

# Three Essays on Commodity Price Shocks and the Macroeconomy

by

Francis K. Dzikpe

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

Department of Economics

University of Manitoba

Winnipeg

Copyright ©2022 by Francis K. Dzikpe

## **Examining Committee Membership**

Supervisor: Dr. Carlos Yopez  
Department of Economics, University of Manitoba

Internal Member: Dr. Umut Oguzoglu  
Department of Economics, University of Manitoba

Internal Member: Dr. Janelle Mann  
Department of Economics, University of Manitoba

External Member: Dr. Francesca Rondina  
Department of Economics, University of Ottawa

## Abstract

Business cycle variations are a common feature of the global economy. When they do occur, they impose severe macroeconomic consequences on the global economy. Hence understanding the sources and consequences of business cycle variations is at the heart of macroeconomics. This thesis focuses on the role of commodity price shocks in explaining the presence of large disruptions in the business cycles of Emerging Market Economies (EME's) and Advanced Economies (AE's). The thesis consists of three Essays. The first essay delves deeper into the resource curse literature by examining the role of commodity price shocks (acting as an income shock) in explaining corruption in resource rich countries. I accomplish this objective in two ways. First, I provide an analytical model detailing how shocks in commodity prices can affect corruption. The model is an extension of the nonbenevolent principal agent framework of Adsera, Boix and Payne (2003) and Bhattacharyya and Hodler (2010) to include commodity endowments whose prices are subject to exogenous fluctuations. These exogenous fluctuations generate income shocks that affect the expected returns from corruption and hence the choice between corruption and productive behavior. Second, I use a dataset on corruption and commodity prices from the International Country Risk Guide (ICRG) and the World Bank's Pink Sheet to empirically gauge the effect of commodity price shocks on corruption in a panel of 51 commodity-dependent countries using the Panel Quantile regression approach of Powell (2016). Results confirm the theoretical proposition that, corruption in resource rich countries increase significantly in response to commodity price shocks and that, significant differences exist in country effects and type of commodity exported.

The second chapter "Accounting for Real Exchange Rates in Emerging Market Economies; The Role of Commodity Prices" co-authored with Dr. Carlos Yezpez, examined the sources of the large real exchange rate variations in EME's by conducting an accounting exercise that decomposes the

real exchange rate changes in EME's into a tradable and non-tradable component following the proposition of Engel (1999). We also conduct a forecast error variance decomposition exercise to quantify the proportion of the variations in the real exchange rates explained by commodity price shocks. We find that the relative price of tradable goods is the largest determinant of real exchange rate changes in both EME's and AE's and that commodity prices have a sizeable impact in explaining the puzzlingly large variability of international prices in EMEs.

The final chapter "Commodity Terms of Trade Shocks and Real Exchange Rate dynamics" examined the contribution of commodity terms of trade shocks to the dynamics of real exchange rates in a sample of 28 countries. Betts and Kehoe (2006); Burstein et al. (2006) individually suggest that the relative importance of tradable and non-tradable goods depends largely on the choice of price series used in measuring tradable and non-tradable goods and that price series such as the PPI and CPI adopted in measuring the relative price of tradable goods in the literature contains a large component of non-tradable goods hence over stating the importance of tradable goods. In an answer to this observation, I re-examined the contribution of tradable goods prices to real exchange rate variations by constructing the relative price of tradable and non-tradable goods using a purely traded goods price -commodity terms of trade prices. I also decompose the historical commodity price variations into (i) common component and (ii) idiosyncratic component using the Panel Structural Vector Autoregressive (PSVAR) approach of Pedroni (2013) and examined the response of the real exchange rate to each component. I find that the relative price of tradable goods variations dominates the variations in real exchange rates even for tradable goods measured using purely traded goods price as the commodity terms of trade prices. I also find that the effects of commodity price shocks in EME's and AE's are mainly due to common factors or spillovers in the commodity terms of trade shocks.

## **Acknowledgements**

Leo Buscaglia once said, “change is the end result of all true learning”. The journey over the past 5 years have been life changing in every sphere of my life. I will forever be grateful to God for the gift of life over this period and to the University of Manitoba for the opportunity and support to accomplish this lifelong dream. The completion of this thesis would not have come to fruition without this support and the support, knowledge, skills, contributions, and criticisms of very distinguished personalities who need commendation.

I want to first and foremost express my sincere appreciation to the chair of my dissertation committee, Dr. Carlos Yopez. Dr. Carlos was one of two potential supervisors that I emailed when applying for the PhD program and his class was the first class I attended when I began the program. I remembered he ask me a question just some few minutes into the class after our introductions and he has since maintained a cordial yet friendly and productive relationship with me. Thank you, Carlos, for being a great role model. I am also grateful to Dr. Umut Oguzoglu and Dr. Janelle Mann, my other committee members who notwithstanding their busy schedule find time to offer their views, suggestions, constructive criticisms, and corrections when necessary to ensure the completion of this work. I will forever cherish my interaction with you and your contribution towards the completion of this work.

To the staff and faculty at the department of Economics, University of Manitoba especially Professors John Serieux, Greg Mason, Julia Witts, Wayne Simpson, and Ms. Betty McGregor, I say a very big thank you for the opportunity to work with you and learn from you. To friends and colleagues especially Evelina, Tomiwa, Raisa, Iqbal, Sidra, Jennifer, Mingjin and Bibhuti, I say a very big thank you for all your words of encouragement. You guys are simply amazing.

## **Dedication**

I dedicate this work first and foremost to the almighty God, to my parents Mr. Philip Dzikpe and Madam Esther Dometi and to my siblings.

## Table of Contents

<b>Abstract.....</b>	<b>iii</b>
<b>Acknowledgements .....</b>	<b>v</b>
<b>Dedication .....</b>	<b>vi</b>
<b>List of Tables .....</b>	<b>xi</b>
<b>List of Figures.....</b>	<b>xiv</b>
<b>Introduction.....</b>	<b>1</b>
<b>1. Commodity Price Shocks and Corruption .....</b>	<b>5</b>
1.1 Introduction.....	5
1.2 Literature Review.....	8
1.3 Data and Methodology.....	13
1.3.1 A Simple Analytical Model.....	13
1.3.2 Empirical Estimation Strategy.....	20
1.3.3 Data.....	25
1.3.4 Measuring commodity price Shocks .....	29
1.4 Empirical Results .....	31
1.4.1 Descriptive Statistics .....	31
1.4.2 Baseline Results.....	32

1.4.3 Disentangling the Effects of Commodity Price Shocks .....	36
1.4.4 Does the type of Commodity Matter? .....	41
1.4.5 Robustness Checks .....	43
1.5 Conclusion .....	44
References.....	46
APPENDIX A.....	51
<b>2. Accounting for Real Exchange Rates in Emerging Economies: The Role of Commodity Prices .....</b>	<b>60</b>
2.1 Introduction.....	60
2.2 Literature Review.....	62
2.3 Data and Methodology.....	66
2.3.1 Data.....	66
2.3.2 Methodology.....	69
3.3.2.1 Mean Square Error (MSE) Decomposition Analysis .....	69
2.3.2.2 Structural Autoregressions (SVARs).....	70
2.3.2.3 Panel Vector Autoregression (PVAR).....	72
2.4 Results.....	74
2.4.1 Real Exchange Rate Accounting .....	74
2.4.2 World Commodity Price Shocks and International Prices .....	78
2.4.2.1 World shocks mediated by Commodity prices (SVAR).....	83

2.4.3 Impulse Response Function (IRF) Analysis.....	88
2.5 Conclusions.....	<b>93</b>
References.....	<b>95</b>
APPENDIX B.....	<b>99</b>
<b>3. Commodity Terms of Trade Shocks and Real Exchange rate Dynamics.....</b>	<b>126</b>
3.1 Introduction.....	<b>126</b>
3.2 Literature Review.....	<b>132</b>
3.3 Data and Methodology.....	<b>136</b>
3.3.1 Data.....	136
3.3.2 Real Exchange Rate and Commodity Price Measures .....	137
3.3.3 Methodology.....	141
3.3.3.1 Mean Square Error (MSE) Decomposition Analysis .....	142
3.3.3.2 Pedroni PSVAR Estimation Approach.....	144
3.3.3.3 Local Projections (LP) Approach .....	148
3.4 Main Results .....	<b>149</b>
3.4.1 Real Exchange Rate Accounting- MSE Decompositions .....	149
3.4.1.1 Exchange Rates, Commodity Price Index and Producer Price Index- Stylized Facts.....	150
3.4.1.2 Real Exchange Rate Accounting .....	154
3.4.2 Commodity Price Shocks and Real Exchange Rates .....	161
3.4.2.1 Commodity Price Shocks and Real Exchange Rates – Variance Decompositions .....	162
3.4.2.2 Impulse Response Function (IRF) Analysis.....	167

3.5 Conclusion .....	171
References.....	173
Appendix C .....	176
<b>4. Summary and Conclusions .....</b>	<b>203</b>

## List of Tables

Table 1.1: Commodity Revenues as a percentage of Total Revenue and GDP.....	21
Table 1.2: Methodologies used in the Corruption Literature.....	23
Table 1.3: Descriptive Statistics .....	32
Table 1.4: Panel Quantile Regression Results .....	33
Table 1.5: OLS regression Results.....	36
Table 1.6: Panel Quantile Regression results -Negative Commodity Price Shocks.....	38
Table 1.7: Panel Quantile Regression results -Positive Commodity Price Shocks .....	39
Table 1.8: Panel Quantile results with Both Positive and Negative Commodity Price Shocks ...	40
Table 1.9: Commodity Group Regression Results .....	42
Table A.1: Sample Countries.....	51
Table A.2: Pairwise Correlations.....	52
Table A.3: Panel Quantile Regression with only Commodity price shocks.....	52
Table A.4: Panel Quantile Regression results -All Controls .....	52
Table A.5: Panel Quantile Regression results -Excluding Internal Conflict .....	53
Table A.6: Panel Quantile Regression results – Only Economic Variables.....	53
Table A.7: Panel Quantile Regression results -Social variables.....	54
Table A.8: Panel Quantile Regression results -Social variables excluding Internal Conflict .....	54
Table A.9: Panel Quantile Regression results - Internal Conflict.....	54
Table A.10: Panel Quantile Regression results – Economic Growth .....	55
Table A.11: Panel Quantile Regression results – Positive Commodity Price Shocks.....	55
Table A.12: Panel Quantile Regression results – Negative Commodity Price Shocks .....	56
Table A.13: Panel Quantile Regression results – Energy Commodity Price Shocks .....	56
Table A.14: Panel Quantile Regression results – Non-Energy Commodity Price Shocks.....	57
Table A.15: Panel Quantile Regression results – Agric Commodity Price Shocks.....	57
Table A.16: Panel Quantile Regression results – Metals & Minerals Commodity Price Shocks .	58
Table A.17: Panel Quantile Regression results – Post 2008 Sub-Sample .....	58
Table A.18: Panel Quantile Regression results – 5-year Averages .....	59
Table A.19: Variables and sources .....	59
Table 2.1A: Period Average MSE Decomposition – Emerging Market Economies.....	75
Table 2.1B: Period Average MSE Decomposition – Advanced Economies .....	75
Table 2.2A. Summary Statistics - World Commodity Prices .....	80
Table 2.2B. Pairwise correlations of Commodity prices and Real Exchange rates.....	80
Table 2.3. Relative Price of Tradeable goods and Real effective exchange rates .....	82
Table 2.4. Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Full sample of countries.....	84
Table 2.5 Share of Variances Explained by World Shocks - Country group results.....	85
Table 2.6A. Share of Variances Explained by World Shocks and Mediated by Agricultural Commodity Prices. NCX country-specific results.....	87
Table 2.6B. Share of Variances Explained by World Shocks and Mediated by Fuel Commodity Prices. NCX country-specific results.....	87
Table 2.6C. Share of Variances Explained by World Shocks and Mediated by Metals and Minerals Commodity Prices. NCX country-specific results.....	88
Table B1.1: Quarterly MSE Decomposition – Advanced Economies.....	103
Table B1.2: Quarterly MSE Decomposition – Advanced Economies.....	104

Table B1.3: Quarterly MSE Decomposition – Advanced Economies.....	105
Table B1.4: Quarterly MSE Decomposition – Advanced Economies.....	106
Table B2.1 MSE Decomposition using Consumer prices –Monthly data .....	107
Table B2.2 MSE Decomposition using Personal consumption expenditures-Costa Rica - Quarterly data.....	107
Table B3.1 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Full Sample Results .....	108
Table B3.2 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Individual Commodity Prices .....	109
Table B3.3 Country Specific Correlations of Commodity Prices and Income.....	110
Table B3.4 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Country Specific Estimates - Monthly.....	111
Table B3.5 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Country Group Estimates -Monthly.....	112
Table B3.6 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Country Group Estimates -Monthly.....	113
Table B3.7 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Country Group Estimates -Monthly.....	114
Table B4: List of Sample countries .....	115
Table 3.1: Summary Statistics .....	129
Table 3.2A: Correlations of Real Exchange Rates, Commodity Prices, and Producer Prices - Cyclical .....	153
Table 3.2B: Correlations of Real Exchange Rates, Commodity Prices, and Producer Prices - Levels.....	153
Table 3.3A: Period Average MSE Decomposition – Advanced Economies.....	155
Table 3.3B: Period Average MSE Decomposition – Emerging Market Economies.....	156
Table 3.4A: Period Average MSE Decomposition – Advanced Economies.....	157
Table 3.4B: Period Average MSE Decomposition – Emerging Market Economies.....	157
Table 3.5A. Share of Variances Explained by Net Export Commodity Price Shocks -AE.....	163
Table 3.5B. Share of Variances Explained by Net Export Commodity Price Shocks -EME.....	163
Table 3.6A. Share of Variances Explained by Common Net Export Commodity Price Shocks - AE .....	164
Table 3.6B. Share of Variances Explained by Common Net Export Commodity Price Shocks - EME .....	164
Table 3.7A. Share of Variances Explained by Idiosyncratic Export Commodity Price Shocks -AE .....	165
Table 3.7B. Share of Variances Explained by Idiosyncratic Export Commodity Price Shocks - EME .....	166
Table C1.1: Sample Countries – Exchange Rate Accounting .....	176
Table C1.2: Sample Countries – PSVAR Analysis .....	176
Table C2.1.1: Period Average MSE Decomposition – Advanced Economies.....	177
Table C2.1.2: Period Average MSE Decomposition – Emerging Market Economies.....	177
Table C2.1.3: Period Average MSE Decomposition – Advanced Economies.....	178
Table C2.1.4: Period Average MSE Decomposition – Emerging Market Economies.....	178
Table C2.1.5: Period Average MSE Decomposition – Advanced Economies.....	179
Table C2.1.6: Period Average MSE Decomposition – Emerging Market Economies.....	179

Table C2.1.7: Period Average MSE Decomposition – Advanced Economies .....	180
Table C2.1.8: Period Average MSE Decomposition – Emerging Market Economies .....	180
Table C2.1.9: Period Average MSE Decomposition – Advanced Economies .....	181
Table C2.2.0: Period Average MSE Decomposition – Emerging Market Economies .....	181
Table C2.2.1: Period Average MSE Decomposition – Advanced Economies .....	182
Table C2.2.2: Period Average MSE Decomposition – Emerging Market Economies .....	182
Table C2.2.3: Quarterly Period Average MSE Decomposition – Advanced Economies.....	183
Table C2.2.4: Quarterly Period Average MSE Decomposition – Advanced Economies.....	183
Table C2.2.5: Quarterly Period Average MSE Decomposition – Advanced Economies.....	184
Table C2.2.6: Quarterly Period Average MSE Decomposition – Advanced Economies.....	184
Table C3.2.1: Panel Unit root or Stationarity Results .....	185
Table C3.2.2: Share of Variances Explained by Export Commodity Price Shocks -AE.....	185
Table C3.2.3: Share of Variances Explained by Export Commodity Price Shocks -EME .....	186
Table C3.2.4: Share of Variances Explained by Common Export Commodity Price Shocks -AE .....	186
Table C3.2.5: Share of Variances Explained by Common Export Commodity Price Shocks -EME .....	186
Table C3.2.6: Share of Variances Explained by Idiosyncratic Export Commodity Price Shocks - AE .....	187
Table C3.2.7: Share of Variances Explained by Idiosyncratic Export Commodity Price Shocks - EME .....	187
Table 3.2.8: FEVDs – Estimated Using the Hamilton Filter – Composite Shocks-EME .....	188
Table 3.2.9: FEVDs – Estimated Using the Hamilton Filter – Composite Shocks-AE.....	188
Table 3.3.0: FEVDs – Estimated Using the Hamilton Filter – Common Shocks-EME.....	189
Table 3.3.1: FEVDs – Estimated Using the Hamilton Filter – Common Shocks-AE .....	189
Table 3.3.2: FEVDs – Estimated Using the Hamilton Filter – Idiosyncratic Shocks-EME .....	190
Table 3.3.3: FEVDs – Estimated Using the Hamilton Filter – Idiosyncratic Shocks-AE .....	190
Table C3.3.4: t-Test Assuming Equal Variances -RER.....	191
Table C3.3.5: t-Test Assuming Unequal Variances RER.....	191
Table C3.3.6: t-Test Assuming Equal Variances -REER .....	192
Table C3.3.7: t-Test Assuming Unequal Variances.....	192
Table 3.3.8: Exchange Rate Regimes of Sample Countries .....	193

## List of Figures

Figure 2.1. MSE Decomposition plots.....	77
Figure 2.2. Real commodity prices in levels and cyclical components. ....	81
Figure 2.3 International prices and World Commodity Price Shocks: EME panel IRFs .....	90
Figure 2.4 International prices and World Commodity Price Shocks: AE panel IRFs .....	90
Figure 2.5 International prices and World Commodity Price Shocks: Full sample IRFs.....	91
Figure 2.6 International prices and World Commodity Price Shocks: Full sample IRFs.....	91
Figure 2.7 Relative International Prices and Net Commodity Exporter IRF's.....	93
Figure B1: International prices and World Commodity Price Shocks: AE sample IRFs.....	117
Figure B2: International prices and World Commodity Price Shocks: EME sample IRFs.....	117
Figure B3: International prices and World Commodity Price Shocks: Full sample IRFs.....	118
Figure B4: International prices and World Commodity Price Shocks: EME sample IRFs.....	118
Figure B5: International prices and World Commodity Price Shocks: AE sample IRFs.....	119
Figure B6: International prices and World Commodity Price Shocks: Full sample IRFs.....	119
Figure B7: International prices and World Commodity Price Shocks: EME sample IRFs.....	120
Figure B8: International prices and World Commodity Price Shocks: AE sample IRFs.....	120
Figure B9: International prices and World Commodity Price Shocks: Full panel IRFs .....	121
Figure B10: International prices and World Commodity Price Shocks: AE panel IRFs.....	121
Figure B11: International prices and World Commodity Price Shocks: EME panel IRFs .....	122
Figure B12: Basic Panel VAR Impulse Response Functions – Full Sample.....	123
Figure B13: Basic Panel VAR Impulse Response Functions – EME Sample.....	124
Figure B14: Basic Panel VAR Impulse Response Functions – AE Sample.....	125
Figure 3.1: Historical Real Exchange Rates, Commodity Prices, and Producer Price Index.....	130
Figure 3.2A: Real Exchange Rates, Commodity Prices and Producer Price Index-AE's .....	151
Figure 3.2B: Real Exchange Rates, Commodity Prices and Producer Price Index -EME's .....	152
Figure 3.3A. Real Bilateral Exchange Rate MSE Decomposition Plots-AE.....	159
Figure 3.3B. Real Bilateral Exchange Rate MSE Decomposition Plots-EME.....	160
Figure 3.4 – World Commodity Prices and Real Exchange Rates – Full Sample IRF.....	168
Figure 3.5A – World Commodity Prices and Real Exchange Rates – AE Sample IRF .....	168
Figure 3.5B – World Commodity Prices and Real Exchange Rates – EME Sample IRF .....	169
Figure C1.1 – World Commodity Prices and Real Exchange Rates – Full Sample IRF .....	194
Figure C1.2 – World Commodity Prices and Real Exchange Rates – AE Sample IRF .....	194
Figure C1.3 – World Commodity Prices and Real Exchange Rates – EME Sample IRF .....	195
Figure C1.4 – World Commodity Prices and Real Exchange Rates – Full Sample IRF .....	195
Figure C1.5 – World Commodity Prices and Real Exchange Rates – AE Sample IRF .....	196
Figure C1.6 – World Commodity Prices and Real Exchange Rates – EME Sample IRF .....	196
Figure C1.7 – World Commodity Prices and Real Exchange Rates – Full Sample IRF .....	197
Figure C1.8 – World Commodity Prices and Real Exchange Rates – AE Sample IRF .....	197
Figure C1.9 – World Commodity Prices and Real Exchange Rates – EME Sample IRF .....	198
Figure C2.0 – World Commodity Prices and Real Exchange Rates – Full Sample IRF .....	198
Figure C2.1 – World Commodity Prices and Real Exchange Rates – AE Sample IRF .....	199
Figure C2.2 – World Commodity Prices and Real Exchange Rates – EME Sample IRF .....	199
Figure C2.3 – MSE Decomposition Plots -AE .....	200
Figure C2.4 – MSE Decomposition Plots - EME.....	202

## **Introduction**

Many Resource-rich countries have historically been dependent on trade in commodities as a major source of revenue. While this phenomenon may not have been problematic some few decades ago, the increased financialization of commodity markets that led to highly volatile commodity spot prices have made the subject pivotal to business cycle studies. Central to the business cycle-commodity price research is the understanding that commodity price shocks are a possible explanation to the observed large disruptions in global business cycles. This thesis contributes to the growing knowledge on commodity prices by analyzing the impact of commodity price shocks on the macroeconomy of emerging market economies (EME's).

The thesis consists of three essays. In the first essay, I examined the role of commodity price shocks (acting as an income shock), in explaining the presence of high levels of corruption in resource rich countries. While corruption does exist in every country, available data and anecdotal evidence suggest that corruption is often rife in developing countries and resource rich EME's. A natural question then is if the presence of and dependence on natural resources is a driver of the high levels of corruption. The literature answers this partially by documenting the corruption inducing effects of natural resource discoveries. In the paper, I document commodity price variations as an alternative explanation to the corruption inducing effects of natural resource windfalls in two ways. First, I provide an analytical model detailing how shocks in commodity prices can affect corruption. The model is an extension of the non-benevolent principal agent framework of Adsera, Boix and Payne (2003) and Bhattacharyya and Hodler (2010) to include commodity endowments whose prices are subject to exogenous fluctuations. These exogenous fluctuations generate income shocks that affect the expected returns from corruption and hence influence the choice between more corruption or productive behavior that increases general

welfare. Secondly, I empirically document the corruption inducing effects of commodity price shocks for a sample 51 commodity-dependent countries using the Panel Quantile regression approach of Powell (2016) and dataset on corruption and commodity prices from the International Country Risk Guide (ICRG) and the World Bank's Pink Sheet. Results show that there are noticeable and significant increases (decreases) in corrupt activities in the sample countries in response to a positive (negative) commodity price variation. Further, the results also show that significance difference exists in the effect of commodity price shocks on corruption. First the impact is more noticeable in the most corrupt countries and second, the impact depends on the type of commodity exported -more significant impact for exporters of non-energy resources.

In the second essay co-authored with Dr. Carlos Yepez, we empirically examined the sources of the large real exchange rate variations in EME's by conducting an accounting exercise that decomposes the real exchange rate changes in EME's into a tradable and non-tradable component following the proposition of Engel (1999). Engel (1999) estimated for a sample of Advanced Economies (AE's) that, variations in real exchange rates are largely (about 90%) explained by variations in the traded goods price. Given exchange rates in EME's are typically more volatile and persistent than in AE's, we seek out in this essay to examine the proportion of real exchange rate variations explained by tradable and non-tradable goods price for the case of EME's which was an area not explored in the literature. We also conduct a forecast error variance decomposition exercise to quantify the proportion of the variations in the real exchange rates explained by commodity price shocks. We find that the relative price of tradable goods is the largest determinant of real exchange rate variations in EME's just as in AE's and that commodity prices have a sizeable impact in explaining the puzzlingly large variability of international prices in EMEs.

The final paper addresses an important question that is a source of disagreement among researchers and policy makers in the literature on real exchange rate dynamics. Specifically, while traditional trade theories propose that real exchange rate variations are mainly the result of variations in non-tradable goods prices, empirical documentation are mixed with many studies favouring a larger role for the relative price of tradable goods. Betts and Kehoe (2006) and Burstein et al. (2006) individually suggest a possible explanation to the contrasting finding in the literature - that the relative importance of traded and non-traded goods depends largely on the choice of price series used in the measurement of the relative price of tradable and non-tradable goods. They suggest that price series such as the PPI and CPI adopted in measuring the relative price of tradable goods in the literature contains a large component of non-traded goods hence overstating the importance of tradable goods to real exchange rate variations. Hence in this paper, I empirically re-examined the contribution of tradable goods prices to real exchange rate variations by constructing the relative price of tradable and non-tradable goods using a purely traded goods price -commodity terms of trade prices, for a sample of 28 countries. I also decompose the response of each country to a commodity price shock into (i) a “common component” that measures the response of each sample country to a commodity price shock that is common to all countries (spillovers) and (ii) an “idiosyncratic component” that measures the response of each sample country to a commodity price shock specific to that country. The Panel Structural Vector Autoregressive (PSVAR) approach of Pedroni (2013) allow us to decompose commodity price shocks into the two components. I find that the relative price of tradable goods variations dominates the variations in real exchange rates even for tradable goods measured using purely traded goods price as the commodity terms of trade prices. I also find that the effect of commodity price shocks in EME’s and AE’s are mainly due to common factors or spillovers in the commodity price shocks.

It is my hope that the contribution of this thesis to the knowledge on the dynamics of commodity price shocks and of real exchange rate variations will inform business cycle, economic growth, and trade policy designs to minimize the exposure of EME's and other commodity dependent countries to real commodity price variations.

# 1. Commodity Price Shocks and Corruption

## 1.1 Introduction

The global economy has occasionally experienced periods of commodity booms and burst characterized mainly by sharp increases or decreases in commodity prices. The most recent of this commodity booms and burst have seen prices of many commodities reach historical heights and lows. Crude oil prices for example reach an all-time historical high of \$133.93 per barrel in June 2008 and historical low of \$16.52 and 11.31 in April 2020 and December 1998<sup>1</sup> respectively. For economies dependent on natural resources however, a heavy dependence on a single or few commodities amid commodity price booms and burst can be a double edge sword that can promote or impede growth – a “resource curse”<sup>2</sup>.

Overwhelmingly, the existing empirical and anecdotal evidence tended to support the resource curse hypothesis. However, a closer investigation reveals a more complicated relationship. First, to a large extent, resource rich countries such as Nigeria, Democratic Republic of Congo, Venezuela, Libya, Russia and Iran tend to economically underperform resource poor countries such as Korea, Singapore and Hong Kong (see Sach and Warner, 2001; Auty, 2001; Frankel, 2010) thus lending impetus to the resource curse hypothesis. Contrastingly however, there are also resource rich countries such as Australia, Canada, Norway and most recently Botswana that

---

<sup>1</sup> Data is for the West Texas Intermediate (WTI) crude oil price obtained from the World Bank pink sheet. The Brent, and Dubai crude oil prices average \$132.83 in July 2008 and \$21.04 in April 2020. Gold prices peaked at an all-time high of \$1968.63 in August 2020 while both Timber and Wheat peaked at a historical height of \$562.84 and \$495.28 in April 2008 and April 2022 respectively.

<sup>2</sup> The idea of a resource curse refers to the observation that, economies with abundant natural resources (economies with high natural resource to GDP ratio) tend to grow less rapidly than resource-scarce economies. For a detailed review of the resource curse hypothesis see Sachs and Warner (1995); Ross (1999); Mehlum et al. (2006) and Warner (2015).

experience significantly high growth rates than many resource-poor countries in Asia, Latin America, and Sub-Saharan Africa. To allude the “blessing” of an abundant natural resource as analogous to a “resource curse” therefore is not only counter intuitive but baffling and begs many questions. As Sala-i-Martin and Subramanian (2013) rightly pointed out, it is important from a policy perspective to understand the resource curse but more important to understand the mechanism by which natural resources cast its spell.

One hypothesis put forward to explain the resource curse hypothesis is corruption (see Baland and Francois, 2000; Torvik, 2002; Bhattacharyya and Hodler, 2010; Sala-i-Martin and Subramanian, 2013). The tenet of these studies is that natural resource abundance fosters rent seeking<sup>3</sup> behavior and breeds corruption in resource rich countries due to the increased economic rents generated from resource booms. These studies assume a multiple equilibrium model where individuals in a resource rich country can choose between entrepreneurship or rent seeking<sup>4</sup>. Increases in exogenous factors such as resource windfalls are assumed to increase the economic rents from natural resources and in turn the benefits of engaging in rent seeking and corruption. Estimates in support of the hypothesis shows corruption accounts for a significant amount of resource misallocation globally. World Bank estimates for example puts the cost of corruption at about \$3.6 trillion or 5 percent of global Gross Domestic Product (GDP) in 2018. This estimate is significantly higher in commodity dependent developing countries in South Sahara Africa and Latin America

---

<sup>3</sup> Rent seeking and corruption have been used interchangeable in the literature with the former regarded as a lesser of two evils (Lamsdorff, 2002). The concept of rent seeking can be traced back to Tullock (1967), Krueger (1974).

<sup>4</sup> Individuals are assumed to possess both entrepreneurship and rent seeking skills and can perfectly transfer between rent seeking and entrepreneurial activities. The choice of a skill depends on a comparison of the benefits to be derived from engaging in each activity – see Baland and Francois (2000).

including Nigeria<sup>5</sup> and Venezuela with World Bank estimates putting the cost of corruption at about 10% of overall official development assistance. Krueger (1974) also estimates rents generated by import licensing alone in Turkey to be about 15% of Gross National Product (GNP) in 1968 while Gallagher (1991) estimates returns from rent seeking to be between 6% and 37% of GDP for a sample of African countries between 1975 to 1987.

To the extent that resource windfalls breed corruption, one would expect that, the income shocks generated by commodity price variations would explain the high and rising trends in corruption in resource rich countries. Unfortunately, empirical estimations focus less on the impact of price shocks. In this study I ask how commodity price shocks or unannounced variations in natural resource prices other than quantity shocks affects corruption in resource rich countries. I accomplish this objective in two ways. First, I provide an analytical model detailing how increases in commodity prices can affect corruption. Secondly, I empirically gauge the effect of commodity price shocks on corruption using a country specific commodity price index and data on corruption from the International Country Risk Guide (ICRG). The country specific commodity price indices were constructed using the primary commodity price dataset from the World Bank's Pink Sheet and data on individual commodity export shares in total exports from the Harvard Atlas of Economic Complexities.

The findings of the study provide important contributions to the literature. First, the study highlights the importance of commodity prices in determining the level of corruption in resource rich countries much like resource abundance or resource discoveries. Second, in an answer to the

---

<sup>5</sup> PricewaterhouseCoopers (PwC), a global accounting and evaluation firm estimates the cost of corruption in Nigeria to increase to about 37% of GDP by 2030 ( see <https://www.pwc.com/ng/en/assets/pdf/impact-of-corruption-on-nigerias-economy.pdf> )

question of the link between commodity price shocks and the dynamics of corruption in resource rich countries, I showed via a two-period analytical model that, positive shocks (increases) in commodity prices leads to higher levels of corruption in the political system of resource rich countries. The empirical estimations using the Panel Quantile regression procedure of Powell (2016) confirm this proposition both symmetrically and asymmetrically. Further, I showed that, increases in the prices of all categories of commodities increases corruption but the impact is more significant for exporters of non-energy commodities thus suggesting shocks to non-energy prices are an important determinant of the level of corruption. Finally, the study also showed that the impact of commodity price shocks on corruption is more pronounced in highly corrupt countries.

The rest of the study is organized as follows. Section 1.2 reviews the existing literature on the resource curse, corruption and commodity prices. Section 1.3 provides the analytical model and details about our data and methodology. Section 1.4 discusses the results. Section 1.5 concludes.

## **1.2 Literature Review**

Corruption is multi-faceted and hence difficult to get a model that encompass its numerous causal factors. It is not surprising therefore that the theoretical literature that examined the link between natural resource abundance and corruption identified several mechanisms that can explain the causation. First the literature identified the voracity effect channel where natural resource windfalls generate increased economic rents that leads to a rapacious and voracious rent seeking and corruption<sup>6</sup>. Second, resource abundance also increases the net benefit from corruption to an economic agent faced with the choice of engaging in corruption or entrepreneurial activities that

---

<sup>6</sup> See Lane and Tornell (1996)

generate wealth<sup>7</sup>. Further, the literature also identified the influence of resource windfalls on the economic rents available to public officials who given their discretionary powers, seeks rent and engage in corrupt activities if the cost to rent seeking and corruption are less than the benefit the public official will derive from rent seeking and corruption<sup>8</sup>. Finally, there are studies that instead of resource abundance/resource windfalls (positive income shocks), documented and explained a link between corruption and adverse income shocks<sup>9</sup>.

Aidt (2016) however argued that the propositions of the theoretical corruption literature though distinct, can be regarded as evolving under two main branches – (i) the helping hand type of corruption and (ii) the grabbing hand type of corruption. Under the “helping hand” type of corruption theories, corruption decisions are optimal and depends on the level of cost and benefit of designing optimal institutions. The “grabbing hand” type of corruption theories on the other hand treats corruption as the result of suboptimal institutions and policies that allow non-benevolent government officials to extract rent.

Some of the distinct theoretical propositions in the literature include Baland and Francois (2000) who proposed a theoretical explanation of the corruption inducing effects of natural resource windfalls. Their model assumes a talent re-allocation framework where natural resource booms may lead to a choice between two distinct skills/talents – rent seeking and entrepreneurship. Individuals in the model are endowed with skills of entrepreneurship and rent seeking and choose between both skills based on the economic returns from engaging in that activity. The model showed that, increase in entrepreneurship can crowd out rent seeking by creating new and better

---

<sup>7</sup> See Baland and Francois (2000)

<sup>8</sup> Bhattacharyya and Hodler (2010) and Aidt (2010) provides a good discussion of this channel.

<sup>9</sup> See Ciccone (2008) for a full discussion.

goods and services. However, because rent seekers also possess entrepreneurial skills and can transfer between rent seeking and entrepreneurial activities, Baland and Francois argued that when a large proportion of individuals are already engaged in rent seeking in an economy, increases in the economy's resources inclines the economy towards more rent seeking and subsequently more corruption.

Torvik (2002) also develops a similar multiple equilibria model where natural resource booms increases the number of entrepreneurs engaged in rent seeking and reduces the number of entrepreneurs running productive firms given that natural resources increase productivity in the non-resource sector only if there are increasing returns to scale in production. They explained this as being the result of profits of rent seekers increasing at all levels of rent seeking when there is a natural resource boom. The increased profits from rent seeking will in turn lure some entrepreneurs away from production into rent seeking.

Bhattacharyya and Hodler (2010) used a game theoretic model to explain how natural resource abundance influence the economic incentives and hence the decision to engage in rent seeking by public officials. Their model assumes a two-period-two-agent model where a politician (good or bad) faced with re-election in the next period chooses the level of rent seeking to engaged in by comparing the difference between probability of staying in office and the probability of losing the election. Natural resource abundance is assumed to reduce this difference by increasing the economic incentive to engage in corruption to the incumbent. The model presented in this paper is similar to the model of Bhattacharyya and Hodler (2010).

There are other studies that instead of resource windfalls, focused on the link between income shocks and corruption. The conclusion of these studies are quite mixed. Rodrik and Subramanian

(2003) for example argued that demand for better institutions rises as countries and their citizens become richer hence indirectly reducing corruption. Other studies such as Mauro (2004); Di Tella and Schargrodsky (2003) and Ciccone (2008) however argued that adverse income shocks can result in reduction in wages and government revenues hence reducing government ability to monitor corruption. The adverse income shocks also affect priority setting in policy formulation hence increasing the incentive to engage in corruption. Corruption thus may rise and fall with income levels opening up a possible link between shocks in incomes as a result of shocks to commodity prices and corruption especially in resource rich countries.

Empirically, while the link between resource windfalls, resource rents, crude oil prices and corruption has been relatively explored, the link between general commodity price shocks has been less considered in the literature. Arezki and Gylfason (2013) for example finds for a panel of 29 Sub-Saharan African countries that, higher resource rents<sup>10</sup> lead to more corruption especially in the less democratic countries. Bhattacharyya and Hodler (2010) use a game theoretic model to predict that, higher resource rents lead to an increase in corruption if the quality of institutions is relatively poor but not otherwise. This prediction was found to be true for a panel of 124 developed and developing countries via a System Generalized Method of Moments (GMM) and Ordinary Least Squares (OLS) estimations. Voors, Bulte, and Damania (2011) used rainfall as an instrument for income shocks for a panel of African countries to study the link between income shocks and corruption. They found that positive income shocks on average tend to invite extra corruption especially in the most corrupt countries. They also find that countries with sufficiently low levels

---

<sup>10</sup> The World Bank estimates resource rents as the difference between the price of a commodity and the average cost of producing the resource or commodity. See <https://databank.worldbank.org/metadataglossary/adjusted-net-savings/series/NY.GDP.TOTL.RT.ZS>

of corruption escapes the detrimental effects of positive income shocks on corruption and may actually experience a virtuous cycle of development.

Arezki and Brückner (2011) uses least squares and system GMM estimation technique to estimate the link between oil prices, corruption, and state stability for a panel of 30 oil-exporting countries for the period 1992 -2005. They find that increases in oil rents significantly increases corruption, significantly deteriorates political rights but significantly improve civil liberties. They explained this as the results of political elites extending civil liberties but reducing political rights so as to evade redistribution and conflicts. Pendergast, Clarke and Van Kooten (2011) also found for a panel of 102 resource rich countries that, the abundance of petroleum resources are associated with increase corruption which negatively affects wellbeing.

Baragwanath (2020) developed a model of rent seeking where natural resource windfalls generate the strategic entry of corrupt politicians and prevents the voters from distinguishing a corrupt politician from politicians with integrity and thus creating circles of corruption and re-election. He then examined the effect of oil windfalls on corruption in Brazil based on his theoretical proposition. He finds that a one standard deviation increase in oil royalties produces about 29% increase in corruption.

While the above theories presented do not specifically establish a direct link between commodity price shocks and corruption which is the main objective of this paper, the theoretical foundations presented sheds light on the role of resource windfalls and adverse income shocks on corruption. This is very crucial especially as the study models commodity prices as an alternative source of resource windfalls but also a source of income shocks that affects resource rich countries. The study adds to the existing literature by examining the link between commodity price shocks and

corruption which have been less explored. The approach of the study which focuses on shocks in the prices of the main commodities produced by each country differs from the approach of Arezki and Brückner (2011) that focus on only oil prices and Bhattacharyya and Hodler (2010); Kooten (2011); Arezki and Gylfason (2013) and Baragwanath (2020) which focuses on resource rents, resource abundance and resource discoveries. Importantly, the study proposes a theoretical explanation of the link between commodity price shocks and corruption as well as provides empirical estimates of the impact of commodity price shocks on corruption in resource rich countries. The commodity price shocks used in the study are country specific and covers all commodities that account for at least 5% of the net exports in each country.

### **1.3 Data and Methodology**

This section presents the methodology of the study. The section is divided into four sections. Section 1.3.1 presents a brief analytical model that explains how commodity price shocks acting as an income shock, induces more corruption from a representative agent in a principal-agent framework. Section 1.3.2 presents the estimation strategy whilst section 1.3.3 and section 1.3.4 present the description of data and sources and an overview of methods used in measuring shocks from commodity prices respectively.

#### **1.3.1 A Simple Analytical Model**

In this section, I model the influence of commodity price shocks on corruption within the context of a non-benevolent principal (the people) and an agent (the incumbent government) who is faced with the choice of (i) working towards raising the welfare of its citizens using resources efficiently and hence get re-elected or (ii) appropriation of state resources for personal benefits and hence

face the prospect of being caught, punished and not get re-elected<sup>11</sup>. The people act as a form of political control of public officials. However, the degree of this political control depends on the presence of democratic institutions that ensure free, fair, and credible elections and the degree of information asymmetry or how well the people are informed of the activities of the government in power. In the model, we assume an information asymmetry between the incumbent government (agent) and the people (principal). The agent exploits this information asymmetry by engaging in more corruption given the associated expected net benefits and cost of engaging in corruption. Commodity price shocks exogenously increases or decreases the expected net benefits of corruption and thus shifts the incumbent towards more corruption. The model follows closely to the model of Adsera, Boix and Payne (2003) and Bhattacharyya and Hodler (2010) and provides the basis for a link between commodity price shocks and corruption. This link is further explored in the empirical estimations conducted in section 1.4.

### **The Model**

Consider an economy populated by an incumbent government (agent), an opposition/challenger and the people (principal). Assume that all agents in this economy are corruptible. An implication of this assumption is that institutions and policies in place in the economy at any point in time, can be dysfunctional and inefficient (see Aidt, 2003). The incumbent and the challenger are each of the same good of type  $\theta$ , which is assumed to be common knowledge. This assumption is necessary given that the people know both the incumbent and the challenger are both corruptible and are expected to seek rents and only inhibited in the pursuit of rent seeking by the given economic and

---

<sup>11</sup> This procedure of Principal agent modeling is based on the assumption that how well a government performs depends on how good citizens are at making politicians accountable for their actions and that the presence of citizens in a democratic dispensation with the power to vote act as control on the politician's choices. See Adsera et al. (2003); Ledeneva, Bratu, and Köker (2017).

democratic institutions. Further we assume two periods  $t \in (1,2)$ . In period one, the incumbent chooses the level of corruption  $c_1 \in (0,1)$ . At the end of period one, the people (voters) observe  $c_1$  and either support the incumbent or the challenger. The people's decision is unobservable but determines the probability of the incumbent staying in office or the challenger winning power. In period two, the politician in office chooses the level of corruption  $c_2 \in (0,1)$ . The two-period model can easily be extended to an infinite model.

Also assume the economy consist of two sectors – (i) a tradable/natural resource sector and (ii) a non-tradable sector. The tradable sector is populated by firms engaged in the extraction of natural resources, majority of which are exported. It is assumed that the tradable sector/natural resource sector yields the greatest revenue to government in the form of resource rents ( $Z_t$ ). The resource rent to government used here refers to the surplus value of a natural resource extracted after all costs and a normal return have been accounted for. Thus, it's the difference between the total revenue that can be generated from the extraction of the natural resource less the cost of extracting the resource plus a normal return on investment to the extractive enterprise. We assume most of the resources are sold externally at world market prices and hence resource rents are dependent mostly on the existing world commodity prices but also slightly on the domestic price at which they are sold to intermediary firms. This assumption is necessary due to the fact that countries globally are increasingly advocating for the processing and use of components of their natural resources to enhance the value of their exports. The resource rent is thus defined as  $Z_t = P_{h,t}^\gamma P_{f,t}^{1-\gamma}$  where  $P_{h,t}$  is the domestic price of the natural resource extracted in period  $t$  and  $P_{f,t}$  is the world price of the natural resource in period  $t$ .  $\gamma$  denotes the share of the natural resource that are sold domestically and  $(1 - \gamma)$  denotes the share of the resource sold externally at the world market price. The natural resource rents are assumed to be positive in every period for the politician in

power ( $Z_t = P_{h,t}^\gamma P_{f,t}^{1-\gamma} \geq 0$ ). The domestic price is assumed to be relatively stable and only an infinitesimally small proportion of the good is sold domestically. The world price on the other hand is exogenously determined in global commodity markets<sup>12</sup> and subject to exogenous shocks. The above effectively means that  $Z_t$  is determined mainly by world prices ( $P_{f,t}$ ). The non-tradable sector produces mainly for the domestic economy and generates a revenue ( $A_t$ ) to the incumbent government. Total income available to the incumbent at any time (in each period) hence is the sum of the domestic revenue and resource rents (i.e.  $R_t = A_t + Z_t$ ).

As in Bhattacharyya and Hodler (2010), corruption lowers the private returns to productive activities, reduces the incentive to work hard and invest more in human and physical capital. Domestic income ( $A_t$ ) thus decreases in corruption. Thus  $A_t = A(c_t)$  with  $A'(c_t) \leq 0$  and  $A''(c_t) < 0$ .  $A(c_t)$  is also assumed to be continuous and  $A'(0) = 0$  and  $A'(1) = -\infty$ . Resource rents on the other hand are assumed to be exogenous to corruption since resource prices are mostly exogenous and firms engaged in resource extraction in most resource rich countries are either owned directly by the state or foreign firms whose engagement in the resource sector depends on prior estimates of resource endowment, profitability, and productivity.

Further it is assumed that the incumbent uses the income available to it to provide general welfare goods to the people. Following Bhattacharyya and Hodler (2010), we assume that the politician in office benefits from a high social welfare for several reasons. First, his salary may depend on the performance of the economy. Second, his status and influence in the international community may depend on the people's welfare and economy's performance. We further opined that, the

---

<sup>12</sup> I assume a domestic economy produces only a minute portion of global supply hence unable to influence prices.

incumbent may be genuinely interested in the people's welfare or is motivated to be interested in the people's welfare since the people's welfare at the end of his tenure may determine whether he gets re-elected or not. The people's welfare however is a function of corruption and decreases with high levels of corruption. A high level of corruption reduces the amount of resources dedicated to providing social services that improves the people's welfare. In each period, the people's welfare can be stated as

$$W_t = w_o + (1 - c_t)[A_t(c_t) + Z_t] \equiv w_o + (1 - c_t)[A_t(c_t) + P_{h,t}^\gamma P_{f,t}^{1-\gamma}] \quad (1.1.1)$$

Where  $w_o$  is the people's initial level of welfare at the start of period one or at the start of the tenure of the incumbent. When deciding which politician to support, the people observe the level of corruption and maximizes their expected welfare. Generally, the people will support the incumbent in period two given that, their expected welfare in period one is greater than or equal to their initial welfare at the start of period one (i.e.  $W_1 = (1 - c_1)[A_1(c_1) + Z_1] \geq w_o$ ). The people are indifferent between the incumbent and the challenger if  $W_1 = w_o$ .

Further, as in Bhattacharyya and Hodler (2010), we assume that the incumbent in each period, derives utility from different sources including from corruption, performance of his official duties which leads to higher social welfare ( $W_t$ ). The utility from corruption for the incumbent is given as  $\pi_t = c_t[A_t(c_t) + P_{h,t}^\gamma P_{f,t}^{1-\gamma}]$ .

Hence the total utility of the agent in any given period is given as

$$U_t(c_t, \theta) = \pi_t(c_t) + W_t(c_t) = [c_t + (1 - c_t)][A_t(c_t) + P_h^\gamma P_f^{1-\gamma}] \quad (1.1.2)$$

Democratic institutions play a key role in limiting the scope of corruption and hence used widely in models explaining corruption or rent seeking. Hence a key feature of the model is democratic

institutions. Though the existence of democratic institutions in itself is not a panacea for the control of corruption, the study holds the view that, such institutions expose politicians (both the incumbent and the challenger) to electoral accountability and thus provide voters with a valuable tool to control corruption. Also, a developed democratic institution offers optimal legal remedies to punish corrupt officials and hence serve as a deterrent to others engaged in corrupt activities. In the model, the people are assumed to hold politicians accountable by exploiting the idea that, a corruptible politician wants to be re-elected simply because holding office is a necessary condition for corruption in the future. Further a minimal level of proceeds obtained from corruption whilst in office is better than being in opposition where revenue from corruption will be zero. We define two threshold levels for the utility derived from corruption. A minimal utility from corruption given as  $\eta_l$  and a maximum threshold given as  $\eta_h$ . We assume that voters can force a compromise between what the corruptible incumbent will want to choose ( $\eta_h$ ) and what the people (median voter) wants ( $\eta_l$ ). The choice between  $\eta_h$  and  $\eta_l$  hence is a major decision faced by incumbent. We further assume that a corrupt politician has a probability  $\rho$  of being caught in period one by existing institutions and made to pay a penalty  $\delta_t$  and with probability  $(1 - \rho)$ , the incumbent escapes being caught. An efficient democratic institution is assumed to be one with a high probability of apprehending corrupt politicians and punishing them while a less efficient system is one where politicians are likely to escape being caught and punished for corruption. Thus, a higher  $\rho$  indicates a more efficient democratic institution and vice versa.

### **Nash Equilibrium**

If we define a minimal acceptable welfare at which the people (voters) will be indifferent between the choice to re-elect the incumbent or reject the incumbent at the polls in favor of the challenger as  $W_t^*$ , then the solution to the sub game is such that, at equilibrium the incumbent will evaluate

and compare the net expected payoff from engaging in corruption in period one against the minimal acceptable welfare needed to ensure his re-election. The net expected payoff in each period is given as

$$\begin{aligned} \text{Net Expected Payoff (NR)} &= -\rho[\Pi(c_t) + W_t(c_t) + \delta_t] + (1 - \rho)[\Pi(c_t) + W_t(c_t)] \\ &\equiv (1 - 2\rho)[\Pi(c_t) + W_t(c_t)] - \rho\delta_t \end{aligned} \quad (1.1.3)$$

Thus, the incumbent will choose  $\eta_h$  or  $\eta_l$  or be indifferent between  $\eta_h$  and  $\eta_l$  given that

$$NR = \begin{cases} \eta_h & \text{if } (1 - 2\rho)[\Pi(c_t) + W_t(c_t)] - \rho\delta_t > W_t^* \\ \text{Any} & \text{if } (1 - 2\rho)[\Pi(c_t) + W_t(c_t)] - \rho\delta_t = W_t^* \\ \eta_l & \text{if } (1 - 2\rho)[\Pi(c_t) + W_t(c_t)] - \rho\delta_t < W_t^* \end{cases} \quad (1.1.4)$$

Given that  $\pi_t = c_t[A_t(c_t) + P_{h,t}^\gamma P_{f,t}^{1-\gamma}]$  and  $W_t = w_o + (1 - c_t)[A_t(c_t) + P_{h,t}^\gamma P_{f,t}^{1-\gamma}]$  the net expected payoff of the incumbent (equation 3.1.4) can be re-stated as

$$NR = \begin{cases} \eta_h & \text{if } A_t(c_t) + P_{h,t}^\gamma P_{f,t}^{1-\gamma} > \frac{W_t^* + \rho\delta_t}{1 - 2\rho} - w_o \\ \text{Any} & \text{if } A_t(c_t) + P_{h,t}^\gamma P_{f,t}^{1-\gamma} = \frac{W_t^* + \rho\delta_t}{1 - 2\rho} - w_o \\ \eta_l & \text{if } A_t(c_t) + P_{h,t}^\gamma P_{f,t}^{1-\gamma} < \frac{W_t^* + \rho\delta_t}{1 - 2\rho} - w_o \end{cases} \quad (1.1.5)$$

Where  $A_t(c_t) + P_{h,t}^\gamma P_{f,t}^{1-\gamma}$  is the total expected revenue to the incumbent. We refer to the right-hand side variable  $(\frac{W_t^* + \rho\delta_t}{1 - 2\rho} - w_o)$  as the incumbents discounted cost of re-lection.

**Proposition:** In period one, exogenous shocks to the export price of the natural resource ( $P_{f,t}$ ) produces similar and equivalent exogenous shocks to the resource rent of government. Positive shocks increase the resource rent of the incumbent while negative shocks reduce resource rent. If we assume a time lag<sup>13</sup> between the reaction of the domestic sector to levels of corruption, then positive shocks to the export price will produce little or no effect on  $A_t(c_t)$  but an equivalent

---

<sup>13</sup> This follows the observation that institutions turn to be highly persistent (see Acemoglu, Egorov and Sonin, 2021)

change in  $Z_t = P_{h,t}^\gamma P_{f,t}^{1-\gamma}$ . Given that  $Z'(P_f) > 0$ , it follows that  $R'(P_f) > 0$ , the expected returns from corruption increases at all levels and thus lowering the opportunity cost of engaging in corrupt activities. The incumbent will choose the maximum level of rent  $\eta_h$ , resulting in a higher level of corruption ( $c_t$ ) in the current period unless  $\frac{W_t^* + \rho\delta_t}{1-2\rho} - w_o$  is sufficiently high. The size of  $\frac{W_t^* + \rho\delta_t}{1-2\rho} - w_o$  is however a function of the probability of being detected when seeking rent ( $\rho$ ) which we used to measure the strength of democratic institutions and the penalty imposed on rent seekers when caught ( $\delta_t$ ). A higher institutional quality (higher  $\rho$ ) results in a higher total re-election cost putting restraints on how fast resources are misappropriated via corruption. Also, a higher penalty term ( $\delta_t$ ) will raise the total cost of re-election as imprisonments, fines and social stereotypes that comes with being caught and punished for engaging in corruption increases the opportunity cost to public officials seeking re-election. The combine effect of a higher  $\rho$  and  $\delta_t$  raises the cost to a corrupt incumbent to seeking re-election and thus will reduce corruption.

### 1.3.2 Empirical Estimation Strategy

The theoretical foundation of this study is that commodity price shocks represent a form of income shock that influences the net expected pay off from corruption and thus influences the level of corruption in a country. Hence the study uses commodity price shocks as a proxy for income shocks in a regression explaining corruption within a cross-country framework. Commodity price shocks are a robust proxy for incomes in many resource rich countries for two reasons. First as shown in Table 1.1, many resource rich countries are dependent on trade in specific commodities or group of commodities. Specifically, the table shows that, the sample countries are heavily dependent on commodity trade with commodities accounting for between 19% to 95% of total government revenues in the sample countries. Hence the real income and fiscal outcomes

(revenues and expenditure) of these countries are directly correlated to movements in their traded commodity prices. This correlation is well documented in Medina (2010); Spatafora and Samake (2012) and Lopez-Martin et al. (2019).

**Table 1.1: Commodity Revenues as a percentage of Total Revenue and GDP**

Country	Commodity revenue 2006-2010		Country	Commodity revenue 2006-2010	
	%of total Revenue	%of GDP		% of total revenue	% of GDP
Algeria	73	30	Nigeria	76	22
Angola	89	35	Norway	29	15
Bahrain	82	23	Oman	83	37
Bolivia	32	11	Papua New Guinea	32	10
Cameron	27	6	Peru	19	4
Chile	23	6	Russia	29	11
Congo	82	33	Saudi Arabia	79	42
Ecuador	24	7	Sudan	55	11
Gabon	60	18	Syria	25	6
Guinea	23	4	Trinidad and Tobago	49	17
Iran	66	17	UAE	76	24
Kuwait	95	62	Venezuela	58	19
Libya	89	56	Yemen	68	22
Mongolia	29	10	Zambia	4	1

Source: Melina (2010)

Secondly, the high dependence on trade in commodities and the high correlation between the fiscal outcomes and the traded prices of commodities implies that shocks to commodity prices should produce a contemporaneous shock in real incomes and fiscal outcomes. This makes commodity price shocks a more robust proxy for income shocks than rainfall and weather as used in Voors et al. (2011).

The study employs the Panel Quantile regression with non-additive fixed effects (QRPD) strategy of Powell (2014; 2016) as the main estimation strategy but also reports the results from OLS estimation for comparison. As indicated in Table 1.2, several estimation procedures have been employed in the literature on corruption. However, QRPD procedure is preferred in this study for several reasons. First, there is substantial heterogeneity in the level of corruption across the sample

countries. QRPD allows us to quantify the effect of commodity price shocks on the distribution of corruption at different points across sample countries. We are thus able to evaluate the impact of commodity price shocks on the least and most corrupt countries. Second, compared to OLS, QRPD is robust to outliers and error terms that are not normally distributed. QRPD is also applicable to both discrete or continuous variables and provides estimates based on the unconditional mean distribution of the outcome variable rather than on the distribution of the outcome variable conditional on all other covariates in the model as used in OLS estimates. This will allow us to obtain unconditional impact of commodity price shocks on corruption.

Finally, compared to other panel quantile approaches that allow for additive fixed effects, the QRPD approach allows for non-additive fixed effects modelled as an unknown function of both an individual fixed effect and an observation specific disturbance term. Specifically, given  $D_{it}$  as the vector of treatment variables and  $\alpha_i$  as the fixed effects, QRPD provides estimates of the distribution of  $Y_{it}|D_{it}$  instead of  $(Y_{it} - \alpha_i)|D_{it}$  as used by quantile models with additive fixed effects. This allows the QRPD obtain estimates than can be interpreted similar to a cross-country regression.

The baseline estimation model is given as

$$Q_{C_{it}}(\tau/D_{it}) = \eta_{it}(\tau) + \alpha_s(\tau)S_{it} + \sum_{j=1}^J \alpha_{sj}(\tau)Controls_{jit} \quad (1.1.6)$$

Where  $S_{it}$  and  $Controls_{jit}$  denotes the treatment variable (commodity price shocks) and the  $j^{th}$  control variable of country  $i$  at time  $t$  as used in the literature on corruption respectively.  $\alpha_s(\tau)$  is the causal effect of commodity price shocks on the corruption measure while  $\alpha_{sj}(\tau)$  is the causal effect of the  $j^{th}$  control variable on corruption.

**Table 1.2: Methodologies used in the Corruption Literature.**

Author(s)	Topic	Corruption Measure	Main Methodology	Findings
Zhang et al. (2016)	The effect of Corruption on Carbon dioxide emissions in APEC countries.	ICRG	Panel Quantile regression (QRPD)	Corruption has a negative effect on CO <sub>2</sub> emissions in lower emission countries
Jetter et al. (2015)	The effect of Democracy on Corruption	CP_Index	Quantile regression; OLS	Democracy increases corruption in poor countries but reduces corruption in countries with GDP per capita above \$2,000.
Cariolle (2014)	Corruption in Turbulent times: A response to Shocks?	ICRG	System GMM; Dynamic Fixed Effects	Positive ex post effects of export fluctuations on corruption and positive ex ante effects of instability on corruption
Arezki and Gylfason (2013)	Resource Rents, Democracy, Corruption and Conflict: Evidence from Sub-Saharan Africa	ICRG	System GMM OLS	Higher resource rents lead to more corruption especially in more corrupt countries
Goel and Ram (2013)	Economic Uncertainty and Corruption	CP_Index	Quantile regression	Economic uncertainty increases corruption
Athanasouli et al. (2012)	Corruption and Firm performance: Evidence from Greek Firms	Survey	Quantile regression; OLS	Corruption is negatively associated with firm size. Small and medium size firms display a higher engagement in corruption.
Okada and Samreth (2012)	The effect of Foreign Aid on Corruption	WGI	Quantile regression; OLS	Foreign aid reduces corruption especially in larger countries with low levels of corruption
Arezki and Brückner (2011)	Oil rents, Corruption and State Stability: Evidence from Panel Data regressions.	ICRG	System GMM; OLS	Increase in oil rents significantly increases corruption.
Voors et al. (2011)	Income Shocks and Corruption in Africa: Does a virtuous circle exists?	ICRG	Pooled OLS	Positive income shocks lead to more corruption especially in more corrupt countries.
Bhattacharyya and Hodler (2010)	Natural Resources, Democracy and Corruption	ICRG	Pooled OLS	Increase in resource rents leads to more corruption if democratic institutions are poor
Mauro (1998)	Corruption and Composition of Government expenditure	ICRG	OLS	Corruption reduces government spending on education and health

Legend: ICRG denotes the corruption Index from Political Risk Services group. CP\_Index is the Corruptions Perceptions Index from Transparency International and WGI is the corruption index from World Governance Indicators.

Source: Authors compilation.

The literature on corruption outlines several factors that can influence the dynamics of corruption in a country. Hence aside commodity price shocks, a host of other control variables were included in the model. The variables included in the model include measures of the quality of institutions, socio-economic conditions of the people, the level of democratic accountability of the government

in power to the people, internal conflicts, ethnic and religious fractionalization, trade openness and a measure of the level of economic development. These variables though not ubiquitous in all studies on corruption, are among the most used in the literature on the determinants of corruption (see Arezki and Gylfason, 2013; Bhattacharyya and Hodler, 2010; Serra, 2006). Dube and Vargas (2013) for example documents the link between civil conflicts and corruption. Civil conflicts are a viable ground for political instability which indirectly results in state capture and corruption. High levels of ethnic fractionalization can increase corruption triggered by in-group favoritism as members of the elected official's ethnic group are more likely to defend the leader under any circumstance. They see any criticism of the leader as an attack on their ethnic group. The reward for such ethnic support is being favored in the allocation of resources and appointments by the corrupt leader. Religious fractionalization on the other hand, can result in in-fighting among the various religious groups leading to conflicts. La Porta et al. (1999) for example argued that religion can shape cultural attitudes towards social hierarchy and whether or not one should question those in power.

It is worth mentioning however that, while there is a degree of consensus among researchers of the negative correlation between resource abundance and level of economic development, there is little consensus on the impact of the other control variables on corruption. Thus, while there is a strong likelihood for corruption and rent seeking to be low in countries with matured democratic institutions, strong sanctions against reported cases of corruption, low conflict as well as low ethnic and religious fractionalization, it is possible to observe isolated cases where these factors are insignificant or of different sign.

### 1.3.3 Data

Data used for the study is annual and covered the period 1985 – 2017. The data are for 51 countries and includes both high-income, middle-income and low-income countries. Annual data is preferred since corruption turns to be persistent and that there are delays between the transmission of price shocks to incomes. For a country to be considered commodity dependent and included in the sample, commodities must account for at least 60% of its total merchandise exports. This follows the proposition of United Nations as captured in the United Nations Conference on Trade and Development (UNCTAD) 2019 State of Commodity Dependence report<sup>14</sup>. Sample countries were drawn from the list of countries in this report.

#### *(a) Commodity prices*

Schmitt-Grohe and Uribe (2018) argued that commodity price shocks transmitted via a basket of multiple commodities offers a more potent way of accounting for the effects of commodity price shocks. Hence for this study, I constructed an export-share weighted commodity price index for each country similar to Miller (1995); Musayev (2014) and Kinda (2016). I use nominal individual commodity price data series from the World bank Pink Sheets to calculate the price index. The data is annual and covers the period 1985 – 2017. The US Consumer Price Index is used to deflate the commodity price indices. For a commodity to be included in the price index calculation, that commodity must account for at least five percent<sup>15</sup> of the net export of the country in a base year<sup>16</sup>.

