Global Shocks and Emerging Economies: Getting Off the Commodity Roller Coaster

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Abstract

Fluctuations in commodity prices have been viewed as a major driver of emerging economies business cycles. By considering a richer structure of the global economy, we show that this is not the case for Brazil, Chile, Colombia and Peru, challenging previous findings. Aggregate shocks to the world commodity market become more relevant only when a less structured model of the international economy is in place. This is due to the fact that aggregate commodity price index reacts endogenously to other global shocks, playing a major role as a propagator, hence, this modelling choice enables capturing general equilibrium effects at world level. Our analytic framework is based on Bayesian structural VAR with block exogeneity in a sample ranging from 2000 to 2017. The global part of the VAR uses a measure of global GDP, an aggregate commodity price index, and the volatility index (VIX). The presence of this last variable, from which we study the impact of uncertainty shock in the international financial market, is responsible for modifying established results. The model also uses the following domestic variables: GDP, CPI, sovereign spread, nominal exchange rate, and policy interest rate. We conclude that global demand fluctuations are the main drivers, at international level, of domestic business cycles.

Keywords: External shocks; Business cycles; Uncertainty; Commodity prices; Global activity; Emerging economy; Bayesian SVAR; Block exogeneity; Open economy macroeconomics.

JEL Codes: C32, E32, F41, F44, F62, F63, O54.

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1 Introduction

Evaluating the impact of global shocks in domestic economies is a theme of interest among international macroeconomists and policy makers. This interest seems ever more important given the high level of worldwide economic integration. But most works do not conduct a deep modeling of the structural relation between international variables. For instance, it is common to study the influence of shifts in commodity price without considering its drivers. Since it also responds endogenously to shocks elsewhere, its importance for national business cycles may be overwhelmed. This missing link limits our understanding of how domestic economies react to various international shocks and the relevance of each of them.

We investigate the impact (at business cycle frequencies) of global shocks in four commodity exporters emerging economies: Brazil, Chile, Colombia and Peru. Three global shocks are analyzed: demand, financial uncertainty and another in the commodity market which we claim to represent a worldwide supply shock. In the international front we investigate the influence of these shocks in global activity, financial volatility and aggregate commodity price index. In the domestic front, we study the impacts on sovereign risk, nominal exchange rate, GDP, consumer price index (CPI), and policy interest rates, which are traditional variables of interest when evaluating shocks affecting emerging economies. These are also variables normally considered in dynamic general equilibrium models for emerging economies, which allows comparisons with the results obtained by these models. The econometric methodology follows Cushman & Zha (1997) and relies on Bayesian Structural VAR (BSVAR) with block recursion restrictions to impose the small open economy hypothesis. The sample ranges from the first quarter of 2000 to the second quarter of 2017 (the last information available when we were conducting the study) which is an interval of relative constancy in the monetary policy framework in these countries, all of them embracing inflation targeting[1]. Choosing countries from the same region (South America) minimizes the role of geography in accounting for differences in the results.

[1]During the 1990s, monetary policy in some of them was based on pegs against the US dollar.

Several scholars have pursued research on the issues we consider, but most analysis are not broad enough to properly deal with general equilibrium in the global economy. In some cases this happens because international linkages are omitted or are just not important for the particular study. In others, the use of factors to extract common information present in large sets of international variables ends up embedding variables and shocks that should be considered apart in order to capture specific global innovations. These practices result in overestimation of the contribution of some shocks for national business cycle. We verify this to be the case in several analysis of the impact of commodity price shocks, which we find to contribute far less than suggested by most works. This shock also produces negligible influence on country spreads after controlling for world financial risk, which is a finding with important modelling consequences, since several DSGE models include world commodities price innovations directly in the equation determining the country spread of commodity exporters emerging economies (Fernández et al. (2018), Drechsel & Tenreyro (2018), Shousha (2016)).

Our analysis relies on a common aggregate commodity price index to all countries instead of a specific index for each of them. The reason for this choice is that we want to study situations in which all prices follow a similar trend, which was the pattern observed during our sample, as shown in Figure 1. Given this pattern, prices of exports and imports tend to move in similar direction in the presence of global shocks, making the overall domestic effect not so obvious. For instance, the prediction that the nominal exchange rate of a country would appreciate following a rise in the price of its relevant exporting commodity (Chen & Rogoff (2003) and Cashin et al. (2004)) seems less straightforward when importing prices also move in similar direction. This point has been raised by Fernández et al. (2017) who defend the use of an aggregate price index as a better manner to capture the transmissions of world shocks to domestic economies, even if exports or imports are highly concentrated in a particular commodity. This last argument is reinforced by the findings of Alquist & Coibion (2014) that comovements in commodities prices reach maximum values in periods of more intense global economic activity. This is an additional reason for focusing on an aggregate price index, given the interest in studying the effects of international macroeconomic shocks that are not commodity specific.

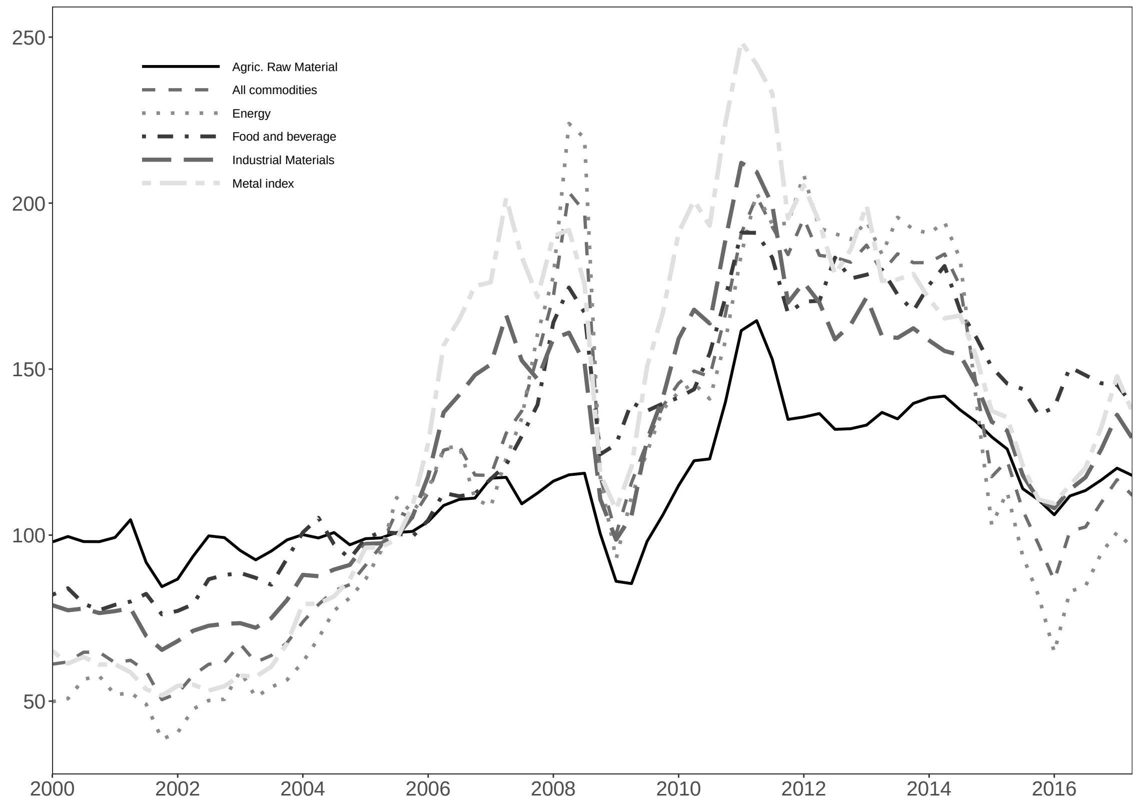

Figure 1: Evolution of commodities prices index

The literature

The impact of shifts in world commodity prices and in world financial conditions are probably the most studied shocks affecting emerging economies.

The financial stance is more commonly studied by verifying the domestic responses following a rise in world risk-free interest rate, which tends to affect adversely emerging economies (Calvo et al. (1993), Mendoza (1991), Arora & Cerisola (2000), Neumeyer & Perri (2005), Uribe & Yue (2006), Fernández et al. (2018), among others). The standard reaction is a devaluation of the domestic currency (through interest parity conditions), producing higher domestic inflation and obliging the monetary authority to increase the domestic policy interest rate, which reduces GDP growth.

More recently, Fernández et al. (2017), Shousha (2016), and Akıncı (2013), among others, have considered the influence of the international interest rate in a broader context where other dimensions of the global economy are taken into account. Fernández et al. (2017) show that a single measure of world price, like the terms of trade, does not properly capture the influence of world shocks in emerging economies. The use of two world prices in their model, the FED's rate and measures of commodity price indexes, explains together around 60% of commodity exporter aggregate fluctuations on post 2000 data. Shousha (2016), on the other hand, finds the contribution of world interest rate shocks negligible for activity fluctuations in emerging economies after controlling for the presence of commodity prices. According to him, the importance of global interest rate has been overstated because its movements reflect endogenous responses to world commodity prices, which he finds to contribute largely for domestic aggregate fluctuations. Akıncı (2013) also verifies a negligible influence (of around 5%) of US real interest rate shocks for emerging markets aggregate activity after controlling for global financial risk, which he finds to explain about 20% of output oscillation[2].

Based on the latest evidences regarding the importance of global financial risk and uncertainty[3] to international and domestic economies, an issue that has gained special attention after the 2008/09 crisis, we find its presence of extreme relevance for properly identifying the main sources of global shocks. This importance is corroborated by different analysis showing economic activity contraction, in rich and emerging countries, following a rise in uncertainty[4]. Carrière-Swallow & Céspedes (2013) verify this impact to be larger in emerging economies[5].

[2] Akıncı (2013) finds the country risk being the main propagator of global financial shocks. When country risk is assumed to not respond directly to such shocks, the variance of output, investment, and the trade balance explained by global financial risk shocks is about two-thirds smaller.

[3] Throughout the paper we will abuse and treat risk and uncertainty interchangeably. Bekaert et al. (2013) acknowledge this difference and decompose the Volatility Index (VIX) of the Chicago Board Options Exchange (CBOE) into uncertainty and risk, verifying that both produce similar impact on the US economy. In particular, uncertainty and risk affect monetary policy similarly, and are also analogously impacted by economic cycle and policies.

[4] Akıncı (2013), Fernández-Villaverde et al. (2011), Carrière-Swallow & Céspedes (2013),Bekaert et al. (2013), Bloom (2009), Bloom et al. (2018), Christiano et al. (2014), Baker et al. (2015), among others.

[5] Another reason for avoiding a world risk-free interest rate, like the Fed Funds rate, has to do with the extensive debate of whether it makes sense to consider shocks to the this free rate, since the FED's policy

In the case of commodities prices, the literature has evolved to frameworks that consider world general equilibrium effects, a necessity that has been strongly pushed forward by Kilian (2009) in the context of oil market. Alquist & Coibion (2014),Charnavoki & Dolado (2014), and Fernández et al. (2018) are among the works that pursue this task in the context of aggregate commodity market. Alquist & Coibion (2014) verify that direct factors associated to commodity markets have played minor role in explaining price changes from 1969 to 2013. Shocks to indirect factors (general equilibrium effects) explain most of the variation in commodity prices between 1969 and 2013, being particularly important in periods of price booms, as in the decade of 2000.

Charnavoki & Dolado (2014) model the world economy before analyzing the influence of external shocks in the Canadian economy, a high income commodity exporter small open economy. They conduct a detailed identification of global shocks as demand, supply[6], and commodity specific, this last one extracted from a factor constructed with the price of relevant commodities for determining the trade balance of Canada.This includes energy, minerals, and food commodities[7]. In opposition to Alquist & Coibion (2014), Charnavoki & Dolado (2014) find that commodity specific shocks explain the largest fraction of the variation in the commodity price factor from 2000 to 2010, followed by supply shocks, with demand shocks playing the smallest role. To our view, given that several commodities from different sectors form their commodity factor, a common shock affecting it seems a wider global phenomenon than something specific to the commodity market[8]. In our analysis, the response following an innovation in the aggregate world commodity price index resembles the reaction to a standard supply shock, impacting the world activity in a very similar fashion

decisions mostly constitute endogenous reactions to shocks elsewhere, including those we try to identify.

[6]Charnavoki & Dolado (2014) consider that their supply shock captures events like the surge of ICT innovations, productivity growth in emerging economies or the deepening of trade liberalization in the 1990s.

[7]According to Charnavoki & Dolado (2014), wars, natural disasters, unexpected changes in the precautionary demand for commodities are all examples of events capable of triggering direct movements to most commodity prices.

[8]According to Charnavoki & Dolado (2014), a negative shock to supply and to the commodity market generate very similar negative effects on world economic activity, while a positive innovation to the world demand increases the commodity price factor and the inflation factor from which the traditional supply shock is obtained.

the commodity specific shock does in Charnavoki & Dolado (2014).

