Accounting for Real Exchange Rates in Emerging Economies

(Preliminary)

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Abstract

This study investigates the determinants of real exchange rate movements in Emerging Market Economies (EMEs). First, we employ Engel (1999) decomposition to assess the relative importance of tradable and non-tradable prices on real exchange rate changes for a sample of EMEs. We find that the relative price of tradables is the largest determinant of real exchange rate changes in these economies. Second, we employ VAR analysis to quantify the contribution of commodity price shocks on international price fluctuations. Our findings indicate that commodity prices have a sizeable impact in explaining the puzzlingly large variability of international prices in EMEs.

Keywords: Exchange Rates, SVAR, Panel VAR, Emerging Market Economies.
JEL classification: C32, C33, F30, F31.

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1. Introduction

Exchange rates are an object of great interest for the conduct of macroeconomic policy in many countries. An important challenge in the understanding exchange of rates is related to their high volatility, which is frequently observed in the large currency trade volumes in foreign exchange markets. In this study we empirically examine the international price channel with emphasis on identifying key determinants of real exchange rate movements for the case of middle-income countries, henceforth Emerging Market Economies (EMEs).

Although there is a rich literature that studies the determinants of exchange rate movements (Engel 1993, Engel 1999, Burnstein et al. 2006, Burnstein and Gopinath 2014), most of this literature focuses on high-income countries while much less is known about the determinants of exchange rate fluctuations from the perspective of EMEs. Hence, the first objective of this research study is to perform an accounting exercise of the determinants of real exchange rate fluctuations for a representative sample of EMEs. In particular, we ask, what is the relative importance of tradable goods prices and non-tradable goods prices for real exchange rate changes?

Our second objective is to quantify the contribution of world commodity prices in international price fluctuations in EMEs. This is motivated by the observation of the widely documented 'disconnect' between international prices and macroeconomic fundamentals (Engel and West, 2005). Specifically, real exchange rates are excessively volatile relative to income. Importantly, we conjecture that commodity prices, which are also highly volatile, make an important contribution to the excessive volatility of real exchange rates. To examine this question our empirical strategy employs structural vector auto-regression (SVAR) and Panel VAR approaches to quantify i) the forecast error variance of international prices explained by world commodity price shocks, and ii) examine the direction in which commodity price shocks are transmitted into international prices.

The findings of our study provide two contributions. First, in an answer to the first research question we show that the relative price of tradeable goods is the dominant component of real exchange rate variations in EMEs. This finding extends the validity of the one documented by Engel (1993, 1999) by showing that it is also the case that tradeable prices characterize real exchange rate movements in EMEs. Our second contribution is to show that world commodity prices have a sizeable effect in the volatility of international prices at different horizons, and that this effect is greater than that for high-income countries. Moreover, our findings are robust to both the level and cyclical components of the data, as well as alternative measures of international prices.

This study is organized as follows. Section 2 reviews the existing literature on real exchange rates and commodity prices. Section 3 provides details about our data and methodology. Section 4 discusses the results. Section 5 concludes.

2. Literature Review

A growing strand of literature has emerged that looked at the empirical role of commodity price shocks on different macro-aggregates. Pressing issues such as business cycle effects, monetary policy, inflation and unemployment effects of commodity price shocks has recently been an area of wide research using multiple estimation techniques including the SVAR, Bayesian, and calibration models. Unfortunately not much has been done on the possible impacts of commodity price shocks on the real exchange rates despite the plethora of signals hinting of a possible link between commodity price fluctuations and the exchange rates. While the focus in many of this studies has mainly been on shocks generated by single world commodity prices (see Bodart et al. 2012; Basher, Haug, and Sadorsky, 2016), a unique consensus has recently emerged since the inspiring work of Fernández, Schmitt-Grohé, and Uribe, (2017) that, favors the use of indices based on multiple commodity prices in business cycle models. The influence of commodity price shocks on the real exchange rates has however remained unanalyzed in the face of the suggestions of Fernández et al. (2017).

Specifically, Fernández, Schmitt-Grohé, and Uribe, (2017) studied the transmission of world shocks to domestic business cycles via world commodity price shocks. The contention of their paper is that, structural models that include only one world price such as the terms of trade underestimate the importance of world shocks to domestic business cycles. Using the SVAR and a panel data for 138 countries, they find that, world shocks estimated from an aggregate of three world commodity price indices constructed –Agricultural, Fuels and Metals and Minerals, explains on average 33% of output fluctuations in individual economies for the entire sample period and about 66% of output fluctuations when estimated on post 2000 data. Thus their main contribution to the growing literature is the proposal for the use of disaggregated world commodity price measures in business cycle models since they offer more channels through which world shocks are transmitted to domestic economies. In this paper, we adopted the data and proposal of Fernández et al. (2017) and argue that disaggregated world commodity prices will provide a more viable way of estimating the true impact of world shocks on domestic real exchange rates which tends to be an area less researched in the existing literature.

Also, Drechsel and Tenreyro, (2018) similarly studied the transmission of world shocks to domestic business cycles in emerging market economies by quantitatively proposing a small open economy where commodity price shocks act as a trigger of business cycle disruptions. Drechsel and Tenreyro, (2018) then apply the model to Argentina data for the period 1900 -2015 using both a calibration method and Bayesian estimation methods. By dividing the economy into final goods sectors and commodity producing sector which produces commodities with prices subject to exogenous fluctuations, they find when applied to Argentina data that, commodity price shocks calculated from multiple commodities, accounted for about 38% variations in post 1950 output growth and about 42% and 61% of variations in consumption and investment respectively. However, the influence of such shocks on the real exchange rate, which is a major macro indicator, is equally ignored in their study.

On the influence of commodity price shocks and the real exchange rates, Amano and Norden (1998) studied the link between exchange rates measured by the real effective exchange rates and the domestic price of oil for Germany, Japan and the United States. They find evidence of a strong long run relationship between the real effective exchange rates and the domestic price of oil using co-integration techniques and monthly data for the period 1973:1 to 1993:6. Specifically, they find that, a 10% rise in the price of oil causes a 0.9% depreciation of the German mark, an even larger 1.7% depreciation of the Japanese yen and a 2.4% appreciation of the US dollar. Also Amano and Norden (1998) argued that, exogenous changes in the terms of trade could determine changes in the real exchange rates. The findings of Amano and Norden (1995) is similar to the findings of Chen and Chen, (2007) who using similar co-integration techniques and monthly data for the period 1972:1 to 2005:10 observed similar long run relationship between the real exchange rates and the real price of oil for a panel of G7 countries.

By focusing exclusively on the real price of oil, the studies of Amano and Norden (1998) and Chen and Chen (2007) do not explore the impact of shocks estimated from the commodity prices on the real exchange rates as our study does.

Bodart, Candelon and Carpantier (2012) studied the real exchange rate changes in commodity exporting developing countries focusing mainly on the real exchange rate fluctuations in response to the dominant commodity price fluctuations. Using the non-stationary panel co-integration estimation methods applied on monthly data for the period 1988 -2008, the find that, the price of the dominant commodity has a significant long run positive impact on the real exchange rate when the exports of the leading commodity have a share of at least 20 percent of the country's total merchandise exports. Bodart et al. (2012) thus focuses on only the major export of each country and uses the real values of these commodities deflated by unit export value indices. By using only the real export values of major exports and not shocks from these values, Bodart et al. (2012) provide only the possible long run relationship between the real exchange rates and the country specific major exports but miss out on the contributions from other relevant export commodities. Also by using real export values, Bodart et al. (2012) abstracts from focusing only on price fluctuations since their metric includes both quantity and price. It is our belief that, such an approach will result in an upward or downward bias hence failing to provide a clearer picture as to the extent of the real exchange rate fluctuations due to fluctuations in the prices of these commodities. In the current paper, we address this concern by focusing on multiple commodities that transmit world shocks more and the unit price indices that captures pure price changes only and also provide quantitative measures of the real exchange rate shocks due to commodity price shocks.

Dauvin, (2014) examines the link between energy prices in general and the real exchange rates for 33 energy and commodity exporting countries over the 1980 – 2011 period. Instead of focusing on just oil prices and oil exporting countries, Dauvin (2014) divided countries in the sample into energy exporting (10 countries) and commodity exporting (23 countries) and used a measure of energy prices as the energy terms of trade that is calculated as the price of energy (oil, gas, coal) deflated by the manufacturing unit value index. The commodity price measure was represented by the commodity terms of trade measured as the weighted average price of the three main commodities exported by each country. Using smooth transition regressions, Dauvin (2014) finds the existence of energy currencies for the sample countries where a 10% rise in energy prices leads to a 2.8% appreciation of their exchange rates. Dauvin (2014) also finds that, there exists a threshold of 0.36 for commodity exporting countries and 0.25 for energy exporting countries beyond which the real effective exchange rate of both energy and commodity exporters reacts to oil prices through the terms of trade.

Similarly, Bodart, Candelon and Carpantier, (2015) examined the link between commodity prices and the real exchange rates and also the role played by structural factors in shaping the real exchange rate –commodity price relationship. By focusing on five structural factors – the exchange rate regime, the degree of financial openness, the degree of export diversification, and the type of main commodity exported by the country, they find that, the real exchange rates of countries specialized in the production of a main primary commodity is related to the international price of the main commodity that they export in the long run. They also find that, the long run commodity price elasticity of the real exchange rate varies directly with the exchange rate regime, the degree of trade openness, the degree of export diversification and the type of commodity that is exported. The degree of financial openness was however found not to affect the long run relationship between the real exchange rate and the international commodity price shocks. These results were based on a panel co-integration test for a 33 developing and emerging market economies for the period 1980 – 2007. Thus the focus of the analysis as in Bodart (2012) is on major export commodities and not on an aggregate of commodities as in our study hence missing a crucial channel through which the exchange rate-commodity price relationship could be transmitted.

