kappa_n}}{\kappa_n},$$

where $\sigma, \kappa_m, \kappa_x, \kappa_n > 0$. c_t denotes final goods consumption, h_t^m hours worked in the importable sector, h_t^x hours worked in the exportable sector, and h_t^n hours worked in the nontradable sector. Households maximize their utility subject to the sequential budget constraint

$$c_t + i_t^m + i_t^x + i_t^n + \frac{\phi_m}{2}(k_{t+1}^m - k_t^m)^2 + \frac{\phi_x}{2}(k_{t+1}^x - k_t^x)^2 + \frac{\phi_n}{2}(k_{t+1}^n - k_t^n)^2 + p_t^\tau d_t$$

$$= \frac{p_t^\tau d_{t+1}}{1+r_t} + w_t^m h_t^m + w_t^x h_t^x + w_t^n h_t^n + u_t^m k_t^m + u_t^x k_t^x + u_t^n k_t^n,$$

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 parameters $\phi_j > 0$, $j = m, x, n$, introduce capital adjustment costs to avoid excessive investment volatility. The variable p_t^τ denotes the relative price of the tradable composite goods in terms of final goods, d_t denotes the stock of debt in period t, expressed in units of the tradable composite goods, and r_t denotes the interest rate on debt held from period t to $t+1$. Consumption, investment, wages, rental rates, and capital adjustment costs are all expressed in units of final goods. The capital stocks obey the following law of motion

$$k_{t+1}^j = (1-\delta)k_t^j + i_t^j, \quad \text{for } j = m, x, n$$

where we assume that the capital depreciation rate $\delta \in (0,1)$ is the same across sectors.

Production of final goods: Final goods are produced using nontradable goods and a composite of tradable goods via the technology

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

with $\chi_\tau \in (0,1)$ and $\mu_{\tau n} > 0$. a_t^τ denotes domestic absorption of the tradable composite goods, and a_t^n denotes domestic absorption of nontraded goods. Households acquire final goods to allocate them to consumption and investment. Producers of final goods behave competitively. Their profits are given by

$$B(a_t^\tau, a_t^n) - p_t^\tau a_t^\tau - p_t^n a_t^n,$$

where p_t^n denotes the relative price of nontradable goods in terms of final goods. The firm's profit maximization conditions define the domestic demand functions for nontradables and for tradable composite goods.

Production of tradable composite goods: The tradable composite goods are

produced using importable and exportable goods as intermediate inputs, via the technology

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

with $\chi_m \in (0,1)$ and $\mu_{mx} > 0$. a_t^m and a_t^x denote the domestic absorptions of importable and exportable goods, respectively. Firms in this sector are assumed to behave competitively in intermediate and final goods markets. Profits are given by

$$p_t^\tau A(a_t^m, a_t^x) - p_t^m a_t^m - p_t^x a_t^x,$$

where p_t^m denotes the relative price of importable goods in terms of final goods and p_t^x denotes the relative price of exportable goods in terms of final goods. Profit maximization conditions define the domestic demand functions for importable and exportable goods.

Production of importable, exportable, and nontradable goods: Importable, exportable, and nontradable goods are produced with capital and labor via the technologies

$$y_t^j = A^j (k_t^j)^{\alpha_j} (h_t^j)^{1-\alpha_j}, \quad \text{for } j = m, x, n$$

where $\alpha_j \in (0,1)$, y_t^j and A^j denote, respectively, output and a productivity factor in sector $j = m, x, n$. Firms are assumed to behave competitively in product and factor markets, and are subject to a working capital constraint that establishes that a fraction φ of the salary expenses for the period must be financed with borrowed funds, which are repaid when production materializes. Profits of firms producing exportable, importable, or nontraded goods are then given by

$$p_t^j y_t^j - (1 + \varphi r_t) w_t^j h_t^j - u_t^j k_t^j,$$

for $j = m, x, n$. Under this specification, firms make zero profits. The maximization

conditions define the sectoral demand functions for capital and labor.

5.2 Competitive Equilibrium

In equilibrium the demand for final goods must equal the supply of this type of goods:

$$c_t + i_t^m + i_t^x + i_t^n + \frac{\phi_m}{2}(k_{t+1}^m - k_t^m)^2 + \frac{\phi_x}{2}(k_{t+1}^x - k_t^x)^2 + \frac{\phi_n}{2}(k_{t+1}^n - k_t^n)^2 = B(a_t^\tau, a_t^n). \quad (8)$$

The demand for nontradables must equal the production of nontradables:

$$a_t^n = y_t^n. \quad (9)$$

Imports (m_t) are defined in units of final goods as the difference between the domestic absorption of importables (a_t^m) and importable output (y_t^m):

$$m_t = p_t^m(a_t^m - y_t^m). \quad (10)$$

Similarly, exports (x_t) are defined in units of final goods, given by the difference between exportable output (y_t^x) and the domestic absorption of exportables (a_t^x):

$$x_t = p_t^x(y_t^x - a_t^x). \quad (11)$$

Combining the definitions for imports and exports, the household's sequential budget constraint, and the definitions of profits in the final- and intermediate-good markets and taking into account that firms make zero profits at all times yields the following economy-wide resource constraint:

$$\frac{p_t^\tau d_{t+1}}{1 + r_t} = p_t^\tau d_t + m_t - x_t. \quad (12)$$

The terms of trade are exogenous to the economy and defined as $tot_t = \frac{p_t^x}{p_t^m}$. The process

for terms of trade is given by an autoregressive process of the form:

$$\ln\left(\frac{tot_t}{tot}\right) = \rho_{tot} \ln\left(\frac{tot_{t-1}}{tot}\right) + exp(\sigma_t)\epsilon_t, \qquad \epsilon_t \sim N(0,1)$$

where tot is the steady state value for the terms of trade, ρ_{tot} captures the terms of trade persistence, $exp(\sigma_t)$ is the time-varying volatility and ϵ_t is a terms of trade level shock.

The terms of trade log-volatility is stochastic and given by the following process:

$$\sigma_t = \alpha_\sigma + \rho_\sigma \sigma_{t-1} + \eta\nu_t, \qquad \nu_t \sim N(0,1)$$

where ρ_σ corresponds to the log-volatility's persistence, ν_t is a terms of trade volatility shock and η determines the standard deviation of a terms of trade volatility shock.

We follow the same parameter transformations as described in Section 3.2:

$$\begin{aligned}
\alpha_\sigma &\equiv (1-\rho_\sigma)\pi \\
\rho_\sigma &\equiv \frac{exp(\overline{\rho}_\sigma)}{exp(\overline{\rho}_\sigma)+1} \\
\eta &\equiv (1-\rho_\sigma^2)^{1/2} exp(\overline{\eta})
\end{aligned}$$

The country interest rate is debt elastic to ensure a stationary equilibrium process. Additionally, we allow the terms of trade level to directly affect the interest rate. This link is consistent with the terms of trade-default premium relationship documented in Appendix 7.3 and is based on the findings of Drechsel and Tenreyro (2018). In Section 2 we show how terms of trade volatility determines default probabilities and required rate premiums in risky small open economies. To illustrate this mechanism in the model, we adjust the interest rate specification so that it directly responds to changes in terms of trade volatility:

$$r_t = r^* + \psi\left(exp(d_t - \bar{d}) - 1\right) + \theta(\ln(tot_t) - \ln(tot)) + \xi(\sigma_t - \pi), \tag{13}$$

where r^* denotes the risk-free world interest rate, $\psi > 0$ captures a positive relationship between interest rates and external debt deviations from its steady-state value $\overline{d}$, tot is the long-term terms of trade level, and π is the average terms of trade log-volatility. The key parameter ξ determines the sensitivity of the interest rate to changes in terms of trade volatility. According to the theoretical framework in Section 2 and to the empirical results from Section 4.3, increased terms of trade volatility leads to higher interest rates. Therefore, we expect the value of the parameter ξ to be positive, capturing the default premium channel in reduced-form.

The real exchange rate (q_t) is defined as the ratio of the foreign consumer price index to the domestic consumer price index:

$$q_t = \frac{E_t P_t^*}{P_t},$$

where E_t denotes the nominal exchange rate, defined as the domestic-currency price of one unit of foreign currency, P_t^* denotes the foreign price of consumption, and P_t denotes the domestic price of consumption. Assuming that the law of one price holds for importable and exportable goods, that the technology of firms producing tradable composite goods is common across countries, and that the terms of trade shocks do not affect the relative price of the tradable composite goods in terms of consumption goods in the rest of the world, Schmitt-Grohé and Uribe (2018) show that the real exchange rate can be rewritten as a function of the relative price of the tradable composite goods in terms of final goods:

$$q_t = p_t^{\tau}. \tag{14}$$

Therefore, the domestic economy becomes more expensive (cheaper) relative to the rest of the world when the relative price of tradable goods increases (decreases). Finally, the trade balance is defined as the difference between exports and imports:

$$tb_t = x_t - m_t, \tag{15}$$

A competitive equilibrium is then a set of 34 sequences $\{\lambda_t, k^m_{t+1}, i^m_t, k^x_{t+1}, i^x_t, k^n_{t+1}, i^n_t, c_t, h^m_t, h^x_t, h^n_t, w^m_t, w^x_t, w^n_t, p^\tau_t, q_t, r_t, u^m_t, u^x_t, u^n_t, a^m_t, a^x_t, a^\tau_t, p^m_t, p^x_t, a^n_t, p^n_t, y^m_t, y^x_t, y^n_t, m_t, x_t, tb_t$ and $d_{t+1}\}$[28] that solve the problem for the households and for the firms in the final goods, tradable composite goods, importable, exportable, and nontradable goods sectors, and satisfy equations (8)-(15), given initial conditions k^m_0, k^x_0, k^n_0, and d_0, and the joint stochastic process for tot_t and σ_t.[29]

5.3 Calibration and Estimation

We calibrate the model to characterize a representative median emerging economy. There is a total of 30 parameters to be calibrated: $\sigma, \kappa_m, \kappa_x, \kappa_n, \phi_m, \phi_x, \phi_n, \delta, \chi_\tau, \mu_{\tau n}, \chi_m, \mu_{mx}, A^m, A^x, A^n, \alpha_m, \alpha_x, \alpha_n, \varphi, tot, \rho_{tot}, \rho_\sigma, \pi, \overline{\eta}, \beta, r^*, \psi, \overline{d}, \theta$ and ξ. The time unit is meant to be a quarter. Table 5 and Table 6 summarize the entire calibration and estimation results. We calibrate a subset of parameters following the literature, and the baseline MXN model. Specifically, we set $\sigma = 2$, $\delta = 0.025$ and $\beta = 0.974$. We set the capital shares in the exportable and importable sectors to $\alpha_m = \alpha_x = 0.35$ and the capital share in the nontradable sector to $\alpha_n = 0.25$. We follow the Frisch elasticity of labor supply of 2.2 used in Mendoza (1991), and we assume the same value across sectors, setting $\kappa_j = 1.455, \forall j = \{m, x, n\}$. Since Corsetti et al. (2008), Gust et al. (2009) and Justiniano and Preston (2010) estimate that at a quarterly frequency the elasticity of substitution between exportable and importable goods ranges from 0.8 to 0.86, we set an intermediate value for $\mu_{mx} = 0.83$. We assume an elasticity of substitution between tradable and nontradable goods equal to 0.5 ($\mu_{\tau n} = 0.5$), following the conclusions from the literature survey of Akinci (2011). We consider the normalizations and estimates of Schmitt-Grohé and Uribe (2018), setting $A^j = 1, \ \forall j = \{m, x, n\}$, $r^* = 1/\beta - 1$,[30] $\chi_\tau = 0.436$, $\chi_m = 0.898$

[28] The variable λ_t corresponds to the Lagrange multiplier associated with the sequential budget constraint in the household problem.