Despite the contributions of Alquist & Coibion (2014) and Charnavoki & Dolado (2014), they do not verify the influence of world financial uncertainty to commodity prices, which has also been found to affect oil prices (Morana (2013)). To the extent that commodities prices are expected to fall after an increase in financial uncertainty, the absence of the later from a global model may alter the conclusions regarding the relevance of supply and demand shocks in explaining oscillations in global and domestic variables. Modeling the international economy using a metric for global activity, an aggregate commodity price index and the VIX puts together variables capable of summarizing the state of the world economy in various dimensions, allowing for a better understanding of global shocks and a more precise measure of their impacts at national level.

The work of Fernández et al. (2018) acknowledges the necessity of integrating these pieces to obtain a more complete perspective on the world economy in order to verify its influence in the business cycle of emerging countries. From this point of view, their work is the closest to ours. The countries of interest constitute another similarity: Brazil, Chile, Colombia, and Peru.

Apart from differences in methodologies[9], our most important departure from the work of Fernández et al. (2018) is related to the modeling of the international economy. Their global supply shock is evaluated by a direct innovation in a country specific aggregate commodity price index[10], individually tailored to reflect the main exporting commodities of each nation. But embedded in each of these indexes is a common factor to all countries aimed at capturing shocks specifically affecting the world commodity market, like an innovation in Chinese demand. The direct shocks to the price index and to the common factor add up to constitute the commodity price shock, accounting for expressive fraction of the forecast error variance (FEV) of the domestic GDPs. They also consider a traditional world demand shock, which is

[9]Their main results rely on a multi-country DSGE while we use Bayesian SVAR.

[10]This approach is similar to ours and different from that of Alquist & Coibion (2014) who do not consider shocks to the commodity price index as a global supply shock.

derived from innovations to the USA GDP time series. This last innovation barely accounts for the FEV of each country's GDP. During the period analyzed, a large fraction of the increase in global demand has not necessarily been originated in the USA, but this does not mean it should not be regarded as a global demand shock. As a result, events capable of influencing the entire world economy, not restricted to the commodity market, end up being absorbed by the common factor. Similar situation applies for changes in the world financial risk[11], which is likely to affect all commodity prices but, according to their set up, are captured by the common factor forming each price factor, even though the triggering shock is not restricted to the commodity market. Embedding important world events in this common commodity price factor renders the commodity price shock a large fraction of each country's FEV, diminishing the influence of other global innovations that are not originated in the commodity market nor restricted to it. As a result, the influence of a traditional global demand shock and of a sudden change in world risk would have their roles diminished as determinants of business cycles.

Our works also diverge with respect to some variables considered in the analysis. We worry about the impacts on inflation and policy interest rate[12]. Including these two variables makes our structure closer to the setup of traditional New Keynesian models, allowing further analysis, like the responses of domestic inflation and monetary policy to global events. We also analyze a broader range of domestic shocks (macroeconomic/political uncertainty, demand, supply, and monetary policy). Fernández et al. (2018) interpret innovations to the domestic GDP as being entirely due to domestic supply shocks[13].

Our simpler and more straightforward approach to the world economy, relying on ready to use variables, uncovers important global shocks, making easier to understand the inter-

[11] Fernández et al. (2018) consider the world risk appetite affecting the demand for domestic economies external debt, helping to close the small open economy.

[12] There are variables they analyze that we do not consider. Since we work with a pure econometric model, while they construct a multi-country emerging market economies DSGE model, we limit the amount of variables studied due to degree of freedoms concern.

[13] We follow the tradition and interpret an unexpected innovation to the GDP equation as a domestic demand shock, while an innovation in the equation of the consumer price index is interpreted as domestic supply shock. We provide, upon request, these impulse responses that corroborate this view.

national linkages guiding world variables. As a result, we verify that global demand shocks explain 55% of the 4 years forecast error variance (FEV) of the aggregate commodity price index, while supply shocks are responsible for 42%. In the case of the world GDP, global demand innovations account for 57% of the 4 years FEV, supply shocks 25% and the remaining 18% has been due to financial uncertainty.

In the domestic front, our results challenge previous findings, specially regarding the relevance of innovations in commodity prices, which we treat as global supply shocks but it is not often viewed in this way. Except for Brazil, where 25% of the 4 years FEV of the GDP can be accounted by global supply shocks, the fraction is negligible for Chile (0,6%), Colombia (6,4%), and Peru (0,4%). Domestic dynamics following such a perturbation is though very similar to those reported by the DSGE models of Fernández et al. (2018) and Drechsel & Tenreyro (2018): the GDP of these commodity exporters emerging economies increases, which is the opposite verified by Charnavoki & Dolado (2014) for Canada.

In opposite direction, global demand shocks have played very important role in explaining local GDP FEV: 36% in Brazil, 16% in Chile, 15% in Colombia, and 33% in Peru. Country specific macroeconomic uncertainty shocks, captured from innovations to a sovereign country spread, also account for a large fraction of 4 years ahead FEV of the GDP: 16% in Brazil, 52% in Chile, 11% in Colombia, and 45% in Peru. Local demand shocks have been responsible for another important fraction of the GDP FEV, while innovations in monetary policy have been irrelevant to all of them.

Our work is also related to the literature aiming at evaluating the relevance of the sovereign risk for emerging countries business cycle (Mendoza (1991), Calvo et al. (1993), Arora & Cerisola (2000), Uribe & Yue (2006), Bocola (2016) among others). We confirm previous findings of a negative relation between country risk shocks and local activity[14],

[14]The domestic reasons responsible for oscillations in the country risk may vary from country to country and also across time, but it is normally associated to excessive external debt, excessive public debt, and uncertainty regarding policies that could drive both to unsustainable levels and take the economy to a crisis. Bocola (2016) has recently developed a theory of pass-through from country risk to economic activity. Accordingly, the bank sector balance sheet is the channel through which country spread affects emerging countries business cycle, mainly by the accumulation of collateral to deal with extreme scenarios.

but verify at least 60% of the sovereign spread FEV have been due to international shocks, which also highlights the relevance of the sovereign spread as a transmitter of global shocks as emphasized by Akıncı (2013), and Fernández et al. (2017).

Besides this introduction, this paper has another 4 sections and 3 appendixes. The data set is described in section 2. Section 3 sets the methodology, including the structural restrictions imposed in the VAR. The results are all presented and analyzed in section 4, while final considerations are drawn in section 5. In appendix A.1 we present details about the database, while appendix A.2 briefly explains the Bayesian priors which follow Sims & Zha (1998) and Waggoner & Zha (2003), and appendix A.3 contains additional impulse response functions.

2 Data

We estimate models using quarterly data for the world economy and four Latin American commodity exporter countries: Brazil, Chile, Colombia and Peru. Being from the same region helps controlling for possible geographical effects. The sample ranges from the first quarter of 2000 through the second of 2017. During this period the world economy was hit by important events: the prominent role assumed by China which led to a commodity price boom, the 2008/2009 financial crisis that pushed the world to a big recession and provoked an immense fall in asset prices, among others. Fernández et al. (2017) estimate global shocks explaining more than 60% of aggregate fluctuations in individual countries from 2003 to 2014, which is twice larger than when their sample ranges from 1960 to 2014.

2.1 International variables

We use three international variables: a volatility index (VIX), the IMF all commodity price index, and a measure of world GDP computed by the World Bank.

The VIX, a stock market (S&P500) volatility index, has been widely used as a measure of economic uncertainty since Bloom (2009)[15]. We find reasonable to assume that sentiments regarding the state of the world finance is well captured by the VIX, since the S&P500 incorporates stocks of big international companies, several of them being major global players in their respective sectors. Global financial uncertainty shocks is captured by innovations to VIX[16].

The World Bank estimates a global GDP at current price using constant US dollar of 2010. The estimation uses information of all Worl Bank members. Our impulse response analysis shows that this measure of global GDP responds to global shocks as one would expect from a GDP series. Similarly, innovations in this world GDP metric produce movements in global and domestic variables that are all expected following a global demand shock. Being easy to access and updated at regular base, the World Bank global GDP series provides a good information regarding the state of the world business cycle.

The commodity price is the IMF all commodity price index that uses the US dollar as the reference currency. Since we evaluate the effect of international shocks on domestic nominal variables, we do not deflate the price index. Our quarterly series is the average over monthly information[17].

We do not analyze shocks in specific commodities markets that would matter most for each of the countries studied. Rather, we are interested in situations where aggregate global shocks matter for all commodity markets causing their prices to co-move. As reported by Alquist & Coibion (2014), our sample period is one of intense co-movement in commodity prices of several sectors, affecting imports and exports in the same direction. Under such scenario, analysis strictly focused on the consequences of variation in the price of the relevant exporting commodity (Chen & Rogoff (2003) and Cashin et al. (2004)) to a specific country is not appropriate, since the net effect on the trade balance is not so obvious (Fernández

[15]Whaley (2009) also provides a detailed discussion about the origins and uses of the VIX index.

[16]We abuse and treat uncertainty and risk shocks altogether, using innovations in VIX to represent both. This distinction has been particularly well elaborated in various works aimed at including ambiguity in general equilibrium macroeconomics models. See Bianchi et al. (2018) and Backus et al. (2015).

[17]The monthly IMF commodity price used to be updated to the IMF web page until July of 2017.

et al. (2017), Bianchi et al. (2018)[18].

Most of the literature has avoided a structural interpretation of innovations in commodity price. For instance, Fernández et al. (2017) explicitly mention that the source of innovation directed to the commodity price index was not a concern of their work, as they simply wanted to evaluate the impact of sudden oscillations in the prices. Charnavoki & Dolado (2014) interpret such innovations as representing any structural shock specific to commodity markets, not distinguishing if it is rooted on supply or demand forces. Among these shocks, they mention natural disasters, wars, and unexpected changes in precautionary demand for commodities. We started with an agnostic view on the nature of a shock in the commodity price index, but our analyses revealed that such an innovation resulted in reactions compatible with a standard textbook supply shock. As such, this would encompass part of the events considered by Charnavoki & Dolado (2014) as supply shocks, but would exclude changes in the world demand, which we manage to identify through innovations to the world GDP series.

2.2 Domestic variables

The domestic variables used allow some understanding of the channels through which structural shocks dissipate. A risk adjusted interested parity (IP) is certainly one of the most important relations linking domestic and the international economies. As such, we incorporate in the models the nominal exchange rates against the US dollar[19] and the Emerging Market Bond Index Global (EMBIG), which is a measure of sovereign spread (country risk) computed by the investment bank J.P.Morgan's. We also include the policy interest rate, which, despite of also entering in IP conditions, is the main monetary instrument in the inflation targeting regime of the countries studied. For the real sector, we use real gross domestic product (GDP) and the consumer price index (CPI). All variables enter in level

[18] For this reason, Bianchi et al. (2018) also analyze the transmission of world shocks by relying on a multiple price specification, regardless if exports or imports of a country were highly concentrated in a particular commodity. They rely on three commodity price indexes: food, fuel, metal and mineral.

[19] Increases in the exchange rate are devaluations of the local currency against the US dollar.

after a logarithm transformation, with the exception of the nominal interest rate that enters without any transformation. The system is estimated with 4 lags, which is standard when using quarterly data.

3 The Econometric Methodology

The empirical model is a structural vector autorregression (SVAR) following general form[20]:

$$A_0 y_t = \sum_{\ell=1}^{p} A_\ell y_{t-\ell} + \varepsilon_t$$

where $t = 1, ..., T$ is the time index and $\ell = 1, ..., p$ is the lag length. A_0 and A_ℓ are $n \times n$ matrices of coefficients, with A_0 informing the contemporaneous relations between the variables present in the column vector y_t that contains all n endogenous variables. Each matrix A_ℓ is formed by lagged coefficients responsible for the dynamics of the variables over time. The $n \times 1$ column vector ε_t contains the structural disturbances[21]. The coefficients in each row i of matrices A_0 and A_ℓ are associated to the equation of the variable $y_{i,t}$ in the same row.

It is convenient to partition $y_{t-\ell}$ in two blocs so that $y_{t-\ell} = (y_{1,t-\ell}, y_{2,t-\ell})'$, where $y_{1,t-\ell}$ and $y_{2,t-\ell}$ are column vectors with dimensions $n_1 \times 1$ and $n2 \times 1$, respectively, and $n = n_1 + n_2$. The vector ε_t and the matrix A_ℓ can also be partitioned to maintain coherence with $y_{t-\ell}$:

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix}, \qquad A_\ell = \begin{bmatrix} A_{11,\ell} & A_{12,\ell} \\ A_{21,\ell} & A_{22,\ell} \end{bmatrix}$$

[20]The exposition follows closely Waggoner & Zha (2003).

[21]In our setup we do not explicitly consider the presence of exogenous variables, although the restriction on the lagged structure of the international variables guarantees complete exogeneity of these variables with respect to domestic ones.