---

<sup>14</sup> The State of Commodity Report is bi-annual report published by UNCTAD and details the evolution of commodity dependence, contains the statistical profile of commodity dependent countries globally and provides indicators describing each country's export or import dependence.

<sup>15</sup> Using the limit of 5% allows us to obtain a price index based on a basket of commodities that is more representative of the commodities produced and exported by a country. Bordart et al. (2012) used 20% whiles Kinda (2016) used 10%.

<sup>16</sup> Year 2001 is used as the base year.

### ***(b) Corruption***

Two main measures of corruption have been widely used in the literature - the International Country Risk Guide (ICRG) corruption indicators (Arezki and Gylfason, 2013; Arezki and Brückner, 2011; Bhattacharyya and Hodler, 2010) and the Transparency International's Corruption Perception Index (Picón and Boehm, 2019; Serra, 2006; Billger and Goel, 2009). For this study, we use the ICRG corruption index as the appropriate measure of corruption for reasons stated below. The ICRG corruption indicator is published by the Political Risk Services (PRS) Group<sup>17</sup> and measures the level of risk posed by corruption to international business operations in a country. The corruption index is a subcomponent of the political risk rating of the PRS group and assesses the level of corruption within a political system. It is measured on a 6-point scale with higher scores indicating less corruption. According to the PRS, the index captures the likelihood that high government officials will demand special payments and bribes connected with imports and export licensing, exchange controls, tax assessment, police protection (Howell, 2011). It also captures actual or potential<sup>18</sup> corruption in the form of excessive patronage, nepotism, job reservations, favor-for-favors, secret party funding, and suspiciously close ties with politics and business.

The ICRG corruption index is our main measure of corruption due to different reasons. First, it is a robust measure that is widely used in research across several fields and covers much more countries and time frame than does the Corruption Perception Index. This allows for the estimation

---

<sup>17</sup> The Political Risk Services (PRS) group is a private world leading political, economic and country risk rating, assessment and forecasting firm established in 1979 headquartered in New York. The group provides both current and historical data covering 140 countries globally detailing each country's political, economic, and financial risk to investors.

<sup>18</sup> Howell (2011) used the term to refer to more subtle and insidious forms of corrupt activities that are not observed directly but are potentially of much greater risk and has the potential to provoke popular backlash.

of more robust results using panel data estimation techniques and minimizes the selection bias across countries and across time. Secondly, the ICRG corruption indicator focuses on corruption mainly in the political system and hence suits well with the theoretical proposition of the paper. Also, the corruption rating of any country in the sample are aggregate indices constructed based on expert knowledge of different countries from political risk experts as well as the application of sound methodology making the scores of each country very reliable. The robust nature and measurement the ICRG corruption index makes it less likely to suffer from the possibility of a ‘bias-gap’ criticism labeled against measures dependent on perceptions. The ‘bias-gap’ used here denotes the argument that, corruption measures based on ‘perceptions’ and ‘experiences’ of citizens might be different from reality either because respondents respond in a political manner – “political bias” or are sensitive to questions about experiences – “sensitivity bias” hence creating a gap between the actual levels of corruption and reported levels of corruption (Agerberg, 2020).

***(c) Other control variables***

I include factors that for the purpose of this study are classified into social and economic factors<sup>19</sup> as controls. These controls are similar to those in Arezki and Gylfason (2013), Bhattacharyya and Hodler (2010) and Serra (2006). Unlike these studies however, all the social factors were obtained from the same source-ICRG indicators, while the economic factors were obtained from World Bank’s Development Indicators (WDI). This is to allow for consistency of measurement, methodology and results. The institutional quality variable was proxied by the Bureaucratic Quality index of ICRG. The index measures the strength and quality of bureaucratic institutions in a country and is rated on a 4-point scale. A higher score indicates a higher quality of institutions

---

<sup>19</sup> The social factors include measures for institutional quality, military in politics, socio-economic conditions, internal conflict, ethnic and religious fractionalization while economic factors include growth per capita and trade openness.

where the bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services. The Socio-economic conditions of the people was proxied by the ICRG's Socio-economic risk Index. The index measures the socio-economic pressures on the people in a country that could constrain government action or fuel social disaffection. The index is a sum of three subcomponents – unemployment, consumer confidence and poverty, each measured on a four (4) point scale. A high score indicates low risk. The inclusion of the socio-economic index is to capture peculiar factors that fuel corruption especially in poor countries.

The level of democracy or autocracy in a country is another variable consistently used in the literature. Democracy promotes the quality of institutions; the accountability of leaders and the stability of the government while autocracy does the opposite. To capture this, I include in the study a measure of the level of military involvement in politics in a country. The military is not elected by anyone hence their involvement in politics is associated with decline in democratic accountability, economic freedom, distortion of government policy and apparent rise of autocracies which are significant breeding grounds for corruption. The ICRG governance indicators provides a rating for the level of military involvement in politics in a country. It is rated on a 0-6-point scale with higher ratings representing lower risk of military involvement in politics. The internal conflict risk measures the level of political violence in a country and its actual or potential impact on governance. It is rated on a 0-12-point scale and has three subcomponent – civil war/coup threat, terrorism/political violence, and civil disorder, each rated on a 0-4-point scale. Higher ratings represent low risk. Ethnic and religious fractionalization were proxied by the ICRG's ethnic tension and religious tension indices each rated on a 0-6-point scale with high ratings indicating lower risk. The Ethnic tension index measures the degree of tension within a country as attributed to racial, nationality or language division while the religious tension index

measures the desire of one religious group to dominate a society and impose its ideology on the society. Finally, the level of economic development is proxied by GDP growth per capita while trade openness is measured as the sum of exports and imports expressed as a percentage of GDP.

### 1.3.4 Measuring commodity price Shocks

Existing literature advocates two main ways of capturing the shocks from international commodity price movements. The first approach argues that, if there is unit root in the international commodity prices, then the commodity price shocks can be calculated as the change in the natural log of the individual commodity prices (Mohtadi, 2018; Brückner et al. 2012; Bruckner and Arezki, 2010). Specifically, the commodity price shock was estimated as

$$CPxShock_{it} = \sum_{c \in C} \theta_{i,c} \Delta \log (ComPrice_{c,t}) \quad (1.1.7)$$

Where  $ComPrice_{c,t}$  is the international commodity price of commodity  $c$  in year  $t$ ,  $\theta_{i,c}$  is the average time invariant value of exports of commodity  $c$  in the GDP of country  $i$ . The advantages of estimating the price shocks this way is that the index does not capture resource discoveries and other quantity/temporary volume shocks that may influence results.

The second approach uses a two-step procedure to calculate the commodity price shock. The first step involves computing a geometrically weighted price index and the second involves running a regression of the commodity price index on its lags (up to three) and a quadratic time trend to obtain the residuals (Deaton and Miller, 1995; Bazzi and Blattman, 2014; Kinda, 2016). The residuals obtained are used as the shocks.

For the purpose of this study which seeks to proxy for income shocks using commodity prices, I follow the procedure of Deaton and Miller (1995); Bazzi and Blattman (2014) and Kinda (2016). This procedure is more robust as it allows us to obtain an index that is stationary and isolated from

its trend. Also, estimating the commodity price shocks using this method, allows us to obtain an index and a shock that is specific to each country and takes into consideration the importance of commodities to each country.

Following Bazzi and Blattman (2014) and Kinda (2016), the country specific commodity price index is calculated as

$$PI_{it} = \frac{\prod_{j=1}^n P_{j,t}^{w_{i,j}}}{CPI_{i,t}} \quad (1.1.8)$$

Where  $PI_{i,t}$  is the commodity price index of country  $i$  in year  $t$ ;  $P_{j,t}$  is the world price of commodity  $j$  at time  $t$  and  $w_{i,j}$  is the country specific weighting of the commodity  $j$  (share of the commodity in exports) at base measure.  $CPI_{i,t}$  is the US consumer price index used to deflate the price index since the commodity prices are denominated in nominal US dollars. For a commodity to be included in the index calculation, it must account for at least 5% of net exports of the country in the base year. Following the literature, we use the median of the sample period -2001- as the base year. The Harvard Atlas of Economic Complexities dataset is used to select the commodities based on the Harmonized Commodity Description and Coding System (HS4) classification<sup>20</sup>. To ensure the indices obtained reflects the importance of commodity trade to each country, each commodity price is weighted by a fixed time invariant average share of the commodity in total national exports. The fixed time invariant share is calculated as the median share from period  $t - 5$  to  $t + 5$ . Calculating the fixed weight using the median approach allows us to obtain a weight more representative of the importance of each commodity to each country across the sample period thus

---

<sup>20</sup> The Harmonised Commodity Description and Coding System (HS) is an Internationally standardised system of names and numbers used to classify traded commodities. It covers more than 5000 different products described in 96 chapters. Numerical codes of 2, 4 and 6 digits are used to describe the levels of hierarchical classification.

allowing our index to cope well with changing trade structure than weights based on a single year (mostly base year) as used in Bazzi and Blattman (2014) and Kinda (2016).

The commodity price shock indicator ( $ComPxShock_{i,t}$ ) is then estimated as the residuals from the regression equation

$$\ln PI_{i,t} = \alpha_{i,0} + \alpha_{i,1}t + \delta_{i,t}t^2 + \sum_p^3 \theta_{i,p} \ln PI_{i,t-p} + \varepsilon_{i,t} \quad (1.1.9)$$

## 1.4 Empirical Results

This section presents the results of the study. Section 1.4.1 presents the table of descriptive statistics across the sample countries. Section 1.4.2 to 1.4.4 presents the empirical estimates from the QRPD procedure while section 1.4.5 presents a series of robustness check results.

### 1.4.1 Descriptive Statistics

The first step in empirically establishing a relationship between the main variables of interest – corruption and commodity price shocks, is to examine the main features of the data used in the estimation. Table 1.3 presents summary statistics of the variables for the panel of 51 countries. The table shows the mean, standard deviation as well as measures for Skewness and Kurtosis. The measures for Skewness and Kurtosis allow us to gain insights into the shape of the distribution of the data and determine the relevance of the estimation procedure. Skewness measures the degree of symmetry of the data series while Kurtosis measures whether or not the data series are heavily tailed relative to a normal distribution. For a normally distributed series, the measures of Skewness and Kurtosis are zero (0) and three (3) respectively.

Table 1.3 shows that, the value of the Skewness measure for the corruption and commodity price shock measures are significantly different from zero. The corruption index has a positive value of

0.79 implying a right skew while the commodity price index has skewness value of -0.91 implying a left skew.

**Table 1.3: Descriptive Statistics**

Variable	Obs	Mean	Std.Dev.	Min	Max	Skewness	Kurtosis
ICRG Corruption	1,675	2.61	1.09	0	6	0.79	3.70
ComPxShock	1,530	0.00	0.09	-0.45	0.32	-0.91	7.18
Bureaucratic Quality	1,675	1.78	0.95	0	4	0.41	2.97
Socioeconomic conditions	1,675	4.96	1.99	1	11	0.59	3.08
Military in Politics	1,675	3.10	1.66	0	6	-0.08	2.00
Religious Tension	1,675	4.43	1.39	0	6	-0.90	3.20
Ethnic Tension	1,675	3.62	1.32	0	6	-0.08	2.50
Internal Conflict	1,675	8.25	2.22	0.25	12	-0.64	3.38
Trade Openness	1,636	0.63	0.32	0.08	2.28	1.22	5.32
Growth Per Capita	1,627	1.35	5.75	-62.38	121.78	4.31	130.76

Notes: The ICRG Corruption denotes the International Country Risk Guide Corruption index. “ComPxShock” is the commodity price shock estimated from equation 3.3.3. Data used is annual data for the period 1985–2017,

The Kurtosis statistic for both variables are also significantly greater than three (3.70 and 7.18). From these results, we can conclude that the data is not normally distributed and will produce non-normal errors. Non-normal errors do not affect the OLS results but do affect standard errors and confidence intervals. The QRPD procedure is more applicable in the face of the non-normal errors. As further checks, I also present the pairwise correlations of the variables in Table A.2 in appendix A. The pairwise results shows main variables are negatively correlated.

### 1.4.2 Baseline Results

Table 1.4 and 1.5 below presents the QRPD and OLS results of the study. The main results are based on the QRPD estimates in Table 1.4. The OLS results in Table 1.5 were presented for comparison to the QRPD estimates. To interpret the effect of each variable on the corruption indicator correctly, it is important to note that, lower values for the ICRG corruption indicator indicates higher risk to corruption hence lower quantiles represent the distribution of countries

with higher levels of corruption. Also, Table 1.5 reports only the coefficients of the commodity price shock indicator from a panel quantile regression with corruption as the dependent variable. I report estimates for when (i) commodity price shock indicator is the sole explanatory variable, (ii) Commodity price shocks with all controls as explanatory variables and (iii) commodity price shocks with different mix of control variables as explanatory variables. Complete estimates of each equation are presented in the appendix. The OLS results are estimated with all controls as well as with and without country and time fixed effects. Also, I provide estimates with or without Internal conflict measure to see if results differ as the risk to internal conflict is likely to be correlated with the ethnic and religious tension measures. The results do not show any such significant variation. It is important to note that the baseline results and hence interpretations are based on the estimates of commodity price shocks with all controls. All other results are presented to ascertain the model variation when different mix of controls are used.

**Table 1.4: Panel Quantile Regression Results**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.349** (0.172)	-0.240** (0.120)	-0.588*** (0.079)	-0.290*** (0.079)	-0.496*** (0.156)
ComPxShock with All Controls	-0.374*** (0.142)	-0.347*** (0.031)	-0.260*** (0.033)	-0.215*** (0.058)	-0.186 (0.133)
ComPxShock, all controls except Internal conflict	-0.500*** (0.064)	-0.485*** (0.058)	-0.347*** (0.084)	-0.433*** (0.063)	-0.339*** (0.082)
ComPxShock with Econ Factors	0.098* (0.055)	-0.086** (0.034)	-0.114*** (0.044)	-0.109* (0.058)	-0.113** (0.052)
ComPxShock with Social factors	-0.093 (0.086)	-0.281*** (0.088)	-0.015 (0.086)	-0.237*** (0.086)	-0.428*** (0.071)
ComPxShock, Social factors except Internal conflict	-0.494*** (0.062)	-0.261*** (0.074)	-0.263*** (0.040)	-0.184** (0.092)	-0.564*** (0.034)
ComPxShock with Internal Conflict	-0.093*** (0.036)	-0.092*** (0.032)	-0.094** (0.037)	-0.092** (0.038)	-0.089*** (0.033)

Legend: The dependent Variable is the ICRG corruption index. "ComPxShock" is the commodity price shock estimated following equation 1.1.9. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10th, 25th, 50th, 75th and 90th quantiles. Lower Quantiles (0.10) signify more corruption. Coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Robust standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

The empirical results in Table's 1.4 and 1.5 are generally consistent with the theoretical expectation of the study and indicates several important findings. First, in line with the theoretical proposition, commodity price shocks have a strong negative effect on the corruption measure. The coefficient of the commodity price shock measure has the expected negative and statistically significant sign for the QRPD estimates across all quantiles in Table 1.4. The OLS estimates in Table 1.5 also have similar negative sign but statistically insignificant. The negative effects persist across the various estimates with different controls. Intuitively, we can conclude that, increases (positive) commodity price shocks reduces the corruption measure while negative commodity price shocks increase the corruption measure. Second, the results in Table 1.4 also shows a significant difference in the effect of commodity price shocks across the different quantile distributions of corruption. Specifically, in Table 1.4, the magnitude of the effect of commodity price shock on corruption is generally larger at lower and mid quantiles (10<sup>th</sup>, 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup>) than at the highest quantile across a large section of the estimates. The magnitude of the coefficients is largest (-0.588) at the 50<sup>th</sup> quantile when only commodity price shock measure was used as the explanatory variable but largest at the 10<sup>th</sup> quantile when estimated with all controls (-0.347) and with all controls except internal conflict (-0.500). The magnitude of the coefficients however varies when estimated with the economic and social variables separately. This is however expected due to a possible omitted variable problem resulting from the different mix of control variables used. Intuitively, given that lower quantiles denote the distribution of countries with high levels of corruption, we can interpret the above to imply that, positive commodity price shocks or commodity price booms invites more corruption in the most corrupt countries than in the least corrupt countries. This finding is similar to the findings of Voors et al. (2011) who used rainfall as

a proxy for income shocks and to Bhattacharyya and Hodler (2010) who used a measure of natural resource rents.

Equally, the baseline results also show that the quality of bureaucratic institutions, military in politics, socio-economic conditions, ethnic and religious fractionalization all have the expected positive and statistically significant sign across the different distributions of corruption with the magnitudes bigger at lower quantiles. The measures for internal conflict, trade openness and economic growth however have a negative sign contrary to expectations. Thus, increases in the quality of bureaucratic institutions, lower risk of military involvement in politics, higher socio-economic conditions reduce the levels of corruption. Lower risk to ethnic and religious tensions also reduces the levels of corruption in resource rich countries similar to the findings of Dincer (2008) while lower risk to internal conflicts, openness to trade and economic growth increases the levels of corruption contrary to the findings of Asongu and Kodila-Tedika (2013).

The corruption inducing effects of internal conflicts, trade openness and economic growth though contrary to expectations, is generally not out of place in the literature and in the context of resource rich countries. Openness to trade for example allow resource rich countries significant access to the international market via increased exports. Economic growth signifies increased production capacity of an economy. This together ensures resource rich countries especially the low and middle-income countries significantly increase rents from trade in their natural resource endowment. This positive correlation between resource earning, openness to trade and economic growth could translate to more rent seeking and corruption especially in the most corrupt countries.

**Table 1.5: OLS regression Results**

	Corruption		
	(1)	(2)	(3)
ComPxShock	-0.178 (0.243)	-0.151 (0.316)	-0.022 (0.219)
Bureaucratic Quality	0.368*** (0.035)	0.377*** (0.033)	0.154*** (0.034)
Socioeconomic Conditions	0.107*** (0.014)	0.064*** (0.014)	0.000 (0.013)
Millitary_in_Politics	0.072*** (0.019)	0.071*** (0.017)	0.039 (0.024)
Religious Tension	0.122*** (0.016)	0.109*** (0.015)	0.141*** (0.025)
Ethnic Tension	0.101*** (0.021)	0.098*** (0.020)	0.079*** (0.028)
Internal Conflict	-0.031** (0.014)	0.011 (0.014)	-0.044*** (0.014)
Trade Openness	-0.364*** (0.080)	-0.192*** (0.071)	0.167 (0.135)
Growth Per Capita	-0.009** (0.004)	-0.004 (0.003)	-0.002 (0.002)
Constant	0.740*** (0.106)	1.041*** (0.148)	2.097*** (0.167)
Year Fixed Effects	No	Yes	Yes
Country Fixed Effects	No	No	Yes
Obs.	1460	1460	1460
R-squared	0.411	0.493	0.761

Legend: The dependent Variable is the ICRG Corruption index. “ComPxShock” is the commodity price index estimated following equation 1.1.9. Results were estimated using robust standard errors. Robust standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively.

The negative effect of economic growth on corruption could also be a possible mechanism that explains the theoretical proposition that resource rich countries economically perform poorly than non-resource rich countries. Also, lower risk to internal conflicts may allow for a greater exploration of the natural resource endowment. As argued by Arezki and Gylfason (2013), internal conflicts are likely to fall in resource rich and less democratic countries given the ability of the political elites to quell the masses more effectively through re-distribution to the public. I add that, such public re-distributions especially at the individual level places more economic pressure on the political elite who may resort to illegal means to fund their activities. Exploring the above mechanisms is beyond the scope of this study.

### 1.4.3 Disentangling the Effects of Commodity Price Shocks.

Next, I examine whether or not there are asymmetries in the effect of commodity price shocks on corruption. Specifically, I ask whether the response of corruption to positive and negative commodity price shocks are the same in terms of magnitude. This objective is accomplished by disentangling the commodity price shocks into positive commodity price shocks ( $ComPx^+$ ) and negative commodity price shocks ( $ComPx^-$ ). I follow the procedure of York and Light (2017) and Allison (2019). The minimum requirement for York and Light (2017) and Allison (2019) asymmetric methodology is for the time series to vary sufficiently in both direction (increase and decrease). This makes commodity prices which are highly volatile suitable to their methodology. Cross sectional data according to York and Light (2017) is also more ideal to the methodology since a single time series is unlikely to possess sufficient statistical power to estimate an asymmetrical relationship unless the asymmetrical relationship is highly pronounced, or the time series is very long. Hence the current study suits best their methodology.

The asymmetric methodology of York and Light (2017) involve taking the first difference of the time varying series and then decomposing each time varying predictor into positive and negative components. If we let  $X_{it}$  be the commodity price index in period  $t = 1, 2, \dots, T$  for country  $i$ , then we can define  $X_{it}^+$  and  $X_{it}^-$  as follows

$$X_{it}^+ = X_{it} - X_{it-1} \text{ if } (X_{it} - X_{it-1}) > 0, \text{ otherwise } 0, \quad (1.2.0)$$

$$X_{it}^- = X_{it} - X_{it-1} \text{ if } (X_{it} - X_{it-1}) < 0, \text{ otherwise } 0. \quad (1.2.1)$$

For  $t = 1$ ,  $X_{it-1}$  is not observed hence both  $X_{it}^+$  and  $X_{it}^-$  are set equal to 0. The  $X_{it}^+$  and  $X_{it}^-$  are the decomposed positive and negative shocks. The asymmetric procedure involves including the unmodified commodity price shock measure ( $ComPxShocks_{it}$ ) and the  $X_{it}^+$  or  $X_{it}^-$  in the QRPD model. The sum of the estimated coefficients of  $ComPxShocks_{it}$  and  $X_{it}^+$  ( $X_{it}^-$ ) is the effect of the

positive (negative) commodity price shocks on corruption. Allison (2019) builds on the method by proposing the shocks be defined as the partial sum processes of the positive and negative shocks respectively. Specifically, we define

$$Z_{it}^+ = \sum_{j=1}^t \Delta X_{it}^+ = \sum_{j=1}^t \max(\Delta X_{it}, 0) \quad (1.2.2)$$

$$Z_{it}^- = \sum_{j=1}^t \Delta X_{it}^- = \sum_{j=1}^t \min(\Delta X_{it}, 0) \quad (1.2.3)$$

Where  $Z^+$  ( $Z^-$ ) is the accumulation of up to time  $t$  of all positive (negative) previous changes in  $X$ . We follow the York and Light (2017) procedure but also present results for the Allison (2019) procedure in the appendix. Results are presented in Table 1.6 to 1.8. We include estimates for both when positive and negative price shocks are used together in the regression equation which was the suggestion of York and Light (2017) but also include results for when the positive and negative commodity prices are included separately.

**Table 1.6: Panel Quantile Regression results -Negative Commodity Price Shocks**

	Corruption				
	Q (0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxneg	0.343*** (0.103)	0.998*** (0.215)	1.427*** (0.349)	0.389 (0.292)	0.808*** (0.226)
Bureaucratic Quality	0.424*** (0.026)	0.342*** (0.013)	0.355*** (0.050)	0.390*** (0.037)	0.493*** (0.010)
Socioeconomic Conditions	0.086*** (0.011)	0.084*** (0.009)	0.036 (0.056)	0.034* (0.021)	0.055*** (0.011)
Military_in_Politics	0.079*** (0.006)	0.078*** (0.005)	0.064*** (0.009)	0.050*** (0.009)	0.069*** (0.008)
Religious Tension	0.152*** (0.009)	0.089*** (0.007)	0.155*** (0.013)	0.198*** (0.021)	0.189*** (0.003)
Ethnic Tension	0.117*** (0.009)	0.143*** (0.007)	0.125*** (0.024)	0.082*** (0.020)	0.091*** (0.010)
Internal Conflict	-0.081*** (0.015)	-0.065*** (0.005)	-0.073*** (0.014)	-0.059*** (0.007)	-0.056*** (0.014)
Trade Openness	-0.465*** (0.042)	-0.166*** (0.064)	0.003 (0.269)	-0.367*** (0.084)	-0.064 (0.048)
Growth Per Capita	-0.007*** (0.001)	-0.009*** (0.001)	-0.009* (0.005)	-0.002 (0.003)	-0.005*** (0.002)

Legend: The dependent Variable is the ICRG corruption index. "ComPxneg" is the negative commodity price shock index estimated following York and Light (2017). The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. Robust standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

Results from Table 1.6 and 1.7 provides interesting insights into the nature of the effect of commodity price shocks on corruption. First the results generally have the expected sign and confirms the earlier finding that, positive commodity price shocks induce more corruption while negative commodity price shocks reduce the level of corruption in resource rich countries. Further, results also show that, the magnitude of the effect of a negative commodity price shock on corruption is much larger than the effect of positive commodity price shock. The coefficient of the negative commodity price shock is positive and statistically significant across all quantiles except 75<sup>th</sup> quantile while the coefficient of the positive commodity price shock is negative across all quantiles except the 10<sup>th</sup> quantile but statistically significant only at the 50<sup>th</sup> and 90<sup>th</sup> quantiles.

**Table 1.7: Panel Quantile Regression results -Positive Commodity Price Shocks**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxpos	0.079 (0.851)	-0.662 (0.699)	-0.407** (0.193)	-0.432 (0.338)	-0.609* (0.337)
Bureaucratic Quality	0.443*** (0.023)	0.399*** (0.004)	0.468*** (0.006)	0.410*** (0.017)	0.456*** (0.009)
Socioeconomic Conditions	0.039 (0.036)	0.081*** (0.018)	0.096*** (0.004)	0.053*** (0.005)	0.078*** (0.019)
Military_in_Politics	0.122*** (0.022)	0.095*** (0.009)	0.053*** (0.005)	0.070*** (0.008)	0.121*** (0.023)
Religious Tension	0.132*** (0.004)	0.158*** (0.022)	0.170*** (0.007)	0.150*** (0.006)	0.129*** (0.008)
Ethnic Tension	0.145*** (0.016)	0.115*** (0.004)	0.154*** (0.008)	0.153*** (0.016)	0.125*** (0.003)
Internal Conflict	-0.097*** (0.010)	-0.062*** (0.005)	-0.065*** (0.003)	-0.060*** (0.004)	-0.101*** (0.011)
Trade Openness	-0.214*** (0.045)	-0.304*** (0.013)	-0.103*** (0.031)	-0.182*** (0.045)	-0.058** (0.027)
Growth Per Capita	-0.007*** (0.002)	-0.005*** (0.002)	-0.011*** (0.001)	-0.011*** (0.002)	-0.007*** (0.001)

Legend: The dependent Variable is the ICRG corruption index. “ComPxpos” is the negative commodity price shock index estimated following York and Light (2017). The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10th, 25th, 50th, 75th and 90th quantiles. Lower Quantiles (0.10) signify more corruption. Robust standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively.

Intuitively, results from Table 1.6 and 1.7 suggest that there is a noticeable reduction in the levels of corruption across resource rich countries during periods of commodity price burst and that the

response to the negative commodity price shocks is more significant than the increase in corruption due to commodity price booms or positive commodity price shocks. Further, Table 1.8 shows the quantile estimates with both positive and negative commodity price shocks included in the same regression. The results generally confirm the observed effects in Table 1.6 and 1.7.

In sum, the results in Table 1.6 through to 1. 8 generally supports our earlier findings while also shedding more light on the differential effects of positive and negative commodity price shocks. These results thus lend credence to theoretical hypothesis that, increases in commodity prices (commodity price booms) increases the net expected payoff from corruption resulting in higher levels of corruption while decreases in commodity prices (commodity price burst) reduces the gains from corruption behaviour hence reduces corruption.

**Table 1.8: Panel Quantile results with Both Positive and Negative Commodity Price Shocks**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxpos	-0.289** (0.117)	-0.221 (0.582)	-0.505 (0.499)	-0.038 (0.500)	0.048 (0.222)
ComPxneg	1.051*** (0.139)	0.686*** (0.158)	0.725*** (0.181)	0.362 (0.246)	1.493*** (0.227)
Bureaucratic Quality	0.440*** (0.013)	0.340*** (0.030)	0.360*** (0.010)	0.436*** (0.018)	0.426*** (0.011)
Socioeconomic Conditions	0.101*** (0.007)	0.068*** (0.025)	0.087*** (0.012)	0.050** (0.022)	0.083*** (0.005)
Millitary_in_Politics	0.067*** (0.006)	0.057*** (0.003)	0.056*** (0.010)	0.096*** (0.018)	0.060*** (0.006)
Religious Tension	0.155*** (0.004)	0.115*** (0.008)	0.112*** (0.005)	0.142*** (0.005)	0.137*** (0.007)
Ethnic Tension	0.143*** (0.005)	0.125*** (0.009)	0.101*** (0.014)	0.133*** (0.006)	0.095*** (0.007)
Internal Conflict	-0.068*** (0.003)	-0.061*** (0.003)	-0.061*** (0.009)	-0.062*** (0.003)	-0.062*** (0.006)
Trade Openness	-0.226*** (0.022)	-0.245*** (0.010)	-0.155* (0.084)	-0.407*** (0.019)	-0.335*** (0.018)
Growth Per Capita	-0.007*** (0.000)	-0.011*** (0.002)	-0.012*** (0.001)	-0.005*** (0.001)	-0.013*** (0.001)

Legend: The dependent Variable is the ICRG corruption index. “ComPxpos” and “ComPxneg” are the positive and negative commodity price shock index estimated following York and Light (2017). The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10th, 25th, 50th, 75th and 90th quantiles. Lower Quantiles (0.10) signify more corruption. Robust standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively.

#### **1.4.4 Does the type of Commodity Matter?**

In this section, the study examines whether the effect of commodity price shocks on corruption depends on the type of commodity. A large part of the ambiguity on the effect of commodity price shocks across the existing empirical literature dwells on the argument that, the effect of commodity price shocks differs across commodities. Korhonen (2004) for example contends that, non-fuel resource endowment had the greatest effect on growth and corruption. Damania et al. (2005) however counter this assertion in a 2005 study. He observed that, the abundance of fuel, ore and mineral resources had the greatest effect on increasing corruption. Similarly, Mohtadi (2019) also finds that, agricultural commodity price shocks reduce pay inequality while non-agricultural commodity price shocks increase capital-tax inequality. To contribute to this debate, the study examines whether or not the observed increase (decrease) in corruption in the presence of positive (negative) commodity price shocks hold across all commodity groups. This objective is accomplished using the annual sectoral/commodity price index data from the World Bank's Pink Sheet. The index is freely available and is calculated as a weighted average of different commodities internationally classified together as being Energy, Non-Energy, Agriculture and Metals & minerals commodity groups respectively. The energy price index is a weighted average of the prices of coal, crude oil, and natural gas while the Metals and Minerals price index is the weighted average prices of aluminum, copper, iron ore, lead, nickel, tin and zinc. The Agricultural price index was calculated as the weighted average prices of beverages (cocoa, coffee, and tea); food (cereals, vegetable oil and meals, and other foods) and agricultural raw materials (timber, and other raw materials). The Non-Energy commodity index is a weighted average of all commodities in the sample except energy and precious metals subgroup. The price shocks were then estimated using equation 1.1.7 and then weighted by the annual export share of GDP of each country to get country specific price shocks.

The estimated results are presented in Table 1.9. The results were estimated with each commodity group with all controls separately and the estimates in the table are the coefficients of each commodity group price shock. Full results are presented in the appendix. The results show that, the coefficients of all four commodity subgroups are negative and statistically significant across all quantiles with the magnitudes of the coefficients bigger at lower quantiles. The results also show that, the coefficients of the non-energy commodity price shocks are larger than the energy commodity price shocks implying a bigger impact on corruption. Within the specific commodity sub-groups, shocks in agricultural commodity prices have the biggest impact especially in more corrupt countries than do energy commodity price shocks. These results suggest that shocks in the prices of all commodity groups have significant negative impact on corruption. However, in terms of magnitude, total non-energy commodity price shocks or more specifically, shocks in agricultural commodity prices have a bigger impact than does energy commodities. This finding is contrary to the findings of Damania et al. (2005) but similar to Korhonen (2004) and Mohtadi (2019). The type of commodity exported thus matters in the effect of commodity price shocks on corruption.

**Table 1.9: Commodity Group Regression Results**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
Energy ComPxShock	-0.659** (0.263)	-1.196*** (0.167)	-1.346*** (0.218)	-0.900*** (0.130)	-0.698*** (0.225)
Non-Energy ComPxShock	-3.580*** (0.242)	-3.914*** (0.064)	-3.952*** (0.638)	-3.345*** (1.262)	-2.510* (1.293)
Agricultural ComPxShock	-6.259*** (1.852)	-3.475*** (0.069)	-5.648*** (0.452)	-4.999*** (0.542)	-4.116*** (0.594)
Metals & Minerals ComPxShock	-0.886** (0.365)	-1.282*** (0.070)	-1.713*** (0.100)	-1.310*** (0.113)	-1.162*** (0.224)

Legend: The dependent Variable is the ICRG corruption index. The commodity price shocks are estimated following equation 1.1.7. The QRPD results were estimated with all controls and with an adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10th, 25th, 50th, 75th and 90th quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Robust standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

### 1.4.5 Robustness Checks

In order to assess the robustness of the study, I conducted a series of estimations. This section presents the results of the robustness checks. The results presented, answers two major questions that have the potential to affect the results presented earlier. For most studies on commodity price shocks, a natural question researchers ask is whether or not global economic events such as the 2003-2009 oil price bubble and 2007-2008 financial crises affects the results of the study. Also, for studies on corruption, questions arise on the persistence of corruption and whether or not estimates with “period averages” better captures the effects of the explanatory variables on corruption.

In an answer to the first question, I re-estimated the model for the 2009-2017 sub-sample. The 2009-2017 period is a relatively stable period for commodity markets and for the occurrence of major global events. Hence estimating the model for this sample will allow us to capture the effects of commodity price shocks devoid of the influence of major global events. The results are presented in Table A.17 in the Appendix A. The results strongly support the earlier finding of a strong negative impact of commodity price shocks on corruption across different quantiles with the biggest impact observed for lower quantiles or highly corrupt countries. Specifically, the coefficient of the commodity price shock is negative and statistically significant across all quantiles except the 50<sup>th</sup> quantile which is negative but insignificant. This estimates thus shows the main results of the study are not significantly influenced by global economic events. Finally, in an answer to the second question, I re-estimate the model using 5-year averages of the data. The results for the estimation are presented in Table A.18 of the Appendix A. The results for the five-year average sample are strongly consistent with our main results. The coefficient of the commodity price shock is negative and statistically significant across all quantiles except the 75<sup>th</sup> quantile. A closer observation however shows that the coefficients are significantly bigger than

observed for our main results. This however could be due to the significantly smaller sample and observation than used in the main estimates with the entire sample period.

## **1.5 Conclusion**

A major concern of many across the globe over the past decade is the dynamic effects of commodity price shocks on different economic and socio-economic phenomena. In this paper, I provide an analytical and empirical evidence that documents the effects of commodity price shocks on an important socio-economic issue -corruption-, across a sample of 51 commodity dependent countries. The analytical model documents how shocks in commodity prices influence the choice to engage in more corruption by a corrupt bureaucrat. The model is a two-period framework built under the assumption that all agents are corruptible. The model demonstrates that, an incumbent corrupt bureaucrat who faces re-election in period two, will evaluate and compare the net expected payoff from engaging in corruption in period one against the minimal acceptable welfare needed to ensure his re-election. This net welfare must be equal to or above the minimum accepted welfare benefits voters will accept to vote for the incumbent over the opposition. We show that, the net expected payoff is largely dependent on revenue from the tradable goods sector which in turn is heavily influenced by commodity price shocks. An increase in commodity prices as shown, will increase the net expected revenue from corruption hence leads to an increase in corruption and vice versa.

The empirical evidence from the Panel Quantile regression approach of Powell (2014; 2016) show that positive commodity price shocks are associated with more corruption while negative commodity price shocks reduce the level of corruption across all levels of corruption in resource rich countries. This result is robust across symmetric and asymmetric estimations of price shocks

and different sub-samples. Disentangling the mechanism of the propagation of the adverse effect of commodity price shocks on corruption, I found that the magnitude of the impact of commodity price shocks is larger and more significant in more corrupt countries and that this effect is observed across different categories of commodities. The results also show that, shocks in the prices of non-energy commodities as well as agricultural commodities have the biggest impact on corruption.

The results of the study thus offer policy makers studying the dynamics of corruption a direct proxy to study how corruption evolves over time. Specifically, since commodity price shocks are more visible, policy makers can observe the trend in such prices in order to predict the trend in corruption behaviour which are mostly difficult to observe. Equally, the results show corruption is a main mechanism to explaining the resource-curse hypothesis and that measures to address corruption would promote the benefits resource rich countries enjoy from trade.

## References

- Acemoglu, D., Egorov, G., & Sonin, K. (2021). Institutional change and institutional persistence. In *The Handbook of Historical Economics* (pp. 365-389). Academic Press.
- Agerberg, M. (2020). Corrupted estimates? Response bias in citizen surveys on corruption. *Political behavior*, 1-26.
- Aguiar, M., & Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. *Journal of political Economy*, 115(1), 69-102.
- Aidt, T. S. (2016). Rent seeking and the economics of corruption. *Constitutional Political Economy*, 27(2), 142-157.
- Allison, P. D. (2019). Asymmetric fixed-effects models for panel data. *Socius*, 5, 2378023119826441.
- Álvarez, R., García-Marín, Á., & Ilabaca, S. (2021). Commodity price shocks and poverty reduction in Chile. *Resources Policy*, 70, 101177.
- Arezki, M. R., & Bruckner, M. (2010). *International commodity price shocks, democracy, and external debt*. International Monetary Fund.
- Arezki, R., & Brückner, M. (2011). Oil rents, corruption, and state stability: Evidence from panel data regressions. *European Economic Review*, 55(7), 955-963.
- Arezki, R., & Gylfason, T. (2013). Resource rents, democracy, corruption and conflict: Evidence from sub-Saharan Africa. *Journal of African Economies*, 22(4), 552-569.
- Asongu, S., & Kodila-Tedika, O. (2013). Crime and conflicts in Africa: consequences of corruption? *European Economics Letters*, 2(2), 50-55.
- Baland, J.-M., & Francois, P. (2000). Rent-seeking and resource booms. *Journal of development Economics*, 61(2), 527-542.

- Baragwanath, K. (2020). The Effects of Oil Windfalls on Political Corruption: Evidence from Brazil.
- Bhattacharyya, S., & Hodler, R. (2010). Natural resources, democracy and corruption. *European Economic Review*, 54(4), 608-621.
- Billger, S. M., & Goel, R. K. (2009). Do existing corruption levels matter in controlling corruption?: Cross-country quantile regression estimates. *Journal of Development Economics*, 90(2), 299-305.
- Bodart, V., Candelon, B., & Carpentier, J.-F. (2012). Real exchange rates in commodity producing countries: A reappraisal. *Journal of International Money and Finance*, 31(6), 1482-1502.
- Boix, C., Adsera, A., & Payne, M. (2003). Are you being served? Political accountability and quality of government. *The Journal of Law, Economics, and Organization*, 19(2), 445-490.
- Brückner, M., Ciccone, A., & Tesei, A. (2012). Oil price shocks, income, and democracy. *Review of Economics and Statistics*, 94(2), 389-399.
- Bulte, E. H., Damania, R., & Deacon, R. T. (2005). Resource intensity, institutions, and development. *World development*, 33(7), 1029-1044.
- Cariolle, J. (2016). The voracity and scarcity effects of export booms and busts on bribery. *Development*, 146.
- Ciccone, A. (2008). Transitory economic shocks and civil conflict. Ciccone, Antonio, Transitory Economic Shocks and Civil Conflict (December 2008). CEPR Discussion Paper No. DP7081, Available at SSRN: <https://ssrn.com/abstract=1344640>
- Deaton, A., & Miller, R. (1996). International commodity prices, macroeconomic performance and politics in Sub-Saharan Africa. *Journal of African Economies*, 5(3), 99-191.

- Di Tella, R., & Schargrotsky, E. (2003). The role of wages and auditing during a crackdown on corruption in the city of Buenos Aires. *The Journal of Law and Economics*, 46(1), 269-292.
- Dincer, O. C. (2008). Ethnic and religious diversity and corruption. *Economics Letters*, 99(1), 98-102.
- 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.
- Fornero, J., Kirchner, M., & Yany, A. (2014). *Terms of trade shocks and investment in commodity-exporting economies*. Banco Central de Chile.
- Frankel, J. A. (2010). *The natural resource curse: a survey*. NBER working paper 15836.
- Garcia-Cicco, J., Pancrazi, R., & Uribe, M. (2010). Real business cycles in emerging countries? *American Economic Review*, 100(5), 2510-2531.
- Howell, L. D. (2011). International country risk guide methodology. *East Syracuse, NY: PRS Group*.
- Kinda, M. T., Mlachila, M. M., & Ouedraogo, R. (2016). *Commodity price shocks and financial sector fragility*. International Monetary Fund.
- Korhonen, I. (2004). Does democracy cure a resource curse? *Available at SSRN 2792024*.
- Lane, P. R., & Tornell, A. (1996). Power, growth, and the voracity effect. *Journal of economic growth*, 1(2), 213-241.
- Ledeneva, A., Bratu, R., & Köker, P. (2017). Corruption studies for the twenty-first century: Paradigm shifts and innovative approaches. *Slavonic and East European Review*, 95(1), 1-20.

- Lopez-Martin, B., Leal, J., & Fritscher, A. M. (2019). Commodity price risk management and fiscal policy in a sovereign default model. *Journal of International Money and Finance*, 96, 304-323.
- Mauro, P. (2004). The persistence of corruption and slow economic growth. *IMF staff papers*, 51(1), 1-18.
- Medina, L. (2010). A Commodity Curse? The Dynamic Effects of Commodity Prices on Fiscal Performance in Latin America. *The Dynamic Effects of Commodity Prices on Fiscal Performance in Latin America (March 1, 2010)*.
- Mohtadi, S. (2018). Commodity price shocks and inequality: cross-country evidence. In.
- Musayev, V. (2014). Commodity price shocks, conflict and growth: The role of institutional quality and political violence.
- Pendergast, S. M., Clarke, J. A., & Van Kooten, G. C. (2010). Corruption, development and the curse of natural resources. *Canadian Journal of Political Science/Revue canadienne de science politique*, 44(2),411-437
- Picón, C., & Boehm, F. (2019). Do the determinants of corruption differ between countries with different levels of corruption? A cross-country quantile regression analysis. *Revista de Economía Del Caribe*(23), 71-83.
- Rodrik, D., & Subramanian, A. (2003). The primacy of institutions:(and what this does and does not mean). *Finance & development*, 40(002).
- Roessler, P. (2016). *Ethnic politics and state power in Africa: The logic of the coup-civil war trap*. Cambridge University Press.
- Sala-i-Martin, X., & Subramanian, A. (2013). Addressing the natural resource curse: An illustration from Nigeria. *Journal of African Economies*, 22(4), 570-615.

- Schmitt-Grohé, S., & Uribe, M. (2018). How Important are Terms-Of-Trade Shocks? *International Economic Review*, 59(1), 85-111.
- Serra, D. (2006). Empirical determinants of corruption: A sensitivity analysis. *Public Choice*, 126(1), 225-256.
- Spatafora, M. N., & Samake, I. (2012). *Commodity price shocks and fiscal outcomes*. International Monetary Fund.
- Tornell, A., & Lane, P. R. (1999). The voracity effect. *American economic review*, 89(1), 22-46.
- Torvik, R. (2002). Natural resources, rent seeking and welfare. *Journal of development economics*, 67(2), 455-470.
- Uribe, M., & Yue, V. Z. (2006). Country spreads and emerging countries: Who drives whom? *Journal of international Economics*, 69(1), 6-36.
- Voors, M. J., Bulte, È. H., & Damania, R. (2011). Income shocks and corruption in Africa: does a virtuous cycle exist? *Journal of African Economies*, 20(3), 395-418.
- Warner, M. A. M. (2015). *Natural Resource Booms in the Modern Era: Is the curse still alive?* International Monetary Fund.
- World Economic Forum. 2019. "Corruption is costing the global economy \$3.6 billion dollars every year". Available at <https://www.weforum.org/agenda/2018/12/the-global-economy-loses-3-6-trillion-to-corruption-each-year-says-u-n/> (Accessed 5 February 2019)
- York, R., & Light, R. (2017). Directional asymmetry in sociological analyses. *Socius*, 3, 2378023117697180.

## APPENDIX A

**Table A.1: Sample Countries**

Countries	Countries
Algeria	Madagascar
Angola	Malawi
Argentina	Mongolia
Australia	Mozambique
Bahrain	Myanmar
Bolivia	Niger
Brazil	Nigeria
Burkina Faso	Norway
Cameron	Oman
Chile	Papua New Guinea
Colombia	Paraguay
Congo	Peru
Cote d'voire	Russia
Ecuador	Saudi Arabia
Ethiopia	Sudan
Gabon	Syria
Gambia	Tanzania
Ghana	Togo
Guatemala	Trinidad and Tobago
Guinea	UAE
Guinea-Bissau	Uganda
Iceland	Uruguay
Iran	Venezuela
Kenya	Yemen
Kuwait	Zambia
Libya	

**Table A.2: Pairwise Correlations**

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) ICRG Corruption	1.000									
(2) ComPxShock_Reg	-0.020	1.000								
(3) Bureaucratic Quality	0.539*	-0.001	1.000							
(4) Socioeconomic Con.	0.485*	0.015	0.571*	1.000						
(5) Military_in_Politics	0.464*	0.003	0.612*	0.516*	1.000					
(6) Religious Tension	0.298*	-0.008	0.211*	0.212*	0.233*	1.000				
(7) Ethnic Tension	0.361*	-0.012	0.371*	0.399*	0.427*	0.258*	1.000			
(8) Internal Conflict	0.283*	0.005	0.414*	0.353*	0.507*	0.360*	0.529*	1.000		
(9) Trade Openness	-0.023	0.022	0.111*	0.197*	0.162*	-0.032	0.153*	0.264*	1.000	
(10) Growth PerCapita	-0.052*	0.105*	-0.001	-0.033	-0.023	0.050*	0.039	0.084*	0.004	1.000

Notes: ICRG Corruption denotes the International Country Risk Guide Corruption index. "ComPxShock" is the commodity price shock estimated from equation 3.3.3. (\*) represent significance at 5%. Data used is annual data for the period 1985–2017.

**Table A.3: Panel Quantile Regression with only Commodity price shocks**

	Corruption				
	(1)	(2)	(3)	(4)	(5)
ComPxShock_Reg	-0.349** (0.172)	-0.240** (0.120)	-0.588*** (0.086)	-0.290*** (0.079)	-0.496*** (0.156)

Legend: The dependent Variable is the ICRG corruption index. "ComPxShock" is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.4: Panel Quantile Regression results -All Controls**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.374*** (0.142)	-0.347*** (0.031)	-0.260*** (0.033)	-0.215*** (0.058)	-0.186 (0.133)
Bureaucratic Quality	0.438*** (0.017)	0.334*** (0.022)	0.441*** (0.010)	0.471*** (0.008)	0.385*** (0.084)
Socioeconomic Conditions	0.078*** (0.006)	0.055* (0.032)	0.058*** (0.007)	0.071*** (0.008)	0.041 (0.026)
Military_in_Politics	0.071*** (0.002)	0.104*** (0.013)	0.035*** (0.009)	0.038*** (0.005)	0.019 (0.012)
Religious Tension	0.171*** (0.005)	0.178*** (0.005)	0.147*** (0.004)	0.174*** (0.002)	0.176*** (0.022)
Ethnic Tension	0.094*** (0.005)	0.114*** (0.010)	0.125*** (0.004)	0.102*** (0.003)	0.129*** (0.038)
Internal Conflict	-0.071*** (0.004)	-0.109*** (0.015)	-0.059*** (0.006)	-0.076*** (0.004)	-0.077*** (0.008)
Trade Openness	-0.367*** (0.023)	-0.277*** (0.030)	-0.182*** (0.013)	-0.149*** (0.037)	0.197 (0.125)
Growth Per Capita	-0.007*** (0.002)	-0.006*** (0.002)	-0.018*** (0.001)	-0.005*** (0.002)	-0.009*** (0.002)

Legend: The dependent Variable is the ICRG corruption index. "ComPxShock" is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.5: Panel Quantile Regression results -Excluding Internal Conflict**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.500*** (0.064)	-0.485*** (0.058)	-0.347*** (0.084)	-0.433*** (0.063)	-0.339*** (0.082)
Bureaucratic Quality	0.368*** (0.015)	0.374*** (0.009)	0.406*** (0.017)	0.342*** (0.010)	0.353*** (0.009)
Socioeconomic Conditions	0.110*** (0.005)	0.121*** (0.006)	0.084*** (0.021)	0.071*** (0.005)	0.090*** (0.006)
Millitary_in_Politics	0.061*** (0.005)	0.057*** (0.007)	0.069*** (0.022)	0.085*** (0.004)	0.101*** (0.009)
Religious Tension	0.122*** (0.010)	0.080*** (0.005)	0.145*** (0.008)	0.106*** (0.004)	0.114*** (0.003)
Ethnic Tension	0.038*** (0.011)	0.059*** (0.004)	0.012 (0.021)	0.045*** (0.009)	0.040*** (0.004)
Trade Openness	-0.319*** (0.022)	-0.320*** (0.034)	-0.048 (0.117)	-0.350*** (0.028)	-0.329*** (0.027)
Growth Per Capita	-0.019*** (0.001)	-0.016*** (0.002)	-0.012*** (0.002)	-0.006*** (0.001)	-0.010*** (0.002)

Legend: The dependent Variable is the ICRG corruption index. “ComPxShock” is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.6: Panel Quantile Regression results – Only Economic Variables**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.098* (0.055)	-0.086** (0.034)	-0.114*** (0.044)	-0.109* (0.058)	-0.113** (0.052)
Trade Openness	-0.606*** (0.033)	-0.375** (0.185)	-0.416** (0.196)	-0.614*** (0.032)	-0.613*** (0.031)
Growth Per Capita	0.002*** (0.000)	0.002** (0.001)	0.002** (0.001)	0.002*** (0.000)	0.002*** (0.000)

Legend: The dependent Variable is the ICRG corruption index. “ComPxShock” is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.7: Panel Quantile Regression results -Social variables**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.093 (0.086)	-0.281*** (0.088)	-0.015 (0.086)	-0.237*** (0.086)	-0.428*** (0.071)
Bureaucratic Quality	0.216* (0.126)	0.385*** (0.017)	0.301*** (0.025)	0.385*** (0.010)	0.394*** (0.014)
Socioeconomic Conditions	-0.010 (0.014)	0.025*** (0.007)	-0.003 (0.020)	0.068*** (0.014)	0.099*** (0.012)
Millitary_in_Politics	0.044* (0.023)	-0.032*** (0.003)	0.013 (0.011)	0.088*** (0.004)	-0.004 (0.005)
Religious Tension	0.108*** (0.040)	0.168*** (0.006)	0.148*** (0.022)	0.168*** (0.005)	0.142*** (0.006)
Ethnic Tension	0.103*** (0.024)	0.178*** (0.014)	0.085*** (0.017)	0.051*** (0.006)	0.097*** (0.006)
Internal Conflict	-0.047* (0.028)	-0.046*** (0.006)	-0.035*** (0.008)	-0.061*** (0.003)	-0.038*** (0.005)

Legend: The dependent Variable is the ICRG corruption index. "ComPxShock" is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively.

**Table A.8: Panel Quantile Regression results -Social variables excluding Internal Conflict**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.494*** (0.062)	-0.261*** (0.074)	-0.263*** (0.040)	-0.184** (0.092)	-0.564*** (0.034)
Bureaucratic Quality	0.422*** (0.005)	0.401*** (0.019)	0.323*** (0.063)	0.289*** (0.100)	0.396*** (0.021)
Socioeconomic Conditions	0.054*** (0.001)	0.059*** (0.007)	0.009 (0.011)	0.039 (0.033)	0.054*** (0.009)
Millitary_in_Politics	0.072*** (0.005)	0.036*** (0.013)	-0.004 (0.016)	0.024 (0.024)	0.021*** (0.005)
Religious Tension	0.156*** (0.004)	0.128*** (0.009)	0.177*** (0.008)	0.093*** (0.015)	0.119*** (0.017)
Ethnic Tension	0.058*** (0.009)	0.063*** (0.004)	0.045*** (0.006)	0.084*** (0.009)	0.093*** (0.011)

Legend: The dependent Variable is the ICRG corruption index. "ComPxShock" is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively

**Table A.9: Panel Quantile Regression results - Internal Conflict**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.093*** (0.036)	-0.092*** (0.032)	-0.094** (0.037)	-0.092** (0.038)	-0.089*** (0.033)
Internal Conflict	0.022*** (0.008)	0.022*** (0.007)	0.022*** (0.009)	0.022** (0.009)	0.021*** (0.008)

Legend: The dependent Variable is the ICRG corruption index. "ComPxShock" is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively.

**Table A.10: Panel Quantile Regression results – Economic Growth**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.004*	-0.004*	-0.004	-0.004	-0.004*
	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)
Growth Per Capita	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

Legend: The dependent Variable is the ICRG corruption index. “ComPxShock” is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.11: Panel Quantile Regression results – Positive Commodity Price Shocks**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxposcum	-0.040	0.100	-0.923***	-0.043	0.070
	(0.790)	(0.627)	(0.141)	(0.133)	(0.171)
Bureaucratic Quality	0.421***	0.364***	0.446***	0.426***	0.459***
	(0.013)	(0.046)	(0.007)	(0.007)	(0.025)
Socioeconomic Conditions	0.045	0.057	0.098***	0.058***	0.065***
	(0.028)	(0.044)	(0.007)	(0.008)	(0.006)
Millitary_in_Politics	0.079***	0.032*	0.092***	0.073***	0.070***
	(0.011)	(0.020)	(0.009)	(0.004)	(0.009)
Religious Tension	0.165***	0.156***	0.154***	0.174***	0.177***
	(0.016)	(0.014)	(0.003)	(0.004)	(0.012)
Ethnic Tension	0.130***	0.166***	0.127***	0.135***	0.118***
	(0.008)	(0.010)	(0.003)	(0.005)	(0.019)
Internal Conflict	-0.071***	-0.083***	-0.098***	-0.063***	-0.074***
	(0.006)	(0.011)	(0.010)	(0.003)	(0.002)
Trade Openness	-0.332***	-0.100	-0.217***	-0.234***	-0.119***
	(0.070)	(0.145)	(0.014)	(0.016)	(0.034)
Growth Per Capita	-0.003	-0.007***	-0.007***	-0.006***	-0.006***
	(0.002)	(0.002)	(0.001)	(0.000)	(0.002)

Legend: The dependent Variable is the ICRG corruption index. “ComPxposcum” is the positive commodity price shock index estimated following Allison, (2019). The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.12: Panel Quantile Regression results – Negative Commodity Price Shocks**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxnegcum	0.341* (0.199)	1.302*** (0.046)	0.607*** (0.162)	0.720*** (0.100)	0.671*** (0.250)
Bureaucratic Quality	0.435*** (0.014)	0.464*** (0.007)	0.435*** (0.009)	0.444*** (0.006)	0.417*** (0.019)
Socioeconomic Conditions	0.054* (0.030)	0.071*** (0.005)	0.045 (0.030)	0.065*** (0.004)	0.035 (0.024)
Millitary_in_Politics	0.074*** (0.006)	0.063*** (0.003)	0.070*** (0.011)	0.068*** (0.005)	0.070*** (0.014)
Religious Tension	0.190*** (0.024)	0.128*** (0.005)	0.183*** (0.018)	0.156*** (0.005)	0.179*** (0.010)
Ethnic Tension	0.140*** (0.008)	0.142*** (0.002)	0.162*** (0.018)	0.147*** (0.006)	0.156*** (0.023)
Internal Conflict	-0.097*** (0.011)	-0.063*** (0.003)	-0.107*** (0.016)	-0.067*** (0.002)	-0.074*** (0.005)
Trade Openness	-0.208 (0.130)	-0.200*** (0.018)	-0.188*** (0.051)	-0.150*** (0.015)	-0.234*** (0.021)
Growth Per Capita	-0.006* (0.003)	-0.014*** (0.001)	-0.008*** (0.002)	-0.006*** (0.000)	-0.007*** (0.002)

Legend: The dependent Variable is the ICRG corruption index. “ComPxnegcum” is the negative commodity price shock index estimated following Allison, (2019). The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.13: Panel Quantile Regression results – Energy Commodity Price Shocks**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
EnergyShock	-0.659** (0.263)	-1.196*** (0.167)	-1.346*** (0.218)	-0.900*** (0.130)	-0.698*** (0.225)
Bureaucratic Quality	0.382*** (0.034)	0.435*** (0.029)	0.438*** (0.013)	0.401*** (0.014)	0.480*** (0.017)
Socioeconomic Conditions	0.041 (0.046)	0.118*** (0.003)	0.077*** (0.017)	0.084*** (0.029)	0.041*** (0.016)
Millitary_in_Politics	0.080*** (0.005)	0.068*** (0.003)	0.068*** (0.016)	0.069*** (0.007)	0.057*** (0.010)
Religious Tension	0.130*** (0.020)	0.152*** (0.012)	0.172*** (0.006)	0.179*** (0.017)	0.214*** (0.011)
Ethnic Tension	0.145*** (0.027)	0.114*** (0.005)	0.154*** (0.014)	0.059*** (0.006)	0.084*** (0.008)
Internal Conflict	-0.089*** (0.016)	-0.078*** (0.012)	-0.098*** (0.014)	-0.079*** (0.014)	-0.076*** (0.005)
Trade Openness	-0.130 (0.227)	-0.295*** (0.039)	-0.199*** (0.067)	-0.387*** (0.040)	0.374* (0.200)
Growth Per Capita	-0.006** (0.003)	-0.011*** (0.001)	-0.006** (0.003)	-0.004*** (0.001)	-0.004** (0.002)

Legend: The dependent Variable is the ICRG corruption index. “EnergyShock” is the Energy commodity price shock index estimated following equation 3.3.1. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.14: Panel Quantile Regression results – Non-Energy Commodity Price Shocks**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
Non-EnergyShock	-3.580*** (0.242)	-3.914*** (0.064)	-3.952*** (0.638)	-3.345*** (1.262)	-2.510* (1.293)
Bureaucratic Quality	0.423*** (0.033)	0.414*** (0.003)	0.429*** (0.016)	0.376*** (0.042)	0.309* (0.160)
Socioeconomic Conditions	0.064*** (0.023)	0.107*** (0.003)	0.064*** (0.018)	0.037 (0.035)	0.021 (0.027)
Military_in_Politics	0.087*** (0.013)	0.043*** (0.002)	0.091*** (0.007)	0.081*** (0.011)	0.038*** (0.014)
Religious Tension	0.180*** (0.025)	0.139*** (0.002)	0.234*** (0.009)	0.220*** (0.034)	0.163*** (0.024)
Ethnic Tension	0.123*** (0.030)	0.166*** (0.003)	0.124*** (0.017)	0.118*** (0.020)	0.070** (0.031)
Internal Conflict	-0.079*** (0.009)	-0.073*** (0.002)	-0.119*** (0.005)	-0.088*** (0.007)	-0.055*** (0.017)
Trade Openness	-0.357*** (0.105)	-0.101*** (0.023)	-0.482*** (0.098)	-0.405*** (0.042)	0.162 (0.129)
Growth Per Capita	-0.005*** (0.001)	-0.008*** (0.000)	-0.004 (0.005)	0.001 (0.005)	-0.005** (0.002)

Legend: The dependent Variable is the ICRG corruption index. “Non-EnergyShock” is the Non-energy commodity price shock index estimated following equation 3.3.1. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.15: Panel Quantile Regression results – Agric Commodity Price Shocks**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
AgricShock	-6.259*** (1.852)	-3.475*** (0.069)	-5.648*** (0.452)	-4.999*** (0.542)	-4.116*** (0.594)
Bureaucratic Quality	0.438*** (0.008)	0.275*** (0.017)	0.407*** (0.019)	0.422*** (0.010)	0.462*** (0.012)
Socioeconomic Conditions	0.078*** (0.007)	0.084*** (0.013)	0.033 (0.030)	0.064*** (0.011)	0.034*** (0.008)
Military_in_Politics	0.067*** (0.009)	0.070*** (0.015)	0.045 (0.031)	0.056*** (0.006)	0.060*** (0.006)
Religious Tension	0.167*** (0.025)	0.096*** (0.015)	0.204*** (0.008)	0.166*** (0.008)	0.258*** (0.007)
Ethnic Tension	0.135*** (0.010)	0.141*** (0.011)	0.147*** (0.016)	0.225*** (0.006)	0.087*** (0.005)
Internal Conflict	-0.074*** (0.013)	-0.063*** (0.002)	-0.075*** (0.023)	-0.084*** (0.002)	-0.070*** (0.004)
Trade Openness	-0.305*** (0.075)	-0.195** (0.086)	-0.302*** (0.031)	-0.244*** (0.028)	0.168*** (0.029)
Growth Per Capita	-0.007*** (0.002)	-0.008*** (0.001)	-0.002 (0.004)	-0.007*** (0.002)	-0.005** (0.002)

Legend: The dependent Variable is the ICRG corruption index. “AgricShock” is the Agricultural commodity price shock index estimated following equation 3.3.1. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. Standard errors are in parenthesis. \*\*\*/\*\* /\* denotes significance at 1%, 5% and 10% respectively.

**Table A.16: Panel Quantile Regression results – Metals & Minerals Commodity Price Shocks**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
M&MShock	-0.886** (0.365)	-1.282*** (0.070)	-1.713*** (0.100)	-1.310*** (0.113)	-1.162*** (0.224)
Bureaucratic Quality	0.440*** (0.022)	0.473*** (0.010)	0.390*** (0.005)	0.414*** (0.010)	0.378*** (0.030)
Socioeconomic Conditions	0.061** (0.012)	0.096*** (0.003)	0.057*** (0.005)	0.039* (0.024)	0.017 (0.015)
Military_in_Politics	0.066*** (0.013)	0.034*** (0.003)	0.078*** (0.003)	0.085*** (0.009)	0.118*** (0.018)
Religious Tension	0.167*** (0.028)	0.155*** (0.006)	0.161*** (0.005)	0.236*** (0.028)	0.235*** (0.008)
Ethnic Tension	0.152*** (0.017)	0.148*** (0.007)	0.100*** (0.007)	0.032 (0.045)	0.016* (0.008)
Internal Conflict	-0.068*** (0.016)	-0.060*** (0.003)	-0.063*** (0.003)	-0.058*** (0.011)	-0.071*** (0.008)
Trade Openness	0.007 (0.237)	-0.083* (0.042)	-0.264*** (0.012)	-0.056 (0.084)	-0.003 (0.058)
Growth Per Capita	-0.009*** (0.002)	-0.008*** (0.001)	-0.005*** (0.001)	-0.002 (0.003)	0.001 (0.001)

Legend: The dependent Variable is the ICRG corruption index. “M&MShock” is the Metals and Minerals commodity price shock index estimated following equation 3.3.1. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. Standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively.