Ferraro, Rogoff and Rossi, (2015) studied the relationship between commodity prices and the realized (nominal) exchange rates. Specifically, they focus on whether or not a country's major export commodity can predict or forecast movements in its nominal exchange rates in pseudo out-of- sample fit and truly out-of-sample forecasting experiment. Using the daily, monthly and quarterly bilateral data for the Canadian –US dollar exchange rate and oil prices for the period 1984:12 to 2010:11, they find that, the predictive ability of commodity prices (oil prices) is transitory and short lived and that contemporaneous realized commodity prices are related to the daily nominal exchange rates of commodity currencies. On the contrary, estimates with the monthly and quarterly series suggest little relationship between commodity prices and exchange rates. Thus commodity prices forecast exchange rates out-of-sample and at the same time exchange rates forecast commodity prices out-of-sample when the daily frequency was used but not when the monthly or quarterly series were used. The results also hold when applied to the Norwegian Krone –US dollar exchange rate rates and oil prices, South African Rand-US dollar exchange rates and gold prices, Australian-US dollar exchange rates and oil prices as well as the Chilean Peso –US dollar exchange rates and Copper prices. Ferraro, Rogoff and Rossi, (2015) thus concluded that, the frequency of data is vital in capturing the full effect of commodity price shocks on the real exchange rates. Due to data limitations however, we use the annual series for this study. Since our focus is on estimating the structural causal impact of unexpected shocks on the international prices and a forecast, we believe the use of annual series will yield equally consistent estimates with little biases.

Coudert, Couharde and Mignon, (2015) examined the relationship between the terms of trade and the real exchange rates in commodity producing countries in the short run and the long run using panel co-integration technique, smooth transition regressions and both annual and monthly data for 68 countries for the period 1980 – 2012. Focusing on the level of volatility in commodity and financial markets and also dividing countries into sub-samples based on income level, they observe that, there is a long run positive relationship between the real exchange rates and the terms of trade with a 10% rise in the terms of trade inducing a real exchange rate appreciation of 2%. Also they show through a smooth transition regression that, only the currencies of advanced oil exporting countries are sensitive to changes in the terms of trade in the short run especially when volatility is high in the commodity markets (a threshold of about 45% triggers the regime switch).

Zhang, Dufour and Galbraith, (2016) on their part examined the nature of the causal relationship between commodity prices and the real exchange rates using Granger causality technique and data on three commodities (crude oil, gold and copper) for four countries (Canada, Australia, Norway and Chile) for the period 1986 – 2015. They observe that, there is a bidirectional causality between commodity prices and exchange rates across multiple horizons with the direction from commodity prices to the real exchange rates being the most significant statistically. They further observe that the causality are stronger at short horizons but grows weaker as the horizons increase.

Other researchers such as Buetzer, Habib and Stracca (2012; 2016); Basher, Haug and Sadorsky, (2016) and Kilian and Zhou (2019) adopted the approach of using single commodity prices to study the link between commodity price shocks and the real exchange rates. In most of these studies however, the focus has been on the oil price-exchange rate relationship. Specifically, Buetzer, Habib, and Stracca (2016) for example studies the link between oil price shocks and global exchange rate configurations and how such oil price shocks are absorbed by the accumulation of foreign exchange reserves and under different exchange rate regimes in heavy oil exporting and importing countries. Using quarterly data for 43 countries for the period 1986Q1 to 2013Q4 and an SVAR and panel fixed effects estimation procedures, they find that, for the full sample of countries, no systematic relationship exist between oil price shocks and exchange rate movements but when estimated for net oil exporters, there exist some level of appreciation of their currencies. Also for currencies with a floating exchange rate regime, they find evidence of a nominal exchange rate appreciation in the wake of oil demand shocks. In an earlier paper in Buetzer, Habib and Stracca (2012) using quarterly data for 44 countries for the period 1986:1 to 2011:1 and measuring the exchange rate using both the nominal and real exchange rates, they observe similarly that the exchange rate of oil exporters does not appreciate against those of oil importers after a shock to the real price of oil. However, they also observe that oil exporters experience significant exchange rate appreciation pressures following an oil demand shock, which they tend to counter by accumulating foreign exchange rate reserves. Basher, Haug and Sadorsky, (2016) did a similar study also for a group of large oil exporting and importing countries using similar SVAR modeling technique as well as a Markov- Switching strategy. Using monthly data for six (6) oil exporting and three (3) oil importing countries for the period 1976 to 2014, they find evidence of significant positive impact of oil shocks on exchange rates in at least one state (state dependent regression coefficients or state dependent volatility for the error process) for each country under the Markov-switching model but no significant impact under the linear regression model. Kilian and Zhou (2019) however using similar monthly data for the period 1973:02 to 2018:06 and SVAR estimation technique, find a strong evidence of oil price shocks (demand and Supply) on the real exchange rate of the US contrary to the weak findings of Buetzer, Habib, and Stracca (2012) and Basher, Haug and Sadorsky, (2016). Killian and Zhou (2019) observe that, oil demand and supply shocks together account for about one third of the unconditional variability in the real exchange rates.

We add to the existing literature by examining the role of a representative set of commodity prices as a source through which commodity price shocks could affect relative international prices including the real exchange rates. Our approach which focuses on shocks generated from multiple commodity prices enlarges the impact of world commodity price shocks on the relative international prices. Importantly, we provide estimates across multiple proxies for the relative international prices – the terms of trade, the real effective exchange rates, and the relative price of tradables, which allows us to examine the sensitivity of international prices to commodity price shocks.

3.0 Data and Methodology

This section presents the data and estimation procedure adopted for the study. Section 3.1 presents a summary of the data and sources. Section 3.2 presents the estimation procedure that includes a variance decomposition analysis (3.2.1) and the SVAR and PVAR estimation techniques (3.2.2).

3.1 Data

The data covers the period 1960 -2014 at annual frequency and is obtained from different sources including the World Banks World Development Indicators (WDI), World Bank Pink Sheet, the International Monetary Fund's (IMF) World Economic Outlook (WEO) and International Financial Statistics (IFS), and the Economic data series of the Federal Reserve Bank of St. Louis. Our sample countries include 7 EMEs for the exchange rate decomposition accounting exercise, and 31 countries for the subsequent SVAR and PVAR analyses.[2]

Commodity prices (P^f, P^m and P^a)

The study uses a panel of three world commodity price index's made available by Fernández, Schmitt-Grohe and Uribe (2017). The data is annual and covers a sample of 31 countries for the period 1960 – 2014. Fernández, Schmitt-Grohe and Uribe (2017) uses the dollar denominated nominal commodity price indices dataset from the World Bank's Pink Sheet to construct the three aggregate commodity price indexes – Fuel, Agriculture and Metals and Minerals each calculated as a weighted average of a series of individual spot commodity price indices. The Fuel price index is a weighted average of the spot prices of coal, crude oil and natural gas while the Metals and Minerals price index is calculated as the weighted average of the spot prices of

[2] Although many of our data series are also available at higher frequency, for our VAR analyses we are constrained to use annual frequency due to the available commodity price data.

aluminum, copper, iron ore, lead, nickel, steel, tin and zinc. The Agricultural price index was calculated as the weighted average prices of beverages (cocoa, coffee, and tea); food (fats and oils, grains, and other foods) and agricultural raw materials (timber, and other raw materials). All other goods are described as a composite and proxied by the US consumer price index (CPI). The US CPI is then used to deflate the three commodity price indexes constructed.

Relative International Prices

Our study uses three different proxies for the relative international prices. These include the terms of trade (ToT), bilateral real exchange rates (RER), and real effective exchange rate (REER).

(a) ***Terms of Trade*** $(\boldsymbol{ToT})$

The terms of trade (ToT) dataset for all countries in the sample was obtained from the dataset made available by Fernández, Schmitt-Grohe and Uribe (2017) and was measured as the ratio of trade-weighted export and import unit value indices obtained mostly from the IMF's World Economic Outlook (WEO) database.

(b) ***Bilateral Real Exchange Rates (RER)***

We compute consumption-based bilateral real exchange rates (RER) as follows. We employ end-of-period-average nominal exchange rates (S_t) from IFS measured as national currency per unit of the US dollar. We also collect CPI Price level data P_t for each country and compute the consumption-based real exchange rate as: $RER_t = S_t * P_{US,t}/P_t$.

In the first part of our study we then use an accounting methodology to decompose the RER into its tradable and non-tradable components of relative prices.

We follow Engel (1999) and construct the relative price of tradable goods measure (X_t) was calculated from equation (2) as

$$x_t = s_t + \ln(PPI_t^*) - \ln(PPI_t) \quad (2)$$

Where x_t is the log of the relative price of the traded goods (X_t) between a domestic economy and the US, $\ln(PPI_t^*)$ is the natural log of the producer price index of the US, $\ln(PPI_t)$ is the natural log of the producer price index of each country in the sample. s_t is the log of the domestic currency price of the US dollar. Data on the producer price index (PPI) of both the US and home country is from the IFS.

(c) Real Effective Exchange Rates **(*REER*)**

The real effective exchange rate data was obtained from the World Bank's World Development Indicators (WDI) database and was measured as the nominal effective exchange rate index adjusted for relative movements in national prices or cost indicators of home country, selected countries or the euro area. The real effective exchange rate data for Argentina, Thailand and Turkey was however obtained from the Economic data series of the Federal Reserve Bank of St. Louis and is based on the manufacturing consumer price index. The data is monthly and was converted to annual series by taking simple averages.

3.2 Methodology

This section describes the empirical analyses employed to quantify i) the contribution of relative tradable prices on real exchange rate movements in EMEs, and ii) estimate the impact of commodity price shocks on real exchange rate fluctuations. Hence, our empirical strategy is divided into two stages. First, we conduct a real exchange rate accounting exercise as in Engel (1999) and measure the relative contribution of tradable and non-tradable goods prices to real exchange rate fluctuations. Specifically, we decompose changes in the real exchange rates into tradable goods (x_t) and non-tradable goods (y_t) prices using a Mean Square Error (MSE) decomposition procedure. The second stage involves the use of the Structural Vector Autoregressions (SVARs) and a Panel Vector Autoregression (PVAR) methodology to gauge the effect of commodity price shocks on real exchange rate fluctuations through a variance decomposition exercise and impulse response function (IRF) analysis, respectively.