The dimensions of $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are, respectively, $n_1 \times 1$ and $n_2 \times 1$. Matrices $A_{11,\ell}$ and $A_{21,\ell}$ are both $n_1 \times n_1$, while $A_{12,\ell}$ and $A_{22,\ell}$ are $n_2 \times n_2$.

Because VARs can easily suffer from overparameterization, a Bayesian approach to estimation helps disciplining the estimated coefficients, their standard errors, and, very important, the confidence intervals of the impulse response functions, which tend to be very wide when the system contains a large number of variables and lags. Since this is our case ($n = 8$ and $p = 4$ in the benchmark model), we follow Sims & Zha (1998), Zha (1999), and Cushman & Zha (1997) and estimate the VAR using bayesian methods with priors suggested by Sims & Zha (1998). Specifically, we combine the Minnesota prior and the sum-of-coefficients prior. More details regarding these priors are in the appendix.

3.1 Lag restriction

It is reasonable to assume that small open emerging economies do not influence world aggregate economic variables. For this reason we follow Cushman & Zha (1997) and impose bloc exogeneity[22] to prevent the recursion of domestic variables from affecting any global variable. This is an important restriction given the existent correlation between domestic and international variables.

In terms of the VAR, the restriction is that $A_{12}(\ell) = 0$, so we assume $y_{1,t-\ell}$ to be the bloc containing international variables, and $y_{2,t-\ell}$ being formed by domestic variables[23]. The matrix A_ℓ then becomes

$$A_\ell = \begin{bmatrix} A_{11,\ell} & 0 \\ A_{21,\ell} & A_{22,\ell} \end{bmatrix}$$

Similar restriction is imposed on the equation for the sovereign spread (country risk), which we assume to be dynamically influenced by its own lags and by past values of the international variables. The reason for not allowing other domestic variables to explain the

[22]For a more detailed explanation and mathematical proofs, refer to Zha (1999).

[23]The reduction in the number of parameters to be estimated is a byproduct of such restriction.

country risk, even with lags, has to do with our choice of not modeling the fiscal sector, which would carry perspectives on the debt dynamics. Government debt and the current account balance are notably the most important domestic variables determining EM sovereign risk. While the effect of shocks in the balance of payment can be captured by the state of global variables, we do not incorporate variables that would properly inform about the state of the public finance. This means that there is no other domestic variable in the system capable of informing about the perspectives of the public debt, which would ultimately influence the country risk. Furthermore, since sovereign spreads are strongly correlated to other domestic variables, specially with the nominal exchange rate through a risk adjusted interest parity condition, allowing a feed back from this variable to country risk would erroneously contaminate the adjustment of the sovereign risk that would feed back to the system.

3.2 Identification of the contemporaneous structural relations

The contemporaneous structural relations are captured by the coefficients of matrix A_0, with each row representing one equation. The system is organized in four different blocs: the international bloc is composed by the world GDP, VIX and the commodity price index; the domestic international finance bloc is formed by the sovereign spread (country risk) and the nominal exchange rate; the domestic real sector is composed by the GDP and the CPI; and the last one is the policy bloc, solely composed by the domestic policy interest rate.

The structural identification of A_0 is based on the informational method proposed by Leeper et al. (1996). Accordingly, a variable would contemporaneously react to a shock if the information content of such shock is relevant to trigger an immediate response of the agents responsible for acting upon that specific variable to the point of disturbing it immediately.

Consistent with such strategy, all variables within a bloc must be allowed to respond contemporaneously to innovations in the same variable from another bloc. Based on this scheme, global variables do not respond to domestic variables. The domestic international finance bloc, given it is formed by forward looking variables, is allowed to move instantaneously to any news arriving from the international bloc. Regardless of observing the movements in these blocs, we consider that agents in charge of the real sector variables wait at least one period to adjust production and prices. Finally, the Central Bank board (or staff) monitors continuously domestic and international variables, which may all contemporaneously affect the determination of the policy interest rate.

Identification inside each bloc satisfies a standard Cholesky ordering. Zha (1999) explains that this is actually a necessity to prevent losing the bloc structure during the estimation procedure, which could happen once the matrix is inverted.

Our recursive structure in the international bloc assumes that global activity is only impacted contemporaneously by its own innovations, which we interpret as a global demand shock (ε_t^{wdem}) that can also disturb VIX and commodity prices on impact. The later is also contemporaneously affected by global financial uncertainty shocks, modeled as innovations in the VIX equation (ε_t^{wunc}). Innovations to the commodity market, which we treat as a world supply shock (ε_t^{wsup}), only affect commodity prices contemporaneously.

In the domestic financial sector, innovations to country risk (ε_t^{cr}), interpreted as a domestic macroeconomic policy uncertainty shock[24], affect contemporaneously the exchange rate. In the real sector, demand shocks (innovations to GDP, (ε_t^{dem})) can affect the CPI on impulse, which is a standard assumption in the literature. Despite of imposing restrictions on all variables, it is important to have in mind that we are mostly interested in identifying shocks in the international variables, so the impulse responses are unaffected by the structure of the domestic contemporaneous restrictions[25]. After imposing these structural restrictions, the impact matrix A_0 becomes

[24] Since country spreads are mostly determined by perspectives on the public finance, we think of a structural shock on it as capturing investors sentiment on the path of public debt based on information that could have been released by authorities or by political episodes that could impact the government finances.

[25] The decomposition of the forecast error variance is influenced by the ordering posterior to the sovereign risk, but the restrictions imposed are standard in the literature.

$$
A_0 = \begin{array}{c} \\ WGDP \\ VIX \\ PCOM \\ CR \\ EXR \\ GDP \\ CPI \\ INTR \end{array}
\begin{array}{c}
\begin{array}{cccccccc} \varepsilon_t^{wdem} & \varepsilon_t^{wunc} & \varepsilon_t^{wsup} & \varepsilon_t^{cr} & \varepsilon_t^{fx} & \varepsilon_t^{dem} & \varepsilon_t^{sup} & \varepsilon_t^{mon} \end{array} \\
\begin{bmatrix}
a_{1,1} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{2,1} & a_{2,2} & 0 & 0 & 0 & 0 & 0 & 0 \\
a_{3,1} & a_{3,2} & a_{3,3} & 0 & 0 & 0 & 0 & 0 \\
a_{4,1} & a_{4,2} & a_{4,3} & a_{4,4} & 0 & 0 & 0 & 0 \\
a_{5,1} & a_{5,2} & a_{5,3} & a_{5,4} & a_{5,5} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & a_{6,6} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & a_{7,6} & a_{7,7} & 0 \\
a_{8,1} & a_{8,2} & a_{8,3} & a_{8,4} & a_{8,5} & a_{8,6} & a_{8,7} & a_{8,8}
\end{bmatrix}
\end{array}.
$$

4 Results

We report responses to a positive global demand shock, to a positive global financial uncertainty shock (drop in uncertainty), and to a negative (adverse) shock in the global commodity market (increase in aggregate commodity price index).

All impulse response functions (IRF) and forecast error variance decomposition are presented in the appendix. The 68% confidence intervals[26] are also shown in the IRFs plots. To facilitate comparisons, the innovations are normalized to guarantee that aggregate commodity price index increases by 10% on impact[27].

4.1 Global shocks and the international economy

The impulse response functions presented in Figure 2 show the world GDP and the commodity price index increasing after an unexpected rise in global demand, while volatility falls. An unexpected drop in world financial uncertainty increases the world GDP and the commodity price index, but reduces volatility. Finally, an adverse supply shock drives prices

[26]These probabilities bands were computed using the method developed by Sims & Zha (1999).

[27]This was only possible in our preferred ordering scheme because the commodity price index comes last in the international bloc.

and volatility upwards and the world GDP downwards. These are all expected reactions following the innovations we aim to identify.

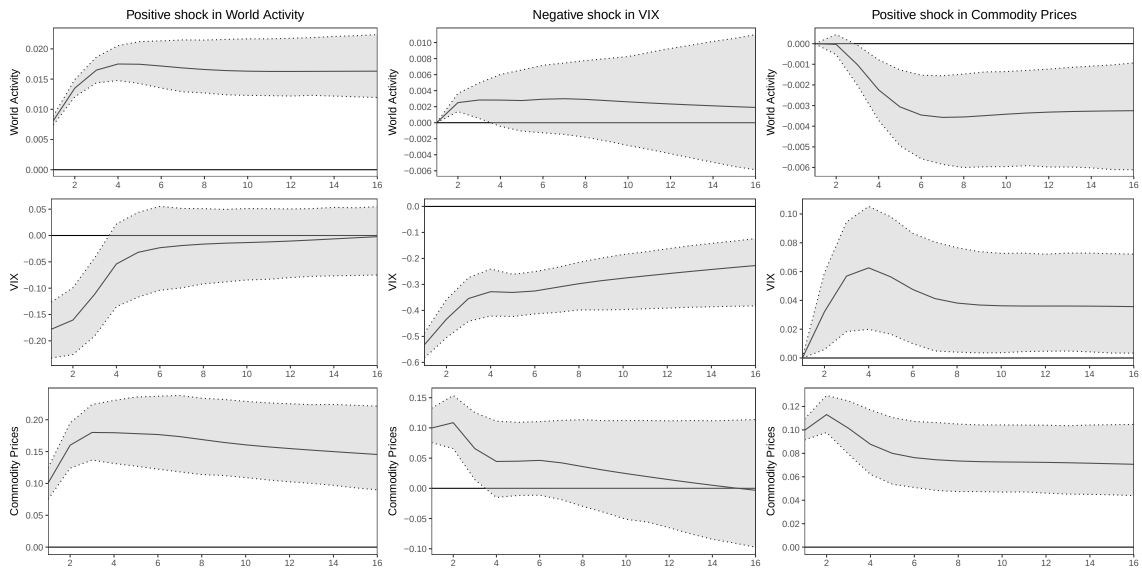

Figure 2: Response of international variables

Just as Kilian (2009) have reported for the oil market, we verify that movements in the aggregate commodity price index are not all the same. Take for instance the responses to a positive perturbation in global demand and uncertainty (drop in uncertainty). They both generate larger output, smaller volatility, and a 10% instantaneous augment in commodity price. The magnitudes and the adjustments are however different. The 0.85% positive demand shock that causes a 10% rise in commodity price also results in a 17.5% drop in volatility. But the commodity price index continues to increase until the $3rd$ quarter, after which it starts to fall slowly in a very persistent manner, resembling the pattern observed in the adjustment of the global GDP. In the case of the financial uncertainty shock, it is needed a 52% drop in volatility to produce an instantaneous 10% increase in commodity price index, which starts falling right after the initial augment, moving towards its regular path in a much faster pace than the the adjustment following the demand shock.

In the case of an adverse global supply shock, commodity price increases instantaneously and volatility goes in the same direction one quarter later. Global GDP falls until the $6th$

quarter. These responses in activity and prices are similar to what happens in Charnavoki & Dolado (2014) after a positive innovation to their commodity specific factor, which we believe to be capturing a world aggregate supply shock, even though they intend to capture this shock from innovations to a measure of world inflation[28]. As we previously mentioned, a shock that affects commodity prices of different sectors (agricultural, mining, energy, and others) similarly does not seem to be very specific to the commodity market, but, on the contrary, is more likely to have its origin in a broader world event. This is why we interpret innovations in the commodity price index as a supply shock, which is also compatible with the following increase in the volatility index.

Before moving to country specific analysis, we anticipate a potential critique to the identification scheme of the international bloc. One could argue that the VIX should react instantaneously to innovations elsewhere, including those originated in the commodity market (or supply as we prefer). This is certainly a reasonable hypothesis given that commodities and its derivatives are traded in the financial market just as any other financial product, making their prices to be as forward looking as the VIX is. We verify this possibility using an identification where global demand shock remains the first, but allowing the commodity price index to come second, responding to an uncertainty shock with a delay. The resulting impulse responses are difficult to reconcile with economic intuition and the nature of the shocks we try to identify. In particular, an adverse shock in commodity markets (increase in price) reduces global volatility. For this matter we decide not to pursue further analysis using this alternative ordering.

[28]The responses in world activity and commodity prices following a shock in their measure of world inflation, which they interpret as being a world supply shock, have the similar pattern as that caused by an innovation in their commodity price factor. The difference occurs in the persistence of global activity, which is stronger under the shock in the level of the commodity price factor and less intense following an innovation in their measure of global inflation.

4.2 The national economies

4.2.1 Global demand shock

Figure 3 show that common patterns emerge to all countries following a positive global demand shock. Country spreads drop between 15% and 18% on impact, which is similar in magnitude to the fall in the VIX. After the 2^{nd} quarter they start increasing, moving towards regular equilibrium path. The Chilean risk adjusts after 4 quarters, while the others move slower in that direction but in a similar manner.

Nominal exchange rates appreciate consistent with the predictions of a risk adjusted interest rate parity. On impact, the Brazilian currency has the most intense gain (7%) and the Peruvian the smallest (2%). All currencies present high persistence that delays the return to regular path. This seems to be related to the similar pattern followed by the world GDP and the commodity price index, favoring a lasting inflow of international funds.

