Pontifícia Universidade Católica
do Rio de Janeiro

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Commodity Prices and Exchanges Rates in the COVID-19 Pandemic

Dissertação de Mestrado

Thesis presented to the Programa de Pós–graduação em Economia, do Departamento de Economia da PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Economia.

Advisor : Prof. Márcio Gomes Pinto Garcia
Co-advisor: Prof. Carlos Viana de Carvalho

Rio de Janeiro
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Abstract

Aguiar, Mateus Della Giustina; Garcia, Marcio Gomes Pinto (Advisor); Carvalho, Carlos Viana (Co-Advisor). **Commodity Prices and Exchanges Rates in the COVID-19 Pandemic**. Rio de Janeiro, 2023. 112p. Dissertação de Mestrado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

It is a consensus in economic theory that the increase in the terms of trade leads to an appreciation of the real exchange rate. However, during the recent period of the COVID-19 pandemic, this relationship appears to have been disrupted, as there has been a significant rise in commodity prices but the real exchange rates of many countries have not appreciated correspondingly. The aim of this M.Sc. Thesis is to examine the reasons for this deviation from the established correlation. I estimate several SVARs for commodity exporting countries with a recursive block identification scheme and conclude that structural shocks other than the commodity one explained the real exchange rate depreciation in the pandemic period. In 2020, the global risk was the main factor responsible for depreciating the exchange rate, while in 2021 the high country risk, specially for emerging countries, and the low level of the domestic interest rate appear as the main factors responsible for this break.

Keywords

Macroeconomics; International Finance; Commodity Shocks; Exchange Rate; SVA.

Resumo

Aguiar, Mateus Della Giustina; Garcia, Marcio Gomes Pinto; Carvalho, Carlos Viana. **Preços de Commodity e Taxa de Câmbio na Pandemia de COVID-19** . Rio de Janeiro, 2023. 112p. Dissertação de Mestrado – Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

É consenso na teoria econômica que o aumento dos termos de troca leva a uma apreciação da taxa de câmbio real. No entanto, durante o período recente da pandemia do COVID-19, essa relação parece ter sido interrompida, pois houve um aumento significativo nos preços das commodities, mas as taxas de câmbio reais de vários países não se valorizaram correspondentemente. O objetivo deste trabalho de pesquisa é examinar as razões para esse desvio da correlação estabelecida. Eu estimo vários SVARs para países exportadores de commodities com um esquema recursivo de identificação em blocos e concluo que outros choques estruturais além do de commodities explicaram a depreciação da taxa de câmbio real no período da pandemia. Em 2020, o risco global foi o principal fator responsável pela depreciação da taxa de câmbio, enquanto em 2021 o alto risco-país, especialmente para os países emergentes, e o baixo nível da taxa de juros doméstica aparecem como os principais responsáveis por essa quebra.

Palavras-chave

Macroeconomia; Finanças Internacionais; Choque de Commodity; Taxa de Câmbio; SVAR.

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1
Introduction

The relationship between commodity prices and the exchange rate [1] in commodity exporting countries is something well known both in the market and academia. Typically, during periods of elevated commodity prices, the exchange rate tends to appreciate, while during periods of declining commodity prices, the exchange rate generally depreciates. However, during the COVID-19 pandemic, this correlation was disrupted, leading to exchange rate forecasting errors by the market and central banks, as well as a lack of understanding regarding the reasons for this deviation.

This paper is the first study to my knowledge that aims to explain this phenomenon, in addition to proposing an empirical model for determining the exchange rate in commodity-exporting countries such as Australia, Brazil, Canada, Chile, Colombia, Mexico, and South Africa. In 2020, the model identifies that the main determinant of exchange rate depreciation was the increase in global risk, while in the second year of the pandemic, high country risk, especially for emerging countries, was the primary driver. Also, the low levels of domestic interest rates in 2021 contributed to exchange rate depreciation in some countries.

The disruption of the traditional relationship between the real effective exchange rate and the prices of commodities exported by the aforementioned countries became apparent between the latter half of 2020 and the end of 2022. During the first quarter of 2020, commodity prices experienced a decline due to decreased expectations regarding future demand for these commodities, and the value of the dollar rose as global uncertainty increased. In the second quarter of 2020, there was a correction in relation to the movement observed in the previous quarter. This correction took longer for some countries, extending throughout 2020 until the exchange rate returned to levels comparable to pre-COVID.

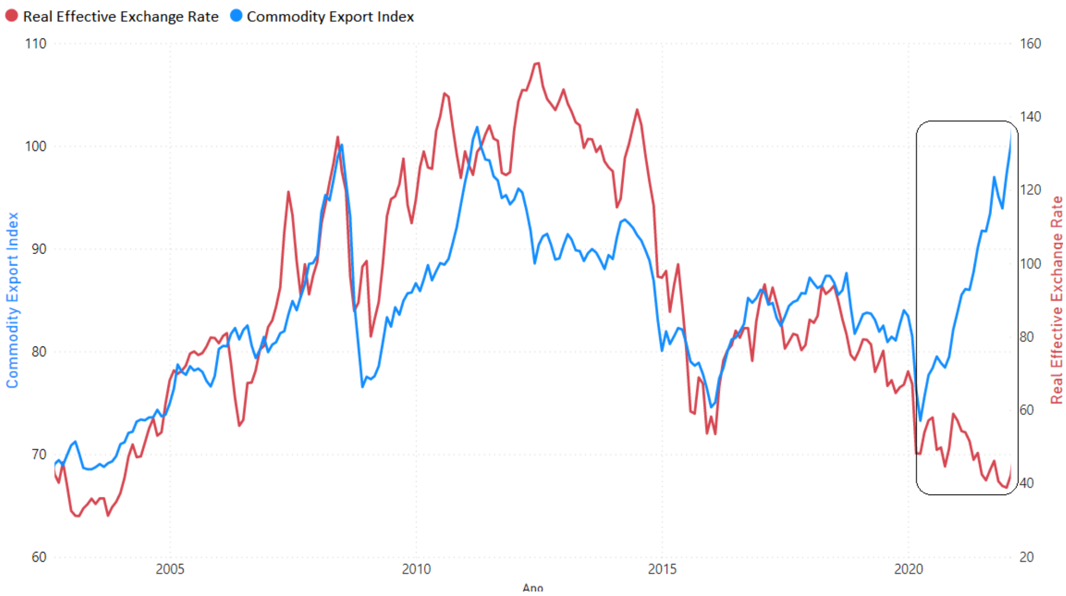
The break in the correlation occurred following this correction, and in some countries, it may have started earlier or slightly later, as was the case in Canada. Commodity prices experienced an upward cycle due to both demand

[1]Throughout the dissertation, I will refer to the exchange rate as the real effective exchange rate (REER), although the results also apply to the real and nominal exchange rate against the US Dollar.

and supply factors. With the availability of vaccines and improved adaptation of the economy and daily life to the COVID-19, global demand for commodities rebounded, while the global production chain remained disrupted due to virus-related restrictions, leading to an increase in commodity prices. The exchange rate in these countries did not appreciate sharply as would be expected looking at previous periods.

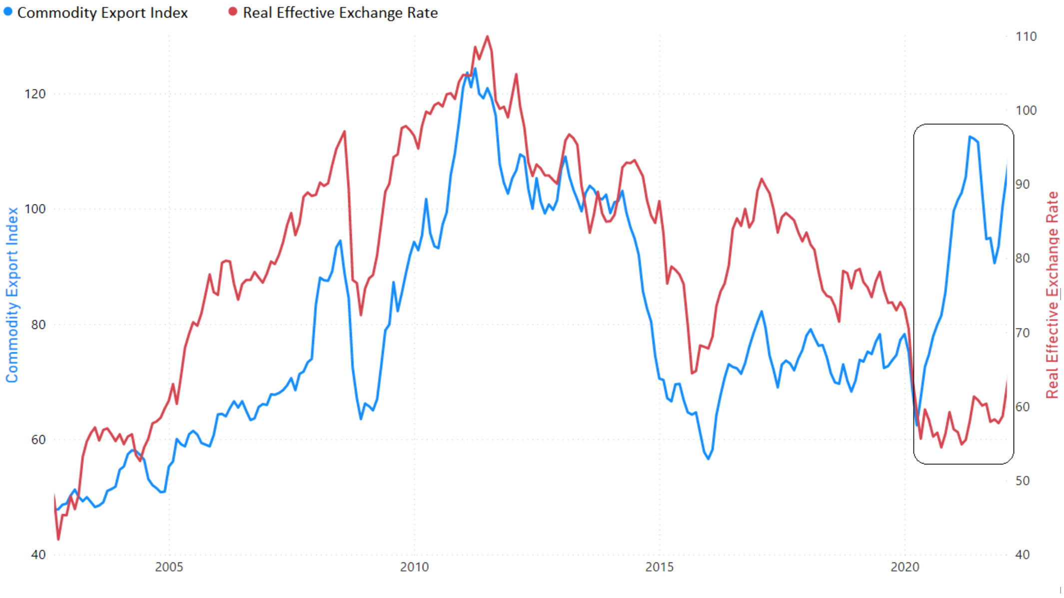
This dynamic can be seen in Figures 1.1, Figure 1.2 and Figure 1.3 for Colombia, Brazil and Canada respectively. Charts for other countries can be found in the appendix A.

Figure 1.1: Colombian Commodity Export Index and Real Effective Exchange Rate



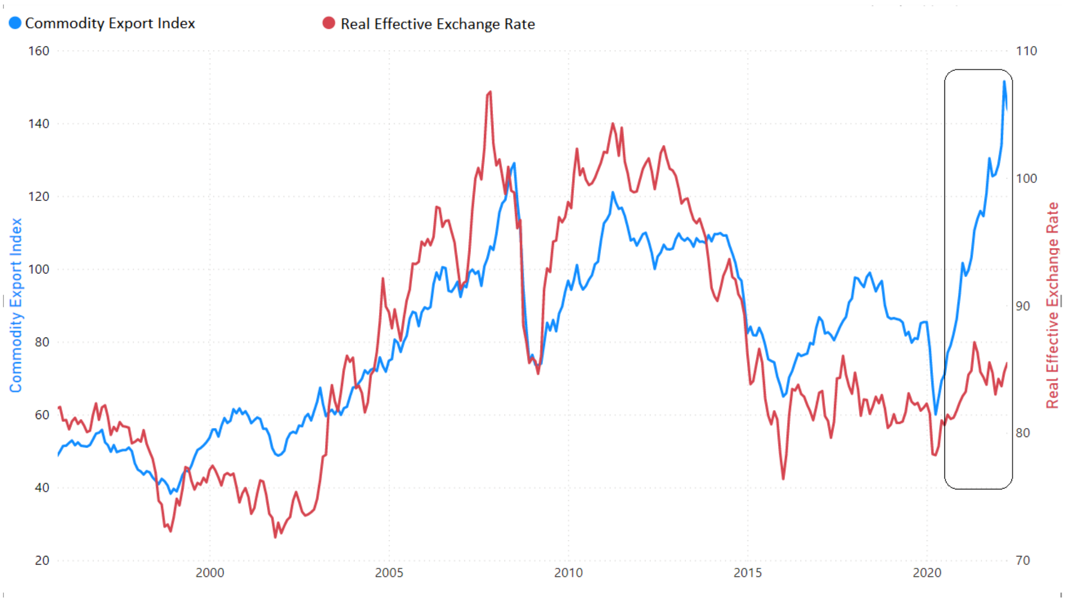
Note: The commodity price index is weighted by the country's exports, and has June 2012 as the reference period. The real effective exchange rate (REER) is an index that has January 2010 as unit base. The more depreciated the exchange rate, higher de REER index.

Figure 1.2: Brazilian Commodity Export Index and Real Effective Exchange Rate



Note: The commodity price index is weighted by the country's exports, and has June 2012 as the reference period. The real effective exchange rate (REER) is an index that has January 2010 as unit base. The more depreciated the exchange rate, higher de REER index.

Figure 1.3: Canadian Commodity Export Index and Real Effective Exchange Rate



Note: The commodity price index is weighted by the country's exports, and has June 2012 as the reference period. The real effective exchange rate (REER) is an index that has

January 2010 as unit base. The more depreciated the exchange rate, higher de REER index.

In order to comprehend the reasons behind the non-appreciation of the exchange rate in the face of the commodity price increase, a Structural Vector Autoregression (SVAR) model is employed to determine the combination of structural shocks that best explains the behavior of the exchange rate in each country individually.

In this way, the present study relates to a literature that tries to identify the impact of a shock in the terms of trade (ToT) on the business cycle of emerging economies through the use of SVAR models. Studies such as those by Aguirre (2011), Zeev et al. (2017), Fernández et al. (2017), and Schmitt-Grohé & Uribe (2018) compare the extent to which the business cycle of emerging economies is explained by ToT shocks in both SVAR and Dynamic Stochastic General Equilibrium (DSGE) models. Di Pace et al. (2020) estimates a SVAR model, but unlike Schmitt-Grohé & Uribe (2018), disaggregates ToT into import and export indices. Broda (2004) estimates a SVAR to compute the effect of a shock on ToT conditional on the country's exchange rate regime. Ferreira & Valério (2022) uses more international variables to identify the real commodity shock in the SVAR. Gruss & Kebhaj (2019) build a new database with commodity export index, commodity import index and ToT index for a panel of countries to estimate the impact of ToT shock on countries' consumption and output. It is worth noting that the primary focus of the aforementioned studies is on the determination of a country's domestic product, with little emphasis placed on the exchange rate. In most of the studies, the variables that are critical in the determination of the exchange rate are omitted.

There are studies that try to measure whether commodity prices and the real exchange rate move together over time. Cashin et al. (2004) find evidence that a longrun relationship between national real exchange rate and real commodity prices exists for about one third of the commodity-exporting countries of their sample. Ricci et al. (2013) employs newly constructed measures of terms of trade to estimate a panel cointegrating relationship between real exchange rates and ToT. They find evidence of a strong positive relation between the CPI-based real exchange rate and commodity terms of trade.

Additionally, there is a body of literature that focuses more specifically on the relationship between commodity prices and exchange rates for commodity currencies.Chen & Rogoff (2003) found, particularly in the cases of Australia and New Zealand, that the US dollar price of their commodity exports has a robust and persistent impact on their floating real exchange rates. Chen et al. (2010) analyze whether exchange rates have predictive power over commodity prices. Finally, Stein (2022) uses high-frequency identification to measure the impact of changes in the price of milk on the New Zealand exchange rate.

This study employs a Structural Vector Autoregression (SVAR) model with recursive block identification, as in Schmitt-Grohé & Uribe (2018), but with a primary objective of analyzing the behavior of the exchange rate. The dissertation makes a contribution to the literature by being the first paper to examine multivariate empirical models for determining exchange rates in commodity-exporting countries. As a result, it is possible to quantify in each country the extent to which the exchange rate is influenced by global risk, global interest rates, commodity prices, country risk, and domestic interest rates. In general, the risk and commodity prices variables have the most significant impact on the exchange rate. Additionally, this model allows for identification of the key global and country-specific factors that contributed to the non-appreciation of the national exchange rate during the pandemic period.

After this introduction, in the second section, the data and their peculiarities are analyzed. In the third section, the SVAR is presented, the baseline model is determined, as well as the hypothesis for identifying the shocks. Impulse response functions, variance decompositions and historic decompositions are performed. In the fourth section, variations of the HP filter parameter (λ) that determines the adjustment of the sensitivity of the trend to short-term fluctuations are performed. In section 5, alternative estimates of the model were calculated to enhance the robustness of the results and investigate additional factors that aid in identifying and determining the exchange rate, such as the DXY and commodity futures prices. It is also discussed how the SVAR identifies the exchange rate behavior in non-commodity exporting countries as a placebo sample. Finally, the sixth section concludes with final remarks.

2
Data

2.1
Data Description

I used monthly data over the following time-periods: Australia (from 1998:1 to 2022:6), Brazil (from 1998:1 to 2022:6), Canada (from 1997:1 to 2022:6), Chile (from 2002:6 to 2022:6), Colombia (from 1999:5 to 2022:6), Mexico (from 1998:1 to 2022:6) and South Africa (from 2000:10 to 2022:6). With regard to section 5.1, for non-commodity exporting countries, I also used monthly data over the following time-periods: Germany (1997:1 to 2022:6) and UK (1998:1 to 2022:6). The choice to use monthly data is linked to the fact of greater robustness given a bigger number of observations. This is the first paper that uses monthly data to identify commodity shocks in the cited literature. All data are logged with the exception of interest rates. In the baseline model the data passes through an HP Filter with a trend smoothing parameter (λ) of 14 400, the usual for monthly data. The data source follows:

- Real Effective Exchange Rates (labeled $REER$) are calculated as weighted averages of bilateral exchange rates adjusted by relative consumer prices. The data for the specifics countries are from Federal Reserve Bank of St. Louis. The index is based on (100) in January 2010.

-Country-specific commodity price indexes (labeled C_p) are obtained from IMF Commodity Terms of Trade Data Base. This data for each country is based on the change in the international price of up to 45 individual commodities and is weighted using the average share of each product in the country's exports in the period from 1980 to 2015. The reference period (=100) is June 2012.[1]

- Global Economic Policy Uncertainty (labeled $GlobalEPU$) is a GDP-weighted average of national EPU indices for 21 countries.[2]. This index is inspired on the methodology of Baker, Scott, Bloom and Davis (2012) in

[1]This database is taken from the paper Gruss & Kebhaj (2019). The approximate weights used are available in Appendix B.

[2]The countries are Australia, Brazil, Canada, Chile, China, Colombia, France, Germany, Greece, India, Ireland, Italy, Japan, Mexico, the Netherlands, Russia, South Korea, Spain, Sweden, the United Kingdom, and the United States

which the index is made by counting words related to economic uncertainty in newspapers through machine learning methods. [3]

- Domestic and global interest rates (labeled D_r and G_r respectively) are from OECD data. There are averages of daily rates, measured as a percentage. These short-term interest rates are based on three-month money market rates where available. The global interest rate is the United State interest rate.

- For Brazil, Colombia, Chile and Mexico, the specific EMBI for each of these countries from J.P Morgan will be used. For South Africa, the CDS, from Bloomberg, will be used, due to the temporal extension of this serie be longer than the EMBI. For developed countries there is no EMBI or CDS. In this way, I chose to use the national EPU from Canada, Australia, Germany and UK. [4]

- New confirmed COVID-19 deaths per million people by country is from Our World in Data.

- 1-month and 36-month commodity futures prices are from Bloomberg. Commodity futures indices with this maturity will be constructed. The time series amplitude of these data is specified in section 5.4 as well as the index construction method and weights used.

I chose to use the real effective exchange rate instead of the nominal exchange rate because it excludes effects related to price changes in the analyzed countries. However, estimates are available in the appendix C for the bilateral nominal national currency to US Dollar exchange rates, and there is not any relevant difference in the results. Also, we can notice that the nominal exchange rate is more explained in terms of variance decomposition than the real effective exchange rate by the model variables, as can be seen in appendix D.

2.2 Commodity Price Index

There are two relevant points regarding the construction of commodity indices that will be used in the model. The first refers to using weighted commodity indices based only on exports or also considering the prices of commodities imported by countries. There are two methods to account for the

[3] I chose to use Global EPU as global risk variable, but I also made the estimates using the VIX, obtaining similar results that are available on request.

[4] The choice between CDS and EMBI for each of the highlighted countries was based on the time series extension. However, the choice between these two variables and the country EPU was due to the fact that the first two variables are much more explanatory for the exchange rate than the EPU in emerging countries. This can be verified by looking at the exchange rate variance decomposition. In any case, the model was alternatively estimated using the countries EPUs when available instead of the EMBI/CDS, and the results obtained were very similar. These results are available on request.

price of imports: the first is to consider a Terms of Trade (ToT) index, and the second is to incorporate the import and export indices separately into the model. Secondly, it must be determined whether to use fixed or rolling weights.

Several studies in the literature examine commodity shocks using the ToT as the reference index, including Broda (2004), Aguirre (2011), Zeev et al. (2017), Fernández et al. (2017), Schmitt-Grohé & Uribe (2018), and Gruss & Kebhaj (2019). However, it is important to note that these studies mainly focus on the domestic product,in which the prices of imported goods have a significant impact. On the other hand, papers that concentrate more on exchange rates, such as Chen & Rogoff (2003),Chen et al. (2010) and Cashin et al. (2004), use commodity indices that only refer to exports.

Di Pace et al. (2020) argue that using terms of trade decreases the importance of the commodity shock. This is because global economic activity shocks, which simultaneously affect export and import prices, are largely undetected in the terms-of-trade measure but significantly affect domestic business cycles. The authors find that the economy's response to a positive export price shock does not mirror the response to a negative import price shock. Moreover, they arrive at a surprising result that a positive shock to import prices makes the exchange rate appreciate, while a positive shock to export prices also has this effect, which was already expected.

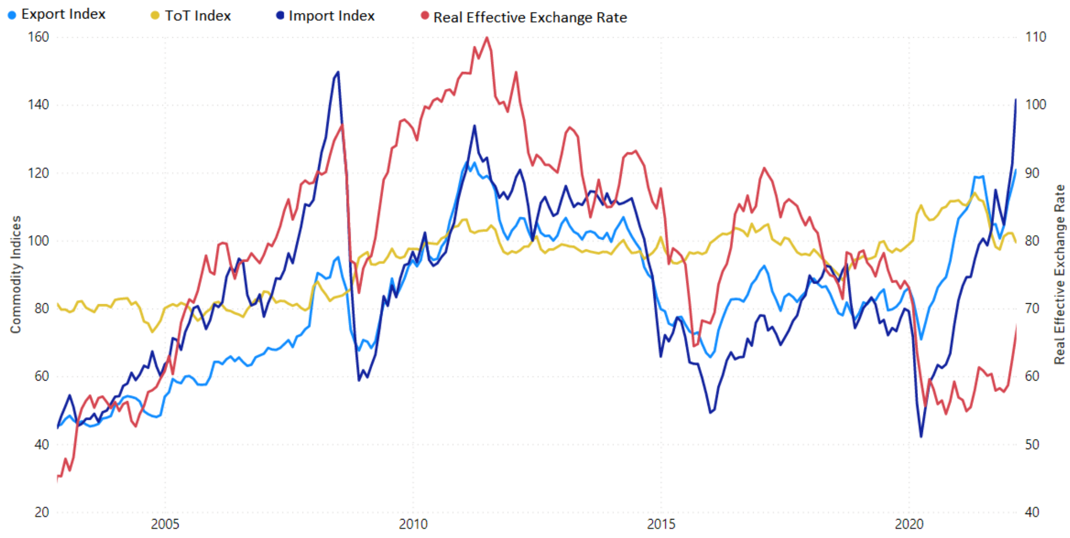
This paper only utilizes export prices when constructing the commodity index. There are some countries that have commodities which are both exported and imported, such as crude oil in Canada, Colombia, and Mexico. Therefore, including separate representations of the export and import indices in the model may cause confusion regarding the effects of shocks between the two indices. In a model that adopts a recursive ordering, the first-placed variable tends to have a disproportionate impact and affect the later-placed variable more than it should due to the shared components that make up the two indices.

The decision to do not include the Term of Trade Index (ToT) in the baseline model is based on the observation that the correlation between the exchange rate and ToT is weaker than that between the exchange rate and an export-only index. Furthermore, when conducting a variance decomposition of the exchange rate, we find that the Commodity Export Index explain a greater share of the exchange rate than the ToT index, supporting the aforementioned point.[5] During the COVID-19 pandemic, the gap between the export index and the exchange rate is larger in some countries than the gap between ToT and the exchange rate. This is because both exported and imported commodity

[5] This finding is documented in Appendix D.

prices increased during the pandemic, resulting in a constant ToT index for some countries where imported commodities hold a significant weight in the balance of payments. An example of this dynamic can be seen in Brazil, as illustrated in Figure 2.1 below:

Figure 2.1: Brazilian Commodity Indices and Real Effective Exchange Rate



Note: The commodity indices are based on 45 commodities weighted by the country's balance of payments.

Anyway, estimations were also conducted using Term of Trade Indices instead of Commodity Export Indices in Appendix E, and the results for the historical decompositions were found to be very similar. The main difference is that during the COVID-19 pandemic for Brazil and South Africa, it was not possible to observe a clear positive ToT shock, as the increase in imported commodity prices offset the rise in exported commodity prices.

Another important consideration is the choice between using rolling weights or fixed weights in the construction of commodity price indices. Most studies adopt fixed weights to avoid endogenous supply responses to price changes from affecting the analysis. As a result, our baseline model uses a fixed weight index. However, the model was also estimated using a rolling weight index (with lagged three-year rolling averages of trade values) to ensure that the weight of commodities in the balance of payments of countries did not change over time, thus distorting the fixed weight index. These results can be found in Appendix F.

2.2.1
The HP Filter Smooth Parameter λ

The time series used in the model, as described in Section 2.1, are mostly first-order integrated and non-stationary. Augmented Dickey-Fuller (ADF) tests were conducted to ascertain the stationarity of these series.[6] Another characteristic of these series is that they are not cointegrated. [7] Thus, putting the series in level is not an option. Looking at the literature on commodity shocks, the standard is to use the HP filter or quadratic detrending of the seriesSchmitt-Grohé & Uribe (2018). [8]

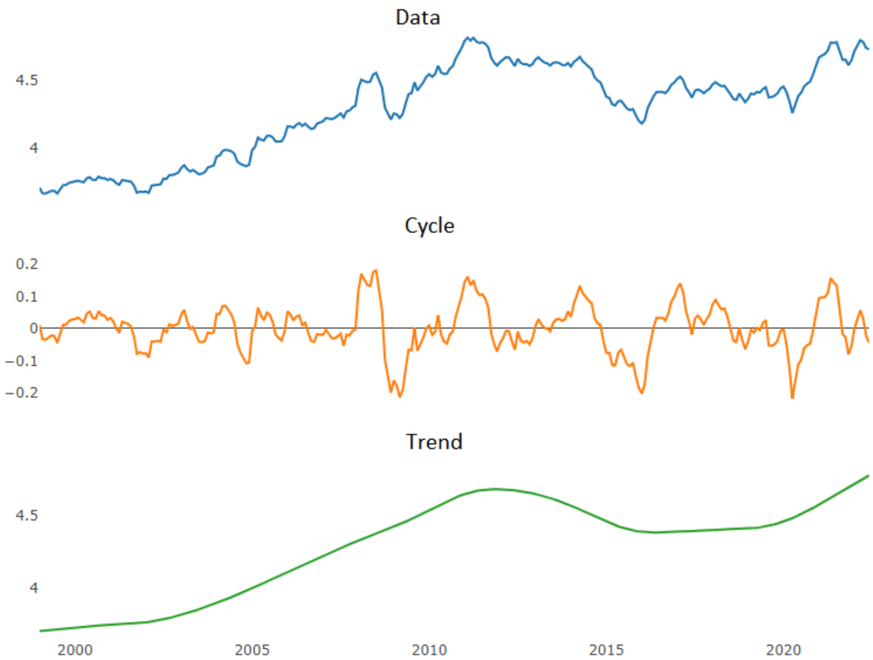
The baseline estimation will be performed utilizing the data processed through the Hodrick-Prescott (HP) filter with a λ value of 14,000 (hereinafter referred to as HP14400), which is the conventional choice for monthly data analysis.However, subsequent analysis will demonstrate that employing this parameter obscures the commodity shock that is the subject of our analysis during the pandemic. The HP filter identifies a portion of this shock as a trend, and as a result, the positive commodity shock present during the pandemic period is challenging to distinguish in the cyclical data incorporated in the model. This dynamic can be observed in Figure 2.2, where Brazil serves as an example.

[6]The results for the seven countries can be obtained upon request, but will not be presented here due to limitations on available space.

[7]The Johansen test was conducted. Results for the seven countries can be obtained upon request.

[8]One of the key results is the historical decomposition of the exchange rate, and differentiating the data based on the order of integration would render this output unintelligible. Structural shocks would continuously shift the x-axis as the data series, making it difficult to interpret. As a result, this procedure will not be showed.

Figure 2.2: HP Cycle and Trend of Brazilian Commodity Price Index



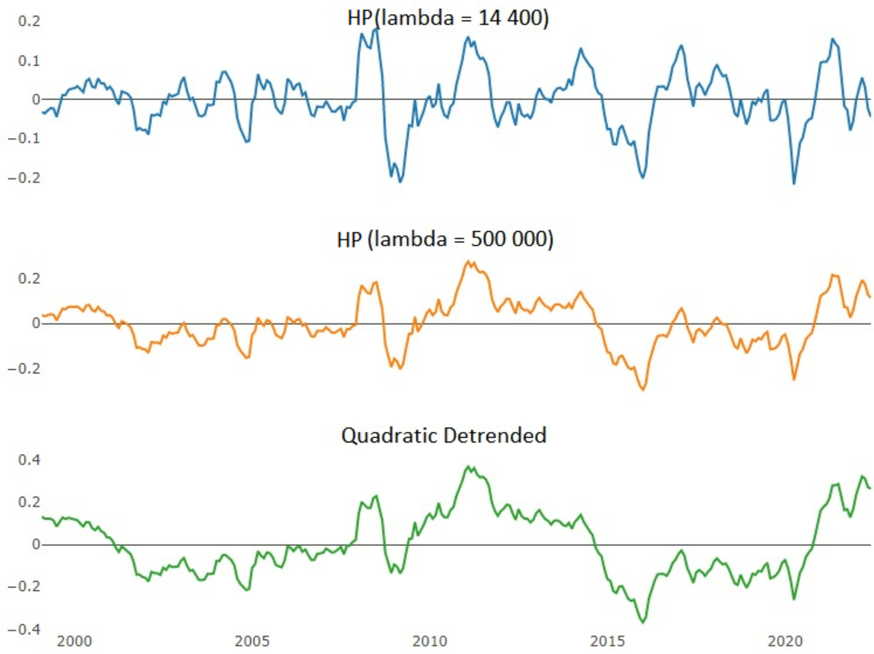
Note: HP filter cycle and trend components with a λ smoothing parameter = 14 400.

It is evident that the application of the HP14400 filter on the series exacerbates the negative shock to commodity prices during the first quarter of 2020, while concurrently diminishing the magnitude of the subsequent price increase. This occurs as the filter categorizes the surge in commodity prices during the pandemic as partially resulting from a shift in the trend of the series.

To achieve a more efficient estimation of the commodity shock, it becomes relevant to increase the trend smoothing parameter to a λ value of 500,000 (hereinafter referred to as HP500000), in order to capture a greater magnitude of the commodity shock during the pandemic. It is important to note that this alternative estimation serves as a complement to the baseline model results, as there is not a unique methodology in the literature for the treatment of non-stationary data prior to estimating SVAR models. Finally, let's estimate the model by quadratically detrend the data as a way to add robustness to the results. It will be observed that the results of this final estimation are comparable to those obtained using the HP500000 method. The estimation results using the quadratically detrended data can be found in Appendix G.

As depicted in Figure 2.3, it is apparent that both the HP500000 and quadratically detrended data methodologies effectively highlight the commodity shock during the pandemic. This is true for all countries in the sample, not just Brazil.

Figure 2.3: Cycle Component of Different Detrended Methods of Brazilian Commodity Price Index



Note: The data is expressed in log.

3
Empirical Model

3.1
SVAR Baseline Model

The empirical model employed is a Structural Vector Autoregression (SVAR) model, which follows the methodology of Schmitt-Grohé & Uribe (2018) but the specification has been modified to improve the identification of shocks on the exchange rate. The structural vector autoregressive system takes the following form:

$$X_t = hxX_{t-1} + ETAe_t \tag{3-1}$$

,

where the vector x_t is given by

$$x_t \equiv \begin{bmatrix} \widehat{G_{EPUt}} \\ \widehat{G_{rt}} \\ \widehat{Cp_t} \\ \widehat{C_{riskt}} \\ \widehat{D_{rt}} \\ \widehat{REER_t} \end{bmatrix}$$

The variables $\widehat{\mathrm{G_{EPU}}_t}$, $\widehat{Cp_t}$, $\widehat{C_{riskt}}$, and $\widehat{REER_t}$ denote the HP cycle component of the logarithm of Global Economic Uncertainty Index, Country Commodity Price Index , Country Risk [1] and the Real Effective Exchange Rate. The variables $\widehat{D_{rt}}$ and $\widehat{G_{rt}}$ denotes the cycle component of the country domestic interest rate and global interest rate.

The objects **hx** and **ETA** are 6-by-6 matrices of coefficients, and **ETA** is assumed to be lower triangular with ones on the main diagonal. The variable e_t is a 6-by-1 random vector with mean zero and identity variance-covariance matrix .