**Table A.17: Panel Quantile Regression results – Post 2008 Sub-Sample**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-0.534*** (0.149)	-0.434*** (0.122)	0.103 (0.213)	-0.355*** (0.126)	-0.295*** (0.109)
Bureaucratic Quality	0.471*** (0.068)	0.279*** (0.042)	0.441*** (0.061)	0.315*** (0.036)	0.331*** (0.029)
Socioeconomic Conditions	0.086*** (0.023)	0.095*** (0.018)	0.173*** (0.021)	0.117*** (0.009)	0.108*** (0.016)
Military_in_Politics	0.131*** (0.038)	0.013 (0.020)	0.064*** (0.019)	0.076 (0.070)	0.078*** (0.018)
Religious Tension	-0.005 (0.046)	0.100** (0.044)	0.039 (0.032)	0.071*** (0.007)	0.081*** (0.013)
Ethnic Tension	0.111** (0.048)	0.213*** (0.028)	-0.047 (0.081)	0.199*** (0.028)	0.219*** (0.014)
Internal Conflict	0.001 (0.031)	0.074** (0.034)	0.069*** (0.024)	0.050 (0.062)	0.039* (0.023)
Trade Openness	-0.413*** (0.089)	-0.264*** (0.065)	0.422*** (0.139)	-0.218 (0.167)	-0.106*** (0.040)
Growth Per Capita	0.002 (0.003)	0.011*** (0.002)	0.007*** (0.002)	0.010*** (0.002)	0.013*** (0.001)

Legend: The dependent Variable is the ICRG corruption index. “ComPxShock” is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively. Sample period is 2009-2017.

**Table A.18: Panel Quantile Regression results – 5-year Averages**

	Corruption				
	Q(0.10)	Q(0.25)	Q(0.50)	Q(0.75)	Q(0.90)
ComPxShock	-1.593*** (0.207)	-2.374*** (0.419)	-1.773*** (0.630)	-0.086 (0.375)	-1.230* (0.668)
Bureaucratic Quality	0.404*** (0.031)	0.473*** (0.055)	0.374*** (0.027)	0.526*** (0.045)	0.416*** (0.026)
Socioeconomic Conditions	0.017 (0.011)	0.072*** (0.011)	0.100*** (0.019)	0.074*** (0.012)	0.016 (0.045)
Military_in_Politics	0.156*** (0.008)	0.109*** (0.011)	0.086*** (0.017)	0.094*** (0.008)	0.086*** (0.008)
Religious Tension	0.182*** (0.007)	0.178*** (0.020)	0.120*** (0.007)	0.177*** (0.012)	0.163*** (0.027)
Ethnic Tension	0.188*** (0.023)	0.129*** (0.020)	0.143*** (0.030)	0.133*** (0.008)	0.159*** (0.013)
Internal Conflict	-0.119*** (0.006)	-0.100*** (0.023)	-0.117*** (0.019)	-0.093*** (0.014)	-0.099*** (0.016)
Trade Openness	-0.354*** (0.049)	-0.179*** (0.044)	-0.004 (0.055)	-0.152 (0.094)	0.473 (0.313)
Growth Per Capita	-0.028*** (0.007)	-0.030*** (0.005)	-0.024*** (0.006)	-0.034*** (0.004)	-0.027*** (0.006)

Legend: The dependent Variable is the ICRG corruption index. “ComPxShock” is the commodity price index estimated following equation 3.3.3. The Panel Quantile results were estimated using the adaptive MCMC Optimization with 10,000 draws and 1500 burn-ins for 10%, 25%, 50%, 75% and 90% quantiles. Lower Quantiles (0.10) signify more corruption. coefficients presented are the coefficients of the commodity price shock indicator from each quantile regression. Standard errors are in parenthesis. \*\*\*/\*\*/\* denotes significance at 1%, 5% and 10% respectively.

**Table A.19: Variables and sources**

Variables	Source
Nominal Commodity Prices	World Bank Pink sheet
ComPxShock	Author constructed
Corruption	International Country Risk Guide (ICRG)
Institutional Quality	International Country Risk Guide (ICRG)
Military In Politics	International Country Risk Guide (ICRG)
Socio-Economic Conditions	International Country Risk Guide (ICRG)
Risk to Internal Conflict	International Country Risk Guide (ICRG)
Ethnic Fractionalization	International Country Risk Guide (ICRG)
Religious Fractionalization	International Country Risk Guide (ICRG)
GDP Growth Per Capita	World Development Indicators (WDI) -World Bank
Trade Openness	World Development Indicators (WDI) – World Bank

## **2. Accounting for Real Exchange Rates in Emerging Market Economies: The Role of Commodity Prices**

### **2.1 Introduction**

Exchange rates are an object of great interest for the conduct of macroeconomic policy in many countries. Their crucial role in the adjustment process in case of macroeconomic disequilibria is undebatable. However, an important challenge in the understanding of exchange rates is related to their high volatility, which is frequently observed in the large currency trade volumes in foreign exchange markets. Different macro models have hence been used to provide possible explanations to the observed exchange rate variations. Engel (1999) for example documented for a group of high-income countries that variations in the prices of the traded goods accounts for almost all of the variations in the real exchange rates of these countries and thus suggesting commodity price variations as a possible channel of explaining the exchange rate volatility. Prior to this, Branson (1981) documented that the observed exchange rate fluctuations in the 1970's and 1980's could be explained by three factors – money, relative prices, and the current account balance while Edwards (1988) uses a model that consist of an exportable, importable and traded goods sector to estimate the causes of exchange rate variability in developing countries.

Although there is a rich literature that studies the dynamics of exchange rate movements (Engel 1993; 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 dynamics of exchange rate fluctuations from the perspective of EMEs. The recent spike in trade activity in EME's alongside the high volatility of currencies of these countries is a reference point for studies on the dynamics of exchange rates in these economies. Hence, in this study we empirically examine the traded goods/commodity price channel of explaining the exchange rate dynamics for the case of middle-

income countries, henceforth Emerging Market Economies (EMEs). This objective is accomplished in two separate ways.

First, following Engel (1999), we 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 tradeable goods prices and non-tradeable goods prices for real exchange rate changes? Our second objective is to quantify the contribution of world commodity prices in the Real effective exchange rate (REER) and tradeable goods ( $X_t$ ) price fluctuations (here in referred to as 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) as well as the documentation by Engel (1999) that variations in traded goods prices explains a large part of the variations in the exchange rates in many countries. Specifically, real exchange rates are excessively volatile relative to income. Hence, we conjecture that commodity prices, which are also highly volatile, could 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 i) quantify 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 goods prices characterize real exchange rate movements in EMEs. Our second contribution shows 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.

The rest of the study is organized as follows. Section 2.2 reviews the existing literature on real exchange rates and commodity prices. Section 2.3 provides details about our data and methodology. Section 2.4 discusses the results. Section 2.5 concludes.

## **2.2 Literature Review**

A growing strand of literature has emerged that examined the empirical role of commodity price shocks on different macro-aggregates. Pressing issues such as general business cycle effects, monetary policy, inflation, and unemployment effects of commodity price shocks has recently been areas of wide research. While the focus in many of these 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.

It is worth noting that, the focus of the literature has not always been on commodity prices. Earlier theoretical literature has ascribed an important role to terms-of-trade shocks on business cycles of middle- and low-income countries (Mendoza 1995, Kose 2002). However, more recent and influential studies (Schmitt-Grohe and Uribe 2017, 2018) have documented a modest effect of terms-of-trade shocks on middle- and low-income countries' business cycles. Notably, terms-of-trade shocks are found to be “less important in data than in theory” (Schmitt-Grohe and Uribe, 2017). Di Pace, Juvenal, Petrella, and Leigh (2020) however attribute this disconnect to the nature of measuring the terms of trade - treating the economy's response to export and import price shocks

as symmetric. They find that, export and import price shocks together account for about 40% of output fluctuations across countries but the contribution from export prices are about twice as large as the contribution from import price shocks. Prior to this observation, a number of studies have already documented a large role for commodity prices. For example, Fernández, Schmitt-Grohé, and Uribe (2017) studied the transmission of world shocks to domestic business cycles via world commodity price shocks using a basket of multiple commodities and find that commodity price shocks explain on average 33% of output fluctuations for sample of 138 countries. Roch (2019) using similar multiple commodity price approach, analyzed the adjustment of output, consumption, investment, trade balance and the real exchange rate to commodity price shocks in a sample of 22 commodity exporting countries and finds that commodity price shocks on average explains about 33, 29, 31, 34, and 25 percent of variations in the real exchange rate, output, consumption, investment, and the trade balance respectively. Drechsel and Tenreyro (2018) find via a quantitative exercise applied to Argentina data that commodity price shocks explain about 38, 42 and 61 percent of the variations in post 1950 output growth, consumption, and investment respectively.

Closely related to the study, Engle (1999) showed that the relative price of tradable goods is the dominant factor accounting for real exchange rate movements in high income countries. Betts and Kehoe (2017) however argued that the relative price of non-traded to traded goods explains a larger portion of the real exchange rate variations than found in the literature especially when the real exchange rate measure is the bilateral exchange rate of large trading pairs and between bilateral exchange rate pairs other than the US. Kilian and Zhou (2019) find a strong evidence of oil price shocks on the real exchange rate of the US and concluded that oil demand and supply shocks together account for about one third of the unconditional variability in the real exchange rates.

Basher, Haug and Sadorsky (2016) find for a group of 6 large oil exporting and 3 oil importing countries in a Markov- Switching framework that evidence of significant positive impact of oil price shocks on exchange rates exist in at least one state for each country. Zhang, Dufour and Galbraith (2016) find on their part 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.

Habib, Buetzer and Stracca (2016) however finds that a systematic relationship between oil price shocks and exchange rate movements exists only for net oil-exporters (appreciation of their currencies). Bodart, Candelon and Carpentier (2015) 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. Dauvin (2014) also find the existence of energy currencies where a 10% rise in energy prices leads to a 2.8% appreciation of the exchange rates of a group of 10 energy exporting and 23 commodity exporting countries. Bodart, Candelon and Carpentier (2012) on their part 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. Finally, Amano and Norden (1998) find evidence of a strong long run relationship between the real effective exchange rates and the domestic price of oil for Germany, Japan, and the United States. 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.

The above papers either focused on high income countries for the accounting exercise, the effect of a single commodity price (oil) or used a general business cycle model to study the impact of commodity price shocks on the real exchange rate. Our approach differs from this previous

literature in several ways. First, we examine the validity of Engel's (1999) finding that bilateral exchange rates are largely driven by fluctuations in the relative price of tradable goods by applying his approach to a sample of 12 emerging market economies. Our choice of the US dollar bilateral exchange rate is motivated by the fact that the US dollar is world-wide dominant currency (see Gopinath 2015; Gopinath et al. 2020). Next, we employ a structural VAR and PVAR approach to estimate the impact of commodity prices on the international price measures ( $X_t$  and REER). Third, in our volatility accounting exercise we use a larger and longer sample compared to other studies. Namely, our sample is composed of 12 EME's and 16 AE's during the period 1985Q1-2015Q4. Finally, our approach differs from studies such as Kilian and Zhou (2019), Basher et al. (2016), Buetzer et al. (2016) in that our measure of commodity price shocks is based on a basket of multiple commodities instead of just one commodity. Furthermore, we provide estimates across alternative measures of the real exchange rates, as well as across different frequencies of data (quarterly and annual) while allowing for a larger set of controls in our VAR and PVAR models to add precision to our estimates.

Our paper contributes to the above literature in three ways. First, we show that the relative price of tradeable goods is the major determinant of real exchange rate changes in EMEs. Second, we document that one key component of tradeable goods prices, namely world commodity prices (i.e., a composite- rather than a single-commodity price), explain about 1/3 of the observed volatility in relative tradeable goods prices, and hence real exchange rate volatility. Third, we find that increases in commodity prices are associated with larger and more persistent real appreciations in EMEs vis-à-vis high-income countries.

## **2.3 Data and Methodology**

This section presents the data and estimation procedure adopted for the study. Section 2.3.1 gives a summary of the data and sources for the two empirical approaches we pursue in this study. Section 2.3.2 discusses the exchange rate accounting methodology (2.3.2.1), as well as the Structural VAR (2.3.2.2) and Panel VAR (2.3.2.3) models. We use the former method to disaggregate exchange rates into tradeable and non-tradeable components of prices, and then employ the latter methods to analyze the forecast error variance decomposition and impulse response functions implied by world commodity price shocks.

### **2.3.1 Data**

The world commodity price data is from three broad groups of commodity indices (fuel, metals, and agriculture) and the frequency is quarterly over the period 1985Q1-2015Q4. The world commodity price index data is drawn from Fernandez, Schmitt-Grohe and Uribe (2017), who construct a trade weighted series of commodity prices from the World Bank Pink Sheet database. The real effective exchange rate and nominal exchange rate data are from the IMF International Financial Statistics (IFS) and the Federal Reserve Bank of St. Louis FRED (for some countries). All other variables in the model were sourced from the IFS and the OECD economic statistics dataset. We classify countries into middle-income (EMEs), and high-income countries based on the IMF's income classification. The first part of the analysis (exchange rate accounting) covers a sample of 11 EMEs (Costa Rica, Colombia, Hungary, Malaysia, Mexico, Morocco, Paraguay, Philippines, South Africa, Thailand, and Turkey) at quarterly and monthly frequency. In the second part, namely the VAR analyses, we use a larger sample of 27 countries (11 EMEs and 16 high income countries as listed in Table B4 of the Appendix), with results presented at both quarterly

and monthly frequency. Sample countries were chosen based on data availability.<sup>21</sup> Finally, while data for world commodity prices extends to 1960, our analysis starts from 1985 based on available data for our international price measures. The choice of the sample period also allows us to focus exclusively on the post Bretton-Woods era of floating exchange rates and it corresponds as well to a period of increased globalization and financialization (Blecker, 2005).

### ***World commodity price series***

We employ a panel of three world commodity price indices made available by Fernández, Schmitt-Grohe and Uribe (2017). They draw on dollar denominated nominal commodity price indices from the World Bank's Pink Sheet and construct three aggregate commodity price indexes – Fuel ( $P^f$ ), Metals and Minerals ( $P^m$ ) and Agriculture ( $P^a$ ). Each index is 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. The Metals and Minerals price index is calculated as the weighted average of the spot prices of 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). The US CPI is then used to deflate the three commodity price indexes constructed.

### ***Relative International Prices***

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

---

<sup>21</sup> The exchange rate accounting results are also available at annual frequency. In the VAR analyses we present the results at quarterly frequency as these estimates are more reliable for capturing the impact of commodity price shocks, which are by nature of high frequency.

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

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

Further, we apply an accounting exercise to decompose the RER into its tradeable and non-tradeable components of relative prices. We follow Engel (1999) and construct the relative price of tradeable goods measure ( $X_t$ ) as

$$x_t = s_t + \ln(PPI_t^*) - \ln(PPI_t) \tag{2.1.1}$$

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, and  $s_t$  is the log of the domestic currency price of the US dollar (i.e., nominal exchange rate). Data on the producer price index (PPI) of both the US and home country is from the IFS.

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

The real effective exchange rate data was obtained from the IFS 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 is obtained from the Federal Reserve Bank of St. Louis and is based on the manufacturing consumer price index.

### 2.3.2 Methodology

This section describes the two empirical analyses that we employ to i) quantify the contribution of relative tradeable goods prices on real exchange rate changes for the case of EMEs, and ii) estimate the impact of world commodity prices on real exchange rate fluctuations. First, we employ a real exchange rate accounting exercise for a sample of EMEs drawing on Engel (1999) in order to measure the relative contribution of tradeable and non-tradeable goods prices to real exchange rate fluctuations. Specifically, we decompose changes in real exchange rates into tradeable goods ( $x_t$ ) and non-tradeable goods ( $y_t$ ) prices using a Mean Squared Error (MSE) decomposition procedure. Second, we use Structural Vector Autoregression (SVAR) and a Panel VAR (PVAR) approach to examine the role of a key component of tradeable goods prices, namely commodity prices, on the dynamics of real exchange rates. In particular, we use the VAR approaches to quantify the effect of commodity price shocks on real exchange rate fluctuations through i) variance decomposition, and ii) impulse response function (IRF) analyses, respectively.

#### 3.3.2.1 Mean Squared Error (MSE) Decomposition Analysis

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

$$q_t = x_t + y_t \tag{2.1.2}$$

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

As in Engel (1999), we use 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<sup>22</sup> 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

$$x_t = s_t + \ln(PPI_t^*) - \ln(PPI_t) \quad (2.1.3)$$

$$y_t = \ln(CPI_t^*) - \ln(PPI_t^*) - (\ln(CPI_t) - \ln(PPI_t)) \quad (2.1.4)$$

Where  $\ln(PPI_t^*)$  is the natural log of the producer price index of the US at time  $t$ ,  $\ln(PPI_t)$  is the natural log of the producer price index of a domestic country at time  $t$  and  $s_t$  is the natural log of the nominal exchange rate at time  $t$ . Last, since the overall PPI index may include a sizeable amount of non-traded goods component, we also compute estimates for the domestic manufacturing PPI. The steps used in Mean Squared Error (MSE) decomposition analysis, the estimation procedure and results using the alternative measures of price indices are presented in the Appendix A.

### 2.3.2.2 Structural Autoregressions (SVARs)

The second part of our empirical analysis employs the SVAR approach to estimate the effect of world commodity prices on RER volatility using two (2) measures of international prices. The first is guided by our finding in the first part of our analysis, namely that the relative price of tradeables ( $X_t$ ) accounts for most real exchange rate fluctuations in EMEs. The second measure is the real effective exchange rate ( $REER_t$ ), which is widely used as the relevant international price on a by country-basis.

---

<sup>22</sup> Our choice of the US dollar as the main bilateral currency was influenced by Gopinath (2015) and Gopinath et al. (2020) who document that most trade globally is invoiced in US dollars and that global trade outside the US declines when the dollar appreciates. This places the US dollar as world-wide dominant currency.

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  $\varepsilon_t$  is a vector of serially and mutually uncorrelated structural innovations,  $A_i$  is a matrix of parameters of the lagged dependent variables,  $\alpha$  is a vector of constants and  $z_t = (p^a, p^f, p^m, i, dpr, cpi, expr, impr$  and  $y)$  is a vector of endogenous commodity price index and other variables in the model.  $p^a$  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. The control variables include the world interest rate (proxied by the real 3-month US Treasury bill rate), the domestic policy rate, the domestic CPI, export to GDP ratio and import to GDP ratio ( $i, dpr, cpi, expr,$  and  $impr$  respectively). All variables were logged, and HP filtered with a smoothing parameter of 1600. The world commodity price index, the real effective exchange rate, the CPI and constant GDP are logged before HP filtered.

If we let  $e_t$  denote the innovations from the reduced form VAR such that it is decomposed according to  $e_t = A_0^{-1} \varepsilon_t$ , then the structural innovations ( $\varepsilon_t$ ) 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.

$$e_t \equiv \begin{pmatrix} e_t^{p^f} \\ e_t^{p^m} \\ e_t^{p^a} \\ e_t^{\text{other controls}} \\ e_t^{\text{Rel.Int.Prices}} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & a_{22} & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{\text{Fuel Px Shock}} \\ \varepsilon_t^{\text{Metal Px Shock}} \\ \varepsilon_t^{\text{Agric Px Shock}} \\ \varepsilon_t^{\text{Cont.Shock}} \\ \varepsilon_t^{\text{Other Shock}} \end{pmatrix}$$

The identification strategy is motivated as follows. We assume that international fuel prices are not affected contemporaneously by either metal prices or agricultural prices. Hence, fuel prices are exogenous and do not respond to any other structural shock in the model. This assumption is based on the observation that oil supply and demand are mostly unaffected or respond only marginally to other commodity price changes, in this case metals and minerals or agricultural sectors. Next, we assume that metal prices are affected contemporaneously by fuel prices but not by agricultural prices. Last, agricultural prices are assumed to be affected contemporaneously by both fuel prices and metal prices because most agricultural production depends heavily on both fuel and metal inputs. In turn, world commodity prices are assumed to have a contemporaneous effect on both the control variables and relative international prices.

Our emphasis is on a structural forecast error variance decomposition in order to provide quantitative estimates of the impact of the commodity price shocks on international price fluctuations. The estimated structural forecast error variance decompositions that we report for each country are the mean and median of the sum of the three commodity price shocks.

### **2.3.2.3 Panel Vector Autoregression (PVAR)**

We estimate a PVAR model to examine how commodity price shocks are transmitted to relative international prices through impulse response function (IRF) analysis.

To this end, we use the model-free Local Projections (LP) technique by Jordà (2005) in order to estimate the effect of commodity price shocks for pooled sample of countries.

The effect of a given commodity price shock  $P_t^j$  with  $j = (a, f, m)$ , on the relative international price  $y_{i,t+h}$  in country  $i$  at time  $t$  is given as

$$y_{i,t+h} - y_{i,t-1} = \alpha^h + \beta^{j,h} P_t^j + \delta^h \omega_{i,t-1} + \epsilon_{i,t+h}, \quad h = 0, 1, \dots, H \quad (2.1.5)$$

Where  $\omega_{i,t-1}$  is a vector of control variables,  $\beta^{j,h}$  estimates the average treatment effect of a period  $t$  commodity  $j$  shock in period  $t + h$ , and the dependent variables  $y_{i,t+h}$  considered are the relative price of tradeable goods ( $x_t$ ) and the real effective exchange rate ( $reer_t$ ).  $P_t^j$  with  $j = (a, f, m)$  is measured as the HP filtered cyclical component of the natural logs of real commodity prices. As a robustness check,  $P_t^j$  is estimated from equation 2.1.6 as

$$\ln PI_{i,t}^j = \alpha_{i,0} + \alpha_{i,1}t + \delta_{i,t}t^2 + \sum_p^3 \theta_{i,p} \ln PI_{i,t-p}^j + \epsilon_{i,t} \quad (2.1.6)$$

Where  $PI_{i,t}^j$  is the real commodity price index of country  $i$  in year  $t$ ,  $t$  is time and  $j = (P^a, P^f, P^m)$ . The error term  $\epsilon_{i,t}$ , is our estimated commodity price shock indicator estimated separately for each commodity  $j$ .

The LP methodology employs a non-parametric technique to estimate IRFs from a data sample and does not require specification and estimation of a dynamic system as commonly performed in a VAR. Our choice of the LP methodology is motivated for several reasons. First, LP's are a useful alternative to estimating IRFs when identification restrictions are not clear-cut. Moreover, when estimated with sufficiently large sample size and with unrestricted lag structure, both LP and VAR's generate similar impulse response functions (see Plagborg-Møller and Wolf, 2019; Herbst and Johansson, 2020). Second, VAR's are more prone to misspecification of the data generating process (DGP). As a result, IRFs from VARs, which are functions of multi-step forecasts into distant horizons, may amplify any existing forecast errors. By contrast, LPs are robust to misspecification error and can be estimated by single equation OLS, hence they are straightforward to implement and provide more reliable estimates, especially across a sample of countries that may

be heterogenous across time. Finally, our interest to estimate IRFs for groups of countries rather than individual countries makes the LP panel technique suitable for the purpose.

## **2.4 Results**

This section discusses the results obtained from our two empirical strategies. Section 2.4.1 examines the relative importance of tradeable and non-tradeable prices to (bilateral) real exchange rate movements in EMEs. Section 2.4.2 presents the results from the SVAR analysis regarding the effect of world commodity price shocks on international price fluctuations in EMEs vis-à-vis High-income countries. Finally, in section 2.4.3 we estimate several PVAR specifications and analyze the models implied IRFs in terms of the effect of commodity price shocks on RER dynamics. We present and discuss the results at quarterly frequency, while additional robustness results are included in the Appendix A.

### **2.4.1 Real Exchange Rate Accounting**

This section focuses on the MSE decomposition of the real exchange rate into tradeable and non-tradeable components of prices for a sample of twelve (12) EMEs following the methodology proposed by Engel (1999). Decompositions are calculated for different measures including consumer prices, output prices, and personal consumption expenditures. We focus on the MSE decomposition using the PPI and CPI indices because we can cover more countries than with the other measures. The results from the MSE decomposition using the PPI and CPI along with their standard errors are presented in Table 2.1 Panels A and B, as well as in Figure 2.1. The decomposition is done at different horizons that our data allows - from one (1) quarter up to 80 quarters (20 years). Importantly, our results show that for all the measures of tradeable and non-

tradeable goods adopted, nearly all the movement in the real exchange rate is accounted for by the traded goods price component in all countries.

**Table 2.1A: Period Average MSE Decomposition – Emerging Market Economies**

Country	4 Quarters			20 Quarters			40 Quarters			60 Quarters		
	Mean	Median	Std Error	Mean	Median	Std Error	Mean	Median	Std Error	Mean	Median	Std Error
Brazil	0.89	0.89	0.01	0.85	0.85	0.02	0.85	0.84	0.01	0.84	0.83	0.01
Colombia	0.97	0.97	0.00	0.98	0.98	0.00	0.98	0.99	0.00	0.99	0.99	0.00
Costa Rica	0.99	0.99	0.00	0.99	0.99	0.00	0.99	0.99	0.00	0.99	0.99	0.00
Hungary	0.93	0.93	0.01	0.95	0.95	0.01	0.96	0.97	0.01	0.96	0.97	0.01
Malaysia	0.88	0.88	0.00	0.90	0.89	0.01	0.91	0.90	0.01	0.91	0.91	0.01
Mexico	0.99	0.99	0.00	0.99	0.99	0.00	0.99	0.99	0.00	0.99	0.99	0.00
Morocco	0.77	0.77	0.00	0.80	0.77	0.02	0.81	0.79	0.02	0.78	0.78	0.02
Paraguay	0.94	0.94	0.00	0.95	0.95	0.01	0.96	0.96	0.01	0.96	0.96	0.01
Philippines	0.86	0.87	0.01	0.86	0.86	0.00	0.86	0.85	0.00	0.85	0.85	0.00
Thailand	0.93	0.94	0.00	0.94	0.94	0.00	0.94	0.94	0.00	0.94	0.94	0.00
Turkey	0.99	0.99	0.00	0.99	0.99	0.00	0.99	0.99	0.00	0.99	0.99	0.00
South Africa	0.97	0.97	0.00	0.98	0.97	0.00	0.98	0.98	0.00	0.98	0.99	0.00

Notes: Figures are the quarterly average of the MSE decompositions across 1-year, 5-years, 10-years and 15-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2015Q4.

**Table 2.1B: Period Average MSE Decomposition – Advanced Economies**

Country	4 Quarters			20 Quarters			40 Quarters			60 Quarters		
	Mean	Median	Std Error	Mean	Median	Std Error	Mean	Median	Std Error	Mean	Median	Std Error
Australia	0.95	0.96	0.00	0.96	0.96	0.00	0.96	0.96	0.00	0.96	0.96	0.00
Austria	0.93	0.93	0.00	0.93	0.93	0.00	0.92	0.93	0.01	0.90	0.93	0.02
Belgium	0.94	0.94	0.00	0.94	0.94	0.00	0.94	0.94	0.00	0.93	0.94	0.00
Canada	0.90	0.90	0.00	0.89	0.89	0.00	0.89	0.89	0.00	0.89	0.89	0.00
Denmark	0.94	0.94	0.00	0.95	0.95	0.01	0.96	0.96	0.01	0.96	0.96	0.00
Finland	0.97	0.97	0.00	0.97	0.97	0.00	0.97	0.97	0.00	0.96	0.97	0.00
Germany	0.96	0.96	0.00	0.97	0.96	0.00	0.97	0.97	0.00	0.97	0.98	0.00
Ireland	0.88	0.88	0.01	0.86	0.86	0.01	0.84	0.85	0.02	0.82	0.84	0.02
Italy	0.97	0.97	0.00	0.97	0.97	0.00	0.97	0.97	0.00	0.97	0.97	0.00
Japan	0.96	0.96	0.00	0.98	0.98	0.00	0.98	0.98	0.00	0.98	0.99	0.00
Netherlands	0.95	0.94	0.00	0.95	0.95	0.00	0.95	0.95	0.00	0.96	0.95	0.00
New Zealand	0.95	0.95	0.00	0.95	0.95	0.00	0.95	0.95	0.00	0.94	0.95	0.00
Norway	0.82	0.82	0.01	0.76	0.78	0.03	0.71	0.74	0.04	0.67	0.73	0.05
UK	0.92	0.92	0.00	0.92	0.92	0.00	0.91	0.92	0.01	0.90	0.92	0.01
France	0.99	0.99	0.00	0.99	0.99	0.00	0.99	0.99	0.00	0.98	0.99	0.01
Czech Republic	0.84	0.84	0.02	0.88	0.89	0.02	0.89	0.89	0.01	0.87	0.88	0.02

Notes: Figures are the quarterly average of the MSE decompositions across 1-year, 5-years, 10-years and 15-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2015Q4.

Specifically, for most countries in the EME sub-sample, tradeable goods prices account for between 90% to 99% of variations in the real exchange rates at all horizons. Only exceptions are Philippines and Morocco where the contribution of traded goods to real exchange rate movements averages about 85% and 78% across horizons respectively<sup>23</sup>. Importantly, the standard errors presented in Table 2.1A and 2.1B shows that the estimated MSE's across horizons are reliable estimates and comparable to the population mean or the average contribution of tradeable goods to real exchange rate variations in the sample countries. Figure 2.1 also shows that tradeable goods ( $x_t$ ) in some cases account for more than 100 percent of the MSE of exchange rates ( $q_t$ ). This result can be clarified through the formula presented in equation B1.5 (in Appendix B) which assumes a co-movement between  $x_t$  and  $y_t$ . Engel (1999) argues this is due to the implicit co-movement assumption (that  $x_t$  and  $y_t$  are strongly correlated) implied by equation (B1.5). That is, 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 (B1.5) 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  $y_t$ .

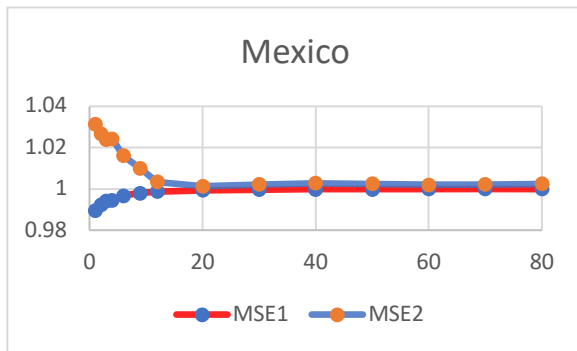
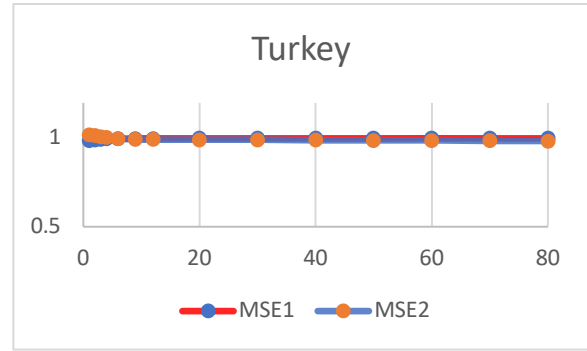
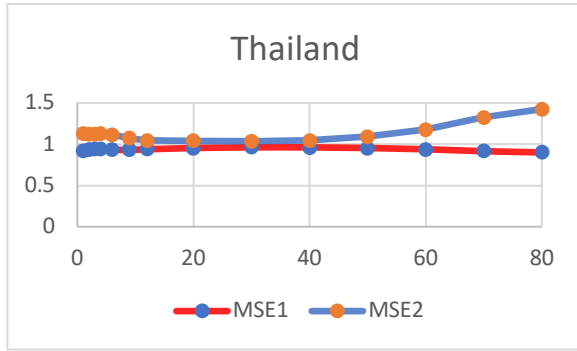
In Appendix B, for robustness we perform the MSE decomposition at monthly frequency. Our results at monthly frequency also indicate that tradeable goods account for almost all the movements in the real exchange rate. Last, we also include in Appendix B the MSE decomposition for 16 high income countries in order to use this latter group as a consistency check for our estimation as well as reference point for the EME subsample.

---

<sup>23</sup> Results from alternative price measures for the real exchange rate are reported in Appendix A.

**Figure 2.1.** MSE Decomposition plots. MSE 1 denotes the MSE decomposition obtained using equation (B1.1) which assumes no co-movement and MSE 2 denotes the MSE decomposition obtained using equation (B1.5) which assumes co-movement. Data used is monthly from 1970:1 -2018:06 and differ for different countries.





The high-income subsample includes the countries which were covered in the work of Engel (1999) as well as some other new countries for which data was available. In all cases and across both quarterly and monthly frequencies, the traded goods component dominates the variation in real exchange rates consistent with Engel (1999). More importantly, our results extend the validity of the findings of Engel (1999) for the case of EMEs. Namely, movements of (bilateral) real exchange rates in EMEs are dominated by movements in tradeable price

#### 2.4.2 World Commodity Price Shocks and International Prices

Our finding that relative prices of traded goods dominate real exchange rate movements in EMEs leads us to ask if there is a dominant component of traded goods prices that may drive the observed high volatility of real exchange rates. Given that commodity markets play a prominent role in world trade, we conjecture that the world commodity prices are plausibly the key driving force

behind real exchange rate movements in EMEs because these countries tend to be less industrialized and more resource-dependent relative to high-income countries.

We begin this section by reporting some summary statistics about the cyclical properties of commodity prices and real exchange rates in the full sample as well as sub-samples of countries. Next, we estimate how much of the variability of real exchange rates is explained by world commodity prices using an SVAR approach on a by-country basis. Last, we examine how world commodity prices affect real exchange rates through impulse response function (IRF) analysis by pooling the data into two country panels using a PVAR methodology via local projections (LP) as in Jordà (2005). We estimate the SVAR in both levels and cyclical components. We then estimate the PVAR in cyclical components due to the non-stationarity of the subsamples in levels. The cyclical components are obtained from HP filtered data.<sup>24</sup>

Figure 2.2 shows the graphs in both levels and cyclical components for the three real world 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. The summary statistics in Table 2.2 panels A and B show that the three world commodity price series display significant volatility over the sample period in both levels and cyclical components. The cyclical components of commodity prices show positive co-variation and are highly volatile with deviations from trend of more than 40% in the full sample of 28 countries. Tables 2.2A and 2.2B summarize the second moments of the cyclical components. Notably, the standard deviation of real-world commodity prices ranges from 3 to 8 times that of aggregate income. All three real

---

<sup>24</sup> Since series are in quarterly frequency, we HP-filter the data with a smoothing parameter of 1600.

world commodity prices display significant positive correlations with each other with pairwise correlations of between 0.30 and 0.56. Table 2.2B shows that the relative price of tradeable goods displays positive co-movement with all three commodity price aggregates. Further, real effective exchange rates (REERs) also show a positive co-movement with all three world commodity prices. These are however slightly smaller than observed with the tradeable goods measure.

**Table 2.2A. Summary Statistics - World Commodity Prices**

Statistics	$x$		
	$p^a$	$p^m$	$p^f$
Standard deviation $\sigma(x)$	6.76	15.61	17.25
Correlation with Agric $\rho(P^a, x)$	1.00	0.56	0.30
Correlation with Metals, $\rho(P^m, x)$	0.56	1.00	0.45
Correlation with Fuel, $\rho(P^f, x)$	0.30	0.45	1.00

Notes: The  $P^f$ ,  $P^m$ , and  $P^a$  denote the cyclical components of real fuel prices, metal prices, and agricultural prices, respectively. Sample period is 1985Q1-2015Q4. Commodity price series are detrended using the HP filter with a smoothing parameter of 1600.

**Table 2.2B. Pairwise correlations of Commodity prices and Real Exchange rates**

Statistics	$x$		
	$p^a$	$p^m$	$p^f$
Correlation with $xt$ $\rho(xt, x)$	0.27	0.25	0.28
Correlation with reer $\rho(\text{reer}, x)$	0.17	0.14	0.12
Relative standard deviation $\sigma(x)/\sigma(y)$	3.33	7.68	8.45

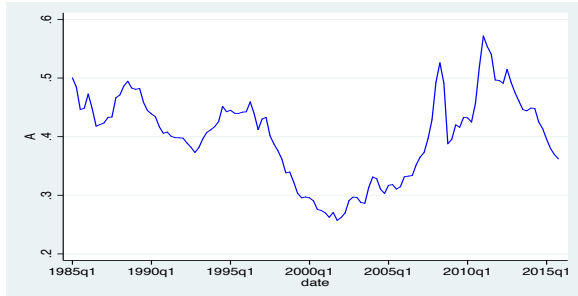
Notes: The  $P^f$ ,  $P^m$ , and  $P^a$  denote the cyclical component of real fuel prices, metal prices, and agricultural prices, respectively.  $\sigma(y)$  is the standard deviation of aggregate real income. Period is 1985Q1-2015Q4. Commodity price series are detrended using the HP filter with a smoothing parameter of 100. Statistics are from a panel of 27 countries and differ for each individual country.

Next, Table 2.3 presents the relative standard deviations of individual countries for two subsamples, EMEs and High-income countries. Again, these relative standard deviations are variations of real commodity prices and international price measures in terms of variations in country-income/output ( $y$ ). The results show that the real fuel commodity prices are as much as 13 times as volatile as output while agricultural and metal commodity prices are about 5 times and 11 times as volatile as output in the median high-income country. Further, the median relative volatility is higher in high-income countries than in EMEs, which is not surprising because EMEs

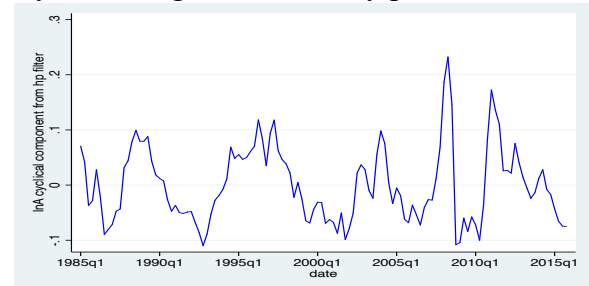
on average have more volatile output. Last, across our measures of international prices there is no large difference in median relative volatilities between EMEs and high-income countries.

**Figure 2.2.** 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 1600. Data is quarterly and covers 1985q1-2014q4

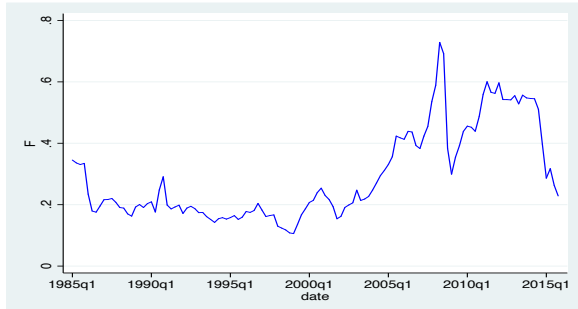
### Levels of Agricultural Commodity prices



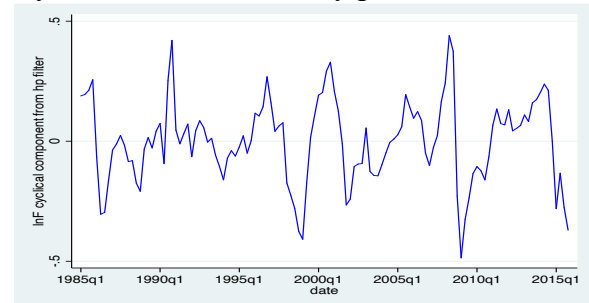
### Cyclical - Agric. commodity prices



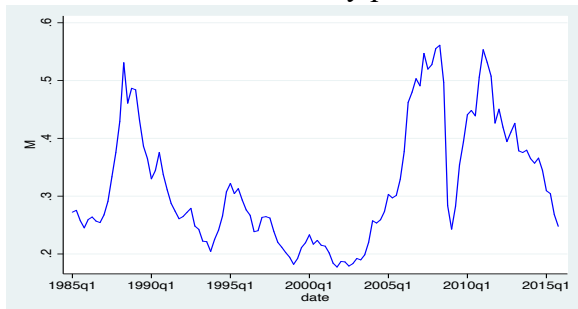
### Levels of Fuel commodity prices



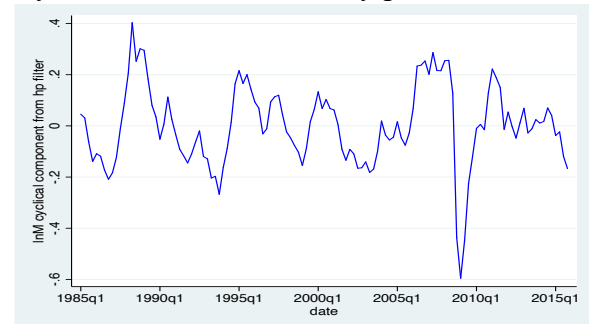
### Cyclical- Fuel commodity prices



### Levels of Metal commodity prices



### Cyclical - Metal commodity prices



**Table 2.3. Relative Price of Tradeable goods and Real effective exchange rates**

Country	Relative Std.Dev, SD(p) / SD(GDP)					
		pA	pM	pF	xt	reer
	Std. Dev (p)	0.07	0.16	0.17		
Middle Income	Std. Dev (Y)	Std. Dev (p)/ Std. Dev (Y)			SD(xt)/ SD(Y)	SD(reer)/ SD(Y)
Costa Rica	0.02	4.31	9.95	10.99	3.45	1.83
Brazil	0.02	4.19	9.69	10.70	5.67	5.68
Colombia	0.01	4.80	11.09	12.25	6.54	4.45
Philippines	0.05	1.45	3.34	3.69	1.74	1.12
South Africa	0.01	11.77	27.18	30.03	20.67	13.39
Turkey	0.04	1.89	4.37	4.83	4.68	1.95
Paraguay	0.04	1.58	3.66	4.04	2.67	1.55
Hungary	0.02	4.22	9.75	10.78	5.69	2.26
Mexico	0.02	2.94	6.80	7.51	9.76	4.07
Malaysia	0.02	3.22	7.43	8.21	3.39	2.10
<b>Mean</b>	<b>0.03</b>	<b>3.18</b>	<b>7.34</b>	<b>8.11</b>	<b>4.60</b>	<b>2.78</b>
<b>Median</b>	<b>0.02</b>	<b>3.22</b>	<b>7.43</b>	<b>8.21</b>	<b>4.43</b>	<b>2.10</b>
<b>High Income</b>						
Canada	0.01	5.30	12.25	13.53	4.45	3.21
Denmark	0.01	4.87	11.25	12.43	5.41	1.45
Finland	0.02	3.21	7.41	8.19	4.06	1.97
France	0.01	6.89	15.91	17.57	7.48	2.05
Germany	0.01	4.57	10.56	11.66	5.17	1.66
Czech Rep	0.02	3.65	8.42	9.31	3.50	2.31
Japan	0.01	4.64	10.72	11.85	5.96	5.27
Norway	0.01	5.60	12.92	14.28	6.20	2.26
UK	0.01	5.26	12.14	13.41	5.50	3.40
Australia	0.01	6.99	16.13	17.82	8.79	6.24
Austria	0.01	5.53	12.77	14.11	5.90	1.11
Belgium	0.01	6.86	15.83	17.49	8.40	1.73
Ireland	0.04	1.92	4.44	4.91	2.46	0.90
Italy	0.01	5.21	12.03	13.29	5.70	2.67
Netherlands	0.01	5.09	11.75	12.98	6.07	1.71
New Zealand	0.01	4.74	10.95	12.10	7.10	4.33
<b>Mean</b>	<b>0.01</b>	<b>5.02</b>	<b>11.59</b>	<b>12.81</b>	<b>5.76</b>	<b>2.64</b>
<b>Median</b>	<b>0.01</b>	<b>5.15</b>	<b>11.89</b>	<b>13.13</b>	<b>5.80</b>	<b>2.15</b>

Notes: The relative prices are measured as the standard deviation of the real variables ( $P^a$ ,  $P^m$  and  $P^f$ ,  $xt$  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, relative price of tradeable goods and real effective exchange rates respectively. Morocco and Thailand were excluded due to data unavailability

### 2.4.2.1 World shocks mediated by Commodity prices (SVAR)

For the SVAR analysis we provide the results of the estimated model in both levels and cyclical components.<sup>25</sup> As our starting point to examine the impact of commodity price shocks on the volatility of international prices, we look at the full sample of 27 countries. Table 2.4 shows that world commodity price shocks accounts for 30% (levels) and 27% (cyclical) of movements in the relative price of traded goods (i.e. bilateral real exchange rate) in the median country. The effect drops slightly when the measure of international prices is the real effective exchange rate (REER) as world commodity shocks explain 27% (levels) and 18% (cyclical) of fluctuations in the median country. The latter estimates are lower because the REER measure is constructed as a trade weighted average of bilateral exchange rates. In terms of means, commodity price shocks accounts for a slightly bigger proportion of movements in the real exchange rate measures 36% (levels) and 28% (cyclical components) of variations in the relative price of tradeable goods, and 28% (levels) and 21% (cyclical component) of variation in the real effective exchange rate. Finally, looking at individual commodity price shocks presented in Table B3.2 in Appendix B, fuel prices explain an important part of the variation in both the relative price of tradeable goods (11% and 12% on average) and the real effective exchange rate (11% and 10% on average). Metals and Mineral prices explain similarly important part of variations in both measures of real exchange rates. Last, agricultural commodity prices explain about half as much as the contribution of fuel and metals & minerals prices. The relative contribution of the individual commodity prices underscores the

---

<sup>25</sup> We tested for non-stationarity in levels and confirm the existence of unit roots. Hence as an alternative, we conducted a co-integration and VECM analysis with results showing the existence of co-integration for only few countries. Nevertheless, the VECM analysis shows similar results to the SVAR analysis. Additional results are available upon request.

importance of computing estimates based on a basket of commodities rather than a single commodity price index.

**Table 2.4. Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Full sample of countries.**

Variable	Levels				Cyclical Component			
	Xt		REER		xt		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Fuel Prices ( $P^f$ )	0.10	0.11	0.09	0.08	0.11	0.12	0.07	0.06
Metal Prices ( $P^m$ )	0.17	0.16	0.13	0.13	0.07	0.06	0.06	0.06
Agric. Prices ( $P^a$ )	0.09	0.08	0.08	0.06	0.10	0.09	0.08	0.06
All three price( $P^f, P^m, P^a$ )	<b>0.36</b>	<b>0.35</b>	<b>0.30</b>	<b>0.27</b>	<b>0.28</b>	<b>0.27</b>	<b>0.21</b>	<b>0.18</b>

Notes: Variance decompositions are based on country-by-country estimates of the SVAR system. The reported figures are the cross-country median and mean estimates. Xt and REER refers to the relative price of tradeable goods and the real effective exchange rates respectively. Statistics are computed across 27 countries

### Commodity price shocks in EMEs

We now 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 and obtain 12 countries in the EME group and 16 countries in the high-income group. The results are summarized in Table 2.5. Our results indicate that for the two measures in levels of international prices, world commodity shocks account on average for 30% to 36% of international price fluctuations in EMEs. Notably, world commodity price shocks explain about 5% more in the level of international price volatility in EMEs than in high-income countries. However, this reported effect is only slightly higher when estimated using the cyclical component of prices. In sum, we report that for both level measures of real exchange rates the magnitude of the effect of world commodity price shocks is higher in EMEs than in high-income countries.

**Table 2.5 Share of Variances Explained by World Shocks - Country group results.**

Country	Levels		Cyclical Components	
	Xt	REER	xt	reer
<b>Middle Income Countries</b>				
Brazil	0.14	0.39	0.24	0.33
Costa Rica	0.75	0.56	0.45	0.24
Colombia	0.51	0.40	0.34	0.17
Mexico	0.51	0.53	0.38	0.27
Morocco	0.38	0.20	0.27	0.04
Philippines	0.30	0.38	0.21	0.08
South Africa	0.24	0.10	0.19	0.18
Turkey	0.36	0.19	0.26	0.19
Paraguay	0.44	0.47	0.51	0.57
Hungary	0.48	0.36	0.54	0.38
Malaysia	0.16	0.18	0.19	0.15
Thailand	0.07	0.19	0.05	0.05
<b>Mean</b>	<b>0.36</b>	<b>0.33</b>	<b>0.30</b>	<b>0.22</b>
<b>Median</b>	<b>0.37</b>	<b>0.37</b>	<b>0.27</b>	<b>0.19</b>
<b>High Income Countries</b>				
Czech Republic	0.43	0.44	0.43	0.33
Canada	0.22	0.18	0.35	0.22
Denmark	0.33	0.04	0.24	0.10
Finland	0.20	0.15	0.35	0.24
France	0.33	0.45	0.32	0.21
Germany	0.35	0.34	0.22	0.09
Japan	0.25	0.30	0.06	0.08
Norway	0.31	0.32	0.21	0.24
UK	0.46	0.43	0.43	0.11
Australia	0.35	0.39	0.32	0.29
Austria	0.33	0.21	0.26	0.06
Belgium	0.37	0.42	0.22	0.14
Ireland	0.49	0.46	0.28	0.26
Italy	0.58	0.06	0.25	0.25
Netherlands	0.32	0.21	0.16	0.14
New Zealand	0.31	0.20	0.39	0.20
<b>Mean</b>	<b>0.35</b>	<b>0.29</b>	<b>0.28</b>	<b>0.19</b>
<b>Median</b>	<b>0.33</b>	<b>0.31</b>	<b>0.27</b>	<b>0.21</b>

Notes: Variance decompositions are based on country –by country estimates of the SVAR system. The reported figures are the cross-country median estimates. Xt and REER refers to the relative price of tradeable goods and the real effective exchange rates respectively. Statistics are computed across 27 countries.

## **World commodity prices and Net Commodity Exporting Countries**

Given our results, a sensible conjecture is that world commodity price shocks may also have a large effect on real exchange rates for net commodity exporting countries. We proceed to examine the strength of the effect of a commodity price shock for the case of net commodity exporters (NCX) in the sample. 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 dataset 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 as net commodity exporters (NCX) for each commodity group and re-estimate the model for that subsample of countries with only the respective commodity price index included. The results are provided in Tables 2.6A to 2.6C. Our estimates suggest that the effects of specific commodity prices in the NCX panels are mixed. On average, agricultural price shocks seems to have a larger impact on real exchange rates (between 11%-21% in cyclical components) than observed when all commodity price indices were used together. Paraguay, Denmark and Netherlands particularly do experience a substantial effect of shocks in Agricultural prices on movement in their real exchange rates (between 13% to 36% in cyclical components). Fuel price index also shows similar magnitude of the effect (12% to 16% in cyclical components) while the effect of metals and minerals commodity is lower (about 6% in cyclical components). We note that the results for the NCX subsamples appear to underestimate a potentially larger effect as documented by Roch (2019). We attribute this discrepancy to our broader measure of world commodity prices compared to the previously mentioned study, which constructs country-specific commodity price indices for the empirical analysis. However, we emphasize that because our results are obtained with a broader measure of prices, they apply to a

broader type of countries (not just NCXs). As such, the findings of this study that the effect of world commodity prices matter for international price fluctuations apply to a wider cross-section of countries.

**Table 2.6A. Share of Variances Explained by World Shocks and Mediated by Agricultural Commodity Prices. NCX country-specific results.**

Country	Levels		Cyclical Component	
	Xt	REER	xt	reer
Brazil	0.17	0.37	0.09	0.04
Canada	0.03	0.03	0.02	0.05
Denmark	0.39	0.11	0.36	0.13
Finland	0.27	0.05	0.17	0.07
Netherlands	0.23	0.02	0.46	0.15
New Zealand	0.12	0.10	0.05	0.08
Paraguay	0.64	0.35	0.36	0.24
<b>Mean</b>	<b>0.27</b>	<b>0.15</b>	<b>0.21</b>	<b>0.11</b>
<b>Median</b>	<b>0.23</b>	<b>0.10</b>	<b>0.17</b>	<b>0.08</b>

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 mean and median estimates. Xt and REER refers to the relative price of tradeable goods and the real effective exchange rates respectively.

**Table 2.6B. Share of Variances Explained by World Shocks and Mediated by Fuel Commodity Prices. NCX country-specific results.**

Country	Levels		Cyclical Component	
	Xt	REER	xt	reer
Australia	0.05	0.14	0.08	0.10
Canada	0.04	0.10	0.09	0.11
Colombia	0.13	0.25	0.04	0.21
Norway	0.53	0.26	0.23	0.13
Paraguay	0.41	0.24	0.18	0.25
<b>Mean</b>	<b>0.23</b>	<b>0.20</b>	<b>0.12</b>	<b>0.16</b>
<b>Median</b>	<b>0.13</b>	<b>0.24</b>	<b>0.09</b>	<b>0.13</b>

Notes: Variance decompositions are based on country –by country estimates of the SVAR system using only Fuel price index. The reported figures are the cross-country mean and median estimates. Xt and REER refers to the terms the relative price of tradeable goods and the real effective exchange rates respectively.

**Table 2.6C. Share of Variances Explained by World Shocks and Mediated by Metals and Minerals Commodity Prices. NCX country-specific results.**

Country	Levels		Cyclical Component	
	Xt	REER	xt	reer
Austria	0.18	0.02	0.02	0.05
Brazil	0.14	0.32	0.07	0.20
Finland	0.20	0.02	0.05	0.02
Belgium	0.35	0.21	0.08	0.01
Japan	0.04	0.05	0.02	0.04
Turkey	0.09	0.06	0.12	0.07
<b>Mean</b>	<b>0.17</b>	<b>0.11</b>	<b>0.06</b>	<b>0.06</b>
<b>Median</b>	<b>0.16</b>	<b>0.06</b>	<b>0.06</b>	<b>0.05</b>

Notes: Variance decompositions are based on country –by country estimates of the SVAR system using only Metals and Minerals commodity price index. The reported figures are the cross-country mean and median estimates. Xt and REER refers to the relative price of tradeable goods and the real effective exchange rates respectively.

### 2.4.3 Impulse Response Function (IRF) Analysis

We now investigate how world commodity price shocks transmit to international prices across income groups. We carry out an IRF analysis using the PVAR approach based on the Local Projections (LP) methodology of Jordà (2005). In what follows, we present the results for the cyclical components of international prices. As in Plagborg-Møller and Wolf (2019), we use an unrestricted lag structure in estimating the IRFs from the LP. The model setup of the variables in the LP is the same as in the previous SVAR analysis. However, the PVAR approach allows us to obtain estimates across the pooled sample of countries instead of individual countries. To account for any possible autocorrelation and outliers, we estimate the LP using robust clustered errors as well as the Newey West standard errors. As a robustness check, we also provide the IRF for commodity price shocks estimated from equation 2.1.6 and also IRF estimated with the lag of Xt and REER in the Appendix B.

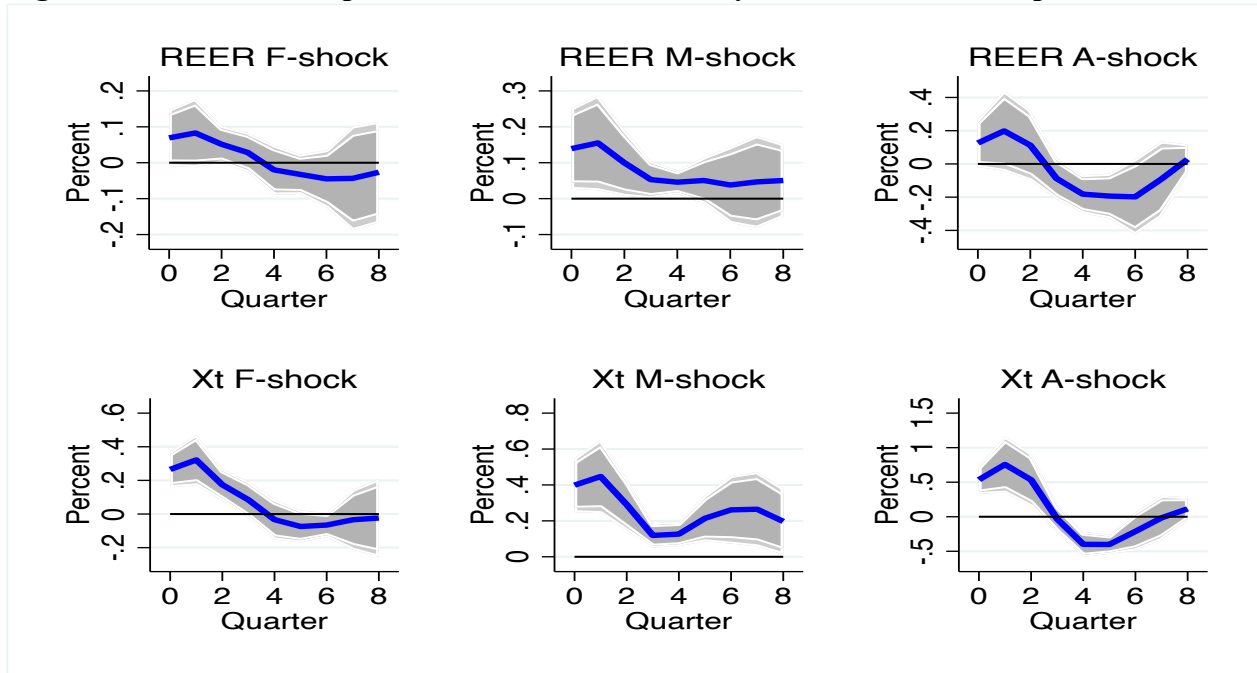
We present results of four panels 1) EMEs, 2) high-income countries (henceforth AEs), 3) full sample of countries, and 4) NCX countries. The IRFs by country-type sample estimated with robust clustered error are presented in Figures 2.3 to 2.5. The IRF results estimated with the newey

west standard errors are presented in figure 2.6 and in appendix B while the results for NCX panels are presented in Figure 2.7. Our focus is on the response of the international prices ( $X_t$  and REER) to a one standard deviation increase in world commodity prices.

First, the results from Figures 2.3 to 2.5 show that a one standard deviation increase in world commodity prices is associated with an appreciation of the relative price of tradeable goods ( $x_t$ ) in both EMEs and AEs. More specifically, the exchange rate in both EMEs and AEs appreciates following a commodity price shock. However, significant difference exists in the response of EME's and AE's to a one standard deviation shock in commodity prices. First, the appreciation appears to last longer for EME's (up to 4<sup>th</sup> quarter) than AE's (up to 2<sup>nd</sup> quarter) before decay. Also, the magnitude of the contemporaneous response of EME exchange rates to commodity shocks is substantially higher than in AE's. Further test of significance shows this difference is statistically significant. The IRF for the real effective exchange rate ( $r_t$ ) is also associated with an appreciation in the real exchange rates in response to a one standard deviation shock in commodity prices in both EME's and AE's consistent with that of the  $x_t$ . The effect across the full sample as shown in figure 2.5 is similar to the observed effect for the EME and AE panels. Across all panels, the impact of the shocks is persistent, lasting between to 2-4 quarters (1-1.5 years) before returning to the steady state.

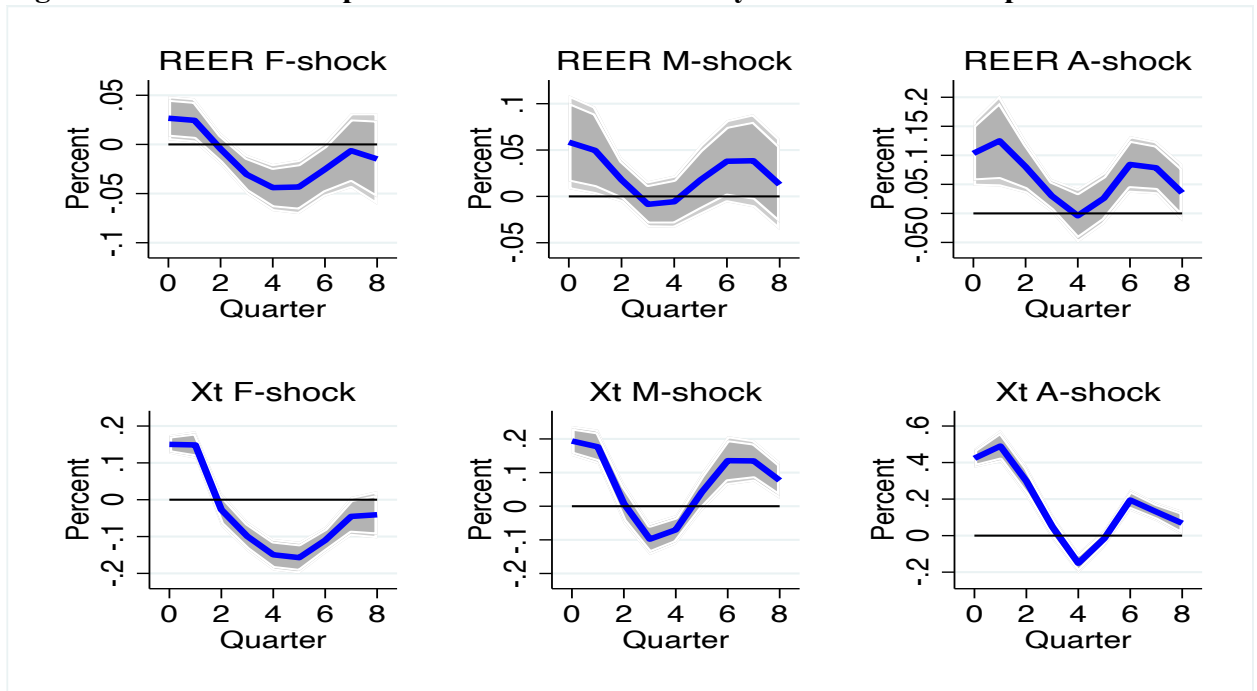
Importantly, these results hold across the full sample (figure 2.6) and for both EMEs and AEs (figure B1 and B2 in Appendix B) when the IRF was estimated with the Newey West Standard errors. Our robustness check results also show results hold when the lags of  $X_t$  and REER were included in the regression and when the Hamilton filter (Figure B9 to B11) was used to estimate the cyclical components of the variables with commodity prices appreciating in response to a commodity price shock.