3.2.1 Mean Square Error (MSE) Decomposition Analysis

Following Engel (1999), the log of real exchange rate (q_t) can be divided into traded and non-traded good prices as follows:

$$q_t = x_t + y_t \tag{3.1}$$

Where q_t is the log of the real exchange rate; x_t is the log of the relative price of traded goods in each country and y_t is the weighted difference of the log of the relative price of non-traded to traded goods prices in each country.

Engel (1999) proposed different ways of measuring the amount of tradable goods and non-tradable goods in an economy. One such way is to use the seasonally unadjusted data for overall producer price index (PPI), Consumer price index (CPI) and the bilateral exchange rates between a domestic currency and the US dollar to construct the traded and non-traded goods. Using the PPI, CPI and bilateral exchange rate data, the traded and the non-traded goods are calculated as

$$x_t = s_t + \ln(PPI_t^*) - \ln(PPI_t) \tag{3.2}$$

$$y_t = \ln(CPI_t^*) - \ln(PPI_t^*) - (\ln(CPI_t) - \ln(PPI_t)) \tag{3.3}$$

Where $\ln(PPI_t^*)$ is the natural log of the producer price index of the US, $\ln(PPI_t)$ is the natural log of the producer price index of a domestic country and s_t is the natural log of the exchange rate measured as the domestic currency price of the US dollar. The steps used in Mean Square

Error (MSE) decomposition analysis, the estimation procedure and results using the other proposed methodologies are presented in the Appendix.

3.2.2 Structural Autoregressions (SVARs)

In the second part of our empirical analysis we employ the SVAR methodology to estimate the effect of world commodity price shocks on three (3) measures of international prices, namely the relative price of tradables (X_t), real effective exchange rates $(REER_t)$, and the terms of trade (TOT_t). Following Kilian (2009), the general representation of the SVAR model takes the form

$$A_0 z_t = \alpha + \sum_{i=1}^{k} A_i z_{t-i} + \varepsilon_t$$

Where ε_t is a vector of serially and mutually uncorrelated structural innovations, A_i is a matrix of parameters of the lagged dependent variables, α is a constant and $z_t = (p^a, p^f \; and \; p^m)$ is a vector of endogenous commodity price variables where p^a is the weighted price index of agricultural commodities, p^f is the weighted price index of fuel prices and p^m is the weighted price index of metal and mineral prices. If we let e_t denote the innovations from the reduced form VAR such that it is decomposed according to $e_t = A_0^{-1}\epsilon_t$, then the innovations can be derived from the reduced form VAR by imposing a recursive identification structure restriction on matrix A_0^{-1}.

The identification restriction imposed on matrix A_0^{-1} is given as.

$$e_t \equiv \begin{pmatrix} e_t^{p^f} \\ e_t^{p^m} \\ e_t^{p^a} \\ e_t^{Relative\ Int.Prices} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{Fuel\ Px\ Shock} \\ \varepsilon_t^{Metal\ Px\ Shock} \\ \varepsilon_t^{Agric\ Px\ Shock} \\ \varepsilon_t^{Other\ Shock} \end{pmatrix}$$

The recursive identification imposed is motivated as follows. The underlying assumption of the model is that the international fuel prices are not affected contemporaneously by either metal prices or agricultural prices. Thus fuel prices are assumed to be exogenous by construction and do not respond to any other structural shock from the model. This simple assumption is based on the motivation that, oil production and demand and hence oil prices are in most cases either unaffected or respond only marginally to shocks emerging from the metals and minerals or agricultural sectors. Also metal prices are assumed to be affected contemporaneously by fuel prices but not by agricultural prices. Agricultural prices on the other hand are affected contemporaneously by both fuel prices and metal prices since most agricultural production depends heavily on both fuel and metal inputs. The three world commodity price measures are then assumed to have a contemporaneous effect on the relative international prices proxied by the terms of trade, real effective exchange rates and a constructed tradable goods measure.

We focus on the structural forecast error variance decomposition to provide quantitative estimates of the impact of the commodity price shocks on the relative price of tradable goods, real effective exchange rates and the terms of trade. The reported structural forecast error variance decomposition reported for each individual country are the median of the sum of the three commodity price shocks while the Median Absolute Deviations (MAD) estimates are reported for the country-group results. We prefer the MAD statistic because it is a more robust measure of variability and is insensitive to outliers compared to other statistics.

3.2.3 Panel Vector Autoregression (PVAR)

After having examined the relative importance of commodity price shocks on international price fluctuations, our objective is to study how commodity price shocks are transmitted to relative international prices. Therefore, for the last part of our empirical analysis we use the Panel Vector

Autoregression (PVAR) methodology of Love and Zicchino (2006) in order to estimate the effect of commodity price shocks for a given pooled-sample of countries. In particular, we focus on Impulse Response Function (IRF) analysis and investigate how shocks to commodity prices affect our 3 measures of relative international prices – the relative price of tradable goods (Xt), real effective exchange rates (REERs), and the terms of trade (ToT).

The PVAR methodology combines the traditional VAR approach which treats all variables in the model as endogenous with a panel data approach which allows for unobserved individual heterogeneity. Following Love and Zucchino (2006), the first order PVAR can be specified as

$$Z_{it} = \omega_0 + \beth Z_{it-1} + \delta_i + \tau_t + e_t \tag{3.9}$$

Where Z_{it} is a vector of endogenous panel variables including the three aggregate commodity prices, real exchange rates and the terms of trade, $\beth$ is the matrix of autoregressive panel coefficients, δ_i is the unobserved individual country effect, which is introduced into the system to account for individual heterogeneity so as to allow us to impose the restriction that the underlying VAR structure is the same for each cross-sectional unit. τ_t is time fixed effects and e_t is the innovation term. The PVAR assumes a recursive identification structure similar to the SVAR approach. The identification assumption is that variables placed earlier in the ordering affect the later variables contemporaneously while the later variables affect the earlier variables only with a lag. Thus variables that are placed earlier in the panel are more exogenous and later variables are more endogenous. In our specification for the PVAR, we place fuel prices first followed by metal and mineral prices, agricultural prices and the relative international price measures. Similar to the SVAR case, fuel prices are placed first since they are assumed to be more exogenous.

We follow, Abrigo and Love (2016) who use forward mean-differencing or 'Helmert procedure' due as an alternative transformation procedure (Arellano and Bover, 1995). Instead of using first difference transformations to eliminate the fixed effects, the Helmert procedure subtracts the average of all available future observations and can be applied to unbalanced panels thereby minimizing data loss. This transformation therefore preserves the orthogonality between transformed variables and lagged regressors thereby allowing the lagged regressors as instruments and GMM can be used to estimate the system equations. Our PVAR estimates are therefore based on the GMM procedure with the lagged variables used as instruments where missing observations are substituted with zero to prevent the problems of having to lose observations when more lags are used.