This paper, similar to much of the related literature including Broda (2004), Aguirre (2011), Zeev et al. (2017), Fernández et al. (2017), Schmitt-

[1] Country Risk is EMBI for Brazil, Chile, Colombia and Mexico, CDS for South Africa and EPU for Australia and Canada

Grohé & Uribe (2018), and Gruss & Kebhaj (2019), assumes that typical commodity exporting countries are small players in the global markets and thus cannot significantly impact global variables or global commodity markets. The exogeneity of commodity prices with respect to domestic variables is thoroughly analyzed in Gruss & Kebhaj (2019), and the conclusion reached is that there are only limited cases in which a country holds monopolistic power in the world market for a specific commodity and that commodity constitutes a significant portion of the country's exports. [2]

This hypothesis imposes restrictions on **hx** such that:

$$hx \equiv \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & 0 & 0 & 0 \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & 0 & 0 & 0 \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & 0 & 0 & 0 \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} \\ \gamma_{61} & \gamma_{62} & \gamma_{63} & \gamma_{64} & \gamma_{65} & \gamma_{66} \end{bmatrix}$$

This **hx** structure plus the fact that **ETA** is a lower triangle matrix guarantee that the variables of the international block (Global EPU, Global Interest Rate and Commodity Price Index) are exogenous to the variables of the domestic block (Country Risk, Domestic Interest Rate and REER). Therefore, for **ETA** identification, all we have to do is order the variables within their respective blocks.

The option to put the domestic and global interest rates separately instead of the countries' interest rate differential was due to the fact that movements in the domestic and global interest rates can have asymmetric effects. Thus, an increase in the global interest rate can have different effects than a decrease in the domestic interest rate, even if the differential has decreased by the same amount. This, in conjunction with the utilization of a recursive block identification method in the model, led to the chosen specification.

The ordering of variables in the international block was determined based on robustness tests and economic theory. Appendix J has the results placing the interest rate in possible alternative positions to the baseline ordering. We can see that whatever the position of the global interest rate, the results do not change. The same goes for the variance decomposition in Appendix D. This robustness of the results stems from the fact that the global interest rate has a small impact on the exchange rate. In this way, the position of this variable

[2] One of the cases that comes close to this dynamic is copper for Chile, thus this paper acknowledges that this hypothesis may introduce some bias for this particular country.

in the international block is irrelevant for the determination of the exchange rate. Therefore, remaining to justify the positioning of the commodity index after the global risk.

The channel through which global risk shocks affect commodities is via demand. An increase in global risk makes agents more cautious, and expectations of economic activity decrease. As a result, projections on future demand for the commodity fall, and so do the prices of these products. However, the way that commodity prices affect global risk is more uncertain.

Alquist et al. (2020) guided by the predictions of a general-equilibrium macroeconomic model with commodity prices, apply a new factor-based identification strategy to decompose the historical sources of changes in commodity prices and global economic activity. The analysis indicates that commodity-related shocks have contributed only modestly to global business cycle fluctuations, while an indirect factor that is highly related to general equilibrium effects explains approximately 65 percent of changes in commodity prices.

In the paper's model, the variable that represents the general equilibrium effects and is highly correlated with global economic activity is the global economic policy uncertainty index (EPU). Thus, this variable tends to affect more than be affected by commodity prices, both in the first period and in all periods.

Because there is clear economic justification and empirical evidence in the literature that global risk affects commodity prices, but there is no economic theory supporting a strong inverse relationship, I chose to place the restriction that a structural shock to global risk affects commodity prices in the same period while a structural commodity price shock does not affect global risk in the same period. This is the strategy for identifying the system of equations.

In the context of the domestic bloc, country risk was placed in first in the ordering, as there exists economic theory supporting its significant impact on both domestic interest rates and the exchange rate. Conversely, the influence of these two factors on country risk is not as evident. Regarding the ordering of interest rates and exchange rates, we have determined that interest rates must take precedence due to their immediate effect on exchange rates. However, it is important to note that the central bank modifies interest rates on a 45-day basis and exchange rates impact interest rates through prices, which can be partially rigid and may require an extended period to adjust. Therefore, it seems more reasonable to hypothesize that a structural shock to the exchange rate will only affect interest rates in the following period, considering the monthly nature of the available data.

To identify the structural coefficients of **hx** and **ETA** we have to estimate by OLS (equation by equation) the system:

$$X_t = BX_{t-1} + AX_t + u_t \tag{3-2}$$

in which A is restricted to be lower triangular with zeros along the main diagonal, what impose the simultaneous restrictions. Also, B is restricted with zeros in the same way of **hx**. By construction, $cov(u_t)$ is diagonal and

$$hx = inv(I - A)B \tag{3-3}$$

$$ETA = inv(I - A)diag(std(u_t)) \tag{3-4}$$

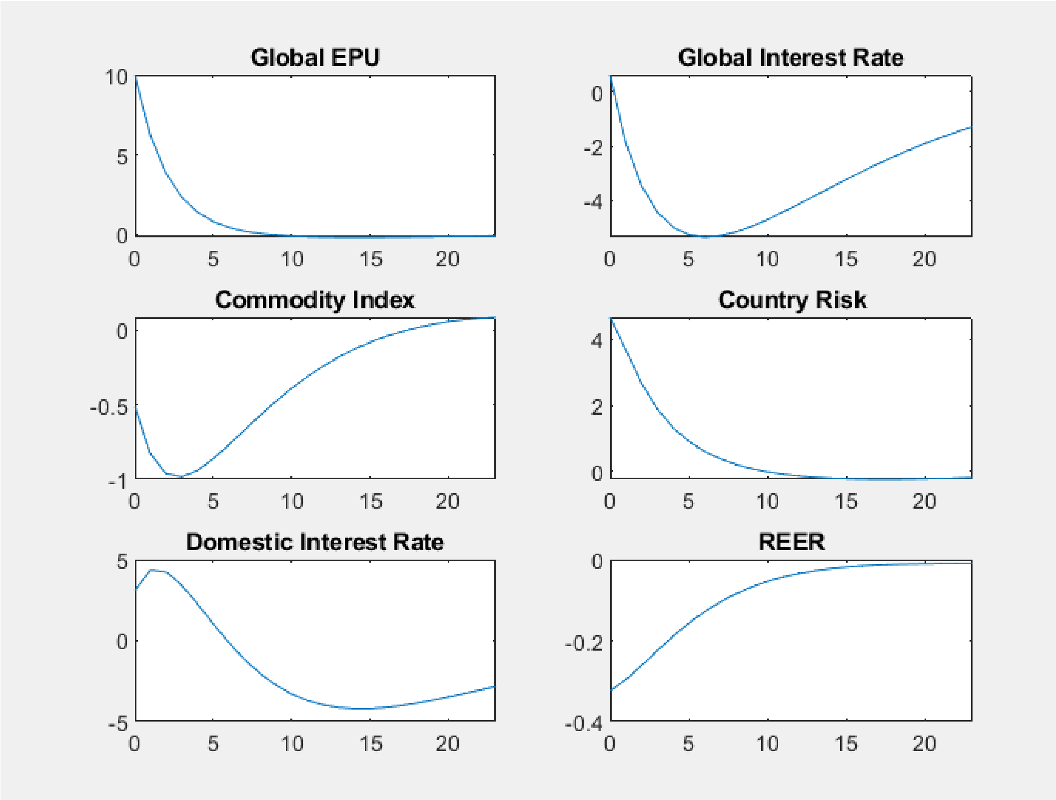
With the structural coefficients identified, is possible to obtain the impulse response functions as well as perform the variance decomposition and the historical decomposition of the exchange rate, which will be done in the remainder of the section.

3.1.1 Impulse Response Functions

Let's look at the impulse response functions of the model's shocks. For convenience and better display of results, the mean impulse response function (IRF) for the seven nations will be graphically represented. Nevertheless, separate impulse response functions for each country and the 66 percent confidence intervals determined through the application of bootstrapping techniques can be found in Appendix I.

A 10 % positive shock was given to the variable of interest. Below in figure 3.1 the average result across the countries of 10 % positive shock in the Global EPU:

Figure 3.1: Average Impulse Response Function of Global EPU Shock

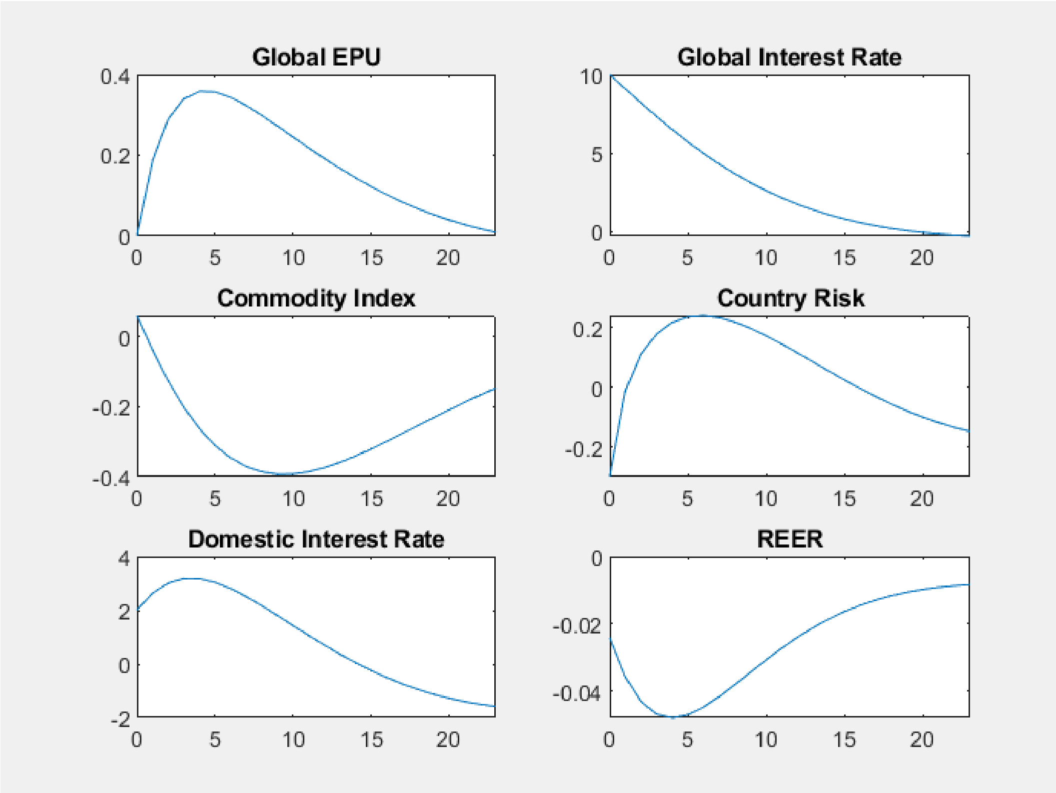


Note: The x axis measures months after the Global EPU shock. Solid lines are point-by-point mean across countries. The y axis measures the per cent desviation from the trend.

A positive shock to global risk causes the US interest rate to fall, given a likely slowdown in economic activity. Additionally, a decrease in commodity prices is predicted owing to the expected decline in demand. The country risk increases driven by an environment of greater global uncertainty, while the domestic interest rate rises and after falls. Finally, the exchange rate, as expected, depreciates in almost 0.4 %. When we look at each country's IRF individually, it becomes evident that fluctuations in the global risk factor do not have a significant impact on the exchange rate in Chile.

Below in figure 3.2, a 10% positive shock in the Global Interest Rate:

Figure 3.2: Average Impulse Response Function of Global Interest Rate Shock

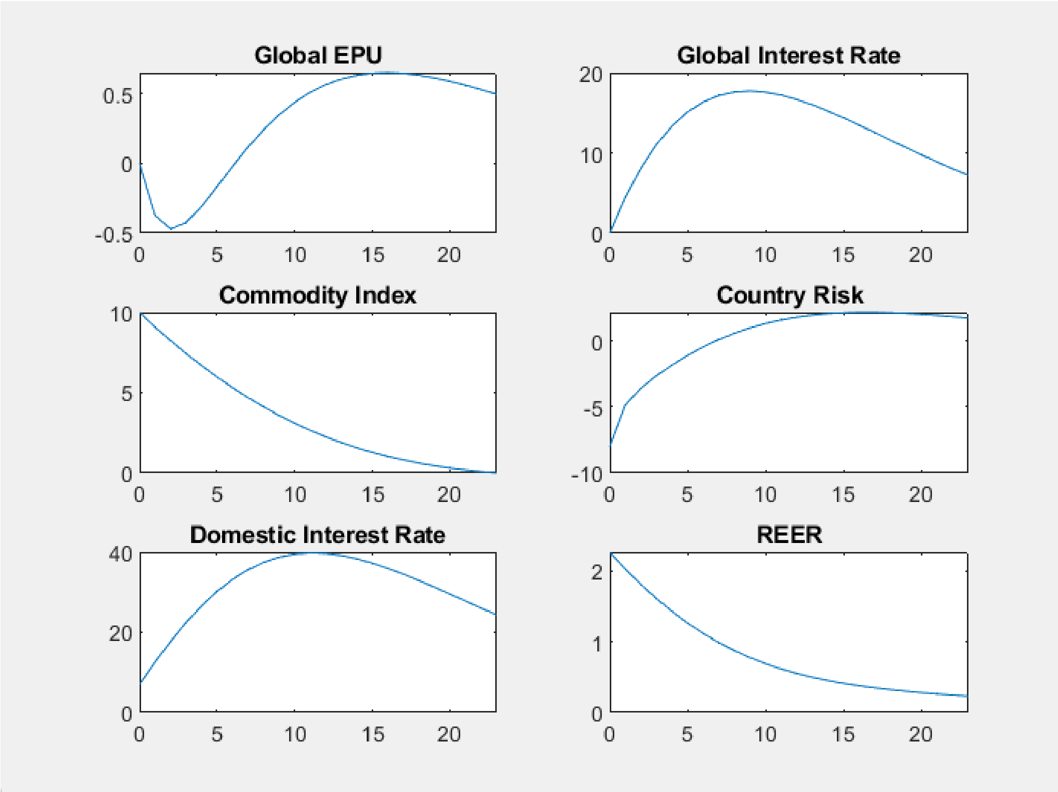


Note: The x axis measures months after the global interest rate shock. Solid lines are point-by-point mean across countries. The y axis measures the per cent desviation from the trend.

An increase in the global interest rate results in an increase in the global risk factor, a decrease in commodity prices, and a slight depreciation in the exchange rate, which is in accordance with economic theory predictions. The behavior of the country risk and the domestic interest rate is uncertain. Surprisingly, the country risk decreases initially, but after three periods, it experiences a positive deviation. Meanwhile, the domestic interest rate increases, and after more than one year, it moves into negative territory. It is important to note that in the individual IRF's the confidence intervals are wide for the country risk, making it impossible to know what happens to this variable. The impact on the domestic interest rate is heterogeneous across countries, justifying the peculiar format of the IRF. Brazil, Canada, Chile, Mexico and South Africa have wide exchange rate confidence intervals, which makes it impossible to state that the exchange rate actually depreciates. Thus, this is a relevant concern when looking at exchange rate historical decomposition's.

Follow below in figure 3.3 the IRF of a 10 % positive shock in the Commodity Price Index:

Figure 3.3: Average Impulse Response Function of Commodity Price Index Shock

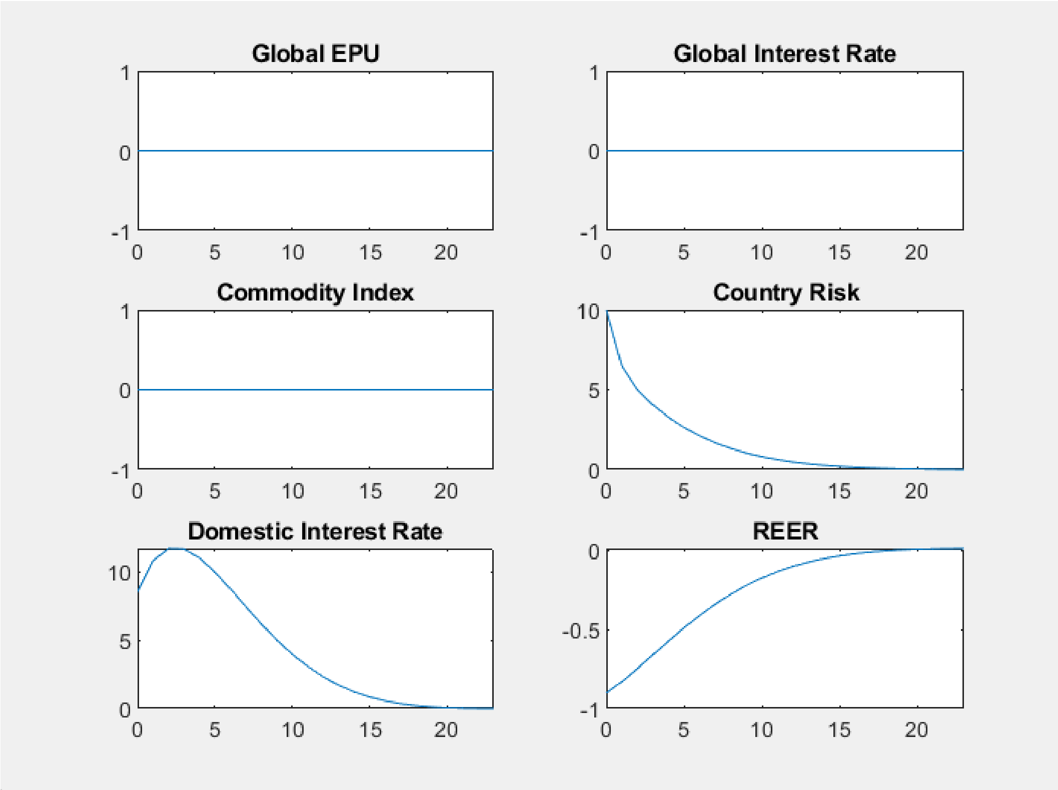


Note: The x axis measures months after the commodity price shock. Solid lines are point-by-point mean across countries. The y axis measures the per cent desviation from the trend.

A positive shock in commodity prices leads to an increase in the global interest rate due to the rise in prices in the United States. The Global Economic Policy Uncertainty (EPU) initially decreases and then increases thereafter. A positive shock in commodity prices leads to an increase in output in the commodity-exporting country, as is widely documented in the literature. As a result, the country risk decreases and domestic interest rates increase. Finally, the exchange rate appreciates by 2%. Upon examining the individual Impulse Response Functions (IRF's), it can be seen that the confidence intervals for the Global EPU are broad, and there is a greater appreciation of the exchange rate in response to a commodity shock for Brazil and Australia, reaching almost 4%.

Follow below in figure 3.4 the IRF of a 10 % positive shock in the Country Risk:

Figure 3.4: Average Impulse Response Function of Country Risk Shock

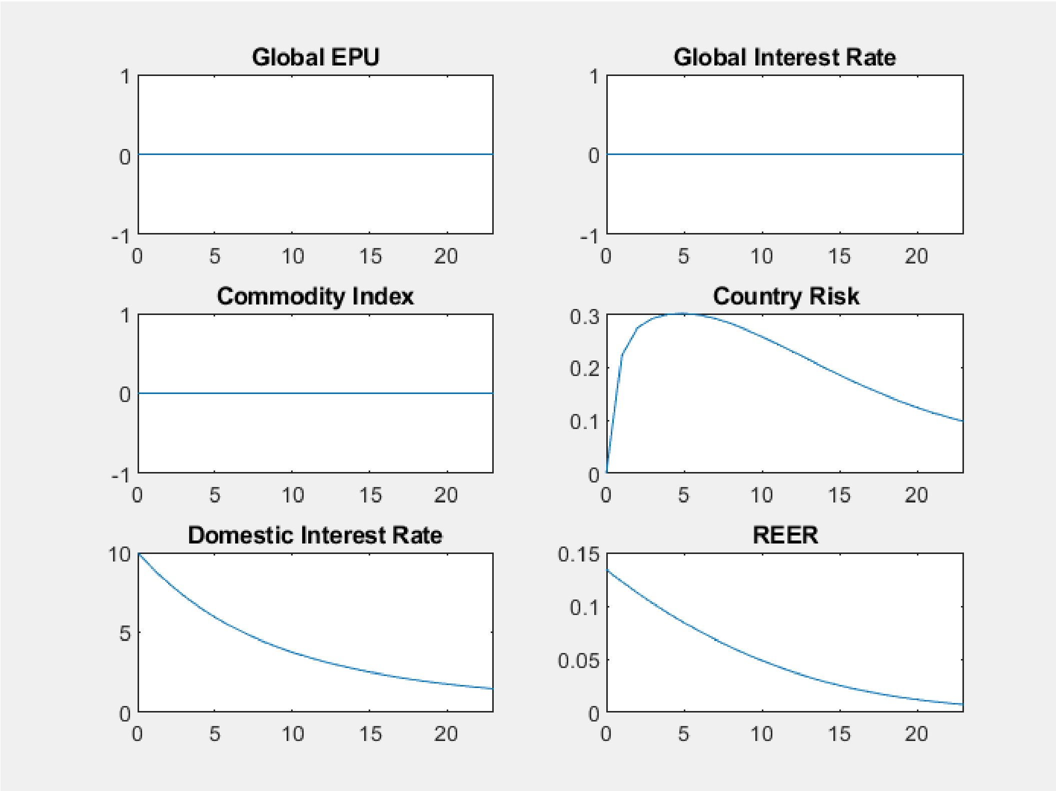


Note: The x axis measures months after the country risk shock. Solid lines are point-by-point mean across countries. The y axis measures the per cent desviation from the trend.

As expected, international block variables are not affected by the domestic block variables. The domestic interest rate rises with increased country risk and the exchange rate depreciates by 1%. Looking at individual IRF's, emerging countries are much more affected by risk, which is to be expected. It is worth noting that this may be due to the fact that the risk measurement variable used is the EPU in Australia and Canada. Notably, Brazil stands out with a significant depreciation of the exchange rate by nearly 2% in response to a country risk shock.

Follow below in figure 3.5 the IRF of a 10 % positive shock in the domestic interest rate:

Figure 3.5: Average Impulse Response Function of Domestic Interest Rate Shock



Note: The x axis measures months after the domestic interest rate shock. Solid lines are point-by-point mean across countries. The y axis measures the per cent desviation from the trend.

A positive shock to the domestic interest rate increases country risk and appreciates the exchange rate slightly by 0.1 %. This impact is more significant in the exchange rates of Australia and Canada. On the other hand, in developing countries, particularly in Latin America, the confidence intervals are quite broad, rendering it difficult to make causal assertions.

3.2 Variance Decomposition

To quantify how much of the exchange rate is explained by each variable in the model, it is necessary to compute the variance decomposition of the exchange rate. Table 3.1 below shows the exchange rate variance decomposition for each country and an average across all countries:

Table 3.1: Real Effective Exchange Rate Variance Decomposition

	Australia	Brazil	Canada	Chile	Colombia	Mexico	SA	Average
Global EPU	10.72	2.44	13.53	0.29	5.76	13.39	9.56	7.96
Global I. R.	6.66	0.22	0.22	4.17	2	1.92	0.99	2.31
Commodity P.I.	20.69	25.34	17.07	19.49	12.64	18.98	10.01	17.89
Country Risk	0.76	30.08	2.68	9.02	10.16	23.15	19.75	13.66
Domestic I.R.	7.76	9.1	6.48	3.54	4.53	1.06	5.8	5.47
REER	53.38	31.79	59.99	63.44	64.87	41.46	53.86	52.69

Notes: Shares are expressed in percent. The last column "Average" is a cross-country mean.

We can observe that, in general terms, the commodity shock is the main determinant of the exchange rate, explaining an average of 17.89 %. The second most important factor is country risk, which explains an average of 13.66%. It is noteworthy that in emerging countries, the proportion of the exchange rate explained by country risk is even higher, emphasizing the importance of country risk in these economies. Considering just emerging countries, we have that 18.4 % of the exchange rate is explained by risk while 17.29 % is explained by commodity. In contrast, developed countries such as Canada and Australia exhibit persistently low levels of risk, resulting in negligible influence on the exchange rate. However, the impact of global risk on the exchange rate in these countries is significant, accounting for 10.72% and 13.53% in Australia and Canada, respectively. This is higher compared to the average influence across all countries of 7.96%.

The global interest rate has little influence on the exchange rate of the selected countries, representing only on average 2.31 % of the exchange rate variance decomposition. The domestic interest rate has a slightly greater contribution, standing out with 7.76% and 9.1% for Australia and Brazil respectively. The overall model demonstrates considerable explanatory power in Brazil and Mexico, accounting for approximately 68% and 59% of the exchange rate, excluding the residual component.

An individual analysis of the selected countries indicates that the global risk factor has a significant impact on the exchange rate in Australia (10.72%), Canada (13.53%), and Mexico (13.39%), whereas the global interest rate has a greater influence in Australia (6.66%) and Chile (4.17%). The commodity prices also play a crucial role in all countries, with a particularly strong effect in Brazil (25.34%), Mexico (18.98%), and Australia (20.69%). The country risk factor stands out as a major contributor in Brazil (30.08%), Mexico (23.15%), and South Africa (19.75%).

Examining the literature on the measurement of commodity shock on business cycle, it can be observed that Schmitt-Grohé & Uribe (2018) found that ToT shocks explain an average of 14% of the real exchange rate variance decomposition without considering global interest rate and 11% with global interest rate included in the model in their sample of 38 emerging countries. Aguirre (2011) reported an average of 1% for a sample of 15 countries. Di Pace et al. (2020) found that together shocks in the import and export commodity indices explain in 1-year, 4-year and 10-year horizon 22%, 31% and 34% respectively of the variance of real exchange rate for 41 emerging countries. Zeev et al. (2017) found 14% for unanticipated TOT Shocks and 23% for TOT News Shocks as average in a panel that has Argentina, Brazil, Chile, Colombia and Peru.

Considering that i found an average percentage of approximately 17%, which rises to 25% with HP500000 and 34% with quadratic detrended data, my results are similar to the literature. Moreover, i have a much more complete model for determining the exchange rate than in the cited papers, in the sense that i consider both domestic and global risk and domestic and global interest rates.

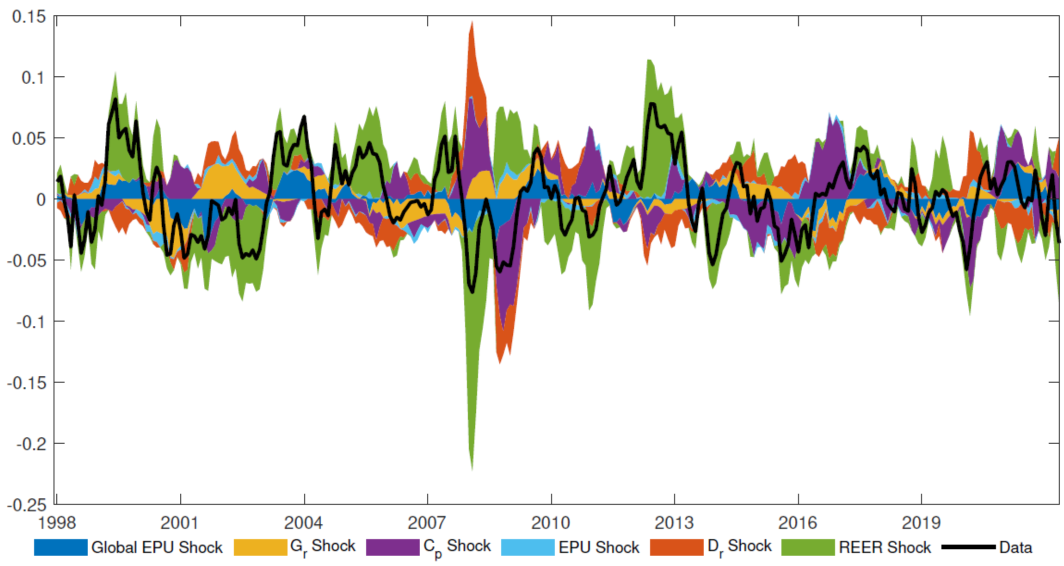
In Appendix D, there are the exchange rate variance decomposition of the alternative models. If the nominal exchange rate is used instead of the real one, the country risk loses importance, however the importance of the Global EPU and the commodity shock increases. The residual component decreases by 10%. When the commodity shock is based on the terms of trade rather than an export index, the importance of this shock decreases by 7%, but the importance of the country risk shock increases by 6%. This change in the share reflects the fact that the export price shock is more relevant to the FX determination than the ToT shock. The model residual component increases by 2%. Finally, if we use the EPU for Brazil, Chile, Colombia and Mexico instead of the EMBI, the importance of this shock decreases to less than half of it was before, and the residual component of the model increases by 6%, justifying the EMBI's preference in the baseline model. The HP500000 will be commented in the next section.

3.3
Historic Decomposition

The historical decomposition quantify how important a shock was in driving the behavior of the endogenous variables in a specific time period in the past. So, it is possible to compute the contribution of each structural shock in driving deviations of the VAR's endogenous variables away from their equilibrium. In this way, this is the model output that fits perfectly with one of the purposes of this paper, which is to explain which shocks caused the usual correlation between exchange rate and commodity price to break during the pandemic period.

Doing the historical decomposition, I can compute the structural shocks that best explain the behavior of the exchange rate in the period of interest for each country in the sample. Below is the historical decomposition of the REER for Australia in Figure 3.6:

Figure 3.6: Australian REER Historic Decomposition



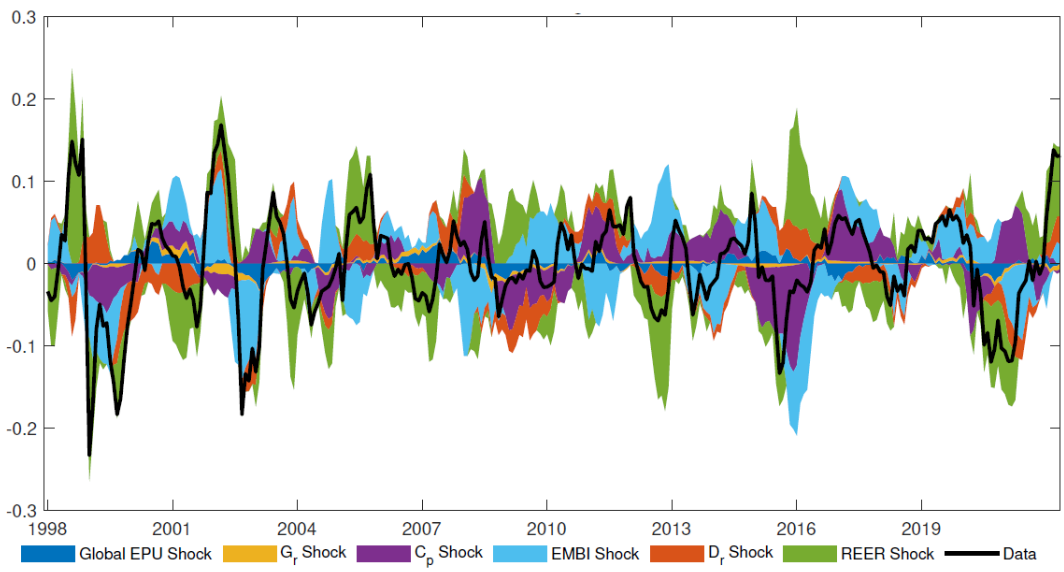
Note: The solid line is the HP14400 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

In Australia, in 2020, the main factors that caused the exchange rate to depreciate were the decrease in commodity prices (at the beginning of the pandemic) and the increase in global risk. The negative shock on commodity prices is amplified when passing the HP with $\lambda = 14{,}400$, as the filter identifies an upward trend in this period. In this way,a pattern observed among countries is that the model amplifies a negative commodity shock at the beginning of 2020 that will subside over the course of the year.

In 2021, the appreciation of the exchange rate was influenced by the global risk, which started to decrease with the rollout of vaccinations and the recovery of the economy. However, the domestic interest rate played a significant role in the non-appreciation of the exchange rate, compensating the increase in the price of commodities. In an effort to revive economic activity, the central bank of Australia reduced the interest rate during the period. Additionally, country risk emerged as a potential factor for the depreciation of the exchange rate, albeit timidly.

The chart 3.6 below shows the historical decomposition of the REER for Brazil:

Figure 3.7: Brazilian REER Historic Decomposition

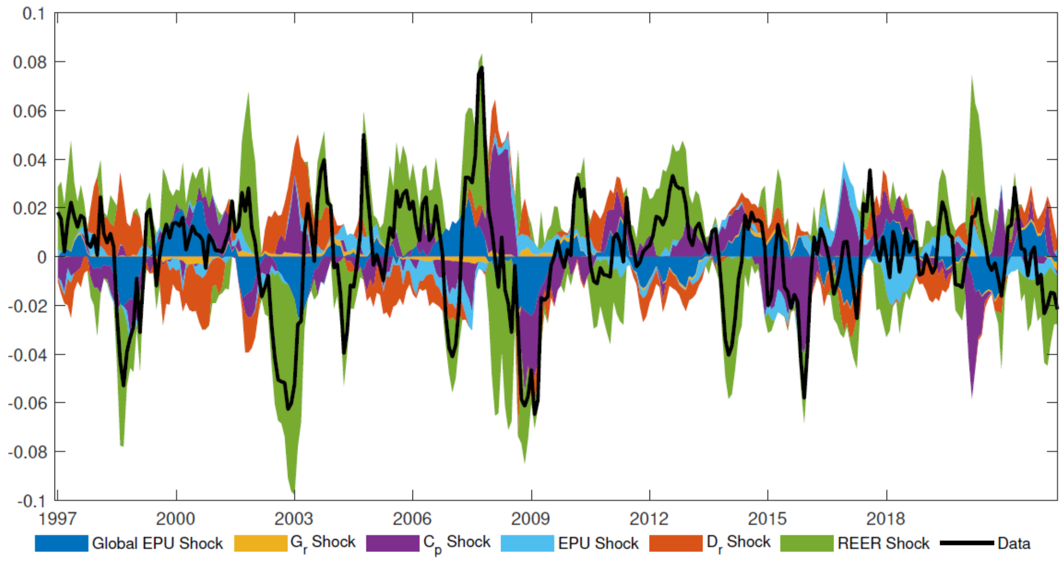


Note: The solid line is the HP14400 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

In Brazil, the main forces in the analyzed period that act in the direction of exchange rate depreciation are global risk, country risk and domestic interest rate. Global risk appears as in Australia in 2020, while low domestic interest rate levels and high country risk were manifested in the later period. The country risk appears to be the main variable responsible for the exchange rate depreciation, as expected by looking at the Brazilian variance decomposition. In 2021, the increase in country risk in Brazil was attributed to several factors including the "PEC dos Precatórios" (Pre-judgment Claims Act), economic stagnation, rising inflation, and a political and institutional crisis. Several factors contributed to this crisis among which the management of the COVID-19 pandemic, corruption scandals, tensions between President Bolsonaro and the Federal Supreme Court (STF), and changes in regulatory bodies and environmental policies. Institutional, political, and fiscal factors significantly impact the Brazilian exchange rate. This dynamic can be observed in the graph, where the country risk structural shock significantly contributed to the depreciation of the exchange rate, as observed during Dilma's re-election in 2014 and her impeachment in 2016.