[29] In Appendix 7.12 we display the entire set of equilibrium conditions from the model.

[30] We parameterize $\beta = 0.974$ to get an interest rate of 2.6% in steady-state. This is equivalent to an annual rate of 11%, the value used in the baseline MXN model.

and $tot = 1$. To calibrate the process parameters $\{\rho_{tot}, \pi, \overline{\rho}_\sigma, \overline{\eta}\}$, we estimate Eq. (5) and Eq. (6) for total terms of trade, without separating between common and idiosyncratic components, using the same methodology as in Section 3.2. We conduct the estimation for each emerging country in our sample and we use the cross-country median estimates as the baseline calibration for the model. In line with the estimated value found in Drechsel and Tenreyro (2018), we set the semi-elasticity of the interest rate to terms of trade deviations to $\theta = -0.199$. However, this choice does not affect our results and conclusions. We parametrize the semi-elasticity of the interest rate to terms of trade volatility deviations from its unconditional mean to match the empirical impact response of the domestic interest rate to a one-standard deviation terms of trade volatility shock found in the VAR and shown in Figure 8. Since we found that a 21% increase in terms of trade volatility yields a 0.23 percentage points increase in domestic interest rate, we set $\xi = 0.011$.

Table 5 Calibrated Parameters

σ	δ	β	α_m, α_x	α_n	$\kappa_m, \kappa_x, \kappa_n$	μ_{mx}	$\mu_{\tau n}$	A^m, A^x, A^n	r^*
2	0.025	0.974	0.35	0.25	1.455	0.83	0.5	1	$1/\beta - 1$
χ_τ	χ_m	tot	ρ_{tot}	π	$\overline{\rho}_\sigma$	$\overline{\eta}$	θ	ξ	
0.436	0.898	1	0.93	-5.33	0.87	-0.59	-0.199	0.011	

We estimate the capital adjustment cost parameters (ϕ_m, ϕ_x, ϕ_n), the sensitivity of the interest rate to debt (ψ) and the parameter governing the working capital constraint (φ) to minimize a weighted difference between the empirical and theoretical impulse-responses to a total terms of trade volatility shock. We consider the first 8 quarters of each impulse-response function and use as weights the reciprocal of the width of the 68% confidence interval associated with the VAR responses. Formally, letting $\Theta \equiv [\phi_m, \phi_x, \phi_n, \psi, \varphi]$, we set Θ as the solution to the problem: [31]

[31] Similarly to Schmitt-Grohé and Uribe (2018), in the model we define the aggregate output in current prices and the real aggregate output as $y_t = p_t^m y_t^m + p_t^x y_t^x + p_t^n y_t^n$ and $y_t^o = p_{sss}^m y_t^m + p_{sss}^x y_t^x + p_{sss}^n y_t^n$ respectively, where p_{sss}^j denotes the stochastic steady state relative price of sector $j = \{m, x, n\}$. Additionally, we define the real aggregate investment and the real trade balance ratio as $i_t^o = (i_t^m + i_t^x + i_t^n)\frac{y_t^o}{y_t}$ and

$$\min_{\Theta} \sum_{h=0}^{7} \sum_{i=y^o,i^o,tby^o,r,RER} \frac{\left| IR_{hi}^{SVAR} - IR_{hi}^{Model}(\Theta) \right|}{\Delta_{hi}}, \tag{16}$$

Table 6 displays the estimation results. The model assigns a relatively low interest rate sensitivity to debt ($\psi = 0.0026$), although high enough to guarantee stationary equilibrium dynamics and induce a positive relationship between domestic interest rates and external debt. Additionally, the model attributes an influential role to the working capital constraint. An estimated value of $\varphi = 0.361$ means that the firm must borrow approximately 36% of the salary expenses to produce in each period. This mechanism is important for studying the effects of terms of trade volatility because it allows stronger output responses to changes in volatility. As volatility increases, interest rates rise due to the default premium channel, discouraging labor demand under higher financing costs and consequently leading to falls in production (see Neumeyer and Perri, 2005 for a detailed analysis of the role of working capital constraints). Finally, we set $\overline{d} = 0.149$ to obtain a stochastic steady state net export share of 0.5% (the median share found in our sample of 12 emerging economies).

Table 6 Estimated Parameters

ϕ_m	ϕ_x	ϕ_n	ψ	φ	$\overline{d}$
306.40	182.27	316.09	0.0026	0.361	0.149

We solve the model by relying on perturbation methods, using a third-order approximation of the policy functions around the steady state. As stated in Fernández-Villaverde et al. (2011), a first-order approximation would bias the dynamics induced by volatility because this approximation is certainty equivalent. Although we would still have the dynamics induced by the default premium channel, we would miss all the effects produced via a precautionary savings channel. A second-order approximation would capture some precautionary effects through the interaction of innovations to the

$tby_t^o = \left(tb_t \frac{y_t^o}{y_t} \right) / y_{sss}$ respectively, where y_{sss} corresponds to the stochastic steady state level of aggregate output.

level and volatility. However, this means that volatility would only affect the economy at times when the terms of trade level is also changing. It is only in a third-order approximation that terms of trade volatility shocks enter as independent arguments in the policy functions with a coefficient different from zero. Additionally, since the third-order approximation and our stochastic processes move the mean of the ergodic distributions of the endogenous variables of the model away from their deterministic steady state values, computing impulse-responses as percentage deviations of the model's steady state is not informative. Therefore, to calculate the impulse-responses, we simulate the model from its deterministic steady-state for 5001 periods. We disregard the first 5000 periods as burn-in and we define the stochastic steady state as the values from the last period. Then, starting from the stochastic steady state, we hit the model with an innovation to the terms of trade level/volatility.

5.4 Results

Figure 11 shows the aggregate impulse-responses to a terms of trade volatility shock of a similar magnitude to that analyzed in the empirical impulse-responses.[32] In line with the empirical results, we find that terms of trade volatility shocks induce a contractionary response in the economy. Aggregate output and investment decline by 0.1% and 0.2% respectively. Consumption contracts by around 0.2% and the net external debt falls by 1.5%. The domestic interest rate rises by 0.2 percentage points, capturing the default premium channel, and the real exchange rate depreciates by 0.1%. Due to the contraction in domestic absorption, there is an improvement in the trade balance, that is consistent with the response observed in the data to common terms of trade volatility shocks.[33]

There are two channels through which terms of trade volatility is transmitted in the model. (i) The first is associated with a precautionary savings channel. Greater volatility

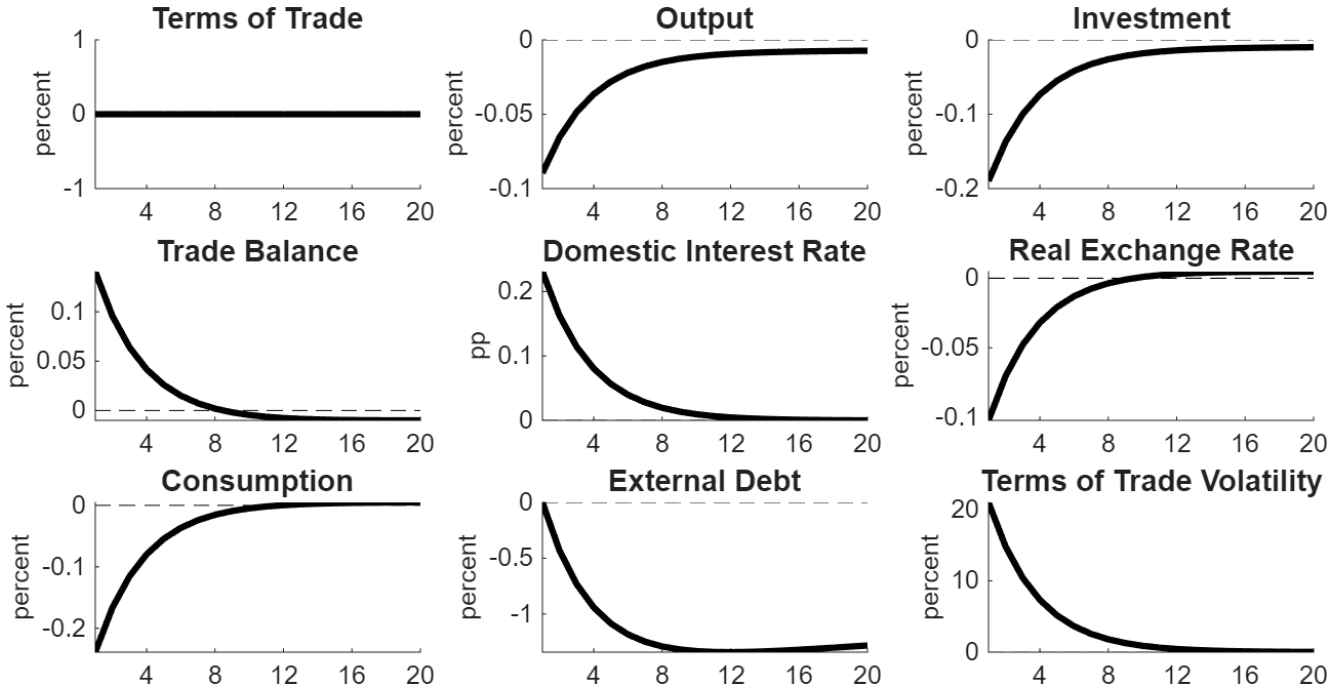
[32] To analyze in detail the ability of the model to replicate the empirical results, in Appendix 7.13 we compare the impulse-responses predicted by the model with the 90% confidence bands from Figure 8.

[33] Appendix 7.14 displays the aggregate effects stemming from a one-standard-deviation negative terms of trade level shock in the model.

makes agents more uncertain about their future income, leading to an increase in the expected marginal utility of future consumption. In response, agents reduce their current spending on both consumption and investment in order to increase their stock of net external assets (or, equivalently, to reduce their stock of net external debt). Under this scenario, the relative price of the nontradable good falls, causing the real exchange rate to depreciate and leading firms in this sector to reduce their labor demand and their production (see Gómez-González and Rees, 2013). (ii) The second is the default premium channel, which acts as an interest rate shock. Greater volatility leads to an increase in the interest rate faced by the domestic economy (a mechanism supported and justified by the two-period model studied in Section 2). Because $\overline{d} > 0$, both due to substitution and income effects, the higher interest rate induces households to reduce their consumption and investment spending, as well as their stock of net external debt. Similarly, given the presence of working capital constraints, the higher financing costs induce firms to significantly reduce their labor demand, putting downward pressure on wages and sectoral production (see Neumeyer and Perri, 2005 and Uribe and Yue, 2006 for more details on the effects of interest rate shocks). To further understand the disaggregated effects and the shock transmission, in Figure 12 we show the sectoral consequences over output, labor and investment.