Domestic GDPs follow the world GDP pattern and increase. The impact reactions are 1.3% in Brazil, 0.5% in Chile and Colombia, and 0.35% in Peru. A humped shape adjustment guarantees a further increase in the GDP gap with intensities that vary across countries. The Colombian GDP presents a smaller augment in the following quarters, with the Brazilian, the Chilean and the Peruvian reacting more positively.

The CPI responses are less homogeneous. It slightly increases in Brazil, but never enough to become significant. The responses in Chile and Colombia are similar, increasing above regular trend. In the case of Peru, it drops on impact, but increases afterwards. The non significant reaction in Brazil CPI may be rooted in the more intense nominal exchange appreciation, which may compensate the upward pressures of a higher commodity price and a positive output gap. In the other countries, it is possible that a less intense appreciation does not produce similar compensation.

Policy interest rates reactions are also heterogeneous, but consistent with the patterns of the CPI response in each country. The Brazilian rate increases in a humped shape pattern, but never being significant. In the other countries, the rates also present a humped shape, but the reactions are more intense and significant. Colombia has the highest reaction, coinciding with its more intense CPI augment.

Overall, the responses of sovereign spread, exchange rate and GDP are all the expected according to traditional small open economies model. CPI responses, on the other hand, do not follow a general pattern, since it apparently depends on the magnitude and persistence followed by nominal exchange rates, which are ultimately related to the intensity of the sovereign spread reaction.

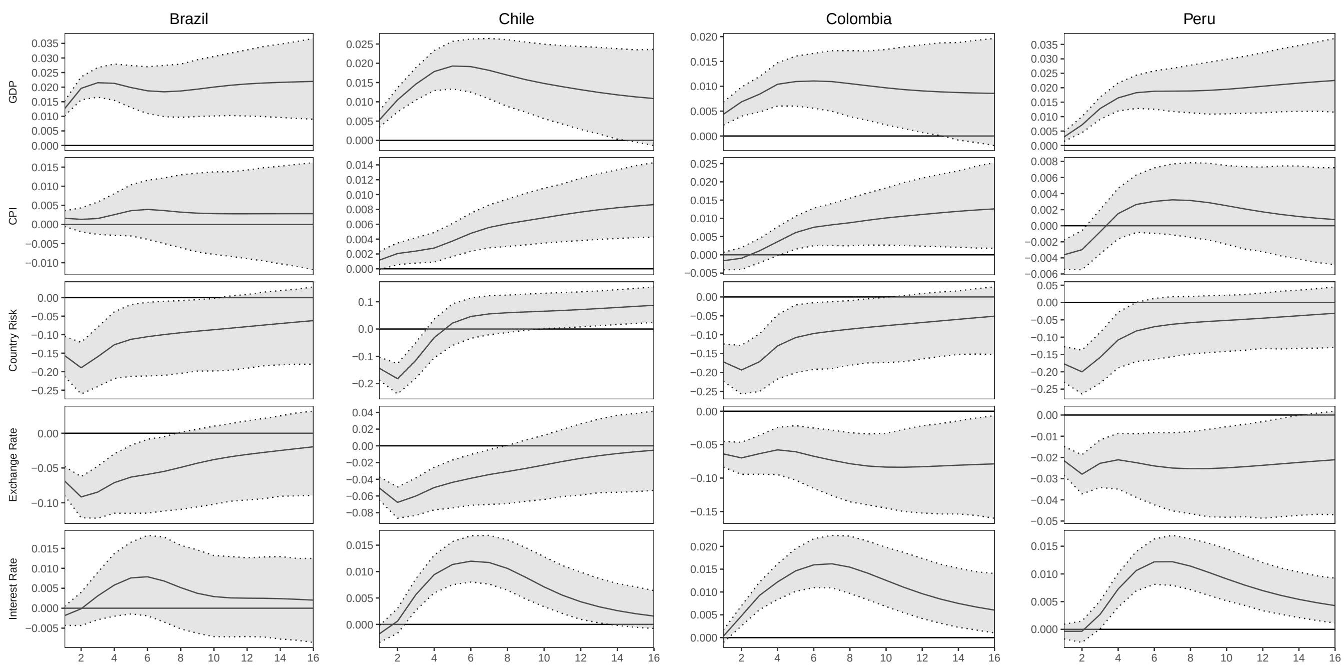

Figure 3: Response of domestic variables to a positve shock in global demand

4.2.2 Global financial uncertainty shock

Figure 4 shows that sovereign spreads fall after the 52% drop in global uncertainty, ranging from -28% in Chile to -34.5% in Brazil. After this instantaneous drop, country risks increase on their return to regular path, adjusting faster in Chile and slower in Brazil.

The nominal exchange rates of Brazil, Chile and Colombia appreciate by 10%, 6%, and 8%, respectively, which is consistent with smaller global and local risk. The magnitudes are also in accordance to those observed in the sovereign risks, being more intense in Brazil and least so in Chile. The Peruvian currency appreciates only 1% on impact, which is a small number compared to the other countries and to the drop in local sovereign risk. After the 3^{rd} quarter this deviation disappears. Our work is silent regarding the different pattern followed by the Peruvian currency, but it is definitely a question that deserves a deeper investigation.

Regarding GDP, Brazil is the only country with a positive significant reaction, with a 0.5% increase on impact followed by further augment that reaches 1.2% in the 4^{th} quarter, after which it very slowly returns to regular path. The pattern followed by the Brazilian GDP is the exception, because the others GDPs do not react significantly.

The CPI of all countries falls significantly, but the highest drop happens in Brazil where the currency appreciation is also more intense. This shows that nominal exchange rate plays the prominent role in determining the local inflation in the aftermath of a global financial uncertainty shock, moving internal prices in opposite direction suggested by the positive output gap. This is also true for the other countries, which further reveals that the increase in commodity prices is more than compensated by the strength of the currency appreciation. Consistent with the most intense drop in CPI, the Brazilian policy interest rate is the only to drop significantly.

Comparing the reactions in all countries, Brazil is the only place where a boom in world GDP and prices, followed by the drop in financial uncertainty, result in smaller policy interest rate. While this may amplify the positive influence of the initial shock, this pattern once again seems to be associated with the most intense drop in the Brazilian sovereign risk which ultimately provokes the intense currency appreciation.

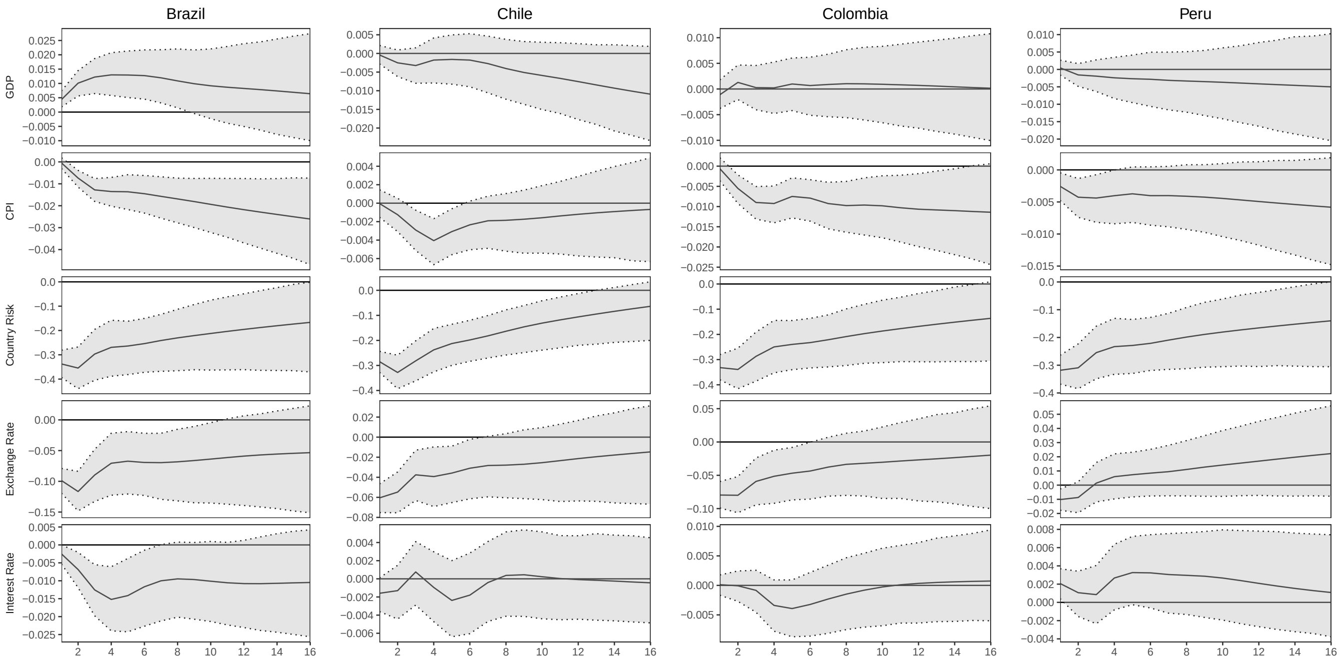

Figure 4: Response of domestic variables to a negative shock in global economic uncertainty

4.2.3 Commodity markets/supply shock

Figure 5 shows that despite of being hit by an adverse shock that elevates the aggregate commodity price index, the sovereign risk of all four commodity exporters falls immediately, varying from -1.8% in Peru to -3.6% in Colombia, but being significant only in Chile and Colombia. It then follows the variation in world volatility, increasing and then slowly falling towards regular path.

Nominal exchange rates significantly appreciate on impact (1% in Colombia and Peru, 2% in Chile, and 2.7%in Brazil), remaining stronger for a long time. This is expected since we are dealing with countries in which the commodity sector plays important role for determining the balance of payment. These results are also in line with those obtained by the DSGE model of Drechsel & Tenreyro (2018), for Argentina, and Fernández et al. (2018) for the same countries we study.

GDP reactions are less homogeneous and opposes the drop in the world GDP. They significantly increase in Brazil, Colombia and Peru, just as reported by Fernández et al.

(2018) and by Drechsel & Tenreyro (2018) for Argentina. The (non significant) GDP fall in Chile is closer to the pattern reported by Charnavoki & Dolado (2014) for Canada.

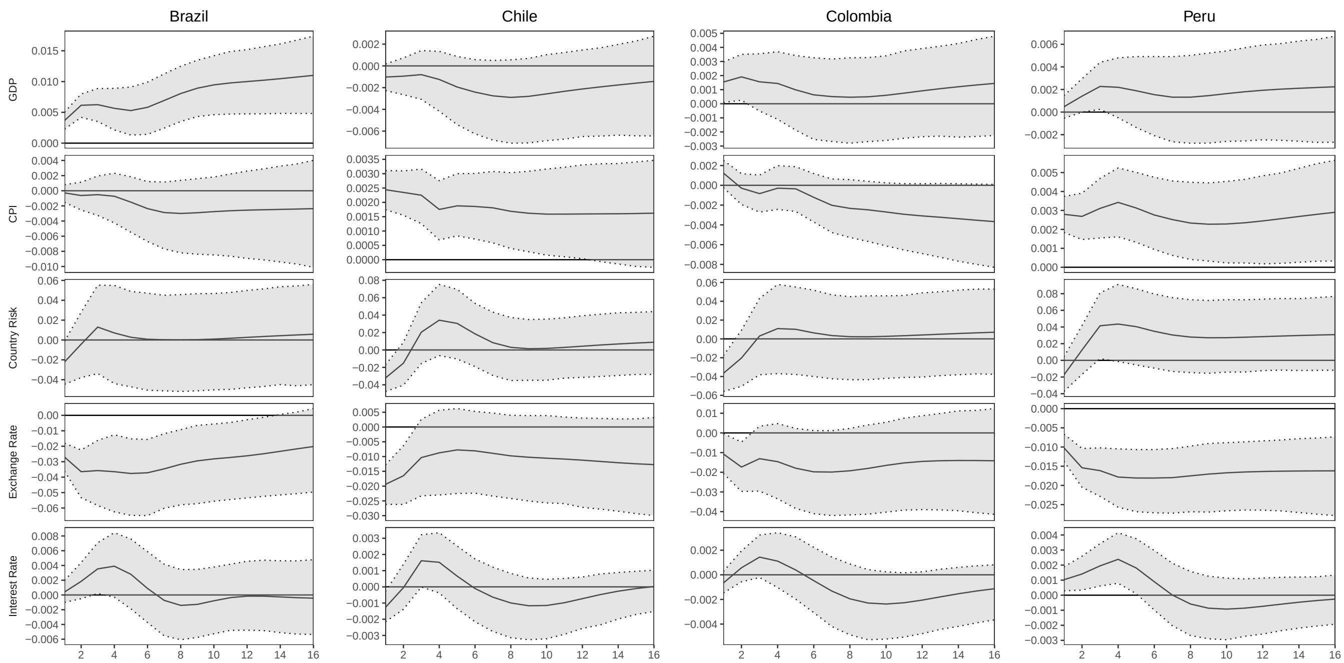

Figure 5: Response of domestic variables to a positive supply shock

4.3 Forecasting error variance decomposition - FEVD

4.3.1 The international bloc

Table 1 reports the FEVD of the international variables. Panel A shows the results of the full model, from which we identify world demand shock ε^{wdem}, world supply shock ε^{wsup}, and world financial uncertainty shock ε^{wunc}.