The chart 3.8 below shows the historical decomposition of the REER for Canada:

Figure 3.8: Canadian REER Historic Decomposition

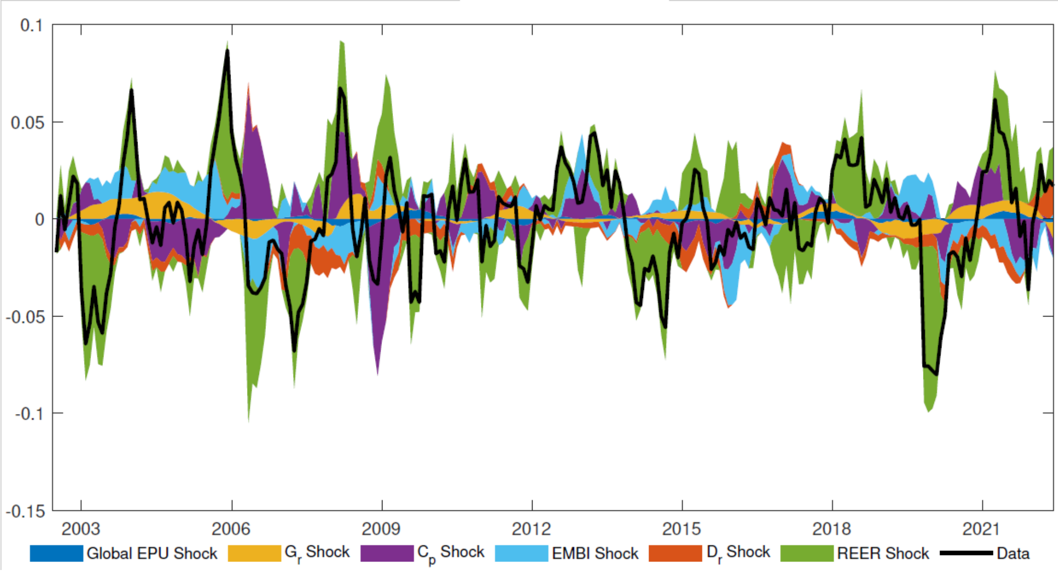


Note: The solid line is the HP14400 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

As in the countries analyzed so far, the rise in global risk is one of the reasons for the exchange rate depreciation in 2020. In 2021, surprisingly, the model captures the country risk as one of the factors that contribute to the exchange rate depreciation. The Canada EPU recorded levels of economic uncertainty in 2021 higher than the pre-pandemic average. It is also noted that for Canada, there is a significant residual component of the exchange rate structural shock that offsets the positive commodity shock.

The chart 3.9 below shows the historical decomposition of the REER for Chile:

Figure 3.9: Chilean REER Historic Decomposition

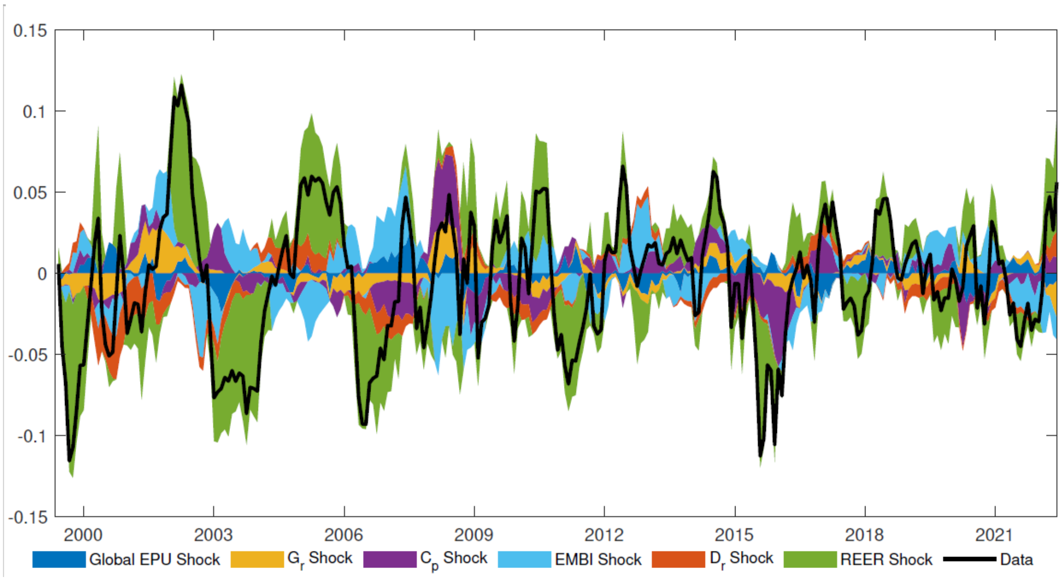


Note: The solid line is the HP14400 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

According to the variance decomposition of the Chilean exchange rate, it is largely unaffected by global risk. This was confirmed through a historical decomposition, which showed that the main factors driving the depreciation of the Chilean peso were idiosyncratic. Country risk appears as the main variable, driven by dissatisfaction with the country's economic and social model that culminated in a new constitution and the election of a left-wing president in 2022. In addition to country risk, the low domestic interest rate also influenced the depreciation of the Chilean exchange rate during the period. Similar to Brazil and Australia, the positive impact of the commodity shock was partially removed by the trend after passing through the HP (Hodrick-Prescott) filter.

The chart 3.10 below shows the historical decomposition of the REER for Colombia:

Figure 3.10: Colombian REER Historic Decomposition

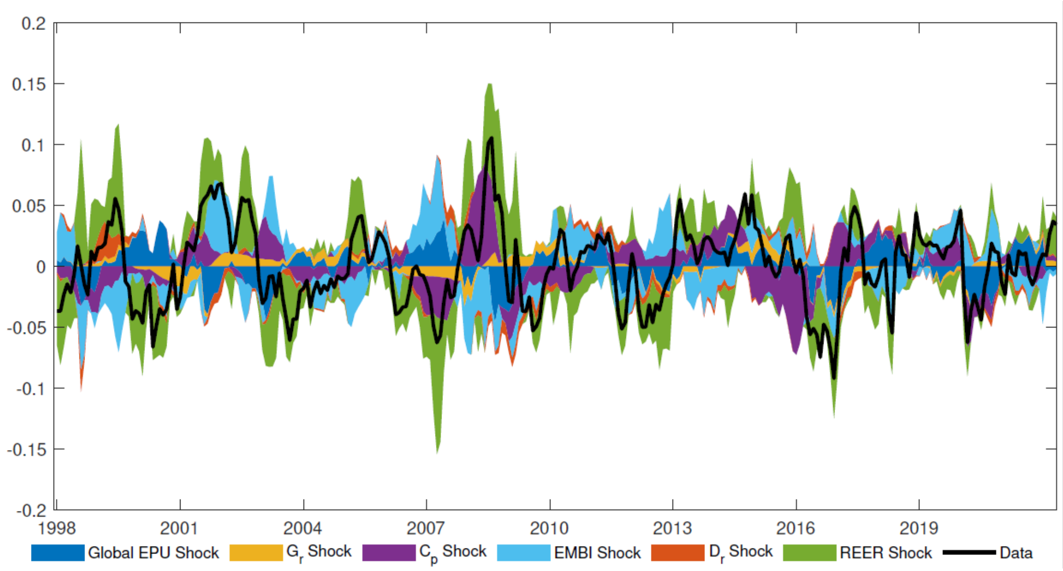


Note: The solid line is the HP14400 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Note that the problem of the HP filter removing the positive commodity shock from its cyclical component is quite evident for Colombia. Global risk appears again as an exchange rate depreciation factor in 2020, while in 2021 country risk appears as the main variable that promotes REER depreciation. Standard & Poor's lowered Colombia's sovereign rating to BB+ in May 2021, following the withdrawal of a fiscal reform due to protests. Fitch came to the same conclusion in July 2021. The sovereign rating downgrades have added to a perception of increased political instability. A series of protests began in Colombia in April 2021 against increased taxes, corruption, and health care reform proposed by the government of ex-president Iván Duque Márquez. Similar to Chile, the dissatisfaction of the population led to the election of a left-wing president at the end of 2022.

The chart 3.11 below shows the historical decomposition of the REER for Mexico:

Figure 3.11: Mexican REER Historic Decomposition

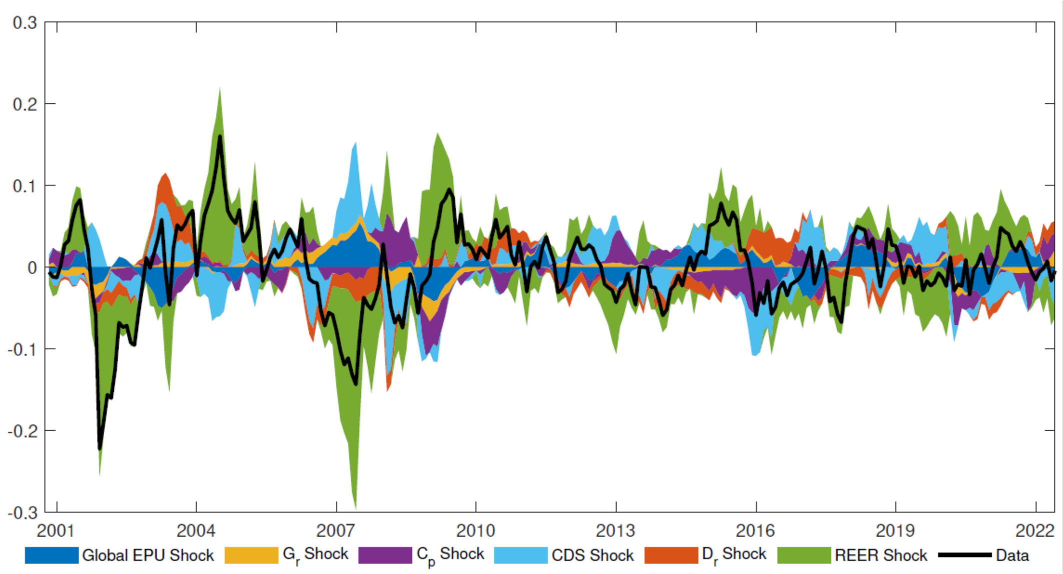


Note: The solid line is the HP14400 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Similar to all the countries analyzed thus far, with the exception of Chile, global risk was the primary factor causing the depreciation of the exchange rate in 2020. The positive commodity shock again is ommited by the HP filter. The country risk was identified as the main variable responsible for the depreciation of the exchange rate, possibly due to the increased debt from economic packages during the pandemic in a country with limited fiscal space for spending and the government's inadequate response to containment of the covid pandemic in a similar way to Brazil.

The chart 3.12 below shows the historical decomposition of the REER for South Africa:

Figure 3.12: South African REER Historic Decomposition



Note: The solid line is the HP14400 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

The same dynamics for commodity prices and global risk that were observed in previous countries also hold true for South Africa. Like most emerging countries, South Africa experienced an increase in its country risk in 2021, driven mainly by civil protests triggered by the arrest of former President Jacob Zuma, the worst civil unrest since the worst civil unrest since the end of the apartheid regime. Civil protests, allied to a high unemployment rate and an already deteriorated fiscal environment coming from 2020 resulted in relatively high levels of economic uncertainty in 2021 in South Africa, which ultimately contributed to the depreciation of the exchange rate. Low levels of domestic interest rates played a secondary role in contributing to the depreciation of the exchange rate, albeit in a more subtle manner.

In general, the global risk during 2020 was largely responsible for the depreciation of the exchange rate in both emerging and developed countries, while the country risk appears as the main reason for the non-appreciation of the exchange rate in 2021 mainly in emerging countries. This greater country risk is associated with a deteriorated fiscal environment coming from 2020 with large expenses related to the pandemic, and in some countries, such as Brazil, Chile, Colombia and South Africa, with institutional and political crises. In addition, low levels of domestic interest rates also played a role in contributing to the depreciation of the exchange rate in Australia, Brazil, Chile, and to a lesser extent, South Africa.

The historical decomposition of the Real Effective Exchange Rate (REER) based on the Total Terms of Trade (ToT) index is presented in Appendix E. It is discernible that only Brazil and South Africa exhibit notable disparities in the analysis. In the case of Brazil, a positive commodity shock that was previously identified as a exchange rate appreciating factor has now been replaced by a country risk shock, which seems incongruous. In the case of South Africa, the model captures that the ToT shock appreciated the exchange rate in the period, but the ToT declined in this country, given the large increase in imported commodities prices.

When evaluating the Impulse Response Function (IRF) of a positive shock to terms of trade in Brazil and South Africa, it is evident that the exchange rate in Brazil remains largely stable, whereas the exchange rate in South Africa experiences depreciation. Both confidence intervals are very wide, which makes the historical decomposition and the results found unreliable, which justify the strange results described above. This is another sign that using an export index is more efficient than ToT index in determining the exchange rate of these two countries. Anyway, the main determinants of exchange rate depreciation in the period are robust to using a ToT index. Appendix F presents the historical decomposition of the Real Effective Exchange Rate (REER) utilizing a rolling weight index rather than a fixed weight index. It is noted that there is no substantial variation in the results.

As a measure of ensuring the accuracy of the results, additional estimations were conducted while considering the impact of the COVID-19 pandemic. To reduce any residual effects in the model, a proxy for COVID-related news was included, which was measured by the number of deaths per million people per month in each country. It's possible that the severity of the pandemic could have contributed to the depreciation of the exchange rate during the studied period, and thus it was important to account for this factor in the analysis. Appendix K shows the average IFR across countries for a COVID-19 deaths shock. However, we can observe that there is no evidence that an increase in deaths from covid and a worsening of the pandemic have any impact on the exchange rate.[3] In this way, it was not possible to conclude that an increase in deaths from covid was necessarily one of the reasons for the non-appreciation of the exchange rate in the period.

[3]This dynamic is also observed for the individual IRFs for each country. The structural shock of covid-19 was automatically identified due to its exogenous nature to the other variables. More information about the identification of this shock can be found in appendix K.

4
Different Trend Smoothing Parameter

In this section, the model will be estimated with the same specification and identification structure, but with the data filtered with HP using a trend smoothing parameter (λ) of 500 000. In the business cycle literature, it is usual to use 14 400 for monthly data. However, Ravn & Uhlig (2002) recommend 129 600. In addition, it is important to note that, for variables in the model that mostly represent prices, there is not such rigidity in relation to which λ to use. Furthermore, the increase in commodity prices during the pandemic is not believed to be due to a change in the long-term growth trend, but rather the result of a cycle generated by the COVID-19 pandemic, as already mentioned.

Therefore, using a higher trend smoothing parameter can help the model to capture the positive commodity shock that occurred during the pandemic. It is imperative to highlight that the model was not estimated specifically for Chile. As the filter eliminates a smoother trend from the series, the likelihood of the series becoming non-stationary increases, thereby also increasing the possibility that the Vector Autoregression (VAR) model is non-stationary[1]. The HP500000 model for Chile does not converge, that is, the IRF and the others outputs are not valid. [2]

The impulse response functions of the HP14400 and HP500000 are very similar, with the difference that in the latter the shocks are more persistent. For this reason, it has been deemed unnecessary to display this model output again. [3]. In the remainder of the section, the exchange rate variance decomposition and historic decomposition will be presented.

[1]One potential reason for not considering the HP500000 as the baseline model could be attributed to the increased likelihood of non-stationarity within the series, leading to lower reliability of the Impulse Response Functions (IRFs) and Variance Decompositions (DVs). Additionally, it is worth noting that the IRFs exhibit a high degree of persistence, which further justifies the selection of the HP14400 as the baseline model.

[2]The non-stationarity of the system is related to the fact that passing HP500000 does not make Chile's domestic interest rate series stationary. In this way, the non-convergence of the system is probably related to this fact.

[3]These IRF are available upon request

4.1
Variance Decomposition

The table below shows the variance decomposition of the HP500000 model for each country individually and in the last column an average of this variable across all countries.

Table 4.1: Real Effective Exchange Rate Variance Decomposition - HP with $\lambda = 500\,000$

	Australia	Brazil	Canada	Colombia	Mexico	SA	Average
Global EPU	33.25	6.69	11.58	5.13	13.43	5.92	12.66
Global I.R.	3.86	1.01	0.75	1.22	0.68	3.15	1.78
Commodity P.I.	16.72	37.9	21.57	28.41	35.8	9.51	24.99
Country Risk	0.86	16.73	0.59	11.53	11.91	18.44	10.01
Domestic I.R.	8	9.03	5.21	0.31	0.45	5.95	4.83
REER	37.28	28.6	60.27	53.36	37.71	57.01	45.7

Notes: Shares are expressed in percent. The last column "Average" is a cross-country mean.

In summary, the average results across countries indicate a loss of importance of country risk and an increase in the importance of the commodity shock and global EPU. As a whole, the average residual for this model decreased by around 7 percentage points. The enhancement in the significance of the Global EPU was mainly driven by Australia, where the shock percentage increased from 10.72% to 33.25%. The commodity shock gained prominence in Brazil and Mexico taking a large share of country risk, with the commodity shock percentage reaching 37.9% and 35.8% respectively, while reaching 28.41% and significantly reducing the residual in Colombia. On the other hand, the proportions in Canada and South Africa remained largely similar to those in the HP14400 model.

Country risk continues to be more important for emerging countries, especially Brazil and South Africa. Global risk continues to be the main risk in developed countries. The domestic interest rate has a significant impact in Australia and Brazil, while the model has the highest explanatory power in Brazil, Mexico, and Australia.

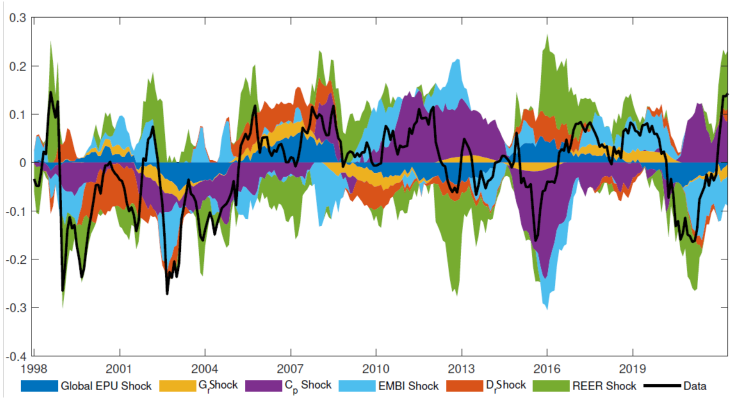
Appendix D shows the variance decomposition for quadratic detrended data which resembles HP500000 with a sahre shift from country risk to global risk and commodity prices with these shares coming in at 14.61% and 34.89% on average across countries respectively.

4.2 Historic Decomposition

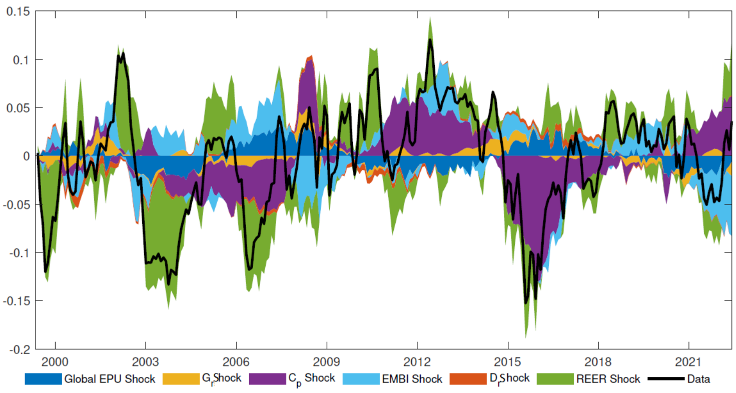
Now, let's look at the historical decomposition. The analysis will be divided into developed and emerging countries. Below is the historical decomposition of emerging countries in figure 4.1:

Figure 4.1: Emerging Countries REER Historical Decomposition- HP with λ = 500 000

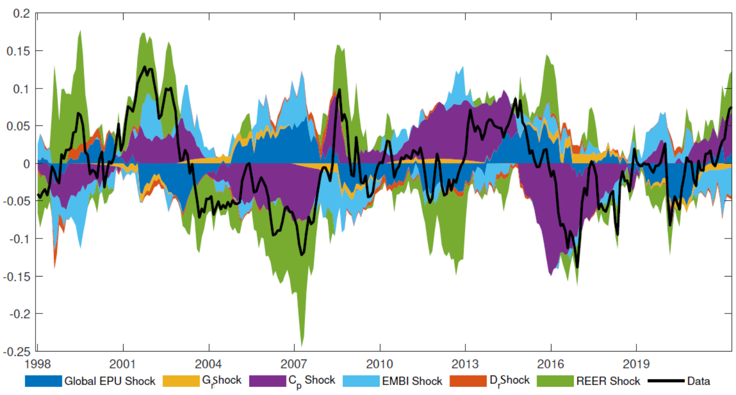
(4.1(a)) Brazil



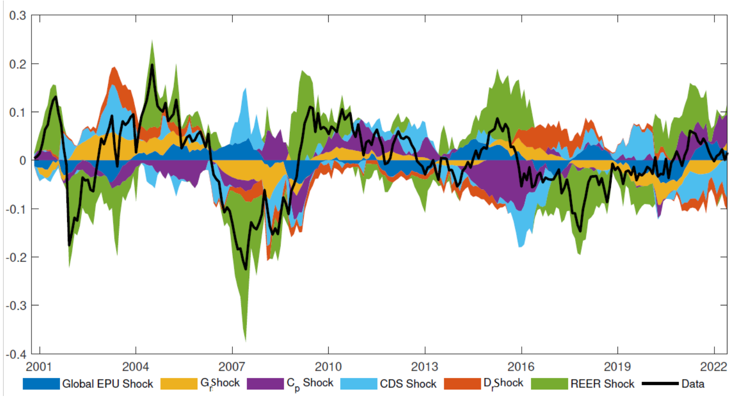
(4.1(b)) Colombia



(4.1(c)) Mexico



(4.1(d)) South Africa



Note: The solid line is the HP500000 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

It can be noted that in all countries, the commodity shock presents itself as a factor of exchange rate appreciation during the pandemic. Additionally, it is worth mentioning that the negative commodity price shock in the first quarter of 2020 is significantly less pronounced, which aligns more closely with the reality. Therefore, it can be concluded that the positive shock was not present in the prior results due to its removal during the application of the HP filter, rather than of a non-appreciation of the exchange rate in the face of a positive commodity shock. By utilizing the Impulse Response Function and Variance Decomposition, we can infer that a positive structural shock in commodity prices would result in a positive impact on the exchange rate, as indicated by the IRF, and the effect would be substantial, as demonstrated by the Variance Decomposition.

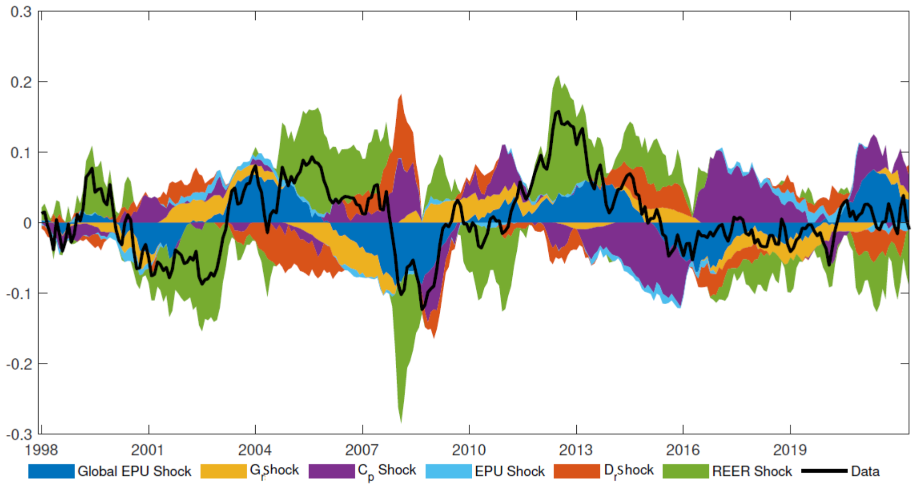
Regarding the previous results of which structural shock made the exchange rate depreciate for emerging countries, our results are robust for whatever λ is used. Global risk continues to be the main exchange rate depreciation shock in 2020, and the period is extended to 2021 for Brazil and Colombia. Country risk continues to be the main exchange rate depreciation factor in 2021 in emerging countries with the low levels of domestic interest rates having a little impact on the exchange rate depreciation for Brazil and South Africa.

Finally, regarding South Africa, it is observed that the US interest rate contributed to the depreciation of the exchange rate during the pandemic, which is surprising given that the Federal Reserve kept the interest rate close to zero for most of 2020 and 2021. The model identifies a positive global interest rate structural shock, which may have contributed to this factor. Additionally, it is important to note that the confidence intervals for the IRF associated with this shock are quite broad, which calls into question the reliability of the results associated with this variable.

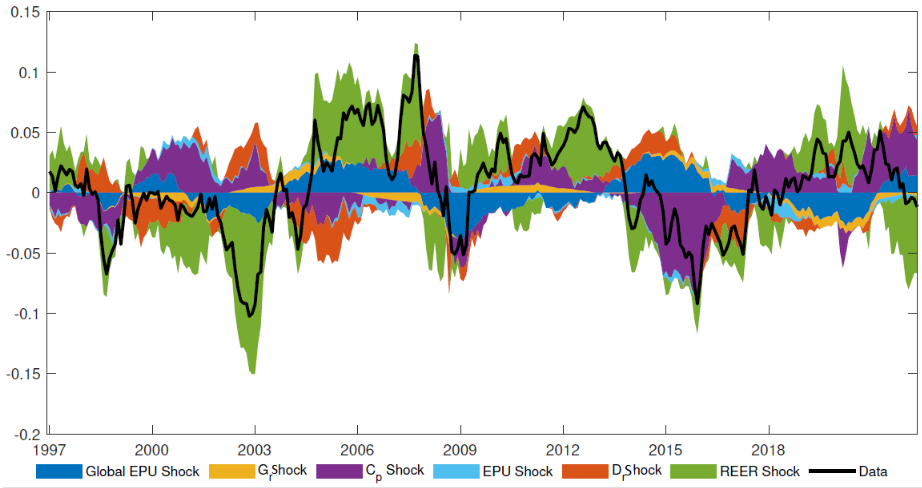
Now let's look at the historical decomposition of developed countries in figure 4.2:

Figure 4.2: Developed Countries REER Historical Decomposition- HP with $\lambda = 500\ 000$

(4.2(a)) Australia



(4.2(b)) Canada



Note: The solid line is the HP500000 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Looking at Australia historic decomposition, the only variation is that now the global risk structural shock makes the exchange rate appreciate, even in 2020. Furthermore, the low domestic interest rate continues to be the main factor that makes the exchange rate depreciate in the period. For Canada, global risk continues to appear as a depreciation factor in the first year, but country risk disappears in the second year, which is not surprising given that the importance of this shock in terms of variance decomposition change from 2.68% to 0.59% when using the HP500000. Thus, unlike emerging countries, idiosyncratic risk does not seem to have had much effect on the exchange rate for the developed countries in the sample.

The historical REER decompositions for the data after removing the quadratic trend are very similar to those presented in this section, with all results being robust to either of the two specifications. The two methods highlight the positive commodity shock. These results can be found in Appendix G.

5
Alternative Estimation

5.1
Non commodity Exporter Countries

In macroeconomic analysis, the issue of endogeneity between variables and the difficulty in identifying exogenous shocks is a widely recognized challenge. To ensure that the model is accurately identifying a structural commodity shock and not a combination of other structural shocks, one approach is to estimate the model for countries with limited weight in their export basket occupied by commodities, or in other words, non-commodity exporting countries. If the model indicates that commodities have a significant impact on the exchange rate of these countries, it is an indication that something other than just the commodity structural shock is being identified, or there may be an omitted variable problem in the model.

In the selection of countries, the criterion is to have a measure of country risk available, which can be challenging for non-commodity exporting countries that are typically developed. In this regard, the EPU index is accessible for England and Germany, which are robust economies and do not have a significant commodity export sector, therefore, these two countries were chosen for analysis.

Let's start by looking at variance decomposition in table 5.3:

Table 5.1: Real Effective Exchange Rate Variance Decomposition for United Kingdom and Germany

	HP (λ = 14 400)		*HP (λ = 500 000)*	
	Germany	United Kingdom	Germany	United Kingdom
Global EPU	2.88	20.22	9.19	30
Global Interest Rate	2.004	1.43	1.59	0.63
Commodity Price Index	4.04	1.99	5.65	3.57
Country Risk	1.51	0.04	2.89	1.47
Domestic Interest Rate	1.82	7.39	1.13	5.24
REER	87.72	68.88	79.51	58.33

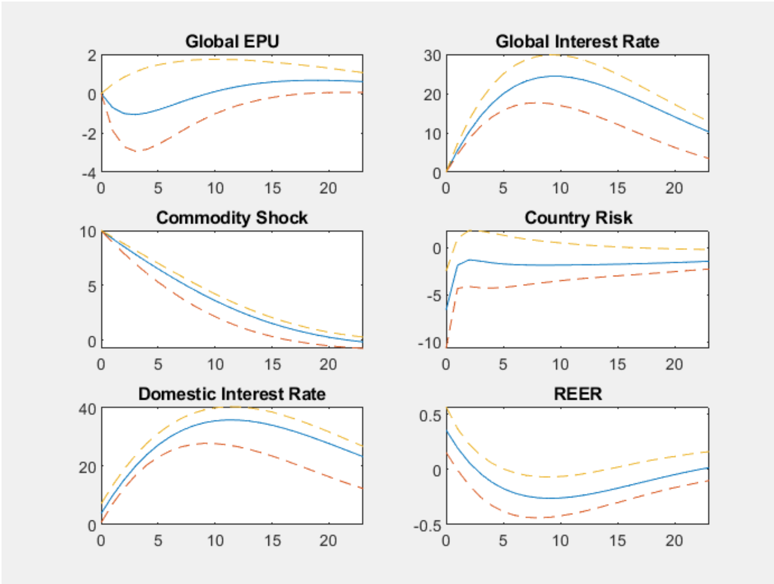
Notes: Shares are expressed in percent. HP (λ) determines which λ parameter was used in filtering the data with HP.

As expected, can be observed that the commodity shock does not explain as much exchange rate as in commodity exporting countries, which is a sign that the true structural shock of commodities is being identified. Furthermore, global risk seems to have a major effect in explaining the exchange rate for the UK. Global interest rate remains little explanatory in determining the exchange rate, while domestic interest rate has a slightly greater effect, at least for the UK. The model is quite ineffective for determining the exchange rate in Germany, but in England we managed to explain a relevant share of the exchange rate.