Driven by both precautionary motives and higher interest rates, households broadly reduce their capital investment expenses. This reduction is slightly more pronounced in the exportable goods sector due to lower adjustment costs. Furthermore, the drop in domestic demand, combined with the inability of the nontradable sector to trade externally, causes a fall in its relative price, thereby restoring market equilibrium. This price decline entails a real exchange rate depreciation and disincentivizes labor and capital demand from firms within this sector, leading to a significant drop in nontradable output. Conversely, although domestic consumption of tradable goods also falls, the real exchange rate depreciation stimulates demand for capital and labor from importable and exportable firms on impact, consequently boosting their production. However, the interest rate hike and

Figure 11 Aggregated responses to a terms of trade volatility shock

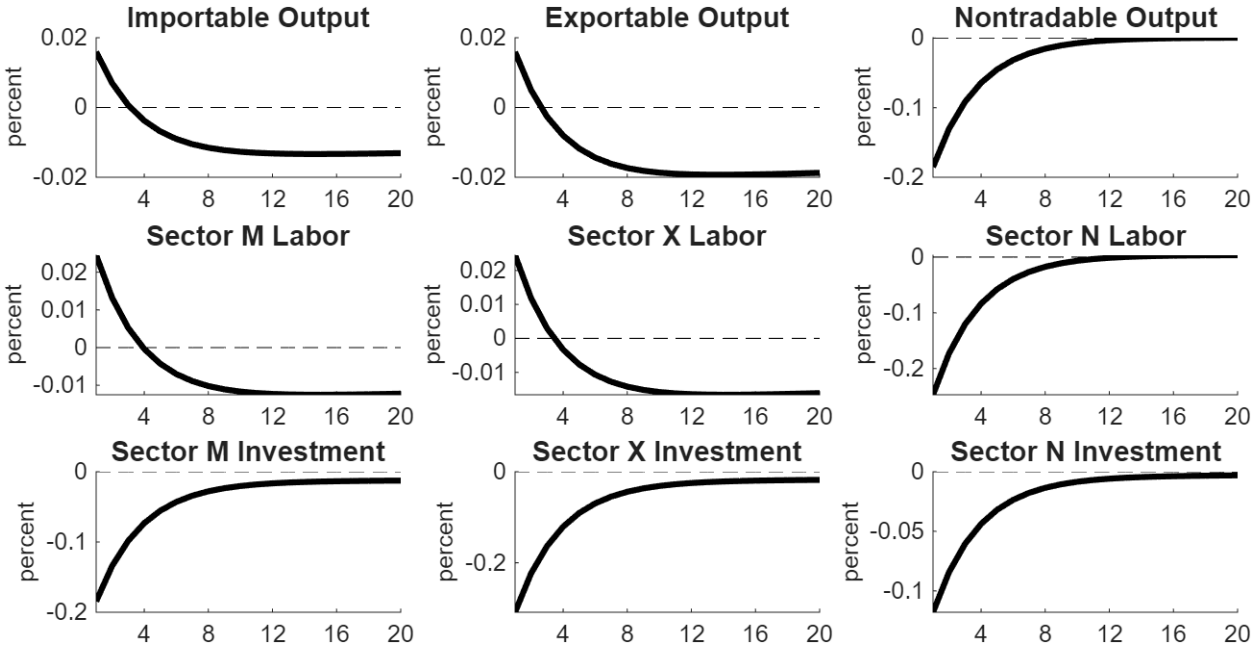


Note: All responses with the exception of the trade balance and the domestic interest rate are expressed in percent deviations from stochastic steady state. The trade balance response is expressed in level deviations from stochastic steady state in percent of the stochastic steady-state output. The domestic interest rate response is expressed in percentage point deviations from stochastic steady state.

working capital constraints eventually dominate and compel firms in the tradable (importable and exportable) sectors to reduce their output in the following periods. In summary, the initial impact on aggregate output is driven primarily by the contraction in the nontradable sector. The fall in its relative price induces a real exchange rate depreciation, driving a reallocation of labor towards the tradable sector. Finally, due to the fall in domestic absorption and the resiliency of the importable and exportable sectors, exports increase and imports decrease on impact, leading to a trade balance improvement.

Intuitively, both the precautionary savings and the default premium channel should generate qualitatively similar results. Both channels would result in decreases in output, consumption, and investment; an improvement in the trade balance and a real exchange depreciation. However, they may provide different predictions regarding the domestic interest rate dynamics. While the default premium channel causes interest rates to rise in

Figure 12 Disaggregated responses to a terms of trade volatility shock



Note: All impulse-responses are expressed in percent deviations from stochastic steady state.

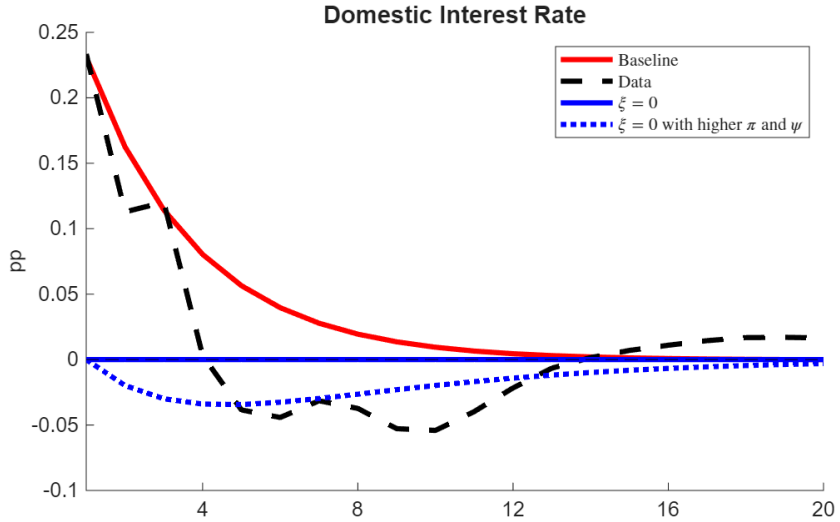
the face of greater terms of trade volatility, the same might not be true for the precautionary savings channel. Let us focus exclusively on the latter channel to illustrate this point.

When a positive terms of trade volatility shock occurs, households decide to consume and invest less in order to decrease their net external debt and protect themselves for the possibility of unfavorable future terms of trade realizations. If the interest rate is positively related to debt, then a decrease in net external debt would result in a fall in the domestic interest rate. In other words, the precautionary savings channel would predict a negative relationship between terms of trade volatility and domestic interest rates. However, as seen in our empirical estimates from Figure 8, interest rates increase in response to a terms of trade volatility shock. Therefore, the precautionary savings channel alone would be unable to generate the positive relationship between volatility and interest rates observed in the data.

To analyze in detail within our model the counterfactual prediction of interest rate dynamics under the precautionary savings channel, we conduct a qualitative exercise in

which we study how the interest rate response varies when the default premium channel is turned off. Figure 13 illustrates the results.

Figure 13 Interest rate response with and without the default premium channel



Note: Interest rate responses to a terms of trade volatility shock. Solid red line denotes the baseline predicted response. Dashed black line denotes the median response estimated in the VAR (see Figure 8). Solid blue line denotes the predicted response when the default premium channel is turned off ($\xi = 0$). Dotted blue line denotes the predicted response when the default premium channel is turned off ($\xi = 0$), and both the sensitivity of the interest rate to debt (ψ) and the average terms of trade log-volatility (π) are increased.

When the default premium channel is turned off, setting $\xi = 0$, the domestic interest rate no longer responds positively to a terms of trade volatility shock, corroborating the role of the default premium channel in inducing a positive response consistent with the data. However, although the interest rate decreases under this scenario, the decrease is quantitatively nil.[34] There are two main reasons for this. First, under the current structure and parameterization of the model, we find that the precautionary savings channel is quantitatively weak. Consequently, the net external debt response to increased volatility is relatively low, resulting in minimal change in the interest rate. Second, even if the precautionary savings channel were stronger, the interest rate would respond minimally due to its weak sensitivity to debt (recall that $\psi = 0.0026$). This implies that net external

[34]This conclusion is obtained by setting $\xi = 0$ and keeping the rest of the parameterization unchanged. We also conduct an alternative exercise in which we turn off the default premium channel and we re-estimate the model parameters, which involves recalibrating the parameter set $[\phi_m, \phi_x, \phi_n, \psi, \varphi, \overline{d}]$. However, the conclusion remains the same.

debt could fall significantly; however, given the low elasticity of the interest rate, significant movements in the rate will not occur.

Therefore, as a second exercise, in addition to turning off the default premium channel, we increase the sensitivity of the interest rate to net external debt deviations and strengthen the precautionary savings channel. To do this, we increase the sensitivity of the interest rate from $\psi = 0.0026$ to $\psi = 0.58$ (the cross-country median value found in Schmitt-Grohé and Uribe, 2018),[35] and we increase the average terms of trade log-volatility from $\pi = -5.33$ to $\pi = -2.53$ (which implies moving from an average volatility of 0.5% to one of 8%). By significantly increasing the average terms of trade volatility, households have greater incentives to behave precautionarily in the face of terms of trade volatility shocks. This is due to a base effect, whereby if agents systematically expect more volatile shocks, an increase in volatility will cause them to react more strongly. Under these changes, as Figure 13 shows, a terms of trade volatility shock produces a lagged and persistent decline in the domestic interest rate. The more important the precautionary savings channel is, the greater the decline in net external debt and the greater the decline in the interest rate. Therefore, this channel alone cannot explain the positive response of the rate observed in the data.

This leads us to conclude that, when studying the effects stemming from terms of trade volatility on the business cycles of emerging economies, relying solely on the precautionary savings channel as the transmission mechanism yields a counterfactual interest rate result. An additional mechanism must be considered, and we argue that the default premium channel serves to this purpose. In Section 2 we theoretically prove the existence of this channel, and including it within the model enables a positive interest rate response to terms of trade volatility shocks. In other words, instead of focusing exclusively on the demand-side of the credit market, we argue that we should also recognize and address the supply-side consequences of terms of trade volatility.

[35] Since in this particular analysis we are concerned about qualitative insights, it is not essential to set a value that is quantitatively consistent with our model. We simply need a value large enough to allow us to visualize changes in the interest rate in response to movements in net external debt.