The 4 quarters FEV of the world GDP is mostly influenced by demand shocks (93.5%). This proportion falls at longer forecasting horizons to 78.4% at 8 quarters and and 56.9% at 16. The importance of supply and uncertainty shocks grow over time. Supply shocks are responsible for 12.2% of the 8 quarters ahead FEV, increasing to 25% for 16. Uncertainty shocks account for 9.4% of the world GDP 8 quarters ahead FEV and 18.1% for 16.

Table 1: Forecast error variance decomposition of the World GDP, commodity price index, and world financial volatility-VIX.

Horizon	World GDP			Commodity Price			Volatility		
	ε^{wdem}	ε^{wsup}	ε^{wunc}	ε^{wdem}	ε^{wsup}	ε^{wunc}	ε^{wdem}	ε^{wsup}	ε^{wunc}
Panel A: Model 1									
4	93.5	2.5	3.9	46.2	48.9	4.9	18.4	6.1	75.5
8	78.4	12.2	9.4	52.7	44.0	3.3	14.8	9.0	76.2
16	56.9	25.0	18.1	55.0	42.5	2.5	13.5	10.0	76.5
Panel B: Model 2									
4	98.5	1.5		37.0	63.0				
8	92.1	7.9		43.8	56.2				
16	83.7	16.3		47.0	53.0				

Notes: Model 1 is the baseline complete VAR model. Model 2 includes the global GDP and the commodity price index as the only international variables in the VAR. ε^{wdem}, ε^{wsup}, and ε^{wunc} refer, respectively, to shocks in the world demand, world supply, and world uncertainty.

In part, our result agrees with those of Charnavoki and Dolado (2014), since they find global demand shocks, global commodity specific shocks (which closer resembles our notion of supply shock) and global supply shocks as important determinants of deviations of global economic activity from regular path after 2000. Our estimates, however, place higher weight on global demand shocks. Alquist and Coibion (2014) observe that factors not directly related to the commodity markets were responsible for most of the variation in world industrial production after 2000. But since they bundle all variables not directly related to the commodity market in the construction of a factor, it is impossible to know the role played by supply and demand shocks in accounting for deviations in world industrial production. None of these works consider the impact of world financial uncertainty on global activity, which we verify to be relevant.

Regarding the FEV of the aggregate commodity price index, we verify that global demand and supply innovations split almost equal proportion for the 4 years FEV: 46.2% and 48.9%, respectively. The relevance of demand shocks increases for longer forecasting horizons, but both shocks remain important even at 16 quarters ahead: 55% and 42.5%, respectively. Our result is closer to those of Alquist and Coibion (2014) since they verify that worldwide aggregate factors, which contaminate commodity prices through general equilibrium channels, play a more important role in accounting for historical oscillations in aggregate commodity prices[29]. Our results do not indicate uncertainty shocks as relevant for the FEV of the commodity price index.

Financial uncertainty shock represents about 3/4 of the volatility FEV from 4 to 16 quarters ahead forecast. At 4 quarters, global demand shock explains 18.4% and supply shock 6.1%. At 16 quarters, demand explains 13.5% and supply 10%.

We also present the FEVD of an alternative VAR without VIX, which we label model 2 and is under panel B in Table 1. It deserves attention the fact that the part of FEV due to financial uncertainty shocks in model 1 is not simply divided between supply and demand shocks, which would result in larger contribution of both. Take for instance the FEVD of global GDP. Dropping VIX from the VAR inflates the influence of world demand shocks to 98.5% for 4 quarters ahead forecasting, from 93.5%. At 16 quarters, its importance grows to 83.7%, an enormous difference from 56.9% when VIX is present. In the other direction, the contribution of supply shocks diminishes.

Similar pattern emerges when analyzing the FEV of commodity price index. A VAR without VIX inflates the relevance of supply shocks, while reducing that of demand shocks.

These results show the importance of having a deeper structure when modeling the global economy, which should include a variable capable of capturing changes in the mood arising at the financial market. This importance is further highlighted when analyzing the national economies.

[29] The historical decomposition of Charnavoki and Dolado (2014) place much higher importance to supply and commodity market shocks than to innovations in demand to account for deviations in commodity prices after 2000. However, global demand shocks have also played significant role according to their estimates.

4.3.2 Domestic FEVD

GDP

Table 2 reports the FEVD for the GDP of all countries. Our main interest rests on the baseline model 1. In line with other works, we verify the relevance of international shocks in the determination of national economy's business cycle. For 4 quarters ahead forecasting, innovations arising at the global level represents 26.9%, 33%, 17.1%, and 30.2% of the FEV in Brazil, Chile, Colombia, and Peru, respectively. As a comparison, the DSGE model of Fernández et al. (2018) estimates world innovations contributing to 21.03% of the 4 quarters FEV in Brazil, 69.65% in Chile, 29.10% in Colombia, and 24.45% in Peru.

For 16 quarters, which is closer to the unconditional FEV, we estimate international innovations contributing with 62.9% in Brazil, 19.6% in Chile, 68.5% in Colombia, and 41.3% in Peru. The unconditional FEV of the DSGE model of Fernández et al. (2018) reaches the following results for these countries: 47.99%, 77.14%, 50.20%, and 41.42%, respectively. Their results for Brazil and Chile are closer to ours only when the VAR does not include VIX (model 2): the 16 quarters FEV becomes 51.4% and 67.0%, respectively. In the case of Colombia and Peru, the contribution of all international shocks for 16 quarters FEV is 25.5% and 46.8%. So, despite of recognizing the relevance of global shocks to national business cycle, the size of this influence varies depending on how the global economy is modeled.

Table 2: Forecast error variance decomposition of the GDP of Brazil, Chile, Colombia, and Peru.

Shock	hor = 4				hor = 8				hor = 16			
	BR	CH	CO	PE	BR	CH	CO	PE	BR	CH	CO	PE
Model 1												
ε^{wdem}	22.0	31.4	2.6	27.8	22.6	32.1	5.8	34.0	36.1	16.4	15.4	33.4
ε^{wunc}	1.2	0.5	13.2	0.2	0.6	2.7	39.1	2.9	1.8	2.6	46.7	7.5
ε^{wsup}	3.7	1.1	1.3	2.2	7.2	0.6	6.2	1.0	25.0	0.6	6.4	0.4
ε^{cr}	11.3	7.3	12.9	23.9	26.9	27.5	15.8	40.4	16.4	51.9	11.5	45.4
ε^{fx}	0.1	1.1	0.1	1.8	0.4	2.4	1.0	0.9	0.4	2.4	3.9	0.6
ε^{dem}	29.1	57.0	69.5	42.9	24	32.8	30.3	16.3	19.6	23.0	14.1	9.0
ε^{sup}	4.9	0.2	0.1	0.9	4.4	0.8	0.0	4.3	2.0	1.0	0.8	3.6
ε^{mon}	3.8	1.4	0.3	0.3	3.5	1.2	1.8	0.2	1.6	2.1	1.2	0.1
Model 2												
ε^{wdem}	10.8	32.7	3.2	20.4	11.3	44.0	9.3	32.1	24.1	44.6	24.0	43.1
ε^{wsup}	9.0	7.8	1.0	1.3	13.7	14.8	0.7	1.6	27.3	22.4	1.5	3.7
ε^{cr}	13.7	1.6	24.6	6.0	28.2	11.8	44.9	19.8	21.5	11.5	37.9	27.4
ε^{fx}	1.0	0.7	0.7	6.2	1.2	0.4	0.6	5.2	0.9	0.2	6.5	2.9
ε^{dem}	58.6	54.4	69.8	65.8	39.9	24.9	40.0	41.0	22.6	15.3	24.8	22.6
ε^{sup}	2.0	0.4	0.1	0.0	1.8	1.0	0.3	0.1	1.2	2.5	1.0	0.1
ε^{mon}	4.8	2.4	0.5	0.4	4.0	3.2	4.1	0.3	2.4	3.5	4.3	0.1
Model 3												
ε^{wsup}	23.2	17.1	14.4	12.9	12.6	30.7	28.8	18.3	8.9	42.2	53.4	20.9
ε^{cr}	16.0	4.2	8.2	12.7	28.7	21.5	12.0	42.9	39.0	21.5	5.4	62.4
ε^{fx}	1.7	1.6	6.7	7.2	4.4	0.7	14.2	4.8	6.1	1.0	11.7	1.5
ε^{dem}	58.5	68.4	66.3	66.3	53.9	33.0	32.5	32.6	45.5	20.4	14.4	12.5
ε^{sup}	0.5	3.2	1.6	0.1	0.2	4.1	3.1	0.4	0.2	3.9	3.4	2.3
ε^{mon}	0.1	5.5	2.8	0.9	0.1	10.0	9.3	1.0	0.3	11.0	11.7	0.3

Notes: Model 1 is the baseline model. Model 2 includes the global GDP and the commodity price index, while Model 3 incorporates the commodity price index as the only international variable. The shocks are: ε^{wdem}, world demand; ε^{wsup} world supply; ε^{wunc} world uncertainty; ε^{cr}, country risk; ε^{fx}, exchange rate shock; ε^{dem}, domestic demand shock; ε^{sup}, domestic supply shock; and ε^{mon} representing the domestic monetary policy shock.

These differences remain when focusing individually on each shock. Specifically, we do not find very expressive contribution of supply shock (commodity shock in other papers) to domestic GDPs. For 8 quarters FEV, its contribution is 7.6% in Brazil, 6.2% in Colombia, 1% in Peru, and 0.6% in Chile. These magnitudes are basically the same for 16 quarters ahead, except for Brazil where the influence grows to 25%.

In the case of Fernández et al. (2018), pure innovations to commodity price accounts for 16.3% of the unconditional FEV of the Brazilian GDP, 0.5% for the Chilean, 17.6% for the Colombian, and 4.9% for the Peruvian. For comparisons purpose, it is important to note that they consider the commodity price shock being formed by a pure commodity market innovation added by a perturbation in the worldwide commodity specific factor that affects all commodity markets similarly. This factor intends to capture things like shifts in the Chinese demand, which they treat differently from a global demand shock. Innovations to this broader metric of commodity price shock explain 27.5% of the Brazilian unconditional FEV of country's GDP, 77.1% of the Chilean, 43.5% of the Colombian, and 40.4% of the Peruvian. According to their SVAR, these proportions are 15%, 53%, 47%, and 80%, for Brazil, Chile, Colombia, and Peru, respectively. These numbers are all in higher ranges than our estimates.

We further verify that the contribution of supply shocks increases in simpler versions of the world economy, making clear how misleading estimates can be if global general equilibrium is not properly treated. When the VAR is estimated without VIX, supply shock contributes with 27.3% and 22.4% of the 16 quarters ahead FEV of the GDP in Brazil and Chile, respectively, but the fractions remain low for Colombia and Peru: 1.5% and 3.7%, respectively. When the commodity price index is the only international variable in the VAR (model 3), then it is no longer appropriate to think of an international supply shock, but we can still treat as global innovations that shift these prices, as several papers approach. In such a situation, the influence of the commodity price shock becomes much higher than in our previous estimates. For 16 quarters ahead, it explains 8.9% of the Brazilian GDP FEV, 42.2% of the Chilean, 53.4% of the Colombian, and of the 20.9% Peruvian. The proportions at shorter forecasting horizons are similarly higher.

Comparing the results of all these alternative models show that international factors responsible for moving commodity prices worldwide are more important drivers of domestic business cycle than supply shocks (commodity market shocks according to most papers). Innovation to the world demand, for instance, is the most important international driver of business cycle in Brazil, Chile and Peru. In Brazil, it explains 22%, 22.6%, and 36.1% of 4, 8, and 16 quarters FEV of the GDP, respectively. In Chile, the fractions are 31.4%, 32.1%, and 16.4%; and in Peru, 27.8%, 34%, and 33.4%. The contribution is smaller in Colombia: 2.6%, 5.8%, and 15.4%. These proportions are all higher when VIX is not included in the VAR (model 2), showing once again the importance of a proper model of the international economy to verify its relevance for domestic business cycles.

Fernández et al. (2018) also verify the relevance of global demand shocks in accounting for domestic business cycles. This conclusion, however, depends on interpreting innovations to their common commodity price factor as a global demand shock, which, according to our view, is the most appropriate way to think[30]. Accordingly, they estimate the unconditional FEV of GDP arising from perturbations at the global demand in 11.1% for Brazil, 76.6% for Chile, 25.8% for Colombia, and 35.5% for Peru.