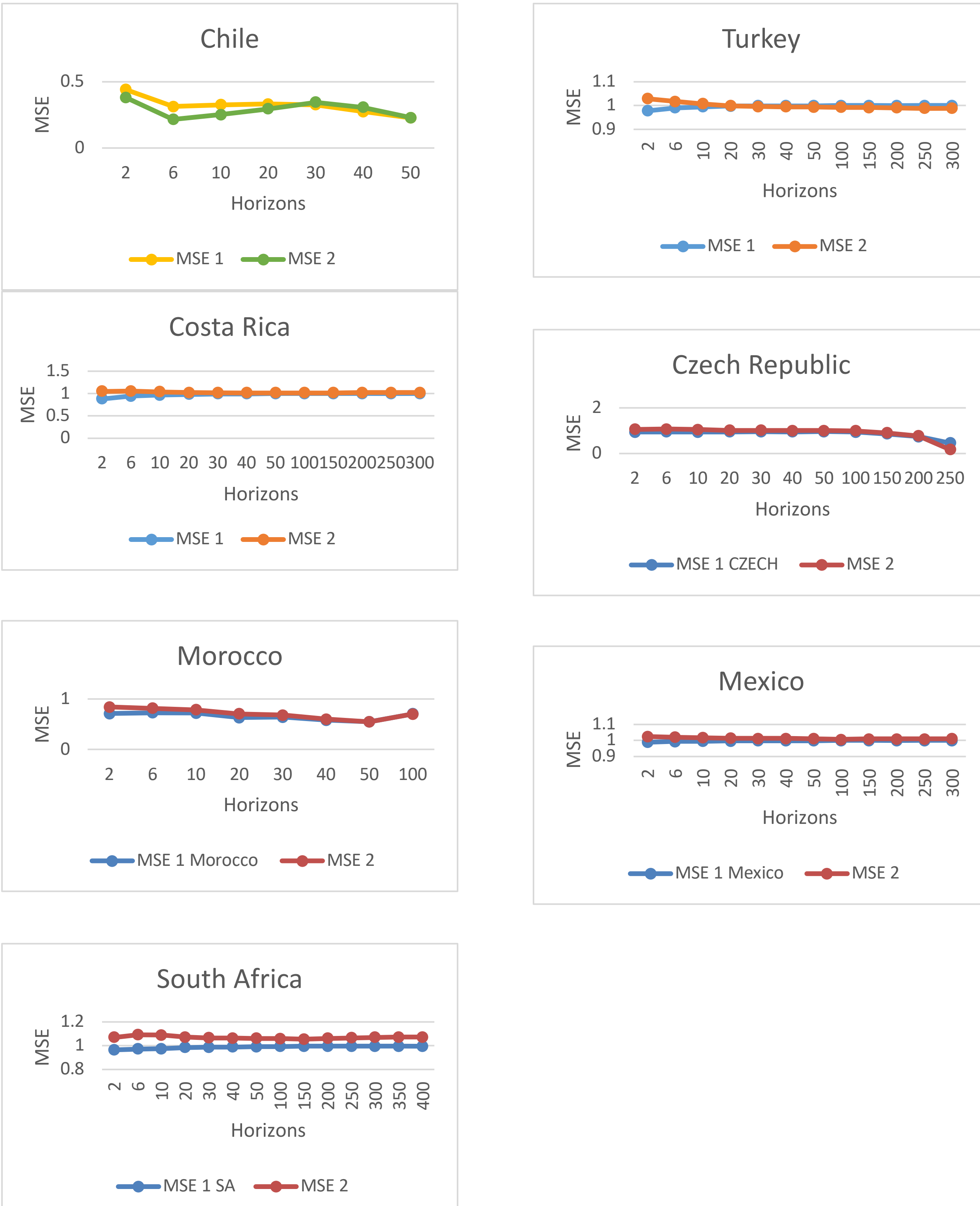
4.0 Results

In this section we proceed to present and discuss the results obtained from our empirical analyses. Section 4.1 examines the relative importance of tradable and non-tradable prices on (bilateral) real exchange rate movements in EMEs. Section 4.2 presents the results from the SVAR analysis regarding the effect of world commodity price shocks on international price fluctuations for both EMEs and high-income countries. Finally, in section 4.3 we estimate several PVAR specifications and analyze the model implied IRFs in terms of the impact of commodity price shocks on international prices.

4.1 Real Exchange Rates in EMEs

This section focuses on the MSE decomposition of the real exchange rates into the traded and non-traded components for a sample of seven (7) EMEs following the methodology proposed by Engel (1999). Results are reported for different measures including Consumer prices, Output prices, Personal consumption expenditures, the overall PPI and CPI and also manufacturing PPI. However, we focused on the MSE decomposition using the PPI and CPI since it covers much more countries than the other measures used and hence was used as the measure of the tradable goods in part two of the study. The results from the MSE decomposition using the PPI and CPI are presented in Figure 1 while results from the other measures of the real exchange rates are reported in Appendix A. We use two different measures of the PPI in calculating the MSE decomposition – the overall PPI and the manufacturing PPI. Results show that for all the measures of the tradable and non-tradable goods adopted, nearly all the movement in the real exchange rate is accounted for by the traded goods price component in all countries. When the overall PPI was used, again the movement in tradable goods accounted for all most all the movements in the real exchange rates except Chile and Morocco in which traded goods accounted for about 30% and 70% of movements in the real exchange rates respectively. However, when the manufacturing PPI index was used to calculate the traded goods, again nearly all movement in real exchange rates in all countries including Chile and Morocco were explained by the traded goods component. Graphical representations of the results are presented in figure 1. Closer investigation of the results from figure 1 however shows that, traded goods (x_t) accounted for more than 100 percent of the MSE of real exchange rates (q_t) when the formula presented in equation 3.8 (in appendix) was used. Engel (1999) however explain this as due to the implicit assumption implied by equation (3.8). He argued that, it is possible for x_t to account for more than 100 percent of the MSE of q_t if the co-movement between x_t and y_t are sufficiently negative since equation (3.8) arbitrarily classifies half of the co-movements as being caused by movements in x_t and the other half as being caused by movement of y_t.

Figure 1. MSE Decomposition plots. MSE 1 denotes the MSE decomposition obtained using equation (3.4) which assumes no co-movement and MSE 2 denotes the MSE decomposition obtained using equation (3.8) which assumes co-movement. Data used is monthly from 1970:1 -2018:06 and differ for different countries.



The MSE decomposition for the quarterly and annual series are presented in appendix A. In all cases, tradable goods account for almost all the movements in the real exchange rate. Most importantly, our results extend the validity of the findings of Engel (1999) to the case of EMEs. Namely, movements in (bilateral) real exchange rates are dominated by movements in relative traded goods prices.

4.2 Impact of Commodity Price Shocks on International Prices

Our finding that relative prices of traded goods dominate real exchange rate movements in EMEs begs the question about what component of traded goods tends to drive the high volatility of real international prices in general, in real exchange rates in particular. Given that commodity markets play a prominent role in world trade, we conjecture that commodity price shocks are plausibly one of the driving forces behind real exchange rate movements in EMEs, which tend to be less industrialized and more resource rich compared to high-income countries.

Hence, in this section we use SVAR analysis to estimate the effect of commodity prices on international prices. Namely, real exchange rates ($X_t, REER_t$) and the terms of trade (TOT_t). Furthermore, we next conduct impulse response function (IRF) analysis using the PVAR methodology of Love and Zicchino (2006) to examine how commodity price shocks are transmitted to relative international prices. We estimate the SVAR and PVAR in both levels and cyclical components, the latter obtained from HP filtered data[3]

Figure 2 shows the graphs in both levels and cyclical components for our three real commodity price variables. The left panels show real commodity prices in levels while the right panels show the cyclical components. Real commodity prices are deflated using the CPI of the US. As

[3] Since series are in annual frequency, we HP-filter the data with a smoothing parameter of 100.

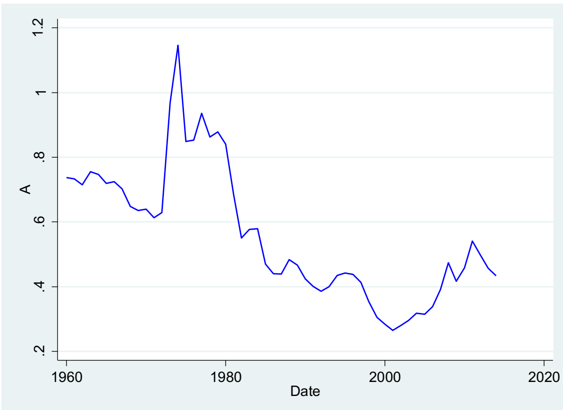
observed from Figure 2 and Table 1, the three commodity prices display significant volatility over the sample period in both levels and their cyclical components. The cyclical components of commodity prices show positive co-variation and are highly volatile with deviations from trend reaching more than 40% in the sample countries. Tables 1A and 1B summarize the second moments of the cyclical components. The standard deviation of the real commodity prices ranges from 12% to 21%. All three real commodity prices also display significantly high correlations with each other with pairwise correlations of between 0.35 and 0.59. The terms of trade displayed a negative variation with all three commodity prices while

The relative price of tradable goods displayed negative co-movement with metal prices but positive variation with fuel and agricultural prices. Finally, the Real effective exchange rate shows stronger positive co-movements with all three commodity prices.

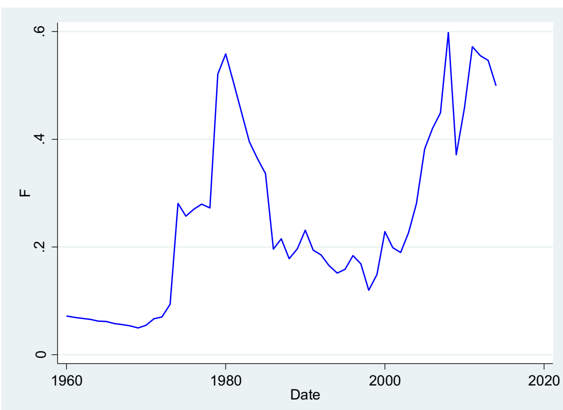
From the above statistics, we conjecture that the negative variations of the terms of trade with the commodity price shocks may be due to the fact that, majority of the countries in our sample are net importers of oil, agricultural commodities and metals respectively. Hence a rise in commodity prices leads to an increase in import price indices relative to export price indices resulting in a fall in the terms of trade measured as the price index of exports divided by the price index of imports.

Figure 2. Real commodity prices in levels and cyclical components. Left panel display the level of US dollar commodity price indices deflated by the US CPI. The right panel shows the cyclical components obtained using the HP filter with a smoothing parameter of 100. Data is annual and covers 1960 -2014.