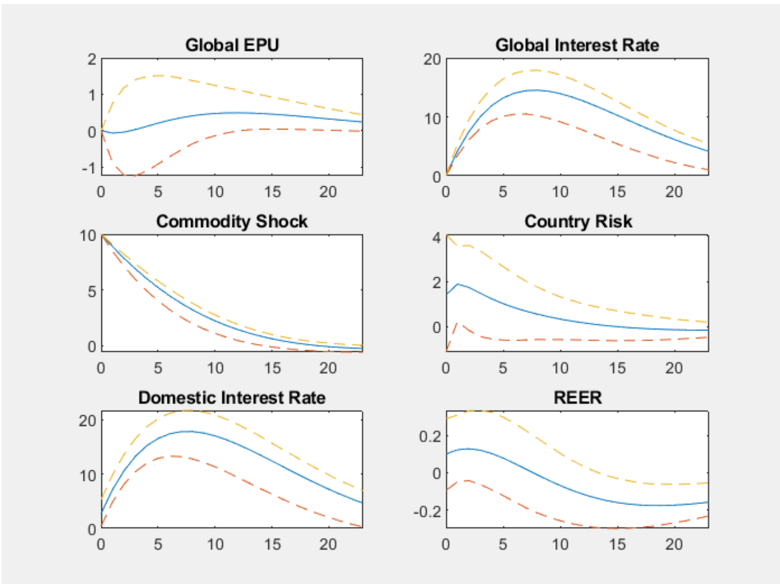
Other evidence that the commodity is not important in determining the exchange rate in these countries can be seen in the commodity shocks IRF's of the two countries that follows in figure 5.1:

Figure 5.1: Non Commodity Exporter Countries Impulse Response Function of Commodity Price Index Shock

(5.1(a)) Germany



(5.1(b)) UK



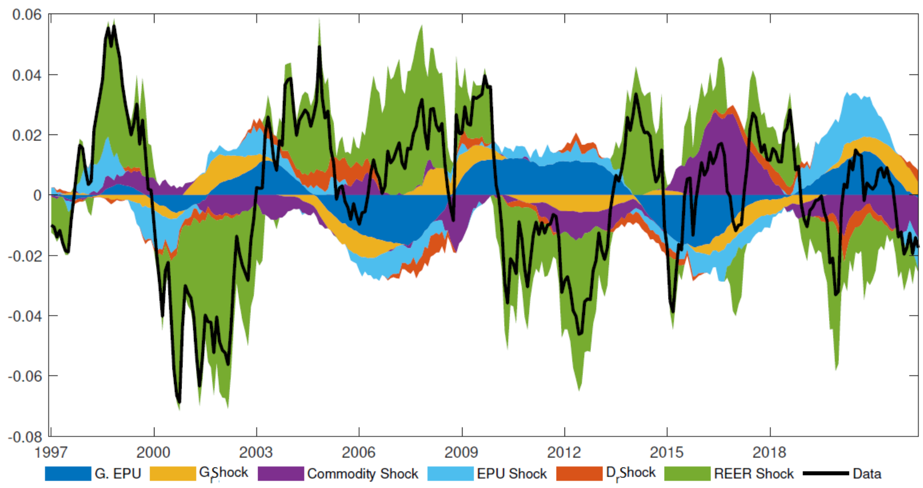
Note: The x axis measures months after the commodity shock. Solid lines are point estimates. Dashed lines mark a 66 percent confidence band estimated using bootstrapping methods.

Upon examining the effect of a 10% positive commodity price shock on the exchange rate in Germany, it can be seen that the exchange rate appreciates initially, however, it begins to depreciate after the fifth month and eventually returns to its equilibrium value. In the case of the United Kingdom, the exchange rate appreciate initially, but begins to depreciate after the tenth month. Furthermore, the confidence interval is wide and the impact ranges from -0.2% to 0.2% in UK and from -0.5% to 0.5% in Germany. Compared to the 2% positive average we had in emerging countries, this impact is much smaller for non-commodity exporting countries.

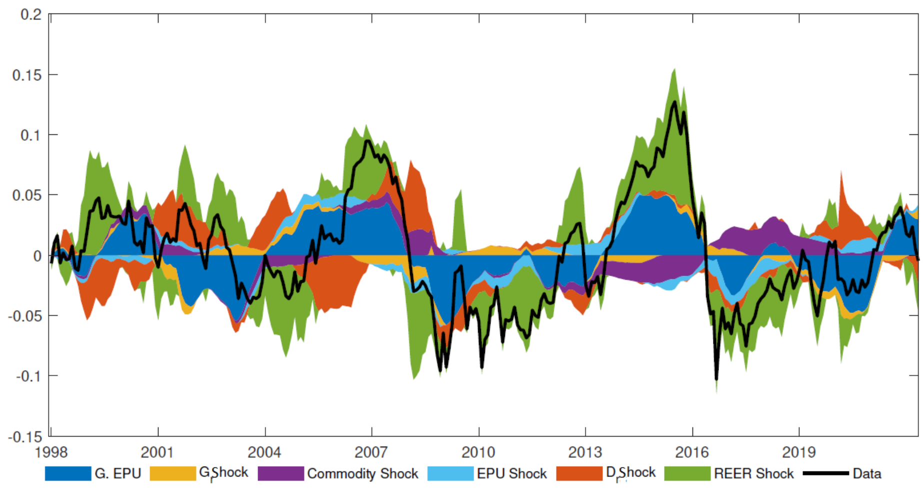
Finally, to complete the analysis, exchange rate historical decomposition will be plotted for these two countries. We choose HP5000000 to exclude the possibility of the commodity shock being withdrawn by the HP filter trend. Follow the historical decomposition's in figure 5.2 below:

Figure 5.2: REER Historic Decomposition of Non Commodity Exporter Countries

(5.2(a)) Germany



(5.2(b)) UK



Note: The solid line is the HP500000 cyclic component of the REER that enters the model. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

For Germany, as already mentioned, in addition to the model explaining only approximately 21% of the exchange rate, the IRFs have wide confidence intervals, so the historic decomposition is not reliable. In any case, the structural commodity shock is responsible for the exchange rate depreciation during the pandemic.

For England, a more explanatory model with much less residual component than the one for Germany was estimated. As expected given the variance decomposition, the global risk was the main determinant of the pound at the time of the pandemic with a dynamic similar to the others analysed countries, in which the global risk is responsible for the exchange rate depreciation in 2020, while in 2021 for appreciating. The structural commodity shock does not seem to affect the exchange rate significantly in almost any period of the series.Therefore, for non-commodity exporting countries, the model captures that the commodity shock have almost no influence on exchange rate.

5.2 Controlling for Dollar Effects

An alternative approach for achieving greater result robustness involves the inclusion of DXY in the international block of variables. It is noteworthy that the price of the commodities constituting the country index is denominated in US dollars, while countries' national exchange rates is composed by a currency basket that includes the US dollar. In many cases, the dollar carries significant weight in said currency baskets, given that countries maintain extensive trade relations with the US. Consequently, both the commodity index and the REER are influenced by the performance of the US dollar. For instance, assuming other factors remain constant, an appreciation of the dollar leads to a decline in commodity prices and a depreciation of the national exchange rate. Thus,not incorporating DXY into the model may overestimate the impact of commodity shocks on the exchange rate.

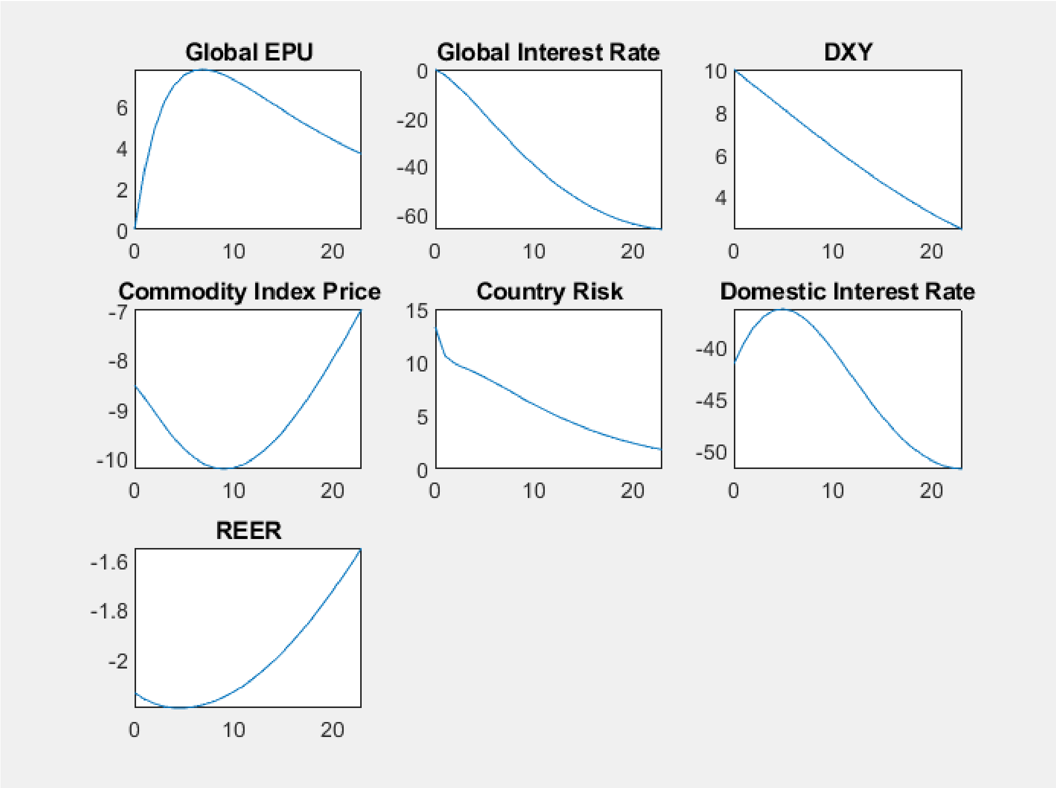
A sign that commodity prices are strongly influenced by the dollar is that approximately 29 % of the commodity price index on average across countries can be attributed to DXY according to variance decomposition analysis. Furthermore, a positive shock to the DXY leads the countries' commodity price index to fall in the same proportion while the exchange rate depreciates, as shown in Figure 5.3. When we look at the exchange rate variance decomposition in the table 5.2 below, we see that both in the HP14400 and in the HP500000 the explanatory power of the model increases and the share of the commodity shock is reduced with the addition of DXY in the model.

Table 5.2: Average Real Effective Exchange Rate Variance Decomposition with DXY

	HP (λ = 14 400)		*HP (λ = 500 000)*	
	Withou DXY	With DXY	Withou DXY	With DXY
Global EPU	7.96	7.56	12.66	11.81
Global Interest Rate	2.31	1.75	1.78	1.74
DXY	-	7.3	-	10.42
Commodity Price Index	17.89	15.17	24.99	22.07
Country Risk	13.66	13.26	10.01	10.66
Domestic Interest Rate	5.47	5.2	4.83	5.19
REER	52.69	49.72	45.7	38.08

Notes: Shares are expressed in percent. HP (λ) determines which λ parameter was used in filtering the data with HP. With DXY is the estimation with DXY in the international block, while without DXY is the opposite.

Figure 5.3: Average Impulse Response Function of DXY Shock



Note: The x axis measures months after the DXY shock. Solid lines are point-by-point mean across countries.

The DXY will be ordered right before the commodity shock as it affects this variable and at the same time is affected in the same period by US interest rates and global risk. This ordering is more likely because the dollar's impact on global risk and interest is less obvious than the reverse for the same period.

As the DXY may be partly compounding the commodity shock, it is more appropriate to examine the historical decomposition in which the commodity shock appears, ie for data treated with the HP filter with a λ of 500 000. [1] See this output in Appendix H.

It is observed that for all countries with the exception of Mexico, during the COVID-19 pandemic, a small part of the positive commodity shock turned into a structural DXY shock in the exchange rate composition. That is, part of the appreciation of the exchange rate in the period was the result of a negative shock in the DXY, that is, a weakening of the dollar, instead of an increase

[1]The results are also robust when I use the HP14400 filter, but is more difficult to discern the impact of the commodity shock on the model with the commodity shock since the positive pandemic commodity shock is removed by the HP trend. These results are available upon request.

in the price of commodities. However, it is noted that all other results are robust to this type of specification, that is, the same structural shocks that determined the exchange rate depreciation continue to do so.

An additional theory that can be examined that involves incorporating the DXY index is from M. Rees (2023). The paper notes that since 2010, there has been a reversal in the relationship between commodity prices and the Terms of Trade (ToT) in the US. Specifically, an increase in commodity prices has led to an improvement in the ToT from that year onwards due to the US becoming a net exporter of oil-related products. Meanwhile, at least in the long run, an increase in ToT has resulted in the appreciation of the US dollar. During the pandemic, the author claim that US experienced an increase in ToT, which caused the dollar to appreciate, something that had not been observed in prior periods. This appreciation of the US dollar could be seen as a partial depreciation of the currencies of commodity-exporting countries relative to the dollar, which could explain why the currencies of these countries did not appreciate despite the increase in commodity prices during the pandemic.

Although my model employs the Real Effective Exchange Rate (REER), it still indicates a break in the correlation between exchange rates and commodities, suggesting that other factors beyond the impact of the US dollar are at play. Nonetheless, we can test this hypothesis by including the DXY in the model, which would allow us to measure the extent to which the appreciation of the US exchange rate contributed to the depreciation in the currencies of commodity-exporting countries during the pandemic. Historical decomposition shows no signs of any structural shock to the dollar that could account for much of the currency depreciation among commodity exporters during the pandemic.

5.3 Commodity Future Prices

An interesting issue to be analyzed is how the exchange rate behaves in the face of shocks to commodity futures prices. If there is a rise in both spot and futures prices, it can be considered a permanent shock since market participants expect prices to remain high for an extended period. There is a theory that suggests permanent price shocks have a more significant influence on exchange rates compared to transitory shocks.

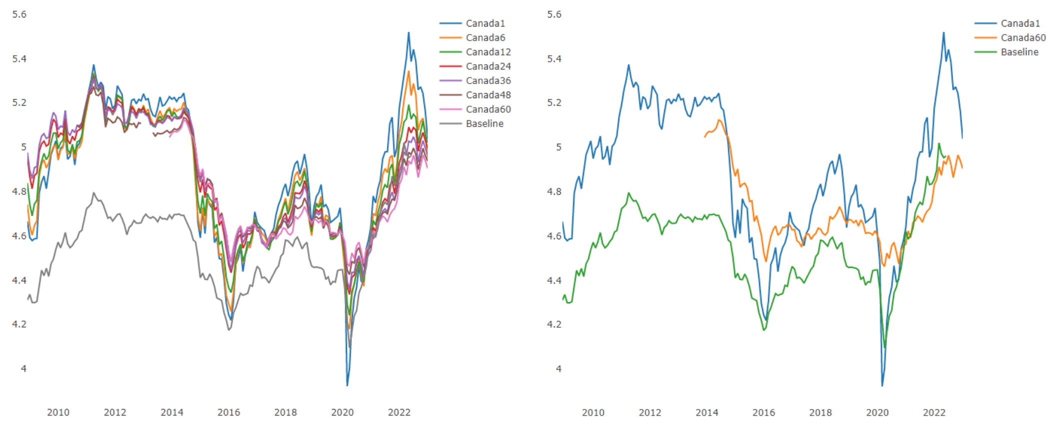
To examine the impact of futures prices on exchange rates, i construct commodity futures indices for each country. Due to the scarcity of future commodity price data, the study focused on Canada, Colombia, and Mexico. These countries were chosen because a significant portion of their respective export baskets, which include the 45 commodities used in the baseline model, could be covered. [2] The procedure performed to construct the index was to reweight the commodities in relation to their corresponding available for each country. The weights used can be found in Appendix L . A consequence of this data limiting factor is that the indices became heavily reliant on crude oil. It is worth noting that the estimation windows used for Canada, Colombia, and Mexico were (2008:1 to 2022:6), (2008:1 to 2022:6), and (2006:2 to 2022:6), respectively.

Figures 5.4, 5.5, and 5.6 display both the spot price index, which uses the weights of the 45 commodities in the baseline model, and the futures indexes for Canada, Colombia, and Mexico, respectively. [3]

Figure 5.4: Canadian Commodity Future and Spot Price Index

(5.4(a)) 1, 6, 12, 24, 36, 48 and 60 Month Futures Contract and Baseline Indices

(5.4(b)) 1 and 60 Month Futures Contract and Baseline Indices



Note: The indices were assembled based on the share of the commodity in the respective country's export basket. The number that comes after the country name indicates the maturity date of the futures contracts for the commodities used in the index. The data is in log.

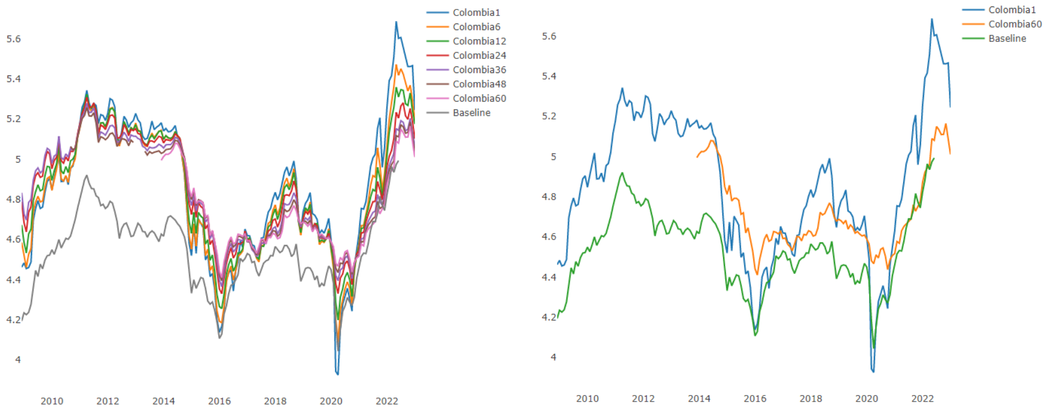
[2]The export basket percentages covered for Canada, Colombia, and Mexico were 60%, 81%, and 66%, respectively.

[3]The reference period (=100) for the baseline index is June 2012. On the other hand, the reference period for the futures price index is January 2020, resulting in a displacement in the level of the two indices.

Figure 5.5: Colombian Commodity Future and Spot Price Index

(5.5(a)) 1, 6, 12, 24, 36, 48 and 60 Month Futures Contract and Baseline Indices

(5.5(b)) 1 and 60 Month Futures Contract and Baseline Indices

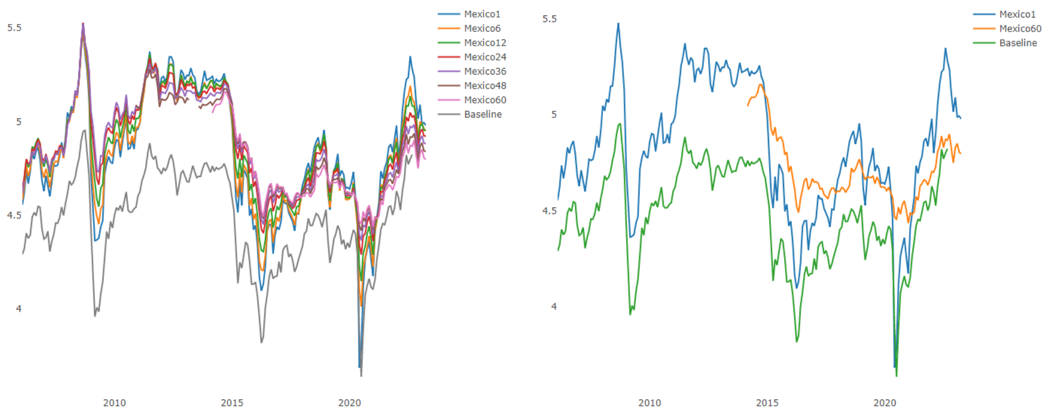


Note: The indices were assembled based on the share of the commodity in the respective country's export basket. The number that comes after the country name indicates the maturity date of the futures contracts for the commodities used in the index.The data is in log.

Figure 5.6: Mexican Commodity Future and Spot Price Index

(5.6(a)) 1, 6, 12, 24, 36, 48 and 60 Month Futures Contract and Baseline Indices

(5.6(b)) 1 and 60 Month Futures Contract and Baseline Indices



Note: The indices were assembled based on the share of the commodity in the respective country's export basket. The number that comes after the country name indicates the maturity date of the futures contract for the commodities used in the index. The data is in log.

It is worth noting that the longer the futures index, the lower its volatility.

This can be attributed to the fact that long-term prices are less susceptible to transitory factors, resulting in a more stable index. During the pandemic years of 2020 and 2021, the growth of the spot index was slightly higher compared to the futures index. However, the two indicators did not show significant deviation, suggesting that market participants regarded the price increase during the pandemic as a permanent movement. In 2022, there was a substantial gap between the two indicators, indicating that market participants viewed the price increase as a transitory phenomenon. It is important to note that a portion of the commodity price increase in 2022 was due to the conflict in Ukraine, especially energy products, which had a ripple effect throughout the production chains of agricultural commodities.

To ensure accurate comparisons and estimations of the model using both present and future indices, it is advisable to adjust the temporal amplitude of the baseline model to match that of the future indices. Otherwise, any differences in the results could be attributed to the discrepancy in the datasets used in the model. To represent the futures index, a maturity of 36 months for the contracts will be selected. This is because the time span of the data exceeds that of a 60-month maturity, and three years is considered sufficient to capture a permanent price change. Comparing the results using the 1-month and 36-month indices also eliminates the possibility of discrepancies in the results that may arise due to the exclusion of certain commodities in the future index that are present in the baseline. Since one month is a relatively short period for price differentiation in relation to the spot, it is reasonable to compare the 1-month index with the 36-month index to assess how the difference in contract maturity affects the exchange rate in response to a positive shock to prices. Additionally, comparing the baseline model to the model using the 1-month prices allows us to determine if the exclusion of certain commodities from the futures index has a significant impact on the results.

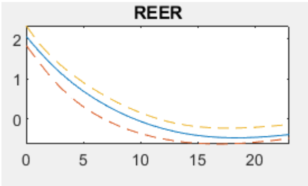
To investigate how the exchange rate responds to shocks in commodity prices with different maturities, will be estimated impulse response functions (IRFs) and REER variance decomposition using the three types of indices. The figure 5.7 and table 5.3 below show the IRFs of a commodity future price shock proportional to the standard deviation of each commodity index [4] and the variance decomposition of the REER for each price index maturity,

[4]Due to the lower variance of the 36-month index futures contract compared to the 1-month index, applying an identical shock of 10% to both indexes would lead to an overestimation of the impact of the 36-month index. To address this issue, the shock applied to each commodity index is proportional to the standard deviation of the cyclical component of the HP-transformed logarithmic series for that index. In order to maintain consistency with the baseline model, the shock in the baseline model was set to 10%. For the 1-month contract, the shocks for Canada, Colombia, and Mexico are 18.33%, 9.16%, and 8.26%,

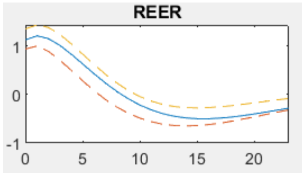
respectively.

Figure 5.7: Impulse Response Functions of Commodity Shock on REER

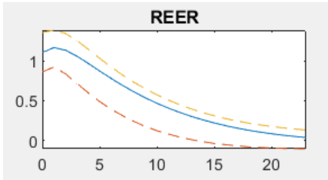
(5.7(a)) Canada Baseline Model



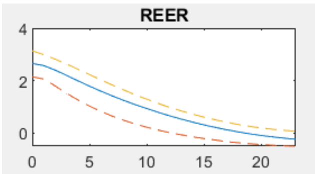
(5.7(b)) Canada Future 1 Month Model



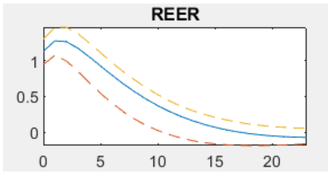
(5.7(c)) Canada Future 36 Months Model



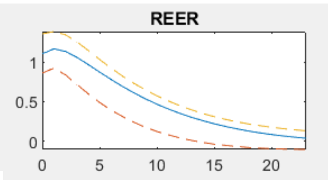
(5.7(d)) Colombia Baseline Model



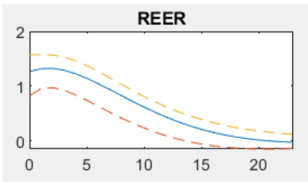
(5.7(e)) Colombia Future 1 Month Model



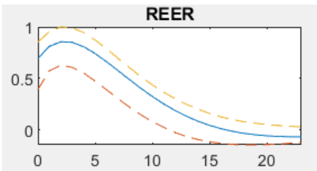
(5.7(f)) Colombia Future 36 Months Model



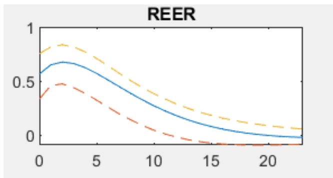
(5.7(g)) Mexico Baseline Model



(5.7(h)) Mexico Future 1 Month Model



(5.7(i)) Mexico Future 36 Months Model



Note: The x axis measures months after the commodity shock. Solid lines are point estimates. Dashed lines mark a 66 percent confidence band estimated using bootstrapping methods. In the baseline model, the commodity price index is based on the spot price of commodities. In the future commodity price model, the commodity index is based on 1 and 36 month commodity contracts. The shocks were given proportionally to the standard deviations of the commodity indices, with the shock in the baseline model normalized to 10 percent.

respectively. For the 36-month contract, the shocks for the same countries are 9.88%, 4.82%, and 4.63%, respectively. It should be noted that the shocks are smaller for indices with lower standard deviations, as previously mentioned.

Table 5.3: Real Effective Exchange Rate Variance Decomposition for Future Commodity Prices Model

	Baseline Model			*Future 1 Month Model*			*Future 36 Month Model*		
	Canada	Colombia	Mexico	Canada	Colombia	Mexico	Canada	Colombia	Mexico
Global EPU	3.99	2.85	18.85	3.25	2.39	16.26	5.67	1.49	25.66
Global Interest Rate	8.2	2.38	3.07	10.37	2.53	3.051	8.02	0.34	1.19
Commodity Price Index	33.02	35.37	30.89	33.01	39.97	33.45	25.61	36.64	19.06
Country Risk	1.44	7.1	18.46	1.2	6.64	19.74	0.91	10.04	27.06
Domestic Interest Rate	5.76	1.19	0.46	4.99	0.47	0.29	6.22	0.48	0.12
REER	47.56	51.09	28.24	47.15	47.97	27.19	53.53	50.97	26.88

Notes: Shares are expressed in percent.In the baseline model, the commodity price index is based on the spot price of commodities. In the future commodity price model, the commodity index is based on 1 and 36-month commodity contracts.

Upon examining the graphs and comparing the model with the 1-month and 36-month commodity index futures, it can be observed that the impulse response functions (IRFs) are practically identical for Canada and Colombia. For Mexico the initial impact is approximately 0.1 % lower for the 36-month futures index shock. Looking at the variance decomposition, the percentage of the REER explained by the 36-month commodity futures price shock is smaller than the 1-month one, reinforcing the evidence that the positive shock at the longest vertex of the commodity futures curve does not appreciates the exchange rate more than a positive shock to the spot price/1 month. However, it is important to clarify that this does not imply that permanent shocks do not have a more significant impact on the exchange rate than transitory shocks. The shock to the index made with 36-month future contracts does not account for short-term movements that also affect the exchange rate. To ascertain whether a permanent shock has a greater impact than a transitory shock, a nonlinear structure on the spot price in the model conditional on the future price must be imposed. However, this goes beyond the scope of the reference model of the dissertation.

Furthermore, upon comparing the baseline model with the 1-month futures model, it can be observed that the IRFs show a greater appreciation of the exchange rate in the baseline model, which could indicate an incompleteness of the 36-month futures index in relation to the 48 commodities included in the baseline index. However, when examining the variance decomposition, similar percentages are found in both models. The share of REER explained by commodity shocks in the baseline has increased compared to the results obtained in section 3.3 when using the entire sample. This finding suggests that commodity prices have played a more significant role in the more recent period, highlighting the importance of using the same dataset for comparing models that incorporate the futures price of commodities.

The results presented above are robust when using a value of $\lambda = 500000$. Historical decompositions will not be discussed in this section, as they are very similar for the different types of index [5]. Moreover, as observed in the chart above, there is no evidence of a detachment between these two indicators at the time of the pandemic. It is important to note that the sample of countries and the temporal window were reduced, the futures price data are limited, and the model used is linear. Therefore, this section aims to assess the impact of commodity futures prices on the exchange rate, rather than to conclude that permanent shocks to commodity prices do not have a more significant impact on the exchange rate than transitory shocks.

[5]These results are available upon request.

6
Conclusion

The break in the correlation between commodity prices and the exchange rate that occurred during the pandemic does not seem to have been an interruption of the causal relationship between these two variables, but rather a result of a set of other macroeconomic shocks that affected the exchange rate in the same period. Using exchange rate historical decomposition, this study manages to point out what were the main factors for a panel of 7 countries in this regard. Global risk was the primary factor behind the non-appreciation of the exchange rate in 2020, while country risk was dominant in 2021, particularly for emerging countries. In addition, for countries like Australia, Brazil, and Chile, the low domestic interest rates also contributed to the depreciation of their exchange rates.

Although the original focus of the dissertation was to investigate the break in the correlation between commodity prices and exchange rates during the pandemic, it ultimately proposed an empirical model for determining exchange rates and filled a gap in the literature. The study also examined the heterogeneity between countries by identifying the variables that most strongly influence exchange rates on an individual country basis and determining their importance shares through variance decomposition. The results revealed that commodity prices are the primary determinant of exchange rates in commodity exporting countries, while country risk assumes an equally important role in emerging countries. For developed countries, global risk is a significant driver of exchange rates, and domestic interest rates are also a crucial factor in Brazil and Australia. These findings have significant implications for exchange rate policy and market forecasting.

The dissertation also investigated other factors that influence exchange rates, including the impact of COVID-19 and the relationship between commodity futures prices and exchange rates. The study conducted various robustness tests to ensure that the results are reliable for a range of issues not previously addressed in empirical papers that measure the impact of commodity shocks on the business cycle. As a result, the research provides contribution to the understanding of the determinants of exchange rates and the impact of various shocks on exchange rate fluctuations.

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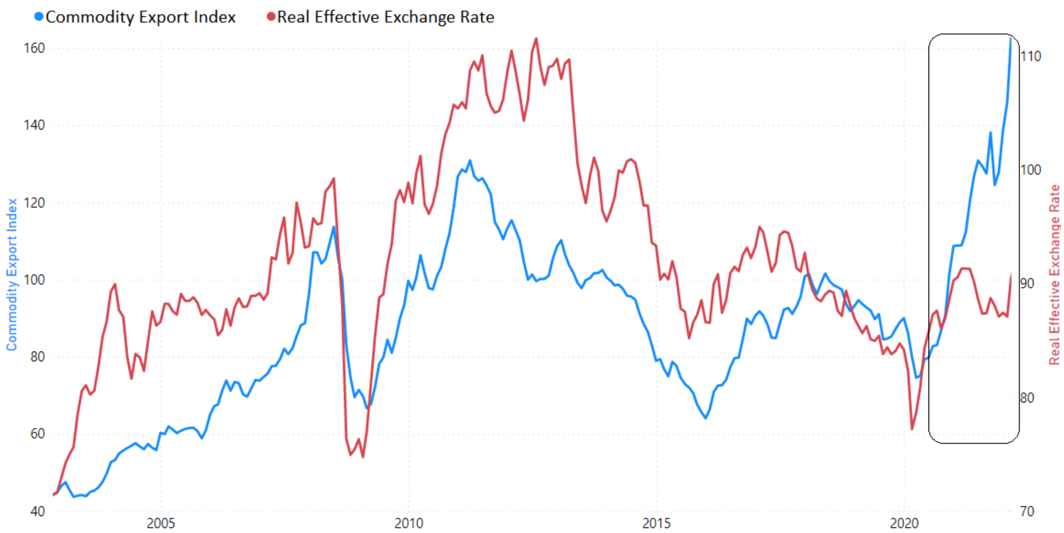
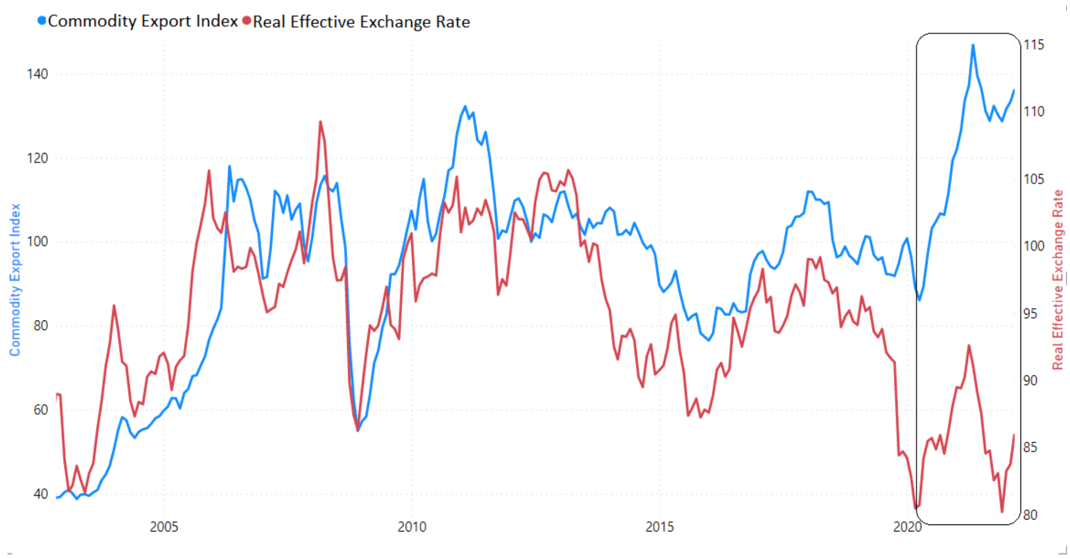
A
Commodity Export Index and Real Effective Exchange Rate

Figure A.1: Australian Commodity Export Index and Real Effective Exchange Rate



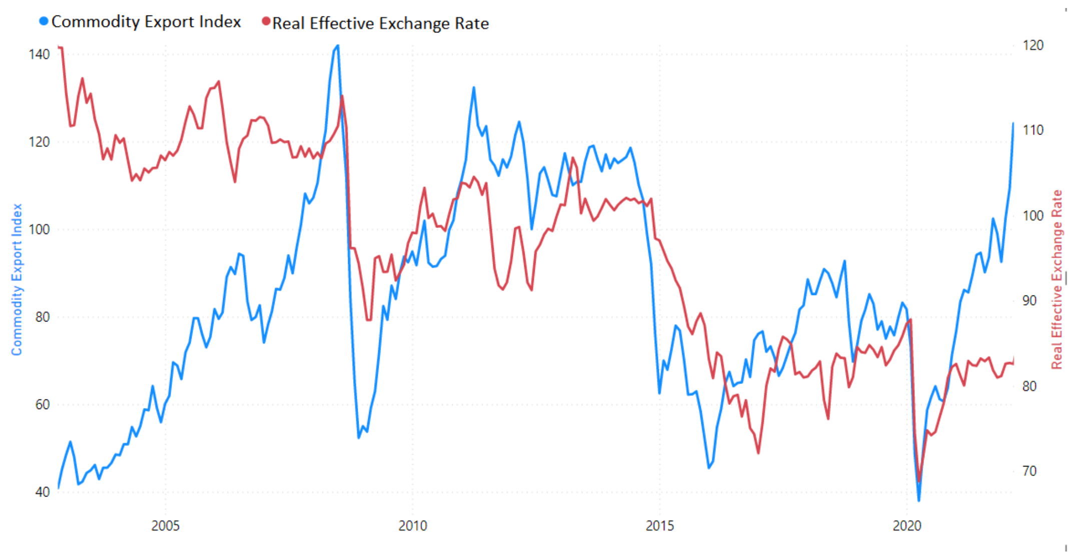
Note: The commodity price index is weighted by the country's exports, and has June 2012 as the reference period. The real effective exchange rate (REER) is an index that has January 2010 as unit base. The more depreciated the exchange rate, higher de REER index.