6 Conclusion

In this paper, we examine the effects of terms of trade volatility on business cycles in emerging economies, distinguishing between common shocks, which affect the entire set of economies, and idiosyncratic shocks, which affect only a reduced group of countries. Using a panel VAR, we find that in the event of a one-standard-deviation common terms of trade volatility shock, output and investment decrease by 0.4% and 0.7%, respectively. The trade balance to output improves by 0.2%, the real exchange rate depreciates by 1%, and the BAA spread increases by around 0.2 percentage points. However, we do not observe significant effects stemming from idiosyncratic terms of trade volatility shocks. While common terms of trade volatility shocks explain about 9% of output fluctuations in emerging economies, idiosyncratic shocks explain 0.3%.

We highlight two main channels through which terms of trade volatility is transmitted to emerging economies. The first is associated with precautionary savings and the second is related to interest rates and risk premiums. We focus on the latter and prove, using a simple two-period small open economy model, that increases in terms of trade volatility lead to higher conditional default probabilities and higher required interest rates by external creditors. We find empirical evidence in favor of this prediction, as the VAR results show that domestic interest rates increase by 0.2 and 0.4 percentage points in response to total and common terms of trade volatility shocks respectively. We call this mechanism as the default premium channel.

Finally, we built on a textbook RBC open economy model to show that the pass-through of terms of trade volatility to domestic interest rates induces households to reduce their consumption and investment spending. Similarly, the higher financing costs induce firms to significantly reduce their labor demand, putting downward pressure on wages and sectoral production, specially those from the nontradable sector. Lastly, we demonstrate that relying solely on the precautionary savings channel as the transmission mechanism yields a counterfactual interest rate result. Through this channel, agents reduce

their net external debt to protect themselves from unfavorable future terms of trade realizations. A decrease in the stock of net external debt results in a fall in the domestic interest rate, rather than the positive response observed in the data. Including the default premium channel in the model enables a positive interest rate response, resolving the counterfactual result. Therefore, we argue that both channels should be considered when studying the effects of terms of trade volatility shocks.

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7 Appendix

7.1 Proof

First, let us demonstrate that the default threshold $\tilde{p_2} = \frac{D_1(1+r^s(D_1))}{\phi}$[36] is strictly increasing with respect to D_1. If we rearrange the quadratic equation that implicitly describes the credit supply we get:

$$D_1(1+r)/\phi = (p_{min} + s) - \frac{s(1+r^*)}{1+r}$$

So, we end up with an expression for $\tilde{p_2}$ as a function of D_1:

$$\tilde{p_2}(D_1) = D_1(1+r)/\phi = (p_{min} + s) - \frac{s(1+r^*)}{1+r^s(D_1)}$$

Since $r^s(D_1)$ is strictly increasing with the level of debt, $\tilde{p_2}(D_1)$ also increases as D_1 raises. Therefore, as $\tilde{p_2}$ is an increasing function within the interval $0 < D_1 \leq D_{max}$, at $D_1 = D_{max}$ the default threshold takes its highest value. Let us find that value.

From the credit supply curve, when $D_1 = D_{max}$ the creditors demand an interest rate given by:

$$1 + r^s(D_{max}) = \frac{\phi(s + p_{min})}{2D_{max}}$$

If we use this result when evaluating $D_1 = D_{max}$ in the definition of $\tilde{p_2} = \frac{D_1(1+r^s(D_1))}{\phi}$, we obtain the highest default threshold:

$$\tilde{p_2}(D_{max}) = \frac{s + p_{min}}{2} = \frac{p_{max}}{2}$$

Since $\tilde{p_2}(D_{max})$ is the threshold of p_2 for which the economy does default, a sufficient condition for $\mathrm{E}(p_2) > \frac{D_1(1+r)}{\phi}$ to hold is that $\mathrm{E}(p_2) > \tilde{p_2}(D_{max})$. For any p_2 above $\tilde{p_2}(D_{max})$,

[36] Maximum value of p_2 such that the equation (1) is satisfied.

the economy decides to commit at every equilibrium combination of (D_1, r). Therefore, we need to prove that the expected value of p_2 is greater than the threshold. Note that this will always be true under one condition:

$$\begin{aligned} & \mathrm{E}(p_2) > \tilde{p_2}(D_{max}) \\ \iff & \frac{p_{max} + p_{min}}{2} > \frac{p_{max}}{2} \\ \iff & p_{min} > 0 \end{aligned}$$

Thus, if p_{min} is a strictly positive value, $\mathrm{E}(p_2) > \frac{D_1(1+r)}{\phi}$ is satisfied.

7.2 Log-Normal Distribution

The next figure illustrates the response of the credit supply in the event of a terms of trade volatility shock, assuming a log-normal distribution for the terms of trade. As with the credit supply response under a uniform distribution, creditors demand higher interest rates for the same amount of debt when volatility shocks occur. This exercise discards the possibility that the findings are due to the choice of distribution and validates our finding of the default premium channel.

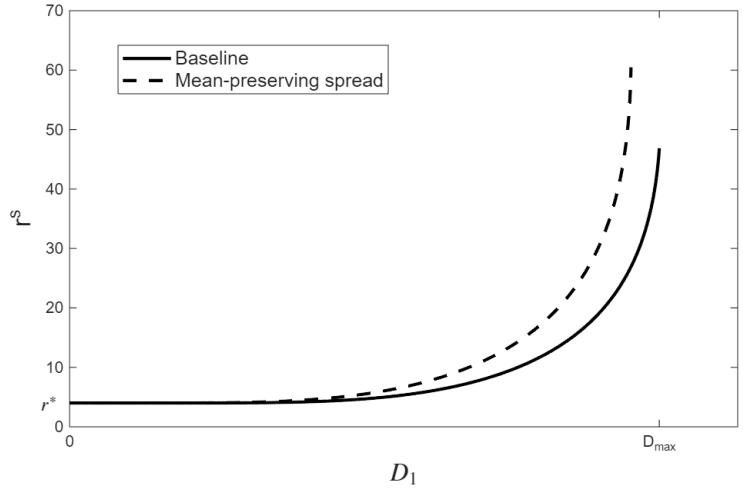


Figure 14 Mean-preserving Spread

7.3 Theoretical Framework: Terms of Trade Level Shock

With the theoretical framework we can also study a variance-preserving shock, such that the expected value of p_2 changes but its variance remains constant. We call this kind of perturbation a terms of trade level shock. We can rationalize this as both p_{min} and p_{max} decreasing in ϵ. Under this structure, the default probability is given by:

$$\pi = \frac{D_1(1+r) - \phi(p_{min} - \epsilon)}{\phi(p_{max} - \epsilon - (p_{min} - \epsilon))} = \frac{D_1(1+r) - \phi p_{min} + \phi\epsilon}{\phi(p_{max} - p_{min})}$$

Taking the derivative with respect to ϵ yields:

$$\frac{\partial \pi}{\partial \epsilon} = \frac{1}{p_{max} - p_{min}}$$

In the presence of uncertainty, the denominator is always positive. Therefore, negative terms of trade level shocks increase default probabilities, regardless of the level of debt and interest rates. Indeed, the following figure illustrates that the shock causes the credit supply to contract, in a similar manner as a terms of trade volatility shock does. As default probabilities rise, creditors are compelled to demand higher interest rates. Although model-level and volatility shocks are different, they generate similar results.

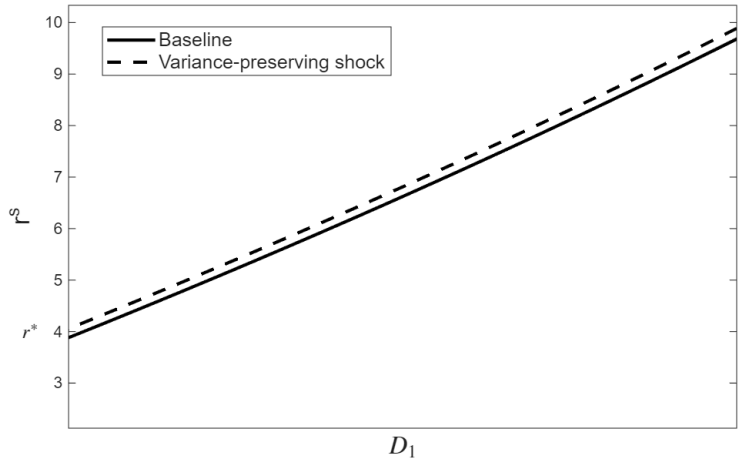


Figure 15 Variance-preserving Shock

The following figure illustrates the determinants of the level shock pass-through. In

other words, it shows which factors amplify the effect of a level shock on the interest rate required by creditors. Similarly to the volatility shock pass-through, higher debt levels and low penalties for default result in greater pass-through.

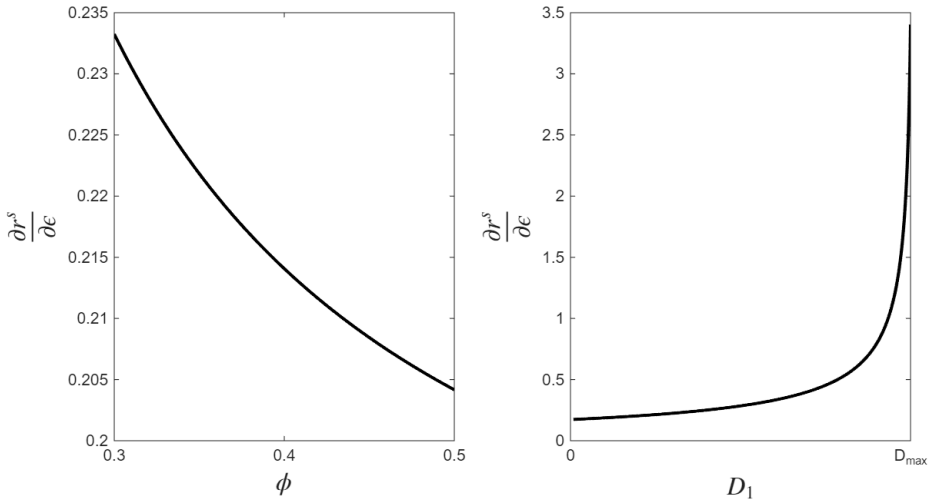


Figure 16 Determinants of the level pass-through

7.4 Principal Component Analysis

The following section is based on chapter 12 of the work by Gareth (2023).

Intuitively, when faced with a large set of correlated variables, Principal Component Analysis (PCA) allows us to summarize this set with a smaller number of representative variables that collectively explain most of the variability in the original set. The goal is to find a low-dimensional representation of the data that captures as much information as possible. Each of these dimensions corresponds to a linear combination of the correlated variables.

For instance, given a $T \times N$ dataset denoted by X, the first principal component would be a linear combination of the sample in the form:

$$f_{t1} = \lambda_{11} X_{t1} + \lambda_{21} X_{t2} + \ldots + \lambda_{N1} X_{tN}$$

that has the largest possible variance, subject to the constraint that the sum of the squared

coefficients is 1 ($\sum_{i=1}^{N} \lambda_{i1}^2 = 1$). The vector $\lambda_1 = (\lambda_{11} \quad \lambda_{21} \quad \dots \quad \lambda_{N1})^T$ is called the first principal component loading vector.