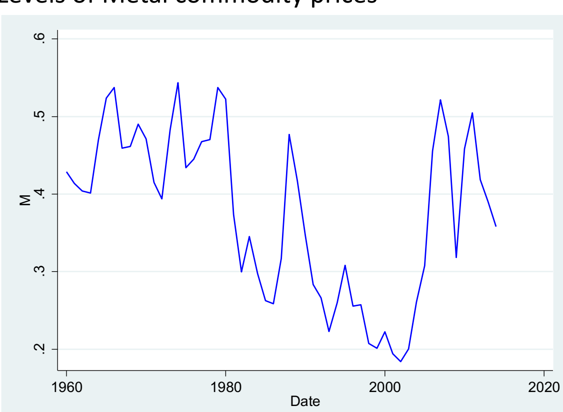
Levels of Agricultural Commodity prices



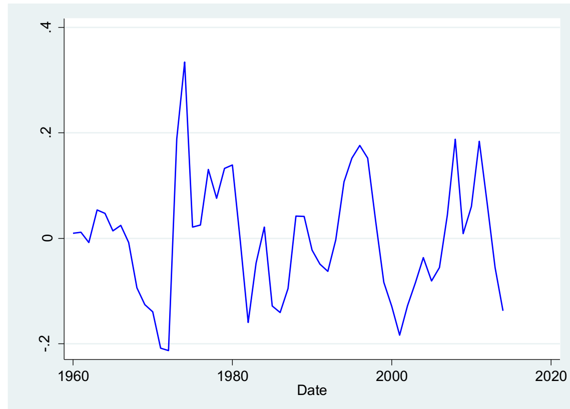
Levels of Fuel commodity prices



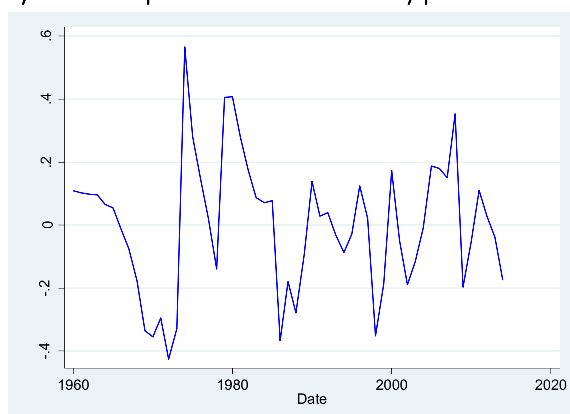
Levels of Metal commodity prices



Cyclical Component Agricultural commodity prices



Cyclical Component Fuel commodity prices



Cyclical Component Metal commodity prices

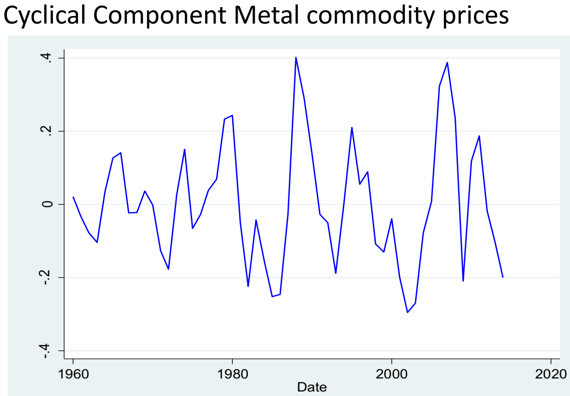


Table 1A. SUMMARY STATISTICS

Statistics	X		
	P^a	P^m	P^f
Standard deviation $\sigma(x)$	11.41	16.55	21.09
Correlation with Agric $\rho(P^a, x)$	1.00	0.59	0.49
Correlation with Metals, $\rho(P^m, x)$	0.59	1.00	0.35
Correlation with Fuel, $\rho(P^f, x)$	0.49	0.35	1.00

Notes: The P^f, P^m *and* P^a denotes the cyclical components of real fuel prices, metal prices and agricultural prices respectively detrended using the HP filter with a smoothing parameter of 100. Data used is annual data for the period 1960 -2014. Results table 1A applies to both individual countries and across panel of 30 countries.

Table 1B. Pairwise correlations of Commodity prices and Real Exchange rates

Statistics	X		
	P^a	P^m	P^f
Correlation with tot, $\rho(\text{tot}, x)$	-0.008	-0.02	-0.09
Correlation with xt $\rho(\text{xt}, x)$	0.006	-0.03	0.10
Correlation with reer $\rho(\text{reer}, x)$	0.14	0.07	0.14
Relative standard devia. $\sigma(x)/\sigma(y)$	3.67	5.67	7.00

Notes: The P^f, P^m *and* P^a denotes the cyclical components of real fuel prices, metal prices and agricultural prices respectively detrended using the HP filter with a smoothing parameter of 100. Data used is annual data for the period 1960 -2014. Statistics applies to the Panel of 30 countries in the sample and differs for each individual country.

Next, Table 2 also presents the relative standard deviations of individual countries for two groups, EMEs and high-income countries. The relative standard deviations are variations of real commodity prices and international price measures in terms of variations in income (y). The results show that the real fuel commodity prices are as much as 10 times as volatile as output while agricultural and metal commodity prices are about 6 times and 8 times as volatile as output in the median high-income country. Further, these relative volatilities are higher in high-income countries vis-à-vis EMEs. In terms of international prices, real effective exchange rates and the terms of trade are slightly less volatile in EMEs than in high-income countries, whereas the relative price of traded goods is quite more volatile in the median high-income country compared to the median EME.

Table 2 Relative Price of Tradable goods and Real effective exchange rates

Country		pA	pM	pF	Tot	reer	xt
	Std. Dev (p)	0.12	0.17	0.21			
Middle Income	**Std. Dev (Y)**	**Std. Dev (p)/ Std. Dev (Y)**					
Costa Rica	0.03	4.00	5.67	7.00	2.67	3.00	2.33
Chile	0.05	2.00	3.40	4.20	2.20	1.60	2.80
Colombia	0.02	6.00	8.50	10.50	4.00	6.00	6.5
Morocco	0.03	4.00	5.67	7.00	2.33	0.67	2.67
Philipines	0.03	4.00	5.67	7.00	1.67	3.00	4.33
South Africa	0.02	6.00	8.50	10.50	7.50	4.00	7.50
Turkey	0.04	3.00	4.25	5.25	1.75	2.00	9.25
Paraguay	0.04	3.00	4.25	5.25	3.00	2.00	4.50
Mexico	0.03	4.00	5.67	7.00	3.33	4.00	13.00
Algeria	0.03	4.00	5.67	7.00	5.67	4.33	2.00
Albania	0.07	1.71	2.43	3.00	3.14		1.29
Argentina	0.06	2.00	2.83	3.50	1.67	2.67	1.83
Malaysia	0.03	4.00	5.67	7.00	1.67	2.00	2.33
Hungary	0.04	3.00	4.25	5.25	0.75	1.00	1.75
Thailand	0.04	3.00	4.25	5.25	1.00	1.25	1.75
Mean	**0.04**	**3.58**	**5.11**	**6.31**	**2.82**	**2.68**	**4.26**
Median	**0.03**	**4.00**	**5.67**	**7.00**	**2.33**	**2.34**	**2.67**
High Income Count.							
Canada	0.02	6.00	8.50	10.50	1.50	2.50	2.00
Denmark	0.02	6.00	8.50	10.50	1.00	1.50	4.50
Finland	0.04	3.00	4.25	5.25	0.75	1.25	5.50
France	0.02	6.00	8.50	10.50	1.50	1.50	3.00
Germany	0.02	6.00	8.50	10.50	2.00	2.00	5.00
Czech Rep	0.03	4.00	5.67	7.00	1.00	1.67	4.67
Japan	0.02	6.00	8.50	10.50	3.50	4.50	4.50
Norway	0.02	6.00	8.50	10.50	3.50	4.00	4.50
UK	0.02	6.00	8.50	10.50	1.50	3.50	3.50
Australia	0.02	6.00	8.50	10.50	3.00	3.50	4.00
Austria	0.02	6.00	8.50	10.50	1.00	1.00	4.50
Belguim	0.02	6.00	8.50	10.50	1.00	2.00	4.00
Ireland	0.04	3.00	4.25	5.25	1.00	1.25	1.75
Italy	0.02	6.00	8.50	10.50	1.50	2.50	4.50
Netherlands	0.02	6.00	8.50	10.50	0.50	1.50	4.50
New Zealand	0.03	4.00	5.67	7.00	3.00	2.33	3.00
Mean	**0.02**	**5.38**	**7.62**	**9.41**	**1.70**	**2.28**	**3.96**
Median	**0.02**	**6.00**	**8.50**	**10.50**	**1.50**	**2.00**	**4.50**

Note: The relative prices are measured as the standard deviation of the real variables (P^a, P^m and P^f, tot, xt and $reer$) divided by standard deviation of real income (y). The lowercase variables denote the cyclical component of agricultural, metals and minerals and fuel commodity price index, terms of trade, relative price of tradable goods and real effective exchange rates respectively.

4.2.1 World shocks mediated by Commodity prices (SVAR)

For the SVAR analysis we provide results for the estimated model in both levels and cyclical components. First, we examine the full sample of countries. Table 3 shows that world commodity price shocks accounts for 10% (levels) and 13% (cyclical) of movements in the relative price of traded goods in the median country. Next, when we use the terms of trade as the relevant measure of international prices, world shocks account for 13% (levels) and 16% (cyclical) of fluctuations in the median country. Last, when our measure of international prices is the real effective exchange rate, world shocks explain 11% (levels) and 10% (cyclical) of fluctuations in the median country. Furthermore, we observe that in terms of individual commodity prices, fuel price shocks account for a significant portion of shocks in the real exchange rates with fuel prices accounting for between 4% and 8% (levels) and between 3% and 11% (cyclical) of the shocks in international prices across our different measures. Metals and minerals explain on average between 3% and 5% of the shocks across measures when estimated in levels, and between 4% and 7% when estimated with the cyclical components. Similarly, agriculture commodity prices account for between 2% and 4% of the shocks when estimated with the levels, and between 4% and 6% when estimated with the cyclical components in the median country across the different measures. Overall, agriculture commodity prices and metals and minerals commodity prices combined explains more than half of the total variations in the real exchange rates attributed to commodity price shocks implying earlier estimates that ignore these sectors have essentially ignored an important contributory factor to the real exchange rate fluctuations.

Table 3. Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Cross – Country Results.

	Levels			Cyclical Component		
Country	**ToT**	**Xt**	**REER**	**tot**	**xt**	**reer**
Fuel Prices (P^f)	0.08	0.05	0.04	0.11	0.03	0.04
Metal Prices (P^m)	0.05	0.03	0.04	0.04	0.07	0.04
Agric. Prices (P^a)	0.04	0.02	0.03	0.06	0.04	0.05
All four price($P^f . P^m, P^a$)	**0.13**	**0.10**	**0.11**	**0.16**	**0.13**	**0.10**

Notes: Variance decompositions are based on country –by country estimates of the SVAR system. The reported figures are the cross-country MAD (median absolute deviation) estimates. ToT, Xt and REER refers to the terms of trade, tradable goods and the real effective exchange rates respectively. Statistics are computed across 30 countries

Commodity price shocks in EMEs

Next, we examine whether the effect of commodity prices varies across income groups. We classify countries into middle-income (EMEs) and high-income based on the IMF's income classification. Hence, 15 countries in our sample are EMEs and 16 are high-income. The results are presented in Table 4. Importantly, our results indicate that for all measures of international prices (except the terms of trade in levels), world commodity shocks account for a sizeable proportion of international price fluctuations in EMEs. Notably, world commodity price shocks explain about twice as much of international price volatility in EMEs than in high-income countries.