Figure A.2: Chilean Commodity Export Index and Real Effective Exchange Rate



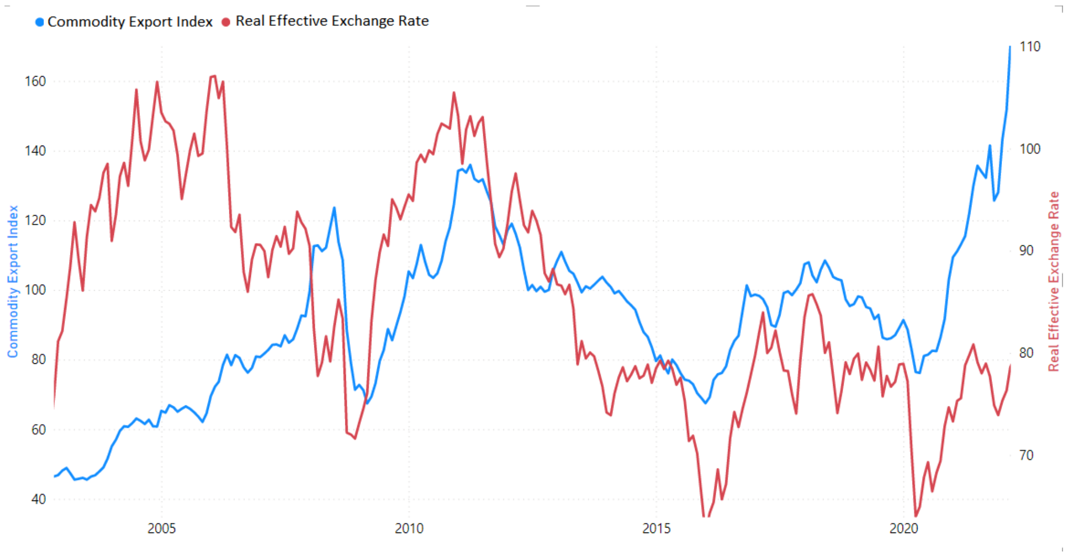
Note: The commodity price index is weighted by the country's exports, and has June 2012 as the reference period. The real effective exchange rate (REER) is an index that has January 2010 as unit base. The more depreciated the exchange rate, higher de REER index.

Figure A.3: Mexican Commodity Export Index and Real Effective Exchange Rate



Note: The commodity price index is weighted by the country's exports, and has June 2012 as the reference period. The real effective exchange rate (REER) is an index that has January 2010 as unit base. The more depreciated the exchange rate, higher de REER index.

Figure A.4: South African Commodity Export Index and Real Effective Exchange Rate



Note: The commodity price index is weighted by the country's exports, and has June 2012 as the reference period. The real effective exchange rate (REER) is an index that has January 2010 as unit base. The more depreciated the exchange rate, higher de REER index.

B
Commodity Weights for Determining the Countries Commodity Export Price Index

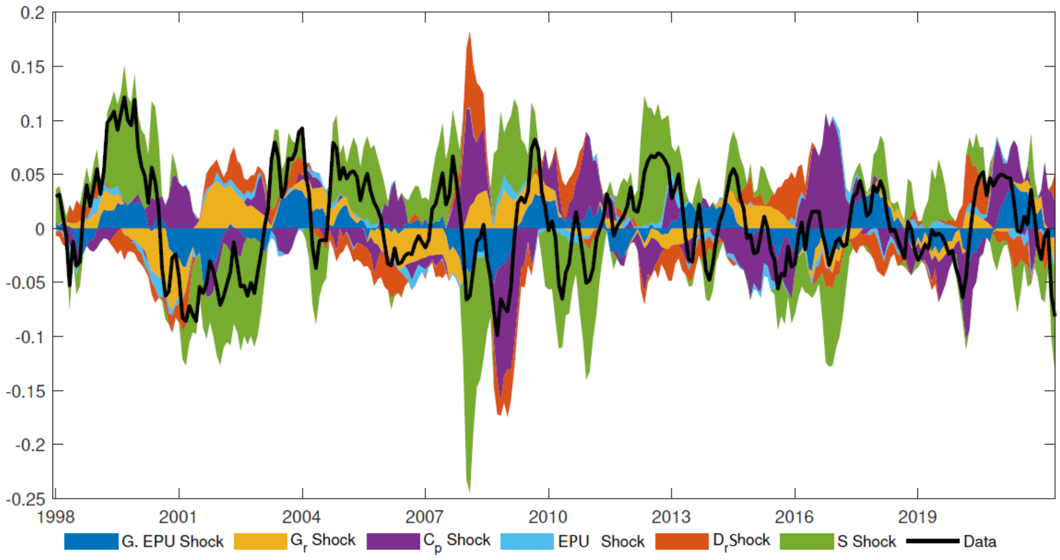
Table B.1: Commodities Weights in Each Country's Export Index

	Commodity	Australia	Brazil	Canada	Chile	Colombia	Mexico	S. Africa
1	Iron Ore	0.3232	0.2061	0.0283	0.023	8e-04	0.0074	0.186
2	Coal, Australia	0.2016	0	0.0226	0.001	0.1617	0	0.1805
3	Natural gas, EU	0.0901	4e-04	0.0684	5e-04	0.0069	2e-04	1e-04
4	Gold	0.0728	0.0206	0.0799	0.0215	0.0431	0.091	0.1846
5	Beef	0.0466	0.0488	0.0163	0.0013	0.0054	0.0323	0
6	Copper	0.0471	0.0238	0.0341	0.7354	0.008	0.0616	0.0351
7	Wheat	0.0311	0.0023	0.0366	0	1e-04	0.0073	0.0014
8	Aluminum	0.0264	0.0109	0.042	0.0017	0.003	0.0098	0.0565
9	Lamb	0.0146	0	0	6e-04	0	0	0
10	Wool	0.0139	3e-04	0	7e-04	0	0	0.0302
11	Zinc	0.0143	7e-04	0.0069	0.001	0	0.0171	0
12	Cotton	0.0097	0.0107	0	0	1e-04	0.0014	6e-04
13	Lead	0.0103	1e-04	0.0033	6e-04	3e-04	0.0288	0.0022
14	Barley	0.0088	0	0.0023	0	0	0	1e-04
15	Nickel	0.0076	0.0036	0.0245	0	0	4e-04	0.0375
16	Hides	0.0065	0.0215	0.0057	0.001	0.0052	0.0076	0.0115
17	Shrimp	0.0047	6e-04	0.0145	0.0048	6e-04	0.0103	0.0107
18	Soft Logs	0.0026	0.0456	0.0394	0.0556	1e-04	0.0012	0.0483
19	Fish Meal	0.0014	5e-04	2e-04	0.0081	0	0.0019	0
20	Rice	0.002	0.0032	0	1e-04	0	0	0
21	Orange	0.0012	8e-04	0	0.0043	3e-04	0.0066	0.0604
22	Tin	8e-04	0.0015	2e-04	0	0	4e-04	1e-04
23	Rapeseed Oil	9e-04	0	0.0128	2e-04	0	1e-04	0.0025
24	Hard Logs	2e-04	2e-04	6e-04	3e-04	5e-04	3e-04	2e-04
25	Corn	2e-04	0.0431	0.0022	0.0046	9e-04	0.0056	0.055
26	Sugar,No. 11	4e-04	0.08	1e-04	0	0.01	0.018	0.0023
27	Soybeans	0	0.1881	0.0102	2e-04	0	0	1e-04
28	Uranium	0	0	0	0	0	0	1e-04
29	Poultry	0	0	0.0014	0	0	0	0
30	Bananas	0	3e-04	0	0	0.0227	0.0033	0
31	Groundnuts	0	9e-04	0	0	0	1e-04	0
32	Soybeans Oil	0	0.0102	6e-04	0	1e-04	1e-04	0
33	Sunflower Oil	0	0	0	0	0	9e-04	0
34	Rubber	1e-04	0.0019	0.0022	0	1e-04	0.0053	0.0064
35	Olive Oil	1e-04	0	0	0.001	0	0	0
36	Palm Oil	0	7e-04	0	0	0.0085	1e-04	0
37	Tea, Kenyan	0	9e-04	2e-04	1e-04	0	0	0
38	Cocoa	0	0.002	3e-04	0	0.0016	6e-04	0
39	Hard Sawnwood	1e-04	0.0038	0.0017	1e-04	2e-04	3e-04	4e-04
40	Soybean Meal	1e-04	0.0548	0.0068	0	0	2e-04	0.0011
41	Soft Sawnwood	4e-04	0.0039	0.0408	0.0232	1e-04	0.002	0
42	Swine	5e-04	0.0108	0.0162	0.0084	0	0.0078	1e-04
43	Coffee index	3e-04	0.0512	0.0027	5e-04	0.0742	0.0117	0
44	Fish	0.0016	0.0012	0.01	0.0898	0.0047	0.0077	0
45	Crude OIL	0.0575	0.144	0.4663	0.0103	0.6408	0.6507	0.0859

Notes: Shares are expressed in decimal values and add up to 1 for each country.

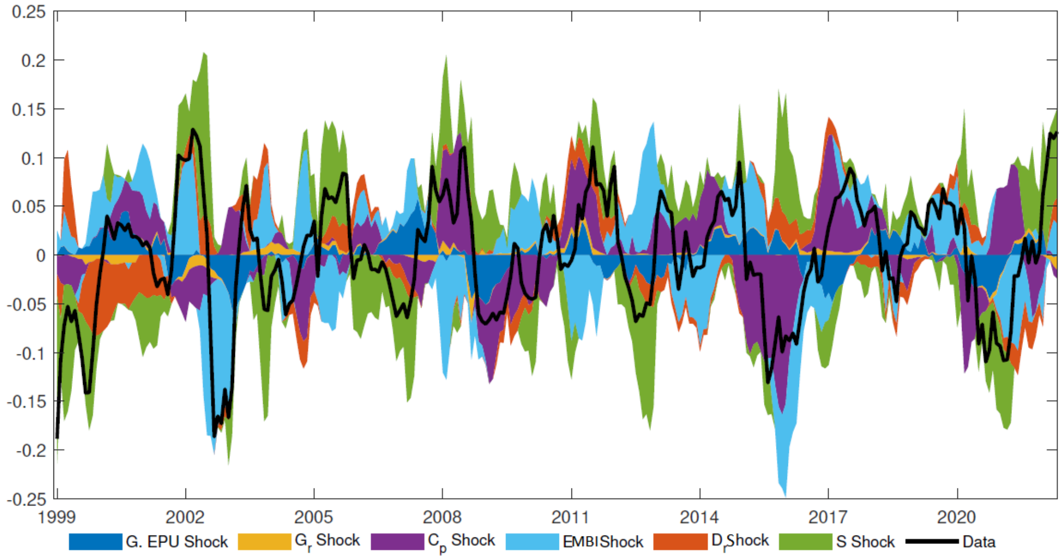
C
Historic Decomposition of Bilateral Nominal National Currency to US Dollar Exchange Rate

Figure C.1: Australian Nominal Exchange Historic Decomposition



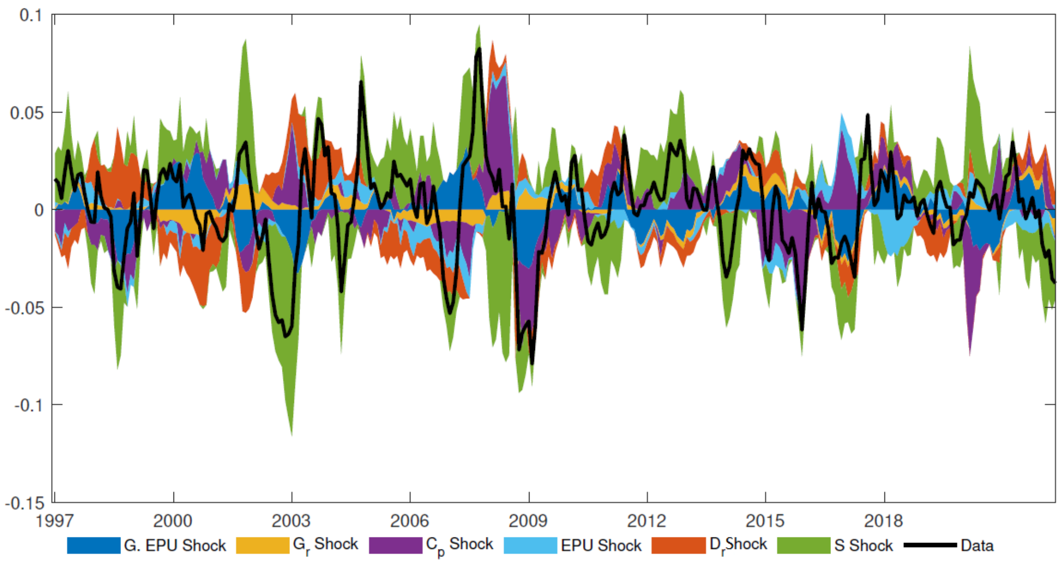
Note: The solid line is the HP14400 cyclic component of the nominal exchange rate that is represented as "S". The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure C.2: Brazilian Nominal Exchange Historic Decomposition



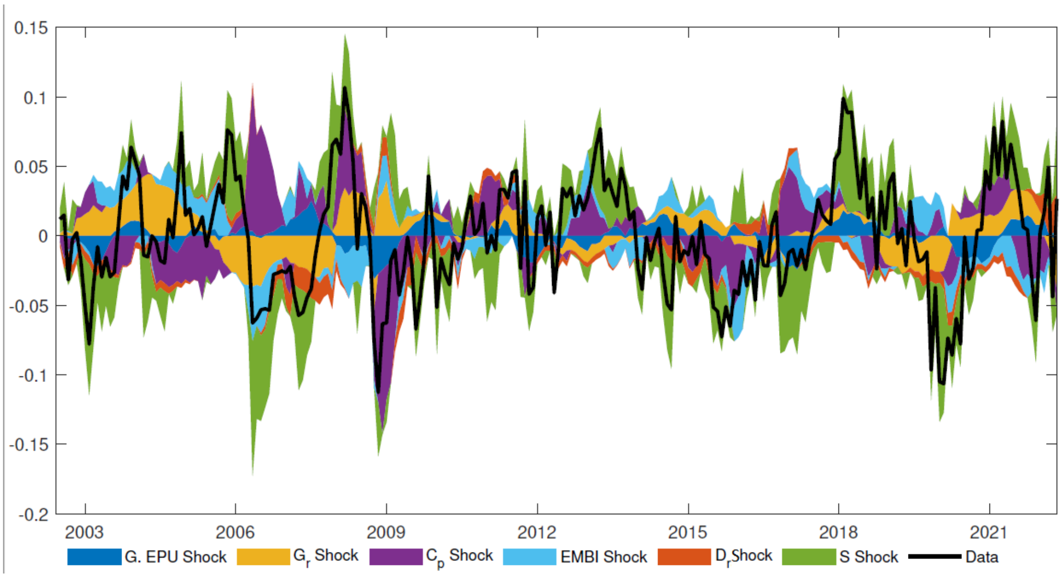
Note: The solid line is the HP14400 cyclic component of the nominal exchange rate that is represented as "S". The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure C.3: Canadian Nominal Exchange Historic Decomposition



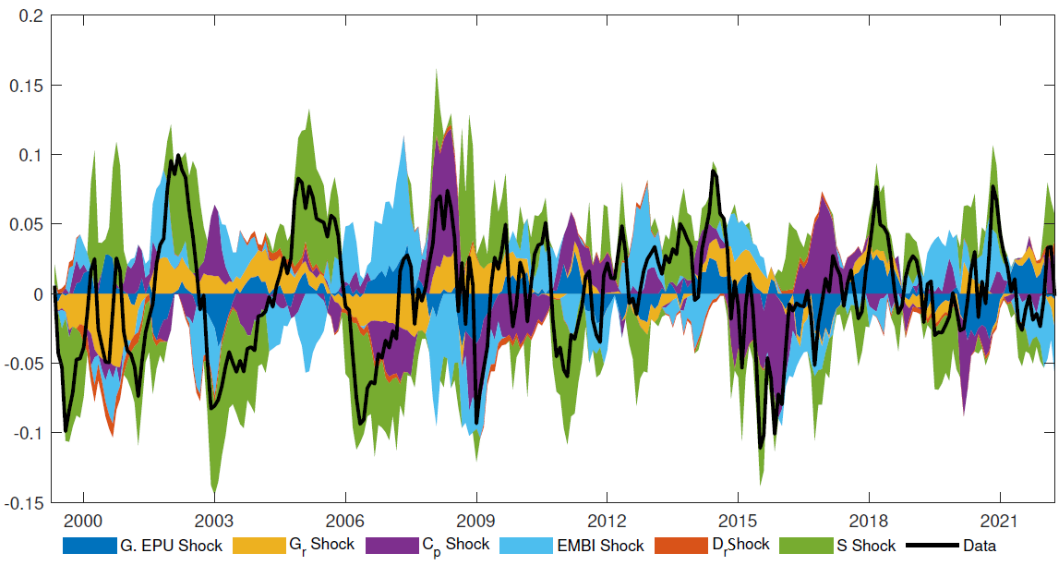
Note: The solid line is the HP14400 cyclic component of the nominal exchange rate that is represented as "S". The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure C.4: Chilean Nominal Exchange Historic Decomposition



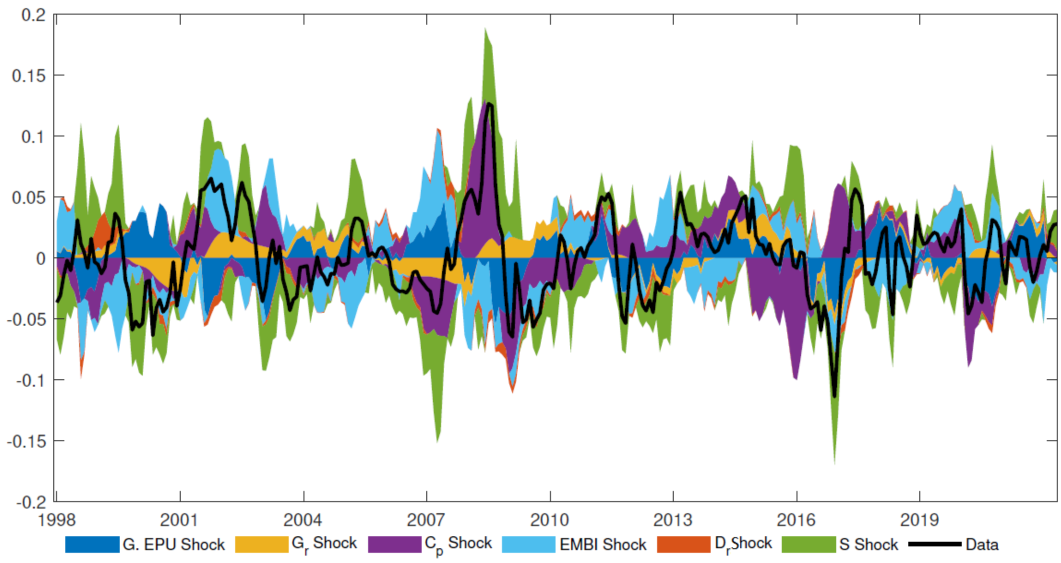
Note: The solid line is the HP14400 cyclic component of the nominal exchange rate that is represented as "S". The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure C.5: Colombian Nominal Exchange Historic Decomposition



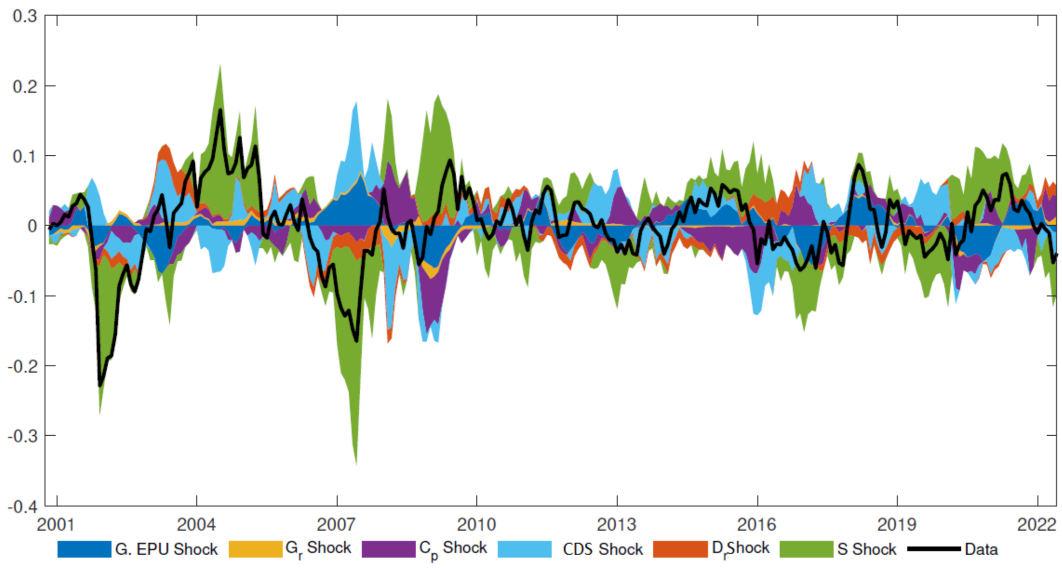
Note: The solid line is the HP14400 cyclic component of the nominal exchange rate that is represented as "S". The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure C.6: Mexican Nominal Exchange Historic Decomposition



Note: The solid line is the HP14400 cyclic component of the nominal exchange rate that is represented as "S". The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure C.7: South African Nominal Exchange Historic Decomposition



Note: The solid line is the HP14400 cyclic component of the nominal exchange rate that is represented as "S". The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

D
Alternative Models Average Variance Decomposition

Table D.1: Average Exchange Rate Variance Decomposition for Alternative Models

	Baseline	HP500000	Quadratic D.	EPU	ToT	Nominal E.R.
Global EPU	7.96	12.66	14.61	9.33	7.27	10.91
Global I. R.	2.31	1.78	3.12	2.24	2.47	4.81
Commodity P.I.	17.89	24.99	34.89	17.59	10.53	22.3
Country Risk	13.66	10.01	7.15	6.5	19.42	15.88
Domestic I.R.	5.47	4.83	6.27	5.16	5.47	3.59
Exchange Rate	52.69	45.7	33.94	59.15	54.81	42

Notes: Shares are expressed in percent. Quadratic D. is the estimation with quadratic detrended data. EPU is the estimation with country EPU instead of EMBI for Brazil, Chile, Colombia and Mexico. Nominal E.R is the estimation with Nominal Exchnage Rates instead of REER.

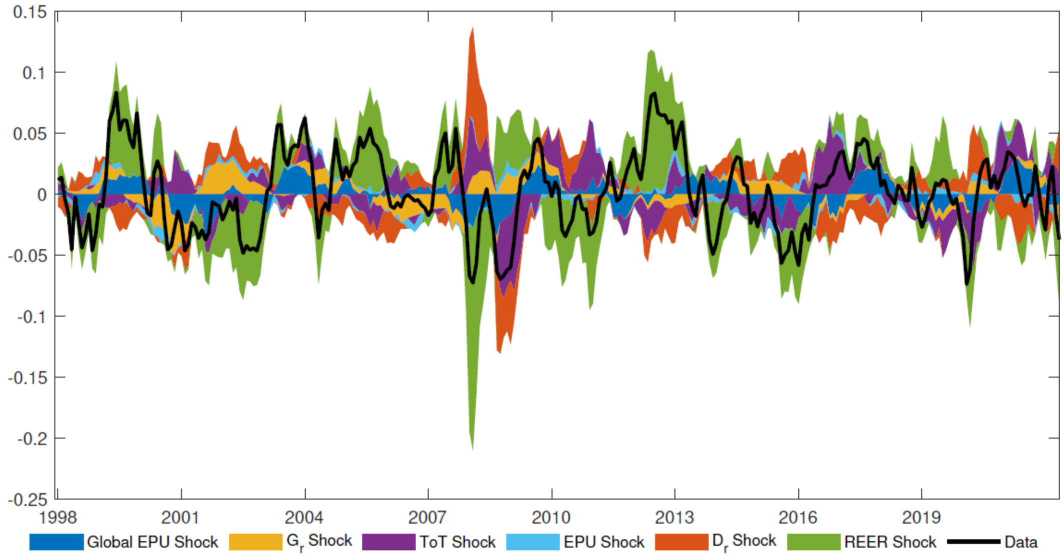
Table D.2: Average Exchange Rate Variance Decomposition for Different Ordering of Global Interest Rate

	Baseline	G_r -> G_{EPU} -> C_p	G_{EPU} -> C_p -> G_r
Global EPU	7.96	7.94	7.96
Global I. R.	2.31	2.33	2.52
Commodity P.I.	17.89	17.89	17.68
Country Risk	13.66	13.66	13.66
Domestic I.R.	5.47	5.47	5.47
Exchange Rate	52.69	52.69	52.69

Notes: Shares are expressed in percent." G_r -> G_{EPU} -> C_p " is the ordering in the international block with Global Interest Rate first and "G_{EPU} -> C_p -> G_r" is the ordering in the international block with Global Interest Rate last.

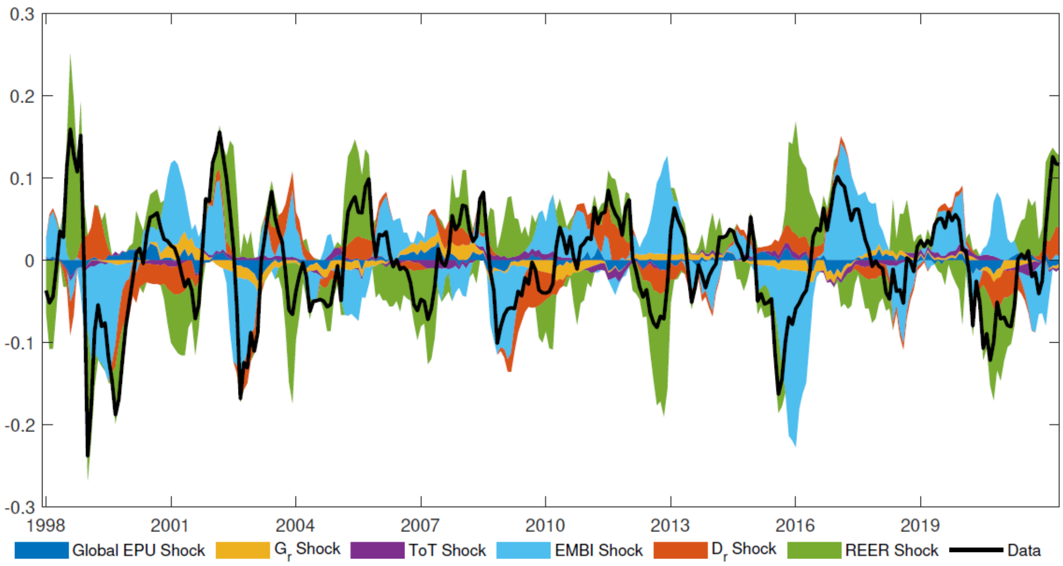
E
Historics Decompositions with Commodity Price Shock as a Term of Trade (ToT) shock

Figure E.1: Australia REER Historic Decomposition with ToT Shock



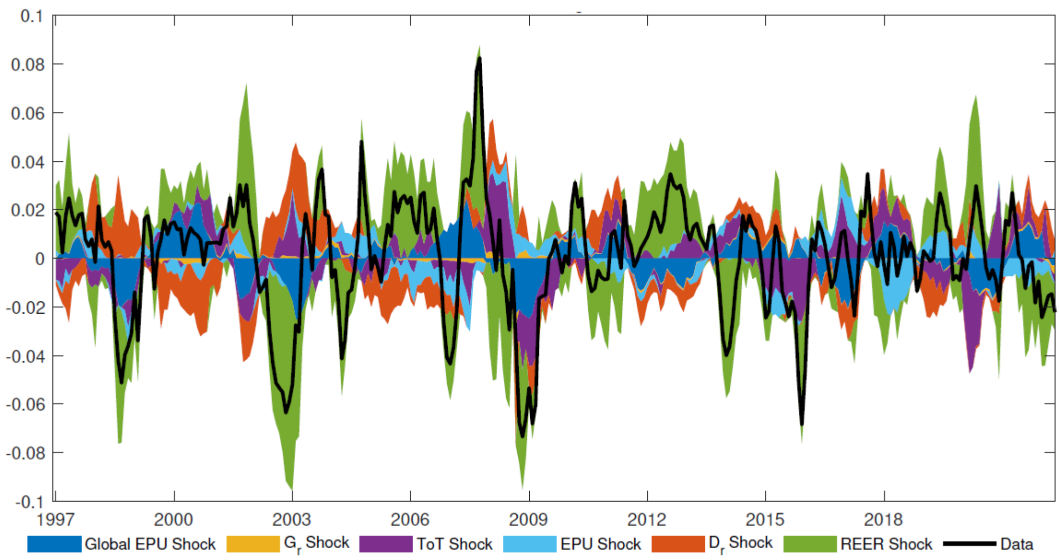
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. ToT shock is the Term of Trade shock.

Figure E.2: Brazilian REER Historic Decomposition with ToT Shock



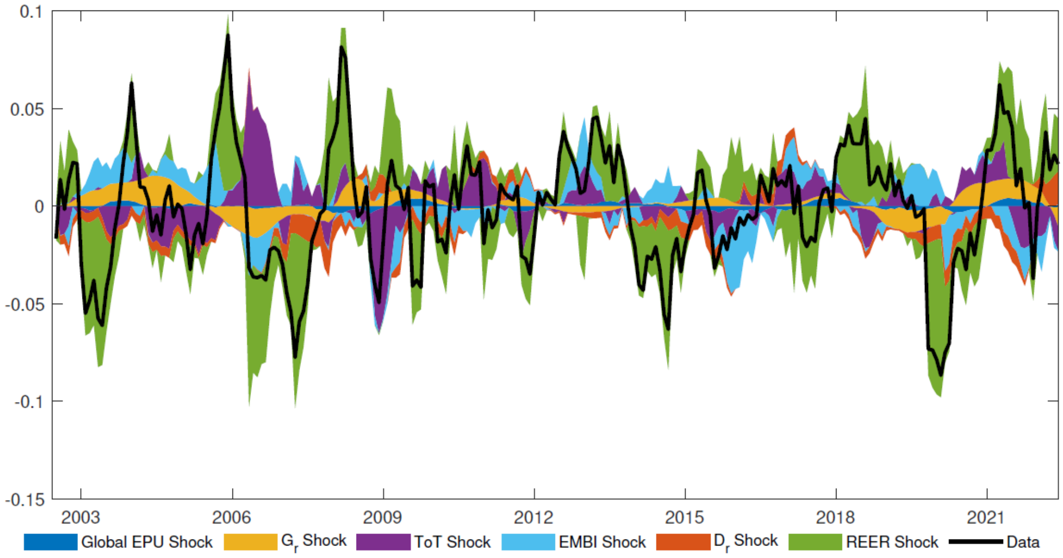
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. ToT shock is the Term of Trade shock.