**Figure 2.3 International prices and World Commodity Price Shocks: EME panel IRFs**



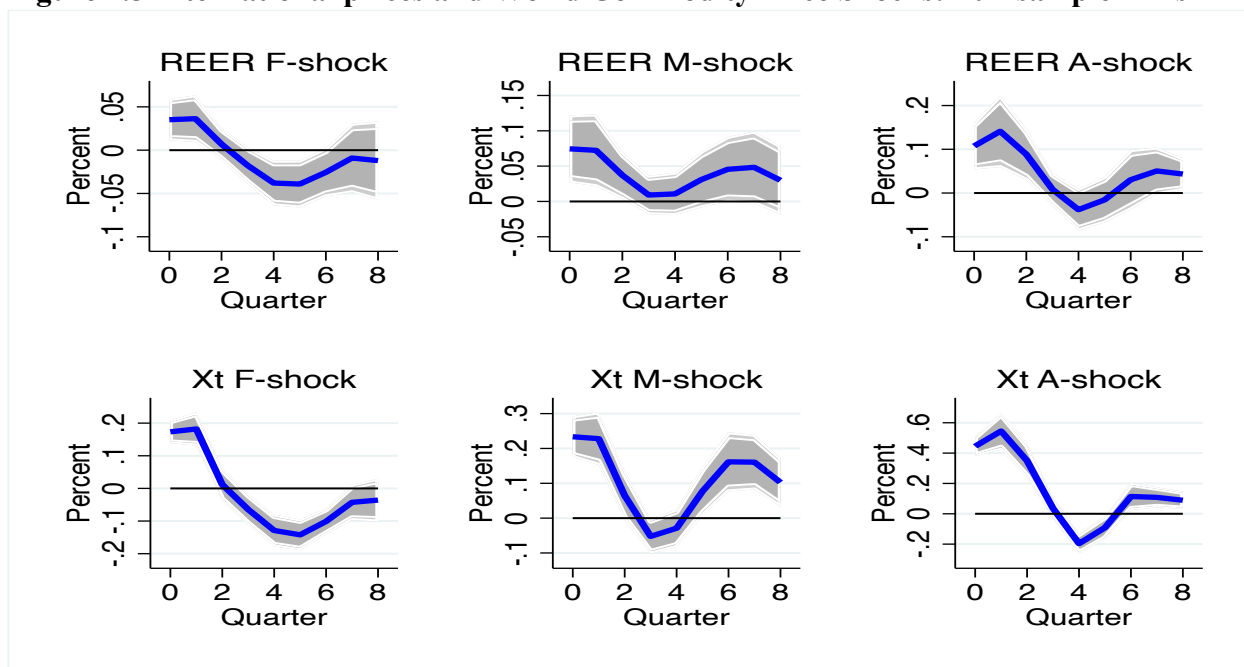
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 11.

**Figure 2.4 International prices and World Commodity Price Shocks: AE panel IRFs**



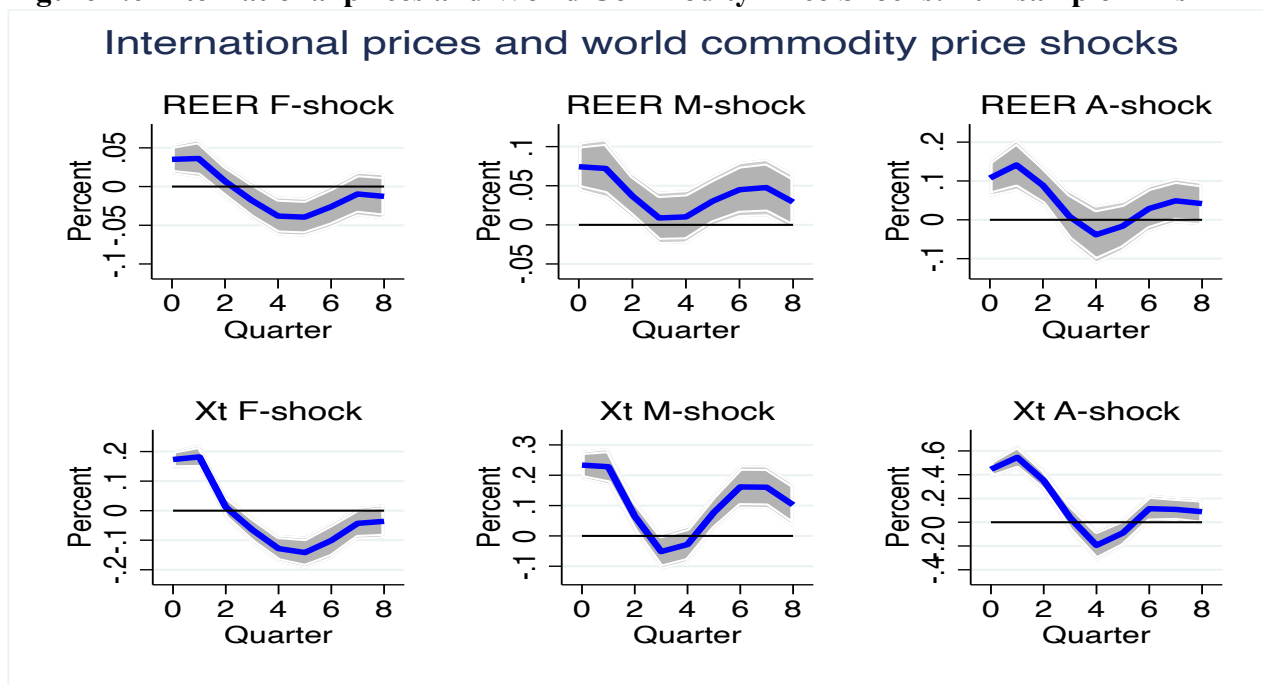
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 16.

**Figure 2.5 International prices and World Commodity Price Shocks: Full sample IRFs**



Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity 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 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 27.

**Figure 2.6 International prices and World Commodity Price Shocks: Full sample IRFs**

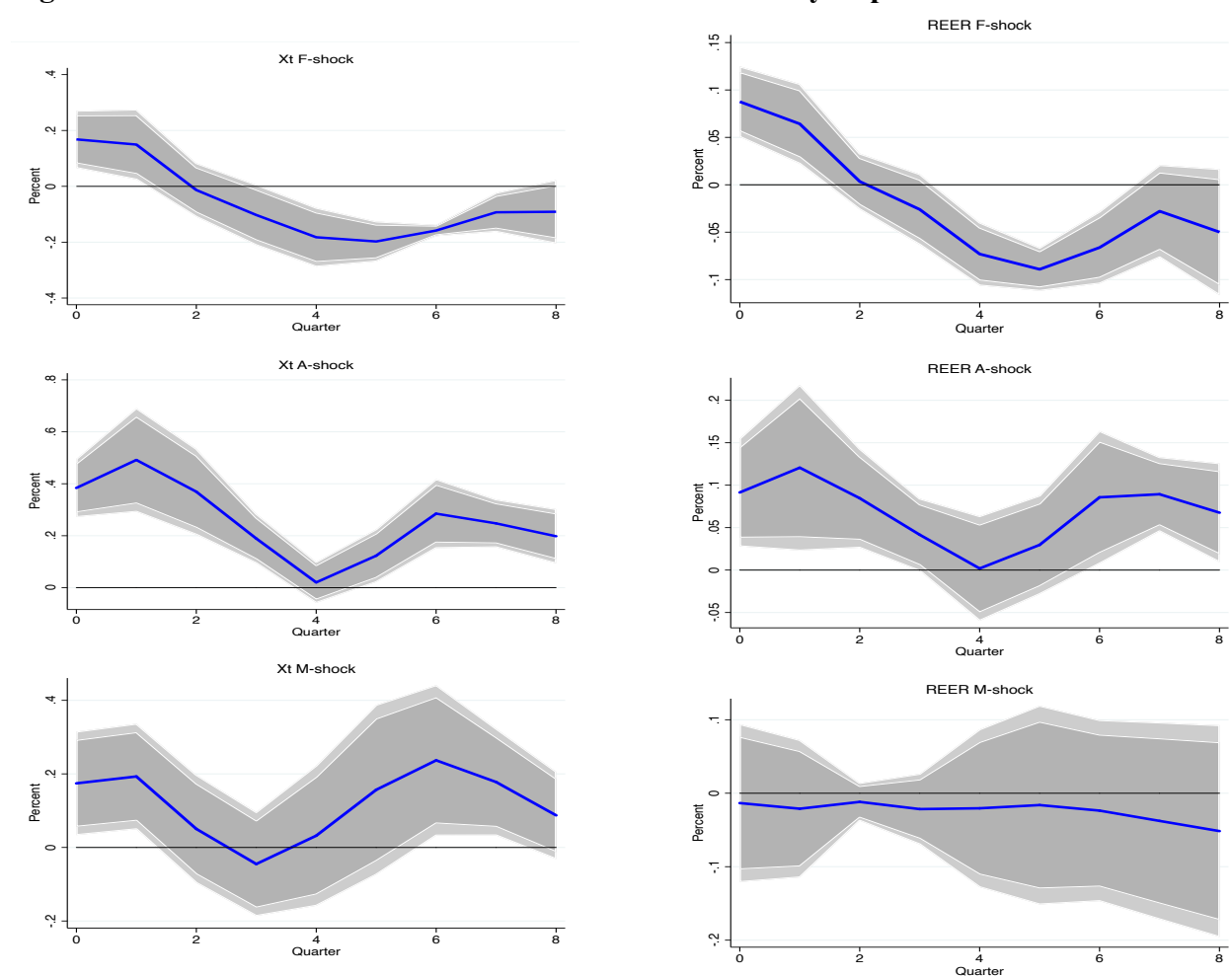


Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with Newey West standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 27.

Next, we examine the IRFs for NCX country panels. Figure 2.7 shows the IRFs for the relative price of tradeable goods (left panel) and the real effective exchange rate (right panel) to a one standard deviation shock in fuel, agricultural, and metals & minerals commodity prices, respectively. Again, the results for the NCX panels are similar to the results obtained for the full sample and sub-samples. An increase in fuel, agricultural and metals and minerals prices is associated with an appreciation of the relative price of tradeable goods and the real effective exchange rate on impact. The appreciation for the fuel panel is however short lived and only up to the 2<sup>nd</sup> quarters for both the  $x_t$  and  $r_t$  and then depreciates. The appreciation for the agric panel last up to the 4<sup>th</sup> quarter and then stays above steady state. For the metals and minerals panel, the appreciation occurs only for the relative price of tradeable goods but not the effect for the real effective exchange rates. As discussed earlier, the NCX panel estimates are not as reliable compared with the other panels for two reasons. First, because that our NCX subsample is very small; and second, because we do not construct a country-specific commodity price index.

To summarize, our panel results based on country income-level indicate that world commodity prices have a significant effect in leading to an appreciation for any of our measures of international prices in both EMEs and AE's on impact. This result holds across estimators with both clustered robust standard errors and Newey West standard errors that account for any outliers and autocorrelation in the sample.

**Figure 2.7 Relative International Prices and Net Commodity Exporter IRF's**



Notes: The IRF's are based on the Local Projections approach of Jordà., (2005). “A”, “F” and “M” are the cyclical components of the Agricultural commodity prices, fuel prices and metals and minerals prices respectively. The NCX panel consist of Agric (Canada, Denmark, Finland, Netherlands, New Zealand and Paraguay; Fuel (Australia, Canada, Colombia, Norway, Paraguay and Metals and Minerals (Austria, Finland, Belgium, Japan and Turkey). Data is quarterly from 1985q1 -2015q4.

## 2.5 Conclusions

What causes the observed high volatility of real exchange rates in Emerging Market Economies (EMEs)? We perform an exchange rate accounting exercise and show that the relative price of tradeable goods is the dominant factor of real exchange rate fluctuations in EMEs. In this study we conjecture that the key component of real exchange rate fluctuations is the world price of commodities and proceed to investigate how large is such effect and in what way commodity prices affect real exchange rate movements. Using SVAR and PVAR approaches to assess our hypothesis

we find that world commodity prices explain about one third of the observed variability in international prices in EMEs. Moreover, we find that this effect appears to be larger in EMEs than in high-income countries. In addition, we find that commodity price shocks tend to be associated with i) a real exchange rate appreciation in EMEs, and ii) an appreciation in high-income countries. Our results lend more credence to the view that commodity prices have important policy implications due to their sizeable impact on both aggregate fluctuations and international competitiveness. Further research is needed to explore the mechanisms through which commodity price shocks transmit into exchange rate dynamics

## References

- Amano, R. A., & Van Norden, S. (1998a). Exchange rates and oil prices. *Review of international economics*, 6(4), 683-694.
- Amano, R. A., & Van Norden, S. (1998b). Oil prices and the rise and fall of the US real exchange rate. *Journal of international Money and finance*, 17(2), 299-316.
- Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of econometrics*, 68(1), 29-51.
- Basher, S. A., Haug, A. A., & Sadorsky, P. (2016). The impact of oil shocks on exchange rates: a Markov-switching approach. *Energy Economics*, 54, 11-23.
- Blecker, R. A. (2005). 7. Financial Globalization, Exchange. *Financialization and the world economy*, 183.
- Bodart, V., Candelon, B., & Carpentier, J.-F. (2012). Real exchanges rates in commodity producing countries: A reappraisal. *Journal of International Money and Finance*, 31(6), 1482-1502.
- Bodart, V., Candelon, B., & Carpentier, J.-F. (2015). Real exchanges rates, commodity prices and structural factors in developing countries. *Journal of International Money and Finance*, 51, 264-284.
- Branson, W. H. (1981). *Macroeconomic determinants of real exchange rates*. NBER Working Paper 801
- Burstein, A., Eichenbaum, M., & Rebelo, S. (2005). Large devaluations and the real exchange rate. *Journal of political Economy*, 113(4), 742-784.
- Chen, S.-S., & Chen, H.-C. (2007). Oil prices and real exchange rates. *Energy economics*, 29(3), 390-404.

- Coudert, V., Couharde, C., & Mignon, V. (2015). On the impact of volatility on the real exchange rate–terms of trade nexus: Revisiting commodity currencies. *Journal of International Money and Finance*, 58, 110-127.
- Dauvin, M. (2014). Energy prices and the real exchange rate of commodity-exporting countries. *International Economics*, 137, 52-72.
- Drechsel, T., & Tenreyro, S. (2018). Commodity booms and busts in emerging economies. *Journal of International Economics*, 112, 200-218.
- Engel, C. (1999). Accounting for US real exchange rate changes. *Journal of Political economy*, 107(3), 507-538.
- Fernández, A., González, A., & Rodríguez, D. (2018). Sharing a ride on the commodities roller coaster: Common factors in business cycles of emerging economies. *Journal of International Economics*, 111, 99-121.
- Fernández, A., Schmitt-Grohé, S., & Uribe, M. (2017). World shocks, world prices, and business cycles: An empirical investigation. *Journal of International Economics*, 108, S2-S14.
- Giovannini, M., Hohberger, S., Kollmann, R., Ratto, M., Roeger, W., & Vogel, L. (2019). Euro Area and US external adjustment: The role of commodity prices and Emerging Market shocks. *Journal of International Money and Finance*, 94, 183-205.
- Gopinath, G. (2015). *The international price system*. NBER Working Paper 21646
- Gopinath, G., Boz, E., Casas, C., Díez, F. J., Gourinchas, P.-O., & Plagborg-Møller, M. (2020). Dominant currency paradigm. *American Economic Review*, 110(3), 677-719.
- Habib, M. M., Bützer, S., & Stracca, L. (2016). Global exchange rate configurations: do oil shocks matter? *IMF Economic Review*, 64(3), 443-470.

- Harri, A., Nalley, L., & Hudson, D. (2009). The relationship between oil, exchange rates, and commodity prices. *Journal of agricultural and applied economics*, 41(2), 501-510.
- Herbst, E., & Johannsen, B. K. (2021). "Bias in local projections", Finance and Economics Discussion Series 2020-010r1. Washington: Board of Governors of the Federal Reserve System, <https://doi.org/10.17016/FEDS.2020.010r1>.
- Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American economic review*, 95(1), 161-182.
- 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), 1053-1069.
- Kilian, L., & Zhou, X. (2022). Oil prices, exchange rates and interest rates. *Journal of International Money and Finance*, 102679.
- Kose, M. A. (2002). Explaining business cycles in small open economies: 'How much do world prices matter?'. *Journal of International Economics*, 56(2), 299-327.
- Melichar, M., & Atems, B. (2019). Global crude oil market shocks and global commodity prices. *OPEC Energy Review*, 43(1), 92-105.
- Mendoza, E. G. (1995). The terms of trade, the real exchange rate, and economic fluctuations. *International Economic Review*, 101-137.
- Natanelov, V., Alam, M. J., McKenzie, A. M., & Van Huylenbroeck, G. (2011). Is there co-movement of agricultural commodities futures prices and crude oil? *Energy Policy*, 39(9), 4971-4984.
- Plagborg-Møller, M., & Wolf, C. K. (2021). Local projections and VARs estimate the same impulse responses. *Econometrica*, 89(2), 955-980.

Roch, F. (2019). The adjustment to commodity price shocks. *Journal of Applied Economics*, 22(1), 437-467.

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

Zhang, H. J., Dufour, J.-M., & Galbraith, J. W. (2016). Exchange rates and commodity prices: Measuring causality at multiple horizons. *Journal of Empirical Finance*, 36, 100-120.

## APPENDIX B

### B.1 STEPS USED IN THE MEAN SQUARED ERROR (MSE) DECOMPOSITION

We adopted two different methodologies proposed by Engel (1999) to decompose the real exchange rate changes into the traded and non-traded components. Following Engel (1999), we assume that the amount of movement in the real exchange rates over a period could have two meanings – the amount of drift or the variance. Hence the mean squared error (MSE) which is the sum of the drift, and the variance is proposed as a comprehensive measure of the movement in the real exchange rates. The fraction of the MSE of the real exchange rate changes ( $q_{t+k} - q_t$ ) accounted for by the MSE of the traded goods component ( $x_{t+k} - x_t$ ) as well as by the non-traded goods aspect ( $y_{t+k} - y_t$ ) can hence be estimated based on the assumption of (i) presence of no co-movement (ii) presence of co-movement.

Assuming no co-movement between  $x_t$  and  $y_t$ , the amount of the Mean squared error (MSE) of the real exchange rate changes over different horizons ( $q_t - q_{t-n}$ ) accounted for by the Mean squared error (MSE) of changes in the traded goods component ( $x_t - x_{t-n}$ ) over different horizons can be measured as

$$\frac{MSE(x_t - x_{t-n})}{MSE(x_t - x_{t-n}) + MSE(y_t - y_{t-n})} \quad (B1.1)$$

Where the MSE and hence the mean and variance of  $x_t$  can be calculated over different horizons using equations (B1.2), (B1.3) and (B1.4) as follows.

$$MSE(x_t - x_{t-n}) = \text{Variance}(x_t - x_{t-n}) + [\text{mean}(x_t - x_{t-n})]^2 \quad (B1.2)$$

$$\text{Mean}(x_t - x_{t-n}) = \frac{n}{N-1}(x_N - x_1) \quad (B1.3)$$

$$\text{Variance}(x_t - x_{t-n}) = \frac{N}{(N-n-1)(N-1)} \sum_{j=1}^{N-n} [x_{j+n} - x_j - \text{mean}(x_j - x_{j-n})]^2 \quad (B1.4)$$

N is the total sample size and “n” is the horizon.

When we take into consideration co-movement between  $x_t$  and  $y_t$  induced by the presence of PPI in both  $x_t$  and  $y_t$ , then the MSE decomposition can be estimated as

$$\frac{MSE(x_t - x_{t-n}) + Mean(x_t - x_{t-n})Mean(y_t - y_{t-n}) + cov(x_t - x_{t-n}, y_t - y_{t-n})}{MSE(q_t - q_{t-n})} \quad (B1.5)$$

## A.2 Other Methodologies

Other methods used in calculating the amount of the traded and non-traded goods components to real exchange rate variation in the sample countries includes (i) Consumer prices and (ii) Personal consumption expenditures. Due to data limitation, we only document the methodology and present results for countries with data. This are to serve as robustness checks.

### (i) Consumer prices

Monthly data from OECD database from 1981 – 2018 on four seasonally unadjusted prices – food ( $f$ ), all goods less food ( $aglf$ ), rent ( $r$ ), and services less rent ( $slr$ ) are used to calculate the amount of traded and non-traded goods for countries for which data is available. This includes Mexico (1981:01 to 2017:12); Czech Republic (1995:01 to 2018:06) and Columbia (1999:01 to 2018:06). Following Engel (1999), Geometric weights for each of the four components of all item’s series were estimated from logarithmic regressions of the form

$$\Delta(ai - r) = \phi_1 \Delta(aglf - r) + \phi_2 \Delta(f - r) + \phi_3 \Delta(slr - r) + \varepsilon$$

Where  $\Delta$  is the first difference operator and lower-case letters denote natural logarithms.  $\phi_1, \phi_2$  and  $\phi_3$  are the weights for all goods less food, food and services less rent obtained from the regression. The geometric weight for rent is computed residually as  $1 - \phi_1 - \phi_2 - \phi_3$ .

The traded and non-traded price index are then calculated as

$$P^T = \frac{\phi_1}{\phi_1 + \phi_2} (aglf) + \frac{\phi_2}{\phi_1 + \phi_2} (f)$$

$$P^N = \frac{\phi_3}{1 - \phi_1 - \phi_2} (slr) + \frac{1 - \phi_1 - \phi_2 - \phi_3}{1 - \phi_1 - \phi_2} (r)$$

Where  $P^T$  and  $P^N$  are the traded and non-traded price index respectively.

## (ii) Personal Consumption Expenditures

We used quarterly data on durable goods, non-durable goods, semi-durable goods and services obtained from the OECD database for countries with full dataset (Costa Rica) to calculate the amount of traded and non-traded goods. We grouped durable, non-durable and semi durable sectors as traded sector and services as non-traded sector.

*How calculation was done*

1. Separate price indexes are calculated as nominal variables divided by real variables to obtain the price index for each series (Durable, Semi-durable, Non-durable and Services)
2. Traded goods price index is calculated as a weighted combination of the durable, semi-durable and non-durable price indexes
3. The weight are calculated as the sample ratio of nominal expenditures of each series (durable, semi-durable and non-durable) to nominal expenditure on all goods (durable + semi-durable + non-durable)
4. Finally, the share of the non-traded goods in overall consumption deflator price index is the sample average ratio of nominal services expenditure to total nominal expenditures (durable + semi-durable + non-durable + services).

These weights are then used to calculate the  $q_t$ ,  $x_t$ , and  $y_t$ .

To calculate the series (values) for  $q_t$ ,  $x_t$ , and  $y_t$ , using estimates from (i) consumer prices and (ii)

Personal consumption expenditures, we use equation (B1.6) and (B1.7) as follows

$$p_t = (1 - \alpha)p_t^T + \alpha p_t^N \quad (\text{B1.6})$$

$$p_t^* = (1 - \beta)p_t^{T*} + \beta p_t^{N*} \quad (\text{B1.7})$$

Where  $\alpha$  and  $1 - \alpha$  are the shares of the non-traded and traded goods in the price index of domestic country,  $\beta$  and  $1 - \beta$  are the shares of the non-traded and traded goods in the price index of the foreign country. Also  $p_t$  is the log of the price index,  $p_t^T$  is the log of the traded goods price index in the domestic country,  $p_t^N$  is the log of the non-traded goods price index in the domestic country,  $p_t^*$  is the log of the price index in the foreign country while  $p_t^{T*}$  and  $p_t^{N*}$  are the log of the traded and non-traded goods price indices in the foreign country.

The real exchange rates ( $q_t$ ), tradable goods ( $x_t$ ), and non-tradable goods ( $y_t$ ) component are then calculated as

$$q_t = s_t + p_t^* - p_t \quad (\text{B1.8})$$

$$x_t = s_t + p_t^{T*} - p_t^T \quad (\text{B1.9})$$

$$y_t = \beta(p_t^{N*} - p_t^{T*}) - \alpha(p_t^N - p_t^T) \quad (\text{B2.0})$$

Where  $q_t$  is the log of the real exchange rate,  $x_t$  is the log of the relative price of the traded goods in each country,  $y_t$  is the weighted difference of the log of the relative price of non-traded to traded goods prices in each country and  $s_t$  is the log of the domestic currency price of the foreign currency.

**Table B1.1: Quarterly MSE Decomposition – Advanced Economies**

Horizon	AE Count.																	
	Australia		Austria		Belgium		Canada		Denmark		Finland		Germany		Ireland		Italy	
	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2
1.00	0.94	1.01	0.94	1.05	0.94	1.04	0.90	1.28	0.93	1.01	0.96	1.03	0.96	1.02	0.91	1.13	0.97	1.04
2.00	0.95	1.07	0.93	1.08	0.94	1.08	0.90	1.29	0.94	1.02	0.96	1.05	0.95	1.03	0.89	1.19	0.97	1.05
3.00	0.96	1.08	0.93	1.07	0.94	1.11	0.89	1.29	0.95	1.03	0.97	1.07	0.95	1.03	0.87	1.22	0.97	1.05
4.00	0.96	1.09	0.93	1.06	0.94	1.13	0.89	1.30	0.95	1.05	0.97	1.07	0.96	1.02	0.86	1.24	0.97	1.05
6.00	0.96	1.11	0.94	1.08	0.94	1.16	0.89	1.32	0.96	1.08	0.98	1.08	0.97	1.02	0.85	1.29	0.98	1.07
9.00	0.97	1.11	0.94	1.10	0.94	1.19	0.89	1.30	0.96	1.09	0.98	1.09	0.98	1.04	0.85	1.31	0.98	1.08
12.00	0.96	1.11	0.93	1.13	0.93	1.23	0.88	1.36	0.97	1.11	0.97	1.11	0.98	1.05	0.83	1.35	0.98	1.10
20.00	0.96	1.11	0.93	1.17	0.94	1.28	0.88	1.47	0.98	1.11	0.97	1.13	0.98	1.06	0.80	1.42	0.98	1.13
30.00	0.96	1.12	0.92	1.18	0.93	1.33	0.88	1.48	0.98	1.10	0.96	1.18	0.99	1.05	0.78	1.49	0.98	1.14
40.00	0.96	1.16	0.87	1.21	0.92	1.41	0.88	1.47	0.98	1.12	0.96	1.20	0.99	1.06	0.75	1.48	0.97	1.16
50.00	0.95	1.21	0.81	1.35	0.90	1.57	0.89	1.45	0.98	1.15	0.94	1.24	0.99	1.07	0.72	1.54	0.97	1.17
60.00	0.94	1.22	0.74	1.43	0.90	1.69	0.89	1.35	0.98	1.18	0.93	1.30	0.99	1.08	0.70	1.39	0.96	1.19
70.00	0.94	1.16	0.73	1.39	0.90	1.63	0.92	1.16	0.98	1.17	0.88	1.41	0.99	1.06	0.68	1.28	0.89	1.22

Notes: Figures are the MSE decompositions across different horizons. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2015Q4.

**Table B1.2: Quarterly MSE Decomposition – Advanced Economies**

Horizon	AE Countries													
	Japan		Netherlands		New Zealand		Norway		UK		France		Czech Republic	
	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2
1.00	0.95	1.02	0.95	1.01	0.95	1.15	0.81	0.99	0.93	1.11	1.00		0.81	0.83
2.00	0.96	1.03	0.95	1.03	0.95	1.16	0.83	0.94	0.93	1.13	1.00		0.82	0.81
3.00	0.97	1.04	0.94	1.05	0.95	1.16	0.83	0.94	0.92	1.13	1.00		0.86	0.84
4.00	0.97	1.04	0.94	1.06	0.95	1.16	0.81	0.93	0.92	1.12	1.00		0.88	0.88
6.00	0.98	1.05	0.94	1.08	0.95	1.18	0.75	0.89	0.91	1.13	1.00		0.90	0.92
9.00	0.99	1.06	0.95	1.10	0.94	1.21	0.73	0.88	0.92	1.15	0.99		0.93	0.95
12.00	0.99	1.06	0.95	1.11	0.94	1.21	0.68	0.84	0.92	1.17	0.99		0.93	0.98
20.00	0.99	1.07	0.97	1.13	0.95	1.20	0.63	0.80	0.92	1.27	0.99		0.94	0.98
30.00	0.99	1.09	0.97	1.15	0.94	1.16	0.55	0.66	0.89	1.31	0.98		0.93	0.99
40.00	0.99	1.09	0.97	1.19	0.93	1.18	0.44	0.42	0.86	1.34	0.96		0.89	0.95
50.00	0.99	1.09	0.96	1.26	0.93	1.16	0.35	0.21	0.84	1.38	0.91		0.83	0.89
60.00	0.99	1.10	0.96	1.33	0.91	1.08			0.84	1.39			0.76	0.84
70.00	0.99	1.10	0.96	1.31	0.86	0.77			0.83	1.29			0.64	0.75
80.00	0.99	1.10	0.96	1.29	0.89	0.76			0.90	1.29			0.55	0.74

Notes: Figures are the MSE decompositions across different horizons. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2015Q4.

**Table B1.3: Quarterly MSE Decomposition – Advanced Economies**

EME Income Countries												
Horizon	Mexico		Morocco		Turkey		Philippines		Paraguay		Brazil	
	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2
1.00	0.99	1.03	0.77	0.92	0.99	1.02	0.85	1.15	0.93	1.19	0.92	0.92
2.00	0.99	1.03	0.76	0.87	0.99	1.01	0.86	1.16	0.94	1.21	0.89	0.87
3.00	0.99	1.02	0.77	0.86	0.99	1.01	0.87	1.17	0.94	1.21	0.88	0.85
4.00	0.99	1.02	0.77	0.89	1.00	1.00	0.87	1.17	0.95	1.20	0.87	0.83
6.00	1.00	1.02	0.76	0.94	1.00	1.00	0.87	1.16	0.96	1.20	0.83	0.79
9.00	1.00	1.01	0.80	0.96	1.00	0.99	0.86	1.15	0.96	1.18	0.82	0.77
12.00	1.00	1.00	0.83	0.98	1.00	0.99	0.85	1.16	0.97	1.17	0.80	0.74
20.00	1.00	1.00	0.90	0.90	1.00	0.99	0.85	1.17	0.97	1.16	0.80	0.75
30.00	1.00	1.00	0.88	0.80	1.00	0.99	0.84	1.15	0.98	1.13	0.81	0.80
40.00	1.00	1.00	0.83	0.62	1.00	0.99	0.84	1.07	0.99	1.12	0.85	0.86
50.00	1.00	1.00	0.79	0.54	1.00	0.99	0.84	1.20	0.99	1.10	0.84	0.96
60.00	1.00	1.00	0.56	0.42	1.00	0.99	0.85	0.84	0.99	1.08	0.79	1.11
70.00	1.00	1.00			1.00	0.99	0.87	0.78	0.99	1.08	0.64	0.92
80.00	1.00	1.00			1.00	0.98	0.89	0.75				

Notes: Figures are the MSE decompositions across different horizons. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2015Q4.

**Table B1.4: Quarterly MSE Decomposition – Advanced Economies**

EME Income Countries												
Horizon	Colombia		Hungary		Malaysia		Thailand		South Africa		Costa Rica	
	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2	MSE1	MSE2
1.00	0.96	1.07	0.91	1.07	0.87	1.08	0.92	1.13	0.96	1.10	1.00	1.02
2.00	0.97	1.06	0.93	1.06	0.88	1.08	0.93	1.12	0.97	1.11	0.99	1.02
3.00	0.98	1.05	0.94	1.03	0.89	1.07	0.94	1.12	0.97	1.11	0.98	1.03
4.00	0.98	1.04	0.95	1.01	0.89	1.07	0.94	1.13	0.97	1.12	0.98	1.03
6.00	0.99	1.03	0.96	0.97	0.90	1.05	0.93	1.11	0.98	1.09	0.98	1.02
9.00	0.99	1.02	0.97	0.96	0.91	1.03	0.93	1.07	0.98	1.08	0.99	1.01
12.00	0.99	1.02	0.98	0.95	0.92	1.03	0.94	1.05	0.99	1.08	0.99	1.02
20.00	0.99	1.01	0.98	0.94	0.95	1.06	0.95	1.04	0.99	1.07	1.00	1.02
30.00	1.00	1.00	0.98	0.93	0.95	1.07	0.96	1.04	0.99	1.07	1.00	1.03
40.00	1.00	1.00	0.98	0.92	0.95	1.11	0.96	1.05	0.99	1.07	1.00	1.04
50.00	1.00	0.99	0.98	0.91	0.94	1.21	0.95	1.09	0.99	1.07	1.00	1.04
60.00	1.00	0.99	0.98	0.89	0.92	1.28	0.94	1.18	0.99	1.07	1.00	1.04
70.00	1.00	0.99	0.97	0.86	0.90	1.33	0.92	1.33	0.99	1.08	1.00	1.05
80.00	1.00	0.99	0.97	0.85	0.90	1.19	0.90	1.42	0.99	1.08	1.00	1.04

## B2.1: Results of the MSE Decomposition of Real Exchange Rate

**Table B2.1 MSE Decomposition using Consumer prices –Monthly data**

Horizons	Mexico	Colombia	Czech Republic
2	0.970332	0.999178	0.986634
6	0.979845	0.999389	0.990582
10	0.986457	0.999449	0.98749
20	0.990372	0.999468	0.978703
30	0.993029	0.999446	0.975982
40	0.994709	0.999369	0.970022
50	0.995708	0.9993	0.968871
80	0.997007	0.998927	0.958272
120	0.997962	0.998806	0.943754
160	0.998516	0.998539	0.911782
200	0.99851	0.998702	0.85479
250	0.99843		
300	0.998412		
350	0.998145		

**Table B2.2 MSE Decomposition using Personal consumption expenditures-Costa Rica - Quarterly data**

Horizons	MSE
2	0.97594
4	0.982509
8	0.985339
12	0.986775
16	0.987551
20	0.987839
30	0.987876
40	0.98814
50	0.988519
60	0.988628
70	0.988489
80	0.988322

## Quarterly SVAR Estimates

**Table B3.1 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Full Sample Results**

Country	Levels		Cyclical Component	
	Xt	REER	xt	reer
Brazil	0.40	0.45	0.29	0.31
Costa Rica	0.29	0.33	0.38	0.28
Colombia	0.32	0.28	0.15	0.25
Czech Republic	0.38	0.52	0.45	0.30
Mexico	0.55	0.33	0.67	0.39
Morocco	0.13	0.19	0.28	0.03
Philippines	0.23	0.32	0.12	0.12
South Africa	0.70	0.49	0.39	0.42
Turkey	0.09	0.07	0.17	0.11
Paraguay	0.70	0.40	0.44	0.37
Canada	0.19	0.30	0.23	0.21
Denmark	0.49	0.12	0.52	0.28
Finland	0.37	0.18	0.39	0.33
France	0.27	0.12	0.37	0.14
Germany	0.14	0.05	0.23	0.10
Japan	0.12	0.09	0.08	0.08
Norway	0.58	0.32	0.42	0.22
UK	0.10	0.15	0.13	0.13
Australia	0.47	0.50	0.29	0.38
Austria	0.29	0.08	0.31	0.19
Belgium	0.38	0.23	0.35	0.30
Hungary	0.30	0.47	0.30	0.32
Ireland	0.11	0.31	0.21	0.35
Italy	0.16	0.08	0.41	0.37
Malaysia	0.45	0.39	0.55	0.34
Netherlands	0.44	0.22	0.50	0.21
New Zealand	0.17	0.22	0.17	0.24
Thailand	0.41	0.32	0.16	0.06
<b>Mean</b>	<b>0.33</b>	<b>0.27</b>	<b>0.32</b>	<b>0.24</b>
<b>Median</b>	<b>0.31</b>	<b>0.29</b>	<b>0.31</b>	<b>0.27</b>

Notes: Variance decompositions are based on country –by country estimates of the SVAR system. The reported figures are the cross-country mean and median estimates. Xt and REER refers to the relative price of tradable goods and the real effective exchange rates respectively.

**Table B3.2 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Individual Commodity Prices**

Country	Xt			REER			xt			reer		
	Pr	Pm	Pa	Pf	Pm	Pa	Pr	Pm	Pa	Pr	Pm	Pa
Brazil	0.01	0.30	0.08	0.05	0.34	0.05	0.10	0.09	0.09	0.09	0.15	0.06
Costa Rica	0.23	0.04	0.01	0.29	0.02	0.02	0.15	0.09	0.14	0.18	0.03	0.07
Colombia	0.01	0.09	0.21	0.10	0.05	0.12	0.02	0.11	0.02	0.16	0.06	0.03
Czech Republic	0.23	0.08	0.06	0.31	0.12	0.06	0.04	0.06	0.34	0.07	0.11	0.13
Mexico	0.48	0.06	0.01	0.24	0.02	0.06	0.49	0.11	0.07	0.27	0.09	0.03
Morocco	0.04	0.08	0.01	0.12	0.07	0.01	0.12	0.06	0.11	0.02	0.01	0.00
Philippines	0.04	0.17	0.02	0.19	0.08	0.03	0.07	0.04	0.01	0.02	0.09	0.01
South Africa	0.10	0.53	0.08	0.07	0.38	0.04	0.21	0.13	0.05	0.24	0.12	0.05
Turkey	0.08	0.01	0.00	0.05	0.01	0.01	0.12	0.03	0.03	0.06	0.03	0.01
Paraguay	0.11	0.30	0.27	0.08	0.15	0.15	0.16	0.12	0.16	0.21	0.11	0.05
Canada	0.04	0.14	0.00	0.08	0.15	0.07	0.10	0.12	0.00	0.11	0.09	0.01
Denmark	0.17	0.30	0.01	0.07	0.05	0.01	0.13	0.16	0.23	0.06	0.05	0.17
Finland	0.02	0.31	0.04	0.05	0.05	0.07	0.16	0.08	0.14	0.20	0.02	0.11
France	0.06	0.21	0.01	0.07	0.00	0.05	0.02	0.15	0.20	0.02	0.01	0.11
Germany	0.02	0.10	0.01	0.02	0.02	0.00	0.02	0.12	0.08	0.01	0.07	0.02
Japan	0.02	0.03	0.06	0.02	0.04	0.02	0.01	0.05	0.03	0.01	0.04	0.03
Norway	0.45	0.12	0.00	0.20	0.11	0.01	0.23	0.05	0.14	0.12	0.05	0.04
UK	0.05	0.03	0.01	0.10	0.04	0.01	0.06	0.03	0.04	0.02	0.08	0.02
Australia	0.04	0.41	0.02	0.09	0.37	0.04	0.09	0.15	0.06	0.10	0.21	0.06
Austria	0.01	0.25	0.03	0.01	0.02	0.06	0.09	0.08	0.15	0.04	0.03	0.11
Belgium	0.12	0.25	0.01	0.04	0.16	0.04	0.06	0.14	0.15	0.04	0.07	0.19
Hungary	0.08	0.15	0.04	0.18	0.20	0.07	0.07	0.08	0.14	0.09	0.17	0.06
Ireland	0.06	0.01	0.04	0.13	0.01	0.17	0.06	0.09	0.07	0.07	0.20	0.09
Italy	0.03	0.12	0.02	0.04	0.01	0.02	0.05	0.20	0.16	0.03	0.12	0.20
Malaysia	0.34	0.01	0.10	0.16	0.12	0.07	0.45	0.02	0.08	0.30	0.03	0.02
Netherlands	0.17	0.25	0.01	0.13	0.00	0.09	0.15	0.15	0.20	0.03	0.06	0.11
New Zealand	0.02	0.10	0.05	0.05	0.06	0.12	0.08	0.03	0.07	0.11	0.03	0.11
Thailand	0.02	0.27	0.10	0.02	0.25	0.05	0.03	0.05	0.08	0.02	0.02	0.02
<b>Mean</b>	<b>0.11</b>	<b>0.17</b>	<b>0.05</b>	<b>0.11</b>	<b>0.10</b>	<b>0.05</b>	<b>0.12</b>	<b>0.09</b>	<b>0.11</b>	<b>0.10</b>	<b>0.08</b>	<b>0.07</b>
<b>Median</b>	<b>0.05</b>	<b>0.13</b>	<b>0.02</b>	<b>0.08</b>	<b>0.05</b>	<b>0.06</b>	<b>0.09</b>	<b>0.09</b>	<b>0.09</b>	<b>0.07</b>	<b>0.06</b>	<b>0.05</b>

**Table B3.3 Country Specific Correlations of Commodity Prices and Income**

Country	pF	pM	pA
<b>Middle Income</b>			
Brazil	0.64	0.59	0.51
Costa Rica	0.11	0.32	0.16
Colombia	0.54	0.63	0.57
Hungary	0.27	0.55	0.20
Malaysia	-0.08	-0.12	0.01
Mexico	0.27	0.29	0.02
Philippines	0.04	0.06	-0.04
South Africa	0.61	0.48	0.52
Turkey	0.48	0.67	0.37
Paraguay	0.09	0.27	0.18
<b>Mean</b>	<b>0.30</b>	<b>0.37</b>	<b>0.25</b>
<b>Median</b>	<b>0.27</b>	<b>0.40</b>	<b>0.19</b>
<b>High Income</b>			
Canada	0.34	0.64	0.34
Denmark	0.43	0.64	0.17
Finland	0.38	0.59	0.34
France	0.44	0.54	0.17
Germany	0.44	0.63	0.31
Czech Rep	0.33	0.52	0.22
Japan	0.60	0.68	0.35
Norway	0.07	0.13	0.03
UK	0.23	0.69	0.44
Australia	0.06	0.33	0.34
Austria	0.50	0.66	0.33
Belgium	0.50	0.75	0.25
Ireland	-0.12	0.27	-0.10
Italy	0.43	0.70	0.34
Netherlands	0.29	0.44	0.12
New Zealand	0.11	0.40	0.39
<b>Mean</b>	<b>0.31</b>	<b>0.54</b>	<b>0.25</b>
<b>Median</b>	<b>0.36</b>	<b>0.61</b>	<b>0.32</b>

NB: Morocco and Thailand are not included due to lack quarterly real GDP data.

**Table B3.4 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Country Specific Estimates - Monthly**

Country	Levels		Cyclical Component	
	Xt	REER	xt	reer
Costa Rica	0.24	0.16	0.18	0.12
Colombia	0.18	0.16	0.04	0.12
Czech Republic	0.34	0.36	0.34	0.25
Mexico	0.45	0.22	0.54	0.21
Morocco	0.17	0.22	0.12	0.07
Philippines	0.21	0.17	0.07	0.08
South Africa	0.21	0.08	0.23	0.10
Turkey	0.36	0.50	0.18	0.14
Paraguay	0.65	0.11	0.29	0.08
Canada	0.44	0.42	0.24	0.24
Denmark	0.24	0.05	0.04	0.08
Finland	0.13	0.11	0.08	0.04
France	0.16	0.06	0.05	0.07
Germany	0.11	0.02	0.08	0.09
Japan	0.20	0.23	0.21	0.23
Norway	0.58	0.22	0.22	0.10
UK	0.05	0.06	0.13	0.11
Austria	0.23	0.02	0.05	0.04
Belgium	0.19	0.07	0.04	0.07
Hungary	0.09	0.16	0.04	0.24
Ireland	0.05	0.06	0.10	0.12
Italy	0.10	0.10	0.07	0.15
Malaysia	0.36	0.10	0.10	0.07
Netherlands	0.28	0.04	0.07	0.06
Thailand	0.32	0.28	0.12	0.10
<b>Mean</b>	<b>0.25</b>	<b>0.16</b>	<b>0.15</b>	<b>0.12</b>
<b>Median</b>	<b>0.21</b>	<b>0.11</b>	<b>0.10</b>	<b>0.10</b>

**Table B3.5 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Country Group Estimates -Monthly**

Country	Levels		Cyclical Components	
	Xt	REER	xt	reer
<b>Middle Income Countries</b>				
Costa Rica	0.24	0.16	0.18	0.12
Colombia	0.18	0.16	0.04	0.12
Mexico	0.45	0.22	0.54	0.21
Morocco	0.17	0.22	0.12	0.07
Philippines	0.21	0.17	0.07	0.08
South Africa	0.21	0.08	0.23	0.10
Turkey	0.36	0.50	0.18	0.14
Paraguay	0.65	0.11	0.29	0.08
Hungary	0.09	0.16	0.04	0.24
Malaysia	0.36	0.10	0.10	0.07
Thailand	0.32	0.28	0.12	0.10
<b>Mean</b>	<b>0.29</b>	<b>0.20</b>	<b>0.17</b>	<b>0.12</b>
<b>Median</b>	<b>0.24</b>	<b>0.16</b>	<b>0.12</b>	<b>0.10</b>
<b>High Income Countries</b>				
Czech Republic	0.34	0.36	0.34	0.25
Canada	0.44	0.42	0.24	0.24
Denmark	0.24	0.05	0.04	0.08
Finland	0.13	0.11	0.08	0.04
France	0.16	0.06	0.05	0.07
Germany	0.11	0.02	0.08	0.09
Japan	0.20	0.23	0.21	0.23
Norway	0.58	0.22	0.22	0.10
UK	0.05	0.06	0.13	0.11
Austria	0.23	0.02	0.05	0.04
Belgium	0.19	0.07	0.04	0.07
Ireland	0.05	0.06	0.10	0.12
Italy	0.10	0.10	0.07	0.15
Netherlands	0.28	0.04	0.07	0.06
<b>Mean</b>	<b>0.22</b>	<b>0.13</b>	<b>0.12</b>	<b>0.12</b>
<b>Median</b>	<b>0.20</b>	<b>0.07</b>	<b>0.08</b>	<b>0.09</b>

**Table B3.6 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Country Group Estimates -Monthly**

Country	Xt			REER			xt			reer		
	Pf	Pm	Pa	Pf	Pm	Pa	Pf	Pm	Pa	Pf	Pm	Pa
Costa Rica	0.10	0.04	0.10	0.13	0.02	0.02	0.10	0.02	0.06	0.08	0.03	0.01
Colombia	0.12	0.05	0.01	0.11	0.05	0.01	0.01	0.02	0.01	0.01	0.06	0.05
Czech Republic	0.28	0.06	0.00	0.31	0.02	0.02	0.17	0.05	0.12	0.06	0.02	0.18
Mexico	0.18	0.03	0.24	0.14	0.02	0.06	0.25	0.07	0.22	0.06	0.04	0.10
Morocco	0.06	0.07	0.04	0.12	0.08	0.02	0.07	0.04	0.02	0.01	0.02	0.04
Philippines	0.04	0.05	0.12	0.07	0.09	0.01	0.04	0.02	0.02	0.02	0.02	0.04
South Africa	0.15	0.03	0.04	0.01	0.05	0.02	0.18	0.05	0.01	0.06	0.03	0.01
Turkey	0.21	0.01	0.13	0.27	0.01	0.22	0.15	0.01	0.02	0.07	0.00	0.07
Paraguay	0.13	0.47	0.04	0.02	0.06	0.03	0.09	0.13	0.07	0.01	0.06	0.01
Canada	0.08	0.21	0.14	0.13	0.19	0.10	0.02	0.18	0.04	0.09	0.09	0.06
Denmark	0.16	0.07	0.00	0.03	0.01	0.01	0.02	0.02	0.00	0.01	0.03	0.05
Finland	0.03	0.09	0.00	0.00	0.04	0.07	0.04	0.02	0.02	0.01	0.02	0.00
France	0.07	0.09	0.00	0.05	0.01	0.00	0.02	0.02	0.00	0.02	0.03	0.02
Germany	0.08	0.03	0.00	0.01	0.00	0.00	0.01	0.02	0.05	0.01	0.02	0.05
Japan	0.08	0.05	0.08	0.03	0.15	0.06	0.11	0.02	0.08	0.10	0.02	0.11
Norway	0.37	0.19	0.01	0.11	0.08	0.03	0.17	0.03	0.02	0.06	0.02	0.02
UK	0.02	0.03	0.00	0.05	0.01	0.00	0.04	0.08	0.01	0.00	0.10	0.02
Austria	0.07	0.15	0.01	0.01	0.00	0.01	0.02	0.02	0.00	0.00	0.01	0.03
Belgium	0.13	0.06	0.01	0.06	0.01	0.00	0.01	0.02	0.00	0.03	0.03	0.02
Hungary	0.06	0.02	0.00	0.11	0.05	0.00	0.01	0.04	0.00	0.03	0.13	0.08
Ireland	0.04	0.01	0.00	0.04	0.00	0.02	0.04	0.02	0.04	0.04	0.01	0.06
Italy	0.06	0.03	0.00	0.00	0.00	0.10	0.01	0.06	0.00	0.02	0.05	0.07
Malaysia	0.14	0.11	0.10	0.07	0.02	0.01	0.03	0.02	0.04	0.05	0.00	0.02
Netherlands	0.19	0.08	0.01	0.01	0.02	0.01	0.03	0.03	0.01	0.01	0.02	0.03
Thailand	0.03	0.26	0.03	0.02	0.25	0.01	0.06	0.04	0.02	0.05	0.04	0.01
<b>Median</b>	<b>0.08</b>	<b>0.06</b>	<b>0.01</b>	<b>0.05</b>	<b>0.02</b>	<b>0.02</b>	<b>0.04</b>	<b>0.02</b>	<b>0.02</b>	<b>0.03</b>	<b>0.03</b>	<b>0.04</b>
<b>MAD</b>	<b>0.05</b>	<b>0.03</b>	<b>0.01</b>	<b>0.05</b>	<b>0.02</b>	<b>0.01</b>	<b>0.03</b>	<b>0.01</b>	<b>0.01</b>	<b>0.02</b>	<b>0.01</b>	<b>0.02</b>

**Table B3.7 Share of Variances Explained by World Shocks and Mediated by Commodity Prices. Country Group Estimates -Monthly**

Country		Pr	Pm	Pa
Brazil	Correlation with xt, $\rho(xt,x)$	-0.32	-0.41	-0.34
	Correlation with reer, $\rho(reer,x)$	0.32	0.52	0.26
Colombia	Correlation with xt, $\rho(xt,x)$	-0.04	-0.33	-0.34
	Correlation with reer, $\rho(reer,x)$	0.29	0.43	0.47
Costa Rica	Correlation with xt, $\rho(xt,x)$	0.39	0.48	0.26
	Correlation with reer, $\rho(reer,x)$	-0.06	-0.11	-0.07
Czech Republic	Correlation with xt, $\rho(xt,x)$	0.21	0.22	0.63
	Correlation with reer, $\rho(reer,x)$	-0.07	-0.01	0.34
Mexico	Correlation with xt, $\rho(xt,x)$	0.26	-0.20	-0.10
	Correlation with reer, $\rho(reer,x)$	0.25	0.06	0.00
Morocco	Correlation with xt, $\rho(xt,x)$	-0.02	0.12	0.28
	Correlation with reer, $\rho(reer,x)$	-0.23	-0.04	0.01
Philippines	Correlation with xt, $\rho(xt,x)$	-0.13	-0.29	-0.20
	Correlation with reer, $\rho(reer,x)$	0.22	0.22	0.22
South Africa	Correlation with xt, $\rho(xt,x)$	0.39	0.48	0.26
	Correlation with reer, $\rho(reer,x)$	0.17	0.23	0.11
Turkey	Correlation with xt, $\rho(xt,x)$	0.43	0.11	-0.05
	Correlation with reer, $\rho(reer,x)$	0.16	0.22	0.02
Paraguay	Correlation with xt, $\rho(xt,x)$	-0.42	-0.46	-0.54
	Correlation with reer, $\rho(reer,x)$	0.06	0.20	0.17
Canada	Correlation with xt, $\rho(xt,x)$	-0.37	-0.60	-0.42
	Correlation with reer, $\rho(reer,x)$	0.55	0.44	0.28
Denmark	Correlation with xt, $\rho(xt,x)$	-0.15	-0.21	-0.35
	Correlation with reer, $\rho(reer,x)$	-0.19	-0.10	0.07
Finland	Correlation with xt, $\rho(xt,x)$	-0.13	-0.28	-0.36
	Correlation with reer, $\rho(reer,x)$	0.07	0.14	0.21
France	Correlation with xt, $\rho(xt,x)$	-0.06	-0.07	-0.44
	Correlation with reer, $\rho(reer,x)$	-0.05	-0.06	0.19
Germany	Correlation with xt, $\rho(xt,x)$	0.09	-0.04	-0.18
	Correlation with reer, $\rho(reer,x)$	-0.17	-0.08	0.15
Japan	Correlation with xt, $\rho(xt,x)$	0.21	0.05	-0.04
	Correlation with reer, $\rho(reer,x)$	-0.24	-0.07	-0.02
Norway	Correlation with xt, $\rho(xt,x)$	-0.51	-0.41	-0.41
	Correlation with reer, $\rho(reer,x)$	0.37	0.34	0.40
UK	Correlation with xt, $\rho(xt,x)$	-0.06	-0.24	-0.20
	Correlation with reer, $\rho(reer,x)$	0.17	0.30	-0.02
Australia	Correlation with xt, $\rho(xt,x)$	-0.26	-0.50	-0.57
	Correlation with reer, $\rho(reer,x)$	0.42	0.52	0.55
Austria	Correlation with xt, $\rho(xt,x)$	-0.04	-0.06	-0.27
	Correlation with reer, $\rho(reer,x)$	-0.04	0.00	0.21
Belgium	Correlation with xt, $\rho(xt,x)$	-0.19	-0.23	-0.34
	Correlation with reer, $\rho(reer,x)$	0.01	-0.03	0.30

Hungary	Correlation with xt, $\rho(xt,x)$	0.06	0.12	-0.20
	Correlation with reer, $\rho(reer,x)$	0.06	-0.01	0.30
Ireland	Correlation with xt, $\rho(xt,x)$	0.20	0.02	-0.10
	Correlation with reer, $\rho(reer,x)$	0.08	-0.07	0.24
Italy	Correlation with xt, $\rho(xt,x)$	-0.02	-0.04	-0.17
	Correlation with reer, $\rho(reer,x)$	0.02	-0.21	-0.05
Malaysia	Correlation with xt, $\rho(xt,x)$	-0.42	-0.37	-0.47
	Correlation with reer, $\rho(reer,x)$	0.35	0.10	0.19
Netherlands	Correlation with xt, $\rho(xt,x)$	-0.22	-0.30	-0.39
	Correlation with reer, $\rho(reer,x)$	-0.22	-0.12	0.13
New Zealand	Correlation with xt, $\rho(xt,x)$	-0.13	-0.37	-0.51
	Correlation with reer, $\rho(reer,x)$	0.24	0.49	0.55
Thailand	Correlation with xt, $\rho(xt,x)$	-0.04	-0.26	-0.34
	Correlation with reer, $\rho(reer,x)$	0.18	0.30	0.22

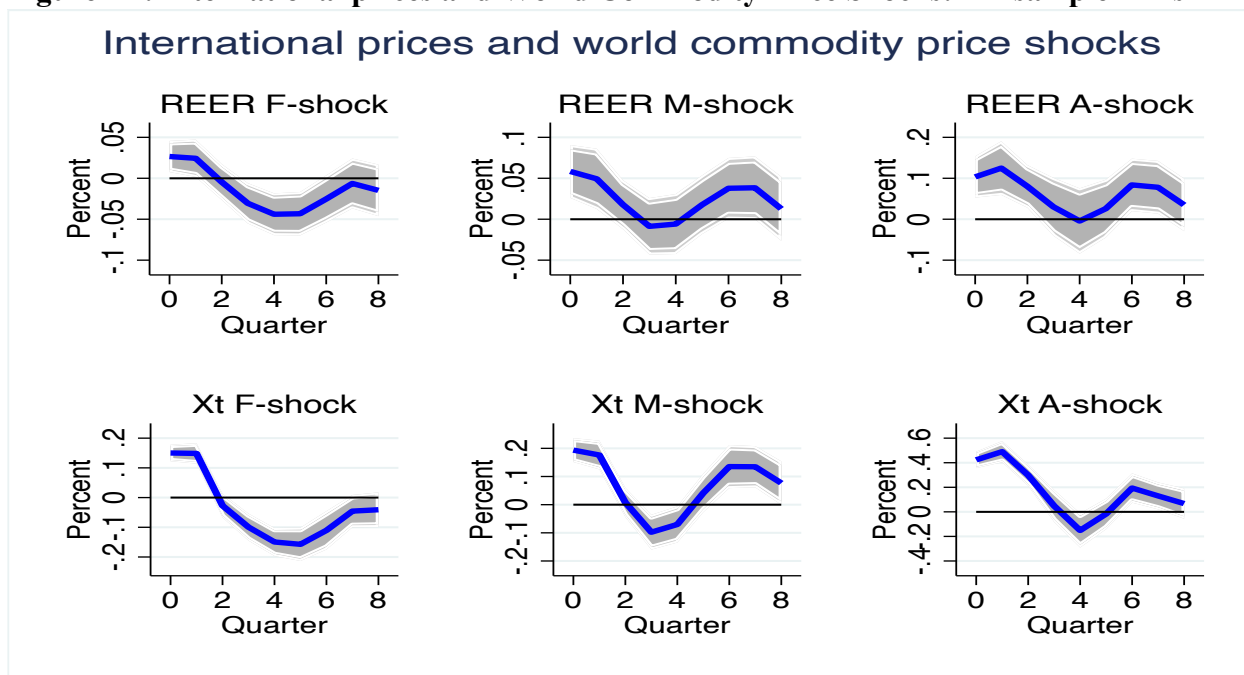
Note: Values are the country specific correlations with real exchange rate and relative price of tradable goods. Data is quarterly and covers the period 1985q1 -2015q4

**Table B4: List of Sample countries**

Country	Data Range						Classification
	Xt	REER	NRER	A	F	M	High Income
Australia	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Austria	1987Q1-2015Q4	1994Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Brazil	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Belgium	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Canada	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Colombia	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	Low Income
Costa Rica	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	Low Income
Czech Republic	1993Q1-2015Q4	1990Q1-2015Q4	1993Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Denmark	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Finland	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
France	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Germany	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Hungary	1985Q1-2015Q4	1990Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	Low Income
Ireland	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Italy	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income
Japan	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	High Income

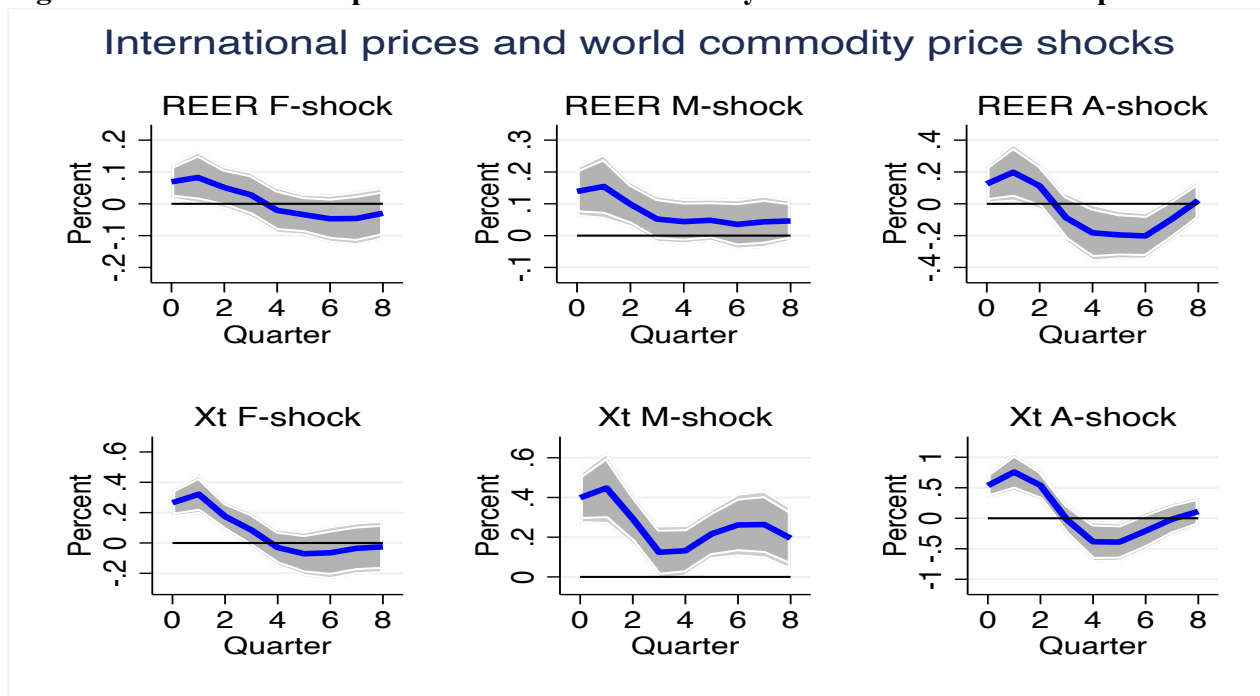
Malaysia	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>Low Income</b>
Mexico	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>Low Income</b>
Morocco	1998Q1- 2015Q4	1988Q1- 2015Q4	1985Q1- 2015Q4	1960Q1- 2015Q4	1960Q1-2015Q4	1960Q1-2015Q4	<b>Low Income</b>
Netherlands	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>High Income</b>
New Zealand	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>High Income</b>
Norway	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>High Income</b>
Paraguay	1996Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>Low Income</b>
Philippines	1993Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>Low Income</b>
South Africa	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>Low Income</b>
Thailand	1985Q1- 2015Q4	1994Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>Low Income</b>
Turkey	1986Q1- 2015Q4	1994Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>Low Income</b>
United Kingdom	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1- 2015Q4	1985Q1-2015Q4	1985Q1-2015Q4	<b>High Income</b>

**Figure B1: International prices and World Commodity Price Shocks: AE sample IRFs**



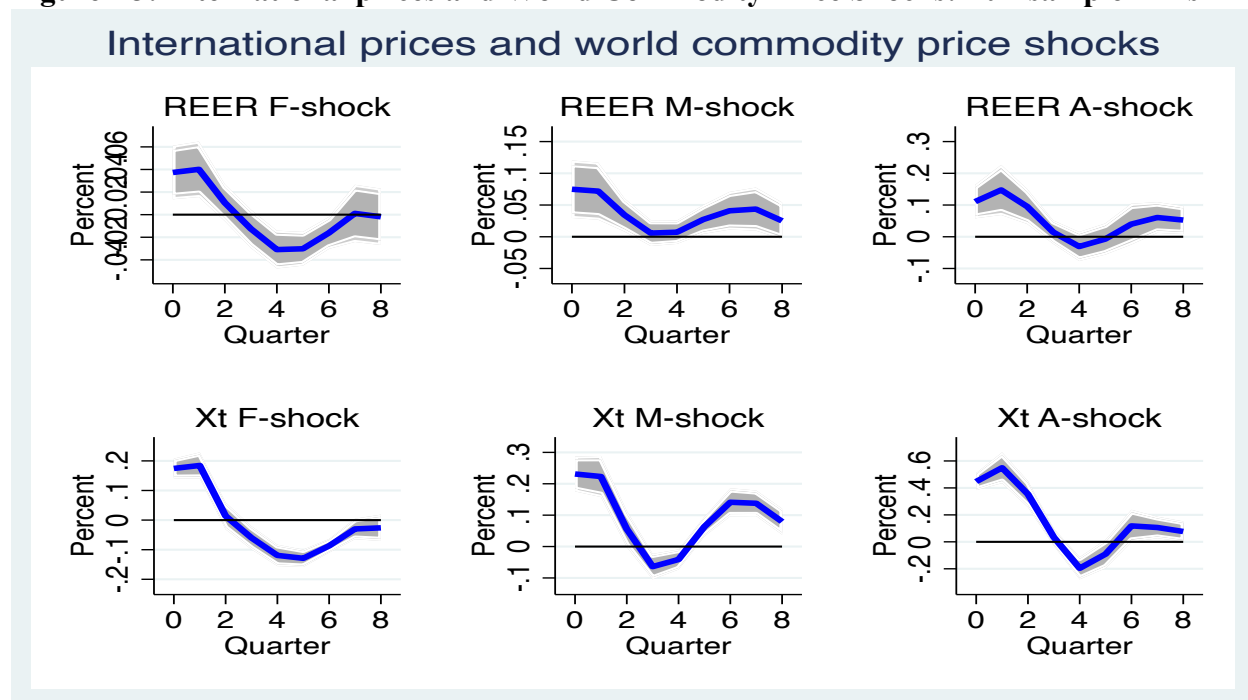
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with Newey West standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 16.