Global financial uncertainty shock only plays major role in accounting for the Colombian business cycle, where its contribution for the 4 quarters ahead FEV of the local GDP is 13.2%, increasing to 39.1% for 8 quarters, and 46.7% for 16. Despite of its small relevance to the other countries, the absence of the VIX from the VAR, and the consequent absence of a global financial uncertainty shock, causes a tremendous change in the contribution of the other shocks (global and domestic). We will discuss this issue later.

A richer domestic structure in the VAR is also important for estimating the relevance of local shocks for business cycle. Despite the loss in degrees of freedom associated to more

[30] The reason for this is that this common factor is the first principal component extracted from several commodity indexes that are tailored for each country in order to take into account the most important commodities to each of them. If world demand movements are behind the variation in commodity prices, this factor would naturally capture this influence. As a result, what they really consider to be a global demand shock, obtained from the residuals of an AR(1) process for the cyclical component of the HP filtered real US GDP estimated independently from the factor model, would tend not to capture important global innovations responsible for affecting commodity prices. For this reason we believe that a global demand shock is closer represented by innovations to their common factor. The peculiarities behind these estimations seem to be causing their measure of world demand shock never contributing more than 1% for the unconditional FEV of the domestic GDPs

variables, there are gains from having the variables interacting among themselves because this allows capturing important general equilibrium effects.

Based on this structure we verify the importance of local demand shock (ε^{dem}) for business cycles. It has accounted for 29.1% of 4 quarters FEV in Brazil, 57% in Chile, 69.5% in Colombia, and 42.9% in Peru. For 16 quarters, when the FEV approaches unconditional values, these proportions reduce, but remain high: 19.6% in Brazil, 23% in Chile, 14.1% in Colombia, and 9% in Peru. We estimate negligible influence of domestic supply shocks (ε^{sup}). In the structure proposed by Fernández et al. (2018) there is only domestic supply shock[31], so nothing can be said about innovations in domestic demand. For 4 quarters, they encounter local supply shock responding for the following fractions: 74% in Brazil, 30.4% in Chile, 70.2% in Colombia, and 75.6% in Peru. Their unconditional estimates are: 22.0% in Brazil, 22.9% in Chile, 45.4% in Colombia, and 58.3% in Peru.

Sovereign risk premium (or macroeconomic policy uncertainty) shock (ε^{cr}) is the other important source of domestic business cycle. It has been responsible for 11.3% of the 4 quarters FEV in Brazil, 7.3% in Chile, 12.9% in Colombia, and 23.9% in Peru. For 8 quarters, the proportions are 26.9% in Brazil, 27.5% in Chile, 15.8% in Colombia, and 40.4% in Peru. And for 16 quarters: 16.4% in Brazil, 51.9% in Chile, 11.5% in Colombia, and 45.4% in Peru. Once more, our estimates are very different from those reported by Fernández et al. (2018), where country spread shocks contributed with less than 5% for 4 quarters FEV in all countries. Their estimates for the unconditional contribution for Brazil is 30%, 0.03% for Chile, 4.43% for Colombia, and 0.3% for Peru. These figures do not change much in their alternative models.

In all countries, shocks to the foreign exchange market (ε^{fx}) and to the monetary policy (ε^{mon}) are not relevant to account for national business cycle. This reflects the endogenous nature of the nominal exchange rate and of the policy interest rate in these countries that follow an inflation targeting regime.

[31]They actually have a productivity shock, which we find to closer resemble our notion of a supply shock.

Sovereign risk

Table 3 reports FEVD for the sovereign spread. Since we restrict it to be influenced only by international variables and by itself, other domestic shocks do not affect the sovereign risk.

The results show that innovations in the world economy substantially influence country spreads, being responsible for more than 50% of the forecasting error variance in all horizons we present. Innovations in world demand and in global financial uncertainty split the relevance. World supply shock has not been an important source of FEV of sovereign spreads. Its maximum contribution happens for Brazil, Chile, and Colombia at 16 quarters FEV: 12%, 7.9%, and 11.6%, respectively[32].

Again, the importance of incorporating a measure of global financial risk (VIX) in the VAR becomes more pronounced when we compare the FEV of model 1 with the alternative model 2, where VIX is not present. In this last situation, the contribution of local macroeconomic uncertainty in the determination of deviations of the country spread substantially increases, showing that an important fraction of the sovereign spread FEV due to global uncertainty ends up being captured by local uncertainty shock, which is certainly a big (numerically speaking) mistake.

[32]This is an important result for DSGE modeling, since some works (Drechsel & Tenreyro (2018), for instance) put innovations to world commodities directly in the equation determining country spreads. This approach, which is not based from first principles, should be reviewed and given place to modeling strategies where commodity prices affect sovereign spreads through other general equilibrium channels.

Table 3: Forecast error variance decomposition of the sovereign spread (EMBI) of Brazil, Chile, Colombia, and Peru.

Shock	hor = 4				hor = 8				hor = 16			
	BR	CH	CO	PE	BR	CH	CO	PE	BR	CH	CO	PE
Model 1												
ε^{wdem}	23.2	22.9	37.6	24.9	28.1	20.3	43.2	24.0	34.6	25.4	47.0	27.3
ε^{wunc}	32.7	43.5	34.2	37.7	30.1	40.3	31.8	42.4	24.6	33.8	26.6	42.2
ε^{wsup}	1.6	3.1	2.6	1.0	5.5	5.9	6.1	0.9	12.0	7.9	11.6	1.9
ε^{cr}	42.6	30.5	25.5	36.4	36.3	33.5	18.9	32.7	28.8	33.0	14.8	28.6
ε^{fx}												
ε^{dem}												
ε^{sup}												
ε^{mon}												
Model 2												
ε^{wdem}	28.5	27.0	44.4	29.0	34.6	24.0	49.8	31.2	38.4	26.0	49.8	34.3
ε^{wsup}	16.4	10.1	13.2	5.7	25.4	9.6	18.6	6.6	31.9	11.7	25.9	10.7
ε^{cr}	55.1	63.0	42.4	65.3	40.0	66.4	31.5	62.2	29.7	62.2	24.2	55.0
ε^{fx}												
ε^{dem}												
ε^{sup}												
ε^{mon}												
Model 3												
ε^{wsup}	22.4	19.3	22.9	12.6	15.4	17.3	17.9	8.5	16.9	35.4	13.0	6.4
ε^{cr}	77.6	80.7	77.1	87.4	84.6	82.7	82.1	91.5	83.1	64.6	87.0	93.6
ε^{fx}												
ε^{dem}												
ε^{sup}												
ε^{mon}												

Notes: Model 1 is the baseline model. Model 2 includes the global GDP and the commodity price index, while Model 3 incorporates the commodity price index as the only international variable. The shocks are: ε^{wdem}, world demand; ε^{wsup} world supply; ε^{wunc} world uncertainty; ε^{cr}, country risk; ε^{fx}, exchange rate shock; ε^{dem}, domestic demand shock; ε^{sup}, domestic supply shock; and ε^{mon} representing the domestic monetary policy shock.

Exchange rate

Table 4 reports the results of the FEVD of nominal exchange rates. Shocks specific to the domestic foreign exchange market seem less important in Brazil than in the other three countries. In Brazil, they represent 11.2%, 7.5%, and 4.7% for 4, 8, and 16 quarters FEV, respectively. Chile and Colombia had the highest proportions due to innovations arising at the local FOREX market: respectively 34.7% and 34.2% for 4 quarters forecasting, and 14% and 10.6% for 16 quarters forecasting. In Peru, the figure is 25.4% for 4 quarters and 8.3% for 8. The conclusions regarding the contribution of shocks specific to local FOREX market to explain exchange rate FEV remain unchanged when VIX is not present (model 2).

Table 4: Forecast error variance decomposition of the nominal exchange rate of Brazil, Chile, Colombia, and Peru.

Shock	hor = 4				hor = 8				hor = 16			
	BR	CH	CO	PE	BR	CH	CO	PE	BR	CH	CO	PE
Model 1												
ε^{wdem}	26.6	42.5	42.2	38.9	25.7	30.2	46.0	39.0	30.6	18.2	46.5	39.1
ε^{wunc}	18.8	10.2	11.0	1.7	15.1	11.5	5.9	4.5	12.2	17.2	3.3	6.3
ε^{wsup}	10.8	6.6	4.6	31.9	12.9	9.5	22.1	42.0	18.9	9.2	35.4	45.4
ε^{cr}	31.3	3.2	5.6	0.9	37.1	15.0	5.0	0.5	32.0	36.3	2.8	0.3
ε^{fx}	11.2	34.7	34.2	25.4	7.5	25.6	18.8	13.2	4.7	14.0	10.6	8.3
ε^{dem}	0.7	0.2	1.9	0.9	0.6	2.1	1.1	0.5	0.9	1.6	0.6	0.3
ε^{sup}	0.3	2.0	0.1	0.2	0.6	5.4	0.1	0.3	0.4	3.2	0.1	0.2
ε^{mon}	0.4	0.7	0.5	0.1	0.6	0.7	1.1	0.1	0.4	0.4	0.7	0.1
Model 2												
ε^{wdem}	22.1	36.1	40.1	28.2	22.5	31.2	43.6	28.1	28.2	30.1	45.7	33.8
ε^{wsup}	31.6	30.0	12.8	33.6	34.4	43.7	26.8	44.8	39.6	50.7	37.0	48.9
ε^{cr}	33.1	1.8	6.1	3.1	33.0	1.8	3.2	5.5	25.5	3.2	1.8	4.1
ε^{fx}	12.2	30.2	38.4	31.9	8.8	18.9	22.9	18.7	5.5	12.6	13.1	11.3
ε^{dem}	0.3	0.2	1.6	3.0	0.3	0.4	0.9	2.3	0.6	0.5	0.5	1.5
ε^{sup}	0.4	1.1	0.0	0.1	0.5	2.5	0.4	0.6	0.4	1.8	0.3	0.4
ε^{mon}	0.3	0.5	1.0	0.0	0.5	1.6	2.1	0.1	0.3	1.2	1.6	0.1
Model 3												
ε^{wsup}	51.0	66.3	18.9	59.3	64.3	79.2	23.0	73.0	72.8	87.4	19.7	85.7
ε^{cr}	14.8	6.8	31.0	2.3	11.2	4.3	41.1	5.4	10.7	2.4	59.0	3.6
ε^{fx}	33.0	26.1	47.1	35.5	22.5	14.5	31.8	17.9	14.1	7.4	16.2	7.6
ε^{dem}	0.4	0.3	2.6	2.0	0.6	0.2	1.4	1.5	1.0	0.1	0.9	0.9
ε^{sup}	0.5	0.0	0.0	0.8	0.4	1.2	0.8	2.1	0.5	2.1	1.4	2.1
ε^{mon}	0.3	0.4	0.4	0.0	1.0	0.6	1.9	0.1	0.8	0.5	2.8	0.1

Notes: Model 1 is the baseline model. Model 2 includes the global GDP and the commodity price index, while Model 3 incorporates the commodity price index as the only international variable. The shocks are: ε^{wdem}, world demand; ε^{wsup} world supply; ε^{wunc} world uncertainty; ε^{cr}, country risk; ε^{fx}, exchange rate shock; ε^{dem}, domestic demand shock; ε^{sup}, domestic supply shock; and ε^{mon} representing the domestic monetary policy shock.

Domestic macroeconomic policy uncertainty shock is an important source of forecasting error of the nominal exchange rate in Brazil and Chile. In the former, it has accounted for 31.3%, 37.1%, and 32% of, respectively, 4, 8 and 16 FEV. In Chile, the proportions are 3.2%, 15%, and 36.3%.

Common to all currencies is the large contribution of international shocks. In Brazil, they account for 56.2%, 53.7%, and 61.7% for 4, 8 and 16 quarters FEV, respectively. In Chile, the proportions are 59.3%, 51.2%, and 44.6%. The Colombian currency has been even more influenced by shifts in international conditions, whose shocks have contributed with 57.8%, 74%, and 85.2%. But the largest impact is in Peru: 72.5%, 85.5%, and 90.8%.

All international shocks are important, but supply is more relevant in Colombia and Peru, while innovations to world demand explains more of the FOREX FEV in Brazil and Chile. World financial uncertainty is also more important for these countries' FOREX FEV.

The other sources of domestic innovations (demand, supply, and monetary) have been irrelevant for explaining the FEV of the nominal exchange rates.

Consumer price index

Table 5 reports the results for the CPI. Because prices tend to be very persistent, the influence of domestic aggregate supply shocks, identified by innovations in the residuals of the CPI, is very high for initial quarters. For 4 quarters forecasting horizon, local supply shocks are responsible for 27.2% of the Brazilian FEV, 51.1% for the Chilean, 53.7% for the Colombian, and 85.2% for the Peruvian. But the contribution of ε^{sup} becomes much smaller for 8 quarters FEV: 10.1% in Brazil, 26.9% in Chile, 35.3% in Colombia, and 38.9% in Peru. For 16 quarters FEV, as we approach unconditional values, the proportions are even smaller: 3.3% in Brazil, 10.8% in Chile, 17.4% in Colombia, and 14.8% in Peru.