Figure E.3: Canadian REER Historic Decomposition with ToT Shock



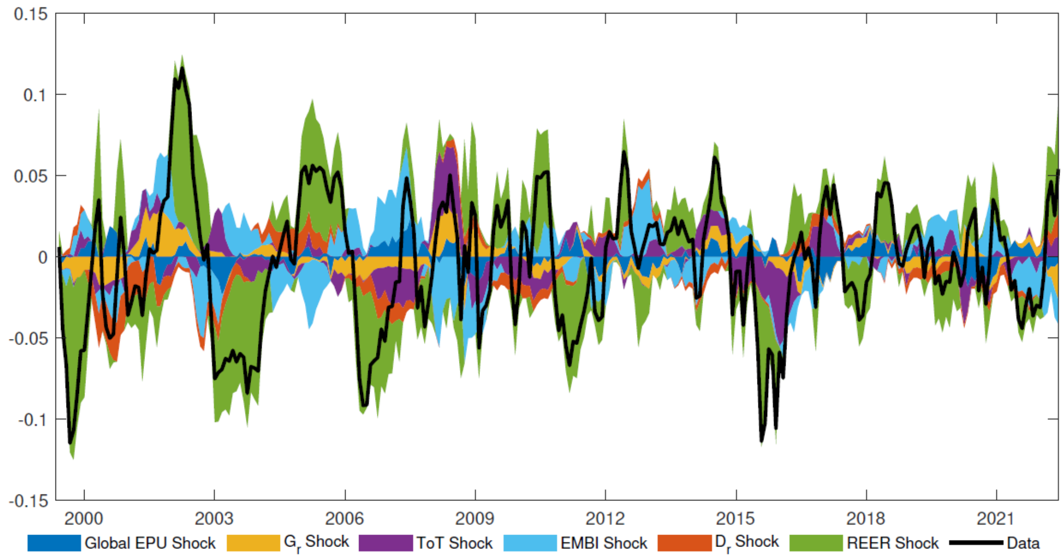
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. ToT shock is the Term of Trade shock.

Figure E.4: Chilean REER Historic Decomposition with ToT Shock



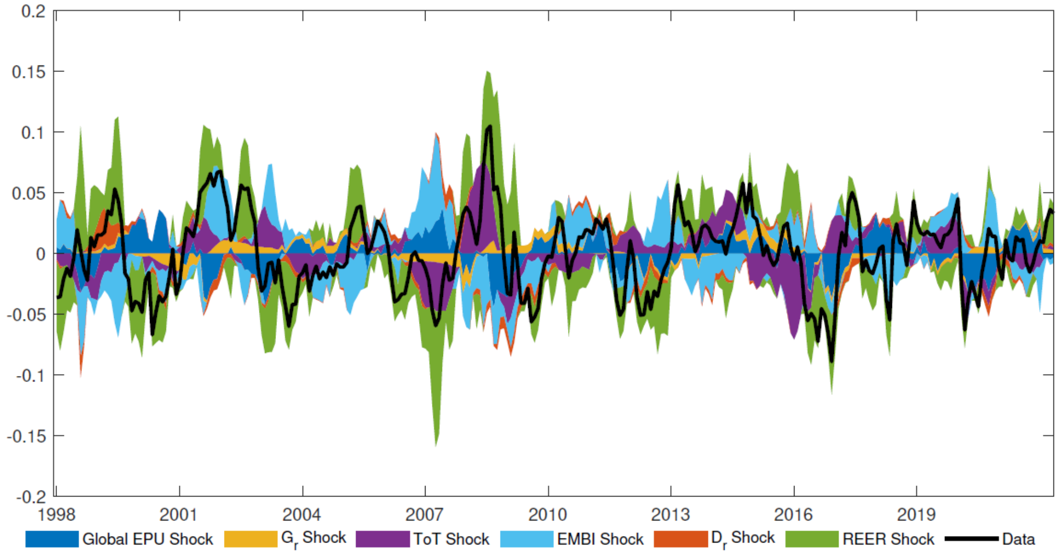
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. ToT shock is the Term of Trade shock.

Figure E.5: Colombian REER Historic Decomposition with ToT Shock



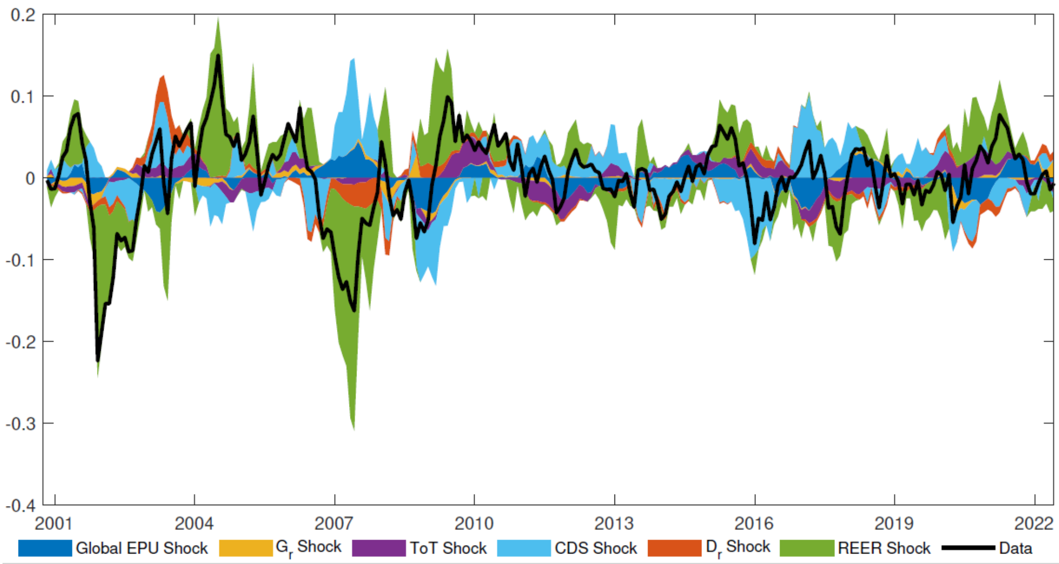
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. ToT shock is the Term of Trade shock.

Figure E.6: Mexican REER Historic Decomposition with ToT Shock



Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. ToT shock is the Term of Trade shock.

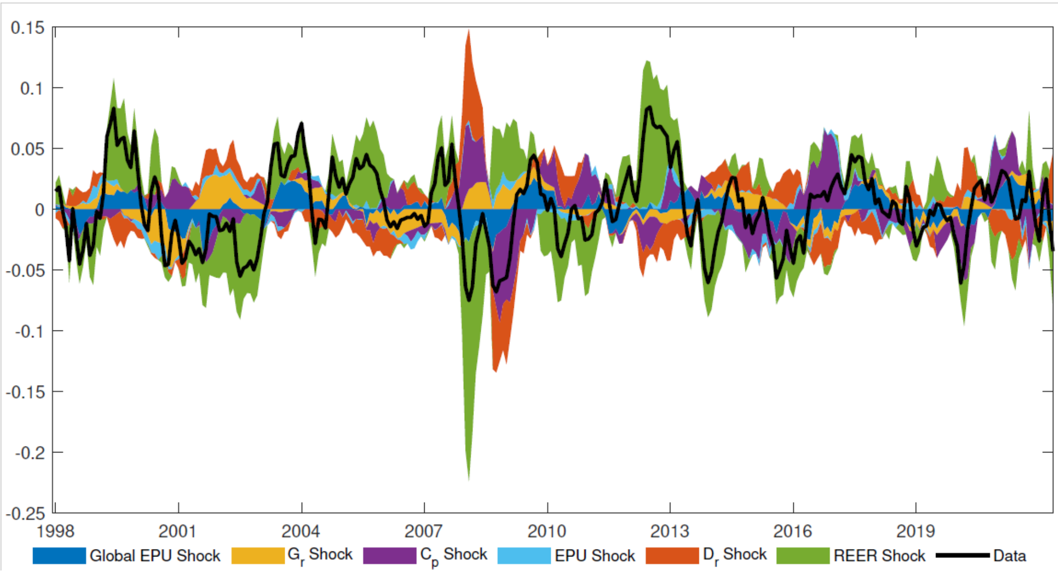
Figure E.7: South African REER Historic Decomposition with ToT Shock



Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. ToT shock is the Term of Trade shock.

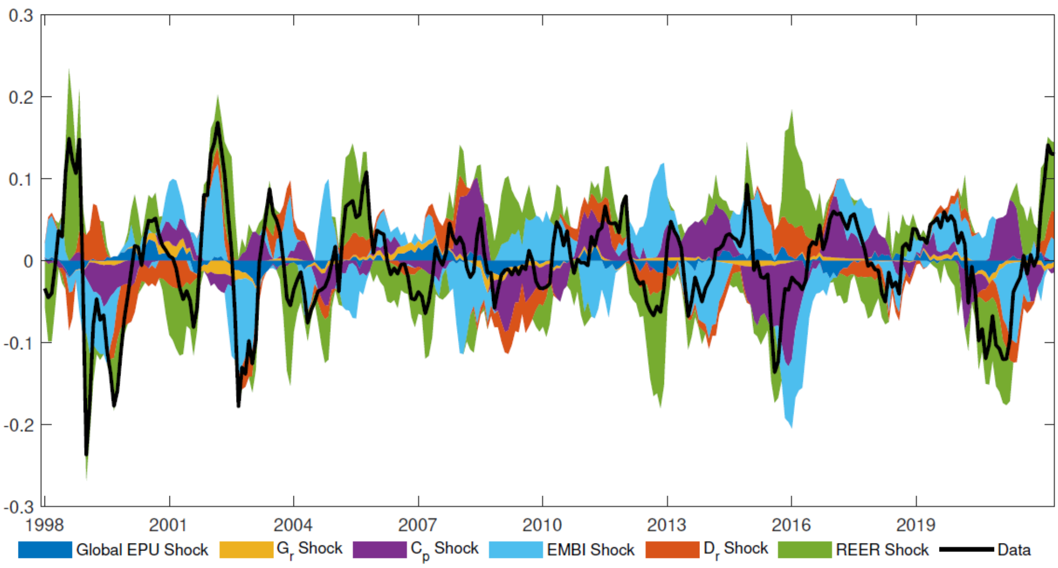
F
Historic Decomposition with Rolling Weights Commodity Price Index

Figure F.1: Australian REER Historic Decomposition with Rolling Weights Commodity Price Index



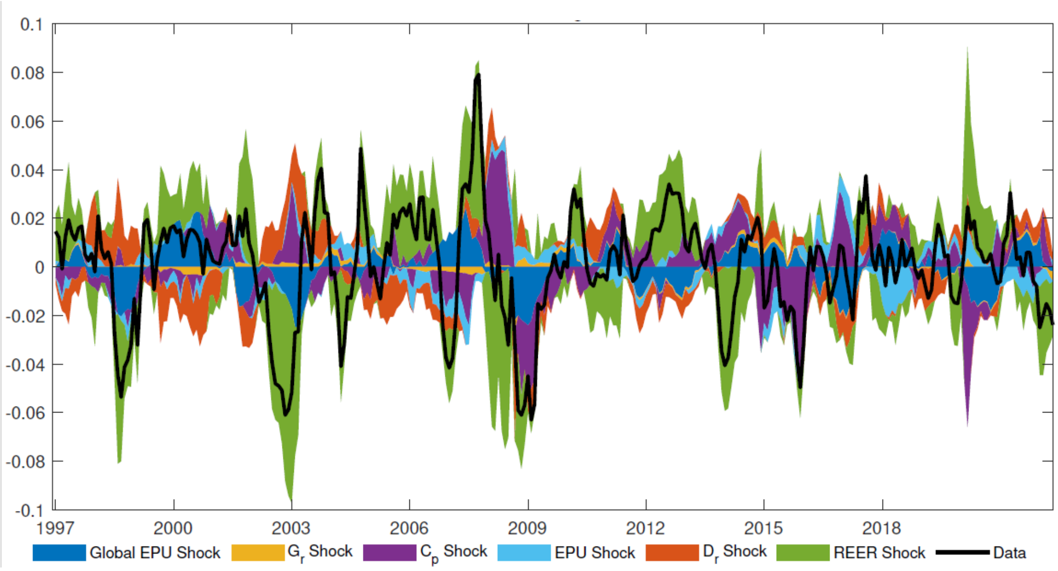
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. C_p shock is the rooling weights commodity price index shock.

Figure F.2: Brazilian REER Historic Decomposition with Rolling Weights Commodity Price Index



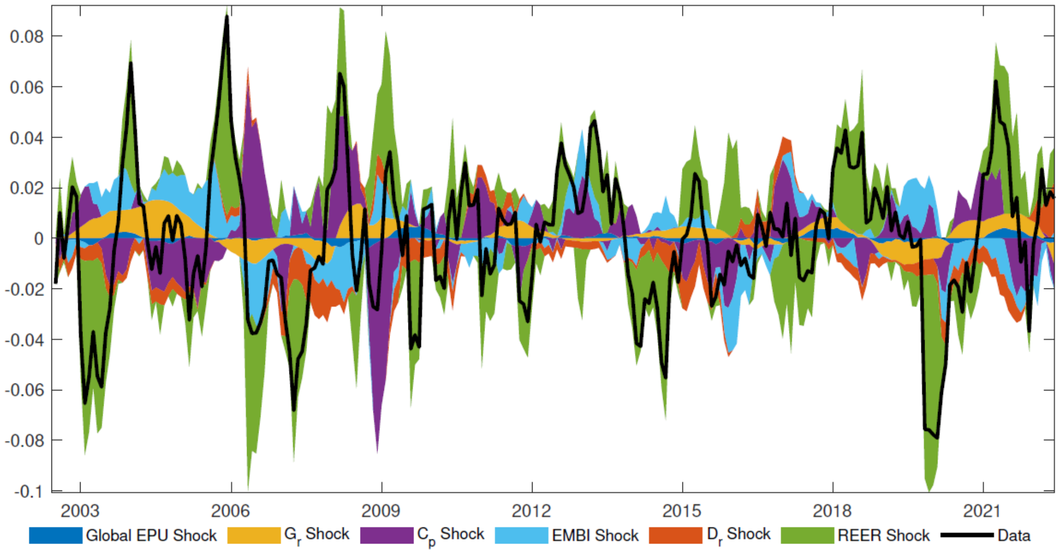
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. C_p shock is the rooling weights commodity price index shock.

Figure F.3: Canadian REER Historic Decomposition with Rolling Weights Commodity Price Index



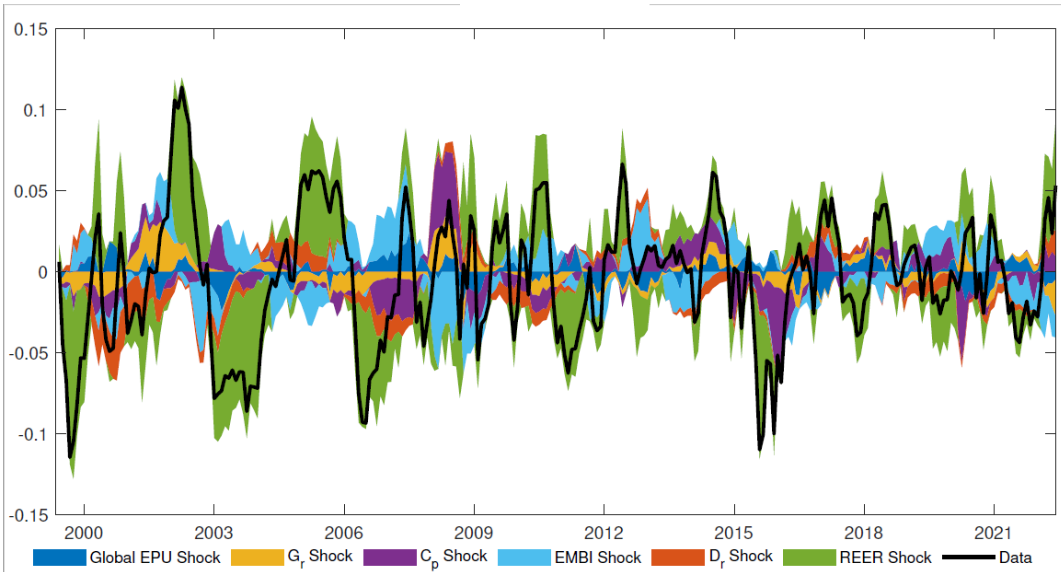
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. C_p shock is the rooling weights commodity price index shock.

Figure F.4: Chilean REER Historic Decomposition with Rolling Weights Commodity Price Index



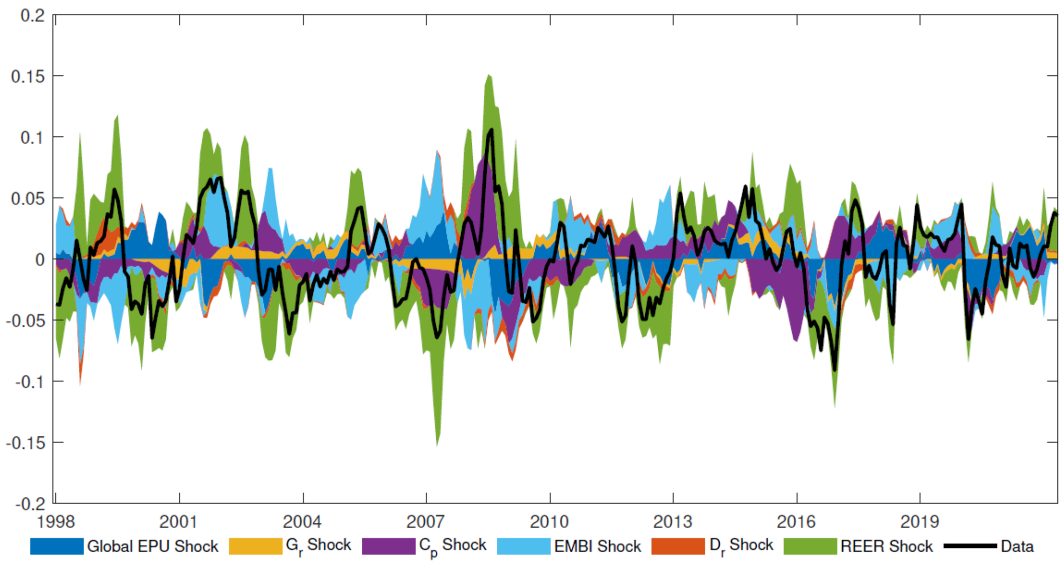
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. C_p shock is the rooling weights commodity price index shock.

Figure F.5: Colombian REER Historic Decomposition with Rolling Weights Commodity Price Index



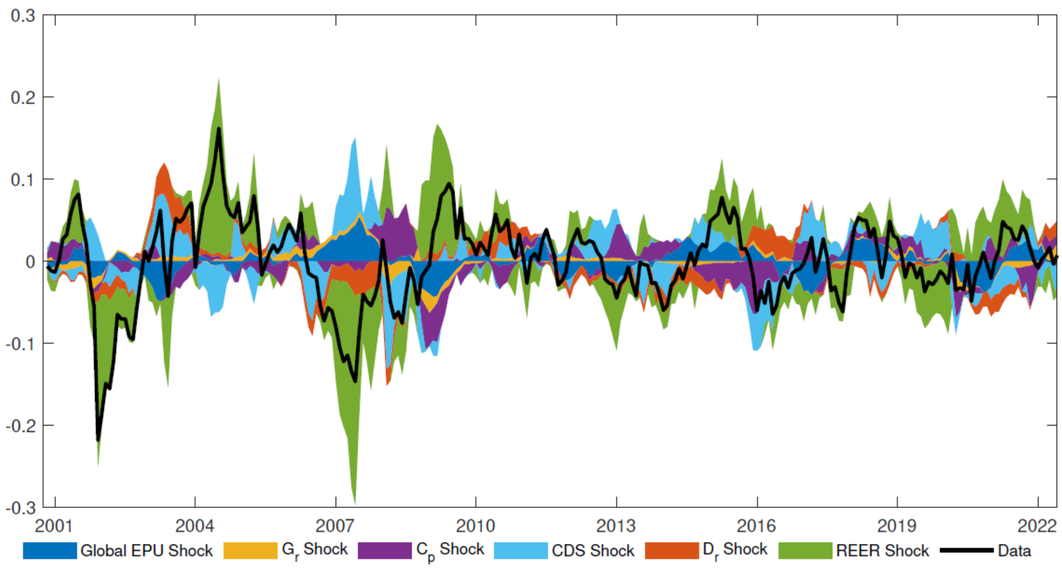
Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. C_p shock is the rooling weights commodity price index shock.

Figure F.6: Mexican REER Historic Decomposition with Rolling Weights Commodity Price Index



Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. C_p shock is the rooling weights commodity price index shock.

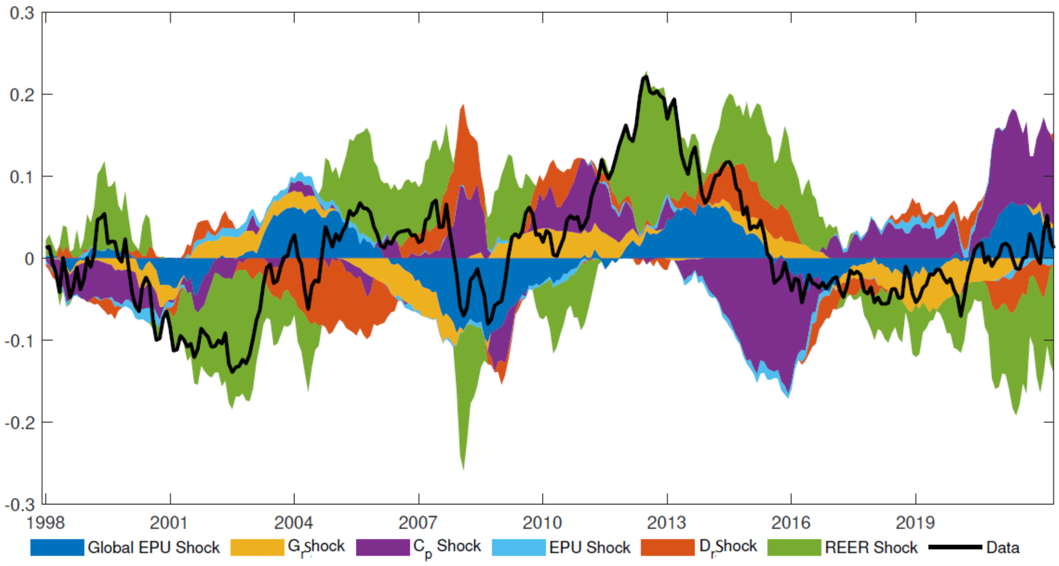
Figure F.7: South African REER Historic Decomposition with Rolling Weights Commodity Price Index



Note: The solid line is the HP14400 cyclic component of the REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. C_p shock is the rooling weights commodity price index shock.

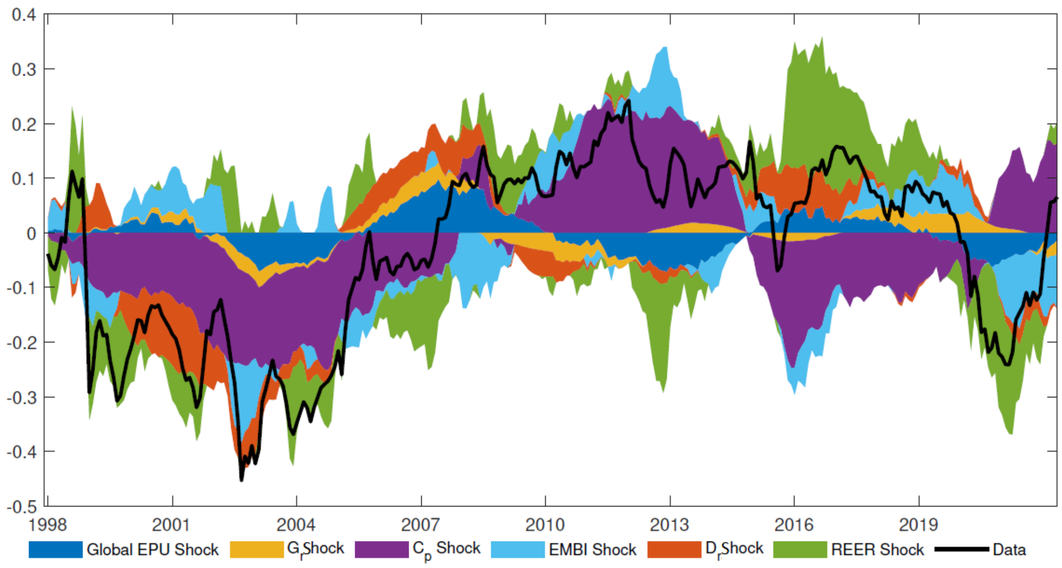
G
Historic Decompositions with Quadratic Detrended Data

Figure G.1: Australian REER Quadratic Detrended Data Historic Decomposition



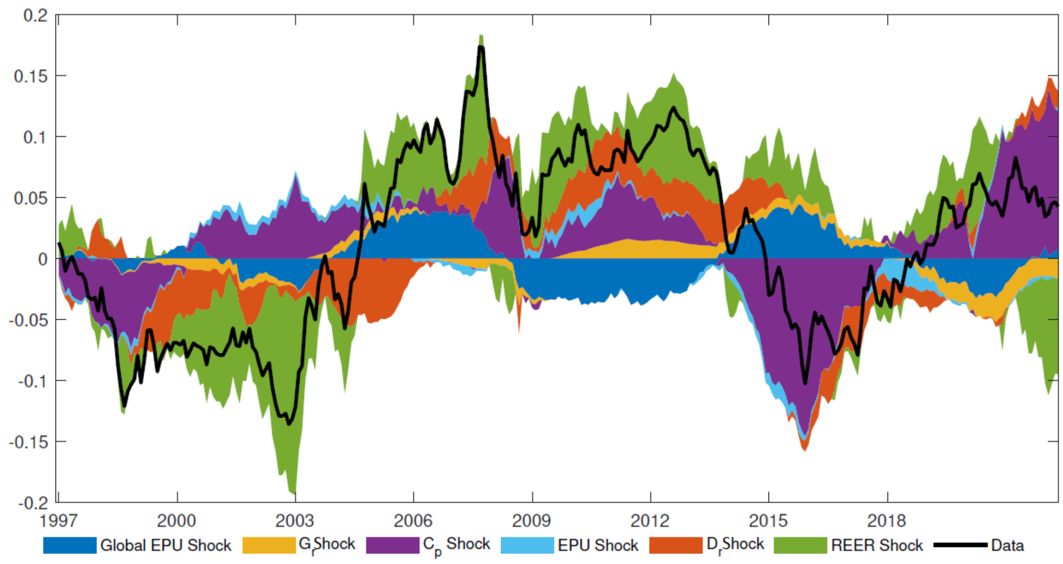
Note: The solid line is the quadratic detrended REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure G.2: Brazilian REER Quadratic Detrended Data Historic Decomposition



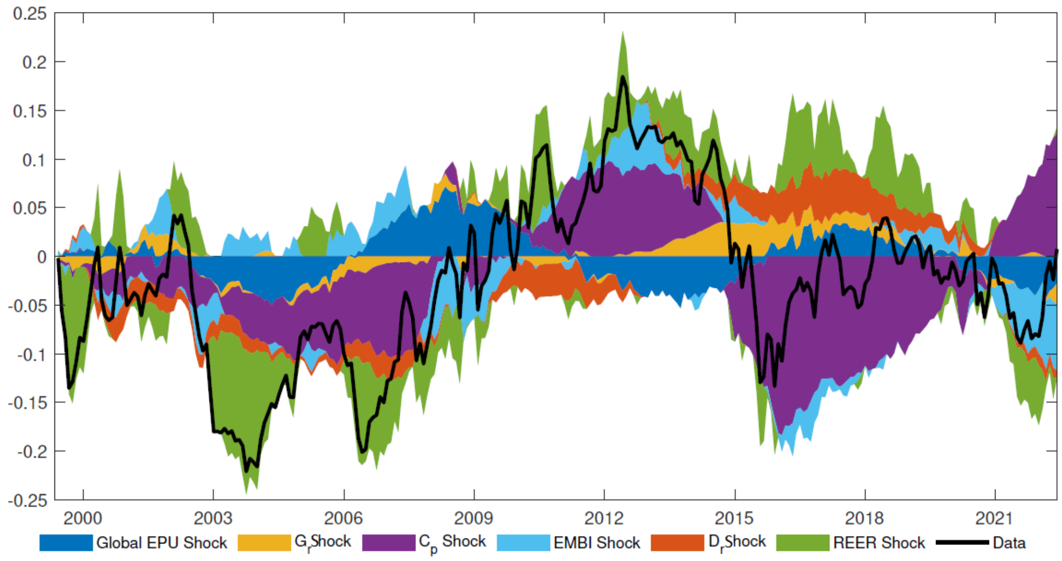
Note: The solid line is the quadratic detrended REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure G.3: Canadian REER Quadratic Detrended Data Historic Decomposition



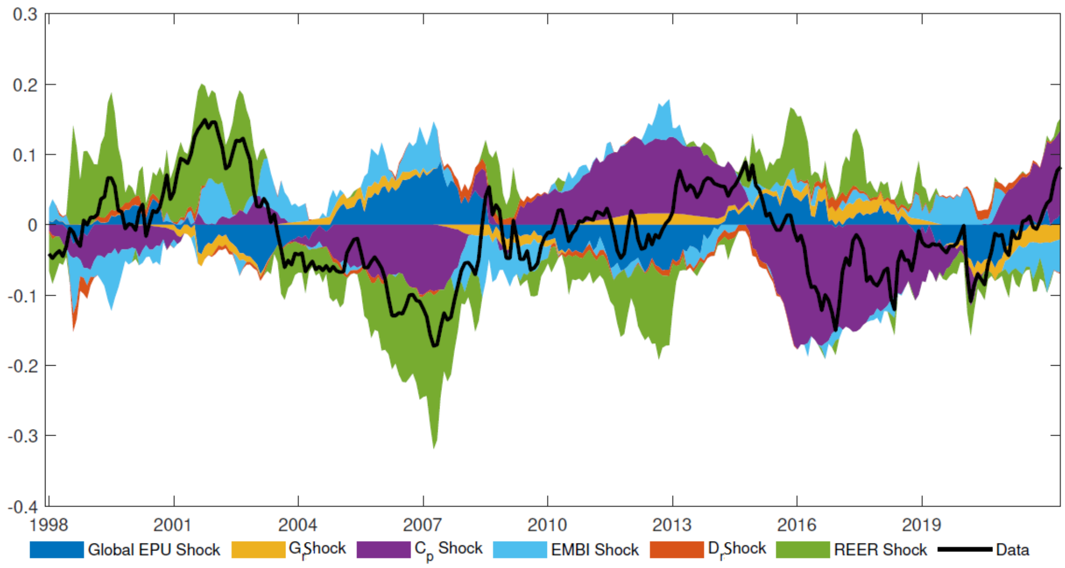
Note: The solid line is the quadratic detrended REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure G.4: Colombian REER Quadratic Detrended Data Historic Decomposition



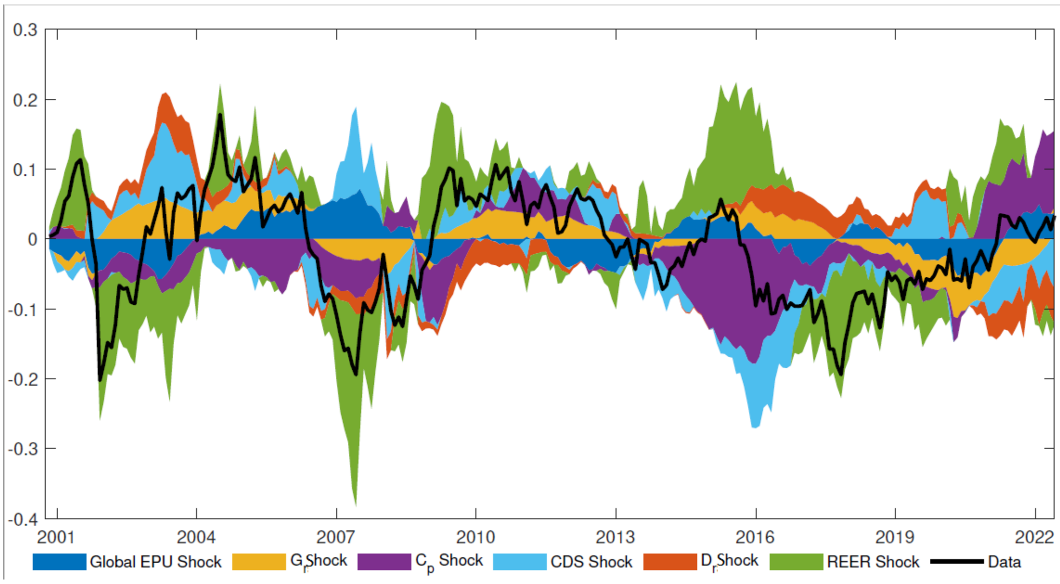
Note: The solid line is the quadratic detrended REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

Figure G.5: Mexican REER Quadratic Detrended Data Historic Decomposition



Note: The solid line is the quadratic detrended REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

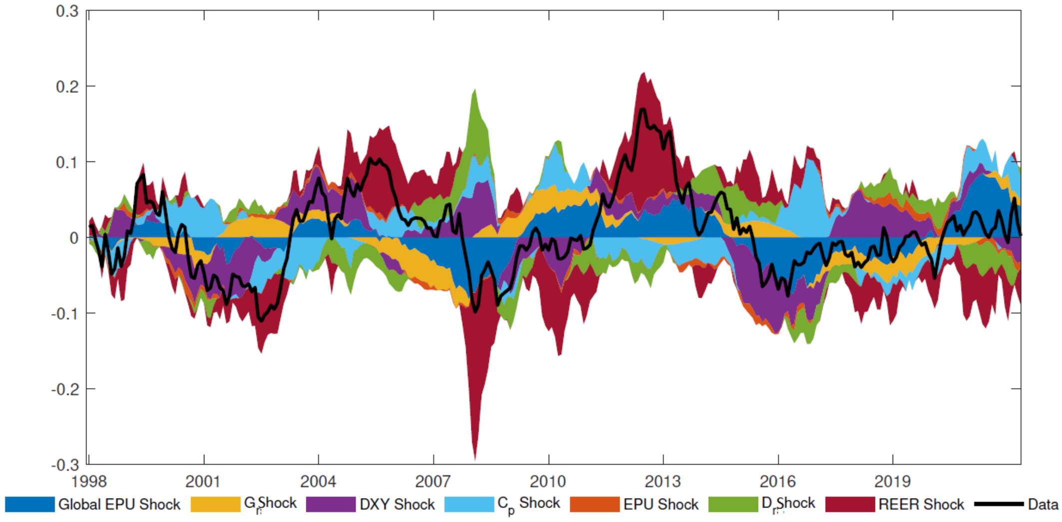
Figure G.6: South African REER Quadratic Detrended Data Historic Decomposition



Note: The solid line is the quadratic detrended REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line.