In other words, the first principal component loading vector λ_1 solves the optimization problem:

$$\max_{\{\lambda_1\}} \left\{ \frac{1}{T} \sum_{t=1}^{T} \left(\sum_{i=1}^{N} \lambda_{i1} X_{ti} \right)^2 \right\}$$
$$\iff \max_{\{\lambda_1\}} \left\{ \frac{1}{T} \sum_{t=1}^{T} f_{t1}^2 \right\}$$

subject to the constraint $\sum_{i=1}^{N} \lambda_{i1}^2 = 1$. The values $f_{11}, \dots, f_{T1}$ are referred to as the scores of the first principal component.

An important caveat is that before conducting PCA, the variables should be standardized (transform the variables so that they have a mean of zero and a variance of one). Otherwise, PCA would assign the highest weight to the most volatile variable, resulting in a biased principal component that does not accurately reflect the underlying correlation structure of the data.

The second principal component is the linear combination of $X_1, \dots, X_N$ that has the maximal variance out of all linear combinations that are uncorrelated with f_1. This same principle applies to subsequent principal components. It can be shown that the principal component loadings $\lambda_1, \lambda_2, \lambda_3 ...$ are given by the ordered sequence of eigenvectors of the covariance matrix, with their respective eigenvalues corresponding to the variances of the components.

With these components, one can then estimate the total variance of the dataset explained by them. Indeed, the total variance present in a standardized data set is given by:

$$\sum_{i=1}^{N} Var(X_i) = \sum_{i=1}^{N} \frac{1}{T} \sum_{t=1}^{T} X_{ti}^2$$

Whereas the variance explained by the mth principal component is:

$$\frac{1}{T}\sum_{t=1}^{T} f_{tm}^2 = \frac{1}{T}\sum_{t=1}^{T}\left(\sum_{i=1}^{N}\lambda_{im}X_{ti}\right)^2$$

Therefore, the proportion of variance explained (PVE) by the mth principal component is:

$$\frac{\frac{1}{T}\sum_{t=1}^{T} f_{tm}^2}{\sum_{i=1}^{N}\frac{1}{T}\sum_{t=1}^{T} X_{ti}^2} = \frac{\frac{1}{T}\sum_{t=1}^{T}\left(\sum_{i=1}^{N}\lambda_{im}X_{ti}\right)^2}{\sum_{i=1}^{N}\frac{1}{T}\sum_{t=1}^{T} X_{ti}^2}$$

The PVE of all principal components sum to one. We can interpret the PVE as the R^2 of the approximation for X given by the first M principal components.

7.5 Explained Variance by Common Factor: Country Level

Country	Explained Variance
Argentina	24%
Brazil	11%
Bulgaria	7%
Chile	47%
Colombia	36%
Ecuador	61%
Indonesia	64%
Malaysia	27%
Mexico	68%
Peru	72%
South Africa	10%
Venezuela	71%

7.6 Estimated Common Factors Under Alternative Samples

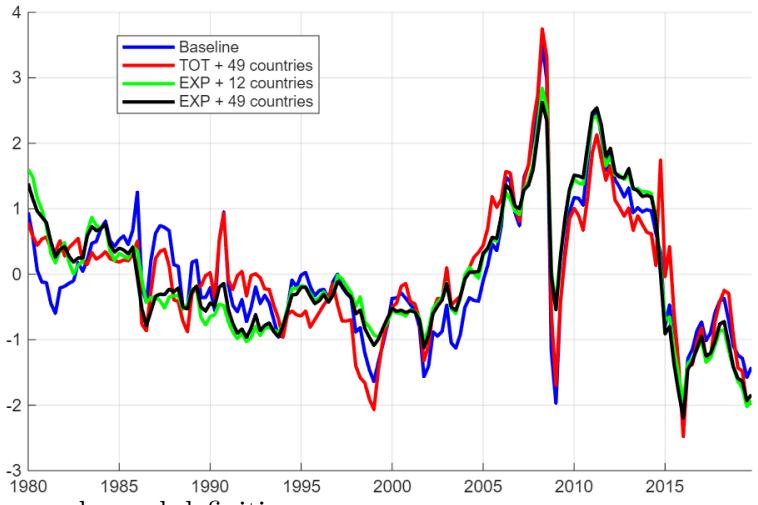


Figure 17 Different samples and definitions

Note: The baseline corresponds to the case in which we use the terms of trade data from our baseline sample of 12 economies. The TOT + 49 countries expands the sample to include 49 emerging countries. The EXP + 12 countries specification uses the same 12 economies as the baseline but with export price index data instead of terms of trade. The EXP + 49 countries specification expands the previous one to the 49 emerging economies.

7.7 Particle Filter Estimates

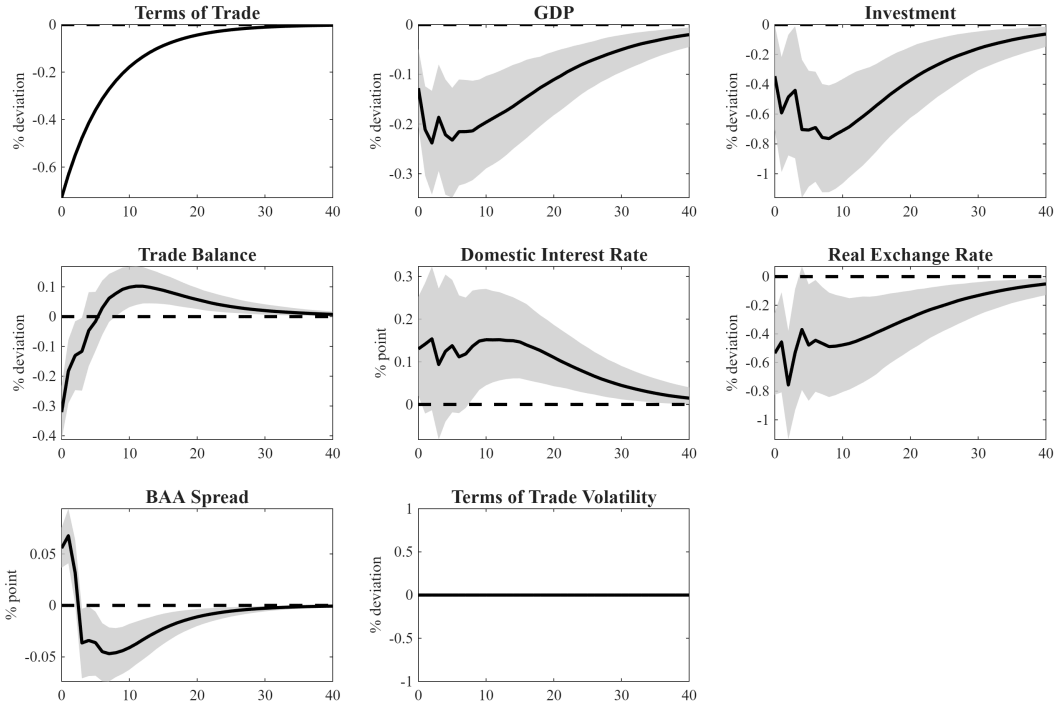
Table 7 Parameter estimates

	Common Component				Idiosyncratic Component			
Country	ρ_ω	π_ω	$\overline{\rho}_{\sigma^\omega}$	$\overline{\eta_\omega}$	ρ_e	π_e	$\overline{\rho}_{\sigma^e}$	$\overline{\eta_e}$
Argentina	0.91	−6.63	0.73	−0.57	0.77	−5.91	0.77	−0.53
	[0.84, 0.98]	[−6.80, −6.46]	[0.27, 1.18]	[−0.93, −0.21]	[0.69, 0.86]	[−6.10, −5.74]	[0.33, 1.24]	[−0.87, −0.18]
Brazil	0.92	−7.12	0.71	−0.62	0.92	−6.00	0.76	−0.80
	[0.85, 0.98]	[−7.32, −6.92]	[0.15, 1.28]	[−0.99, −0.25]	[0.86, 0.99]	[−6.19, −5.80]	[0.20, 1.30]	[−1.16, −0.44]
Bulgaria	0.91	−7.63	0.80	−0.62	0.80	−6.36	1.00	−0.32
	[0.85, 0.97]	[−7.80, −7.46]	[0.39, 1.21]	[−1.02, −0.21]	[0.71, 0.89]	[−6.55, −6.17]	[0.60, 1.40]	[−0.61, −0.04]
Chile	0.91	−4.82	0.82	−0.62	0.89	−4.55	0.60	−1.15
	[0.84, 0.98]	[−4.98, −4.66]	[0.30, 1.35]	[−1.00, −0.25]	[0.81, 0.96]	[−4.71, −4.38]	[0.06, 1.14]	[−1.66, −0.64]
Colombia	0.92	−5.96	0.60	−0.66	0.89	−5.52	0.86	−0.46
	[0.85, 0.99]	[−6.13, −5.77]	[0.05, 1.16]	[−1.07, −0.25]	[0.81, 0.96]	[−5.70, −5.33]	[0.34, 1.42]	[−0.81, −0.10]
Ecuador	0.92	−4.88	0.78	−0.64	0.88	−4.85	0.57	−0.75
	[0.85, 0.99]	[−5.10, −4.70]	[0.28, 1.29]	[−1.02, −0.25]	[0.81, 0.96]	[−5.02, −4.67]	[0.12, 1.02]	[−1.10, −0.41]
Indonesia	0.91	−5.38	0.61	−0.52	0.90	−5.43	0.85	−0.52
	[0.86, 0.96]	[−5.53, −5.24]	[0.13, 1.10]	[−0.80, −0.26]	[0.83, 0.97]	[−5.64, −5.21]	[0.21, 1.48]	[−0.83, −0.20]
Malaysia	0.91	−5.00	0.78	−0.62	0.92	−4.81	0.74	−0.78
	[0.85, 0.98]	[−5.18, −4.83]	[0.35, 1.21]	[−1.00, −0.25]	[0.86, 0.97]	[−4.99, −4.63]	[0.24, 1.25]	[−1.17, −0.39]
Mexico	0.92	−6.28	0.78	−0.65	0.85	−6.42	0.74	−0.64
	[0.85, 0.99]	[−6.44, −6.12]	[0.18, 1.38]	[−1.05, −0.25]	[0.76, 0.94]	[−6.64, −6.19]	[0.20, 1.28]	[−0.96, −0.33]
Peru	0.91	−5.10	0.76	−0.60	0.81	−5.25	0.61	−0.95
	[0.84, 0.98]	[−5.25, −4.93]	[0.23, 1.30]	[−1.01, −0.20]	[0.73, 0.90]	[−5.43, −5.06]	[0.08, 1.14]	[−1.35, −0.53]
South Africa	0.92	−7.40	0.76	−0.62	0.87	−6.35	0.81	−0.52
	[0.85, 0.99]	[−7.56, −7.24]	[0.33, 1.20]	[−1.00, −0.23]	[0.79, 0.95]	[−6.49, −6.21]	[0.22, 1.40]	[−1.08, 0.10]
Venezuela	0.91	−3.60	0.75	−0.62	0.92	−4.08	0.63	−0.82
	[0.85, 0.97]	[−3.77, −3.42]	[0.24, 1.26]	[−0.98, −0.26]	[0.87, 0.97]	[−4.26, −3.90]	[0.11, 1.16]	[−1.16, −0.49]

Note: We report in brackets the 95% probability intervals associated to each estimation. Each row displays the country median estimates obtained with the particle filter.