Table 5: Forecast error variance decomposition of the consumer price index of Brazil, Chile, Colombia, and Peru.

Shock	hor = 4				hor = 8				hor = 16			
	BR	CH	CO	PE	BR	CH	CO	PE	BR	CH	CO	PE
Model 1												
ε^{wdem}	5.6	4.9	0.6	0.5	9.3	27.2	1.2	0.3	14.4	60.2	16.3	2.0
ε^{wunc}	33.0	12.7	22.6	0.4	37.1	8.9	22.6	0.5	41.1	8.6	12.8	8.4
ε^{wsup}	0.1	0.7	2.6	10.6	3.5	3.8	2.9	40.5	3.8	2.3	24.2	32.6
ε^{cr}	21.1	24.2	1.9	0.5	21.4	26.1	0.9	9.2	16.5	14.8	0.5	34.9
ε^{fx}	4.6	2.4	14.6	1.8	5.2	1.6	34.3	1.1	4.8	0.6	25.4	0.6
ε^{dem}	8.3	1.6	0.4	0.8	12.9	1.6	0.3	9.3	15.6	1.0	1.5	6.6
ε^{sup}	27.2	51.1	53.7	85.2	10.1	26.9	35.3	38.9	3.3	10.8	17.4	14.8
ε^{mon}	0.2	2.4	3.6	0.1	0.5	3.9	2.5	0.1	0.5	1.7	1.9	0.1
Model 2												
ε^{wdem}	8.4	3.7	0.4	1.1	15.9	19.6	0.4	0.8	25.6	58.3	8.0	5.7
ε^{wsup}	9.0	3.3	1.5	11.5	22.9	2.7	2.9	43.1	27.5	2.5	23.0	33.7
ε^{cr}	35.1	35.5	12.6	0.4	23.5	41.6	7.3	2.9	10.7	20.9	6.7	22.3
ε^{fx}	3.1	2.4	10.1	1.9	2.7	1.4	29.9	2.0	1.7	0.6	32.6	2.9
ε^{dem}	13.0	1.9	0.6	0.9	20.8	2.1	0.4	14.8	28.5	1.8	1.5	20.2
ε^{sup}	31.2	51.5	67.6	84.2	13.4	29.1	52.4	36.3	5.0	14.0	24.4	15.2
ε^{mon}	0.3	1.7	7.2	0.1	0.7	3.4	6.8	0.1	1.2	2.0	3.8	0.1
Model 3												
ε^{wsup}	7.7	1.3	3.9	3.6	12.0	10.3	7.7	8.0	25.2	26.7	32.2	7.6
ε^{cr}	19.4	6.1	7.9	2.1	35.0	3.4	4.7	1.5	45.3	4.8	6.5	10.8
ε^{fx}	9.6	5.9	5.7	3.2	11.9	5.6	18.0	4.4	8.7	5.4	29.3	5.8
ε^{dem}	2.6	0.9	0.9	0.8	1.6	0.8	0.7	1.5	0.6	0.5	1.7	1.7
ε^{sup}	60.5	85.7	71.1	90.2	39.2	79.3	59.0	84.1	19.7	61.4	24.8	73.1
ε^{mon}	0.1	0.1	10.5	0.1	0.3	0.7	10.0	0.4	0.5	1.2	5.5	1.0

Notes: Model 1 is the baseline model. Model 2 includes the global GDP and the commodity price index, while Model 3 incorporates the commodity price index as the only international variable. The shocks are: ε^{wdem}, world demand; ε^{wsup} world supply; ε^{wunc} world uncertainty; ε^{cr}, country risk; ε^{fx}, exchange rate shock; ε^{dem}, domestic demand shock; ε^{sup}, domestic supply shock; and ε^{mon} representing the domestic monetary policy shock.

International factors are important for determining oscillations in the CPIs. Global financial uncertainty shock accounts for a large share of the FEV already for 4 quarters forecasting: 33% in Brazil, 12.7% in Chile, and 22.6% in Colombia. Its influence in the Peruvian CPI is negligible (0.4%). International supply shocks, on the other hand, account for 10.6% of the Peruvian 4 quarters FEV, but are almost irrelevant for the other three countries.

The influence of global financial uncertainty shocks is high in Brazil and Colombia even for 16 quarters ahead FEV (41.1% and 12.8%, respectively), increases in Peru (8.4%), and reduces a little in Chile (8.6%). World supply shocks increase its contribution to the Peruvian FEV at longer horizons, reaching 32.6% for 16 quarters. The same happens for Colombia where their contribution after 16 quarters is 24.2%.

Global demand shocks have produced higher impact in the Chilean CPI, but only at longer horizons, contributing with 27.2% after 8 quarters and 60.2% after 16. In Brazil, the contribution is 9.3% for 8 quarters and 14.4% for 16. In Peru, a significant influence occurs after 16 quarter, 16.3%.

Regarding other domestic shocks, we observe shocks in the foreign exchange market being relevant in Colombia for all quarters analyzed: 14.6%, 34.3% and 25.4% for 4, 8 and 16 quarters, respectively. In Brazil, innovations to the domestic demand have played important role for the FEV of the CPI at all forecasting horizons: 8.3%, 12.9% and 15.6% for 4, 8 and 16 quarters.

Another important pattern is that monetary shocks have not influenced the FEV of any country in any forecasting horizon. This once again reinforces that monetary policy has mostly been responding endogenously to shocks elsewhere.

Some results change when VIX is dropped from the VAR, while others remain similar. In Peru, for instance, international supply shocks are still the main contributor to the FEV of the CPI. Even the values are very similar to those obtained with the full model. Global demand innovations continue not to influence the CPI FEV. In Brazil, the influence of global uncertainty is distributed between global demand and global supply shocks when VIX is absent. In Chile, innovations arising at the world level remain as important, but the fraction due to world uncertainty has mostly been captured by domestic macroeconomic policy uncertainty. Similar thing happens in Colombia, but domestic supply and FOREX shocks also gain in importance.

All these exemplify how avoiding a more complete structure for the international economy can easily lead to wrong conclusions regarding the relevance of shocks in accounting for the movements in important domestic macroeconomic variables.

Policy interest rate

Finally, the FEVD of policy interest rate is presented in Table 6. Given that central bankers tend to smooth movements in the policy rates over the cycle, monetary shocks are expected to cause a persistent effect on these rates. This is indeed observed according to the elevated proportions of the FEV due to monetary policy specially at 4 quarters: 24.8% in Brazil, 49.9% in Chile, 27% in Colombia, and 78.2% in Peru. These fractions become much smaller at 16 quarters ahead forecasting: 10.1% in Brazil, 14.9% in Chile, 9.6% in Colombia, and 32% in Peru.

Local supply and demand shocks play minor role in affecting the FEV. The largest contribution happens in Brazil, where 11.5% of the 4 quarters FEV of the policy rate is due to local supply shock, and in Chile, where local demand and supply shocks have contributed, respectively, with 8.3% and 15.3% of the policy rate FEV at 8 quarters.

Global shocks and domestic macroeconomic policy uncertainty have been the main source of FEV, following the pattern of the CPI. Global demand shock has contributed to the FEV of policy rates in all countries. In Colombia and Peru, its importance appears from 4 to 16 quarters FEV. In Chile, for 8 and 16 FEV, and in Brazil only at 16 quarters. At this forecasting horizon, the FEV due to global demand shock ranges from 10% to 15%.

Global supply shock has been important for determining 4 quarters FEV in Chile (14.2%) and Colombia (33.6%). The proportions for 8 and 16 quarters FEV are basically the same. In Brazil, 8 and 16 quarters FEV are 10.8% and 20.9%, respectively, and in Peru 13.3% and 25.1%.

Table 6: Forecast error variance decomposition of the policy interest rate of Brazil, Chile, Colombia, and Peru.

Shock	hor = 4				hor = 8				hor = 16			
	BR	CH	CO	PE	BR	CH	CO	PE	BR	CH	CO	PE
Model 1												
ε^{wdem}	0.4	5.8	15.7	11.2	1.9	11.5	15.1	24.3	13.9	14.4	10.0	15.3
ε^{wunc}	11.1	2.7	3.2	1.3	9.9	4.6	3.2	6.8	7.1	4.3	19.1	19.3
ε^{wsup}	3.0	14.2	33.6	5.2	10.8	12.9	32.9	13.3	20.9	13.0	33.3	25.1
ε^{cr}	44.9	14.4	0.5	0.1	53.2	14.2	0.2	0.6	40.8	35.7	0.3	4.5
ε^{fx}	1.8	4.1	17.6	1.0	1.5	4.9	32.9	0.6	1.1	3.9	24.8	0.4
ε^{dem}	2.4	4.1	0.7	2.3	1.5	8.3	0.5	1.6	1.1	4.9	0.6	1.2
ε^{sup}	11.5	4.8	1.6	0.7	6.9	15.3	1.7	1.9	5.0	8.7	2.3	2.1
ε^{mon}	24.8	49.9	27.0	78.2	14.1	28.3	13.5	50.9	10.1	14.9	9.6	32.0
Model 2												
ε^{wdem}	0.8	4.8	17.6	11.8	2.4	13.7	18.7	29.7	12.7	14.2	14.6	23.1
ε^{wsup}	1.0	17.5	24.7	6.7	17.5	12.3	22.4	11.9	28.1	13.8	18.7	23.9
ε^{cr}	59.6	14.9	1.7	0.8	56.0	17.0	2.0	5.2	41.7	27.2	8.2	11.4
ε^{fx}	4.3	4.4	15.3	1.4	3.9	4.7	34.6	1.1	2.9	3.6	29.6	0.9
ε^{dem}	3.5	5.8	0.4	3.2	2.0	9.2	0.3	2.2	1.7	7.4	1.1	2.1
ε^{sup}	7.9	3.9	4.3	1.0	4.9	14.2	3.0	1.0	3.5	11.3	7.7	1.7
ε^{mon}	23.0	48.6	36.0	75.0	13.2	28.9	19.0	48.8	9.4	22.5	20.0	36.7
Model 3												
ε^{wsup}	12.5	7.9	22.5	9.6	14.5	8.0	23.4	12.3	37.4	7.5	13.6	14.7
ε^{cr}	16.2	0.1	3.1	2.3	16.0	13.1	19.2	26.0	23.1	26.4	30.8	49.9
ε^{fx}	6.9	12.3	6.9	5.7	11.7	19.8	19.2	4.2	6.8	16.7	16.9	2.8
ε^{dem}	0.9	3.1	0.8	0.2	5.7	2.9	0.6	0.3	5.9	2.9	1.0	0.5
ε^{sup}	7.8	25.3	9.0	15.1	8.1	19.6	5.2	16.0	4.5	16.2	10.4	10.8
ε^{mon}	55.8	51.2	57.6	67.0	44.2	36.6	32.4	41.2	22.3	30.3	27.2	21.4

Notes: Model 1 is the baseline model. Model 2 includes the global GDP and the commodity price index, while Model 3 incorporates the commodity price index as the only international variable. The shocks are: ε^{wdem}, world demand; ε^{wsup} world supply; ε^{wunc} world uncertainty; ε^{cr}, country risk; ε^{fx}, exchange rate shock; ε^{dem}, domestic demand shock; ε^{sup}, domestic supply shock; and ε^{mon} representing the domestic monetary policy shock.

Domestic macroeconomic policy uncertainty shock has been the other big source of forecasting error variance of the Brazilian and the Chilean policy interest rates. In Brazil, it has accounted for 44.9%, 53.2%, and 40.8% of 4, 8, and 16 quarters FEV, by far the most intense influence when compared to the other countries. In Chile, the fractions are, respectively, 14.4%, 14.2%, and 35.7%. The Colombian and the Peruvian policy rates have basically not been impacted by local macroeconomic policy uncertainty shocks.

When VIX is left out of the model, the influence of local macroeconomic policy uncertainty remains almost the same in Brazil, but gains importance in Colombia and Peru for 16 quarters ahead forecasting.

5 Concluding remarks

A rich but parsimonious structure that allows capturing general equilibrium relations in the global economy distinguishes our work from most research in the field. The SVAR model using a measure of global GDP, an aggregate commodity price index, and the VIX (a measure of volatility in the US equity market) allows identifying world supply and demand shocks, and global financial uncertainty shock. The absence of one of these variables lead to wrong conclusions regarding the relevance of international and domestic shocks at the national level.

Global supply shocks, identified from the residuals of the aggregate commodity price index equation, have been an important driver of business cycle only in Brazil, explaining 25% of 4 years forecasting error variance of the GDP. For the other countries, the magnitude has never been superior to 7%. This small influence conflicts with most results in the literature. Commodity price innovations become generally important, in line with other papers, when the commodity price is the only international variable in the VAR. This suggests that several works have probably taken endogenous reaction in commodity price as a direct innovation to it, inflating its relevance in the determination of domestic business cycles.