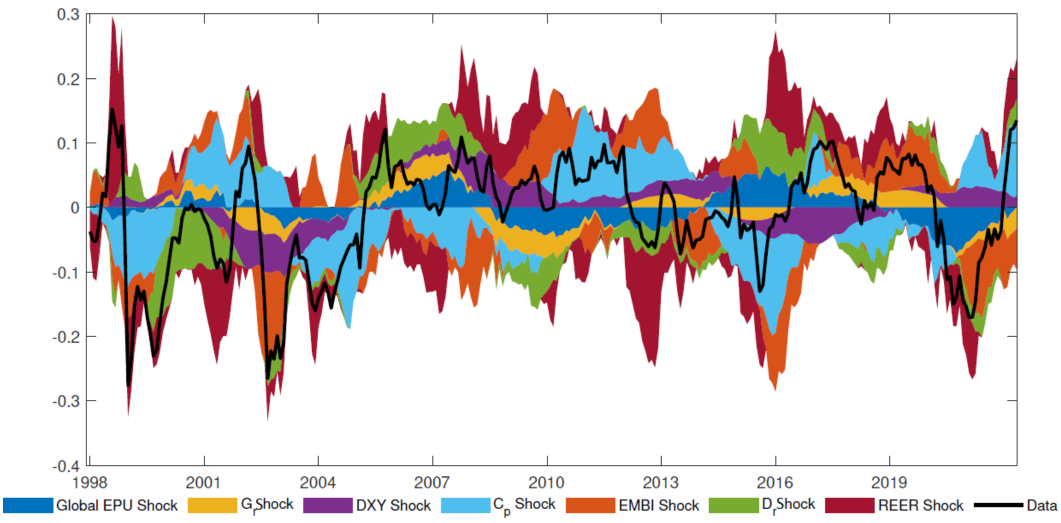
H
REER Historic Decomposition with DXY and HP with $\lambda = 500\ 000$

Figure H.1: Australian REER Historic Decomposition with DXY and HP with $\lambda = 500\ 000$



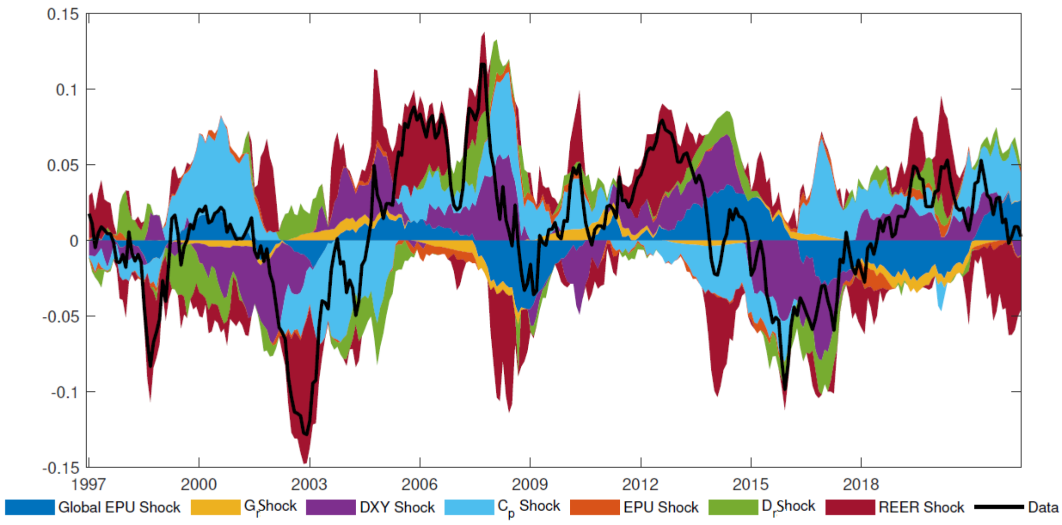
Note: The solid line is HP500000 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. DXY shock is in the purple color.

Figure H.2: Brazilian REER Historic Decomposition with DXY and HP with $\lambda = 500\ 000$



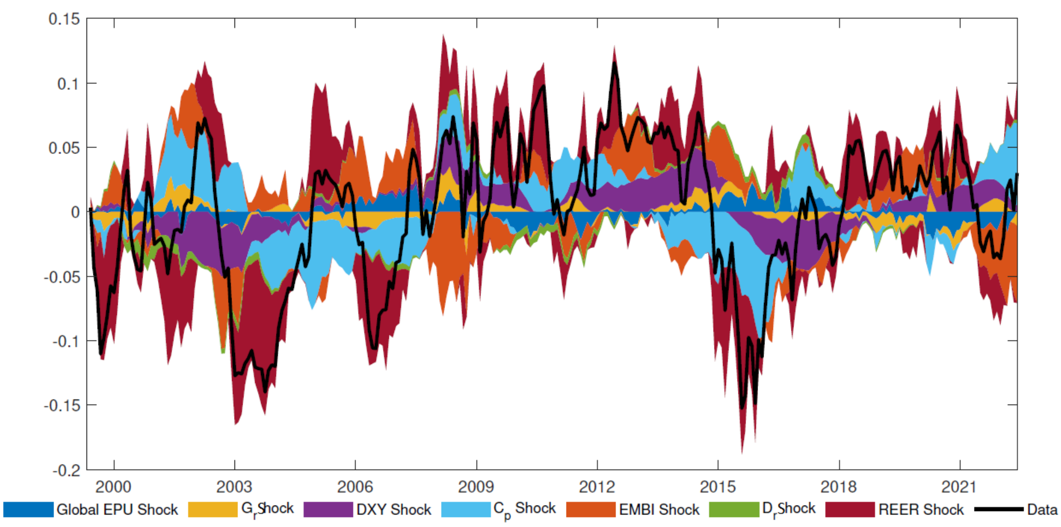
Note: The solid line is HP500000 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. DXY shock is in the purple color.

Figure H.3: Canadian REER Historic Decomposition with DXY and HP with $\lambda = 500\ 000$



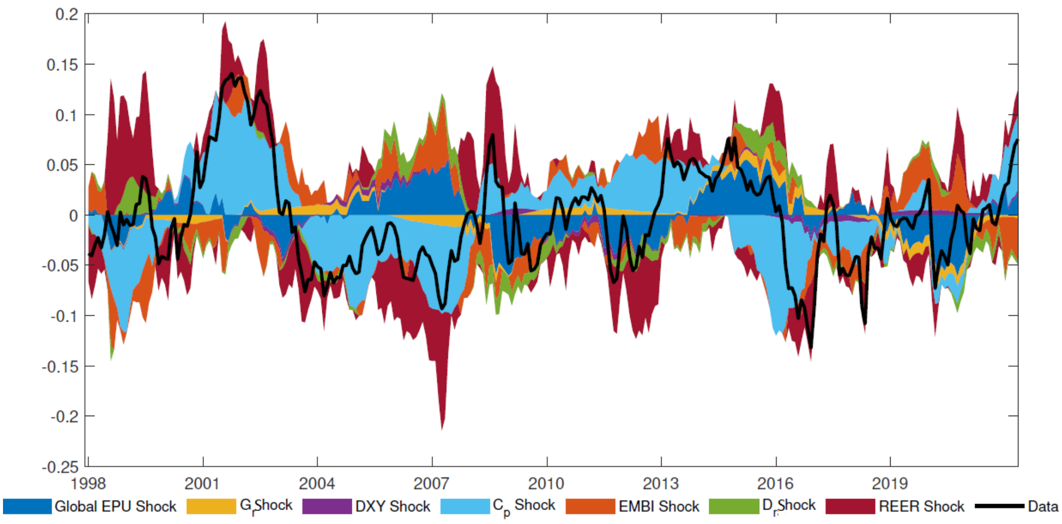
Note: The solid line is HP500000 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. DXY shock is in the purple color.

Figure H.4: Colombian REER Historic Decomposition with DXY and HP with $\lambda = 500\ 000$



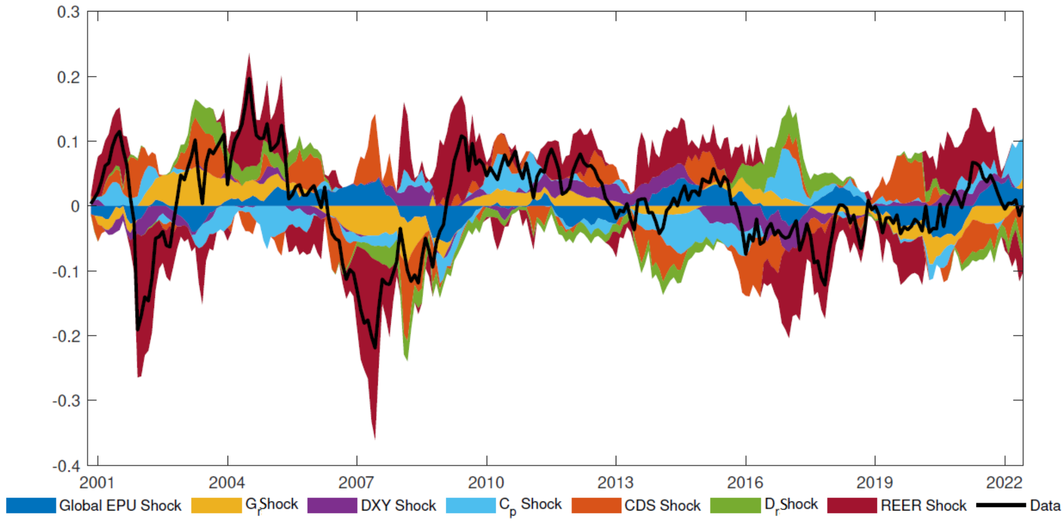
Note: The solid line is HP500000 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. DXY shock is in the purple color.

Figure H.5: Mexican REER Historic Decomposition with DXY and HP with $\lambda = 500\ 000$



Note: The solid line is HP500000 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. DXY shock is in the purple color.

Figure H.6: South African REER Historic Decomposition with DXY and HP with $\lambda = 500\ 000$



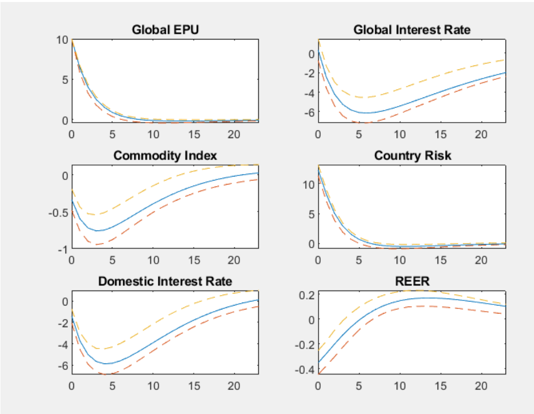
Note: The solid line is HP500000 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. DXY shock is in the purple color.

I
Country Individual Impulse Response Functions

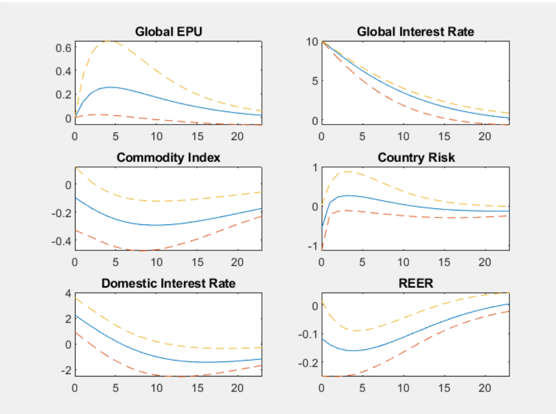
Note for all the figures in this section: The x axis measures months after the commodity shock. Solid lines are point estimates. Dashed lines mark a 66 percent confidence band estimated using bootstrapping methods.

Figure I.1: Australia Impulse Response Functions

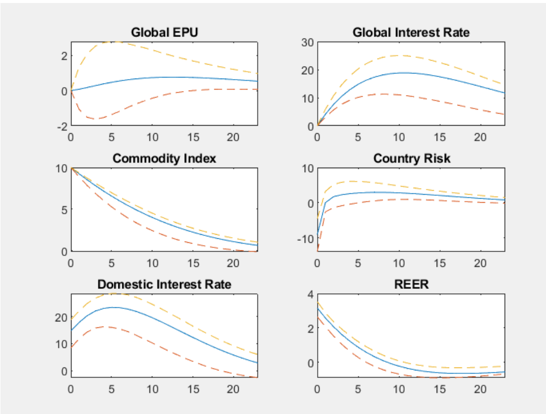
(I.1(a)) Global Risk Shock



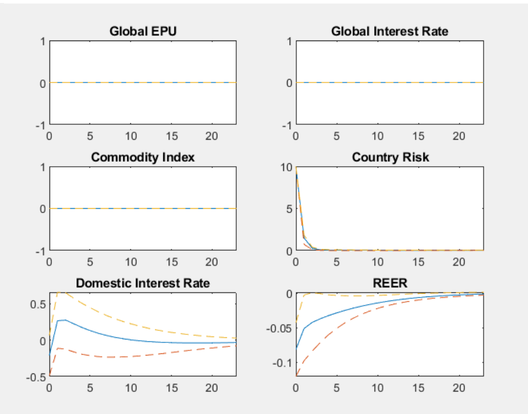
(I.1(b)) Global Interest Rate Shock



(I.1(c)) Commodity Price Shock



(I.1(d)) Country Risk Shock



(I.1(e)) Domestic Interest Rate Shock

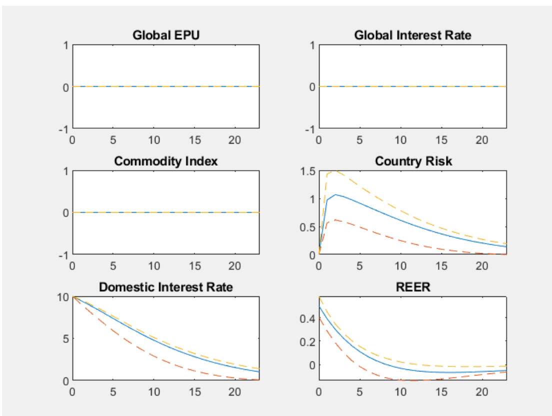
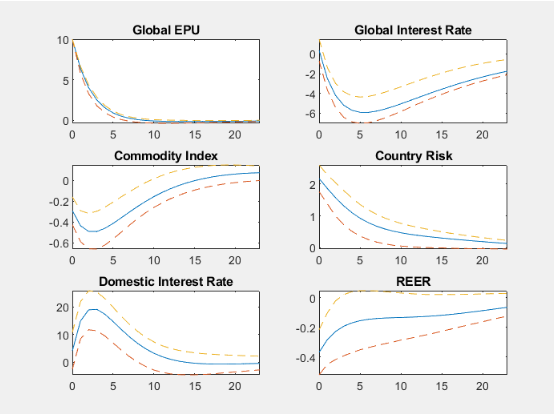
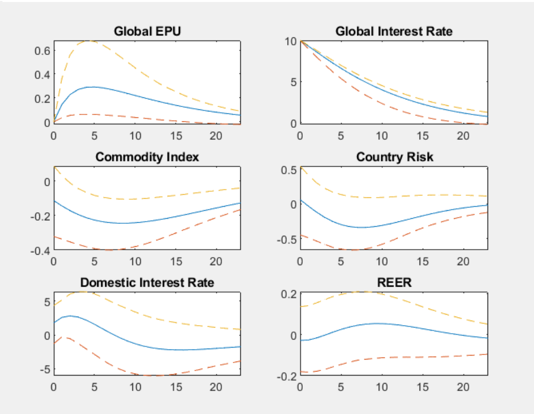


Figure I.2: Brazil Impulse Response Functions

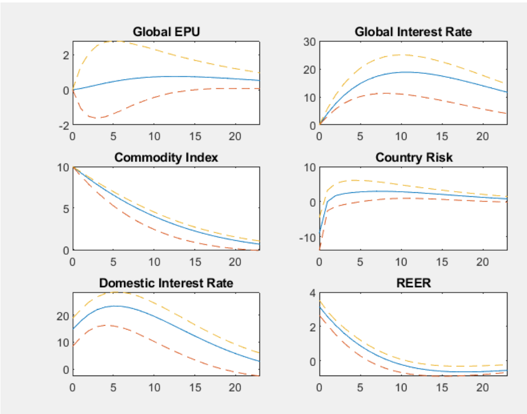
(I.2(a)) Global Risk Shock



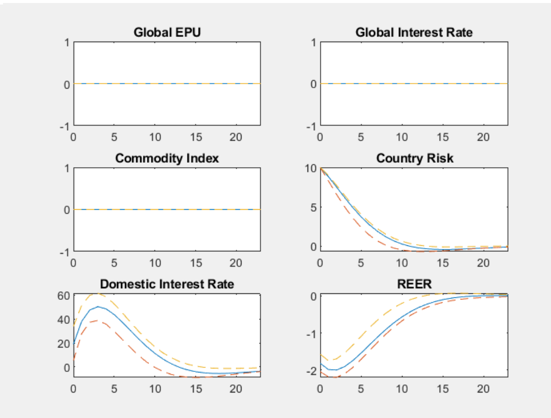
(I.2(b)) Global Interest Rate Shock



(I.2(c)) Commodity Price Shock



(I.2(d)) Country Risk Shock



(I.2(e)) Domestic Interest Rate Shock

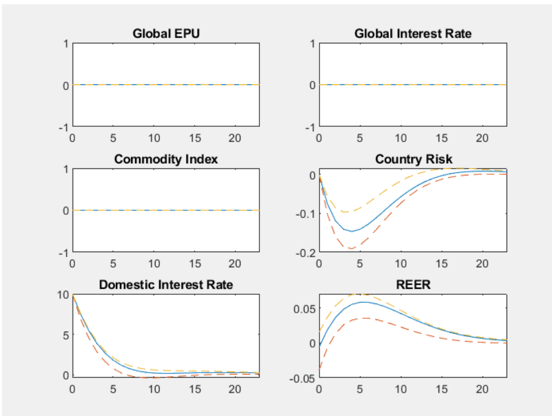
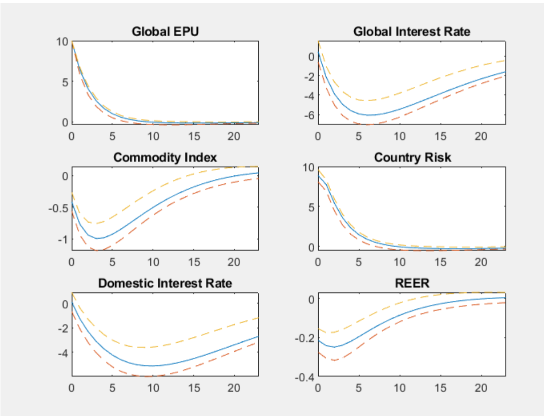
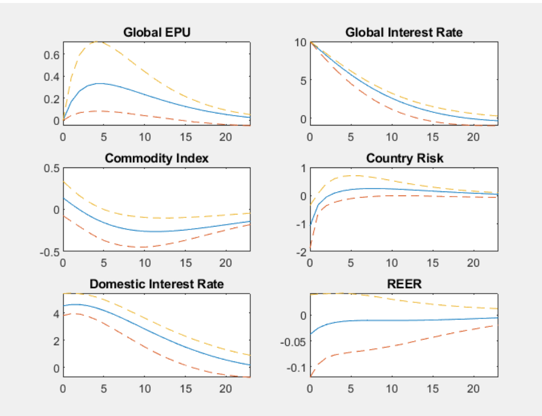


Figure I.3: Canada Impulse Response Functions

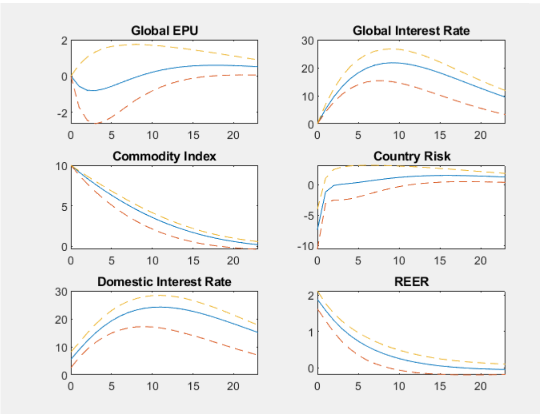
(I.3(a)) Global Risk Shock



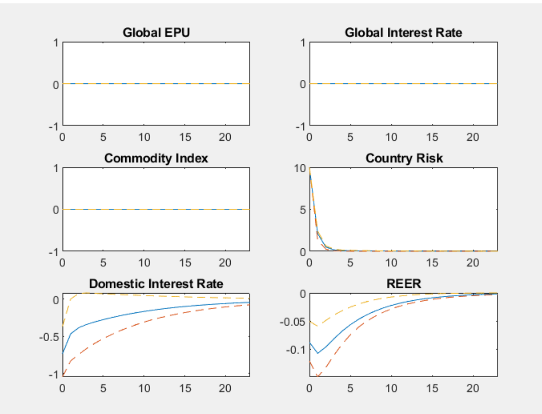
(I.3(b)) Global Interest Rate Shock



(I.3(c)) Commodity Price Shock



(I.3(d)) Country Risk Shock



(I.3(e)) Domestic Interest Rate Shock

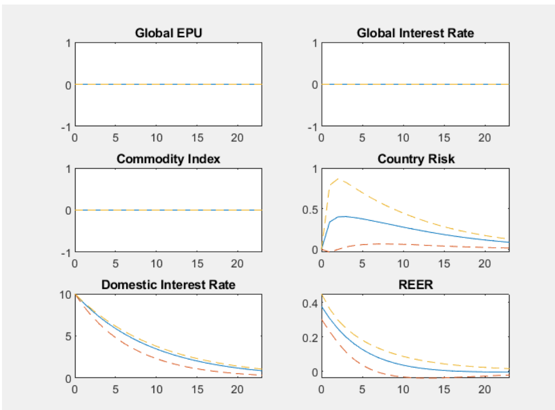
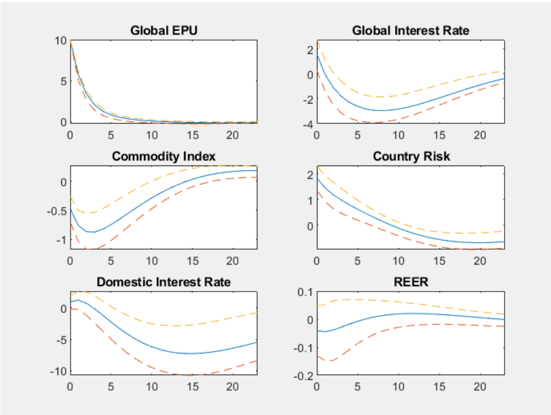
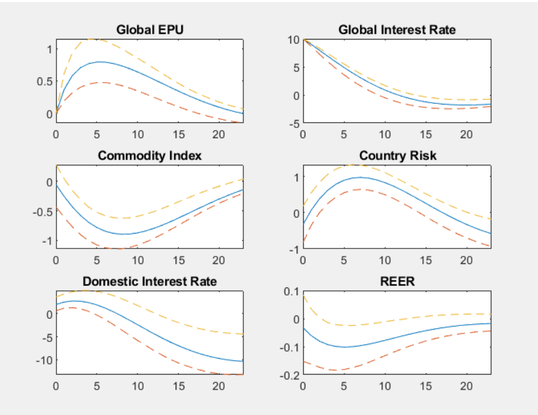


Figure I.4: Chile Impulse Response Functions

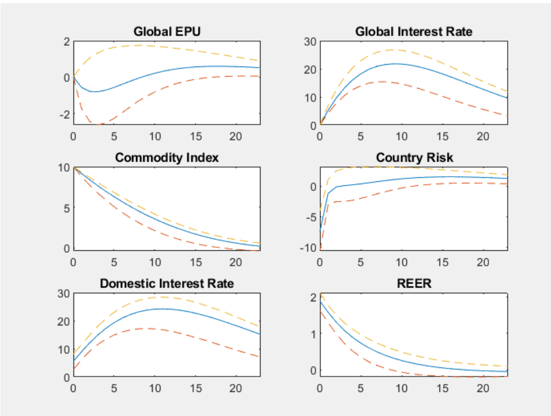
(I.4(a)) Global Risk Shock



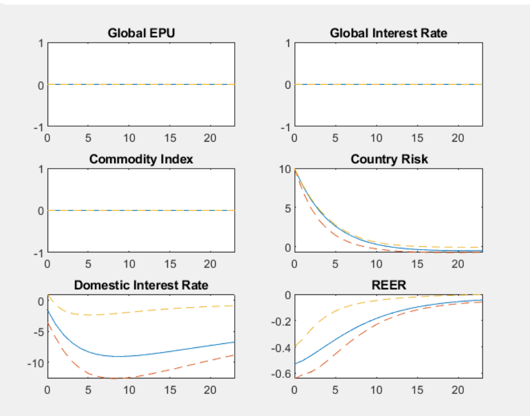
(I.4(b)) Global Interest Rate Shock



(I.4(c)) Commodity Price Shock



(I.4(d)) Country Risk Shock



(I.4(e)) Domestic Interest Rate Shock

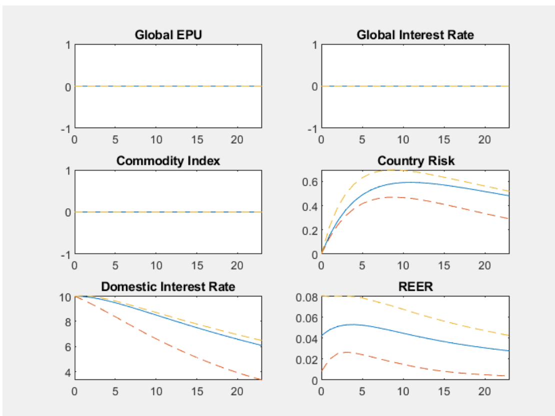
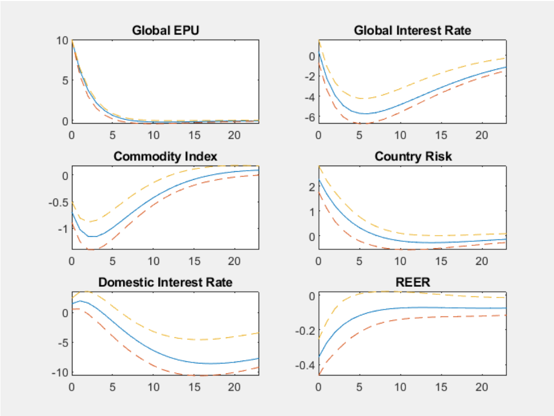
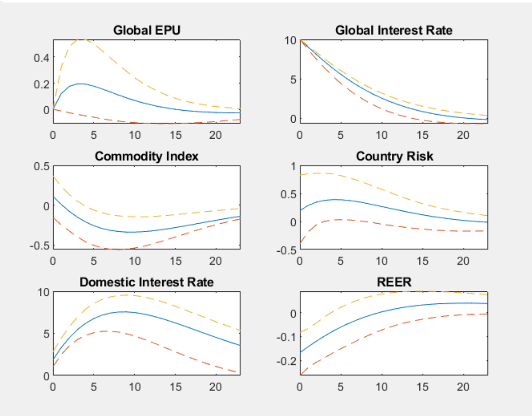


Figure I.5: Colombia Impulse Response Functions

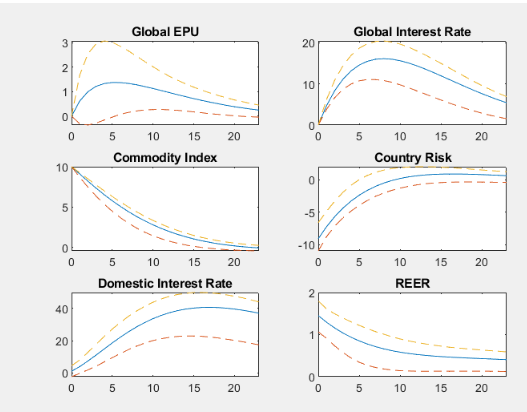
(I.5(a)) Global Risk Shock



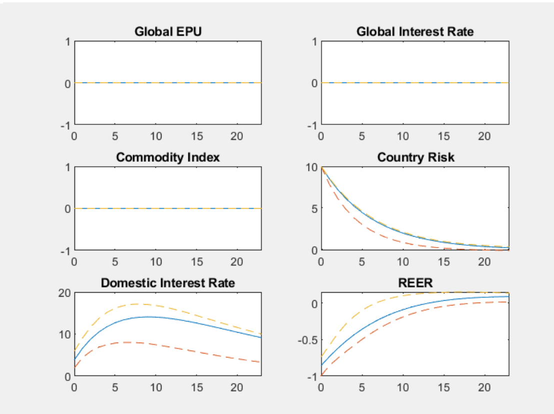
(I.5(b)) Global Interest Rate Shock



(I.5(c)) Commodity Price Shock



(I.5(d)) Country Risk Shock



(I.5(e)) Domestic Interest Rate Shock

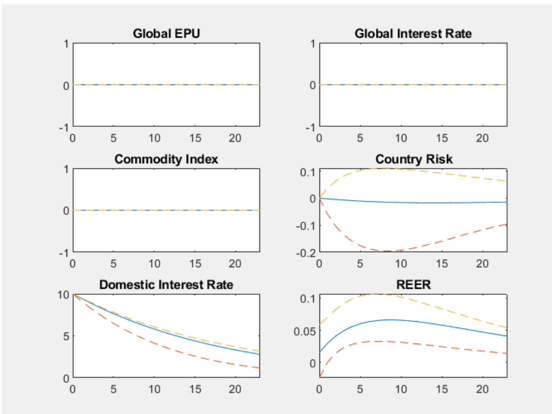
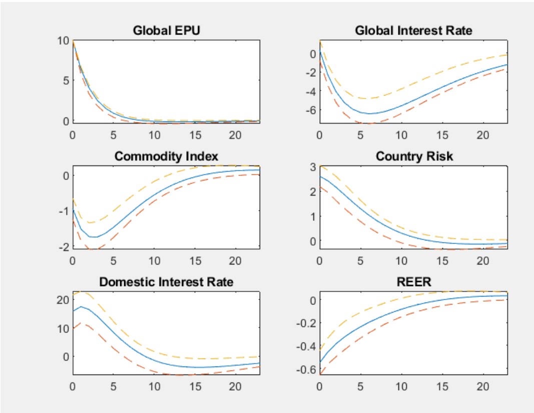
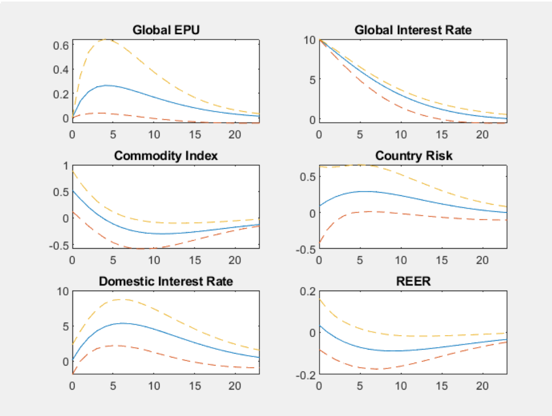