**Figure B2: International prices and World Commodity Price Shocks: EME sample IRFs**



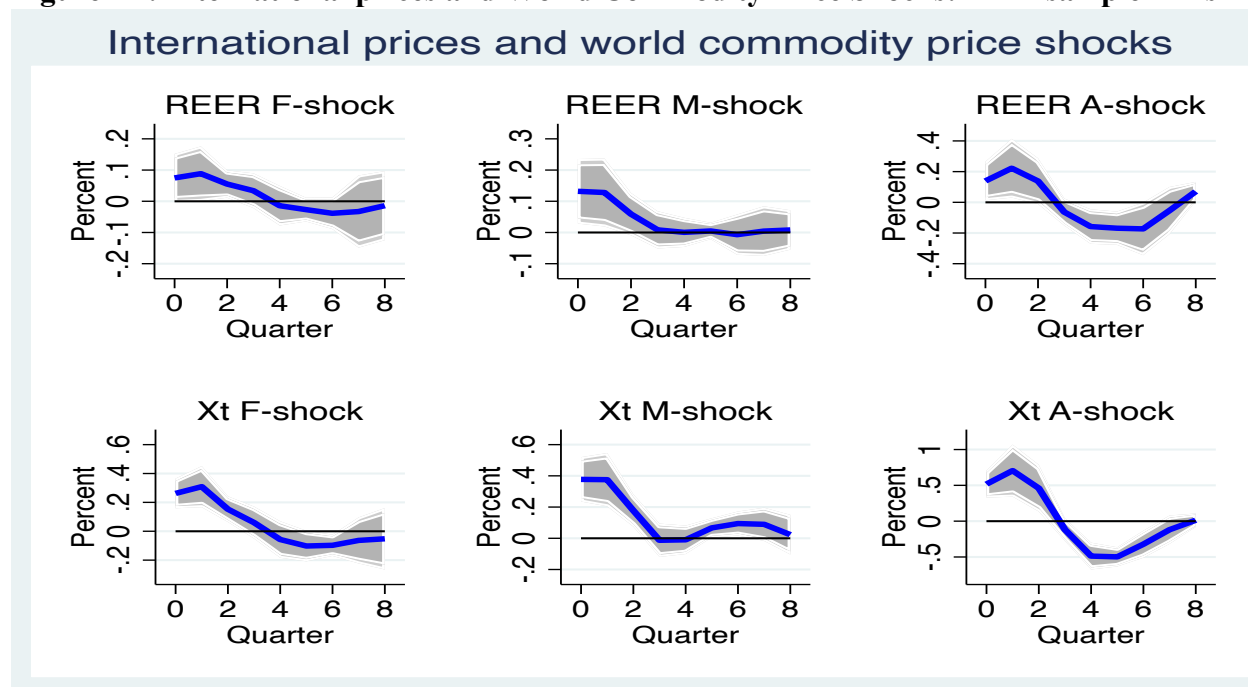
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with Newey West standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 11.

**Figure B3: International prices and World Commodity Price Shocks: Full sample IRFs**



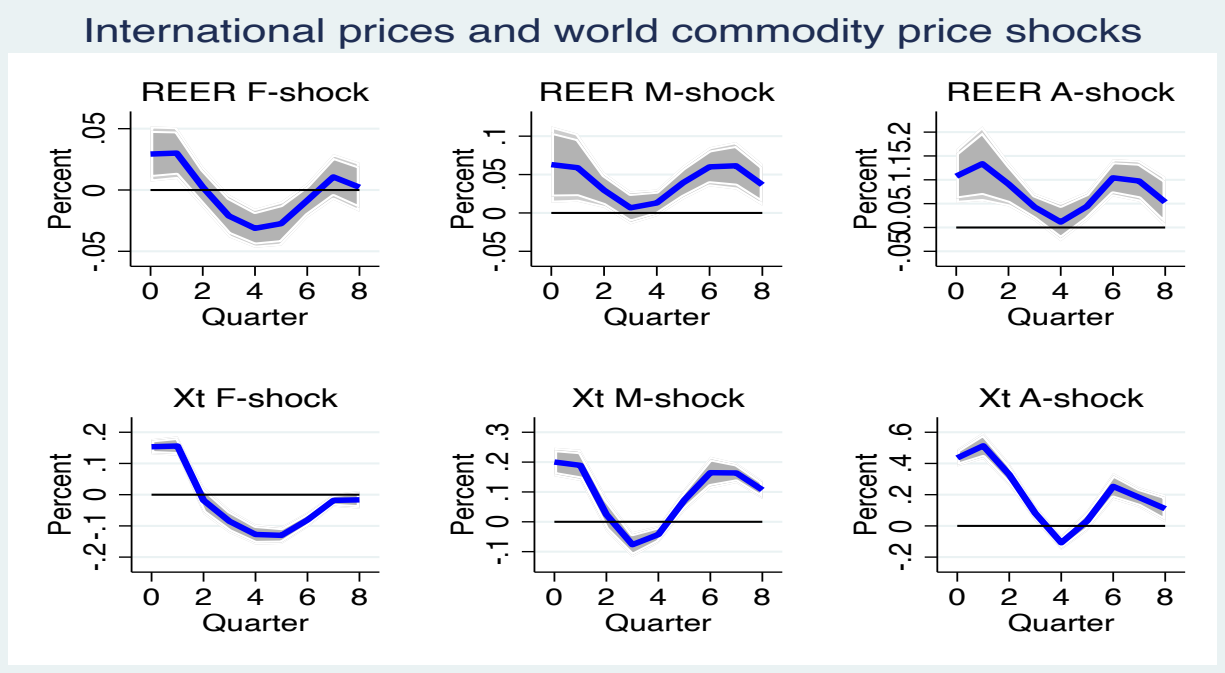
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors and lags REER and Xt. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 27.

**Figure B4: International prices and World Commodity Price Shocks: EME sample IRFs**



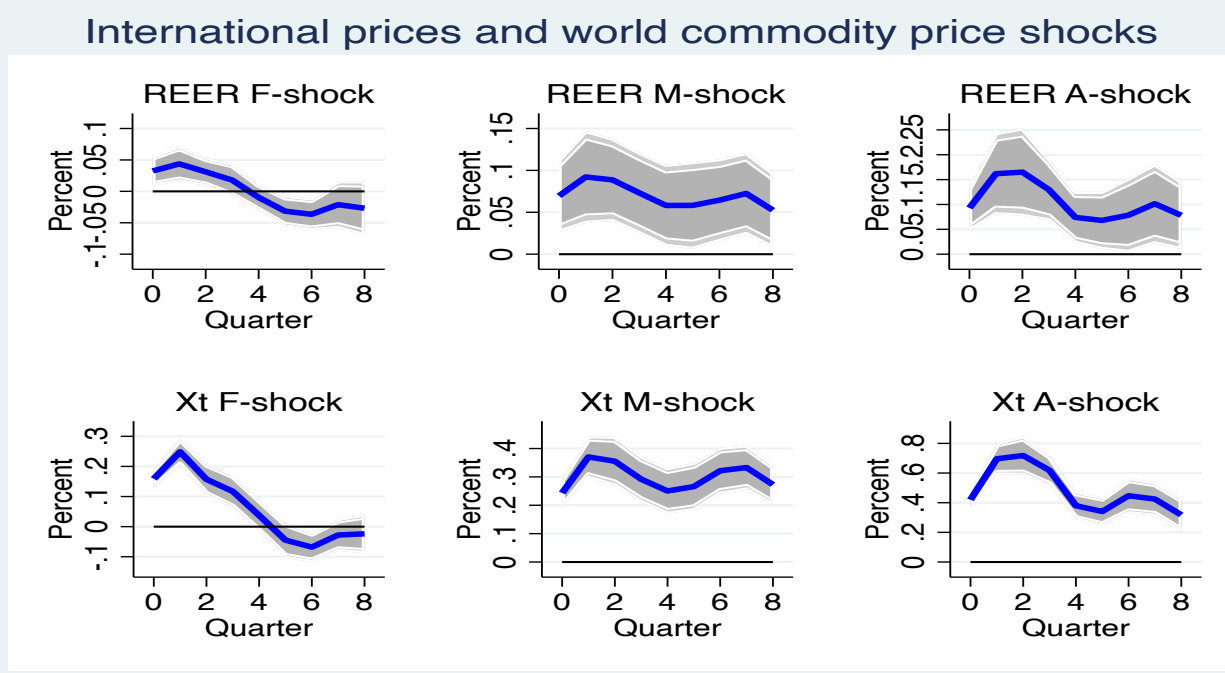
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors and lags REER and Xt. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 11.

**Figure B5: International prices and World Commodity Price Shocks: AE sample IRFs**



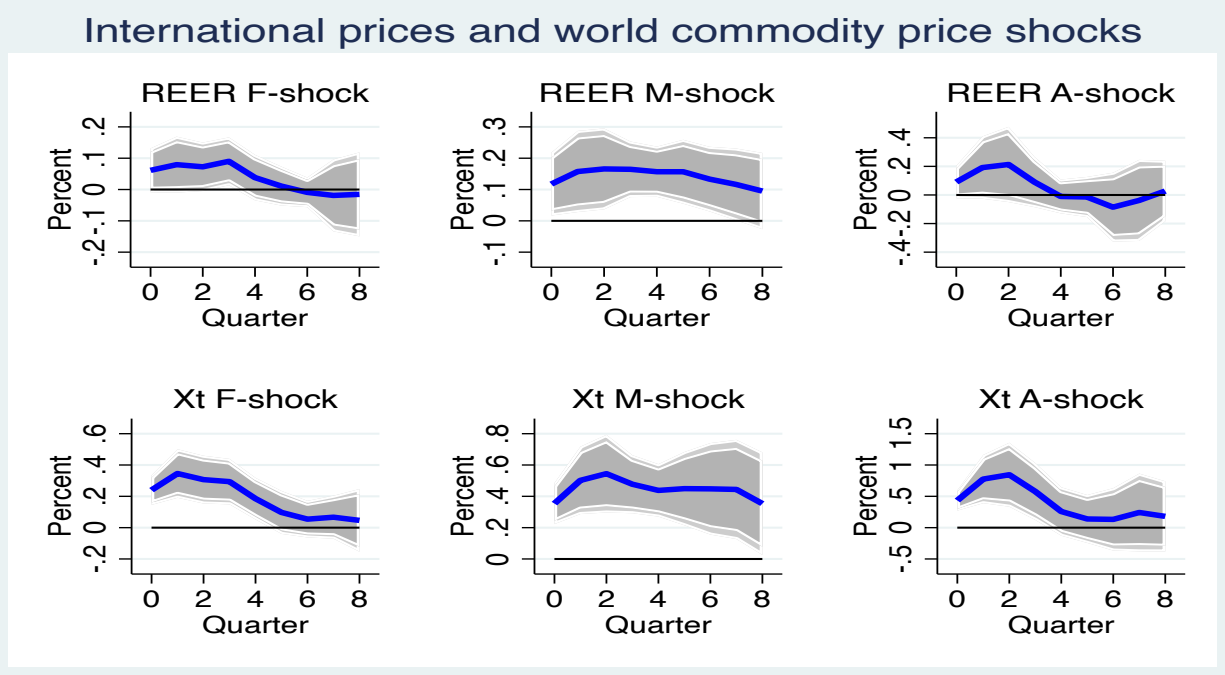
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors and lags REER and Xt. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the HP filter with a smoothing parameter of 1600. Data is quarterly from 1985q1 -2015q4 and the sample size is 16.

**Figure B6: International prices and World Commodity Price Shocks: Full sample IRFs**



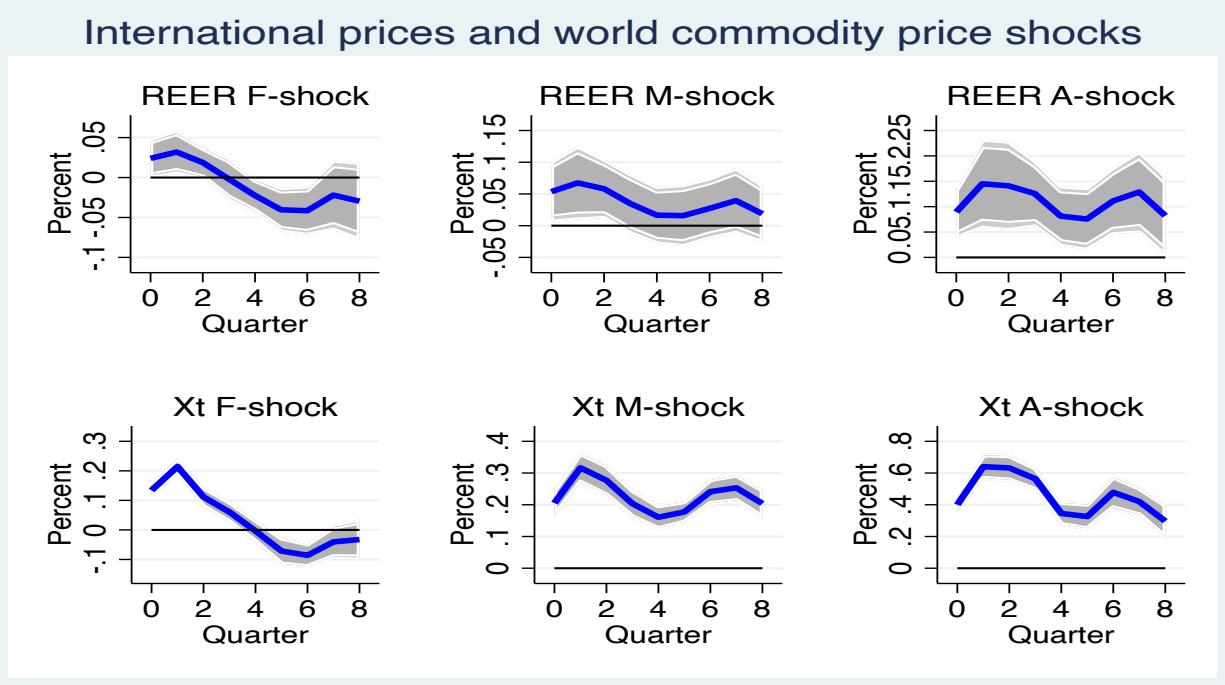
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the natural logs of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The commodity price shock variable was obtained from equation (2.1.6). Data is quarterly from 1985q1 -2015q4 and the sample size is 27.

**Figure B7: International prices and World Commodity Price Shocks: EME sample IRFs**



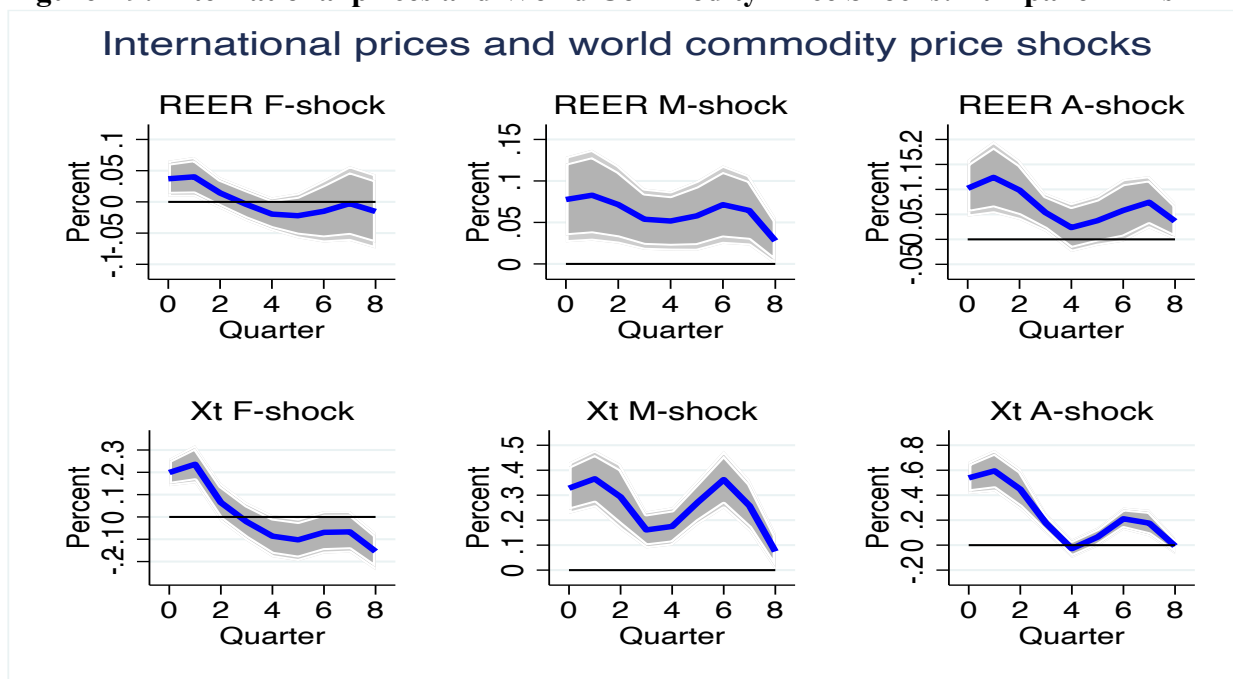
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the natural logs of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The commodity price shock variable was obtained from equation (2.1.6). Data is quarterly from 1985q1 -2015q4 and the sample size is 11.

**Figure B8: International prices and World Commodity Price Shocks: AE sample IRFs**



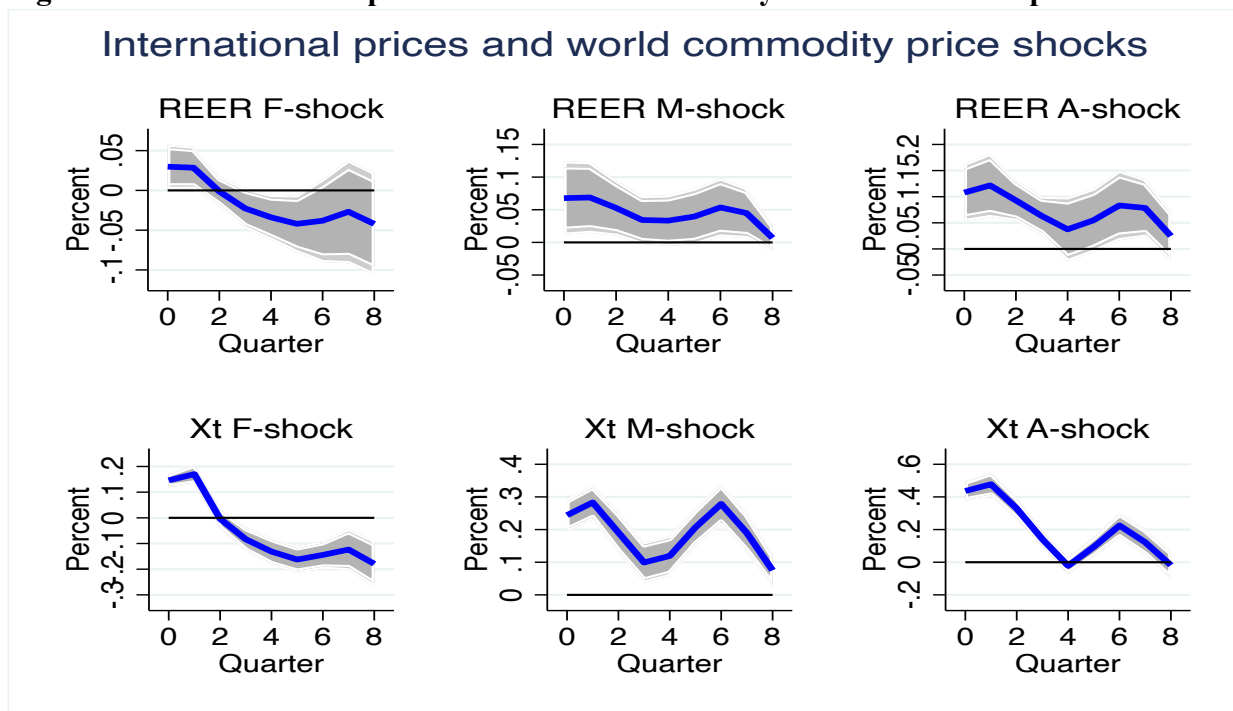
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the natural logs of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The commodity price shock variable was obtained from equation (2.1.6). Data is quarterly from 1985q1 -2015q4 and the sample size is 16.

**Figure B9: International prices and World Commodity Price Shocks: Full panel IRFs**



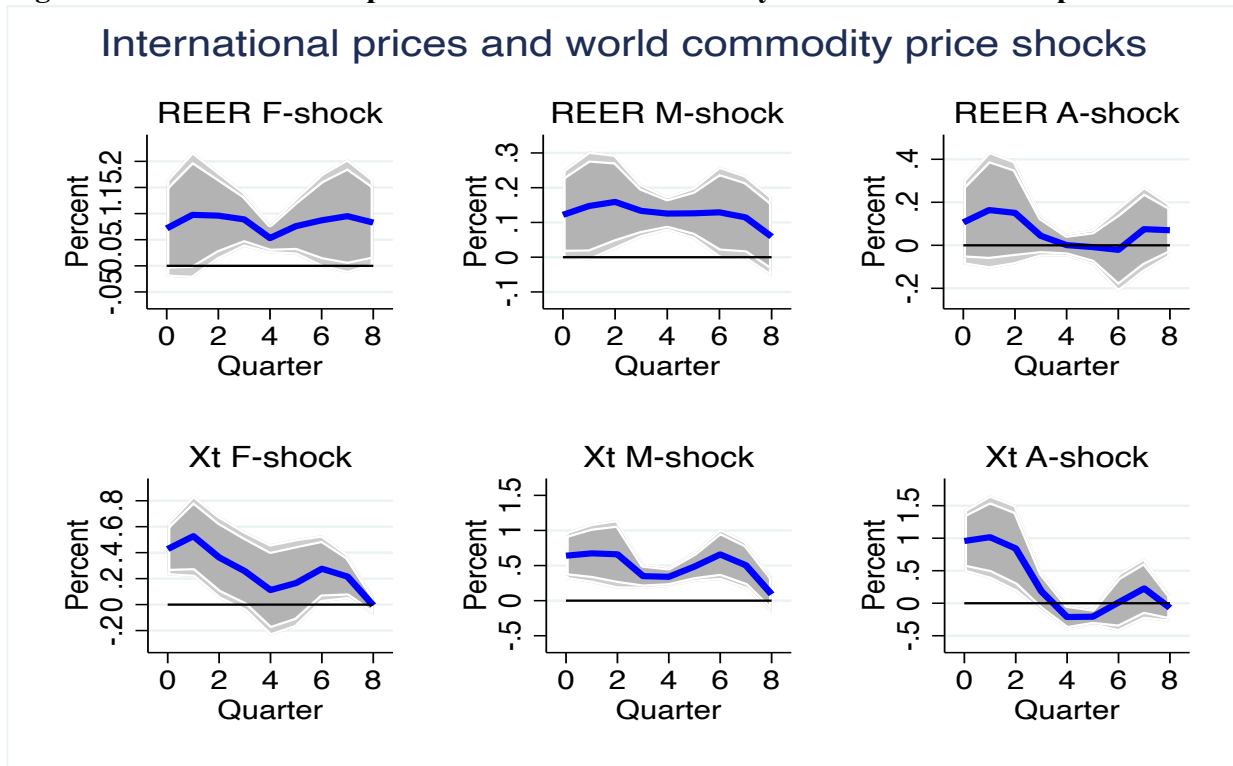
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the Hamilton Filter. Data is quarterly from 1985q1 -2015q4 and the sample size is 27.

**Figure B10: International prices and World Commodity Price Shocks: AE panel IRFs**



Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the Hamilton Filter. Data is quarterly from 1985q1 -2015q4 and the sample size is 16.

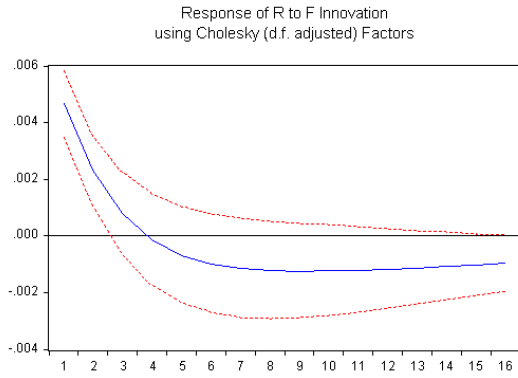
**Figure B11: International prices and World Commodity Price Shocks: EME panel IRFs**



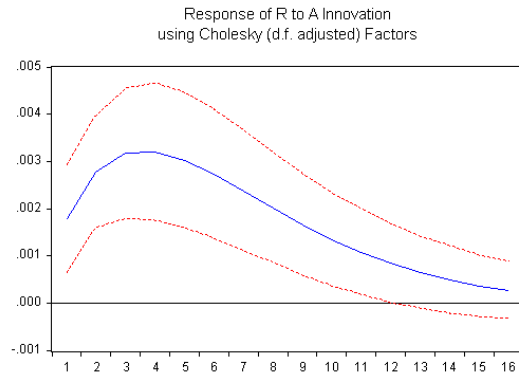
Notes: The IRF's are based on the Local Projections approach of Jordà., (2005) estimated with clustered standard errors. "A", "F" and "M" are the cyclical components of the Agricultural, Fuel and Metals and Minerals commodity prices respectively. The Cyclical components of the variables were obtained from the natural logarithm of variables filtered by the Hamilton Filter. Data is quarterly from 1985q1 -2015q4 and the sample size is 11.

## Figure B12: Basic Panel VAR Impulse Response Functions – Full Sample

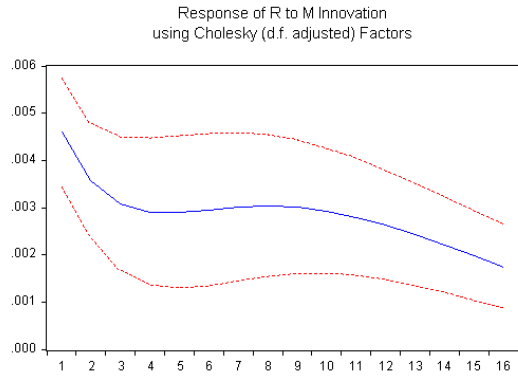
### Response of REER to Fuel Price Index



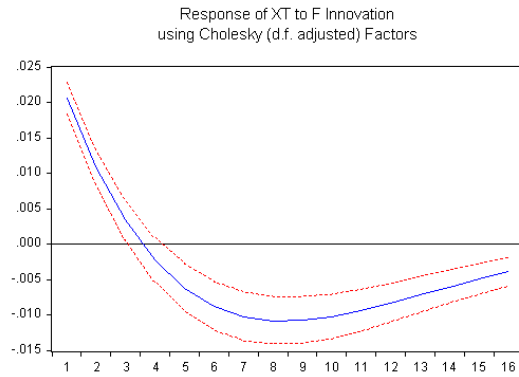
### Response of REER to Agric Price Index



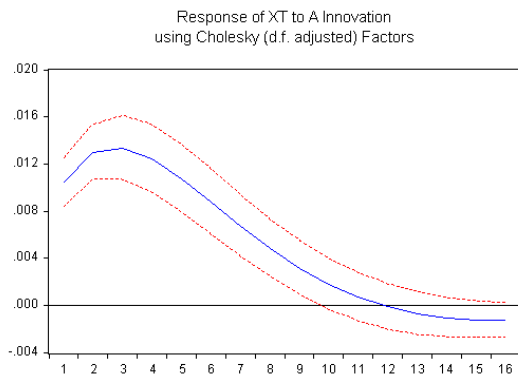
### Response of REER to Metal Price Index



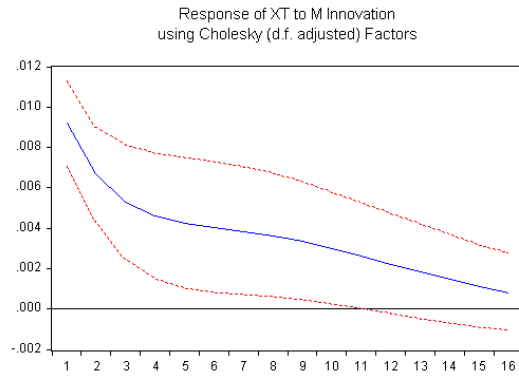
### Response of Xt to Fuel Price Index



### Response of Xt to Agric Price Index

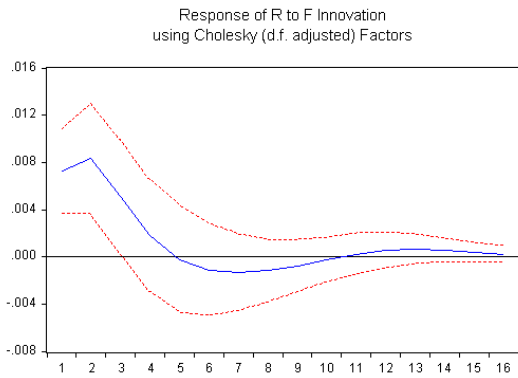


### Response of Xt to Metal Price Index

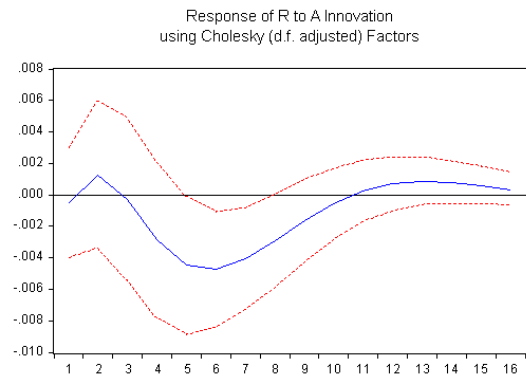


**Figure B13: Basic Panel VAR Impulse Response Functions – EME Sample**

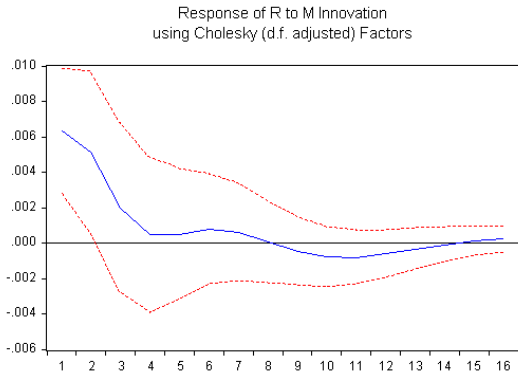
**Response of REER to Fuel Price Index**



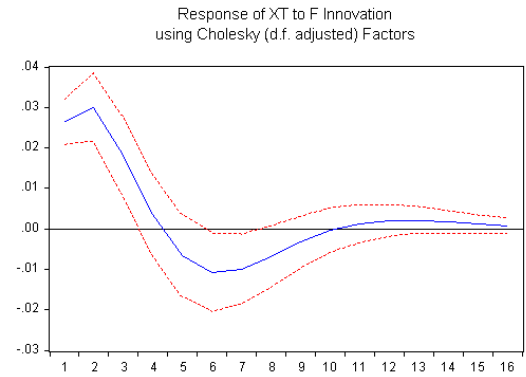
**Response of REER to Agric Price Index**



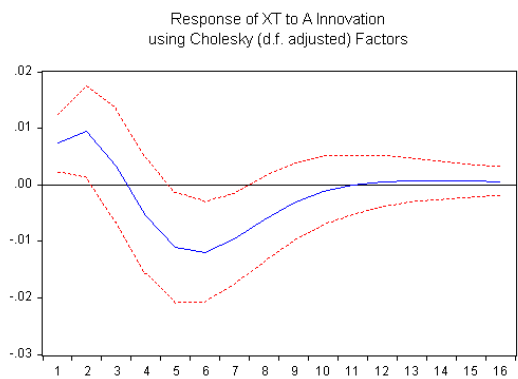
**Response of REER to Metal Price Index**



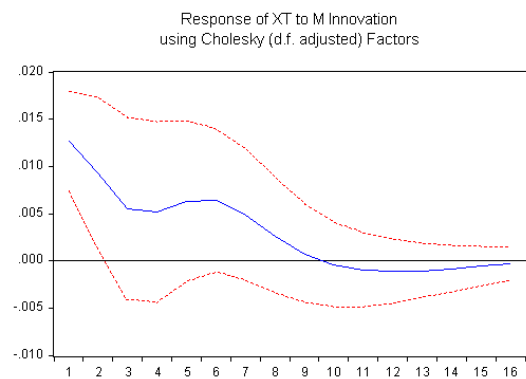
**Response of Xt to Fuel Price Index**



**Response of Xt to Agric Price Index**

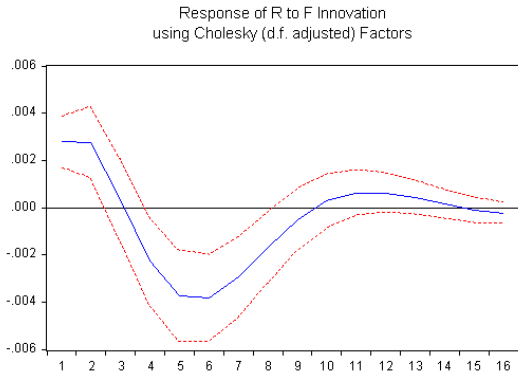


**Response of Xt to Metal Price Index**

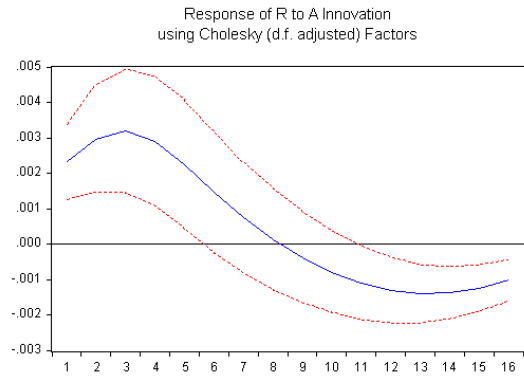


**Figure B14: Basic Panel VAR Impulse Response Functions – AE Sample**

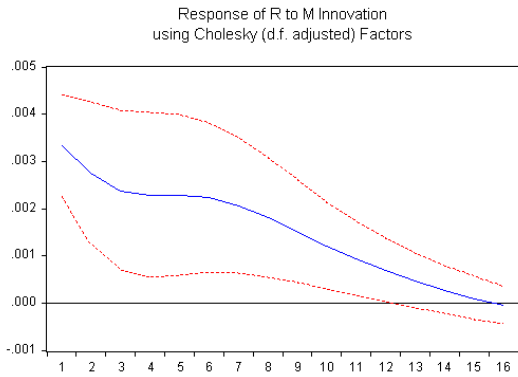
**Response of REER to Fuel Price Index**



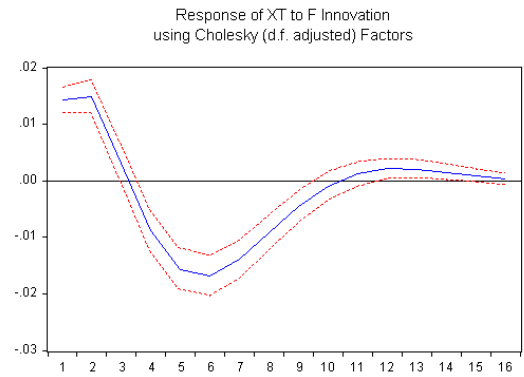
**Response of REER to Agric Price Index**



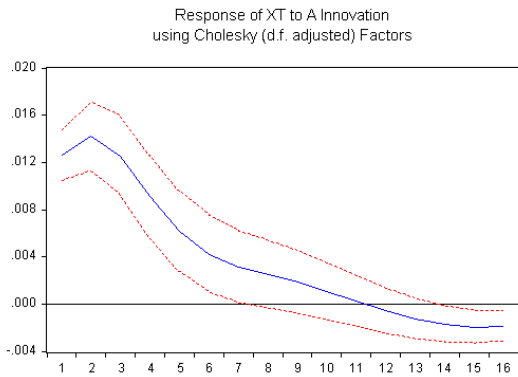
**Response of REER to Metal Price Index**



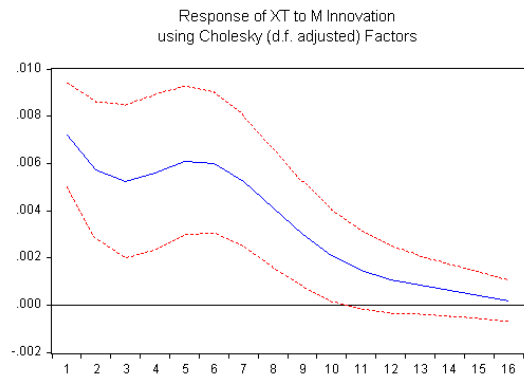
**Response of Xt to Fuel Price Index**



**Response of Xt to Agric Price Index**



**Response of Xt to Metal Price Index**



### 3. Commodity Terms of Trade Shocks and Real Exchange rate Dynamics

#### 3.1 Introduction

The dynamics of foreign exchange rates is a central part of the global economy. A consistent feature of the economy of many countries is that exchange rates are highly volatile especially since the demise of the Breton Woods system of flexible exchange rates in the 1970's. This volatility is often more severe for emerging market economies (EME's) and developing economies hence affecting policy decisions and exposing the already fragile economic environment of EME's to further uncertainty (see Roch 2019; Yopez 2020). Despite this widely known fact, a puzzling feature of the debate on the variability of exchange rates is the disconnect between the high and persistent exchange rate volatility and the variations in macroeconomic variables. Itskhoki and Mukhin (2021); Engel and Zhu (2019) summarized the literature explaining this observed disconnect.

Fundamental among the theories used to explain exchange rate variations is the understanding of the behaviour, source and consequences of these variations. For real exchange rate variations, the cross-country variations in relative prices of goods classified as tradable vs non-tradable goods<sup>26</sup> have been a significant area of focus (Evans, 2011). The thrust of these theories is that arbitrage ensures the price of traded goods obey the law of one price. Hence the variations in the price of non-tradable domestic goods determines cross-country real exchange rate variations. Empirical documentation of the importance of the tradable and non-tradable goods are however ambiguous. Engle (1999) for example showed that, variations in the relative price of tradable goods account

---

<sup>26</sup> Traded goods are categorized as goods that can be traded internationally such as crude oil, gas, gold, timber etc. Non-tradable goods are goods produced solely for domestic consumption and not be traded internationally such as electricity, water supply, real estate (see Betts and Kehoe, 2006; Evans 2011)

for nearly all of the variations in the real exchange rate of high-income economies (AE's). Yopez and Dzikpe (2022) further corroborated this finding as true for not just AE's but also for EME's. Betts and Kehoe (2017) however contend that the relative price of non-tradable goods is the dominant factor in explaining real exchange rate variations especially for bilateral exchange rates of large trading pairs and for bilateral pairs other than the US dollar. Burstein, Eichenbaum and Rebelo (2005) also adds that the relative price of non-tradable goods is the major cause of the large exchange rate depreciations that follow currency devaluations. In a follow up paper, Burstein et al. (2006) estimate the contribution of non-tradable goods to real exchange rate variations at roughly 50%.

How do we reconcile these mixed findings? Betts and Kehoe (2006) and Burstein et al. (2006) individually suggest that the relative importance of tradable and non-tradable goods depends largely on the measurement of tradable and non-tradable goods. Specifically, Betts and Kehoe (2006) argued that the choice of price series used to measure the relative price of tradable and non-tradable goods accounts for the mixed findings in the literature. Price series that include a significant amount of non-tradable goods such as price series based on consumption values (producer price index (PPI), consumer price index (CPI)) will overstate the importance of tradable goods prices in real exchange rate variations. On the other hand, price series based on production site values such as gross output deflators with little or no non-tradable goods component produces estimates where non-tradable goods explain a dominant portion of real exchange rate variations. Burstein et al. (2006) observe similar effects and document that price series such as the CPI is effectively a composite price for tradable and non-tradable goods whiles the PPI excludes import prices hence accounting for the large share of the variance of real exchange rates explained by tradable goods prices. If the proposition of Betts and Kehoe (2006) and Burstein et al. (2006) about

the choice of price series as a critical determinant of the observed relative importance of tradable and non-tradable goods holds, then it's important to determine the role of pure traded goods price in real exchange rate variations. This essay answered this question by examining the contribution of commodity terms of trade prices<sup>27</sup>, a purely traded goods price, in real exchange rate variations.

There are several reasons why commodity terms of trade prices are a better measure of tradable goods price than PPI and CPI based measures. First, unlike the PPI, a relative price of tradable goods constructed from commodity terms of trade price indices are unaffected by the inclusion of components of non-tradable goods. Second, for a small open economy, commodity prices are exogenous and devoid of measurement as nominal prices are the historical prices of each commodity in the global commodity trade market. Finally, a historical analysis of the dynamics of real exchange rates shows a more symmetrical relationship with the dynamics of commodity prices than the PPI. Figure 3.1 plots the cyclical component of the real effective exchange rates, commodity prices and the PPI for Australia, Canada, Brazil, and Mexico while table 3.1 shows the volatility of the PPI, REER and commodity price index as implied by different statistical measures. A closer look at the graphs and the table reveals interesting features of commodity prices and the PPI that may be fundamental to understanding the relevance of each measure to real exchange rate variations. First, figure 3.1 shows that the relationship between commodity price index and the REER is more symmetric and more volatile than the relationship between PPI and REER for Australia and Canada. The reverse is observed for Brazil and Mexico. This is however expected given domestic producer prices are often more volatile in EME's than in AE's. Table 3.1 which

---

<sup>27</sup> Country specific commodity price indices calculated from a broad range of individual commodity prices are often broadly called commodity terms of trade prices in the literature. (see Spatafora and Tytell, 2009; Aizenman et al. 2012). Hence the use of commodity terms of trade prices in this paper refers to country specific (i) Net export commodity price indices and (ii) Export commodity price indices.

provides measures of the standard deviation, coefficient of variation and the relative standard deviation further document this relationship. Estimates of the standard deviation and the coefficient of variation for Australia and Canada, are larger for commodity prices than for PPI. The relative standard deviation, which measures the variations in the commodity prices and the PPI in terms of variations in the REER shows that commodity prices are about twice as volatile as the REER for Australia and Canada and about twice as volatile as the REER for Brazil and Mexico.

**Table 3.1: Summary Statistics**

Statistics	$x$							
	Australia		Canada		Brazil		Mexico	
	Pcom	PPI	Pcom	PPI	Pcom	PPI	Pcom	PPI
Standard deviation $\sigma(x)$	25.33	20.47	22.92	15.72	23.26	47.82	31.57	39.99
Correlation with reer $\rho(\text{reer}, x)$	0.87	0.69	0.32	-0.22	0.26	-0.26	-0.12	-0.35
Coefficient of variation (cv)	0.40	0.25	0.32	0.18	0.34	0.54	0.51	0.54
Relative. std dev. $\sigma(x)/\sigma(\text{reer})$	2.31	1.87	2.26	1.55	1.44	2.95	2.41	3.05

Notes: Pcom denotes the real export commodity price index while the PPI denotes the real producer price index. Estimates are for the levels of each variable. Data used is quarterly for the period 1985q1 -2019q4. Results is similar to results obtained for real net commodity export price index and for cyclical components of the variables.

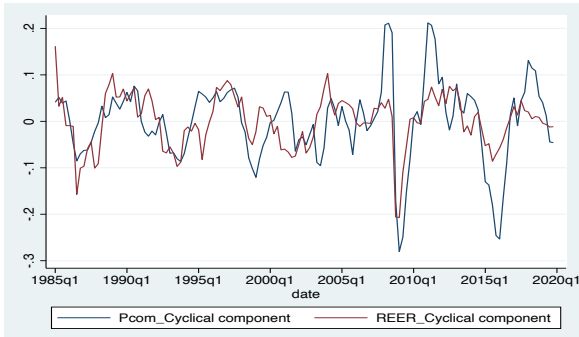
Despite these advantages, it must be noted that commodity prices are not a full measure of traded goods prices especially for countries with large manufacturing sectors. However, the study argue that commodity prices do remain an important indicator of traded goods price in many countries<sup>28</sup> due to the increased dependence on commodity market and the fact that the net commodity price indices used to construct the traded goods price in this study is a weighted index of export and import prices making the price series adopted equally important for net importers. On this backdrop, the first research question the study answers is to examine the real exchange rate-commodity price hypothesis by quantifying the proportion of the variance of real exchange rates explained by purely traded goods prices as the commodity terms of trade price. To further document the dynamics of the effects, the study also empirically examines the theoretical

---

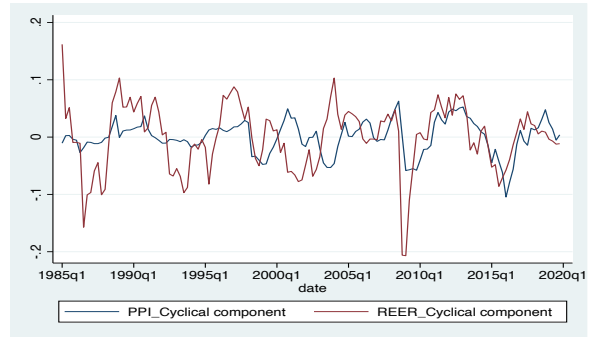
<sup>28</sup> This is particularly true for commodity exporting countries but also true for net commodity exporters and importers.

**Figure 3.1: Historical Real Exchange Rates, Commodity Prices (Pcom) and Producer Price Index (PPI)**

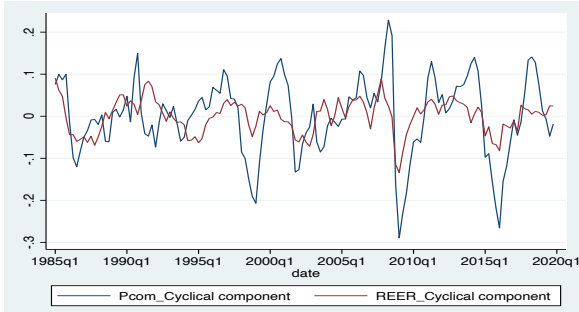
**A) REER and Pcom -Australia**



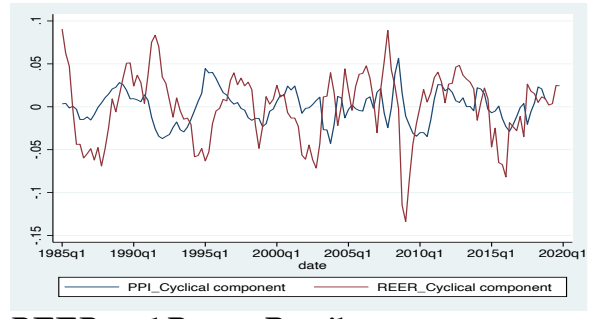
**REER and PPI -Australia**



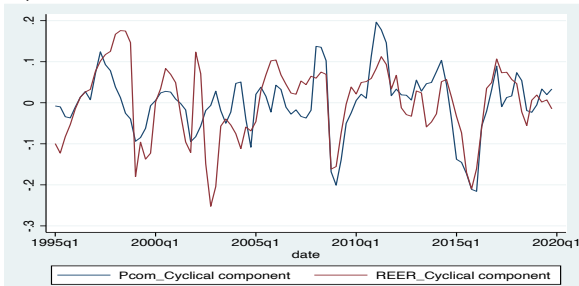
**B) REER and Pcom -Canada**



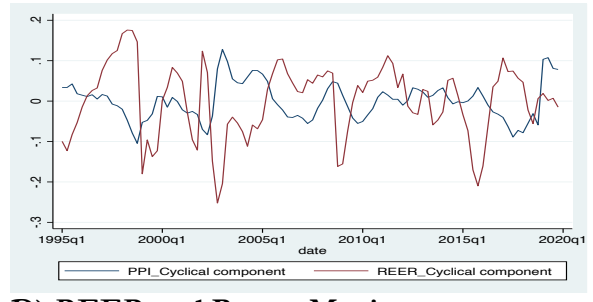
**REER and PPI -Canada**



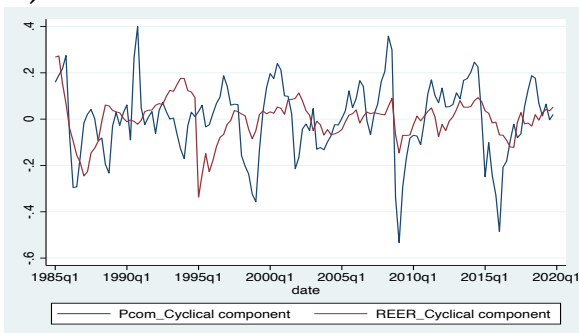
**C) REER and Pcom -Brazil**



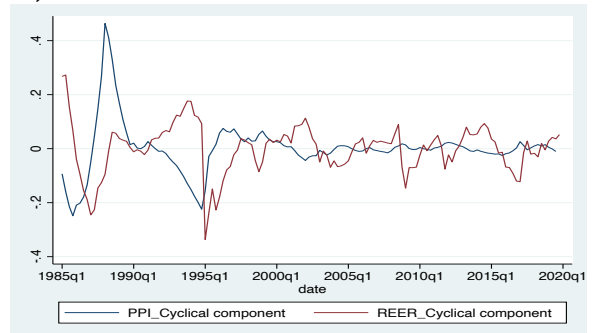
**REER and Pcom -Brazil**



**D) REER and Pcom -Mexico**



**D) REER and Pcom -Mexico**



proposition of Fernández, González, and Rodríguez, (2018) that common factors (global factors) in commodity prices drives the dynamics of commodity price shocks. This decomposition allows

us to understand the role of global commodity price variations and country specific price variations on real exchange rate variations.

The analysis proceeds in two steps. First, I follow the decomposition procedure in Engel (1999) and Yepez and Dzikpe (2022) to decompose the real exchange rate into a tradable and a non-tradable component for a sample of 16 AE's and 12 EME's in order to determine the relative importance of each component to real exchange rate variations. Second, I empirically re-examined the contribution of commodity price shocks to real exchange rate variations in EME's and AE's with a focus on decomposing the commodity price shocks into a country specific idiosyncratic shock and a common component using the heterogeneous Panel Structural VAR (PSVAR) approach of Pedroni (2013) and the Local Projections (LP) approach of Jordà (2005). The PSVAR<sup>29</sup> model was estimated separately for a sample of six (6) EME's and six (6) AE's while the LP was estimated for a larger sample of 28 countries<sup>30</sup>.

The findings of our study provide three important contributions. First, in an answer to the research question of the contribution of tradable goods estimated from a price series with no non-traded component, the study finds that the relative price of tradable goods estimated from commodity terms of trade prices remains the dominant component of real exchange rate variations in EMEs and AE's contrary to the observation in Betts and Kehoe (2017) and Burstein et al. (2006). The second contribution of the paper shows that the variations in tradable goods are mostly driven by world commodity price variations. Finally, in an answer to the second research question, the study

---

<sup>29</sup> The PSVAR was preferred over the SVAR due to its ability to account for the heterogeneous dynamics of panel members and decompose shocks into a common and idiosyncratic component. Section 3.3.3.2 below explains the different components.

<sup>30</sup> The LP approach allows for the inclusion of countries with missing data as well as for unbalanced panels (time varying dates). This is not possible using the PSVAR approach.

finds via a decomposition procedure that common factors in the commodity price variations dominates the response of the real exchange rates of sample countries.

The rest of the study is organized as follows. Section 3.2 presents a review of the recent literature. Section 3.3 describes the data and presents the exchange rate accounting procedure and the PSVAR and LP estimation methodology. Section 3.4 reports and discusses the main empirical results. Section 3.5 concludes.

### **3.2 Literature Review**

The volatility of exchange rates has several implications on an economy. This makes understanding the determinants and effects of real exchange rate variations crucial to policy makers and macroeconomists. There is a vast theoretical and empirical literature that examined the source and effect of exchange rate variations. Historically, traditional open economy macro models that explained real exchange rate variations have classified goods into tradable and non-tradable categories. These theories assume that purchasing power parity holds for traded goods hence real exchange rate movements can be explained by the cross-country variations in the relative price of non-traded goods (see Betts and Kehoe, 2006; Balassa, 1964; Evans, 2011).

Empirical estimates of the relative importance of traded and non-traded goods to real exchange rate variations are however mixed. While studies such as Rogers and Jenkins (1995); Engle (1999); Obstfeld (2001) and most recently Yopez and Dzikpe (2022) documented a greater importance of the relative price of tradable goods to variation in the real exchange rate, Betts and Kehoe (2017); Burstein et al. (2005; 2006) documented a more important role for the relative price of non-traded goods.

Specifically, Engle (1999) decomposed the real bilateral exchange rate of the US against a sample of high-income countries and found that the relative price of tradable goods accounts for more than 90% of the variations in the real bilateral exchange rate of the US. These results are based on different measures for the relative price of tradable and non-tradable goods including the PPI and CPI based estimators, consumer price estimators and output prices. Milesi-Ferretti and Micossi (1994) documented a similar sized role for the relative price of traded goods in the real exchange rate variations of Belgium, Denmark, France, Italy, UK, Germany, Spain, and the Netherlands while Rogers and Jenkins (1995) also observed similar stronger importance of tradable goods prices to real exchange rate variations for a sample of 11 OECD countries using similar measures as in Engle (1999). Yepez and Dzikpe (2022) most recently extended the approach of Engle (1999) for a sample of 12 emerging market economies (EME's) and 16 high income countries (AE's) using a measure of tradable and non-tradable goods constructed from a country specific producer price index and consumer price index. They observe similarly large importance of the relative price of tradable goods in explaining the variations of the real exchange rates for both EME's and AE's.

Betts and Kehoe (2017) on the other hand studied the bilateral real exchange rates of 1225 country pairs and contends that the relative price of non-tradable goods explains a larger portion of the variation in the real exchange rates especially when the real exchange rate measure is the bilateral exchange rate of large trading pairs and between bilateral exchange rate pairs other than the US dollar. This result is similar to results obtained in Betts and Kehoe (2006) where again the relative price of non-tradable goods was found to explain a larger share of the variations in the bilateral real US-Canada, US-Germany, US-Japan, US-Korea, and US-Mexico exchange rates using a tradable goods price measure constructed from the PPI and CPI as well as a gross sectoral output

deflator. Further, Betts and Kehoe (2006) observe that the relative importance of tradable goods seems larger for measures with little or no non-traded goods price elements (Gross output deflators) than for measures with significantly larger non-traded elements (CPI-PPI based measures). Finally, Burstein et al. (2005) find the relative price of non-tradable goods to be the major determinant of exchange rate depreciations following large currency devaluations in Argentina, Brazil, Korea, Mexico and Thailand. Burstein et al. (2006) estimate the contribution of non-tradable goods to real exchange rate variations at about 50% for a sample of 11 OECD (Organization for Economic Cooperation and Development) countries using prices of goods at the dock as a measure of traded goods price.

The above mixed findings on the role of tradable and non-tradable goods to real exchange rate variations leads to a strand of literature that examines the contribution of and the transmission of commodity terms of trade shocks/commodity price shocks to real exchange rate variations. Carrière-Swallow, Magud, and Yépez (2021) for example use a panel vector autoregressive procedure to examine the response of domestic variables such as the real exchange rate, output and domestic demand to commodity terms of trade shocks under a fixed and flexible exchange rate regime and find that commodity terms of trade shocks have a sizeable impact on domestic variables and that flexible exchange rates play a shock absorbing role by reducing the response of output to terms of trade shocks. Aizenman, Edwards and Riera-Crichton (2012) observe similar sizeable effect of commodity terms of trade shocks on the real exchange rates for a sample of Latin American countries but note that the active management of international reserves and exchange rates lowers the short run and long run impact of terms of trade shocks. Finally, Roch (2019) analyzed the adjustment of output, consumption, investment, trade balance and the real exchange rate to commodity price shocks in a sample of 22 commodity exporting countries and found that,

commodity price shocks on average explains about 34%, 36%, and 37% of the variation in output, consumption, and investment in EME's against 16%, 19%, and 27% in AE's.

The approach of this paper is similar to Engle (1999), and Yopez and Dzikpe (2022) but differs from the above papers in three ways. First, the paper measures the relative price of tradable goods using a purely traded goods price -commodity terms of trade price and assess the contribution of the purely tradable goods measure to real exchange rate variations. This contrasts with the CPI and PPI based measures as used in the above papers. Second, the paper presents results across monthly and quarterly series for commodity price index-based measures of tradable and non-tradable goods and for EME's and AE's. Third, the paper decomposes commodity price shocks into a country specific idiosyncratic component and a common component and assess the relative response of sample countries to each component of commodity price shock.

The paper contributes to the above literature in three (3) ways. First, the paper shows that commodity price based relative price of tradable goods on average explains about 60%-72% percent of the variations in the real exchange rates in EME's and AE's. This result confirms the relative price of tradable goods as the dominant determinant of real exchange rate variations. The result also documents commodity price variations as a driving force behind the observed large role of traded goods prices in real exchange rate variations. Second, the PSVAR results show that common factors in commodity price variations dominates the effects of commodity price shocks on the real exchange rate in the sample countries. This finding thus empirically documents the theoretical proposition in Fernández, González, and Rodríguez (2018) that common factors in commodity price variations are a driving force in the effect of commodity price shocks on business cycle of EME's and AE's. Finally, the important role of the commodity price based relative price of tradable goods in the accounting exercise, highlights the importance of the choice of price series

in the measurement of traded and non-traded goods, but that tradable goods price remains a dominant force in real exchange rate fluctuations.

### **3.3 Data and Methodology**

This section presents the data and estimation procedure adopted for the study. Section 3.3.1 to 3.3.2 gives a summary of the data and sources for the empirical approach while Section 3.3.3 discusses the exchange rate accounting methodology (3.3.3.1), the empirical Panel Structural VAR approach (3.3.3.2) and Local Projections (LP) approach (3.3.3.3). The exchange rate accounting methodology uses real commodity prices instead of the CPI and PPI based approach in Engel (1999) and Yopez and Dzikpe (2022) to disaggregate exchange rates into tradable and non-tradable components of prices.

#### **3.3.1 Data**

The world commodity price data used is from the IMF International Financial Statistics (IFS) commodity terms of trade dataset compiled by Gruss and Kebhaj (2019). The dataset contains country specific commodity price indices for monthly, quarterly, and annual frequencies and spans the period 1980-present. The index is calculated as the change in the international price of up to 45 individual commodities weighted by trade level data<sup>31</sup>. For this study, I use data for the period 1980-2019 on monthly and quarterly frequency for the exchange rate accounting exercise. For the Panel Structural VAR exercise, I used the quarterly commodity price data for the period 1985Q1-2019Q4 due to the short span of some of the control macroeconomic variables included in the PSVAR model. Real effective exchange rate, the nominal exchange rate data and the control

---

<sup>31</sup> To get country specific index, each of the change in the 45 individual commodity prices are weighted by the ratio of commodity exports to total exports, exports to GDP and net exports to GDP separately. I focus on the indices weighted by the ratio of commodity exports to total exports.

macroeconomic variables in the empirical SVAR model were drawn from the IMF International Financial Statistics (IFS) dataset and the Federal Reserve Bank of St. Louis-FRED (for some countries). The real bilateral national currency-USD exchange rate data are from the Economic Research Service of the US Department of Agriculture. I classify countries into middle-income (EMEs), and high-income countries based on the IMF's income classification. The first part of the analysis (exchange rate accounting) covers a sample of 12 EMEs and 16 AE's<sup>32</sup> at quarterly and monthly frequency. In the second part, namely the VAR analyses, I use a slightly smaller sample of 12 countries (6 EMEs and 6 high income countries as listed in Table C1.2 of the Appendix), with results presented at quarterly frequency. The reduced sample size and the use of quarterly data in the VAR exercise is based on data availability for the macroeconomic variables used as control variables in the model. Countries with missing data for any of the macroeconomic variables as well as countries with less than 20 years of data (wide time varying dates) for each macroeconomic variable were dropped<sup>33</sup>. The choice of the sample period also allows us to focus exclusively on the post Bretton-Woods era of floating exchange rates (Blecker, 2005).