Table 4. Share of Variances Explained by World Shocks - Country group results.

	Levels			Cyclical Component		
Country	**ToT**	**Xt**	**REER**	**Tot**	**xt**	**Reer**
Middle Income Countries						
Costa Rica	0.39	0.08	0.12	0.52	0.26	0.27
Colombia	0.12	0.08	0.66	0.06	0.22	0.65
Chile	0.37		0.52	0.52		0.69
Mexico	0.23	0.44	0.15	0.26	0.46	0.19
Morocco	0.39	0.11	0.18	0.38	0.15	0.19
Philippines	0.25	0.54	0.55	0.34	0.68	0.48
South Africa	0.18	0.08	0.07	0.09	0.39	0.09
Turkey	0.25	0.33	0.10	0.49	0.22	0.21
Paraguay	0.07	0.80	0.48	0.12	0.73	0.37
Argentina	0.08	0.53	0.34	0.37	0.48	0.39
Albania	0.32	0.09		0.16	0.11	
Algeria	0.52	0.66	0.63	0.77	0.76	0.10
Hungary	0.18	0.10	0.32	0.14	0.15	0.43
Malaysia	0.23	0.36	0.53	0.29	0.54	0.41
Thailand	0.30	0.25	0.43	0.55	0.43	0.55
Median	**0.25**	**0.29**	**0.38**	**0.34**	**0.41**	**0.38**
MAD	**0.07**	**0.20**	**0.20**	**0.18**	**0.19**	**0.17**
High Income Countries						
Czech Republic	0.17	0.44	0.23	0.12	0.30	0.53
Canada	0.47	0.30	0.32	0.72	0.36	0.27
Denmark	0.41	0.14	0.23	0.35	0.23	0.28
Finland	0.11	0.20	0.12	0.18	0.35	0.18
France	0.64	0.44	0.10	0.52	0.45	0.18
Germany	0.44	0.17	0.32	0.51	0.16	0.26
Japan	0.71	0.30	0.35	0.66	0.40	0.32
Norway	0.37	0.10	0.07	0.59	0.47	0.09
UK	0.39	0.15	0.23	0.54	0.22	0.32
Australia	0.33	0.30	0.29	0.59	0.50	0.43
Austria	0.20	0.12	0.22	0.14	0.17	0.17
Belgium	0.50	0.21	0.21	0.42	0.26	0.22
Ireland	0.72	0.16	0.31	0.68	0.19	0.19
Italy	0.50	0.27	0.22	0.58	0.25	0.19
Netherlands	0.36	0.14	0.13	0.39	0.18	0.16
New Zealand	0.41	0.21	0.16	0.53	0.31	0.22
Median	**0.41**	**0.20**	**0.22**	**0.53**	**0.28**	**0.22**
MAD	**0.09**	**0.07**	**0.08**	**0.12**	**0.08**	**0.05**

Notes: Variance decompositions are based on country –by country estimates of the SVAR system. The reported figures are the cross-country MAD (median absolute deviation) estimates. ToT, Xt and REER refers to the terms of trade, tradable goods and the real effective exchange rates respectively. Statistics are computed across 31 countries.

Finally, we examine the strength of the effect of a commodity price shock for the case in which the countries are net exporters of a given commodity. As in Bordart et al. (2012), we classify a country as a net commodity exporter if the given commodity accounts for at least 20% of exports for that country. We draw on the Harvard Atlas of Economic Complexity and obtain data for 2014 net exports of Agricultural, Fuel and Metals and Minerals commodity trades based on the HS4 and STIC classifications across countries in our sample. We then group countries with at least 20% of net export in each category of commodities mentioned and provide estimates for them. The results are provided in tables 5A, 5B and 5C. Our estimates suggest that the effects of the shocks are somewhat mixed in that other than the terms of trade, there is no particular preponderance of commodity price shocks on international price movements for net commodity exporters.

Table 5A. Share of Variances Explained by World Shocks and Mediated by Agricultural Commodity Prices. Country-specific results.

	Levels			Cyclical Component		
Country	**ToT**	**Xt**	**REER**	**tot**	**xt**	**reer**
Argentina	0.05	0.45	0.15	0.35	0.31	0.12
Canada	0.22	0.03	0.03	0.31	0.05	0.01
Denmark	0.32	0.04	0.01	0.08	0.13	0.13
Finland	0.01	0.12	0.09	0.02	0.23	0.11
France	0.32	0.30	0.03	0.12	0.34	0.09
Netherlands	0.28	0.04	0.04	0.20	0.06	0.04
New Zealand	0.23	0.09	0.02	0.36	0.13	0.08
Paraguay	0.03	0.43	0.23	0.03	0.40	0.17
Median	**0.22**	**0.11**	**0.03**	**0.16**	**0.18**	**0.10**
MAD	**0.10**	**0.07**	**0.02**	**0.14**	**0.13**	**0.02**

Notes: Variance decompositions are based on country –by country estimates of the SVAR system using only Agricultural price index. The reported figures are the cross-country MAD (median absolute deviation) estimates. ToT, Xt and REER refers to the terms of trade, tradable goods and the real effective exchange rates respectively.

Table 5B. Share of Variances Explained by World Shocks and Mediated by Fuel Commodity Prices.

	Levels			Cyclical Component		
Country	**ToT**	**Xt**	**REER**	**Tot**	**xt**	**reer**
Algeria	0.55	0.10	0.35	0.68	0.13	0.01
Australia	0.05	0.11	0.04	0.15	0.06	0.17
Canada	0.21	0.09	0.03	0.59	0.08	0.06
Colombia	0.03	0.01	0.50	0.00	0.07	0.35
Norway	0.22	0.07	0.01	0.40	0.06	0.04
Paraguay	0.07	0.41	0.35	0.06	0.45	0.16
Median	**0.14**	**0.10**	**0.19**	**0.28**	**0.07**	**0.11**
MAD	**0.09**	**0.02**	**0.16**	**0.24**	**0.01**	**0.07**

Notes: Variance decompositions are based on country –by country estimates of the SVAR system using only Agricultural price index. The reported figures are the cross-country MAD (median absolute deviation) estimates. ToT, Xt and REER refers to the terms of trade, tradable goods and the real effective exchange rates respectively.

Table 5C. Share of Variances Explained by World Shocks and Mediated by Metals and Minerals Commodity Prices

	Levels			Cyclical Component		
Country	**ToT**	**Xt**	**REER**	**Tot**	**xt**	**reer**
Austria	0.03	0.01	0.07	0.01	0.03	0.02
Finland	0.02	0.15	0.11	0.00	0.26	0.17
Belguim	0.20	0.04	0.08	0.06	0.10	0.03
Japan	0.36	0.08	0.11	0.16	0.06	0.10
Turkey	0.23	0.01	0.05	0.11	0.09	0.07
Median	**0.20**	**0.04**	**0.08**	**0.06**	**0.09**	**0.07**
MAD	**0.16**	**0.03**	**0.03**	**0.05**	**0.04**	**0.04**

Notes: Variance decompositions are based on country –by country estimates of the SVAR system using only Agricultural price index. The reported figures are the cross-country MAD (median absolute deviation) estimates. ToT, Xt and REER refers to the terms of trade, tradable goods and the real effective exchange rates respectively.

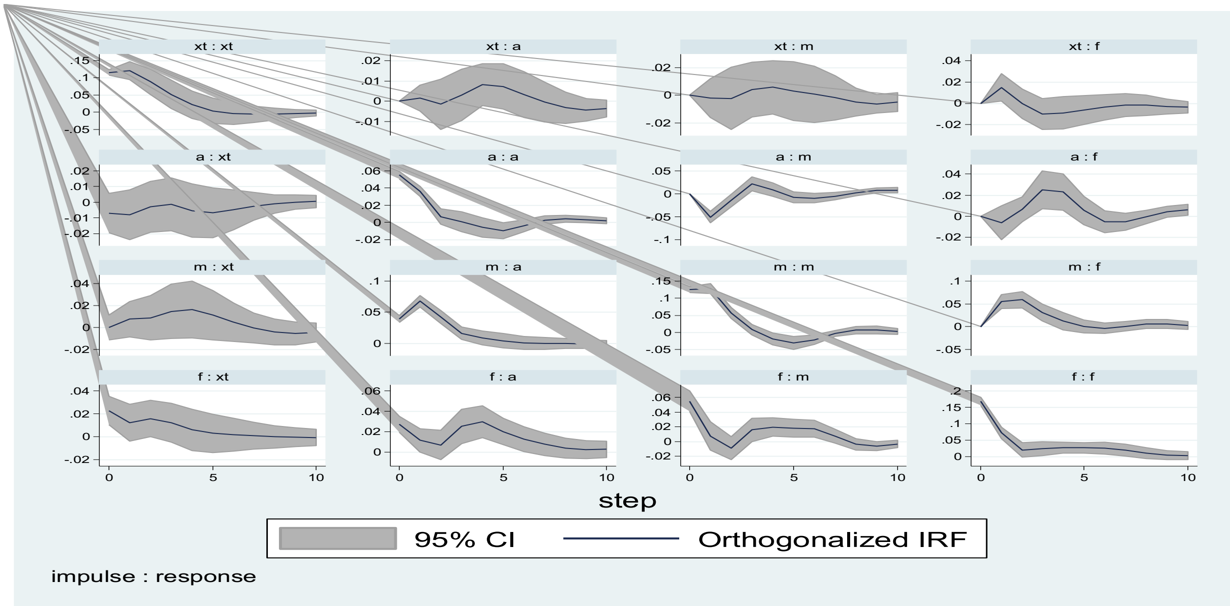
4.2.2 World Shocks mediated by Commodity Prices – PVAR Impulse Response Functions

In order to infer the general relationship between the commodity price shocks and the relative international prices across the panel of countries, we carry out an IRF analysis using the PVAR methodology of Love and Zicchino (2006). For ease of exposition, we present the results for the cyclical components of international prices. We use the conventional AIC, BIC and HQ optimum

lag selection criteria to select the number of lags in estimating the PVAR. The setup of the variables in the PVAR is the same as in the previous SVAR analysis. However the PVAR allows us to obtain estimates across the pooled-sample of countries instead of individual countries.
We present results for a pooled-sample of EMEs and for net commodity exporter panels. Finally, we also include a few country-specific IRFs from the SVAR for comparison. The IRFs for the EME sample are presented in Figures 3.1 to 3.3, the results for net commodity exporting panels are presented in Figures 4.1-4.3. Our focus is on the first column of each graph which depicts the response of the international prices to a one standard deviation shock in the commodity price measures.