Figure I.6: Mexico Impulse Response Functions

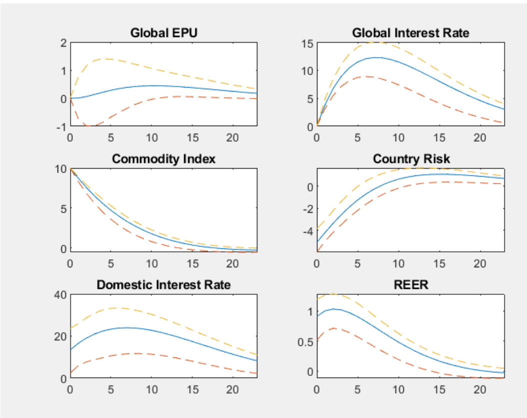
(I.6(a)) Global Risk Shock



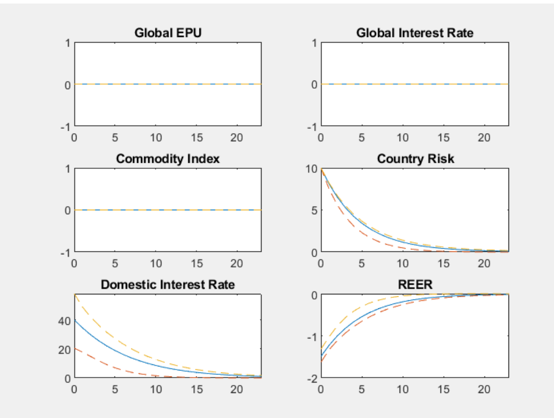
(I.6(b)) Global Interest Rate Shock



(I.6(c)) Commodity Price Shock



(I.6(d)) Country Risk Shock



(I.6(e)) Domestic Interest Rate Shock

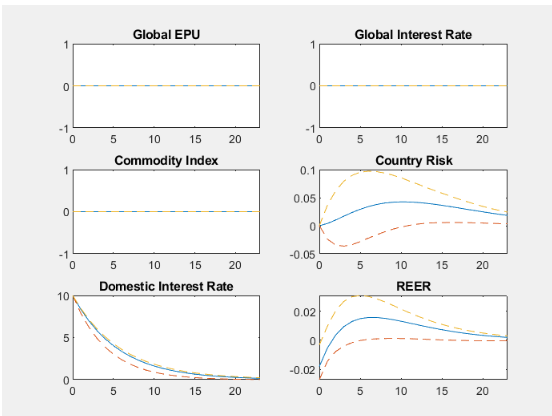
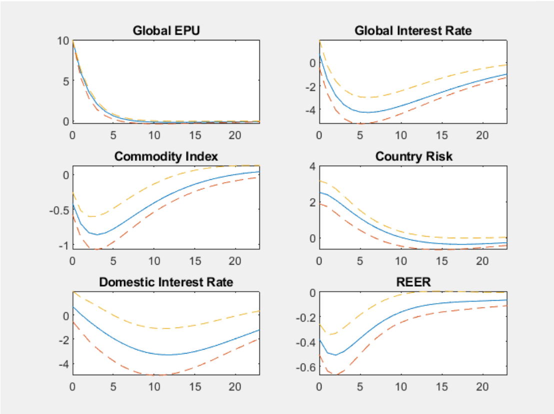
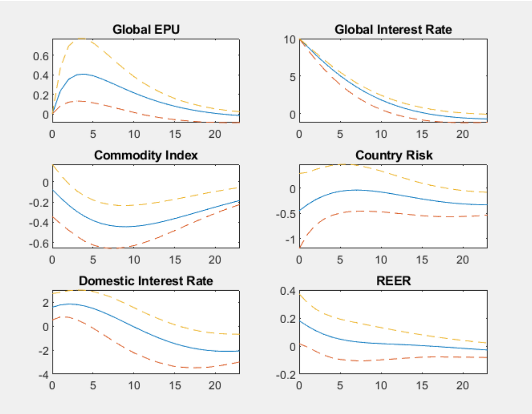


Figure I.7: South Africa Impulse Response Functions

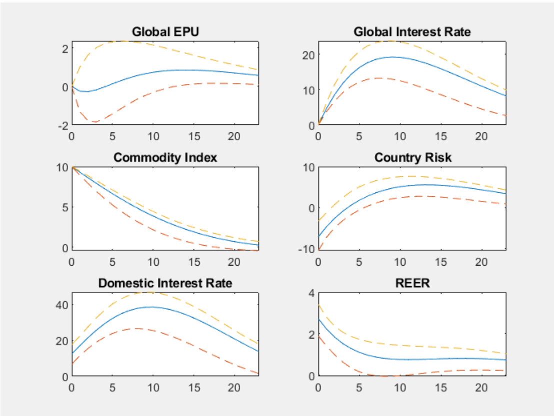
(I.7(a)) Global Risk Shock



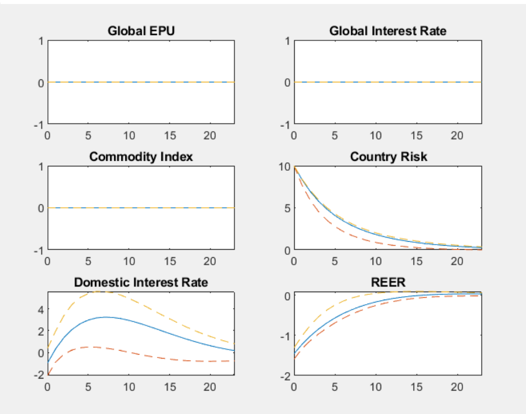
(I.7(b)) Global Interest Rate Shock



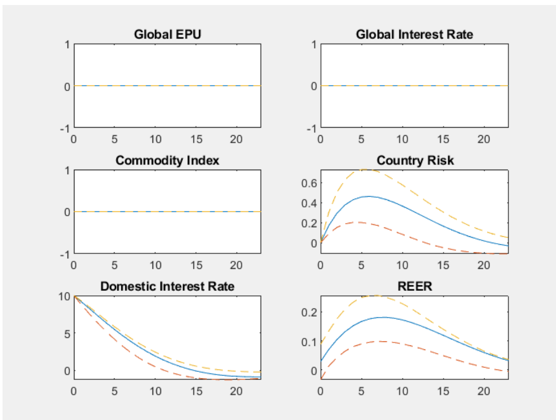
(I.7(c)) Commodity Price Shock



(I.7(d)) Country Risk Shock



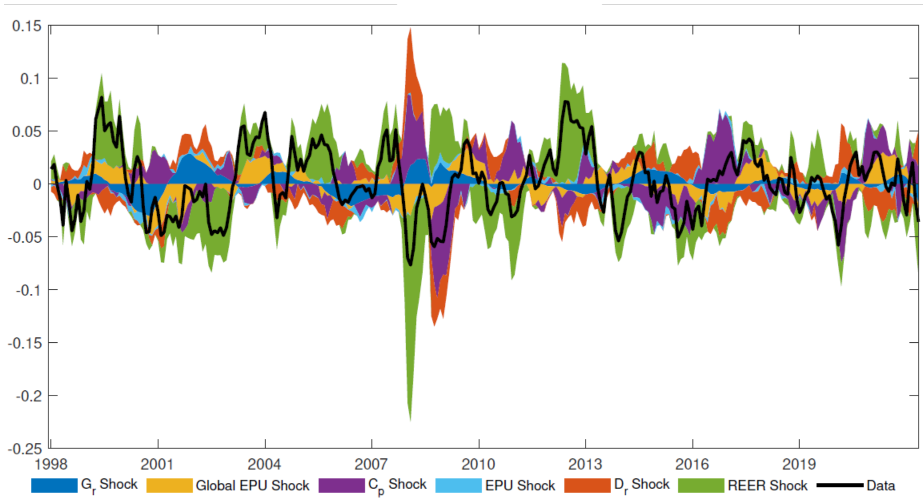
(I.7(e)) Domestic Interest Rate Shock



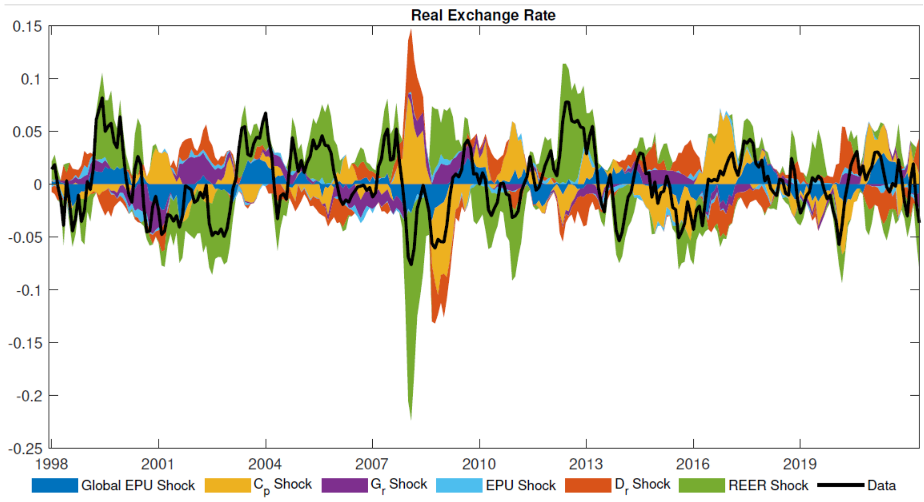
J
Historic Decomposition with Different Global Interest Rate Ordering

Figure J.1: Australia REER Historical Decomposition with Different Global Interest Rate Ordering

(J.1(a)) Global Interest Rate First



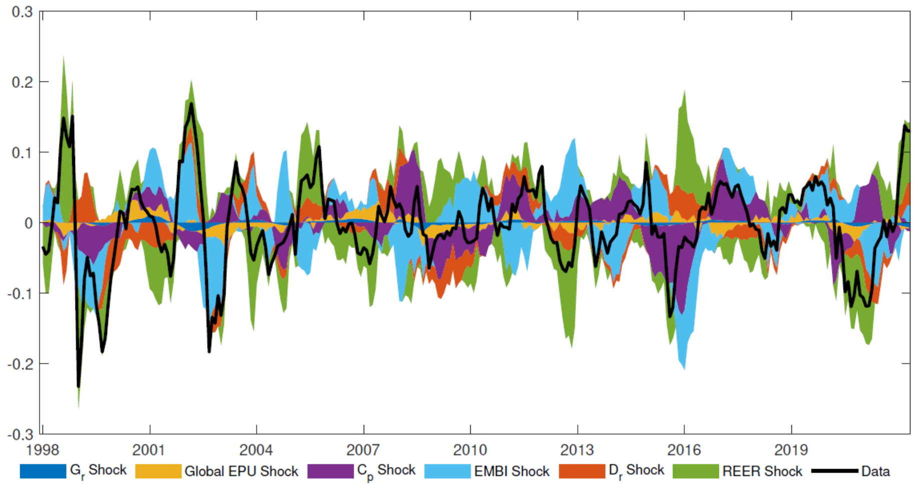
(J.1(b)) Global Innterest Rate Last



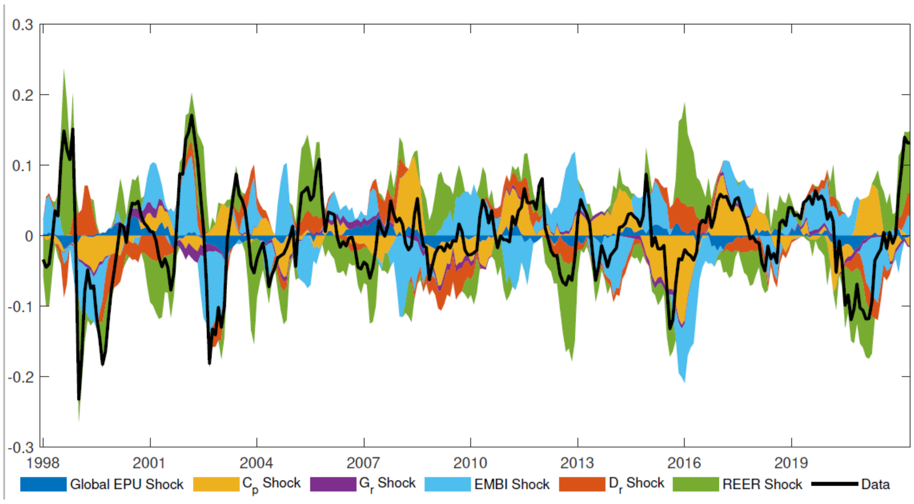
Note: The solid line is HP14400 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. The ordering in the international block in (J.1(a)) is G_r -> G_{EPU} -> C_p and in (J.1(b)) is G_{EPU} -> C_p -> G_r

Figure J.2: Brazil REER Historical Decomposition with Different Global Interest Rate Ordering

(J.2(a)) Global Interest Rate First



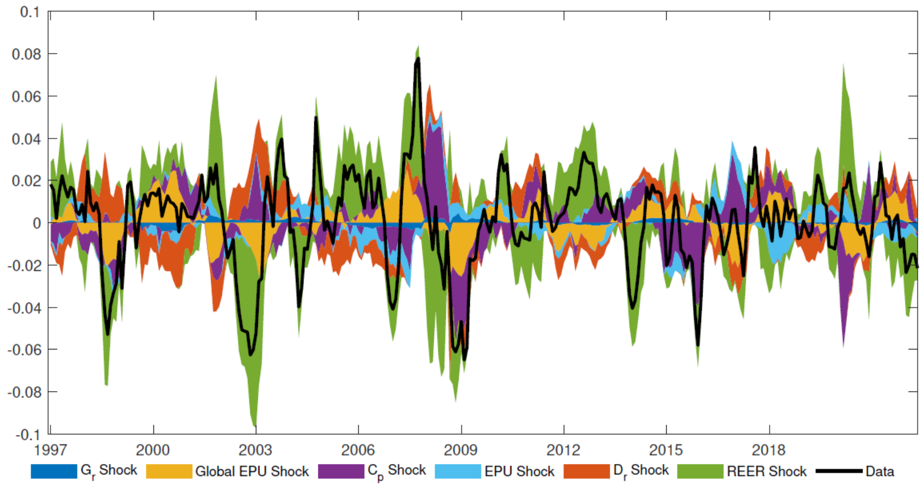
(J.2(b)) Global Innterest Rate Last



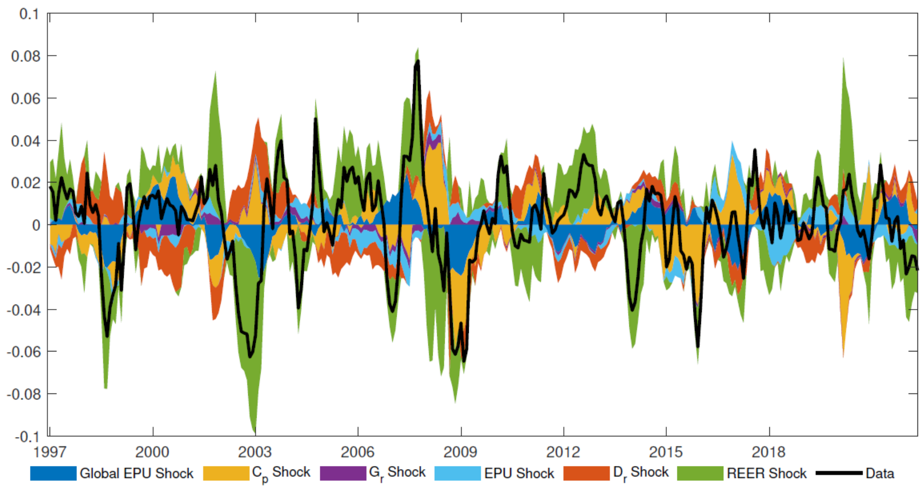
Note: The solid line is HP14400 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. The ordering in the international block in (J.1(a)) is G_r -> G_{EPU} -> C_p and in (J.1(b)) is G_{EPU} -> C_p -> G_r

Figure J.3: Canada REER Historical Decomposition with Different Global Interest Rate Ordering

(J.3(a)) Global Interest Rate First



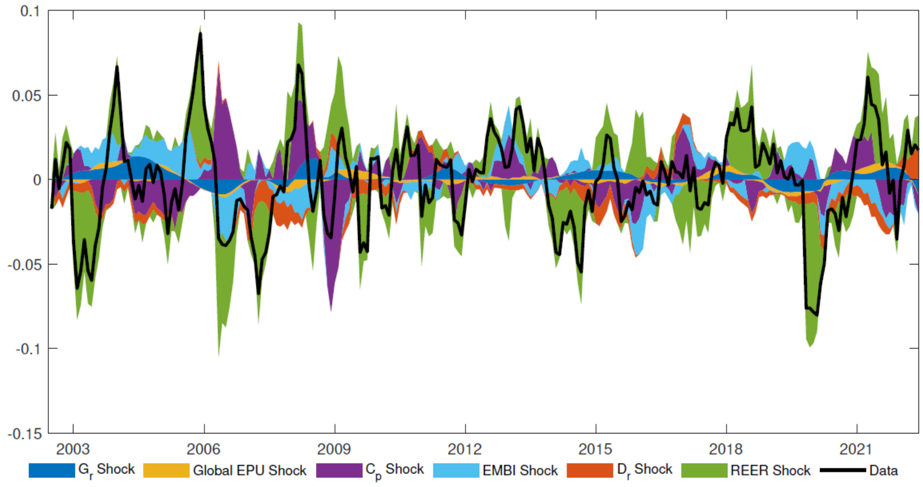
(J.3(b)) Global Innterest Rate Last



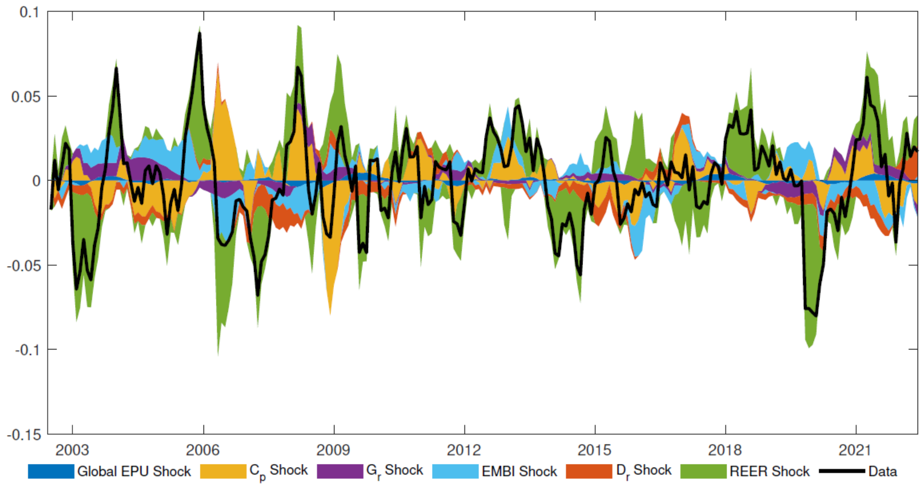
Note: The solid line is HP14400 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. The ordering in the international block in (J.1(a)) is G_r -> G_{EPU} -> C_p and in (J.1(b)) is G_{EPU} -> C_p -> G_r

Figure J.4: Chile REER Historical Decomposition with Different Global Interest Rate Ordering

(J.4(a)) Global Interest Rate First



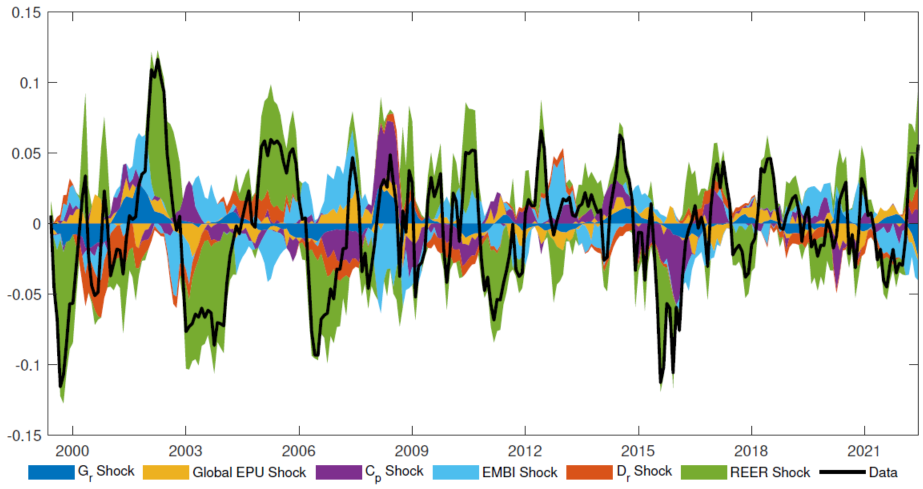
(J.4(b)) Global Innterest Rate Last



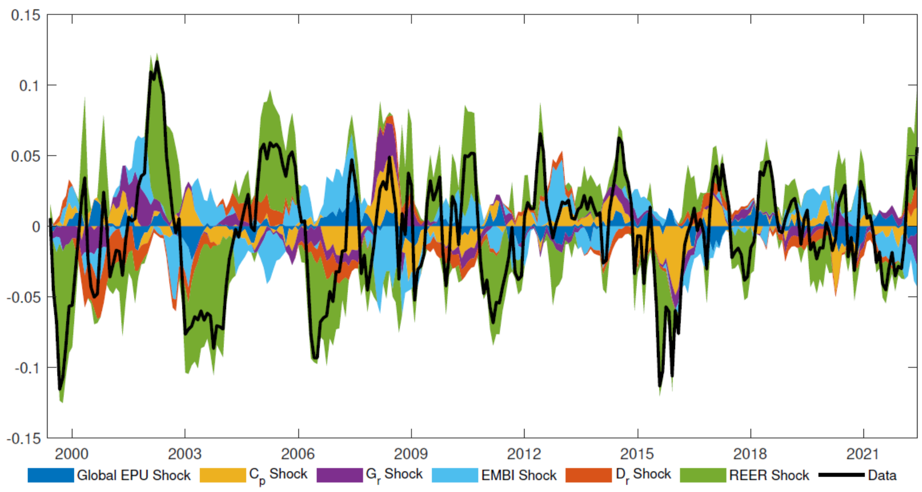
Note: The solid line is HP14400 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. The ordering in the international block in (J.1(a)) is G_r -> G_{EPU} -> C_p and in (J.1(b)) is G_{EPU} -> C_p -> G_r

Figure J.5: Colombia REER Historical Decomposition with Different Global Interest Rate Ordering

(J.5(a)) Global Interest Rate First



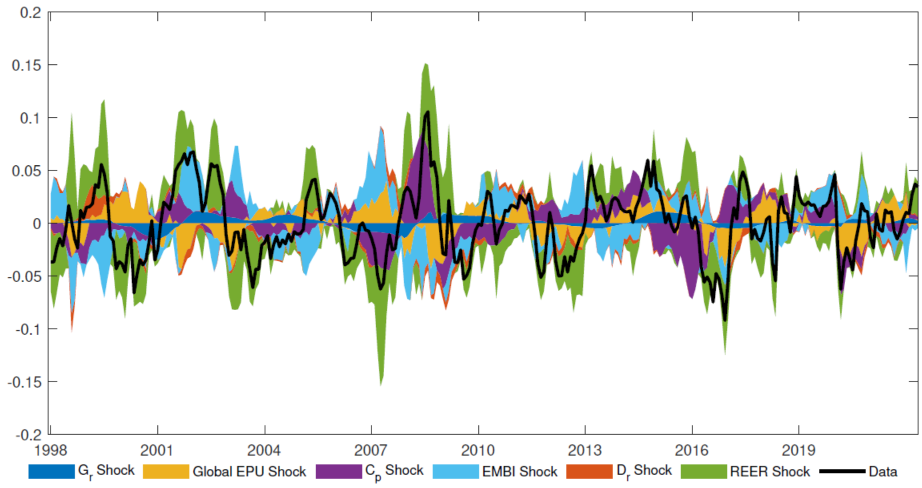
(J.5(b)) Global Innterest Rate Last



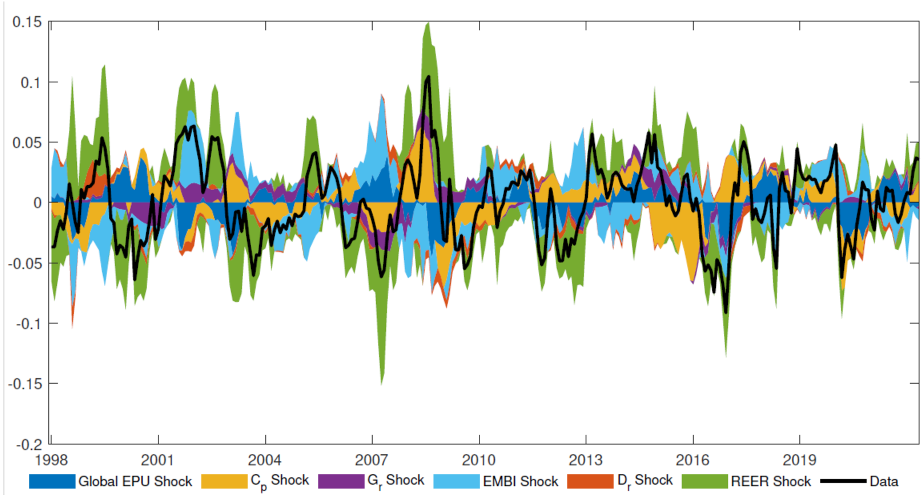
Note: The solid line is HP14400 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. The ordering in the international block in (J.1(a)) is G_r -> G_{EPU} -> C_p and in (J.1(b)) is G_{EPU} -> C_p -> G_r

Figure J.6: Mexico REER Historical Decomposition with Different Global Interest Rate Ordering

(J.6(a)) Global Interest Rate First



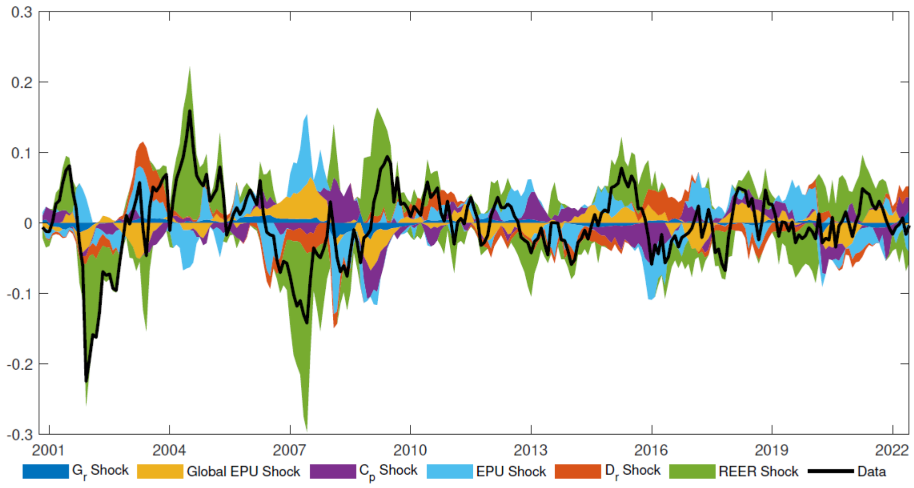
(J.6(b)) Global Innterest Rate Last



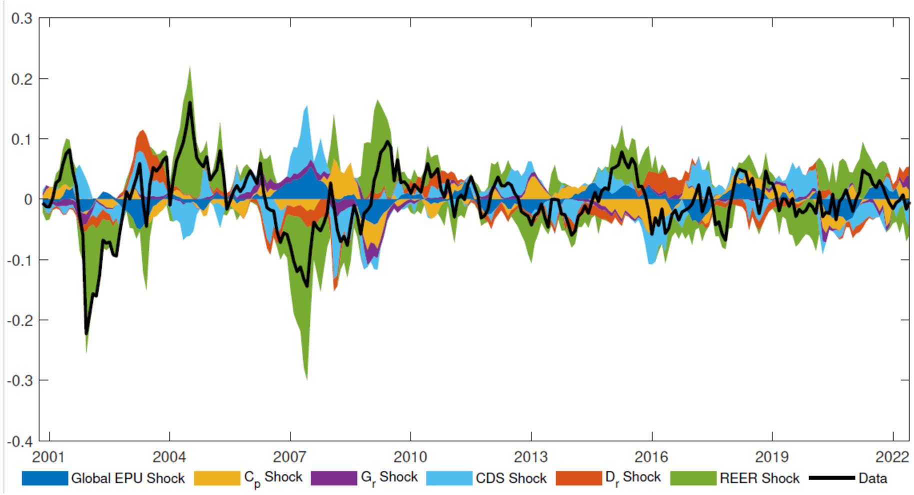
Note: The solid line is HP14400 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. The ordering in the international block in (J.1(a)) is G_r -> G_{EPU} -> C_p and in (J.1(b)) is G_{EPU} -> C_p -> G_r

Figure J.7: South Africa REER Historical Decomposition with Different Global Interest Rate Ordering

(J.7(a)) Global Interest Rate First



(J.7(b)) Global Innterest Rate Last



Note: The solid line is HP14400 cyclic component of REER. The other colored areas represent the structural shocks of the other variables. The sum of the colored areas equals the solid line. The ordering in the international block in (J.1(a)) is G_r -> G_{EPU} -> C_p and in (J.1(b)) is G_{EPU} -> C_p -> G_r

K
Average Impulse Response Functions of COVID-19 Shock

To identify the COVID-19 shock, we utilized the same restrictions as mentioned previously. In addition, we assumed that COVID-19 is exogenous to all variables in the model. We incorporated this assumption into the model by implementing the following changes:

The structural vector autoregressive system takes the following form:

$$X_t = hxX_{t-1} + ETAe_t \tag{K-1}$$

,

where the vector x_t is given by

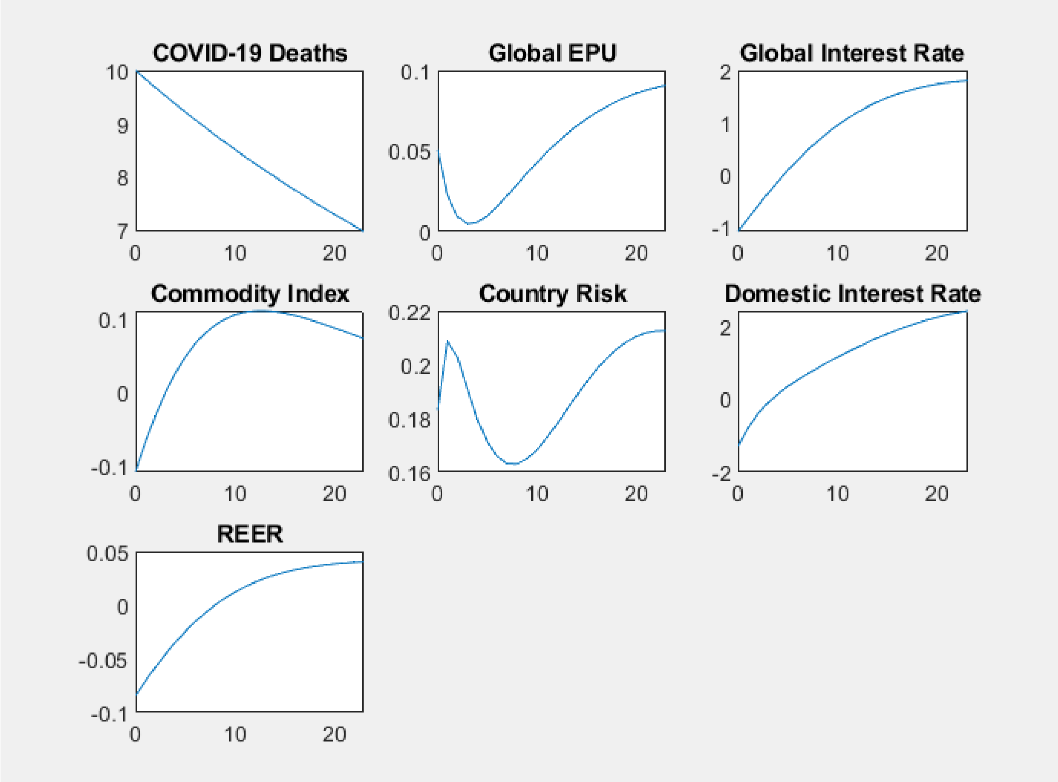
$$x_t \equiv \begin{bmatrix} \widehat{Covid_{deathst}} \\ \widehat{G_{EPUt}} \\ \widehat{G_{rt}} \\ \widehat{Cp_t} \\ \widehat{C_{riskt}} \\ \widehat{D_{rt}} \\ \widehat{REER_t} \end{bmatrix}$$

and the matrix hx is such that:

$$hx \equiv \begin{bmatrix} \gamma_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & 0 & 0 & 0 \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & 0 & 0 & 0 \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & 0 & 0 & 0 \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} & \gamma_{57} \\ \gamma_{61} & \gamma_{62} & \gamma_{63} & \gamma_{64} & \gamma_{65} & \gamma_{66} & \gamma_{67} \\ \gamma_{71} & \gamma_{72} & \gamma_{73} & \gamma_{74} & \gamma_{75} & \gamma_{76} & \gamma_{77} \end{bmatrix}$$

The IRFs of a 10% positive shock on COVID deaths follow in the figure K.1 below:

Figure K.1: Average Impulse Response Functions of COVID-19 Shock



Note: The x axis measures months after the 10 % positive COVID-19 shock. Solid lines are point-by-point mean across countries excludind Chile.

L
Weights Used to Construct Commodity Futures Price Indices

Table L.1: Commodities Weights in Each Country's Future Export Index

	Commodity	Canada	Colombia	Mexico
1	Aluminium	0.070	0.003	0.014
2	Coal	0.037	0.199	0
3	Crude Oil	0.778	0.788	0.985
4	Natural Gas	0.114	0.008	0

Notes: Shares are expressed in decimal values and add up to 1 for each country.