### **3.3.2 Real Exchange Rate and Commodity Price Measures**

To empirically gauge the nature of the link between relative price of tradable goods and commodity prices, the study uses three different proxies for the real exchange rate. I use a measure of bilateral tradable goods ( $X_t$ ) measure as discussed below, the real National currency-US dollar bilateral exchange rate (RER) and the real effective exchange rate (REER) as measures of the real exchange rates.

---

<sup>32</sup> Sample countries are included in the appendix.

<sup>33</sup> This is to ensure we have enough sample size to gauge the variation of the real exchange rate over time. The choice of 20 years of data is similar to Kinda (2016).

### (c) Bilateral Real Exchange Rates (RER)

For the exchange rate accounting exercise, I compute a country specific commodity price index-based bilateral real exchange rates (RER) as follows. Following Engle (1999), I employ the end-of-period-average nominal exchange rates ( $S_t$ ) data from IFS measured as the national currency price of the US dollar and a commodity price index data compiled by Gruss and Kebhaj (2019) and available in the IMF's Commodity Terms of trade dataset. The commodity price index based real exchange rate is estimated as:  $RER_t = S_t * P_t/P_{US,t}$  where  $P_t/P_{US,t}$ <sup>34</sup> is the US dollar denominated relative price between the two countries.

Following the standard practice in the literature, I apply an accounting exercise to decompose the RER into its tradable and non-tradable components of relative prices. I construct the relative price of tradable goods measure ( $X_t$ ) as

$$x_t = s_t + \ln(Pcom_t) \quad (3.1.1)$$

Where  $x_t$  is the log of the relative price of tradable goods between a domestic economy and the US,  $s_t$  is the log of the nominal exchange rate and  $\ln(Pcom_t)$  is the natural log of the country specific commodity price index.

For the PSVAR estimation, the real bilateral exchange rate data used are from the Economic Research Service of the US Department of Agriculture. The data are estimated using country specific nominal exchange rate and CPI data as  $RER_t = (S_t * P_{US,t})/(\$ * P_t)$  where  $S_t$  is measured as national currency price of the US dollar and  $P_t$  and  $P_{US,t}$  are the CPI of the domestic and foreign/US respectively. Measured this way, a real domestic exchange rate appreciation

---

<sup>34</sup>  $P_t/P_{US,t}$  in this case will be replaced by commodity price index given the international commodity price index is an index of the relative price for a unit of traded commodities in both the domestic and foreign country.

(depreciation) occurs when the rate falls (rises). To ensure symmetry in the interpretation of the RER and REER, I normalized the RER by taking the reciprocal of each country series which gives a real appreciation as an increase in the rate.

#### **(d) Real Effective Exchange Rates (*REER*)**

The real effective exchange rate data was obtained from the IFS 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 Thailand and Turkey is obtained from the Federal Reserve Bank of St. Louis and is based on the manufacturing consumer price index.

#### **(e) Measuring commodity prices**

The real commodity price index was obtained from the IMF commodity terms of trade database. The index was constructed as the change in the international price of up to 45 individual commodity prices weighted using country level trade data (see Gruss and Kebhaj, 2019). The individual commodity price series were sourced from the IMF primary commodity price dataset and were categorized into Energy (coal, crude oil, natural gas); Metals (aluminum, copper, gold, iron ore, lead, nickel, tin, uranium and zinc); Food and Beverages (bananas, barley, beef, cocoa, coffee, corn, fish, fish meal, groundnut, lamb, olive oil, oranges, palm oil, poultry, rapeseed oil, rice, shrimp, soybean meal, soybean oil, soybeans, sugar, sunflower seed oil, swine meat, tea and wheat) and Agricultural raw materials (cotton, hard logs, hard sawnwood, hides, natural rubber, soft logs, soft sawnwood, and wool). For each commodity, real prices are computed as the US dollar commodity price divided by the IMF's unit value index for manufactured exports. Using the manufacturing trade price index as a deflator is standard in the literature and preferred to using the CPI as the latter includes non-tradable goods which may distort price trends (see Deaton and

Miller, 1996; Gruss and Kebhaj, 2019). The country specific commodity price indices are then calculated as

$$\Delta \log (PI)_{i,t} = \sum_{j=1}^J \Delta P_{j,t} \Omega_{i,j,\tau} \quad (3.1.2)$$

Where  $PI_{i,t}$  is the commodity price index of country  $i$  in year  $t$ ,  $P_{j,t}$  is the logarithm of the real-world price of commodity  $j$  at time  $t$ .  $\Delta$  denotes first differences and  $\Omega_{i,j,\tau}$  is the country specific weighting of commodity  $j$  calculated as

$$\Omega_{i,j,\tau} = \frac{x_{i,t,\tau}}{\sum_{j=1}^J x_{i,j,\tau}} \quad (3.1.3)$$

$$\Omega_{i,j,\tau} = \frac{x_{i,t,\tau} - m_{i,t,\tau}}{\left(\sum_{j=1}^J x_{i,j,\tau} + \sum_{j=1}^J m_{i,j,\tau}\right)} \quad (3.1.4)$$

Gruss and Kebhaj (2019) presents indices for both exports, imports and net commodities using both a time varying weight and a fixed weight and thus allowing researchers to choose the index that best matches the research interest. For this study, which seeks to quantitatively gauge the amount of exchange rate variations attributed to a commodity price based relative price of tradable goods as well as gauge the nature of the effect of commodity price shocks on the real exchange rate across countries, I use mainly the country specific export commodity price indices and the net export commodity price indices weighted by the fixed time invariant individual commodity exports to total exports (3.1.3) and the ratio of net exports to total trade (3.1.4) respectively. The main empirical results are based on the net commodity export prices weighted by the fixed time invariant weight, but I also present the results for export commodity price indices and for both net commodity and export commodity prices weighted by a time-varying weight in the appendix for comparison. The time-varying weights are calculated as the average net commodity export (net export) flows over the previous three calendar years preceding period  $t$ . The advantage of using the fixed time invariant weight is that it is exogenous to temporal domestic shocks and or volume

fluctuations. It's however unable to capture changing commodity trade pattern especially in countries with significant changes in the types of commodities traded. Presenting results for both the fixed and time invariant weights addresses this issue. Also, using 45 individual commodities ensures that the effects of changes in the trade pattern are minimised as most commodities are already covered in the index. Calculating an index for 45 commodities even though have the advantage of covering a larger basket of goods produced in each country, raises issues of including commodities not traded by a country and hence overestimating the impact of commodity prices. The study holds the view that this issue may be prevalent in dominant commodity exporting countries especially for countries dependent on trade in a single or few commodities. The inclusion of results for net commodity price indices helps present a basis for comparison of results hence ameliorates issues related to the large basket of commodities.

### **3.3.3 Methodology**

This section describes the two empirical methodologies the study employs to quantify the contribution of commodity price based relative tradable and non-tradable goods prices to real exchange rate changes in EMEs and AE's and to estimate the impact of world commodity price shocks on real exchange rate fluctuations. First, I employ a real exchange rate accounting exercise for a sample of EMEs and AE's drawing on Engel (1999) to gauge the relative contribution of tradable goods prices to real exchange rate fluctuations. Specifically, I decompose changes in real exchange rates into tradable goods ( $x_t$ ) and non-tradable goods ( $y_t$ ) prices using a Mean Squared Error (MSE) decomposition procedure. However unlike in Engle (1999) and Yopez and Dzikpe (2022), the current study employed country specific commodity price indices in place of the CPI and PPI based approaches as used in the studies referenced. Second, I use the Panel structural VAR (PSVAR) approach of Pedroni (2013) and the Local Projections (LP) technique of Jordà (2005) to

examine the role of a key component of tradable goods prices, namely commodity prices, on the dynamics of real exchange rates in a sample of AE's and EME's. I use two measures obtained from the PSVAR and LP models, namely i) variance decomposition from the PSVAR, and ii) impulse response function (IRF) analyses from the LP<sup>35</sup>, respectively to quantify the effect of commodity price shocks on real exchange rate fluctuations.

### 3.3.3.1 Mean Squared Error (MSE) Decomposition Analysis

Following Engel (1999), the log of real exchange rate ( $q_t$ ) is divided into tradable and non-tradable good prices as follows

$$q_t = x_t + y_t \tag{3.1.5}$$

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

In contrast to Engel (1999), the study uses a country specific real commodity price index and the bilateral nominal exchange rates between a domestic currency and the US dollar<sup>36</sup> to construct the tradable and non-tradable goods price. Engle (1999); Yopez and Dzikpe (2022) and similar papers uses the seasonally unadjusted data for overall producer price index (PPI), Consumer price index (CPI) and the bilateral exchange rate between a domestic currency and the US dollar to construct the tradable and non-tradable goods measure. The disadvantage of this approach as recognized by

---

<sup>35</sup> The PSVAR uses the advantage of cross-sectional variations in the data to provide reliable individual country responses to an innovation in commodity prices while LP's provide best estimates even when identification restrictions are not clear cut.

<sup>36</sup> Our choice of the US dollar as the main bilateral currency was influenced by Gopinath (2015) and Gopinath et al. (2020)

Engle (1999) however is that the PPI includes some outputs that are non-traded, are drawn from different sources hence measured differently and differs from one country to the other. Also using the PPI and CPI implies there is significant co-movement between  $x_t$  and  $y_t$  due to the correlations between the two variables. Using the real commodity price index ensures the study focuses exclusively on traded goods of each country. If the finding of a higher contribution of the relative price of tradable goods to real exchange rate variations holds, then the use of commodity price indices as a measure of tradable goods prices will allow us to quantify the contribution of purely traded goods real exchange rate variations. The tradable and the non-tradable goods are hence calculated as

$$x_t = s_t + \ln(Pcom_t) \quad (3.1.6)$$

$$y_t = \ln(RER_t) - x_t \quad (3.1.7)$$

Where  $s_t$  is the natural log of the nominal exchange rate measured as domestic currency per unit of US dollar at time  $t$  and  $\ln(Pcom)$  is the natural log of the real commodity price index at time  $t$ .  $y_t$  is the residual between the natural log of the real bilateral exchange rate and the relative price of tradable goods<sup>37</sup> at time  $t$ . Equally, I also present results for when the  $y_t$  is estimated as  $y_t = \ln(REER_t) - x_t$ .

Additionally, to gauge the effect of only commodity terms of trade prices on the real exchange rate, I also estimate the tradable goods price as

$$x_t = \ln(Pcom_t) \quad (3.1.8)$$

---

<sup>37</sup> The RER is the real exchange rate indicator hence the different between the RER and the  $x_t$  is the non-tradable goods measure.

The steps used in the Mean Squared Error (MSE) decomposition analysis and the estimation procedure are presented in Appendix B. Importantly, the amount of the MSE of the real exchange rate changes accounted for by the MSE of changes in the relative price of tradable goods over different horizons are calculated using equation 3.1.9 as

$$\frac{MSE(x_t - x_{t-n})}{MSE(x_t - x_{t-n}) + MSE(y_t - y_{t-n})} \quad (3.1.9)$$

### 3.3.3.2 Pedroni PSVAR Estimation Approach

A central challenge in estimating business cycle effects of external shocks including exogenous commodity price shocks is the issue of identification. Since the inspirational work of Sims (1980), SVAR's based on Cholesky decomposition, or other short run identification have been the main stay of the empirical macroeconomic literature. Despite their popularity and apparent advantage of allowing for the inclusion of structural shocks based on economic theory, SVAR's have faced increased criticism over the years (see Gottschalk, 2001). Specifically, issues of identification persists and SVARs are believed to provide unreliable estimates and impulse responses due to the short span of macro dataset for most countries and measurement error. Also, SVAR's suffer from the "curse dimensionality"<sup>38</sup> criticism when too many variables are included in a model. In the same vein, too few variables in the SVAR also pose's the problem of omitted variable bias hence creating a conundrum for most researchers.

For this study therefore, I used the heterogenous Panel Structural VAR (PSVAR) approach of Pedroni (2013) to quantify the effect of commodity price shocks on the real exchange rate

---

<sup>38</sup> The idea that traditional VAR systems suffer the risk of over parameterization in the presence of large number of variables in the model (see Bańbura, Giannone, and Reichlin, 2010; Gottschalk, 2001)

measures. PSVARs are able to effectively handle a large set of variables and hence parameters without loss of efficiency unlike the traditional VAR's. Further, the sample countries used in traditional VAR's are likely to differ significantly in the state of their economies and other country specific characteristics. Hence the response of each country to commodity price and other external shocks are likely to differ. The heterogenous PSVAR allows us to draw on the cross-sectional variations in the panel to increase the efficiency of our estimates while also allowing for complete heterogeneity across the sample countries. PSVAR further allows us to decompose the commodity price shocks into a country specific idiosyncratic shock and a common shock that is common to all countries. I draw on this advantage of the PSVAR to provide a country specific quantitative estimate of the shares of real exchange rate variations<sup>39</sup> accounted for by both common and idiosyncratic commodity price shocks.

Following the literature, I included the following control variables in the PSVAR model: a measure of international commodity prices ( $Pcom$ ); real exchange rate measures proxied by the real national currency-US dollar bilateral exchange rates ( $rer$ ) and the real effective exchange rate ( $reer$ ); a measure of world interest rate proxied by the real 3-month US Treasury bill rate ( $i$ ); the domestic policy rate ( $dpr$ ); the domestic CPI ( $cpi$ ); export to GDP ratio ( $expr$ ) and import to GDP ratio ( $impr$ ). All variables were obtained from the IMF's IFS except for the real national currency-US dollar bilateral exchange rates ( $rer$ ) which was obtained from the Economic Research Service of the US Department of Agriculture. Except for export to GDP ratio ( $expr$ ) and import to GDP ratio ( $impr$ ), I first take the generate the natural log of each variable and then apply the HP filter with a smoothing parameter of 1,600 to obtain the cyclical components. The export to GDP ratio

---

<sup>39</sup> I use the National currency-US dollar real bilateral exchange rate ( $rer$ ) and the real effective exchange rates ( $reer$ ) as measures of real exchange rate variations.

(*expr*) and import to GDP ratio (*impr*) were estimated as the country specific nominal exports and imports divided by country specific nominal GDP and then HP filtered to obtain the cyclical component. I used quarterly series and a country specific commodity price index in my estimation and focused on the response of the real exchange rate measures to real commodity price shocks.

The baseline reduce form VAR estimation model is given as

$$B_i z_{i,t} = A_i(L) z_{i,t-1} + \varepsilon_{i,t} \quad (3.2.0)$$

Where  $A_i(L)$  is a matrix polynomial in the lag operator of order  $q = 4$  and  $\varepsilon_{i,t}$  is the structural error.  $z_{i,t} = \{ pcom_{i,t}, i_{i,t}, dpr_{i,t}, cpi_{i,t}, expr_{i,t}, impr_{i,t}, gdp_{i,t}, rer_{i,t}, (reer_{i,t}) \}$  is a vector of country specific endogenous variables of dimension  $t = [1, \dots, T_i]$  for each  $i = [1, \dots, M]$ . The  $i$  and  $t$  subscripts denote the time and cross-sectional dimensions and imply an unbalanced panel.

As mentioned, the variance decompositions and the impulse responses from the PSVAR can be decomposed into an idiosyncratic and common component. Following Pedroni (2013), the idiosyncratic and common shocks are estimated through the following steps. First, the variables in the model are logged and demeaned to eliminate any time-invariant fixed effects and to guarantee stationarity<sup>40</sup>. Second, I compute the cross-sectional averages of the data  $\bar{z}_t = (\sum_{i=1}^M z_{i,t})/M$  and then estimate a set of  $M + 1$  reduced-form VARs – one for each country and another for the cross-sectional averages using the structural model in equation 3.2.0 as

---

<sup>40</sup> Stationarity test results are presented in Appendix C.

$$\begin{aligned}
z_{1,t} &= B_1^{-1}A_1(L)z_{1,t-1} + u_{1,t} \\
&\vdots \\
z_{N,t} &= B_N^{-1}A_N(L)z_{N,t-1} + u_{N,t} \\
\bar{z}_t &= \bar{B}^{-1}\bar{A}(L)\bar{z}_{t-1} + \bar{u}_{.,t}
\end{aligned} \tag{3.2.1}$$

The optimal lag order of  $q = 4$  is selected based on the AIC and BIC information criteria<sup>41</sup>. The country specific reduced form VAR residuals are then orthogonalized and the structural composite and common shocks ( $u_{i,t}$  and  $\bar{u}_{.,t}$ ) backed out by imposing a short run recursive identification restriction on the matrix  $B_i$ <sup>42</sup> ( $u_{i,t} = B_i^{-1}\varepsilon_{i,t}$  and  $\bar{u}_{.,t} = \bar{B}_i^{-1}\bar{\varepsilon}_{.,t}$ ). The common components in the structural shocks are backed out from the reduced form VAR for the cross-country averages. The recursive identification is motivated by the underlying assumption that commodity prices are exogenous and not affected contemporaneously by the other macro variables in the model. Finally, the orthogonalized structural composite shocks are decomposed into country specific idiosyncratic shocks and common shocks as

$$u_{i,t} = \lambda_i \bar{u}_t + \tilde{u}_{i,t}$$

Where  $u_{i,t}$  is the composite shock,  $\bar{u}_t$  is the common shock and  $\tilde{u}_{i,t}$  is the idiosyncratic shock.  $\lambda_i$  is a loading matrix that reflects the relative importance of common shocks to each country.

The estimation procedure involve estimating separate VARs for a sample of 6 EME's and 6 AE's<sup>43</sup> for the period 1985:Q1-2019:Q4. The VARs under each category were estimated separately for the real exchange rate measures ( $rer_t$  and  $reer_t$ ). To ensure the robustness of the estimate, I also

---

<sup>41</sup> AIC, BIC identify optimal lags of 2,3 and 4 across sample countries. However, the optimum lag of 4 was used for both EME and AE to ensure comparability of results.

<sup>42</sup> I impose a short run restriction because I'm more interested in the short run responses of the model variables to real commodity price shocks and also because long run restrictions might yield inaccurate IRF's (see Christiano et al. 2006)

<sup>43</sup> List of sample countries are included in Appendix C.

estimate the variance decompositions with different arrangement of the variable in the VAR. The paper's emphasis is on the structural forecast error variance decomposition in order to provide quantitative estimates of the impact of commodity price shocks on the real exchange rate measures. For a country to be included in the sample, the country must have at least 20 years of data<sup>44</sup>.

### 3.3.3.3 Local Projections (LP) Approach

To ensure the robustness of the IRF estimates, I use the model-free Local Projections (LP) technique by Jordà (2005) to gauge the nature of the effect of commodity price shocks for a pooled sample of countries. The choice of the LP methodology is motivated for several reasons. First, the LP methodology employs a non-parametric technique to estimate the IRF from a data sample and does not require specification and estimation of a dynamic system as commonly performed in a VAR and thus avoid errors associated with misspecification. Also, LP's are a useful alternative to estimating IRFs when identification restrictions are not clear-cut. Furthermore, when estimated with sufficiently large sample size and with unrestricted lag structure, both LP and VAR's generate similar impulse response functions (see Plagborg-Møller and Wolf, 2021; Herbst and Johansen, 2020). Thus, using the IRF's from the LP reduces errors and prevents amplifying any existing errors in the model and data series as the IRF's are functions of multi-step forecast into distant horizons.

The effect of a given commodity price shock ( $Pcom_t$ ), on the bilateral real exchange rates (real effective exchange rate)  $y_{i,t+h}$  in country  $i$  at time  $t$  is given as

$$y_{i,t+h} - y_{i,t-1} = \alpha^h + \beta^h Pcom_{i,t} + \delta^h \omega_{i,t-1} + \epsilon_{i,t+h}, \quad h = 0, 1, \dots, H \quad (3.2.2)$$

---

<sup>44</sup> I follow the procedure used in Kinda (2016)

Where  $\omega_{i,t-1}$  is a vector of control variables,  $\beta^h$  estimates the average treatment effect of a period  $t$  commodity price shock in period  $t + h$ , and  $y_{i,t+h}$  denotes the dependent variables considered- the real bilateral exchange rates ( $rer_t$ ) and the real effective exchange rate ( $reer_t$ ).  $Pcom_t$  is measured as the HP filtered cyclical component of the natural log of real commodity prices. As a robustness check,  $Pcom_t$  is also estimated as the residuals from a non-linear regression model as given in equation 3.2.3

$$\ln PI_{i,t} = \alpha_{i,0} + \alpha_{i,1}t + \delta_{i,t}t^2 + \sum_p^3 \theta_{i,p} \ln PI_{i,t-p} + \varepsilon_{i,t} \quad (3.2.3)$$

Where  $PI_{i,t}$  is the real commodity price index of country  $i$  in year  $t$  and  $t$  is time. The error term  $\varepsilon_{i,t}$ , is our estimated commodity price shock indicator estimated separately for each country.

### 3.4 Main Results

This section presents and discusses the main results of the study. Section 3.4.1 presents the results from the exchange rate accounting exercise while Section 3.4.2 presents the results from the PSVAR and LP empirical estimation techniques. Specifically, I present the forecast error variance decompositions of the real exchange rate measures ( $rer_t$  and  $reer_t$ ) from the PSVAR analysis in section 3.4.2.1 and the impulse responses of the real bilateral exchange rate ( $rer_t$ ) and the real effective exchange rates ( $reer_t$ ) to a one standard deviation shock in the real commodity price index from the LP technique in section 3.4.2.2. The impulse responses (IRF) were estimated by clustering the errors and using the Newey West robust standard errors separately to eliminate any autocorrelation or heteroskedasticity induced by any outliers.

#### 3.4.1 Real Exchange Rate Accounting- MSE Decompositions

In this section, the study documents some key stylized facts of the commodity price-real exchange rate versus the producer price-real exchange rate relationship and presents the results from the

MSE decomposition exercise for a sample of 28 countries for the period 1985Q1 -2019Q4<sup>45</sup>. The MSE decompositions presented are the contributions of the relative prices of tradable and non-tradable goods to real exchange rate variations following the approach of Engel (1999); Yopez and Dzikpe (2022). Unlike in Engle (1999) however, the MSE decompositions focused on using a composite commodity price measure as the appropriate tradable goods in calculating the relative price of tradable goods. Results are presented for each individual country across monthly<sup>46</sup> frequency. The quarterly results are presented in Appendix C.

#### **3.4.1.1 Exchange Rates, Commodity Price Index and Producer Price Index- Stylized Facts**

Table 3.2A & 3.2B and Figure 3.2A & 3.2B below document some key empirical features about the relationship between commodity prices, the producer price index and the real exchange rate. Table 3.2 panels A and B shows the pairwise correlations of the levels and cyclical components of the real effective exchange rate, commodity prices and the producer price index. Figure 3.2A and 3.2B on the other hand plots the natural logs and cyclical components of commodity prices, real effective exchange rates and producer price index for the period 1985q1-2020q4.

Figure 3.2A and 3.2B shreds more insights into the relationship between commodity prices and the real exchange rates. The figure shows that commodity prices in general are highly more volatile than both the real effective exchange rates and the producer price index. The real effective exchange rates on the other hand are more volatile than does producer price index.

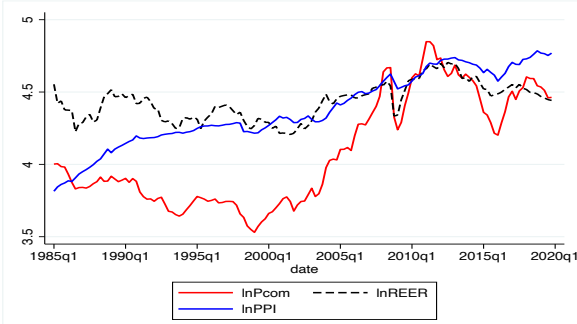
---

<sup>45</sup> This corresponds to Post Bretton Wood era of flexible exchange rates to ensure exchange rate regime variation do not affect results.

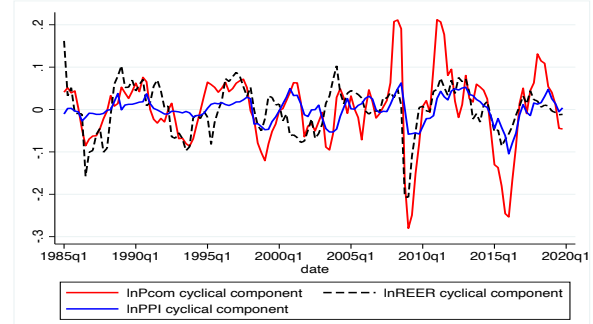
<sup>46</sup> For the MSE decompositions, I present the monthly on monthly and quarterly series for two reasons (i) RER, REER and commodity price data are readily available on monthly frequencies for most countries and (ii) Exchange rates are highly variable hence MSE decomposition at monthly frequency better captures the historical variations in the exchange rates.

**Figure 3.2A: Real Exchange Rates, Commodity Prices (Pcom) and Producer Price Index (PPI)-AE's**

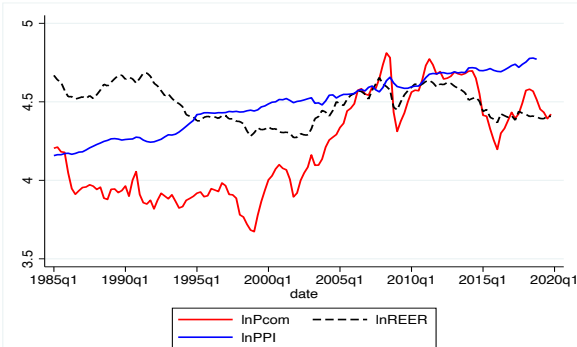
**A) Logs of Pcom, REER, PPI-Australia**



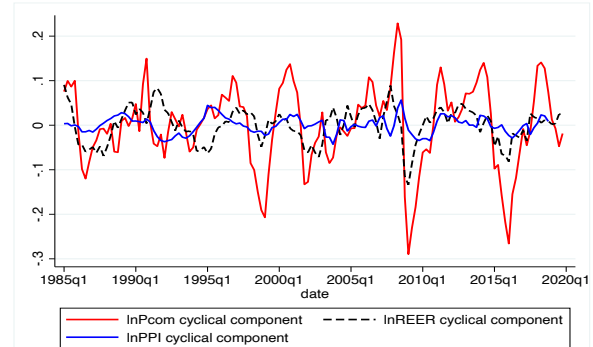
**Cyclical Components -Australia**



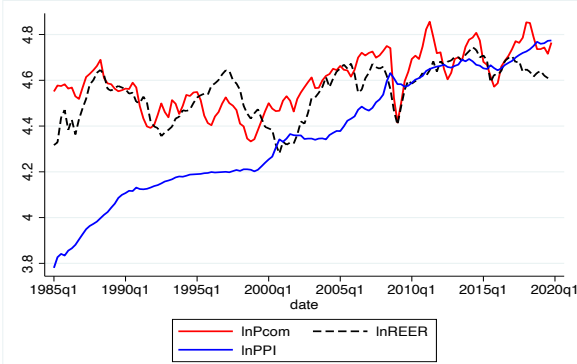
**B) Logs of Pcom, REER, PPI-Canada**



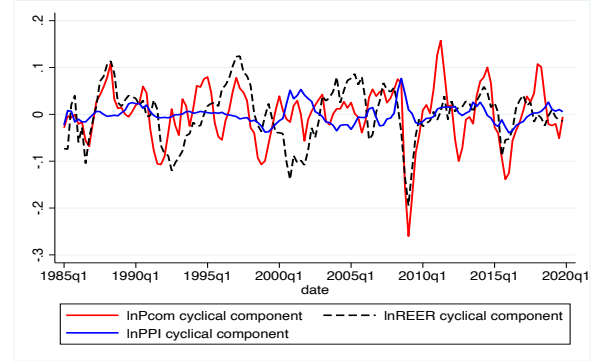
**Cyclical Components -Canada**



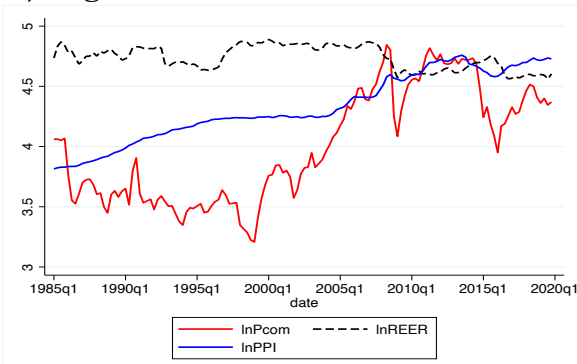
**C) Logs -Pcom, REER, PPI -New Zealand**



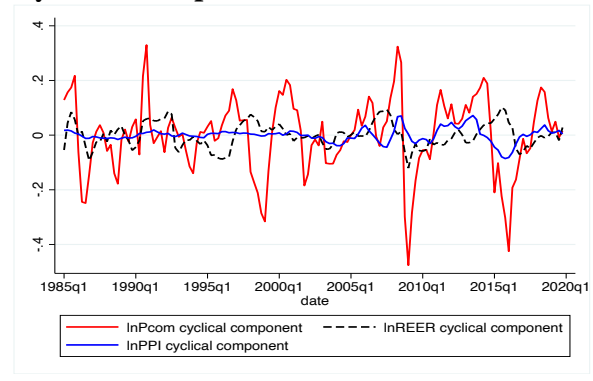
**Cyclical Components -New Zealand**



**D) Logs -Pcom, REER, PPI -UK**

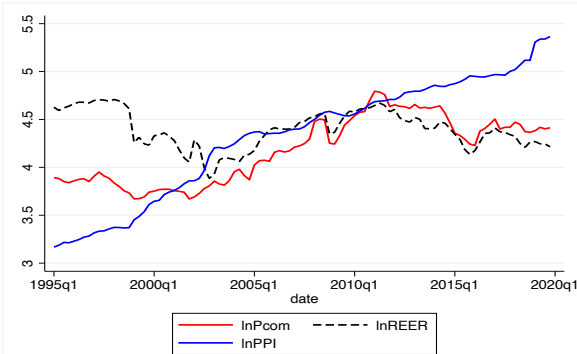


**Cyclical Components -UK**

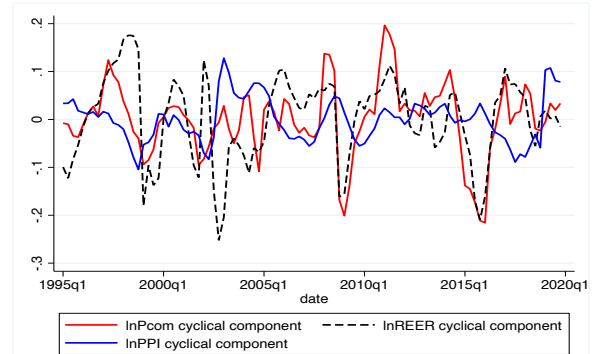


**Figure 3.2B: Real Exchange Rates, Commodity Prices (Pcom) and Producer Price Index (PPI)-EME's**

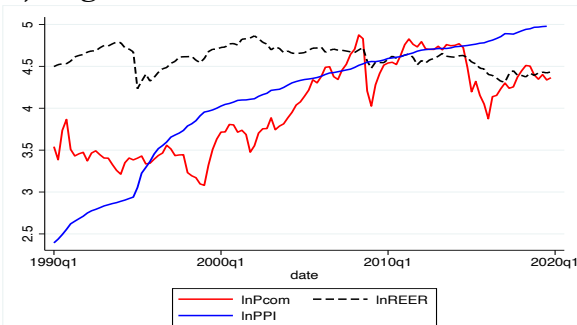
**A) Logs of Pcom, REER, PPI-Brazil**



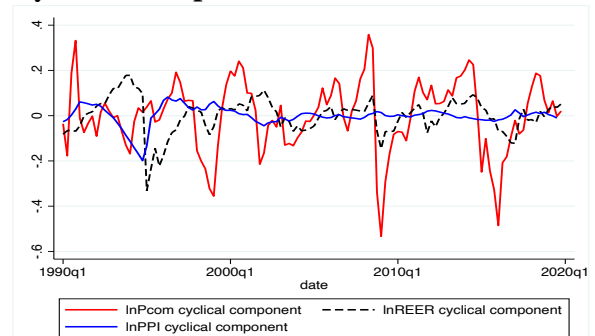
**Cyclical Components -Brazil**



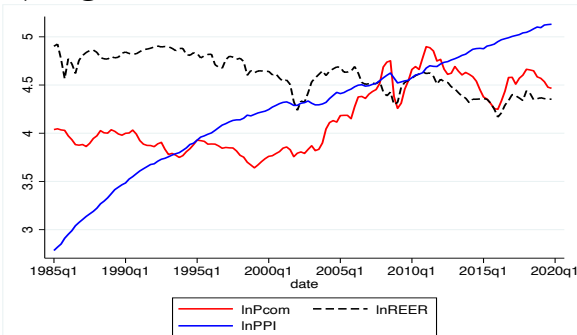
**B) Logs of Pcom, REER, PPI-Mexico**



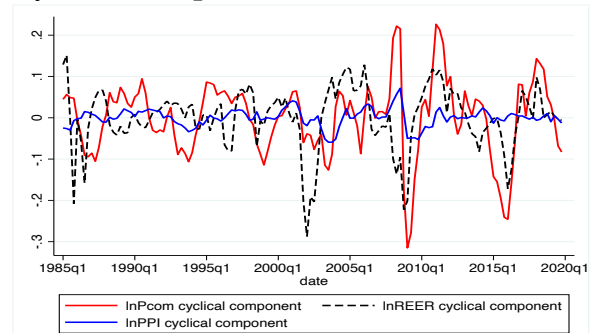
**Cyclical Components -Mexico**



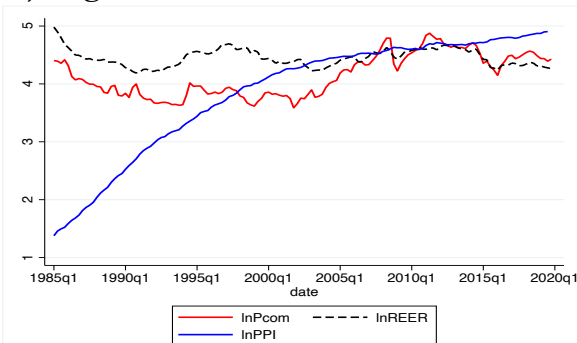
**C) Logs -Pcom, REER, PPI -South Africa**



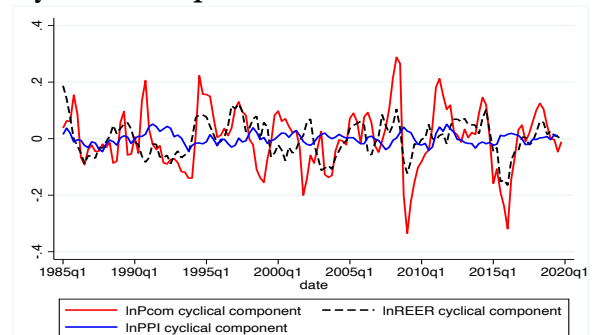
**Cyclical Components -South Africa**



**D) Logs -Pcom, REER, PPI -Colombia**



**Cyclical Components -Colombia**



A close investigation of the cyclical components shows that movements in the real exchange rates closely follows movements in commodity prices though the later is more volatile. This is the case in both EME's and AE's. The producer price indices are generally more stable than both the real effective exchange rates and commodity prices. The correlation estimates from Table 3.2A and 3.2B further provides more insight into the relationship observed in figure 3.2A and 3.2B. Specifically, the table shows that, commodity prices are typically more strongly correlated in absolute terms with the real effective exchange rates across the sample countries in both levels and cyclical components than the correlation between the real effective exchange rates and producer price index. These strong correlations imply that movements in the real commodity prices are more closely related to real exchange rate variations than movements in the producer price index. It also indicates that, commodity prices are an important component of traded goods prices in the sample countries.

**Table 3.2A: Correlations of Real Exchange Rates, Commodity Prices, and Producer Prices -Cyclical**

Country	Pairwise Correlations		Country	Pairwise Correlations	
	REER and Pcom	REER and PPI		REER and Pcom	REER and PPI
Australia	0.58	0.34	Brazil	0.56	-0.41
Canada	0.55	-0.008	Colombia	0.51	-0.23
Italy	-0.02	-0.15	Costa Rica	0.06	0.33
Netherlands	-0.12	-0.46	Hungary	0.25	-0.43
New Zealand	0.47	-0.27	Mexico	0.27	-0.21
Norway	0.45	0.28	South Africa	0.29	-0.12
UK	0.12	-0.20	Paraguay	0.15	-0.29

**Source:** Author constructed. Commodity Price Index data are from IMF's Terms of trade dataset whiles data on Producer Price Index (PPI) and Real Effective Exchange Rates (REER) are from the IMF IFS. Sample Period is 1985Q1 -2019Q4. Correlations are for the HP filtered cyclical components of each variable.

**Table 3.2B: Correlations of Real Exchange Rates, Commodity Prices, and Producer Prices -Levels**

Country	Pairwise Correlations		Country	Pairwise Correlations	
	REER and Pcom	REER and PPI		REER and Pcom	REER and PPI
Australia	0.87	0.69	Brazil	0.26	-0.26
Canada	0.32	-0.22	Colombia	0.41	-0.04
Italy	-0.16	-0.53	Costa Rica	0.72	0.87
Netherlands	0.11	-0.05	Hungary	0.86	0.83
New Zealand	0.71	0.63	Mexico	-0.12	-0.35
Norway	0.14	-0.34	South Africa	-0.57	-0.84
UK	-0.46	-0.62	Paraguay	0.55	0.42

**Source:** Author constructed. Commodity Price Index data are from IMF's Terms of trade dataset whiles data on Producer Price Index (PPI) and Real Effective Exchange Rates (REER) are from the IMF IFS. Sample Period is 1985Q1 -2019Q4. Correlations are for variables in levels

I do not seek in this study to investigate whether the high volatility of commodity prices implies a higher chance of predicting real exchange rate fluctuations. But the study is of the view that the implied higher correlation between commodity prices and the real effective exchange may be an indication of a higher prediction ability. This proposition is documented empirically by Zhang, Dufour and Galbraith (2016) who find that there is a bidirectional causality between commodity prices and exchange rates across multiple horizons. Relatedly, Bodart et al. (2015) also 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 they export in the long run.

### **3.4.1.2 Real Exchange Rate Accounting**

This section presents the results of the MSE decomposition of the real exchange rate into tradable and non-tradable components of prices for a sample of twelve (12) EMEs and sixteen (16) AE's. Decompositions are calculated for (i) tradable goods price measured using Net Commodity Export price index and (ii) tradable goods price measured using Export Commodity price index. Results are presented in monthly frequency<sup>47</sup>. The results from the MSE decomposition on a by-country basis are presented in Table 3.3A and 3.3B, Tables 3.4A and 3.4B as well as in Figure 3.3 panels A and B. The decomposition is done at different horizons that the data allows - from six (6) months up to 300 months (25 years). I present the results for the real exchange rate decomposition approach and tradable goods price measure indicated in equation 3.1.6 and 3.1.8<sup>48</sup>. The inclusion of the results for tradable goods are measured using only commodity prices (equation 3.1.8) allows us to shed more light on the contribution of commodity prices to exchange rate fluctuations.

---

<sup>47</sup> Monthly frequency allows us to better capture the relevance of each category to real exchange rate variations. Results on quarterly frequency are presented in Appendix C.

<sup>48</sup> Real exchange rates are decomposed as  $q_t = x_t + y_t$ . The traded goods ( $x_t$ ) are estimated in 3.1.6 as  $x_t = s_t + \ln(Pcom)$  and in equation 3.1.8 as  $x_t = \ln(Pcom)$ .

The main result from tables 3.3A and 3.3B document that the constructed relative price of tradable goods on average accounts for about 70% of the variations in the real exchange rate across all countries. Specifically, for all countries (both EME's and AE's), the relative price of tradable goods constructed from net commodity export prices account for between 60% to 74% of the variations in the real exchange rates at all horizons on average. A closer investigation however shows that the contribution of tradable goods to real exchange rate fluctuations in AE's are stable at about 71% for short (6-12 months) and about 73% for long horizons (180-300 months) while the contribution in EME's varies from about 62% at short horizons to about 60% at long horizons. This result drops to between 24% to 26% on average across both EME's and AE's (shown in table 3.4A and 3.4B) when tradable goods are measured using only net commodity export price index.

**Table 3.3A: Period Average MSE Decomposition – Advanced Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.59	0.61	0.59	0.58	0.57	0.57	0.54	0.53	0.47	0.50	0.47	0.49
Austria	0.73	0.73	0.74	0.73	0.74	0.74	0.75	0.76	0.72	0.74	0.72	0.73
Belgium	0.87	0.86	0.87	0.87	0.87	0.87	0.87	0.87	0.84	0.87	0.83	0.87
Canada	0.55	0.56	0.54	0.53	0.53	0.52	0.56	0.56	0.55	0.56	0.53	0.56
Denmark	0.70	0.73	0.75	0.78	0.79	0.83	0.83	0.87	0.84	0.88	0.84	0.87
Finland	0.77	0.76	0.78	0.77	0.79	0.79	0.78	0.78	0.75	0.76	0.73	0.76
France	0.71	0.71	0.72	0.72	0.73	0.73	0.74	0.74	0.72	0.73	0.72	0.72
Germany	0.72	0.72	0.72	0.72	0.73	0.73	0.73	0.74	0.71	0.73	0.71	0.72
Ireland	0.72	0.73	0.73	0.74	0.74	0.75	0.75	0.76	0.75	0.75	0.74	0.75
Italy	0.71	0.71	0.71	0.71	0.71	0.71	0.70	0.71	0.68	0.70	0.67	0.68
Japan	0.56	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.53	0.57	0.52	0.55
Netherlands	0.93	0.93	0.94	0.94	0.94	0.94	0.94	0.94	0.91	0.93	0.88	0.93
New Zealand	0.68	0.71	0.71	0.74	0.72	0.73	0.71	0.72	0.70	0.71	0.69	0.69
Norway	0.47	0.47	0.48	0.47	0.49	0.48	0.52	0.54	0.52	0.52	0.51	0.51
UK	0.79	0.83	0.84	0.90	0.87	0.92	0.90	0.94	0.90	0.92	0.90	0.92
Czech Republic	0.75	0.75	0.75	0.75	0.75	0.75	0.77	0.75	0.79	0.79	0.80	0.81
<b>Average</b>	<b>0.70</b>	<b>0.71</b>	<b>0.71</b>	<b>0.72</b>	<b>0.72</b>	<b>0.73</b>	<b>0.73</b>	<b>0.74</b>	<b>0.71</b>	<b>0.73</b>	<b>0.70</b>	<b>0.72</b>
<b>Median</b>	<b>0.72</b>	<b>0.72</b>	<b>0.73</b>	<b>0.74</b>	<b>0.74</b>	<b>0.74</b>	<b>0.74</b>	<b>0.74</b>	<b>0.72</b>	<b>0.73</b>	<b>0.72</b>	<b>0.73</b>

Notes: Results are for tradable goods measured as  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Net Commodity Export Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table 3.3B: Period Average MSE Decomposition – Emerging Market Economies**

Country	6months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.48	0.49	0.49	0.50	0.50	0.50	0.50	0.51	0.51	0.51	0.51	0.51
Colombia	0.52	0.52	0.53	0.53	0.53	0.53	0.55	0.55	0.56	0.57	0.56	0.57
Costa Rica	0.60	0.61	0.60	0.61	0.60	0.61	0.59	0.59	0.58	0.57	0.58	0.56
Hungary	0.70	0.75	0.70	0.72	0.68	0.68	0.64	0.61	0.60	0.58	0.57	0.56
Malaysia	0.62	0.62	0.61	0.61	0.60	0.60	0.59	0.60	0.59	0.59	0.59	0.59
Mexico	0.52	0.53	0.53	0.54	0.54	0.54	0.53	0.54	0.53	0.52	0.53	0.52
Morocco	0.59	0.60	0.60	0.61	0.60	0.61	0.61	0.62	0.61	0.62	0.60	0.62
Paraguay	0.71	0.70	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.67	0.67
Philippines	0.57	0.56	0.59	0.59	0.60	0.62	0.61	0.61	0.59	0.60	0.59	0.59
Thailand	0.71	0.71	0.74	0.75	0.75	0.77	0.76	0.77	0.75	0.77	0.73	0.75
Turkey	0.62	0.62	0.60	0.60	0.59	0.58	0.57	0.55	0.56	0.54	0.55	0.54
South Africa	0.70	0.73	0.73	0.77	0.74	0.77	0.73	0.73	0.70	0.70	0.69	0.68
<b>Average</b>	<b>0.61</b>	<b>0.62</b>	<b>0.62</b>	<b>0.63</b>	<b>0.62</b>	<b>0.63</b>	<b>0.61</b>	<b>0.61</b>	<b>0.60</b>	<b>0.60</b>	<b>0.60</b>	<b>0.60</b>
<b>Median</b>	<b>0.61</b>	<b>0.61</b>	<b>0.60</b>	<b>0.61</b>	<b>0.60</b>	<b>0.61</b>	<b>0.60</b>	<b>0.61</b>	<b>0.59</b>	<b>0.59</b>	<b>0.58</b>	<b>0.58</b>

Notes: Results are for tradable goods measured as  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Net Commodity Export Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

Importantly, the results document that tradable goods remain an important determinant of real exchange rate variations across EME's and AE's even when tradable goods are measured using purely traded goods prices contrary to the finding in Betts and Kehoe (2006; 2017) and Burstein et al. (2006).

Table C2.1.1 and C2.1.2 in Appendix C present the result for the real exchange rate proxied by the REER. The relative price of tradable goods is constructed as in equation 3.1.6 while the non-tradable goods is constructed by replacing the RER with REER in equation 3.1.7. The results showed the importance of tradable goods in the real exchange rate variations dwindles to about 39% for both AE's and EME's.

**Table 3.4A: Period Average MSE Decomposition – Advanced Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.18	0.20	0.19
Austria	0.33	0.34	0.32	0.32	0.30	0.31	0.29	0.28	0.31	0.31	0.34	0.32
Belgium	0.16	0.15	0.17	0.18	0.17	0.17	0.19	0.18	0.20	0.19	0.19	0.19
Canada	0.23	0.23	0.23	0.23	0.22	0.22	0.20	0.21	0.20	0.20	0.22	0.21
Denmark	0.20	0.20	0.17	0.17	0.15	0.13	0.12	0.10	0.11	0.09	0.11	0.09
Finland	0.28	0.28	0.27	0.27	0.25	0.26	0.24	0.24	0.28	0.27	0.30	0.28
France	0.36	0.36	0.34	0.34	0.32	0.33	0.29	0.26	0.31	0.31	0.32	0.32
Germany	0.34	0.35	0.33	0.33	0.31	0.32	0.29	0.27	0.31	0.31	0.33	0.32
Ireland	0.31	0.32	0.31	0.32	0.30	0.30	0.29	0.29	0.33	0.31	0.36	0.32
Italy	0.37	0.37	0.36	0.36	0.34	0.35	0.33	0.32	0.36	0.35	0.38	0.36
Japan	0.38	0.37	0.38	0.37	0.37	0.37	0.35	0.34	0.34	0.34	0.35	0.34
Netherlands	0.05	0.05	0.05	0.04	0.04	0.04	0.03	0.02	0.03	0.02	0.03	0.02
New Zealand	0.16	0.16	0.14	0.14	0.13	0.12	0.12	0.10	0.12	0.12	0.13	0.12
Norway	0.37	0.37	0.36	0.36	0.37	0.37	0.37	0.37	0.38	0.37	0.37	0.37
UK	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Czech Republic	0.37	0.37	0.38	0.39	0.38	0.39	0.40	0.39	0.49	0.42	0.52	0.44
<b>Average</b>	<b>0.26</b>	<b>0.26</b>	<b>0.25</b>	<b>0.25</b>	<b>0.24</b>	<b>0.24</b>	<b>0.23</b>	<b>0.22</b>	<b>0.25</b>	<b>0.24</b>	<b>0.26</b>	<b>0.24</b>
<b>Median</b>	<b>0.30</b>	<b>0.30</b>	<b>0.29</b>	<b>0.29</b>	<b>0.28</b>	<b>0.28</b>	<b>0.26</b>	<b>0.25</b>	<b>0.29</b>	<b>0.29</b>	<b>0.31</b>	<b>0.30</b>

Notes: Results are for tradable goods measured as  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Net Commodity Export Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table 3.4B: Period Average MSE Decomposition – Emerging Market Economies**

Country	6months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.06	0.07	0.06	0.07	0.06	0.07	0.06	0.06	0.05	0.05	0.05	0.05
Colombia	0.30	0.29	0.28	0.27	0.26	0.25	0.22	0.21	0.22	0.20	0.21	0.20
Costa Rica	0.36	0.36	0.33	0.34	0.32	0.31	0.32	0.31	0.30	0.30	0.30	0.30
Hungary	0.07	0.07	0.06	0.06	0.06	0.06	0.04	0.04	0.04	0.03	0.04	0.03
Malaysia	0.25	0.25	0.24	0.24	0.22	0.22	0.20	0.19	0.19	0.17	0.19	0.17
Mexico	0.28	0.29	0.27	0.27	0.25	0.26	0.25	0.24	0.27	0.27	0.27	0.27
Morocco	0.46	0.47	0.47	0.49	0.48	0.49	0.50	0.50	0.51	0.50	0.49	0.50
Paraguay	0.20	0.20	0.19	0.19	0.19	0.19	0.17	0.18	0.14	0.15	0.13	0.11
Philippines	0.41	0.40	0.42	0.42	0.42	0.42	0.41	0.40	0.40	0.40	0.43	0.40
Thailand	0.27	0.26	0.27	0.27	0.28	0.28	0.26	0.27	0.24	0.26	0.26	0.26
Turkey	0.32	0.31	0.36	0.37	0.39	0.41	0.43	0.44	0.45	0.45	0.44	0.44
South Africa	0.13	0.12	0.12	0.12	0.11	0.12	0.10	0.09	0.10	0.09	0.10	0.09
<b>Average</b>	<b>0.26</b>	<b>0.26</b>	<b>0.26</b>	<b>0.26</b>	<b>0.25</b>	<b>0.26</b>	<b>0.25</b>	<b>0.24</b>	<b>0.24</b>	<b>0.24</b>	<b>0.24</b>	<b>0.24</b>
<b>Median</b>	<b>0.28</b>	<b>0.28</b>	<b>0.27</b>	<b>0.27</b>	<b>0.25</b>	<b>0.26</b>	<b>0.23</b>	<b>0.22</b>	<b>0.23</b>	<b>0.23</b>	<b>0.24</b>	<b>0.23</b>

Notes: Results are for tradable goods measured as  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Net Commodity Export Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

This is however expected for two reasons. First the relative price of tradable goods in equation 3.1.6 were constructed using the nominal national currency -US dollar bilateral exchange rates and

a commodity price index hence making the RER the most appropriate measure of real exchange rate and not REER to ensure consistency. Second, the REER is a weighted average of different bilateral nominal exchange rates hence the contribution of tradable goods to variations in the REER is expected to be lower.

Also in Appendix C, I present the MSE decompositions for tradable goods measured using Export commodity price index. These results are presented in tables C2.1.5 through to C2.2.2. The results show that, commodity export prices explain on average between 51% to 54% of the variations in RER significantly lower than for net commodity export price case. This is however expected given our sample includes both commodity exporters and importers. The result for REER holds across countries with tradable goods explaining less of the variations in REER than observed for RER.

Figure 3.3A and 3.3B plots the MSE decompositions across different horizons for the full sample and for the two measures of tradable goods expressed in equation 3.1.6 and 3.1.8. The figures plotted are the MSE decompositions calculated from the net commodity export price based relative price of tradable goods and RER based non-tradable goods price measures. The red line plots the MSE of tradable goods estimated using equation 3.1.6 while the blue lines plot the MSE of tradable goods estimated using equation 3.1.8. These results further document the results presented in tables 3.3A through to 3.4B above. To account for any uncertainty in the MSE estimates, I also present a plot of the MSE from equation 3.1.6 across different horizons with the 95% Confidence bands in the Table C2.3 and C2.4. the results show the estimated MSE's falls within the confidence bands and this further documenting the empirical estimates of the MSE decomposition.

Figure 3.3A. Real Bilateral Exchange Rate MSE Decomposition Plots. MSE(F1) and MSE(F2) denotes the MSE decompositions from equation (3.1.6) and (3.1.8) respectively.

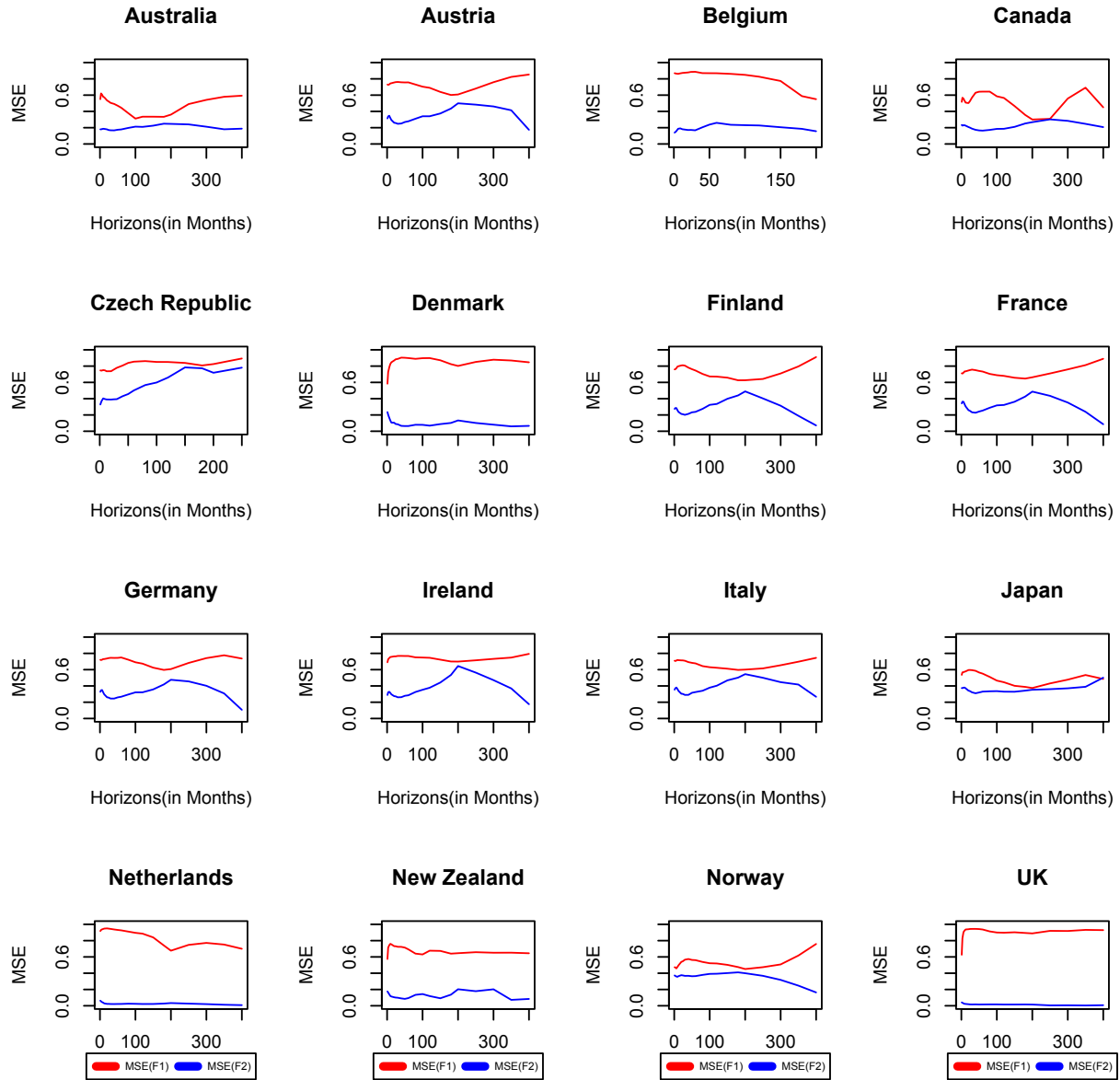
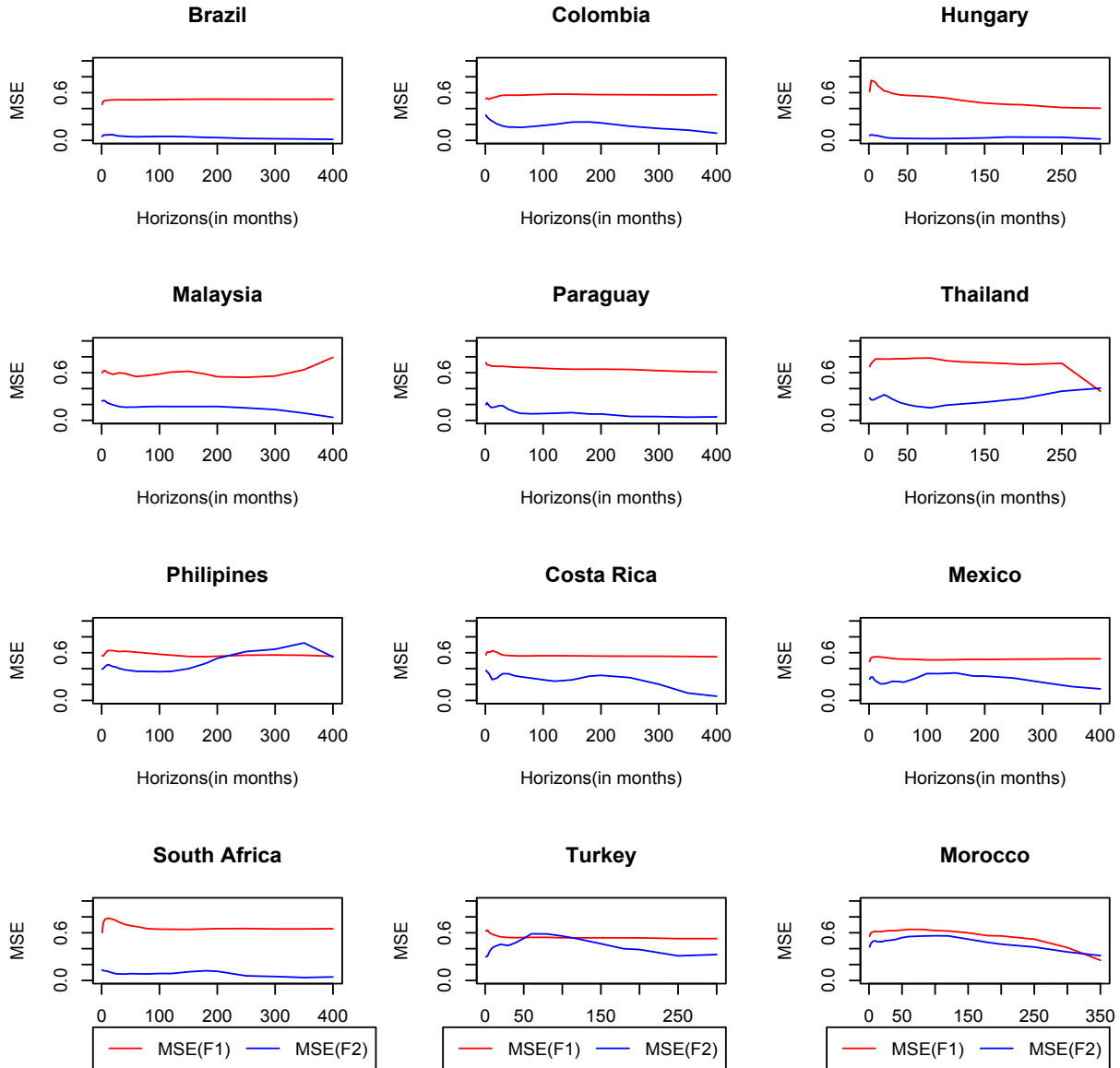


Figure 3.3B. Real Bilateral Exchange Rate MSE Decomposition Plots. MSE(F1) and MSE(F2) denote the MSE decompositions estimated from equation (3.1.6) and (3.1.8) respectively.



In Appendix C (table 2.2.3 through 2.2.6), I perform the MSE decomposition at quarterly frequency for net commodity export price index-based measure of tradable goods for RER. Results from the quarterly MSE decompositions is mostly in tandem with the results from the monthly estimates and holds for both EME's and AE's.

The results from the MSE decompositions documents three important findings – (i) that the measurement of tradable and non-tradable goods may be important in the determination of the relevance of tradable and non-tradable goods prices to real exchange rate variations. However contrary to Betts and Kehoe (2006; 2017) and Burstein et al. (2006), the relative price of tradable goods measured using purely tradable goods price as the export and net commodity export price indices explains a larger share of the variation in the real exchange rates, (ii) that for both short and long horizons the relative price of tradable goods remains an important determinant of the variations in real exchange rates in EME's and AE's and (iii) that the variance of the real exchange rates explained by the relative price of tradable goods is mostly driven by commodity price variations. Thus, measurement of traded and non-traded goods price matters in exchange rate accounting exercise, but the contribution of traded good price remains strong even for pure traded goods.

### **3.4.2 Commodity Price Shocks and Real Exchange Rates**

Given the finding in the exchange rate accounting exercise, the study next examines the role of commodity prices, a major component of the constructed relative price of tradable goods measure in driving the volatility in the real exchange rate measures. Two main estimation procedures namely the variance decompositions and impulse response functions are employed to gauge the importance of commodity prices to real exchange rate variations. I provide results for two measures of the real exchange rates – a real bilateral national currency-US dollar exchange rates (RER) and the real effective exchange rates (REER). Section 3.4.2.1 presents the results of the variance decompositions from the PSVAR estimation procedure while section 3.4.2.2 presents the results from the impulse response function analysis from the Local Projections (LP) estimation procedure of Jordà (2005). In Appendix C, I present a series of robustness check results including

the IRF's estimated with Newey West Standard errors, IRF's estimated when commodity price shocks was estimated from equation 3.2.3 and the IRF's when the lags of the  $X_t$  and REER were included in the regression model.

### **3.4.2.1 Commodity Price Shocks and Real Exchange Rates – Variance Decompositions**

Table 3.5A and 3.5B below presents the results from the variance decomposition analysis. The results presented are the responses of the country specific real national currency-US dollar bilateral exchange rates (RER) and the real effective exchange rates (REER) to a one-standard deviation shock in the net commodity export price index. The variance decompositions were estimated using the PSVAR for six (6) EME's and (6) AE's<sup>49</sup>. The main results of the variance decomposition are based on the analysis of the country specific responses to an aggregate/composite commodity price shock. However, I also present results for the country specific responses to commodity price shocks specific to each country (idiosyncratic shocks) as well as country specific responses to commodity price shocks common to all countries (common shocks or spillovers). The decomposition of the composite results into an idiosyncratic and common component allows us to understand the contribution of each component to real exchange rate variations and the importance of each source to each country.