7.8 VAR: Terms of Trade Level Shock

Figure 18 Impulse-responses for a one-standard-deviation negative terms of trade shock

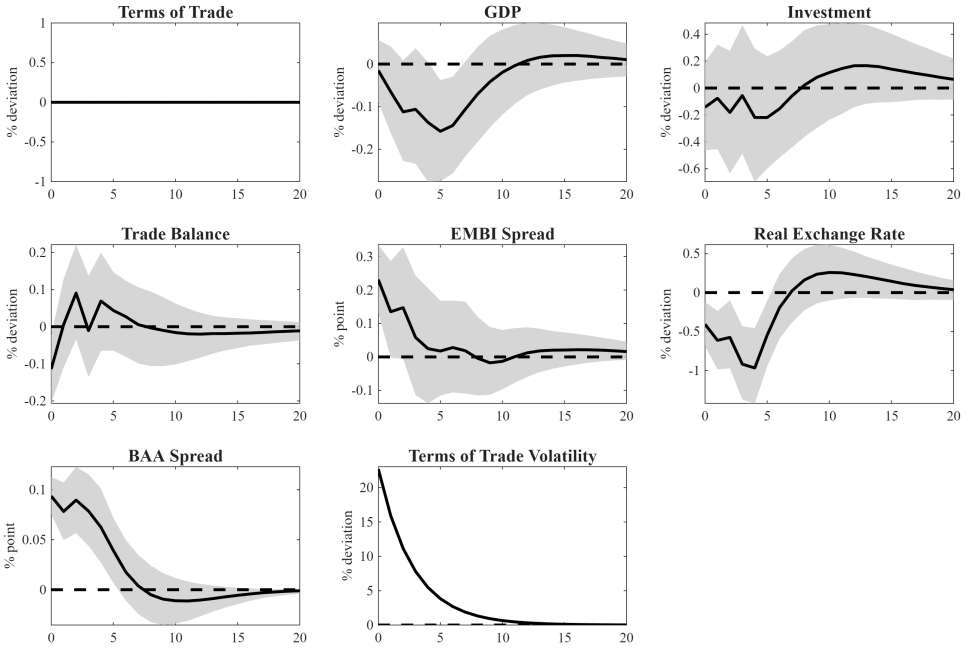


Note: 90% confidence bands in light-grey computed through 1,000 bootstrap replications.

7.9 Impulse-responses with EMBI spreads

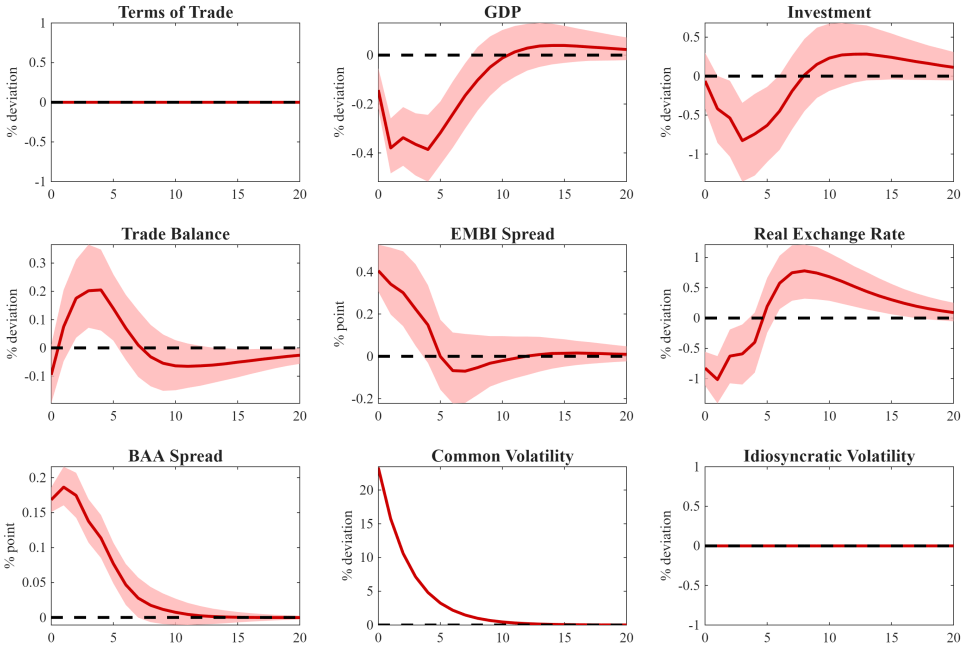
The following figures display the same responses as in Figure 8, Figure 9 and Figure 10, except that we use the EMBI spread instead of the domestic interest rate to show explicitly how volatility shocks are affecting our proxy of default premiums. Both total- and common terms of trade volatility shocks increase the EMBI spread, while idiosyncratic shocks appear to have no effect. Therefore, if we look at the responses of domestic interest rates or EMBI spreads, we arrive to the same conclusions.

Figure 19 Impulse-responses for a one-standard-deviation terms of trade volatility shock



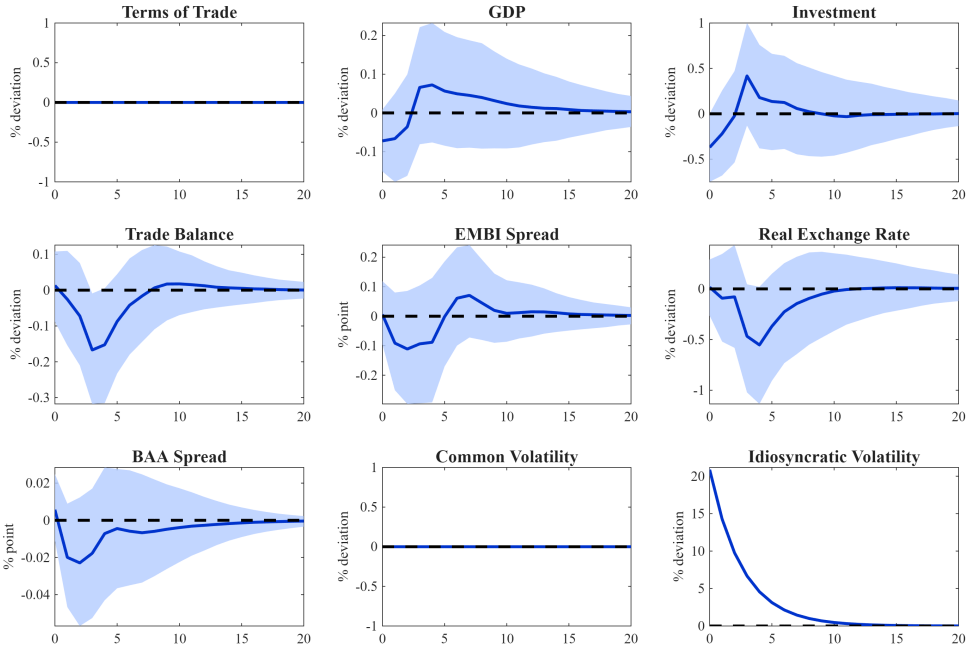
Note: 90% confidence bands in light-grey computed through 1,000 bootstrap replications.

Figure 20 Impulse-responses for a one-standard-deviation common terms of trade volatility shock



Note: 90% confidence bands in light-red computed through 1,000 bootstrap replications.

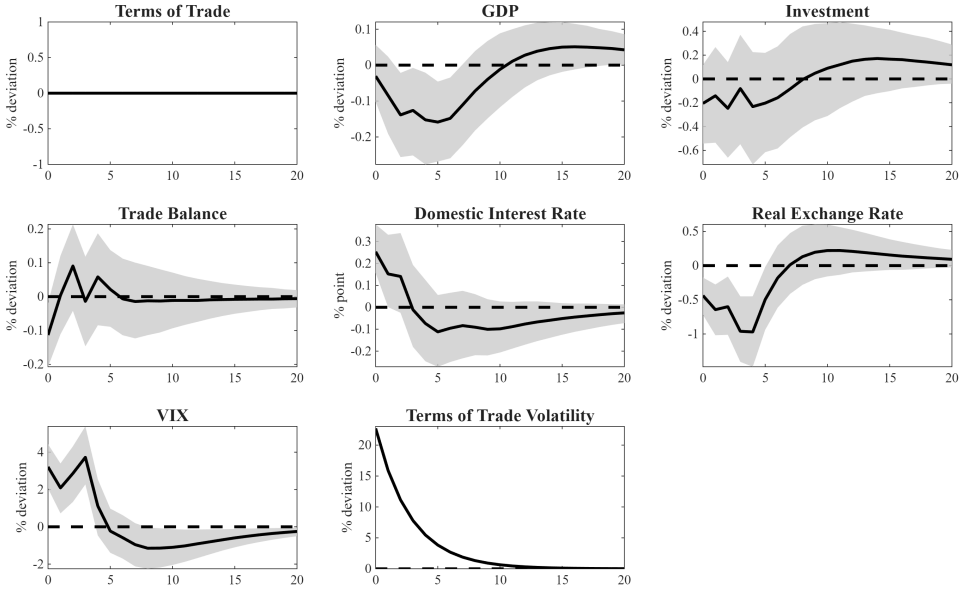
Figure 21 Impulse-responses for a one-standard-deviation idiosyncratic terms of trade volatility shock



Note: 90% confidence bands in light-blue computed through 1,000 bootstrap replications.