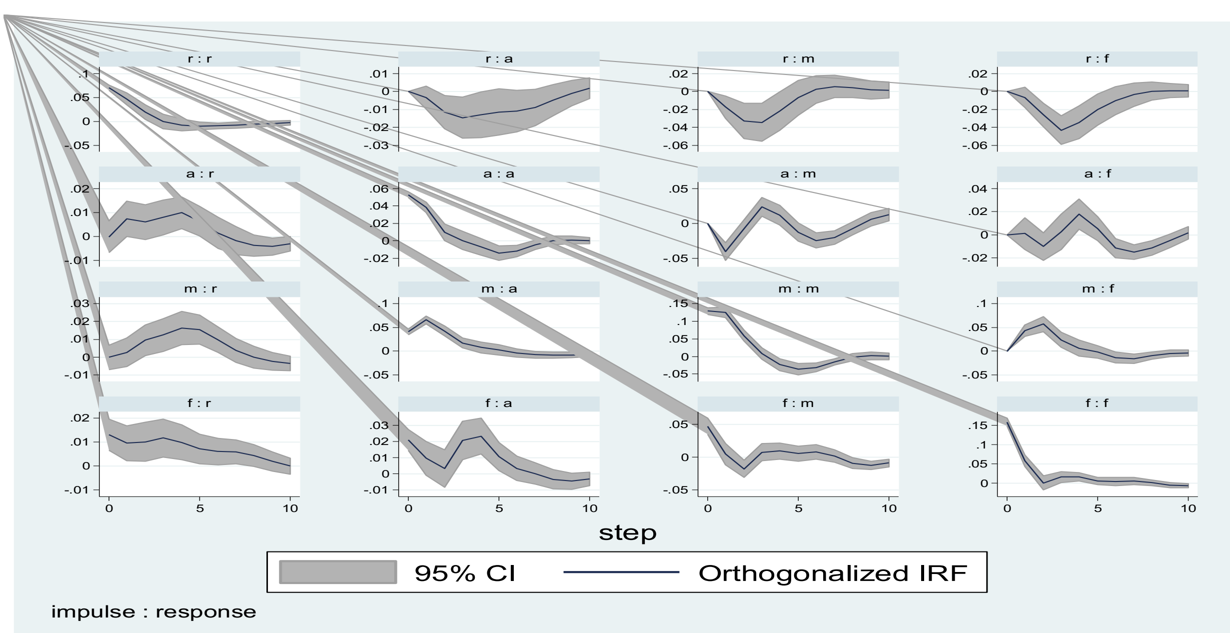
The results from Figure 3.1 shows that fuel commodity prices are associated with a depreciation of the relative price of tradable goods (x_t) In EMEs. Next, Figure 3.2 shows a similar depreciation on impact in the real effective exchange rate (r_t), in addition metals and agricultural commodity price shocks are associated with a depreciation in the medium run (year 5). Last, Figure 3.3 suggests that, for the panel of EMEs, there is no significant effect of world commodity prices on the terms of trade (tot_t).

Figure 3.1 **Impulse Response Functions-Commodity Prices and Relative Price of Tradable goods**



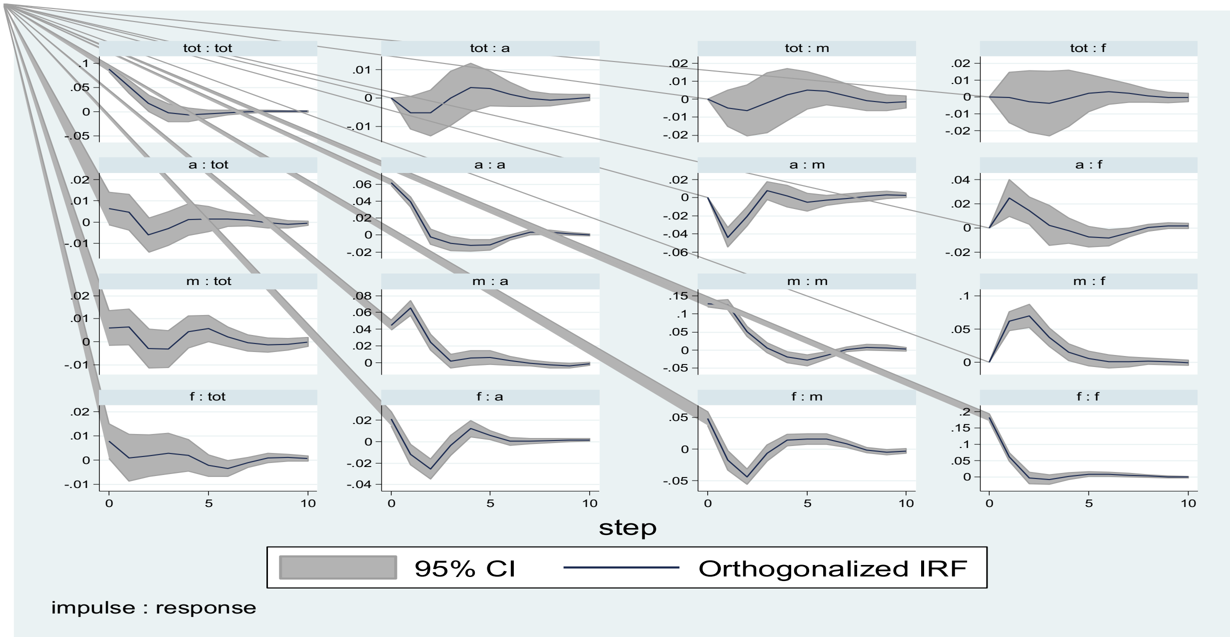
Notes: The IRF's are based on the Panel VAR approach of Love and Zicchino (2006). "a", "f" and "m" are the cyclical components of the Agricultural commodity prices, fuel prices and metals and minerals prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 100. Data is annual from 1960 -2014 and the sample size is 15

Figure 3.2 **Impulse Response Functions-Commodity Prices and Real Effective Exchange rates**



Notes: The IRF's are based on the Panel VAR approach of Love and Zicchino (2006). "a", "f" and "m" are the cyclical components of the Agricultural commodity prices, fuel prices and metals and minerals prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 100. Data is annual from 1960 -2014 and the sample size is 15

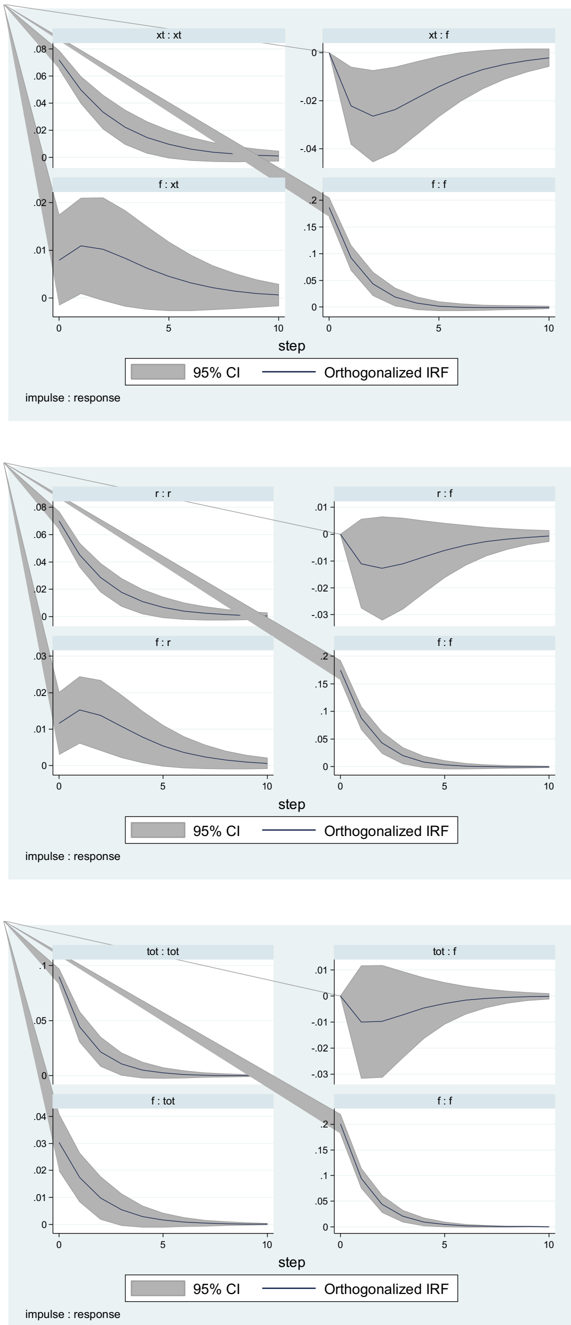
Figure 3.3 Impulse Response Functions-Commodity Prices and Terms of Trade



Notes: The IRF's are based on the Panel VAR approach of Love and Zicchino (2006). "a", "f" and "m" are the cyclical components of the Agricultural commodity prices, fuel prices and metals and minerals prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 100. Data is annual from 1960 -2014 and the sample size is 15