Results from table's 3.5A and 3.5B below shows that aggregate/composite net commodity export price shocks explain on average about 17% (cyclical component) and 24% (levels) of the variations in the real bilateral exchange rates in the median high-income country and between 21% (cyclical component) and 25% (levels) of the variations in the median EME. For the real effective exchange rates, commodity price shocks explain about 10% (cyclical component) and 13% (levels) of the

---

<sup>49</sup> The sample size of 6 for both EME's and AE's were used to allow for comparison. Countries with at least 15 years of data across all variables were included in the sample.

variations in AE's and 16% (cyclical component) and 17% (levels) of the variations in EME's respectively.

**Table 3.5A. Share of Variances Explained by Net Export Commodity Price Shocks -AE**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.19	0.19	0.08	0.06	0.15	0.14	0.06	0.04
Canada	0.31	0.31	0.18	0.18	0.27	0.27	0.14	0.13
Germany	0.21	0.22	0.08	0.08	0.18	0.19	0.07	0.08
New Zealand	0.12	0.12	0.03	0.02	0.10	0.09	0.03	0.02
Norway	0.36	0.36	0.38	0.38	0.14	0.12	0.30	0.29
UK	0.21	0.23	0.02	0.02	0.20	0.22	0.03	0.03
<b>Mean</b>	<b>0.24</b>	<b>0.24</b>	<b>0.13</b>	<b>0.13</b>	<b>0.17</b>	<b>0.17</b>	<b>0.10</b>	<b>0.10</b>
<b>Median</b>	<b>0.21</b>	<b>0.23</b>	<b>0.08</b>	<b>0.07</b>	<b>0.17</b>	<b>0.17</b>	<b>0.06</b>	<b>0.06</b>
<i>CI_lower bound</i>	<i>0.22</i>	<i>0.19</i>	<i>0.12</i>	<i>0.06</i>	<i>0.16</i>	<i>0.15</i>	<i>0.09</i>	<i>0.05</i>
<i>CI_upper bound</i>	<i>0.25</i>	<i>0.23</i>	<i>0.14</i>	<i>0.09</i>	<i>0.22</i>	<i>0.18</i>	<i>0.11</i>	<i>0.08</i>

**Notes:** The figures presented are the median responses of each country to composite net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table 3.5B. Share of Variances Explained by Net Export Commodity Price Shocks -EME**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.13	0.13	0.06	0.06	0.13	0.14	0.06	0.06
Costa Rica	0.04	0.04	0.21	0.21	0.11	0.12	0.24	0.25
Hungary	0.45	0.48	0.38	0.39	0.38	0.40	0.32	0.32
Mexico	0.29	0.30	0.17	0.18	0.24	0.24	0.17	0.17
South Africa	0.41	0.43	0.19	0.19	0.33	0.33	0.13	0.13
Turkey	0.10	0.10	0.00	0.00	0.04	0.04	0.03	0.03
<b>Mean</b>	<b>0.24</b>	<b>0.25</b>	<b>0.17</b>	<b>0.17</b>	<b>0.20</b>	<b>0.21</b>	<b>0.16</b>	<b>0.16</b>
<b>Median</b>	<b>0.21</b>	<b>0.22</b>	<b>0.18</b>	<b>0.19</b>	<b>0.18</b>	<b>0.19</b>	<b>0.15</b>	<b>0.15</b>
<i>CI_lower bound</i>	<i>0.22</i>	<i>0.19</i>	<i>0.16</i>	<i>0.17</i>	<i>0.20</i>	<i>0.19</i>	<i>0.15</i>	<i>0.14</i>
<i>CI_upper bound</i>	<i>0.26</i>	<i>0.22</i>	<i>0.18</i>	<i>0.19</i>	<i>0.22</i>	<i>0.20</i>	<i>0.17</i>	<i>0.16</i>

**Notes:** The figures presented are the median responses of each country to composite net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

Importantly, the results from table 3.5A to 3.5B reaffirm our earlier finding in the exchange rate accounting exercise in section 3.4.1 and document commodity prices as an important driver of the real exchange rate variations in AE's and EME's. Further, the results show that commodity price shocks explain a slightly higher proportion of the variations in the real exchange rates in EME's

than in AE's contrary to the observation in the accounting exercise where the effects is more pronounced for AE's than for EME's. This could however be due to the larger sample variation for AE's than EME's in the accounting exercise.

**Table 3.6A. Share of Variances Explained by Common Net Export Commodity Price Shocks -AE**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.16	0.16	0.07	0.05	0.13	0.12	0.05	0.04
Canada	0.25	0.25	0.15	0.14	0.22	0.22	0.11	0.11
Germany	0.16	0.16	0.06	0.06	0.14	0.14	0.05	0.05
New Zealand	0.10	0.10	0.02	0.02	0.09	0.08	0.02	0.02
Norway	0.26	0.27	0.29	0.29	0.11	0.09	0.23	0.23
UK	0.18	0.19	0.02	0.02	0.17	0.18	0.03	0.03
<b>Mean</b>	<b>0.19</b>	<b>0.19</b>	<b>0.10</b>	<b>0.10</b>	<b>0.14</b>	<b>0.14</b>	<b>0.08</b>	<b>0.08</b>
<b>Median</b>	<b>0.17</b>	<b>0.18</b>	<b>0.06</b>	<b>0.06</b>	<b>0.13</b>	<b>0.13</b>	<b>0.05</b>	<b>0.05</b>
<i>CI_lower bound</i>	<i>0.18</i>	<i>0.16</i>	<i>0.09</i>	<i>0.06</i>	<i>0.13</i>	<i>0.13</i>	<i>0.07</i>	<i>0.04</i>
<i>CI_upper bound</i>	<i>0.19</i>	<i>0.19</i>	<i>0.11</i>	<i>0.08</i>	<i>0.15</i>	<i>0.15</i>	<i>0.09</i>	<i>0.06</i>

**Notes:** The figures presented are the median responses of each country to common net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table 3.6B. Share of Variances Explained by Common Net Export Commodity Price Shocks -EME**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.11	0.11	0.05	0.05	0.11	0.12	0.05	0.05
Costa Rica	0.03	0.03	0.18	0.18	0.09	0.10	0.22	0.22
Hungary	0.37	0.39	0.33	0.35	0.33	0.35	0.28	0.28
Mexico	0.26	0.27	0.14	0.14	0.19	0.20	0.13	0.13
South Africa	0.33	0.34	0.15	0.15	0.28	0.28	0.11	0.11
Turkey	0.09	0.10	0.00	0.00	0.04	0.04	0.02	0.03
<b>Mean</b>	<b>0.20</b>	<b>0.21</b>	<b>0.14</b>	<b>0.15</b>	<b>0.17</b>	<b>0.18</b>	<b>0.13</b>	<b>0.14</b>
<b>Median</b>	<b>0.20</b>	<b>0.21</b>	<b>0.15</b>	<b>0.15</b>	<b>0.17</b>	<b>0.18</b>	<b>0.13</b>	<b>0.13</b>
<i>CI_lower bound</i>	<i>0.19</i>	<i>0.19</i>	<i>0.14</i>	<i>0.14</i>	<i>0.15</i>	<i>0.15</i>	<i>0.11</i>	<i>0.11</i>
<i>CI_upper bound</i>	<i>0.22</i>	<i>0.22</i>	<i>0.16</i>	<i>0.16</i>	<i>0.17</i>	<i>0.17</i>	<i>0.13</i>	<i>0.12</i>

**Notes:** The figures presented are the median responses of each country to common net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

Finally, results in table 3.6A to 3.7B reveals interesting dynamics in the response of the real exchange rate measures to commodity terms of trade price variations. As indicated in section

3.3.3.2, the Pedroni PSVAR methodology allows as to decompose each countries real exchange rate variations to commodity price shocks into responses due to (i) commodity price shocks that are specific to each country (idiosyncratic shocks) and (ii) commodity price shocks that are common to all countries (common shocks or spillovers). Decomposing the response of the real exchange rates to commodity price shocks this way allows us to determine the importance of common components and idiosyncratic components to real exchange rate variations.

Results from table 3.6A and 3.6B shows that commodity price shocks common to all countries or more simply commodity price spillovers explain a significantly higher proportion of between 13% (cyclical components) to 19% (levels) of the variations in the real bilateral exchange rates and about 8% (cyclical components) to 10% (levels) of the variations in the real effective exchange rates in AE's. In EME's spillover effects of commodity price shocks explain about 17% (cyclical components) to 20% (levels) and between 13% (cyclical components) to 15% (levels) of the variation in the real bilateral exchange rates and the real effective exchange rates respectively.

**Table 3.7A. Share of Variances Explained by Idiosyncratic Export Commodity Price Shocks -AE**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.03	0.03	0.01	0.01	0.03	0.02	0.01	0.01
Canada	0.06	0.06	0.03	0.03	0.05	0.05	0.03	0.03
Germany	0.06	0.06	0.02	0.02	0.05	0.05	0.02	0.02
New Zealand	0.02	0.02	0.00	0.00	0.01	0.01	0.00	0.00
Norway	0.10	0.10	0.09	0.09	0.03	0.03	0.07	0.07
UK	0.03	0.03	0.00	0.00	0.03	0.03	0.01	0.01
<b>Mean</b>	<b>0.05</b>	<b>0.05</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.02</b>	<b>0.02</b>
<b>Median</b>	<b>0.05</b>	<b>0.05</b>	<b>0.02</b>	<b>0.02</b>	<b>0.03</b>	<b>0.03</b>	<b>0.01</b>	<b>0.01</b>
<i>CI_lower bound</i>	<i>0.05</i>	<i>0.04</i>	<i>0.03</i>	<i>0.01</i>	<i>0.03</i>	<i>0.03</i>	<i>0.02</i>	<i>0.01</i>
<i>CI_upper bound</i>	<i>0.05</i>	<i>0.05</i>	<i>0.03</i>	<i>0.02</i>	<i>0.04</i>	<i>0.04</i>	<i>0.02</i>	<i>0.02</i>

**Notes:** The figures presented are the median responses of each country to idiosyncratic export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

For the idiosyncratic components, tables 3.7 panels A and B shows that the response to commodity price shocks specific to each country accounts for approximately between 3% to 5% and between 2% to 3% of the variations in the real bilateral exchange rates and the real effective exchange rates in AE's and about 3% to 4% and 2% to 3% of the variations in RER and REER in EME's respectively.

**Table 3.7B. Share of Variances Explained by Idiosyncratic Export Commodity Price Shocks -EME**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.01
Costa Rica	0.01	0.01	0.03	0.03	0.02	0.02	0.03	0.03
Hungary	0.08	0.08	0.04	0.04	0.05	0.05	0.04	0.04
Mexico	0.03	0.04	0.03	0.03	0.05	0.05	0.04	0.04
South Africa	0.08	0.09	0.04	0.04	0.05	0.05	0.02	0.02
Turkey	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Mean</b>	<b>0.04</b>	<b>0.04</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.02</b>	<b>0.02</b>
<b>Median</b>	<b>0.02</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>
<i>CI_lower bound</i>	<i>0.03</i>	<i>0.03</i>	<i>0.02</i>	<i>0.02</i>	<i>0.05</i>	<i>0.05</i>	<i>0.04</i>	<i>0.04</i>
<i>CI_upper bound</i>	<i>0.03</i>	<i>0.03</i>	<i>0.02</i>	<i>0.03</i>	<i>0.05</i>	<i>0.05</i>	<i>0.04</i>	<i>0.05</i>

**Notes:** The figures presented are the median responses of each country to idiosyncratic export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

Importantly, these results documents that across both EME's and AE's commodity price shocks are mostly exogenous and common to all countries. Further the results show that the responses of the real exchange rate measures to common shocks are about twice as large as the response to commodity price shocks that are specific to each country. The importance of common factors in the effects of commodity price shocks was first examined theoretically by Fernández, González, and Rodríguez, (2018).

The results of the real bilateral exchange rates and the real effective exchange rates to a composite, common and idiosyncratic export commodity price shocks are presented in table 3.2.2 through to table 3.2.7 in Appendix C. Importantly these results shows similarly significant response of the

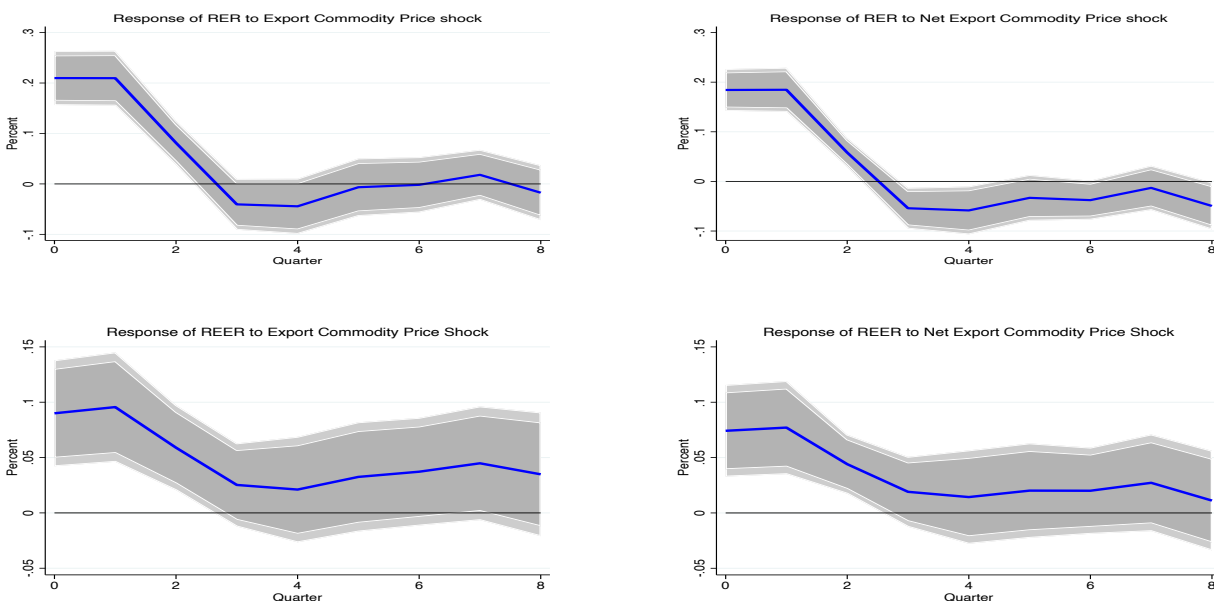
real bilateral exchange rates and the real effective exchange rates of EME's and AE's to a composite, common and idiosyncratic export commodity price shocks as observed for net export commodity price shocks.

### **3.4.2.2 Impulse Response Function (IRF) Analysis**

The variance decompositions in section 3.4.2.1 quantitatively estimates the share of real exchange rate fluctuations accounted for by commodity price variations. In this section the study investigates the transmission mechanism of world commodity price shocks to real exchange rate fluctuations across the sample countries and for country groups -EME's vs AE's. To achieve this objective, the study employs an Impulse response function (IRF) analysis. IRF's describe the evolution of a model's variables in response to a shock in one or more of the variables in the model hence appropriate for analyzing transmission mechanisms. The IRF analysis is conducted using the Local Projections (LP) methodology of Jordà (2005). Following Plagborg-Møller and Wolf (2019), I use an unrestricted lag structure with confidence bands of 95% and 90% respectively in estimating the IRFs. I also estimate the model with clustered errors as well as with the Newey West robust standard errors for reasons stated in the previous section. Though LP's are unaffected by the arrangement of variables in a model, the study set up model variables in the LP similar to the PSVAR analysis in the previous section. The LP's are however preferred for the reasons stated in section 3.3.3.3.

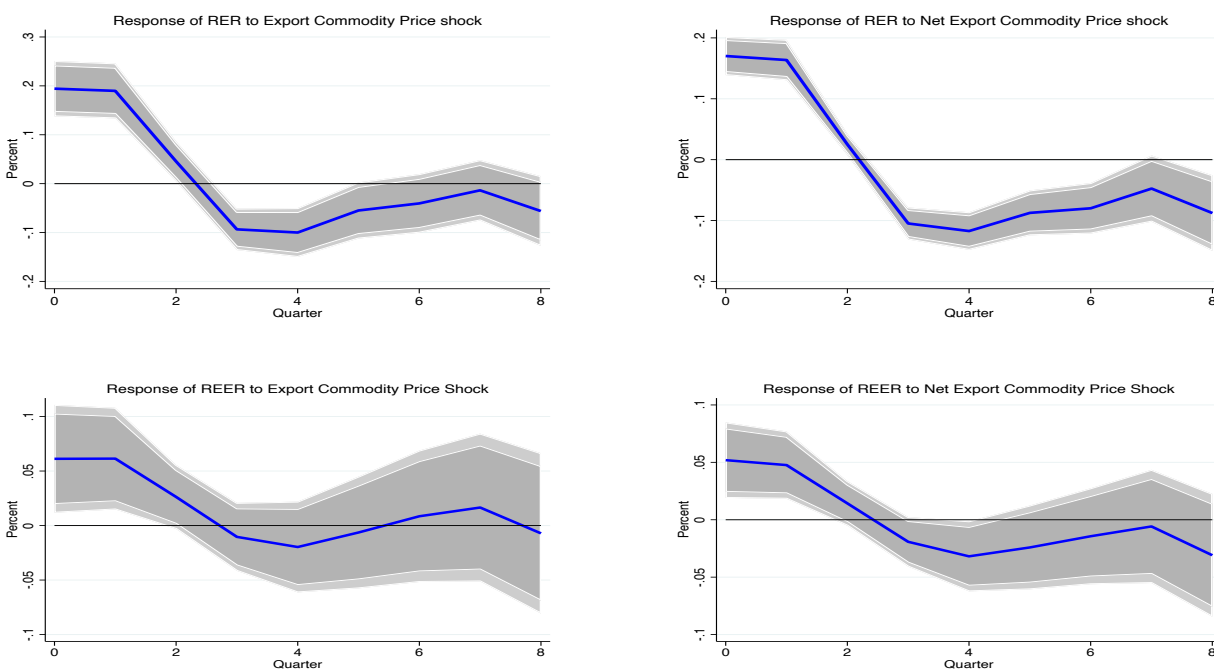
Results from the IRF analysis are presented for (i) full sample, (ii) EME's and (iii) AE's in Figure 3.4A to 3.4C. The results presented are the responses of real exchange rate measures (RER and REER) to a one standard deviation shock in the world export and net export commodity price indices.

**Figure 3.4 – World Commodity Prices and Real Exchange Rates – Full Sample IRF**



**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) and estimated for the cyclical components of the variables obtained using the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 23 (T=3220; N=23). The CI's are constructed with  $\alpha = 0.05$  and 0.10.

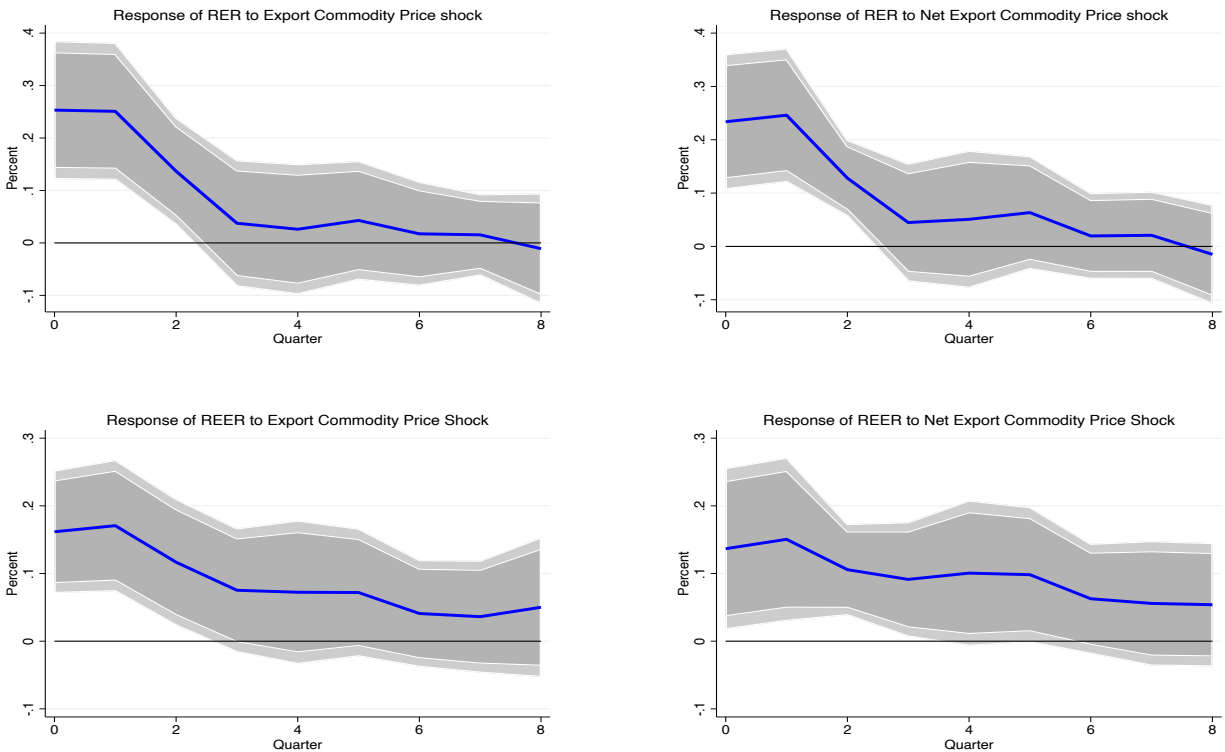
**Figure 3.5A – World Commodity Prices and Real Exchange Rates – AE Sample IRF**



**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) and estimated for the cyclical components of the variables obtained using the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 16 (T=2240; N=16). The CI's are constructed with  $\alpha = 0.05$  and 0.10.

For the full sample, results from figure 3.4A shows that a one standard deviation shock in both export and net export commodity prices is associated with an appreciation<sup>50</sup> of the real bilateral exchange rates and the real effective exchange rates across the sample countries. More specifically, exchange rates in the sample countries appreciate following a commodity price shock. Similarly, results from figure 3.4B and 3.4C also shows similar appreciation in the real bilateral exchange rates and the real effective exchange rates in EME's and AE's following a commodity price shock as observed for the full sample.

**Figure 3.5B – World Commodity Prices and Real Exchange Rates – EME Sample IRF**



**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) and estimated for the cyclical components of the variables obtained using the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 7 (T=980; N=7). The CI's are constructed with  $\alpha = 0.05$  and 0.10.

<sup>50</sup> Exchange rate used is measured as the inverse of national currency per US dollar, end-of-period rate hence an increase in measures of RER and REER denotes an appreciation for the domestic country and a depreciation for the US dollar.

However, a closer investigation reveals that significant difference exists in the response of the real bilateral exchange rates and the real effective exchange rates of AE's and EME's to a one standard deviation shock in both export and net export commodity prices. First, for both measures of exchange rates, the appreciation is more persistent in EMEs (up to 4<sup>th</sup> quarter), whereas for AEs the appreciation turns into a depreciation after the 2<sup>nd</sup> quarter. Second, the magnitude of the contemporaneous response of real bilateral exchange rates and the real effective exchange rates in EME's to both export and net export commodity shocks appears higher (about twice as large) than in AEs similar to the finding in the variance decomposition exercise. To determine if the difference in the magnitude of the responses between EME's and AE's are statistically significant, the study conduct a difference in mean test for the impulse responses from the EME and AE sample. The difference in mean test measures the absolute difference between the mean values of two different groups (in this case EME's vs AE's). The test assumes a null hypothesis of the difference in mean of zero between the two groups. The results are presented in Table 3.3.4 to 3.3.7 in Appendix C. Importantly, I find that the difference in the magnitude of the responses are statistically significant both under the assumption of equal variance or unequal variance.

Results from the robustness checks conducted and present in Appendix C further affirms the results above. Specifically, the IRF's obtained when the model was estimated with the Newey West standard errors, with the lags of  $X_t$  and REER as well as when commodity price shocks were estimated from equation 3.2.3 shows that the real exchange rate measures appreciate following a commodity price shock and that the magnitude of the impact are larger in EME's than in AE's. Similar results were obtained when the Hamilton filter (Figure C2.0 -C2.2) was used instead of the HP filter to estimate the cyclical component of the data.

### 3.5 Conclusion

Recent findings of exchange rate models predict that exchange rate fluctuations are largely the result of cross-country variations in tradable goods prices contrary to the proposition of traditional exchange rate theory. Attempts to reconcile this difference has identified the choice of price series used in measuring tradable and non-tradable goods as the basis for the observed discrepancy between the traditional theoretical proposition and empirical findings. This study weighs into this debate by examining the importance of tradable goods estimated from a price series that contains no non-tradable components to real exchange rate variations. In the study I measure the tradable goods using net commodity export and export commodity price indices and perform a standard exchange rate accounting exercise following Engle (1999) and Yopez and Dzikpe (2022). I show that tradable goods price estimated from net export commodity price indices explain on average about 70% of real exchange rate fluctuations in EME's and AE's. This share reduces to between 24%-26% when net export commodity price is used as a sole measure of the relative price of tradable goods.

The study further investigates the extent to which commodity prices matter for the dynamic behavior of real exchange rates by decomposing the commodity price shocks into a country specific idiosyncratic component and a common component. Results based on LP and the dynamic PSVAR models suggest that world commodity prices explain on average about 18% to 24% of the of the observed variability in the real national currency-US dollar bilateral exchange rates of both EME's and AE's. For the real effective exchange rates, the forecast error variance decompositions show that commodity prices explain on average about 13% to 16% of the observed variability. Decomposing the forecast error variance decomposition shows that, the effect of commodity price shocks on the real exchange rates of EME's and AE's is mostly driven by common commodity

price shocks or common factors. Common factors in the commodity price shocks were found to explain between 13% to 20% of the overall response of the real exchange rates to commodity price shocks. Country specific idiosyncratic commodity price shocks explain a relatively small portion of between 2% to 5% of the variations in the real exchange rates. Impulse responses from the LP analysis further documents the nature of the effect of a country specific commodity price shock on the real exchange rate measures. Specifically, I find that commodity price shocks tend to be associated with larger contemporaneous and more persistent real exchange rate appreciations in EMEs than AE's. Results re robust across different specifications for the PSVAR and for the cyclical components estimated using the Hamilton filter.

Importantly, the findings of the real exchange rate accounting exercise re-affirm the results from chapter two and documents the relative price of tradable goods as the dominant determinant of real exchange rate variations. The findings from the forecast error variance decompositions and impulse response functions also shed more light on the nature of the effect of commodity price shocks in EME's and AE's and documents the component of commodity price shocks that drives the effect of commodity price shocks in EME's and AE's.

## References

- Aizenman, J., Edwards, S., & Riera-Crichton, D. (2012). Adjustment patterns to commodity terms of trade shocks: the role of exchange rate and international reserves policies. *Journal of International Money and Finance*, 31(8), 1990-2016.
- Balassa, B. (1964). The purchasing-power parity doctrine: a reappraisal. *Journal of political Economy*, 72(6), 584-596.
- Betts, C. M., & Kehoe, T. J. (2006). US real exchange rate fluctuations and relative price fluctuations. *Journal of Monetary Economics*, 53(7), 1297-1326.
- Betts, C. M., & Kehoe, T. J. (2008). *Real exchange rate movements and the relative price of non-traded goods*. NBER Working Paper 14437
- Blecker, R. A. (2005). 7. Financial Globalization, Exchange. *Financialization and the world economy*, 183.
- Bodart, V., Candelon, B., & Carpentier, J.-F. (2015). Real exchanges rates, commodity prices and structural factors in developing countries. *Journal of International Money and Finance*, 51, 264-284.
- Burstein, A., Eichenbaum, M., & Rebelo, S. (2005). Large devaluations and the real exchange rate. *Journal of political Economy*, 113(4), 742-784.
- Burstein, A., Eichenbaum, M., & Rebelo, S. (2006). The importance of nontradable goods' prices in cyclical real exchange rate fluctuations. *Japan and the World Economy*, 18(3), 247-253.
- Carrière-Swallow, Y., Magud, N. E., & Yépez, J. F. (2021). Exchange rate flexibility, the real exchange rate, and adjustment to terms-of-trade shocks. *Review of International Economics*, 29(2), 439-483.

- Christiano, L. J., Eichenbaum, M., Vigfusson, R., Kehoe, P. J., & Watson, M. W. (2006). Assessing structural VARs [with comments and discussion]. *NBER macroeconomics annual*, 21, 1-105.
- Deaton, A., & Miller, R. (1996). International commodity prices, macroeconomic performance and politics in Sub-Saharan Africa. *Journal of African Economies*, 5(3), 99-191.
- Delle Chiaie, S., Ferrara, L., & Giannone, D. (2017). Common factors of commodity prices. European Central Bank Working paper 2122
- Engel, C. (1999). Accounting for US real exchange rate changes. *Journal of Political economy*, 107(3), 507-538.
- Engel, C. M., & Zhu, F. (2019). Exchange rate puzzles: evidence from rigidly fixed nominal exchange rate systems. BIS Working Paper 805
- Evans, M. D. (2011). *Exchange-rate dynamics*. Princeton University Press.
- Fernández, A., González, A., & Rodríguez, D. (2018). Sharing a ride on the commodities roller coaster: Common factors in business cycles of emerging economies. *Journal of International Economics*, 111, 99-121.
- Gottschalk, J. (2001). *An introduction into the SVAR methodology: identification, interpretation and limitations of SVAR models*. (No. 1072). Kiel working paper.
- Gruss, B., & Kebhaj, S. (2019). *Commodity terms of trade: A new database*. International Monetary Fund.
- Herbst, E., & Johannsen, B. K. (2021). "Bias in local projections". Finance and Economics Discussion Series 2020-010r1. Washington: Board of Governors of the Federal Reserve System,

- Itskhoki, O., & Mukhin, D. (2021). Exchange rate disconnect in general equilibrium. *Journal of Political Economy*, 129(8), 2183-2232.
- Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American economic review*, 95(1), 161-182.
- Milesi-Ferretti, M. G., & Micossi, S. (1994). *Real exchange rates and the prices of nontradable goods*. International Monetary Fund.
- Obstfeld, M. (2001). International macroeconomics: beyond the Mundell-Fleming model. In: National Bureau of Economic Research Cambridge, Mass., USA.
- Pedroni, P. (2013). Structural Panel VARs. *Econometrics*, 1(2), 180-206.
- Plagborg-Møller, M., & Wolf, C. K. (2021). Local projections and VARs estimate the same impulse responses. *Econometrica*, 89(2), 955-980.
- Roch, F. (2019). The adjustment to commodity price shocks. *Journal of Applied Economics*, 22(1), 437-467.
- Rogers, J. H., & Jenkins, M. (1995). Haircuts or hysteresis? Sources of movements in real exchange rates. *Journal of International Economics*, 38(3-4), 339-360.
- Yépez, C., & Dzikpe, F. (2022). Accounting for real exchange rates in emerging economies: The role of commodity prices. *International Review of Economics & Finance*, 79, 476-492.
- Yépez, C. A. (2020). International risk sharing in emerging economies. *International Finance*, 23(3), 434-459.
- Zhang, H. J., Dufour, J.-M., & Galbraith, J. W. (2016). Exchange rates and commodity prices: Measuring causality at multiple horizons. *Journal of Empirical Finance*, 36, 100-120.

## Appendix C

**Table C1.1: Sample Countries – Exchange Rate Accounting**

<b>Countries</b>	<b>Countries</b>
Australia	Italy
Austria	Japan
Belgium	Malaysia
Brazil	Mexico
Canada	Morocco
Colombia	Netherlands
Costa Rica	New Zealand
Czech Republic	Norway
Denmark	Paraguay
Finland	Philippines
France	South Africa
Germany	Thailand
Hungary	Turkey
Ireland	UK

**Table C1.2: Sample Countries – PSVAR Analysis**

<b>Countries</b>	<b>Countries</b>
Australia	Brazil
Canada	Costa Rica
Germany	Hungary
New Zealand	Mexico
Norway	South Africa
UK	Turkey

**Table C2.1.1: Period Average MSE Decomposition – Advanced Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.28	0.27	0.28	0.26	0.27	0.26	0.26	0.26	0.27	0.26	0.28	0.27
Austria	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.47	0.46	0.48	0.47
Belgium	0.41	0.41	0.41	0.41	0.41	0.42	0.42	0.42	0.43	0.42	0.42	0.42
Canada	0.29	0.27	0.28	0.26	0.26	0.26	0.24	0.23	0.23	0.21	0.22	0.22
Denmark	0.43	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
Finland	0.41	0.41	0.40	0.40	0.40	0.40	0.40	0.40	0.41	0.41	0.43	0.42
France	0.44	0.44	0.44	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Germany	0.43	0.43	0.43	0.43	0.43	0.42	0.43	0.43	0.43	0.43	0.43	0.43
Ireland	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.41	0.40	0.42	0.41
Italy	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.44	0.44	0.45	0.45
Japan	0.38	0.38	0.38	0.38	0.37	0.38	0.37	0.38	0.40	0.38	0.42	0.39
Netherlands	0.40	0.40	0.40	0.40	0.40	0.40	0.41	0.41	0.42	0.41	0.42	0.41
New Zealand	0.32	0.30	0.31	0.30	0.31	0.30	0.31	0.31	0.34	0.32	0.36	0.34
Norway	0.49	0.48	0.49	0.49	0.49	0.49	0.49	0.49	0.50	0.49	0.49	0.49
UK	0.33	0.32	0.32	0.32	0.32	0.32	0.33	0.33	0.33	0.33	0.34	0.34
Czech Republic	0.39	0.39	0.39	0.40	0.40	0.40	0.39	0.39	0.37	0.38	0.35	0.37
<b>Average</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.40</b>	<b>0.39</b>
<b>Median</b>	<b>0.40</b>	<b>0.41</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.40</b>	<b>0.41</b>	<b>0.41</b>	<b>0.42</b>	<b>0.41</b>	<b>0.42</b>	<b>0.41</b>

Notes: Results are for  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(REER_t) - x_t$  using Net Export Commodity Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.1.2: Period Average MSE Decomposition – Emerging Market Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.46	0.46	0.47	0.48	0.48	0.49	0.49	0.50	0.49	0.50	0.49	0.50
Colombia	0.33	0.32	0.32	0.32	0.33	0.32	0.33	0.33	0.35	0.35	0.36	0.35
Costa Rica	0.33	0.33	0.34	0.34	0.35	0.34	0.38	0.37	0.40	0.43	0.41	0.44
Hungary	0.36	0.36	0.37	0.38	0.39	0.38	0.42	0.43	0.46	0.46	0.50	0.48
Malaysia	0.31	0.30	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.29	0.28	0.28
Mexico	0.35	0.35	0.36	0.36	0.37	0.37	0.40	0.40	0.42	0.44	0.43	0.46
Morocco	0.49	0.49	0.50	0.50	0.50	0.51	0.51	0.51	0.52	0.52	0.53	0.53
Paraguay	0.32	0.32	0.33	0.33	0.34	0.33	0.35	0.37	0.37	0.37	0.37	0.37
Philippines	0.37	0.38	0.37	0.37	0.38	0.38	0.38	0.38	0.39	0.39	0.40	0.39
Thailand	0.31	0.31	0.31	0.31	0.32	0.32	0.32	0.33	0.32	0.32	0.32	0.32
Turkey	0.35	0.34	0.38	0.39	0.41	0.42	0.43	0.47	0.45	0.48	0.45	0.48
South Africa	0.28	0.27	0.28	0.28	0.28	0.28	0.30	0.29	0.33	0.31	0.34	0.33
<b>Average</b>	<b>0.36</b>	<b>0.35</b>	<b>0.36</b>	<b>0.36</b>	<b>0.37</b>	<b>0.37</b>	<b>0.38</b>	<b>0.39</b>	<b>0.40</b>	<b>0.40</b>	<b>0.41</b>	<b>0.41</b>
<b>Median</b>	<b>0.34</b>	<b>0.34</b>	<b>0.35</b>	<b>0.35</b>	<b>0.36</b>	<b>0.35</b>	<b>0.38</b>	<b>0.38</b>	<b>0.40</b>	<b>0.41</b>	<b>0.41</b>	<b>0.42</b>

Notes: Results are for  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(REER_t) - x_t$  using Net Export Commodity Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.1.3: Period Average MSE Decomposition – Advanced Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.38	0.37	0.41	0.42	0.44	0.45	0.50	0.50	0.59	0.56	0.62	0.61
Austria	0.48	0.48	0.48	0.48	0.48	0.48	0.49	0.49	0.51	0.50	0.51	0.51
Belgium	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.38	0.36	0.39	0.37
Canada	0.40	0.39	0.42	0.42	0.44	0.45	0.44	0.45	0.46	0.46	0.47	0.48
Denmark	0.44	0.44	0.43	0.43	0.42	0.42	0.39	0.40	0.36	0.34	0.35	0.33
Finland	0.41	0.41	0.39	0.40	0.38	0.38	0.37	0.38	0.39	0.40	0.41	0.41
France	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.45	0.46
Germany	0.45	0.45	0.45	0.45	0.46	0.46	0.46	0.47	0.47	0.47	0.47	0.47
Ireland	0.41	0.41	0.40	0.40	0.38	0.38	0.37	0.36	0.36	0.36	0.38	0.38
Italy	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.45	0.44	0.46	0.45
Japan	0.46	0.46	0.46	0.47	0.46	0.46	0.47	0.47	0.53	0.47	0.56	0.51
Netherlands	0.28	0.29	0.26	0.25	0.24	0.23	0.22	0.19	0.21	0.19	0.20	0.18
New Zealand	0.27	0.27	0.27	0.27	0.27	0.27	0.26	0.27	0.26	0.27	0.25	0.26
Norway	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
UK	0.07	0.08	0.06	0.06	0.06	0.05	0.05	0.04	0.05	0.04	0.04	0.04
Czech Republic	0.36	0.36	0.36	0.36	0.36	0.36	0.32	0.35	0.28	0.28	0.26	0.25
<b>Average</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.38</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.40</b>	<b>0.39</b>
<b>Median</b>	<b>0.41</b>	<b>0.41</b>	<b>0.42</b>	<b>0.42</b>	<b>0.43</b>	<b>0.43</b>	<b>0.41</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.43</b>	<b>0.43</b>

Notes: Results are for  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(REER_t) - x_t$  using Net Export Commodity Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.1.4: Period Average MSE Decomposition – Emerging Market Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.12	0.12	0.12	0.11	0.11	0.11	0.12	0.11	0.14	0.12	0.15	0.12
Colombia	0.43	0.43	0.45	0.46	0.46	0.48	0.49	0.49	0.53	0.51	0.55	0.54
Costa Rica	0.35	0.34	0.33	0.34	0.33	0.34	0.36	0.36	0.36	0.37	0.34	0.35
Hungary	0.12	0.13	0.12	0.13	0.11	0.12	0.09	0.09	0.07	0.06	0.06	0.05
Malaysia	0.37	0.37	0.39	0.39	0.41	0.42	0.43	0.44	0.42	0.44	0.41	0.42
Mexico	0.33	0.34	0.32	0.33	0.32	0.31	0.34	0.33	0.37	0.37	0.39	0.39
Morocco	0.50	0.49	0.50	0.50	0.51	0.51	0.52	0.52	0.52	0.53	0.53	0.53
Paraguay	0.29	0.30	0.31	0.31	0.32	0.32	0.30	0.30	0.27	0.28	0.25	0.26
Philippines	0.41	0.40	0.39	0.40	0.38	0.37	0.36	0.35	0.37	0.36	0.37	0.36
Thailand	0.32	0.31	0.30	0.31	0.30	0.30	0.32	0.31	0.36	0.33	0.36	0.35
Turkey	0.30	0.29	0.32	0.33	0.33	0.34	0.33	0.34	0.32	0.33	0.34	0.33
South Africa	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.17	0.18	0.18	0.17	0.17
<b>Average</b>	<b>0.31</b>	<b>0.31</b>	<b>0.31</b>	<b>0.32</b>	<b>0.31</b>	<b>0.32</b>	<b>0.32</b>	<b>0.32</b>	<b>0.33</b>	<b>0.32</b>	<b>0.33</b>	<b>0.32</b>
<b>Median</b>	<b>0.32</b>	<b>0.32</b>	<b>0.32</b>	<b>0.33</b>	<b>0.32</b>	<b>0.33</b>	<b>0.34</b>	<b>0.33</b>	<b>0.36</b>	<b>0.34</b>	<b>0.35</b>	<b>0.35</b>

Notes: Results are for  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(REER_t) - x_t$  using Net Export Commodity Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.1.5: Period Average MSE Decomposition – Advanced Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.48	0.49	0.46	0.45	0.44	0.43	0.40	0.39	0.37	0.35	0.37	0.35
Austria	0.61	0.62	0.61	0.61	0.62	0.62	0.64	0.65	0.63	0.63	0.59	0.62
Belgium	0.48	0.48	0.47	0.46	0.47	0.46	0.45	0.45	0.46	0.45	0.47	0.46
Canada	0.45	0.45	0.43	0.43	0.42	0.42	0.41	0.40	0.40	0.39	0.40	0.39
Denmark	0.52	0.52	0.53	0.53	0.55	0.54	0.59	0.60	0.58	0.59	0.57	0.56
Finland	0.57	0.57	0.58	0.57	0.60	0.58	0.63	0.66	0.63	0.63	0.62	0.63
France	0.56	0.55	0.56	0.55	0.58	0.58	0.58	0.58	0.56	0.55	0.55	0.55
Germany	0.54	0.54	0.54	0.54	0.55	0.55	0.55	0.55	0.54	0.53	0.51	0.53
Ireland	0.60	0.60	0.62	0.61	0.64	0.64	0.66	0.66	0.64	0.64	0.64	0.64
Italy	0.53	0.53	0.53	0.53	0.54	0.54	0.56	0.55	0.55	0.54	0.53	0.53
Japan	0.57	0.58	0.57	0.57	0.58	0.58	0.59	0.59	0.60	0.60	0.59	0.60
Netherlands	0.53	0.52	0.54	0.53	0.55	0.54	0.56	0.56	0.54	0.54	0.52	0.53
New Zealand	0.53	0.52	0.53	0.52	0.55	0.54	0.59	0.59	0.60	0.60	0.60	0.59
Norway	0.46	0.46	0.46	0.46	0.47	0.47	0.49	0.51	0.49	0.49	0.48	0.48
UK	0.48	0.48	0.49	0.48	0.50	0.49	0.51	0.52	0.51	0.51	0.51	0.51
Czech Republic	0.51	0.51	0.48	0.46	0.46	0.45	0.39	0.43	0.31	0.34	0.29	0.26
<b>Average</b>	<b>0.52</b>	<b>0.53</b>	<b>0.52</b>	<b>0.52</b>	<b>0.53</b>	<b>0.53</b>	<b>0.54</b>	<b>0.54</b>	<b>0.52</b>	<b>0.52</b>	<b>0.52</b>	<b>0.51</b>
<b>Median</b>	<b>0.53</b>	<b>0.52</b>	<b>0.53</b>	<b>0.53</b>	<b>0.55</b>	<b>0.54</b>	<b>0.56</b>	<b>0.56</b>	<b>0.54</b>	<b>0.54</b>	<b>0.53</b>	<b>0.53</b>

Notes: Results are for tradable goods measured as  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Export Commodity Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.1.6: Period Average MSE Decomposition – Emerging Market Economies**

Country	6months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.48	0.49	0.49	0.50	0.49	0.50	0.50	0.51	0.50	0.51	0.51	0.51
Colombia	0.48	0.48	0.47	0.46	0.47	0.47	0.49	0.48	0.51	0.50	0.52	0.51
Costa Rica	0.57	0.57	0.57	0.57	0.57	0.57	0.56	0.57	0.56	0.55	0.56	0.55
Hungary	0.46	0.46	0.45	0.44	0.45	0.45	0.44	0.44	0.44	0.43	0.43	0.43
Malaysia	0.48	0.48	0.47	0.47	0.45	0.45	0.43	0.41	0.43	0.43	0.43	0.43
Mexico	0.50	0.50	0.50	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.52
Morocco	0.46	0.46	0.46	0.46	0.47	0.46	0.48	0.46	0.47	0.46	0.47	0.46
Paraguay	0.67	0.66	0.66	0.65	0.65	0.63	0.65	0.64	0.65	0.64	0.64	0.64
Philippines	0.52	0.52	0.53	0.52	0.53	0.53	0.53	0.53	0.54	0.54	0.54	0.54
Thailand	0.53	0.54	0.53	0.52	0.51	0.51	0.46	0.47	0.45	0.46	0.47	0.47
Turkey	0.57	0.57	0.55	0.54	0.54	0.52	0.53	0.51	0.52	0.51	0.52	0.52
South Africa	0.57	0.58	0.57	0.58	0.58	0.59	0.58	0.59	0.59	0.59	0.60	0.60
<b>Average</b>	<b>0.52</b>	<b>0.53</b>	<b>0.52</b>	<b>0.52</b>	<b>0.52</b>	<b>0.52</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.52</b>	<b>0.51</b>
<b>Median</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>	<b>0.51</b>

Notes: Results are for tradable goods measured as  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Export Commodity Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.1.7: Period Average MSE Decomposition – Advanced Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.28	0.27	0.29	0.28
Austria	0.28	0.27	0.27	0.26	0.26	0.26	0.24	0.24	0.24	0.24	0.25	0.24
Belgium	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.40	0.39	0.41	0.39
Canada	0.38	0.38	0.37	0.38	0.37	0.37	0.35	0.35	0.35	0.35	0.36	0.36
Denmark	0.38	0.39	0.37	0.37	0.36	0.35	0.35	0.34	0.36	0.36	0.36	0.35
Finland	0.34	0.34	0.33	0.32	0.32	0.32	0.30	0.31	0.30	0.30	0.31	0.31
France	0.31	0.31	0.31	0.31	0.30	0.30	0.30	0.30	0.31	0.31	0.31	0.31
Germany	0.32	0.32	0.32	0.32	0.32	0.32	0.31	0.31	0.33	0.32	0.33	0.32
Ireland	0.30	0.30	0.29	0.29	0.29	0.28	0.27	0.28	0.29	0.28	0.30	0.29
Italy	0.38	0.39	0.37	0.37	0.37	0.36	0.35	0.35	0.36	0.36	0.36	0.36
Japan	0.40	0.40	0.39	0.40	0.38	0.39	0.38	0.38	0.42	0.39	0.45	0.40
Netherlands	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.39	0.38	0.38	0.38
New Zealand	0.22	0.22	0.21	0.21	0.20	0.20	0.17	0.17	0.18	0.19	0.19	0.20
Norway	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.40	0.40	0.40	0.40
UK	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.42	0.42	0.42	0.42
Czech Republic	0.29	0.29	0.30	0.30	0.29	0.29	0.27	0.29	0.25	0.25	0.25	0.24
<b>Average</b>	<b>0.34</b>	<b>0.34</b>	<b>0.34</b>	<b>0.34</b>	<b>0.33</b>	<b>0.33</b>	<b>0.32</b>	<b>0.32</b>	<b>0.33</b>	<b>0.33</b>	<b>0.34</b>	<b>0.33</b>
<b>Median</b>	<b>0.36</b>	<b>0.36</b>	<b>0.35</b>	<b>0.35</b>	<b>0.34</b>	<b>0.33</b>	<b>0.33</b>	<b>0.33</b>	<b>0.34</b>	<b>0.33</b>	<b>0.34</b>	<b>0.34</b>

Notes: Results are for tradable goods measured as  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Export Commodity Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.1.8: Period Average MSE Decomposition – Emerging Market Economies**

Country	6months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.13	0.14	0.14	0.16	0.15	0.16	0.15	0.16	0.17	0.16	0.17	0.16
Colombia	0.37	0.37	0.35	0.35	0.33	0.33	0.30	0.29	0.30	0.29	0.29	0.28
Costa Rica	0.43	0.43	0.38	0.40	0.36	0.35	0.36	0.35	0.34	0.33	0.33	0.32
Hungary	0.28	0.28	0.28	0.28	0.27	0.28	0.25	0.27	0.24	0.25	0.25	0.25
Malaysia	0.40	0.40	0.39	0.40	0.38	0.38	0.37	0.35	0.37	0.37	0.37	0.36
Mexico	0.41	0.41	0.40	0.40	0.39	0.39	0.38	0.38	0.40	0.40	0.40	0.40
Morocco	0.36	0.36	0.36	0.36	0.37	0.37	0.36	0.36	0.35	0.36	0.36	0.36
Paraguay	0.26	0.26	0.25	0.24	0.25	0.24	0.22	0.24	0.20	0.20	0.19	0.16
Philippines	0.38	0.38	0.37	0.38	0.36	0.36	0.34	0.33	0.34	0.34	0.35	0.35
Thailand	0.34	0.34	0.33	0.33	0.32	0.33	0.30	0.29	0.31	0.30	0.33	0.32
Turkey	0.27	0.27	0.28	0.30	0.29	0.30	0.27	0.29	0.25	0.25	0.29	0.25
South Africa	0.25	0.24	0.25	0.26	0.25	0.24	0.25	0.24	0.28	0.26	0.29	0.26
<b>Average</b>	<b>0.32</b>	<b>0.32</b>	<b>0.32</b>	<b>0.32</b>	<b>0.31</b>	<b>0.31</b>	<b>0.30</b>	<b>0.30</b>	<b>0.30</b>	<b>0.29</b>	<b>0.30</b>	<b>0.29</b>
<b>Median</b>	<b>0.35</b>	<b>0.35</b>	<b>0.34</b>	<b>0.34</b>	<b>0.33</b>	<b>0.33</b>	<b>0.30</b>	<b>0.29</b>	<b>0.30</b>	<b>0.29</b>	<b>0.31</b>	<b>0.30</b>

Notes: Results are for tradable goods measured as  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Export Commodity Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizons. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.1.9: Period Average MSE Decomposition – Advanced Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.33	0.33	0.33	0.34	0.33	0.34	0.34	0.34	0.41	0.34	0.43	0.36
Austria	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Belgium	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.48	0.49	0.48	0.49	0.48
Canada	0.44	0.44	0.45	0.44	0.45	0.45	0.44	0.44	0.45	0.45	0.46	0.45
Denmark	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Finland	0.42	0.41	0.41	0.41	0.41	0.41	0.40	0.39	0.39	0.39	0.38	0.38
France	0.43	0.44	0.43	0.44	0.43	0.43	0.43	0.43	0.44	0.44	0.43	0.44
Germany	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.44	0.43
Ireland	0.39	0.39	0.39	0.39	0.40	0.39	0.40	0.40	0.42	0.41	0.42	0.41
Italy	0.44	0.44	0.44	0.44	0.44	0.44	0.43	0.43	0.44	0.43	0.44	0.44
Japan	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.34	0.34	0.34	0.34
Netherlands	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.47	0.47	0.48	0.48
New Zealand	0.32	0.30	0.31	0.29	0.30	0.29	0.29	0.29	0.31	0.29	0.32	0.29
Norway	0.50	0.50	0.50	0.51	0.50	0.50	0.50	0.51	0.51	0.51	0.51	0.51
UK	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Czech Republic	0.41	0.41	0.41	0.41	0.41	0.41	0.39	0.41	0.36	0.39	0.35	0.37
<b>Average</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.42</b>	<b>0.43</b>	<b>0.42</b>
<b>Median</b>	<b>0.44</b>	<b>0.44</b>	<b>0.44</b>	<b>0.44</b>	<b>0.44</b>	<b>0.44</b>	<b>0.43</b>	<b>0.43</b>	<b>0.44</b>	<b>0.44</b>	<b>0.44</b>	<b>0.44</b>

Notes: Results are for tradable goods measured as  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(REER_t) - x_t$  using Export Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.2.0: Period Average MSE Decomposition – Emerging Market Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.28	0.29	0.30	0.31	0.32	0.32	0.36	0.37	0.40	0.41	0.41	0.46
Colombia	0.49	0.49	0.51	0.52	0.53	0.54	0.58	0.59	0.61	0.63	0.62	0.66
Costa Rica	0.40	0.39	0.39	0.39	0.40	0.39	0.43	0.42	0.48	0.47	0.51	0.49
Hungary	0.52	0.52	0.53	0.54	0.53	0.53	0.55	0.54	0.57	0.55	0.57	0.58
Malaysia	0.49	0.49	0.51	0.50	0.52	0.52	0.54	0.55	0.54	0.55	0.54	0.54
Mexico	0.46	0.46	0.46	0.47	0.47	0.47	0.48	0.48	0.49	0.49	0.50	0.50
Morocco	0.47	0.47	0.47	0.47	0.47	0.47	0.46	0.47	0.44	0.44	0.44	0.43
Paraguay	0.34	0.35	0.37	0.37	0.39	0.40	0.41	0.43	0.48	0.44	0.51	0.45
Philippines	0.41	0.42	0.42	0.42	0.42	0.42	0.44	0.43	0.47	0.47	0.48	0.48
Thailand	0.43	0.44	0.44	0.44	0.46	0.44	0.50	0.50	0.52	0.53	0.52	0.54
Turkey	0.31	0.30	0.35	0.36	0.37	0.39	0.40	0.41	0.43	0.42	0.42	0.42
South Africa	0.37	0.38	0.39	0.41	0.41	0.43	0.44	0.45	0.45	0.46	0.44	0.45
<b>Average</b>	<b>0.42</b>	<b>0.42</b>	<b>0.43</b>	<b>0.43</b>	<b>0.44</b>	<b>0.44</b>	<b>0.47</b>	<b>0.47</b>	<b>0.49</b>	<b>0.49</b>	<b>0.50</b>	<b>0.50</b>
<b>Median</b>	<b>0.42</b>	<b>0.43</b>	<b>0.43</b>	<b>0.43</b>	<b>0.44</b>	<b>0.44</b>	<b>0.45</b>	<b>0.46</b>	<b>0.48</b>	<b>0.47</b>	<b>0.50</b>	<b>0.49</b>

Notes: Results are for tradable goods measured as  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(REER_t) - x_t$  using Export Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon estimated using formula in equation 3.6. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.2.1: Period Average MSE Decomposition – Advanced Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.50	0.50	0.52	0.54	0.55	0.55	0.58	0.59	0.62	0.63	0.63	0.65
Austria	0.49	0.49	0.50	0.50	0.50	0.50	0.50	0.50	0.49	0.50	0.48	0.49
Belgium	0.50	0.50	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Canada	0.53	0.53	0.54	0.54	0.56	0.56	0.58	0.59	0.59	0.60	0.58	0.60
Denmark	0.49	0.49	0.49	0.50	0.49	0.49	0.48	0.49	0.48	0.48	0.48	0.48
Finland	0.47	0.48	0.47	0.47	0.46	0.47	0.45	0.43	0.44	0.43	0.43	0.43
France	0.50	0.50	0.50	0.50	0.50	0.50	0.51	0.50	0.51	0.51	0.51	0.51
Germany	0.50	0.50	0.50	0.50	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Ireland	0.46	0.46	0.46	0.46	0.45	0.45	0.44	0.45	0.46	0.46	0.46	0.46
Italy	0.49	0.48	0.49	0.48	0.48	0.48	0.48	0.48	0.49	0.48	0.48	0.48
Japan	0.39	0.39	0.39	0.39	0.39	0.39	0.38	0.39	0.37	0.37	0.36	0.37
Netherlands	0.50	0.50	0.49	0.50	0.49	0.49	0.50	0.50	0.50	0.50	0.51	0.51
New Zealand	0.43	0.43	0.46	0.49	0.47	0.49	0.45	0.44	0.46	0.47	0.46	0.48
Norway	0.53	0.53	0.54	0.54	0.53	0.53	0.53	0.54	0.53	0.54	0.53	0.53
UK	0.50	0.50	0.50	0.50	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Czech Republic	0.52	0.53	0.53	0.53	0.53	0.53	0.55	0.54	0.56	0.55	0.56	0.55
<b>Average</b>	<b>0.49</b>	<b>0.49</b>	<b>0.49</b>	<b>0.50</b>	<b>0.49</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>
<b>Median</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>	<b>0.50</b>	<b>0.49</b>	<b>0.49</b>	<b>0.49</b>	<b>0.49</b>	<b>0.49</b>	<b>0.49</b>	<b>0.49</b>	<b>0.49</b>

Notes: Results are for tradable goods measured as  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(REER_t) - x_t$  using Export Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon estimated using formula in equation 3.6. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.2.2: Period Average MSE Decomposition – Emerging Market Economies**

Country	6 months		12 months		24 months		60 months		180 months		300 months	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.46	0.47	0.48	0.48	0.48	0.49	0.49	0.50	0.49	0.50	0.50	0.50
Colombia	0.39	0.39	0.39	0.39	0.38	0.38	0.37	0.37	0.38	0.38	0.39	0.39
Costa Rica	0.36	0.35	0.36	0.35	0.36	0.35	0.39	0.39	0.41	0.43	0.42	0.44
Hungary	0.41	0.42	0.43	0.42	0.44	0.44	0.47	0.48	0.52	0.51	0.54	0.54
Malaysia	0.43	0.44	0.44	0.44	0.44	0.45	0.45	0.45	0.46	0.46	0.45	0.45
Mexico	0.41	0.41	0.41	0.41	0.41	0.41	0.42	0.41	0.44	0.44	0.45	0.46
Morocco	0.46	0.46	0.46	0.46	0.46	0.47	0.46	0.46	0.44	0.45	0.43	0.45
Paraguay	0.33	0.33	0.34	0.33	0.35	0.34	0.35	0.36	0.36	0.37	0.37	0.37
Philippines	0.35	0.35	0.35	0.35	0.35	0.35	0.36	0.35	0.37	0.36	0.39	0.36
Thailand	0.35	0.35	0.34	0.34	0.34	0.35	0.36	0.35	0.38	0.36	0.39	0.38
Turkey	0.34	0.32	0.37	0.38	0.40	0.41	0.43	0.48	0.45	0.49	0.46	0.49
South Africa	0.30	0.30	0.30	0.30	0.30	0.30	0.31	0.31	0.34	0.32	0.35	0.34
<b>Average</b>	<b>0.38</b>	<b>0.38</b>	<b>0.39</b>	<b>0.39</b>	<b>0.39</b>	<b>0.40</b>	<b>0.41</b>	<b>0.41</b>	<b>0.42</b>	<b>0.42</b>	<b>0.43</b>	<b>0.43</b>
<b>Median</b>	<b>0.38</b>	<b>0.37</b>	<b>0.38</b>	<b>0.38</b>	<b>0.39</b>	<b>0.39</b>	<b>0.41</b>	<b>0.40</b>	<b>0.42</b>	<b>0.44</b>	<b>0.43</b>	<b>0.45</b>

Notes: Results are for tradable goods measured as  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(REER_t) - x_t$  using Export Price Index. Figures are the monthly average of the MSE decompositions across 6-months, 1-year, 2-years, 5-years, 15-years and 25-years horizon estimated using formula in equation 3.6. Data used for the MSE decomposition are in levels. Sample period is 1985M1-2019M12.

**Table C2.2.3: Quarterly Period Average MSE Decomposition – Advanced Economies**

Country	4 Quarters		12 Quarters		20 Quarters		60 Quarters		80 Quarters		120 Quarters	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.58	0.58	0.55	0.54	0.53	0.53	0.45	0.44	0.45	0.45	0.47	0.48
Austria	0.74	0.75	0.75	0.76	0.75	0.76	0.72	0.74	0.71	0.74	0.72	0.74
Belgium	0.87	0.87	0.87	0.88	0.87	0.87	0.83	0.87	0.83	0.87	0.83	0.87
Canada	0.54	0.53	0.56	0.55	0.57	0.57	0.56	0.57	0.53	0.56	0.55	0.58
Denmark	0.83	0.85	0.86	0.88	0.87	0.89	0.87	0.89	0.87	0.89	0.87	0.88
Finland	0.79	0.80	0.80	0.80	0.79	0.80	0.73	0.75	0.73	0.73	0.73	0.73
France	0.73	0.74	0.74	0.74	0.74	0.74	0.71	0.72	0.71	0.71	0.72	0.72
Germany	0.73	0.73	0.74	0.74	0.74	0.74	0.71	0.73	0.70	0.73	0.71	0.73
Ireland	0.76	0.76	0.76	0.77	0.76	0.77	0.75	0.75	0.74	0.75	0.74	0.75
Italy	0.72	0.72	0.71	0.71	0.71	0.71	0.67	0.68	0.66	0.66	0.66	0.66
Japan	0.58	0.58	0.59	0.59	0.58	0.59	0.52	0.55	0.51	0.54	0.51	0.52
Netherlands	0.94	0.95	0.94	0.95	0.94	0.94	0.90	0.93	0.89	0.92	0.87	0.91
New Zealand	0.77	0.77	0.75	0.74	0.74	0.74	0.70	0.69	0.70	0.69	0.69	0.68
Norway	0.49	0.47	0.52	0.53	0.53	0.54	0.52	0.53	0.52	0.52	0.52	0.52
UK	0.94	0.95	0.94	0.95	0.94	0.95	0.93	0.93	0.93	0.93	0.93	0.93
Czech Republic	0.74	0.74	0.75	0.75	0.77	0.76	0.80	0.81	0.81	0.82	0.81	0.82
<b>Average</b>	<b>0.73</b>	<b>0.74</b>	<b>0.74</b>	<b>0.74</b>	<b>0.74</b>	<b>0.74</b>	<b>0.71</b>	<b>0.72</b>	<b>0.71</b>	<b>0.72</b>	<b>0.71</b>	<b>0.72</b>
<b>Median</b>	<b>0.74</b>	<b>0.74</b>	<b>0.75</b>	<b>0.74</b>	<b>0.74</b>	<b>0.74</b>	<b>0.71</b>	<b>0.73</b>	<b>0.71</b>	<b>0.73</b>	<b>0.72</b>	<b>0.73</b>

Notes: Results are for  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Net Export Commodity Price Index. Figures are the quarterly average of the MSE decompositions across 4; 12; 20; 60; 80; and 120-quarters horizon. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2019Q4.