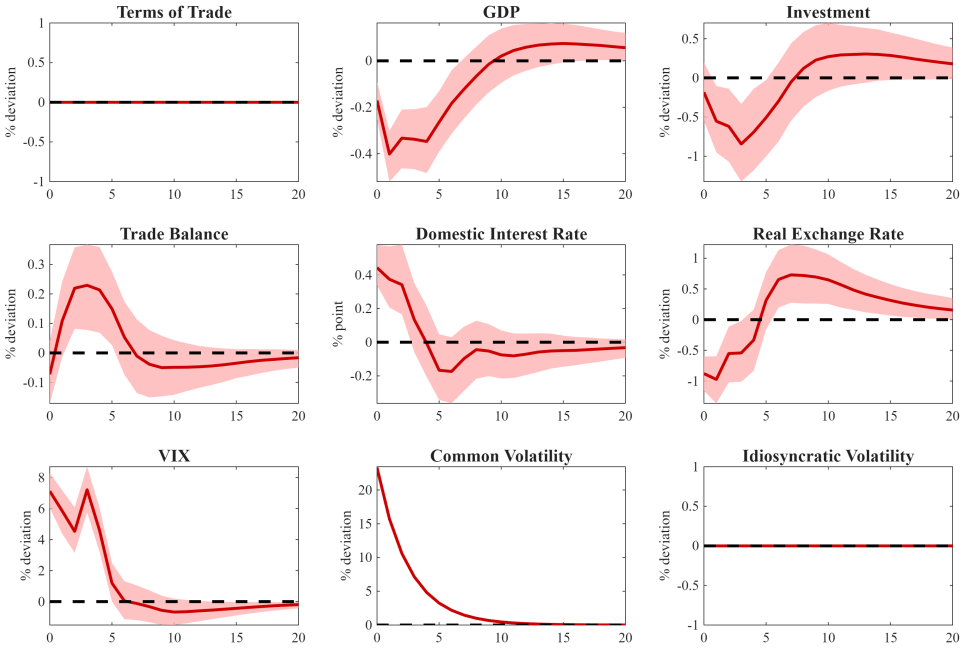
7.10 Impulse-Responses with VIX Index

Figure 22 Impulse-responses for a one-standard-deviation terms of trade volatility shock



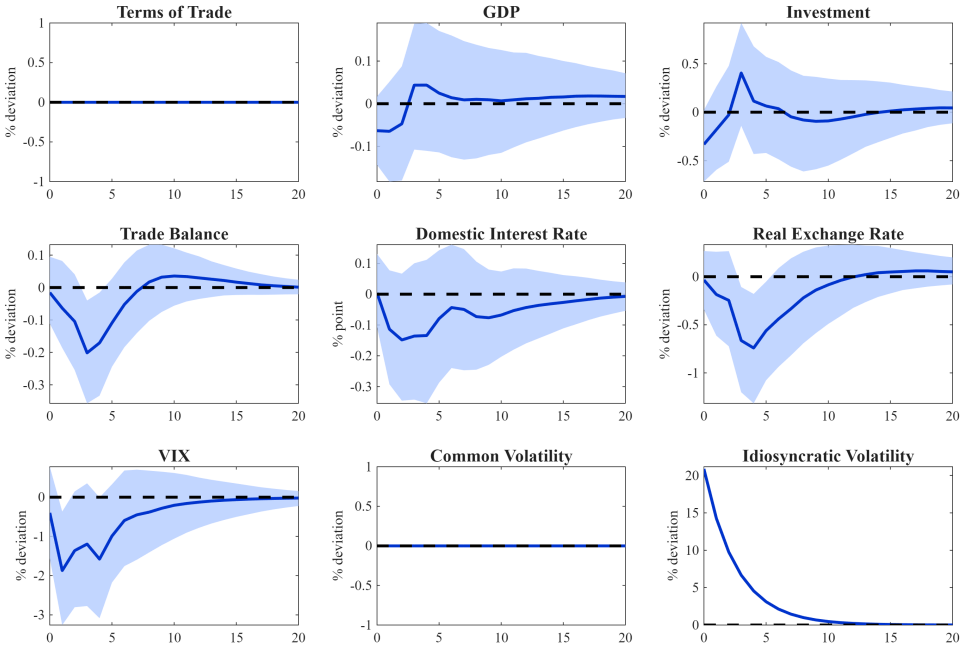
Note: 90% confidence bands in light-grey computed through 1,000 bootstrap replications.

Figure 23 Impulse-responses for a one-standard-deviation common terms of trade volatility shock



Note: 90% confidence bands in light-red computed through 1,000 bootstrap replications.

Figure 24 Impulse-responses for a one-standard-deviation idiosyncratic terms of trade volatility shock

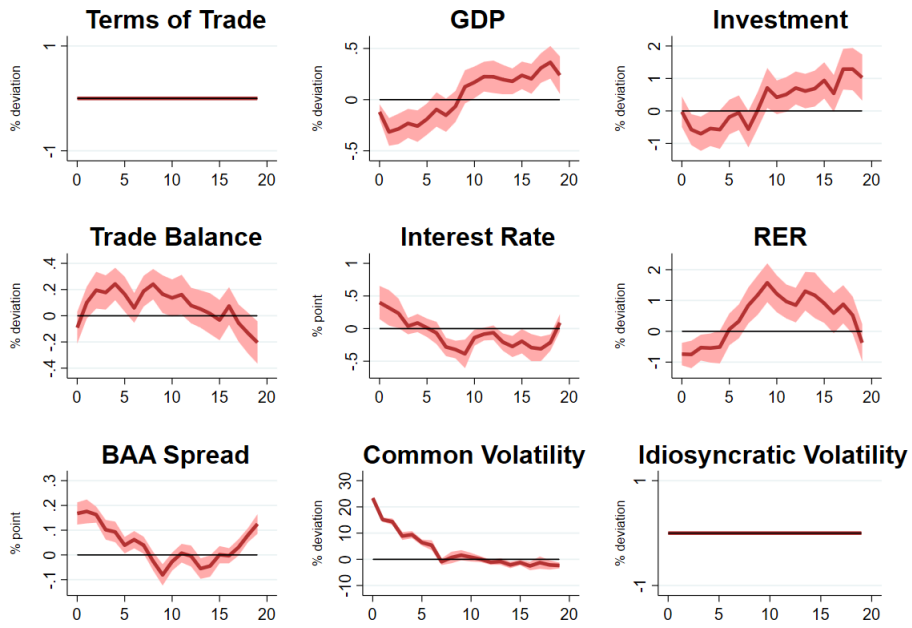


Note: 90% confidence bands in light-blue computed through 1,000 bootstrap replications.

7.11 Local Projections

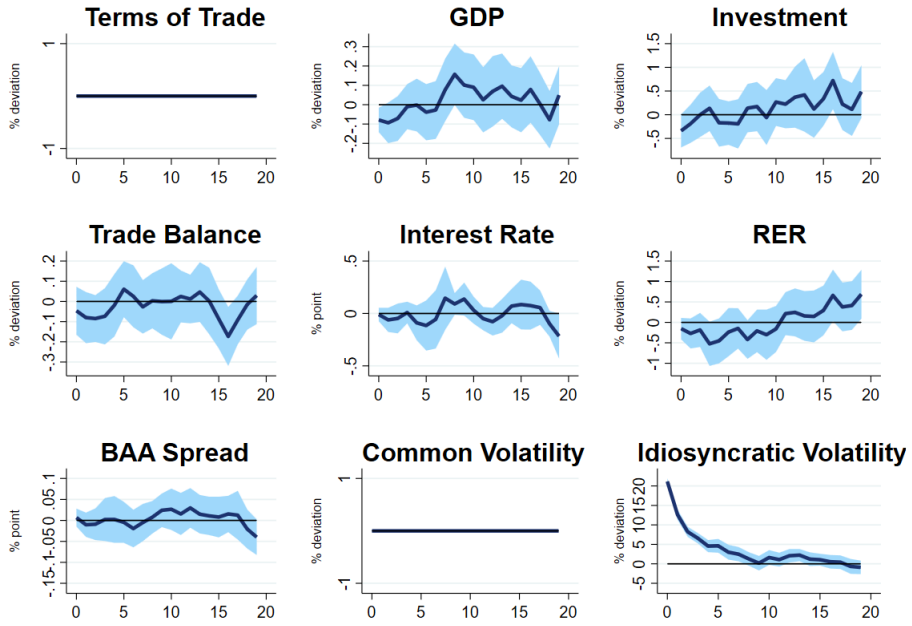
We perform a Local Projections exercise to analyze the impact of a one-standard-deviation terms of trade volatility shock (both common and idiosyncratic) on the economic variables of emerging economies. The equation specifications follow the system in equation (7), which implies including the same variables, lags, and dynamic restrictions. The following figures illustrate the estimated impulse-response functions:

Figure 25 Impulse-responses for a one-standard deviation common terms of trade volatility shock with local projections



Note: 90% confidence bands in light-red.

Figure 26 Impulse-responses for a one-standard deviation idiosyncratic terms of trade volatility shock with local projections



Note: 90% confidence bands in light-blue.

7.12 Equilibrium Conditions

(1)-(3) Capital transition equations

$$k^m_{t+1} = (1-\delta)k^m_t + i^m_t$$

$$k^x_{t+1} = (1-\delta)k^x_t + i^x_t$$

$$k^n_{t+1} = (1-\delta)k^n_t + i^n_t$$

(4) Marginal utility of consumption

$$\lambda_t = \left(c_t - \frac{(h^m_t)^{\kappa_m}}{\kappa_m} - \frac{(h^x_t)^{\kappa_x}}{\kappa_x} - \frac{(h^n_t)^{\kappa_n}}{\kappa_n} \right)^{-\sigma}$$

(5)-(7) Sector-specific labor supply

$$w_t^m = (h_t^m)^{\kappa_m - 1}$$
$$w_t^x = (h_t^x)^{\kappa_x - 1}$$
$$w_t^n = (h_t^n)^{\kappa_n - 1}$$

(8) Euler equation

$$\lambda_t p_t^\tau = \beta(1 + r_t)\lambda_{t+1} p_{t+1}^\tau$$

(9)-(11) Sector-specific capital optimality condition

$$\lambda_t \left(1 + \phi_m(k_{t+1}^m - k_t^m)\right) = \beta\lambda_{t+1}\left(u_{t+1}^m + 1 - \delta + \phi_m(k_{t+2}^m - k_{t+1}^m)\right)$$
$$\lambda_t \left(1 + \phi_x(k_{t+1}^x - k_t^x)\right) = \beta\lambda_{t+1}\left(u_{t+1}^x + 1 - \delta + \phi_x(k_{t+2}^x - k_{t+1}^x)\right)$$
$$\lambda_t \left(1 + \phi_n(k_{t+1}^n - k_t^n)\right) = \beta\lambda_{t+1}\left(u_{t+1}^n + 1 - \delta + \phi_n(k_{t+2}^n - k_{t+1}^n)\right)$$

(12)-(13) Final goods firm optimality conditions

$$p_t^\tau = \chi_\tau (a_t^\tau)^{-1/\mu_{tn}} \left(\chi_\tau (a_t^\tau)^{1-1/\mu_{tn}} + (1-\chi_\tau)(a_t^n)^{1-1/\mu_{tn}}\right)^{\frac{1}{\mu_{tn}-1}}$$
$$p_t^n = (1-\chi_\tau)(a_t^n)^{-1/\mu_{tn}} \left(\chi_\tau (a_t^\tau)^{1-1/\mu_{tn}} + (1-\chi_\tau)(a_t^n)^{1-1/\mu_{tn}}\right)^{\frac{1}{\mu_{tn}-1}}$$

(14)-(15) Tradable goods firm optimality conditions

$$p_t^m = p_t^\tau \chi_m (a_t^m)^{-1/\mu_{mx}} \left(\chi_m (a_t^m)^{1-1/\mu_{mx}} + (1-\chi_m)(a_t^x)^{1-1/\mu_{mx}}\right)^{\frac{1}{\mu_{mx}-1}}$$
$$p_t^x = p_t^\tau (1-\chi_m)(a_t^x)^{-1/\mu_{mx}} \left(\chi_m (a_t^m)^{1-1/\mu_{mx}} + (1-\chi_m)(a_t^x)^{1-1/\mu_{mx}}\right)^{\frac{1}{\mu_{mx}-1}}$$