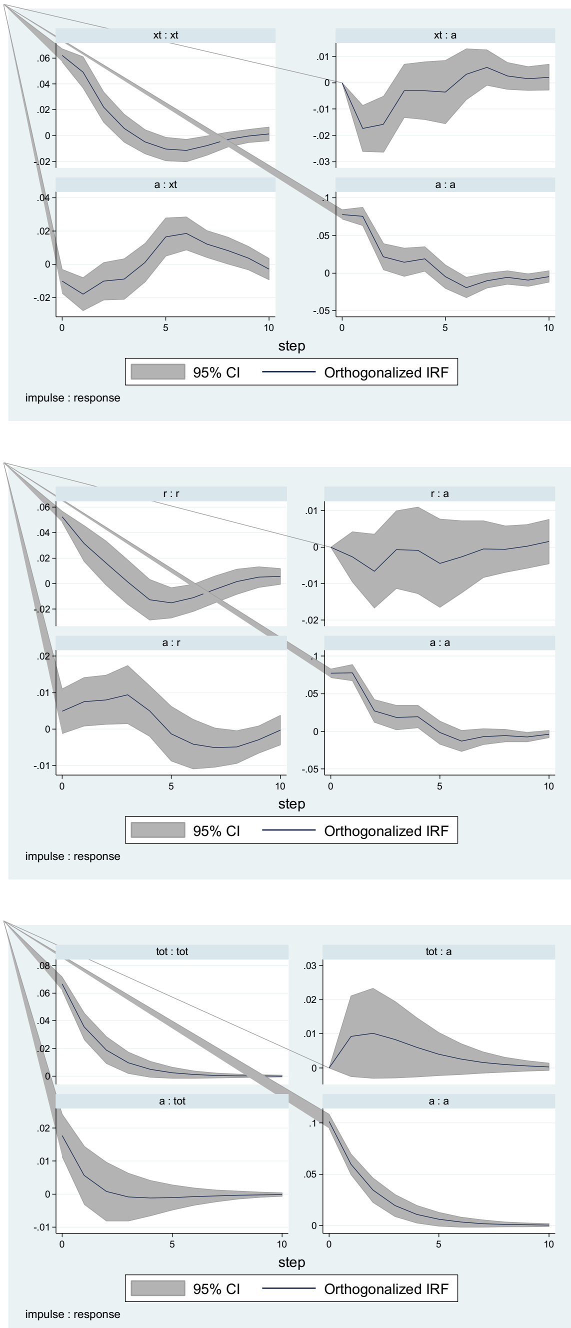
Next, we examine the IRFs for net commodity exporting panels summarized in Figures 4.1 to 4.3. The lower left panels in Figure 4.1 show that an increase in fuel prices is associated with a real exchange rate depreciation as well as a sizeable improvement in the terms of trade. Next, in Figure 4.2 for the case of agricultural prices we also observe a significant improvement in the terms of trade, and an appreciation on impact followed by a depreciation on the medium run in the relative price of traded goods. Last, Figure 4.3 shows that an increase in the price of metals and minerals is associated with a small but significant improvement in the terms of trade.

Figure 4.1 Impulse Response Functions-Fuel Prices and Relative International Prices



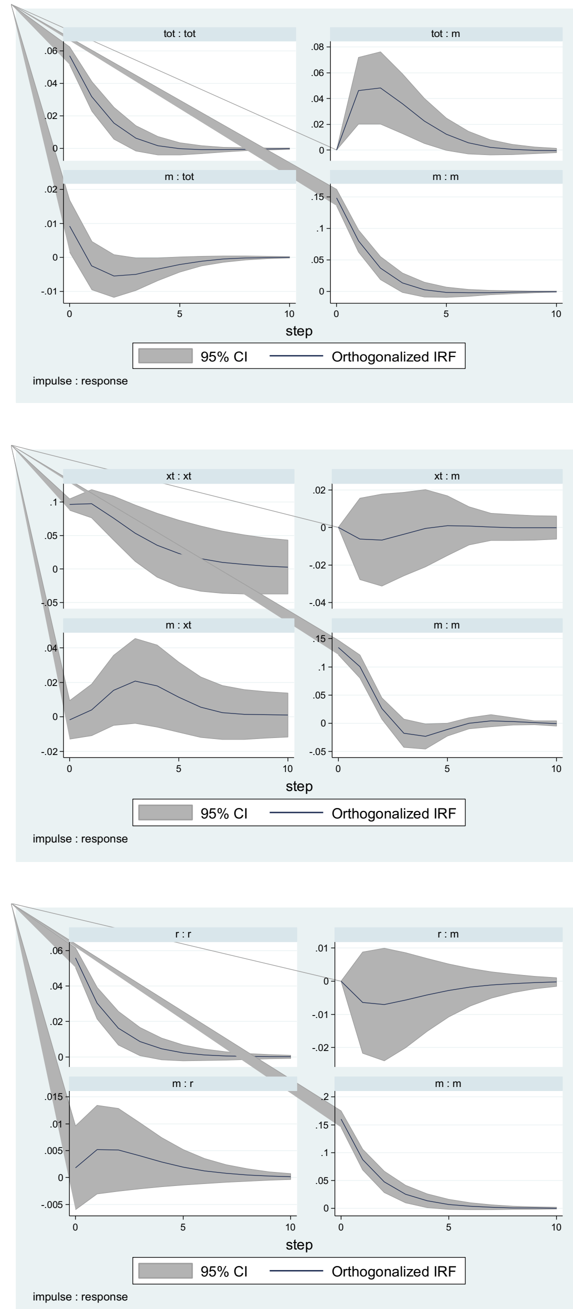
Notes: The IRF's are based on the Panel VAR estimates of Love and Zicchino (2006). "a", "f" and "m" are the cyclical components of the Agricultural, fuel and metals and minerals prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 100. Data is annual from 1960 -2014 and the sample size is 6

Figure 4.2 Impulse Response Functions - Agricultural Prices and Relative International Prices



Notes: The IRF's are based on the Panel VAR estimates of Love and Zicchino (2006). "a", "f" and "m" are the cyclical components of the Agricultural, fuel and metals and minerals prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 100. Data is annual from 1960 -2014 and the sample size is 8

Figure 4.3 Impulse Response Functions- Metals and Minerals Prices and Relative International Prices



Notes: The IRF's are based on the Panel VAR estimates of Love and Zicchino (2006). "a", "f" and "m" are the cyclical components of the Agricultural, fuel and metals and minerals prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 100. Data is annual from 1960 -2014 and the sample size is 6
from 1960 -2014.

In sum, the panel results for EME countries indicate that world commodity prices have a significant effect in leading to a depreciation of real exchange rates, even though the effect on the terms of trade is somewhat muted. In contrast, the panel results for net commodity exporting countries show that there is a sizeable improvement on the terms of trade from a commodity price shock. The former result suggests that world commodity prices do have an important effect on real exchange rates. Finally, the latter result is in the expected direction, since it is consistent with the fact that a major exported commodity drives the dynamics of the terms of trade of net commodity exporting countries.

5. Conclusions

What drives the high volatility of real exchange rate fluctuations in Emerging Market Economies (EMEs)? We perform an exchange rate accounting exercise and show that the relative price of traded goods is the dominant factor of real exchange rate movements in EMEs. We then ask, how important are world commodity prices in explaining the volatility of international prices in EMEs? We employ SVAR and PVAR techniques and find that world commodity prices explain about 20% of the high variation of international prices in EMEs. Moreover, we find that the effect of world commodity prices is about as twice as large in EMEs than in high income countries. We also show that commodity price shocks i) tend to be associated with real exchange rate depreciations in EMEs, and ii) lead to an improvement in the terms of trade of net commodity exporting countries. As world commodity shocks are associated with important macroeconomic implications for both business cycles and international competitiveness, further research is needed in order to explore the mechanisms through which commodity price shocks get amplified in EMEs.

References

Abrigo, M.R. and Love, I., 2016. *Estimation of panel vector autoregression in stata: A package of programs*. University of Hawaii. Working paper, (16-2).

Aguiar, M. & Gopinath, G. 2007. *Emerging market business cycles: The cycle is the trend*. Journal of political Economy, 115(1), 69-102.

Arellano, M. and Bover, O., 1995. *Another look at the instrumental variable estimation of error-components models*. Journal of econometrics, 68(1), pp.29-51.

Drechsel, T., & Tenreyro, S. 2018. *Commodity booms and busts in emerging economies*. Journal of International Economics, 112, 200-218.

Dube, O. & Vargas, J. F. 2013. *Commodity price shocks and civil conflict: Evidence from Colombia.* The Review of Economic Studies, 80(4), 1384-1421.

Engel, C., 1999. *Accounting for US real exchange rate changes*. Journal of Political Economy, 107(3), pp.507-538.

Fornero, J. A., Kirchner, M. & Yany, A. 2016. *Terms of trade shocks and investment in commodity-exporting economies*. Banco Central de Chile.

Garcia-Cicco, J., Pancrazi, R., & Uribe, M. 2010. *Real business cycles in emerging countries?*. American Economic Review, 100(5), 2510-31.

Kilian, L., 2009. *Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market.* American Economic Review, 99(3), pp.1053-69.

Kinda, M.T. 2016. *Commodity price shocks and financial sector fragility*. International Monetary Fund.

Love, I. and Zicchino, L., 2006. *Financial development and dynamic investment behavior: Evidence from panel VAR.* The Quarterly Review of Economics and Finance, 46(2), pp.190-210.

Mohtadi, S. 2018. *Commodity price shocks and inequality: cross-country evidence*. Department of Applied Economics, Universitat Autonoma de Bacelona.

Schmitt-Grohé, S., & Uribe, M. 2018. *How Important are Terms-Of-Trade Shocks?*. International Economic Review, 59(1), 85-111.

Torvik, R., 2002. *Natural resources, rent seeking and welfare.* Journal of development economics, 67(2), pp.455-470.

Uribe, M., & Yue, V. Z. 2006. *Country spreads and emerging countries: Who drives whom?*. Journal of international Economics, 69(1), 6-36.