Despite the small influence in local business cycles, an adverse world supply shock (instantaneous increase in the commodity price index), despite of causing the world GDP to fall, increases the GDP of Brazil, Colombia, and Peru, a result that is similar to the DSGE models of Drechsel & Tenreyro (2018) and Fernández et al. (2018). These local reactions are different from the findings of Charnavoki & Dolado (2014) for Canada, maybe because its intense integration to the US economy plays a more relevant role in the determination of the Canadian domestic business cycle than it does for the South American countries.

Innovations to global demand are found to be the most important international factor influencing the GDPs of Brazil, Chile and Peru. Perturbations to global financial uncertainty have been more important than supply (commodity market) shocks in the determination of business cycle of Chile, Colombia, and Peru. In Colombia, global financial uncertainty has been the most important international contributor for business cycle.

Perturbations to the sovereign risk, which we interpret as shocks to uncertainty regarding national macroeconomics policy, are another important source of oscillation of national GDPs. The direction is standard: larger sovereign spread results in smaller GDP.

Reactions of nominal exchange rates and consumer price indexes are mostly proportional to the magnitude of the reaction of country spreads following international shocks. The larger the response, the greater the oscillation in FOREX and in CPI. Policy interest rates react according to the pass through to local CPI. This leaves clear the role played by sovereign risk as a propagator of global shocks.

The results we encounter poses important challenge for DSGE modelling. Future developments should more carefully consider the general equilibrium structure of the global economy in order to understand the impact of world episodes at national level. It is important that the relation between global and domestic variables is derived form first principles, avoiding the imposition of linkages in ad hoc manner that, at the end, is responsible for driving the results. For example, one should have commodity prices affecting domestic economies through channels like relative prices, trade balance, incentive for investment, output, tax collection, etc., instead of imposing this relation directly by placing commodity price in the equation determining the sovereign spread. This relation exists, as we show, but being able to capture the appropriate channels that correlate both variables is an important challenge that will allow differentiating countries with respect to their responses to world shocks. The same is true for the other international variables.

6 Competing interests

The authors declare that they have no competing interests.

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A Appendix

A.1 Data

Table 7: Data description

Country	Variable	Source	Abbreviation
International	Volatility Index or Global Economic Uncertainty	Federal Reserve of St.Louis	VIX
	All Commodity Prices	International Monetary Fund	PCOM
	Global Real Economic Activity	Kilian's http://goo.gl/TnbwJd	WGDP
Brazil	Gross Domestic Product	Banco Central do Brasil	GDP
	Consumer Price Index	Banco Central do Brasil	CPI
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	Nominal Exchange Rate	Banco Central do Brasil	EXR
	SELIC Rate	Banco Central do Brasil	INTR
Chile	Gross Domestic Product	Banco Central de Chile	GDP
	Consumer Price Index	Banco Central de Chile	CPI
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	Nominal Exchange Rate	Banco Central de Chile	EXR
	Monetary Policy Interest Rate	Banco Central de Chile	INTR
Colombia	Gross Domestic Product	Banco de la República	GDP
	Consumer Price Index	Banco de la República	CPI
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	Nominal Exchange Rate	Banco de la República	EXR
	Intervention Rate	Banco de la República	INTR
Peru	Gross Domestic Product	Banco Central de Reserva del Perú	GDP
	Consumer Price Index	Banco Central de Reserva del Perú	CPI
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	Nominal Exchange Rate	Banco Central de Reserva del Perú	EXR
	Reference Rate for Monetary Policy	Banco Central de Reserva del Perú	INTR

A.2 Bayesian priors for the VAR estimation

In order to estimate the Bayesian VAR we use priors suggested by Sims & Zha (1998) that were also used by Zha (1999) and Cushman & Zha (1997) in their BSVAR with block lagged restriction, as in our case. We combine two unit root priors: the Minnesota prior and the sum-of-coefficients prior. The Minnesota prior imposes the restriction that coefficients on the first lag has prior mean of 1. In the approach of Sims & Zha (1998), this is done by creating the variables such that for the i'th equation, a set of *k-1* dummy observations, indexed by $j = 1, ..., m$, $l = 1, ..., p$, is inserted in the data sample, with data taking the values specified by equation 1:

$$\begin{aligned} y_i(r,j)\ ;\ r=1,...,k-1; j=1,...,m &= \begin{cases} \mu_1\mu_2\sigma_r/l^{\mu_4}, & \text{if } r=j, r\leq m \\ 0, & \text{otherwise} \end{cases} \\ x_i(r,s)\ ;\ r=1,...,k-1; s=1,...,k-1 &= \begin{cases} \mu_1\mu_2\sigma_r/l^{\mu_4}, & \text{if } r=s, \\ 0, & \text{otherwhise} \end{cases} \end{aligned} \tag{1}$$

where μ_1, μ_2 and μ_4 are hyperparameters. μ_1 controls the overall tightness of A_0; μ_2 controls the relative tightness of the matrix A_l, and μ_4 controls the tightness on lag decay. These hyperparameters are set at its default values suggested by Sims & Zha (1998), which are, respectively, 1, 0.5 and 1.

The sum-of-coefficients prior is used in cases where the variables have a unit root, so this information can be reflected via a prior that incorporates the belief that coefficients on lags of the dependent variable sum to 1. In a system of m equations, l lags and k coefficients, it introduces m observations, indexed by i, of the form:

$$\begin{aligned} y(i,j)\ ;\ i=1,...,m; j=1,...,m &= \begin{cases} \mu_5\bar{y}_{0i}, & \text{if } i=j, \\ 0, & \text{otherwise} \end{cases} \\ x(i,s)\ ;\ i=1,...,m; s=1,...,k &= \begin{cases} \mu_5\bar{y}_{0i}, & \text{if } i=j, \text{ all l }, \\ 0, & \text{otherwise} \end{cases} \end{aligned} \tag{2}$$

where $\bar{y}_{0i}$ is the average of initial values of the variable i and μ_5 is a hyperparameter that controls the weight of the prior. For instance, as $\mu_5 \to \infty$, the model tends to a form that can be expressed entirely in terms of differenced data. In this paper this hyperparameter is set to its default value of 1.

A.3 Impulse Response Functions

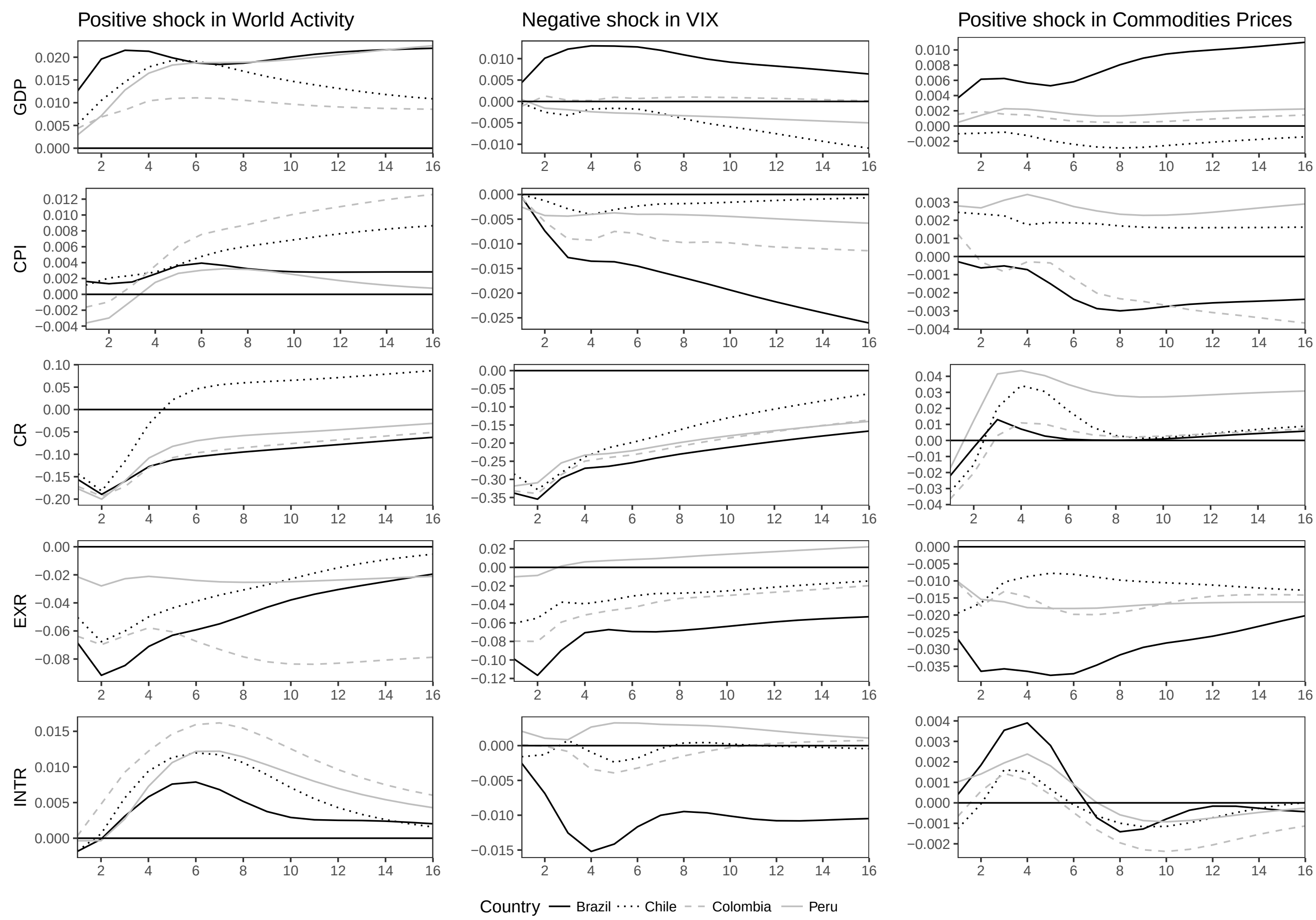

Figure 6: Response of all countries to international shocks

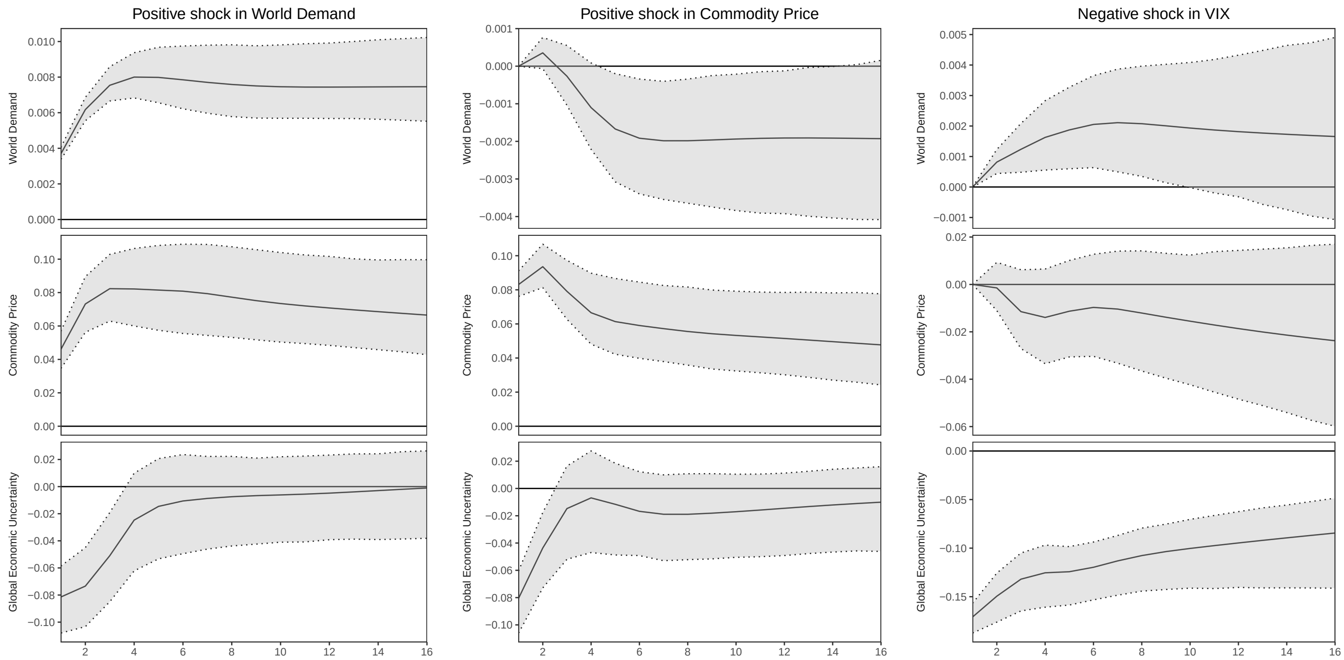

Figure 7: Response of international variables - alternative ordering in the international bloc: WGDP PCOM VIX