(16) Production of tradable composite goods

$$a_t^\tau = \left(\chi_m (a_t^m)^{1-1/\mu_{mx}} + (1-\chi_m)(a_t^x)^{1-1/\mu_{mx}}\right)^{\frac{1}{1-1/\mu_{mx}}}$$

(17)-(19) Production of importable, exportable and nontradable goods

$$y_t^m = A^m (k_t^m)^{\alpha_m} (h_t^m)^{1-\alpha_m}$$
$$y_t^x = A^x (k_t^x)^{\alpha_x} (h_t^x)^{1-\alpha_x}$$
$$y_t^n = A^n (k_t^n)^{\alpha_n} (h_t^n)^{1-\alpha_n}$$

(20)-(25) Sector-specific factor demands

$$u_t^m = p_t^m A_m \alpha_m (k_t^m)^{\alpha_m - 1} (h_t^m)^{1-\alpha_m}$$
$$w_t^m (1+\varphi r_t) = p_t^m A_m (1-\alpha_m)(k_t^m)^{\alpha_m} (h_t^m)^{-\alpha_m}$$
$$u_t^x = p_t^x A_x \alpha_x (k_t^x)^{\alpha_x - 1} (h_t^x)^{1-\alpha_x}$$
$$w_t^x (1+\varphi r_t) = p_t^x A_x (1-\alpha_x)(k_t^x)^{\alpha_x} (h_t^x)^{-\alpha_x}$$
$$u_t^n = p_t^n A_n \alpha_n (k_t^n)^{\alpha_n - 1} (h_t^n)^{1-\alpha_n}$$
$$w_t^n (1+\varphi r_t) = p_t^n A_n (1-\alpha_n)(k_t^n)^{\alpha_n} (h_t^n)^{-\alpha_n}$$

(26) Final goods market clearing condition

$$\left(\chi_\tau (a_t^\tau)^{1-1/\mu_{tn}} + (1-\chi_\tau)(a_t^n)^{1-1/\mu_{tn}}\right)^{\frac{1}{1-1/\mu_{tn}}} =$$
$$c_t + i_t^m + i_t^x + i_t^n + \frac{\phi_m}{2}(k_{t+1}^m - k_t^m)^2 + \frac{\phi_x}{2}(k_{t+1}^x - k_t^x)^2 + \frac{\phi_n}{2}(k_{t+1}^n - k_t^n)^2$$

(27) Nontradable market clearing condition

$$a_t^n = y_t^n$$

(28)-(29) Imports and exports

$$m_t = p_t^m(a_t^m - y_t^m)$$
$$x_t = p_t^x(y_t^x - a_t^x)$$

(30) Economy-wide resource constraint

$$\frac{p_t^\tau d_{t+1}}{1+r_t} = p_t^\tau d_t + m_t - x_t$$

(31)-(33) Terms of trade

$$\text{tot}_t = p_t^x / p_t^m$$
$$\ln\left(\frac{tot_t}{tot}\right) = \rho_{tot} \ln\left(\frac{tot_{t-1}}{tot}\right) + exp(\sigma_t)\epsilon_t$$
$$\sigma_t = (1-\rho_\sigma)\pi + \rho_\sigma \sigma_{t-1} + \eta\nu_t$$

(34) Real exchange rate

$$q_t = p_t^\tau$$

(35) Domestic Interest Rate

$$r_t = r^* + \psi(\exp(d_t - \bar{d}) - 1) + \theta(\ln(\text{tot}_t) - \ln(tot)) + \xi(\sigma_t - \pi)$$

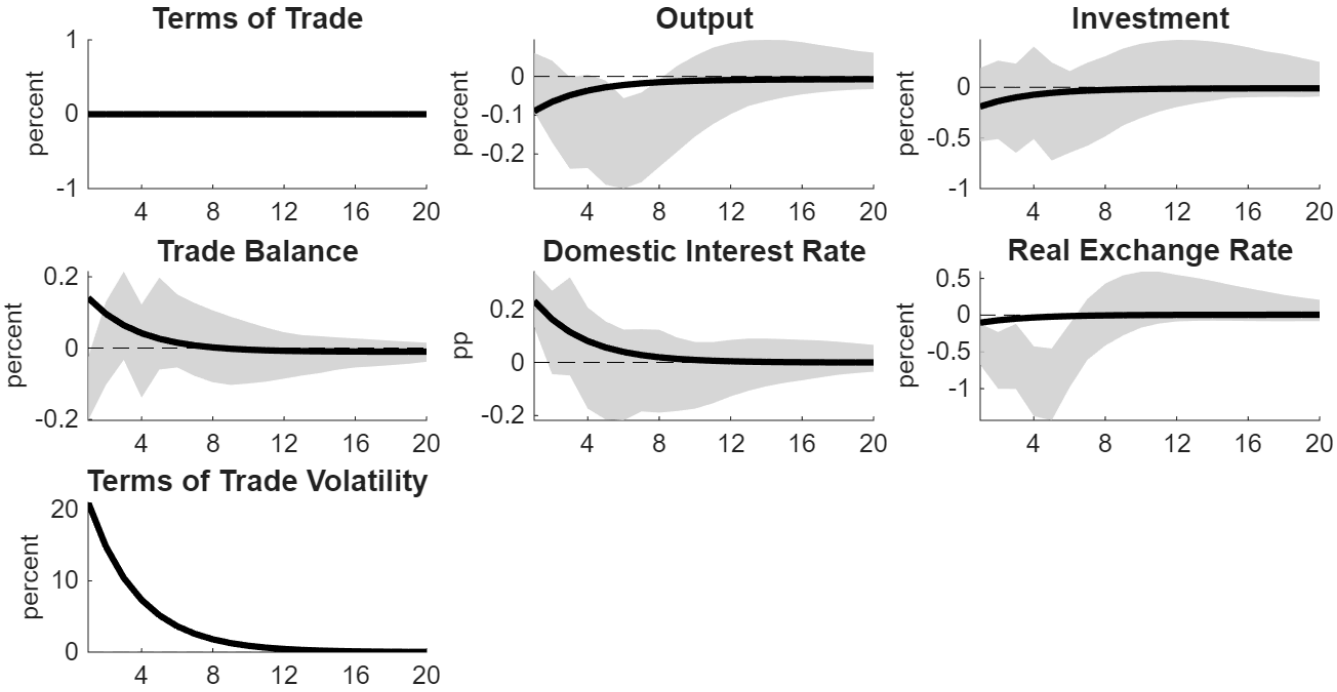
(36) Trade balance

$$tb_t = x_t - m_t$$

7.13 Impulse-Response Matching

The following figure compares the impulse-responses predicted by the model, to a terms of trade volatility shock, with the 90% confidence bands associated with the estimated impulse-responses from the VAR. The investment and interest rate responses coincide qualitatively and quantitatively with the empirical trajectories, resembling the median dynamics of the confidence bands. Additionally, the model captures the declines in output and depreciation of the real exchange rate. However, the model responses are inaccurate respect to their form and magnitude. For instance, in the data we do not find a contemporaneous decline in GDP, but rather a lagged decline. The output fall on impact observed in the model is mainly due to the presence of working capital constraints. When interest rates increase contemporaneously, the constraints discourage labor demand and lead to output declines. We added this channel to the model because otherwise, the output response is much smaller, and the contractionary response of the economy cannot be fully captured. Finally, the model fails to capture a deterioration of the trade balance on impact. This could be due to the low precision with which this response is estimated in the data. In fact, Figure 9 shows empirically that in the face of common terms of trade volatility shocks, there is a positive—albeit lagged— response from the trade balance.

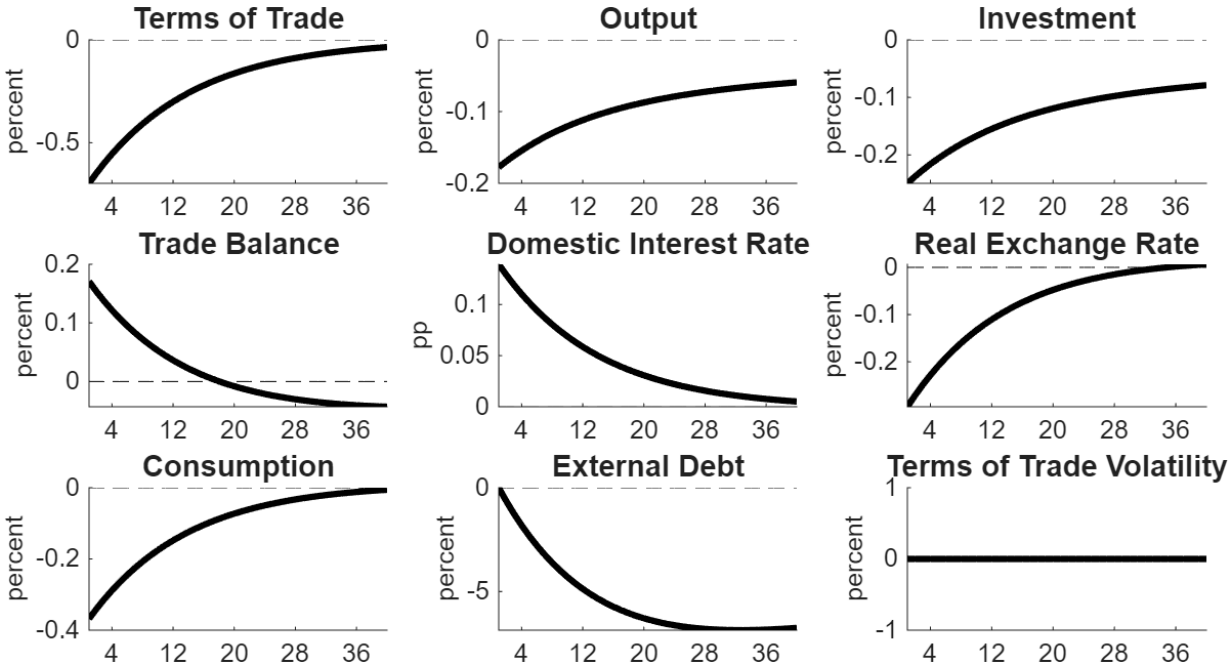
Figure 27 Impulse-responses for a terms of trade volatility shock: Model versus Data



Note: Solid lines denote the model predicted impulse-responses. Grey areas correspond to the 90% confidence bands associated to the impulse-responses estimated in the VAR (see Figure 8). All model responses with the exception of the trade balance and the domestic interest rate are expressed in percent deviations from stochastic steady state. The trade balance response is expressed in level deviations from stochastic steady state in percent of the stochastic steady-state output. The domestic interest rate response is expressed in percentage point deviations from stochastic steady state.

7.14 Model: Terms of Trade Level Shock

Figure 28 Aggregated responses to a negative terms of trade level shock



Note: All responses with the exception of the trade balance and the domestic interest rate are expressed in percent deviations from stochastic steady state. The trade balance response is expressed in level deviations from stochastic steady state in percent of the stochastic steady-state output. The domestic interest rate response is expressed in percentage point deviations from stochastic steady state.