**Table C2.2.4: Quarterly Period Average MSE Decomposition – Advanced Economies**

Country	4 Quarters		12 Quarters		20 Quarters		60 Quarters		80 Quarters		120 Quarters	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.50	0.50	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Colombia	0.53	0.52	0.54	0.54	0.55	0.55	0.56	0.57	0.56	0.57	0.56	0.57
Costa Rica	0.62	0.62	0.60	0.61	0.60	0.60	0.58	0.56	0.58	0.56	0.58	0.56
Hungary	0.71	0.73	0.66	0.63	0.65	0.62	0.58	0.57	0.57	0.56	0.56	0.56
Malaysia	0.60	0.61	0.60	0.60	0.59	0.59	0.58	0.59	0.58	0.58	0.58	0.58
Mexico	0.55	0.55	0.54	0.55	0.54	0.54	0.53	0.52	0.53	0.52	0.53	0.52
Morocco	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.61	0.62	0.57	0.62
Paraguay	0.67	0.68	0.68	0.68	0.67	0.68	0.66	0.67	0.66	0.67	0.66	0.66
Philippines	0.61	0.62	0.61	0.62	0.61	0.62	0.59	0.60	0.59	0.60	0.59	0.58
Thailand	0.76	0.77	0.77	0.77	0.77	0.77	0.76	0.77	0.75	0.77	0.75	0.77
Turkey	0.58	0.58	0.56	0.55	0.56	0.54	0.54	0.53	0.54	0.53	0.54	0.53
South Africa	0.78	0.78	0.76	0.77	0.75	0.76	0.70	0.68	0.70	0.67	0.69	0.66
<b>Average</b>	<b>0.63</b>	<b>0.63</b>	<b>0.62</b>	<b>0.62</b>	<b>0.62</b>	<b>0.62</b>	<b>0.60</b>	<b>0.60</b>	<b>0.60</b>	<b>0.60</b>	<b>0.59</b>	<b>0.59</b>
<b>Median</b>	<b>0.62</b>	<b>0.62</b>	<b>0.61</b>	<b>0.62</b>	<b>0.61</b>	<b>0.62</b>	<b>0.58</b>	<b>0.59</b>	<b>0.58</b>	<b>0.58</b>	<b>0.58</b>	<b>0.58</b>

Notes: Results are for  $x_t = s_t + \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Net Export Commodity Price Index. Figures are the quarterly average of the MSE decompositions across 4; 12; 20; 60; 80; and 120-quarters horizon. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2019Q4.

**Table C2.2.5: Quarterly Period Average MSE Decomposition – Advanced Economies**

Country	4 Quarters		12 Quarters		20 Quarters		60 Quarters		80 Quarters		120 Quarters	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.19	0.19	0.18	0.18	0.18	0.18	0.20	0.19	0.20	0.19	0.20	0.19
Austria	0.31	0.32	0.29	0.27	0.29	0.27	0.32	0.32	0.33	0.32	0.35	0.33
Belgium	0.18	0.18	0.18	0.18	0.20	0.19	0.22	0.21	0.22	0.21	0.22	0.21
Canada	0.22	0.22	0.21	0.21	0.20	0.20	0.20	0.19	0.21	0.20	0.21	0.21
Denmark	0.14	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.10	0.09	0.09	0.09
Finland	0.25	0.26	0.23	0.22	0.23	0.23	0.29	0.26	0.30	0.27	0.30	0.27
France	0.32	0.33	0.29	0.27	0.28	0.26	0.31	0.30	0.32	0.31	0.32	0.31
Germany	0.31	0.32	0.29	0.27	0.28	0.27	0.31	0.31	0.32	0.31	0.33	0.32
Ireland	0.31	0.31	0.29	0.28	0.29	0.28	0.34	0.32	0.36	0.33	0.38	0.33
Italy	0.35	0.36	0.33	0.31	0.33	0.32	0.37	0.36	0.38	0.36	0.39	0.37
Japan	0.37	0.37	0.35	0.35	0.34	0.34	0.34	0.33	0.34	0.33	0.34	0.34
Netherlands	0.04	0.04	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.02
New Zealand	0.12	0.12	0.11	0.11	0.11	0.10	0.11	0.11	0.12	0.11	0.12	0.11
Norway	0.36	0.36	0.36	0.37	0.36	0.36	0.38	0.37	0.38	0.37	0.36	0.37
UK	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02
Czech Republic	0.39	0.40	0.40	0.40	0.41	0.40	0.52	0.50	0.55	0.52	0.55	0.52
<b>Average</b>	<b>0.24</b>	<b>0.24</b>	<b>0.23</b>	<b>0.22</b>	<b>0.23</b>	<b>0.22</b>	<b>0.25</b>	<b>0.24</b>	<b>0.26</b>	<b>0.25</b>	<b>0.26</b>	<b>0.25</b>
<b>Median</b>	<b>0.28</b>	<b>0.28</b>	<b>0.26</b>	<b>0.24</b>	<b>0.26</b>	<b>0.24</b>	<b>0.30</b>	<b>0.28</b>	<b>0.31</b>	<b>0.29</b>	<b>0.31</b>	<b>0.29</b>

Notes: Results are for  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Net Export Commodity Price Index. Figures are the quarterly average of the MSE decompositions across 4; 12; 20; 60; 80; and 120-quarters horizon. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2019Q4.

**Table C2.2.6: Quarterly Period Average MSE Decomposition – Advanced Economies**

Country	4 Quarters		12 Quarters		20 Quarters		60 Quarters		80 Quarters		120 Quarters	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.07	0.07	0.06	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Colombia	0.25	0.25	0.22	0.21	0.21	0.20	0.21	0.20	0.20	0.20	0.20	0.19
Costa Rica	0.30	0.28	0.31	0.32	0.31	0.31	0.29	0.29	0.29	0.29	0.26	0.28
Hungary	0.06	0.06	0.05	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
Malaysia	0.22	0.22	0.20	0.20	0.20	0.19	0.19	0.18	0.19	0.18	0.18	0.18
Mexico	0.25	0.26	0.24	0.23	0.24	0.23	0.27	0.26	0.27	0.27	0.26	0.25
Morocco	0.50	0.49	0.50	0.51	0.51	0.51	0.52	0.51	0.51	0.51	0.49	0.51
Paraguay	0.19	0.17	0.18	0.17	0.17	0.17	0.13	0.10	0.12	0.09	0.11	0.09
Philippines	0.43	0.43	0.42	0.41	0.41	0.41	0.40	0.40	0.42	0.40	0.46	0.41
Thailand	0.28	0.27	0.28	0.27	0.26	0.26	0.23	0.24	0.24	0.25	0.24	0.25
Turkey	0.40	0.42	0.43	0.46	0.47	0.46	0.52	0.49	0.51	0.49	0.51	0.49
South Africa	0.11	0.12	0.10	0.10	0.10	0.09	0.10	0.09	0.09	0.09	0.09	0.08
<b>Average</b>	<b>0.26</b>	<b>0.25</b>	<b>0.25</b>	<b>0.25</b>	<b>0.25</b>	<b>0.24</b>	<b>0.25</b>	<b>0.24</b>	<b>0.24</b>	<b>0.24</b>	<b>0.24</b>	<b>0.23</b>
<b>Median</b>	<b>0.25</b>	<b>0.25</b>	<b>0.23</b>	<b>0.22</b>	<b>0.22</b>	<b>0.21</b>	<b>0.22</b>	<b>0.22</b>	<b>0.22</b>	<b>0.22</b>	<b>0.22</b>	<b>0.22</b>

Notes: Results are for  $x_t = \ln(Pcom_t)$  and  $y_t = \ln(RER_t) - x_t$  using Net Export Commodity Price Index. Figures are the quarterly average of the MSE decompositions across 4; 12; 20; 60; 80; and 120-quarters horizon. Data used for the MSE decomposition are in levels. Sample period is 1985Q1-2019Q4.

**Table C3.2.1: Panel Unit root or Stationarity Results**

VARIABLES	IPS TEST		Fisher Type Unit Root Test (Augmented Dicky-Fuller)							
	NO TREND	CONST + T	NO TREND				CONST + T			
			P	Z	L*	Pm	P	Z	L*	Pm
<b>PANEL A: LEVELS</b>										
Pcom	0.4600	-0.9627	27.65	0.69	0.61	-1.91	43.59	-1.01	-0.89	-0.25
REER	-2.03**	-1.40	67.61**	-2.01**	-2.26**	2.25**	60.00	-1.38	-1.48	1.46
W. Interest	-1.99**	1.98	49.92	-2.01**	-1.79**	0.41	17.98	2.19	1.96	-2.92
RER	-7.16***	-5.00***	167.91***	-7.38***	-8.88***	12.71***	130.42***	-4.93***	-5.87***	8.80***
DPR	-1.43	-1.60	55.14	-1.41	-1.42	0.95	69.45**	-1.51	-1.95**	2.45***
CPI	8.67	3.13	87.72***	0.43	-0.31	4.35***	50.76	-0.39	-0.44	0.50
EXPR	-0.02	-1.35	44.75	-0.01	0.01	-0.13	58.56	-1.37	-1.32	1.31
IMPR	-1.71**	-4.68***	61.81	-1.74**	-1.78**	1.65**	115.12***	-4.65***	-5.46***	7.21***
Y	8.39	4.35	14.17	5.72	6.24	-3.32	15.94	4.39	4.43	-3.13
<b>PANEL B: FIRST DIFFERENCE</b>										
Pcom	-37.99***	-38.00***	1320.7***	-34.32***	-76.24***	132.9***	1148.4***	-31.77***	-66.29***	114.9***
REER	-42.57***	-43.34***	1476.3***	-36.49***	-85.22***	149.1***	1339.8***	-34.55***	-77.34***	134.8***
W. Interest	-41.55***	-41.84***	1491.5***	-36.81***	-86.10***	150.7***	1298.2***	-34.13***	-74.94***	130.5***
RER	-41.31***	-42.39***	1434.6***	-35.97***	-82.81***	144.7***	1311.4***	-34.22***	-75.71***	131.9***
DPR	-42.67***	-43.31***	1359.8***	-34.70***	-78.50***	136.9***	1249.0***	-33.0***	-72.10***	125.4***
CPI	-43.47***	-46.50***	1298.8***	-33.55***	-74.98***	130.6***	1279.5***	-33.37***	-73.86***	128.6***
EXPR	-42.45***	-43.17***	1366.2***	-34.86***	-78.87***	137.6***	1251.9***	-33.12***	-72.27***	125.7***
IMPR	-47.51***	-48.66***	1424.2***	-35.67***	-82.21***	143.7***	1321.7***	-34.13***	-76.29***	132.9***
Y	-35.81***	-36.39***	1073.2***	-30.04***	-61.95***	107.1***	974.3***	-28.23***	-56.24***	96.7***

Legend: \*\*\* (\*\*) denotes the rejection of the null hypothesis of a unit root or non-stationarity at 1% and (5%) significance level.

**Table C3.2.2: Share of Variances Explained by Export Commodity Price Shocks -AE**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.35	0.35	0.21	0.21	0.24	0.22	0.13	0.11
Canada	0.27	0.27	0.16	0.15	0.23	0.23	0.11	0.10
Germany	0.27	0.29	0.10	0.11	0.23	0.24	0.08	0.09
New Zealand	0.27	0.27	0.16	0.16	0.25	0.25	0.13	0.14
Norway	0.28	0.27	0.32	0.31	0.13	0.11	0.24	0.23
UK	0.20	0.22	0.02	0.02	0.18	0.19	0.02	0.03
<b>Mean</b>	<b>0.27</b>	<b>0.28</b>	<b>0.16</b>	<b>0.16</b>	<b>0.21</b>	<b>0.21</b>	<b>0.12</b>	<b>0.12</b>
<b>Median</b>	<b>0.27</b>	<b>0.27</b>	<b>0.16</b>	<b>0.16</b>	<b>0.23</b>	<b>0.22</b>	<b>0.12</b>	<b>0.11</b>

**Notes:** The figures presented are the median responses of each country to composite export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table C3.2.3: Share of Variances Explained by Export Commodity Price Shocks -EME**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.27	0.29	0.16	0.16	0.17	0.18	0.09	0.09
Costa Rica	0.00	0.00	0.03	0.04	0.03	0.04	0.05	0.06
Hungary	0.47	0.49	0.41	0.42	0.39	0.41	0.35	0.35
Mexico	0.24	0.24	0.19	0.19	0.17	0.16	0.17	0.18
South Africa	0.34	0.35	0.14	0.14	0.24	0.24	0.08	0.08
Turkey	0.18	0.19	0.00	0.00	0.09	0.09	0.01	0.01
<b>Mean</b>	<b>0.25</b>	<b>0.26</b>	<b>0.16</b>	<b>0.16</b>	<b>0.18</b>	<b>0.19</b>	<b>0.13</b>	<b>0.13</b>
<b>Median</b>	<b>0.26</b>	<b>0.27</b>	<b>0.15</b>	<b>0.15</b>	<b>0.17</b>	<b>0.17</b>	<b>0.09</b>	<b>0.09</b>

**Notes:** The figures presented are the median responses of each country to composite export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table C3.2.4: Share of Variances Explained by Common Export Commodity Price Shocks -AE**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.20	0.20	0.12	0.12	0.14	0.13	0.08	0.07
Canada	0.20	0.20	0.12	0.11	0.18	0.18	0.09	0.08
Germany	0.19	0.20	0.07	0.08	0.16	0.17	0.05	0.06
New Zealand	0.15	0.15	0.09	0.09	0.14	0.14	0.08	0.08
Norway	0.22	0.21	0.26	0.25	0.11	0.09	0.20	0.19
UK	0.16	0.17	0.02	0.02	0.14	0.16	0.02	0.02
<b>Mean</b>	<b>0.19</b>	<b>0.19</b>	<b>0.11</b>	<b>0.11</b>	<b>0.14</b>	<b>0.14</b>	<b>0.09</b>	<b>0.08</b>
<b>Median</b>	<b>0.19</b>	<b>0.20</b>	<b>0.10</b>	<b>0.10</b>	<b>0.14</b>	<b>0.15</b>	<b>0.08</b>	<b>0.07</b>

**Notes:** The figures presented are the median responses of each country to common export commodity price shocks (common shocks). RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table C3.2.5: Share of Variances Explained by Common Export Commodity Price Shocks -EME**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.15	0.16	0.09	0.09	0.10	0.10	0.05	0.05
Costa Rica	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02
Hungary	0.33	0.35	0.31	0.31	0.31	0.32	0.27	0.27
Mexico	0.18	0.18	0.14	0.14	0.11	0.11	0.11	0.11
South Africa	0.21	0.22	0.09	0.09	0.15	0.16	0.05	0.05
Turkey	0.16	0.17	0.00	0.00	0.08	0.08	0.01	0.01
<b>Mean</b>	<b>0.17</b>	<b>0.18</b>	<b>0.10</b>	<b>0.11</b>	<b>0.13</b>	<b>0.13</b>	<b>0.08</b>	<b>0.09</b>
<b>Median</b>	<b>0.17</b>	<b>0.18</b>	<b>0.09</b>	<b>0.09</b>	<b>0.11</b>	<b>0.11</b>	<b>0.05</b>	<b>0.05</b>

**Notes:** The figures presented are the median responses of each country to common export commodity price shocks (common shocks). RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table C3.2.6: Share of Variances Explained by Idiosyncratic Export Commodity Price Shocks -AE**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.15	0.15	0.09	0.09	0.09	0.09	0.05	0.05
Canada	0.07	0.07	0.04	0.04	0.05	0.05	0.02	0.02
Germany	0.08	0.09	0.03	0.03	0.06	0.07	0.02	0.03
New Zealand	0.12	0.13	0.07	0.07	0.11	0.11	0.05	0.05
Norway	0.06	0.06	0.07	0.06	0.02	0.02	0.04	0.04
UK	0.04	0.04	0.00	0.00	0.04	0.04	0.00	0.01
<b>Mean</b>	<b>0.09</b>	<b>0.09</b>	<b>0.05</b>	<b>0.05</b>	<b>0.06</b>	<b>0.06</b>	<b>0.03</b>	<b>0.03</b>
<b>Median</b>	<b>0.08</b>	<b>0.08</b>	<b>0.05</b>	<b>0.05</b>	<b>0.06</b>	<b>0.06</b>	<b>0.03</b>	<b>0.03</b>

**Notes:** The figures presented are the median responses of each country to idiosyncratic export commodity price shocks (Idiosyncratic shocks). RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table C3.2.7: Share of Variances Explained by Idiosyncratic Export Commodity Price Shocks -EME**

Country	Levels				Cyclical Component			
	RER		REER		rer		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.12	0.12	0.07	0.07	0.08	0.08	0.04	0.04
Costa Rica	0.00	0.00	0.02	0.03	0.02	0.03	0.03	0.04
Hungary	0.13	0.14	0.11	0.11	0.08	0.09	0.08	0.08
Mexico	0.06	0.06	0.05	0.05	0.05	0.05	0.06	0.06
South Africa	0.13	0.14	0.06	0.06	0.08	0.09	0.03	0.03
Turkey	0.02	0.02	0.00	0.00	0.01	0.01	0.00	0.00
<b>Mean</b>	<b>0.08</b>	<b>0.08</b>	<b>0.05</b>	<b>0.05</b>	<b>0.05</b>	<b>0.06</b>	<b>0.04</b>	<b>0.04</b>
<b>Median</b>	<b>0.09</b>	<b>0.09</b>	<b>0.06</b>	<b>0.06</b>	<b>0.06</b>	<b>0.06</b>	<b>0.04</b>	<b>0.04</b>

**Notes:** The figures presented are the median responses of each country to idiosyncratic export commodity price shocks (Idiosyncratic shocks). RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the HP filter with a smoothing parameter of 1,600. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table 3.2.8: FEVDs – Estimated Using the Hamilton Filter – Composite Shocks-EME**

Country	Levels				Cyclical Component			
	RER		REER		RER		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.13	0.13	0.06	0.06	0.13	0.13	0.06	0.05
Costa Rica	0.04	0.04	0.21	0.21	0.10	0.11	0.25	0.25
Hungary	0.45	0.48	0.38	0.39	0.37	0.41	0.35	0.35
Mexico	0.29	0.30	0.17	0.18	0.18	0.19	0.13	0.13
South Africa	0.41	0.43	0.19	0.19	0.41	0.45	0.27	0.27
Turkey	0.10	0.10	0.00	0.00	0.10	0.11	0.02	0.02
<b>Mean</b>	<b>0.24</b>	<b>0.25</b>	<b>0.17</b>	<b>0.17</b>	<b>0.22</b>	<b>0.23</b>	<b>0.18</b>	<b>0.18</b>
<b>Median</b>	<b>0.21</b>	<b>0.22</b>	<b>0.18</b>	<b>0.19</b>	<b>0.15</b>	<b>0.16</b>	<b>0.19</b>	<b>0.19</b>
<i>CI_lower bound</i>	<i>0.22</i>	<i>0.19</i>	<i>0.16</i>	<i>0.17</i>	<i>0.18</i>	<i>0.13</i>	<i>0.17</i>	<i>0.18</i>
<i>CI_upper bound</i>	<i>0.26</i>	<i>0.22</i>	<i>0.18</i>	<i>0.19</i>	<i>0.40</i>	<i>0.28</i>	<i>0.35</i>	<i>0.38</i>

**Notes:** The figures presented are the mean and median responses of each country to composite Net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the Hamilton filter. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table 3.2.9: FEVDs – Estimated Using the Hamilton Filter – Composite Shocks-AE**

Country	Levels				Cyclical Component			
	RER		REER		RER		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.19	0.19	0.08	0.06	0.13	0.11	0.08	0.07
Canada	0.31	0.31	0.18	0.18	0.18	0.17	0.09	0.08
Germany	0.21	0.22	0.08	0.08	0.20	0.21	0.09	0.10
New Zealand	0.12	0.12	0.03	0.02	0.13	0.11	0.10	0.08
Norway	0.36	0.36	0.38	0.38	0.25	0.25	0.23	0.23
UK	0.21	0.23	0.02	0.02	0.21	0.23	0.04	0.04
<b>Mean</b>	<b>0.24</b>	<b>0.24</b>	<b>0.13</b>	<b>0.13</b>	<b>0.18</b>	<b>0.18</b>	<b>0.11</b>	<b>0.10</b>
<b>Median</b>	<b>0.21</b>	<b>0.23</b>	<b>0.08</b>	<b>0.07</b>	<b>0.19</b>	<b>0.19</b>	<b>0.09</b>	<b>0.08</b>
<i>CI_lower bound</i>	<i>0.22</i>	<i>0.19</i>	<i>0.12</i>	<i>0.06</i>	<i>0.17</i>	<i>0.17</i>	<i>0.09</i>	<i>0.07</i>
<i>CI_upper bound</i>	<i>0.25</i>	<i>0.23</i>	<i>0.14</i>	<i>0.09</i>	<i>0.20</i>	<i>0.21</i>	<i>0.12</i>	<i>0.11</i>

**Notes:** The figures presented are the mean and median responses of each country to composite Net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the Hamilton filter. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table 3.3.0: FEVDs – Estimated Using the Hamilton Filter – Common Shocks-EME**

Country	Levels				Cyclical Component			
	RER		REER		RER		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.11	0.11	0.05	0.05	0.12	0.11	0.05	0.04
Costa Rica	0.03	0.03	0.18	0.18	0.10	0.10	0.24	0.23
Hungary	0.37	0.39	0.33	0.35	0.36	0.39	0.29	0.30
Mexico	0.26	0.27	0.14	0.14	0.16	0.16	0.11	0.11
South Africa	0.33	0.34	0.15	0.15	0.36	0.36	0.22	0.22
Turkey	0.09	0.10	0.00	0.00	0.10	0.10	0.02	0.02
<b>Mean</b>	<b>0.20</b>	<b>0.21</b>	<b>0.14</b>	<b>0.15</b>	<b>0.20</b>	<b>0.21</b>	<b>0.16</b>	<b>0.15</b>
<b>Median</b>	<b>0.20</b>	<b>0.21</b>	<b>0.15</b>	<b>0.15</b>	<b>0.16</b>	<b>0.16</b>	<b>0.16</b>	<b>0.15</b>
<i>CI lower bound</i>	<i>0.19</i>	<i>0.19</i>	<i>0.14</i>	<i>0.14</i>	<i>0.19</i>	<i>0.16</i>	<i>0.15</i>	<i>0.16</i>
<i>CI upper bound</i>	<i>0.22</i>	<i>0.22</i>	<i>0.16</i>	<i>0.16</i>	<i>0.21</i>	<i>0.16</i>	<i>0.16</i>	<i>0.16</i>

**Notes:** The figures presented are the mean and median responses of each country to composite Net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the Hamilton filter. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table 3.3.1: FEVDs – Estimated Using the Hamilton Filter – Common Shocks-AE**

Country	Levels				Cyclical Component			
	RER		REER		RER		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.16	0.16	0.07	0.05	0.11	0.10	0.07	0.06
Canada	0.25	0.25	0.15	0.14	0.15	0.14	0.08	0.06
Germany	0.16	0.16	0.06	0.06	0.15	0.16	0.07	0.07
New Zealand	0.10	0.10	0.02	0.02	0.09	0.08	0.07	0.06
Norway	0.26	0.27	0.29	0.29	0.18	0.18	0.17	0.17
UK	0.18	0.19	0.02	0.02	0.18	0.19	0.03	0.03
<b>Mean</b>	<b>0.19</b>	<b>0.19</b>	<b>0.10</b>	<b>0.10</b>	<b>0.14</b>	<b>0.14</b>	<b>0.08</b>	<b>0.08</b>
<b>Median</b>	<b>0.17</b>	<b>0.18</b>	<b>0.06</b>	<b>0.06</b>	<b>0.15</b>	<b>0.15</b>	<b>0.07</b>	<b>0.06</b>
<i>CI lower bound</i>	<i>0.18</i>	<i>0.16</i>	<i>0.09</i>	<i>0.06</i>	<i>0.13</i>	<i>0.13</i>	<i>0.07</i>	<i>0.06</i>
<i>CI upper bound</i>	<i>0.19</i>	<i>0.19</i>	<i>0.11</i>	<i>0.08</i>	<i>0.16</i>	<i>0.16</i>	<i>0.09</i>	<i>0.09</i>

**Notes:** The figures presented are the mean and median responses of each country to composite Net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the Hamilton filter. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table 3.3.2: FEVDs – Estimated Using the Hamilton Filter – Idiosyncratic Shocks-EME**

Country	Levels				Cyclical Component			
	RER		REER		RER		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Brazil	0.02	0.02	0.01	0.01	0.02	0.02	0.01	0.01
Costa Rica	0.01	0.01	0.03	0.03	0.01	0.02	0.01	0.01
Hungary	0.08	0.08	0.04	0.04	0.03	0.03	0.06	0.06
Mexico	0.03	0.04	0.03	0.03	0.03	0.03	0.02	0.02
South Africa	0.08	0.09	0.04	0.04	0.08	0.08	0.05	0.05
Turkey	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00
<b>Mean</b>	<b>0.04</b>	<b>0.04</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>
<b>Median</b>	<b>0.02</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.03</b>	<b>0.02</b>	<b>0.02</b>	<b>0.02</b>
<i>CI_lower bound</i>	<i>0.03</i>	<i>0.03</i>	<i>0.02</i>	<i>0.02</i>	<i>0.03</i>	<i>0.02</i>	<i>0.03</i>	<i>0.02</i>
<i>CI_upper bound</i>	<i>0.03</i>	<i>0.03</i>	<i>0.02</i>	<i>0.03</i>	<i>0.03</i>	<i>0.03</i>	<i>0.03</i>	<i>0.02</i>

**Notes:** The figures presented are the mean and median responses of each country to composite Net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the Hamilton filter. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table 3.3.3: FEVDs – Estimated Using the Hamilton Filter – Idiosyncratic Shocks-AE**

Country	Levels				Cyclical Component			
	RER		REER		RER		reer	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
Australia	0.03	0.03	0.01	0.01	0.02	0.02	0.01	0.01
Canada	0.06	0.06	0.03	0.03	0.04	0.03	0.02	0.01
Germany	0.06	0.06	0.02	0.02	0.05	0.06	0.03	0.03
New Zealand	0.02	0.02	0.00	0.00	0.04	0.03	0.03	0.02
Norway	0.10	0.10	0.09	0.09	0.07	0.07	0.06	0.06
UK	0.03	0.03	0.00	0.00	0.03	0.04	0.01	0.01
<b>Mean</b>	<b>0.05</b>	<b>0.05</b>	<b>0.03</b>	<b>0.03</b>	<b>0.04</b>	<b>0.04</b>	<b>0.03</b>	<b>0.02</b>
<b>Median</b>	<b>0.05</b>	<b>0.05</b>	<b>0.02</b>	<b>0.02</b>	<b>0.04</b>	<b>0.04</b>	<b>0.02</b>	<b>0.02</b>
<i>CI_lower bound</i>	<i>0.05</i>	<i>0.04</i>	<i>0.03</i>	<i>0.01</i>	<i>0.04</i>	<i>0.03</i>	<i>0.02</i>	<i>0.02</i>
<i>CI_upper bound</i>	<i>0.05</i>	<i>0.05</i>	<i>0.03</i>	<i>0.02</i>	<i>0.04</i>	<i>0.04</i>	<i>0.03</i>	<i>0.03</i>

**Notes:** The figures presented are the mean and median responses of each country to composite Net export commodity price shocks. RER and REER refer to the real National Currency-USD bilateral exchange rate and the real effective exchange rates respectively. The cyclical components were estimated using the Hamilton filter. Data is quarterly and sample period is 1985Q1-2019Q4.

**Table C3.3.4: t-Test Assuming Equal Variances -RER**

	<i>-0.1702196</i>	<i>-0.2337773</i>
Mean	0.042011538	-0.069835638
Variance	0.008859403	0.006794954
Observations	8	8
Pooled Variance	0.007827179	
Hypothesized Mean Difference	0	
df	14	
t Stat	2.528438503	
P(T<=t) one-tail	0.012051875	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.02410375	
t Critical two-tail	2.144786688	

**Table C3.3.5: t-Test Assuming Unequal Variances RER**

	<i>-0.1702196</i>	<i>-0.2337773</i>
Mean	0.042011538	-0.069835638
Variance	0.008859403	0.006794954
Observations	8	8
Hypothesized Mean Difference	0	
df	14	
t Stat	2.528438503	
P(T<=t) one-tail	0.012051875	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	0.02410375	
t Critical two-tail	2.144786688	

**Table C3.3.6: t-Test Assuming Equal Variances -REER**

	<i>0.0519133</i>	<i>0.1366881</i>
Mean	-0.008049363	0.089865463
Variance	0.000730961	0.001044572
Observations	8	8
Pooled Variance	0.000887767	
Hypothesized Mean Difference	0	
df	14	
t Stat	-6.57247682	
P(T<=t) one-tail	6.22125E-06	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	1.24425E-05	
t Critical two-tail	2.144786688	

**Table C3.3.7: t-Test Assuming Unequal Variances**

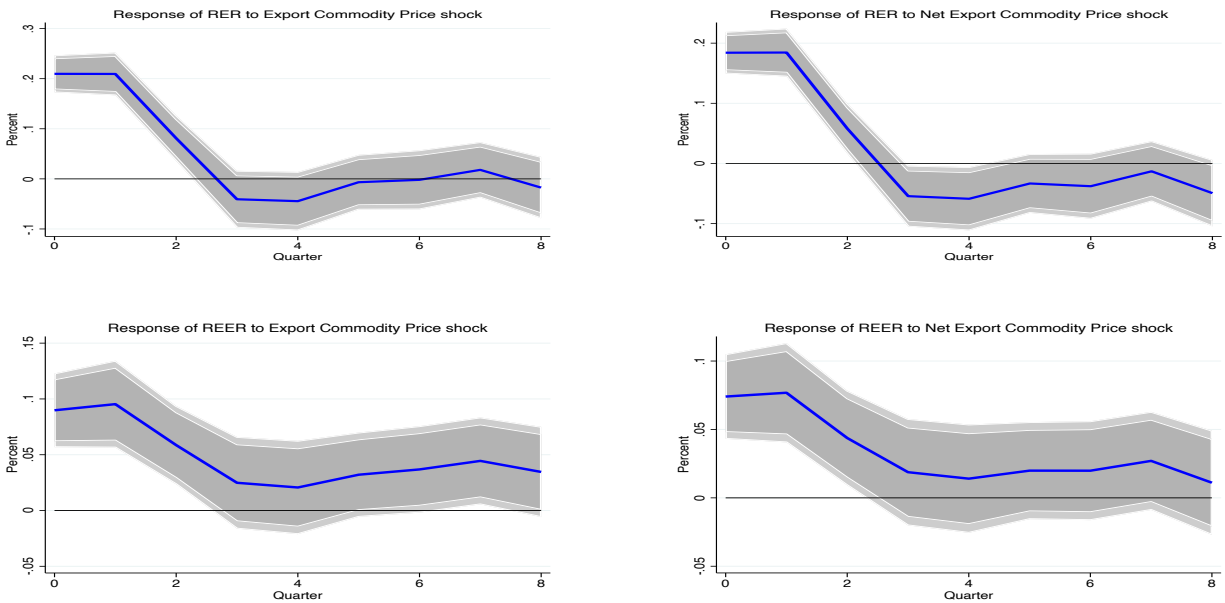
	<i>0.0519133</i>	<i>0.1366881</i>
Mean	-0.008049363	0.089865463
Variance	0.000730961	0.001044572
Observations	8	8
Hypothesized Mean Difference	0	
df	14	
t Stat	-6.57247682	
P(T<=t) one-tail	6.22125E-06	
t Critical one-tail	1.761310136	
P(T<=t) two-tail	1.24425E-05	
t Critical two-tail	2.144786688	

**Table 3.3.8: Exchange Rate Regimes of Sample Countries**

Country	Exchange Rate Regime
Australia	Free Floating
Austria	Free Floating*
Belgium	Free Floating*
Brazil	Floating
Canada	Free Floating
Colombia	Floating
Costa Rica	Crawl-like arrangement
Czech Republic	Free Floating
Denmark	Conventional peg
Finland	Free Floating*
France	Free Floating*
Germany	Free Floating
Hungary	Floating
Ireland	Free Floating*
Italy	Free Floating*
Japan	Free Floating
Malaysia	Floating
Mexico	Free Floating
Morocco	Pegged exchange rate within Horizontal bands
Netherlands	Free Floating
New Zealand	Floating
Norway	Free Floating
Paraguay	Floating
Philippines	Crawl-like arrangement
South Africa	Floating
Thailand	Floating
Turkey	Floating
UK	Free Floating

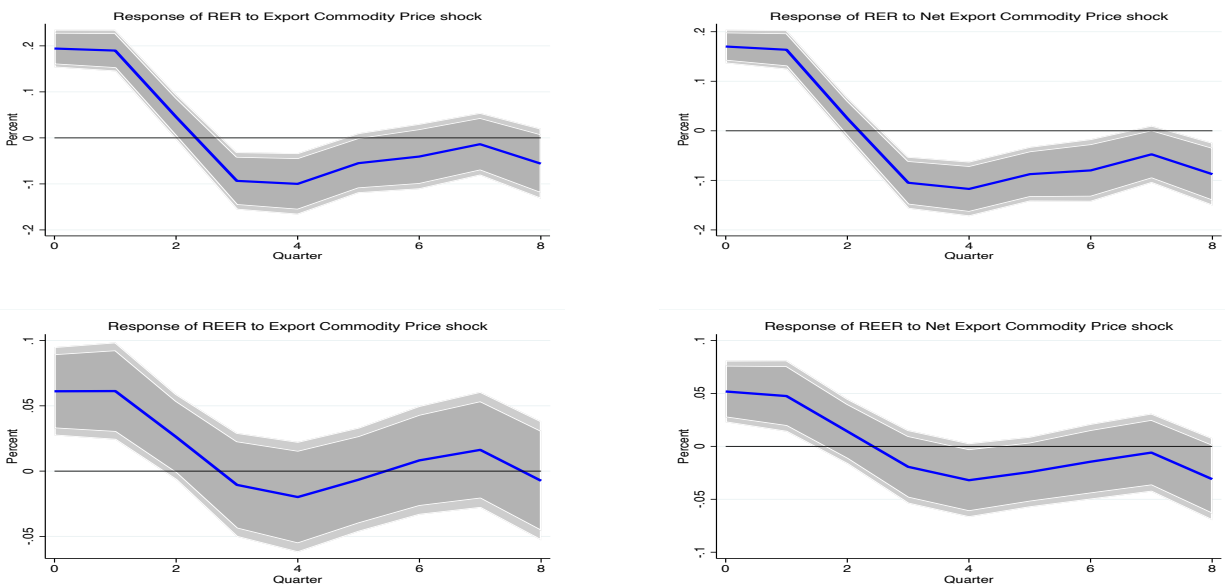
**Source:** IMF's Annual Report on Exchange Arrangements and Exchange Restrictions 2021. A free-floating exchange rate is market determined with rare market interventions while a floating exchange rate is market determined but market interventions may be direct or indirect. In a crawl-like peg arrangement, exchange rate must remain within a narrow margin of 2% relative to a statistically identified trend for six months or more. Pegged exchange rate with within horizontal bands occurs when the value of the currency is maintained within certain margins of fluctuation of at least  $\pm 1\%$  around a fixed central rate. "\*" refers to members of the European Monetary Union.

**Figure C1.1 – World Commodity Prices and Real Exchange Rates – Full Sample IRF**



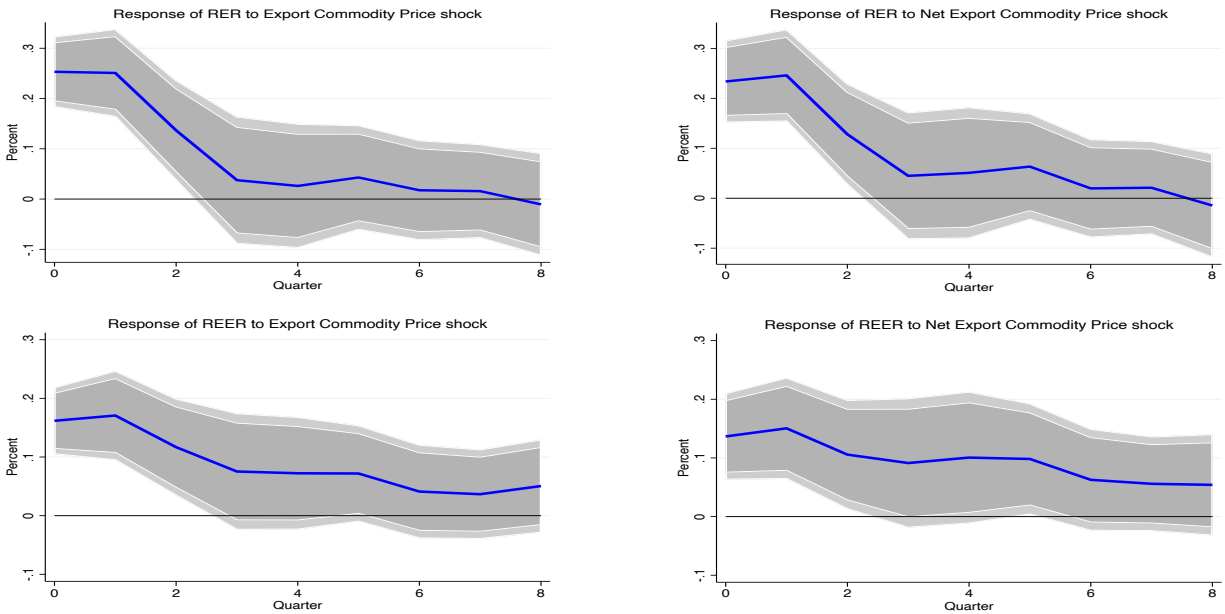
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) with Newey West robust standard errors. Cyclical components of the variables were obtained from the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 7 (T=980; N=7). The CI's are constructed with  $\alpha = 0.05$  and 0.10

**Figure C1.2 – World Commodity Prices and Real Exchange Rates – AE Sample IRF**



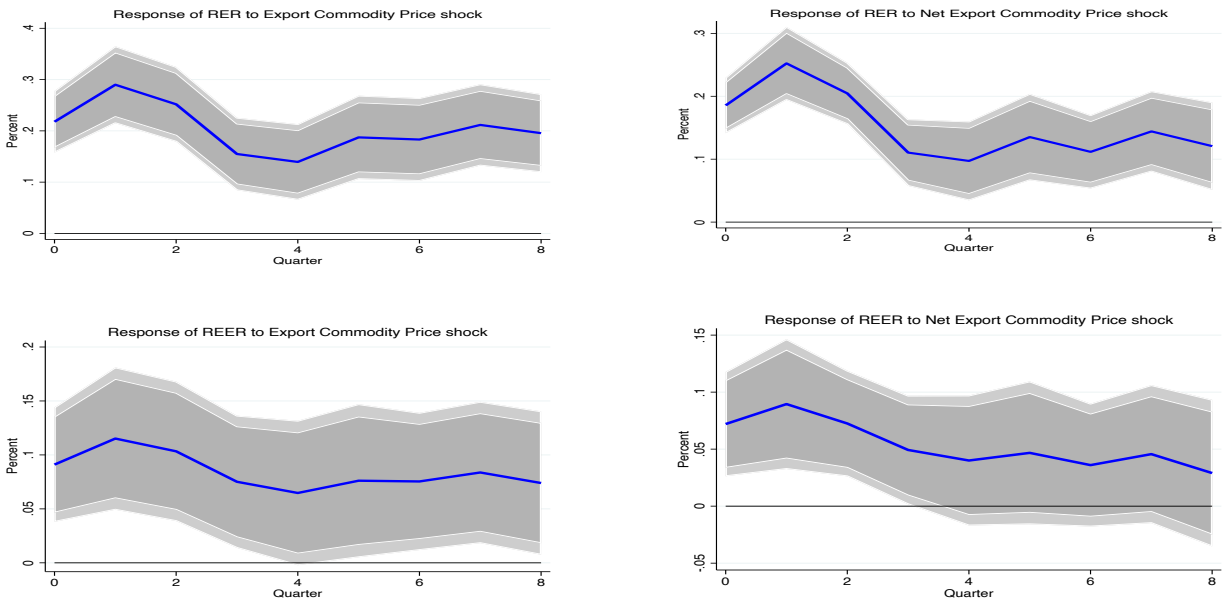
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) with Newey West robust standard errors. Cyclical components of the variables were obtained from the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 7 (T=980; N=7). The CI's are constructed with  $\alpha = 0.05$  and 0.10

**Figure C1.3 – World Commodity Prices and Real Exchange Rates – EME Sample IRF**



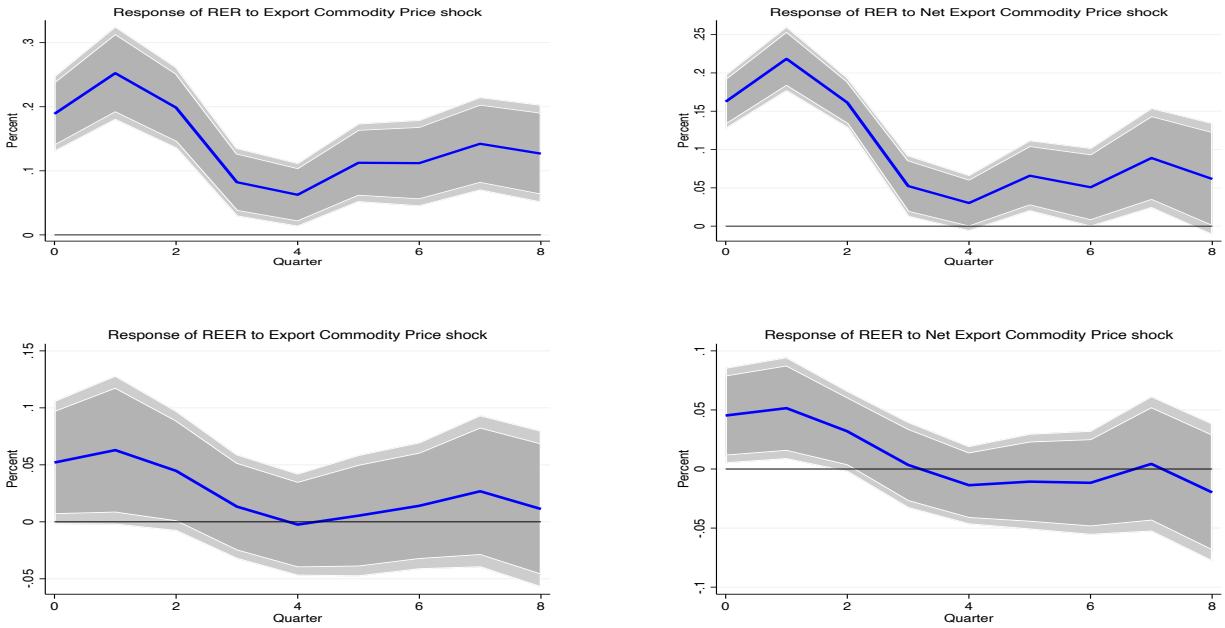
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) with Newey West robust standard errors. Cyclical components of the variables were obtained from the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 7 ( $T=980$ ;  $N=7$ ). The CI's are constructed with  $\alpha = 0.05$  and  $0.10$

**Figure C1.4 – World Commodity Prices and Real Exchange Rates – Full Sample IRF**



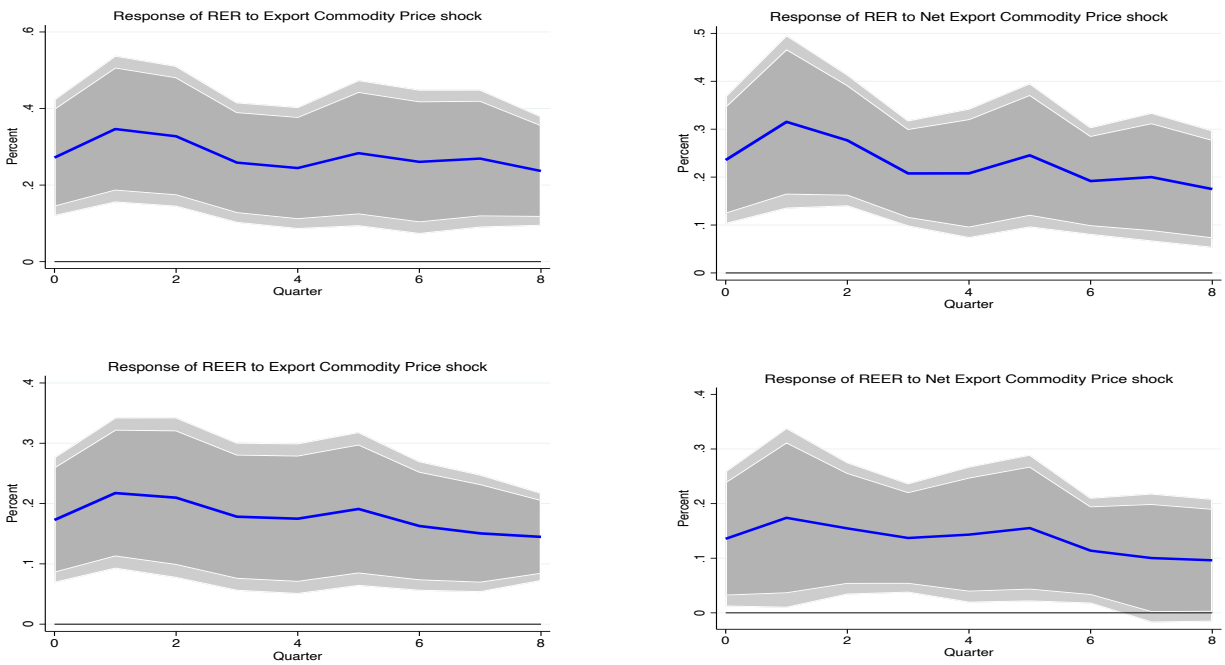
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) estimated with clustered errors. Commodity price shock measure was estimated from equation 3.2.3. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 16 ( $T=2240$ ;  $N=16$ ). The CI's are constructed with  $\alpha = 0.05$  and  $0.10$ .

**Figure C1.5 – World Commodity Prices and Real Exchange Rates – AE Sample IRF**



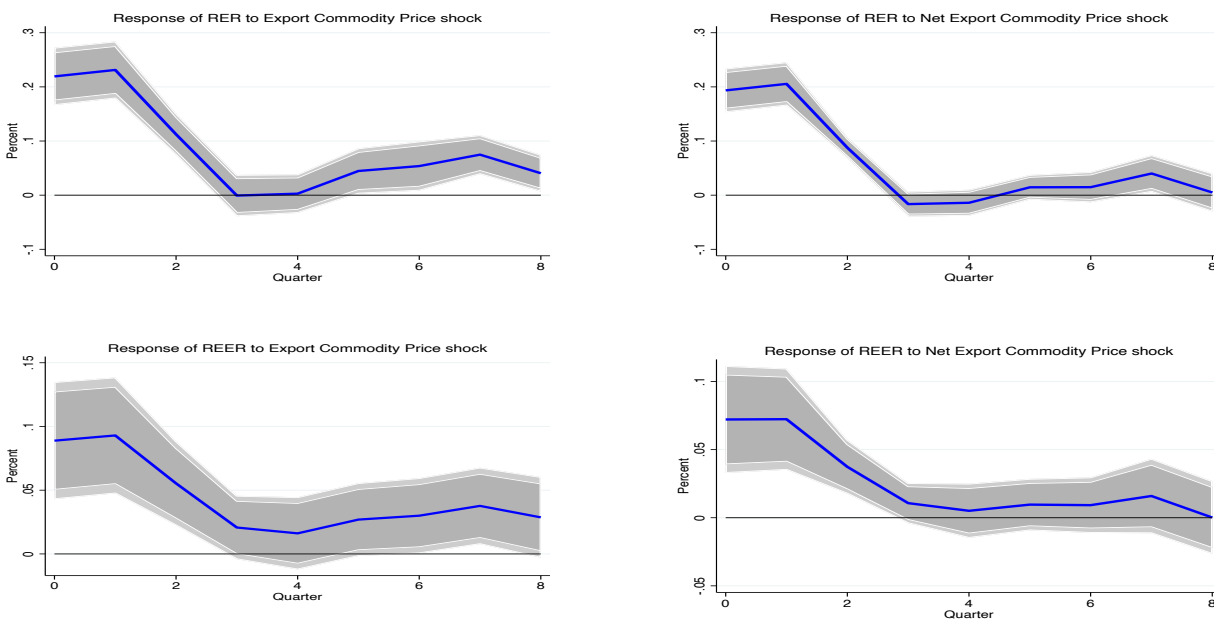
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) estimated with clustered errors. Commodity price shock measure was estimated from equation 3.2.3. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 16 ( $T=2240$ ;  $N=16$ ). The CI's are constructed with  $\alpha = 0.05$  and  $0.10$ .

**Figure C1.6 – World Commodity Prices and Real Exchange Rates – EME Sample IRF**



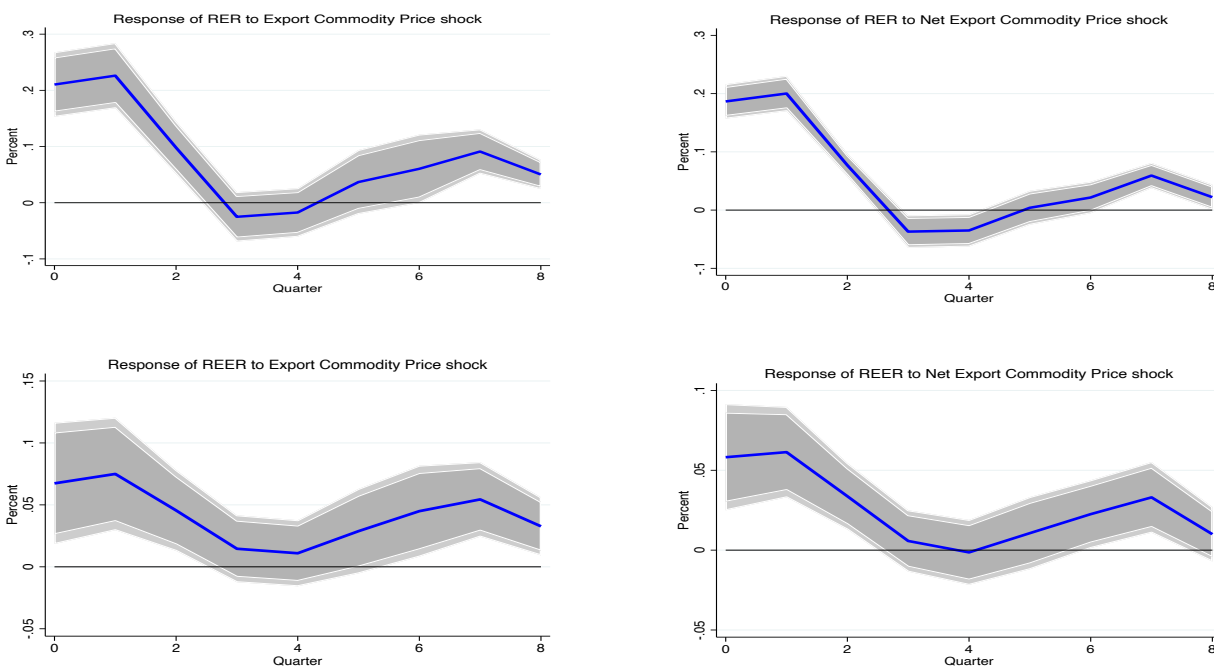
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) estimated with clustered errors. Commodity price shock measure was estimated from equation 3.2.3. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 16 ( $T=2240$ ;  $N=16$ ). The CI's are constructed with  $\alpha = 0.05$  and  $0.10$ .

**Figure C1.7 – World Commodity Prices and Real Exchange Rates – Full Sample IRF**



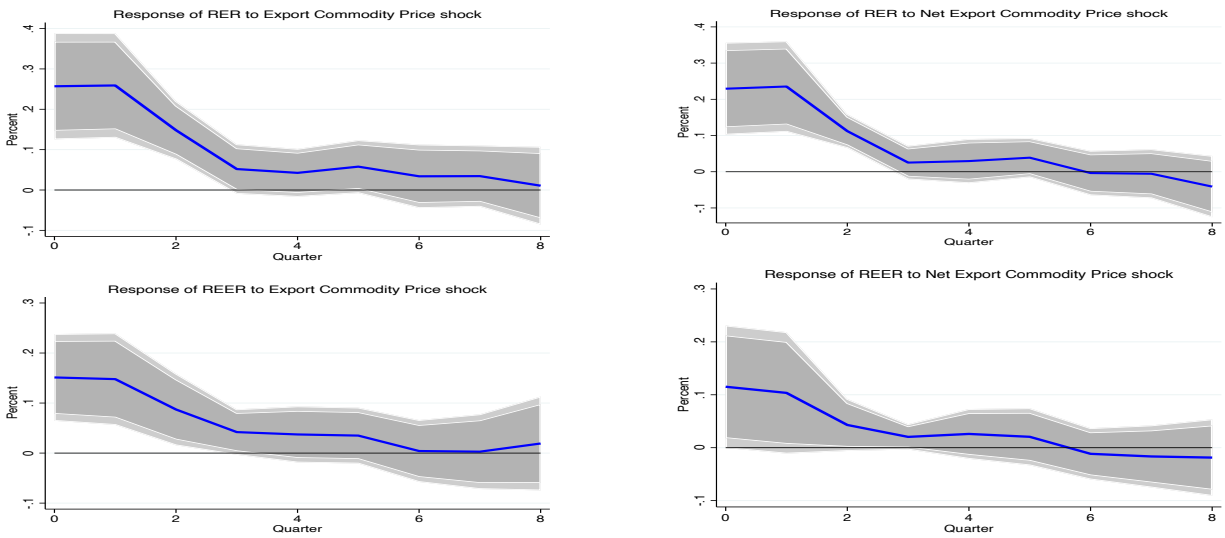
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) with lags of RER and REER included. Cyclical components of the variables were obtained from the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 7 (T=980; N=7). The CI's are constructed with  $\alpha = 0.05$  and 0.10

**Figure C1.8 – World Commodity Prices and Real Exchange Rates – AE Sample IRF**



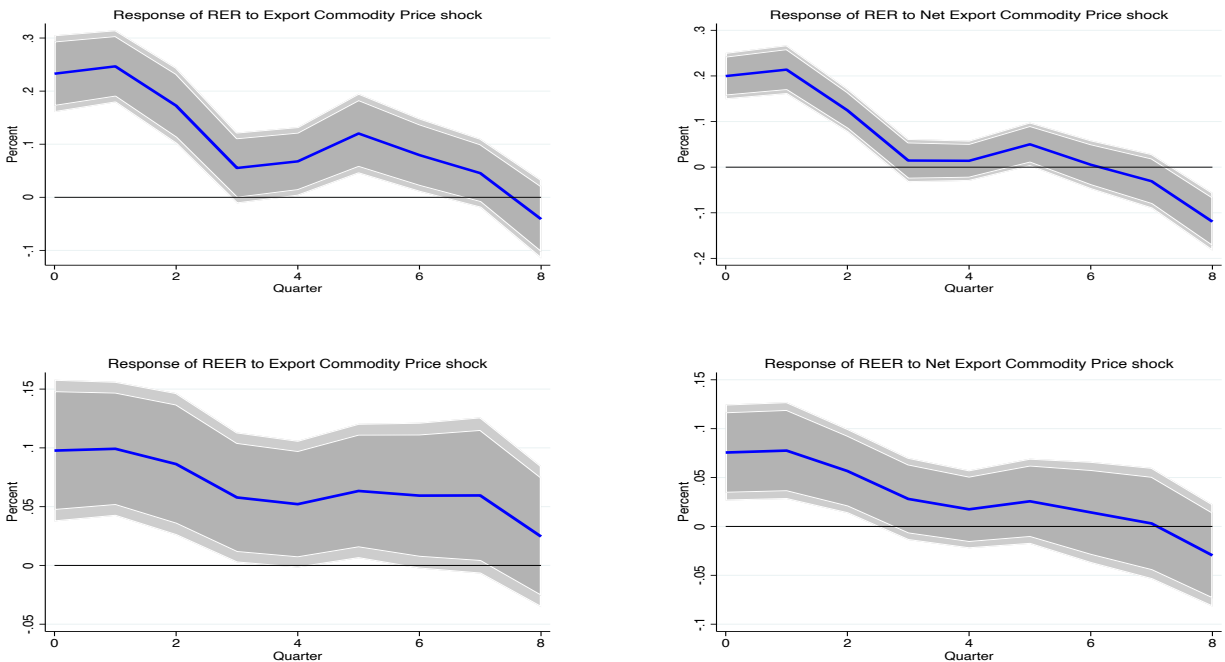
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) with lags of RER and REER included. Cyclical components of the variables were obtained from the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 7 (T=980; N=7). The CI's are constructed with  $\alpha = 0.05$  and 0.10

**Figure C1.9 – World Commodity Prices and Real Exchange Rates – EME Sample IRF**



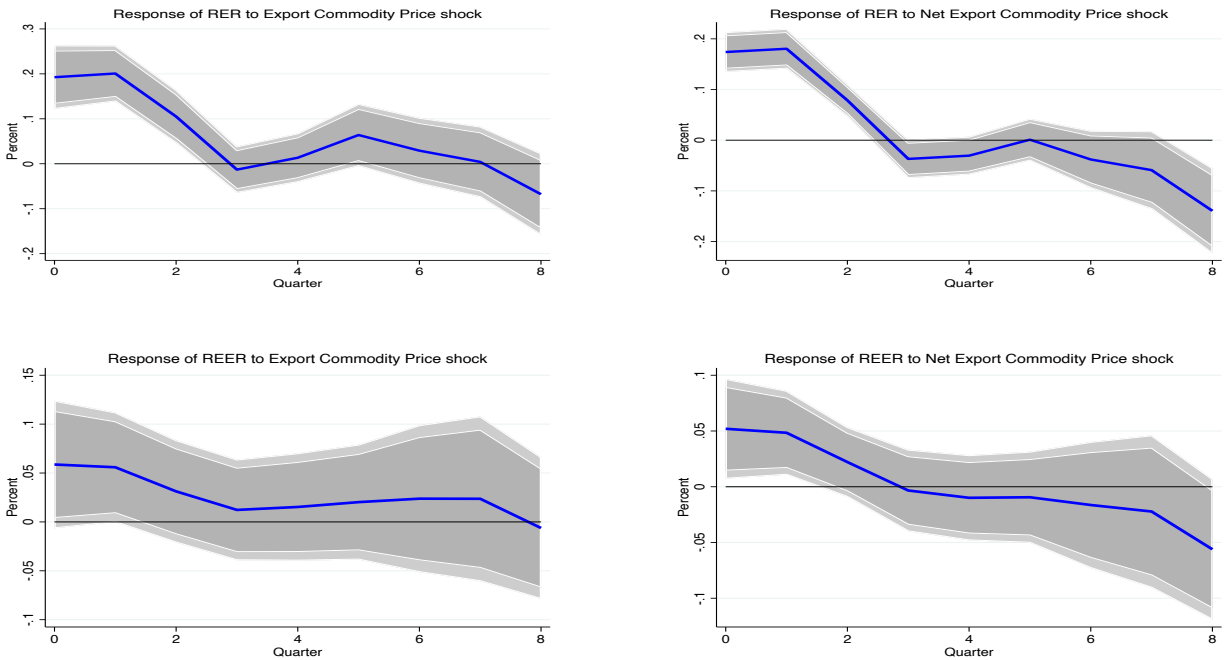
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) with lags of RER and REER included. Cyclical components of the variables were obtained from the HP filter with a smoothing parameter of 1600. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 7 (T=980; N=7). The CI's are constructed with  $\alpha = 0.05$  and 0.10.

**Figure C2.0 – World Commodity Prices and Real Exchange Rates – Full Sample IRF**



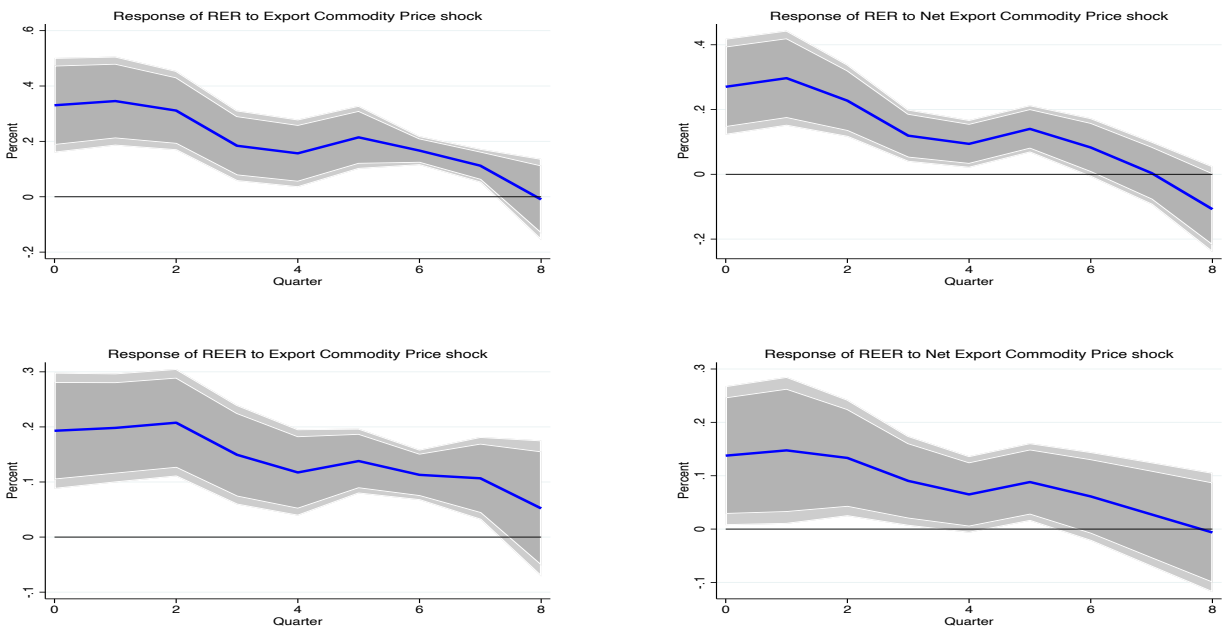
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) and estimated for the cyclical components of the variables obtained using the Hamilton filter. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 23 (T=3220; N=23). The CI's are constructed with  $\alpha = 0.05$  and 0.10.

**Figure C2.1 – World Commodity Prices and Real Exchange Rates – AE Sample IRF**



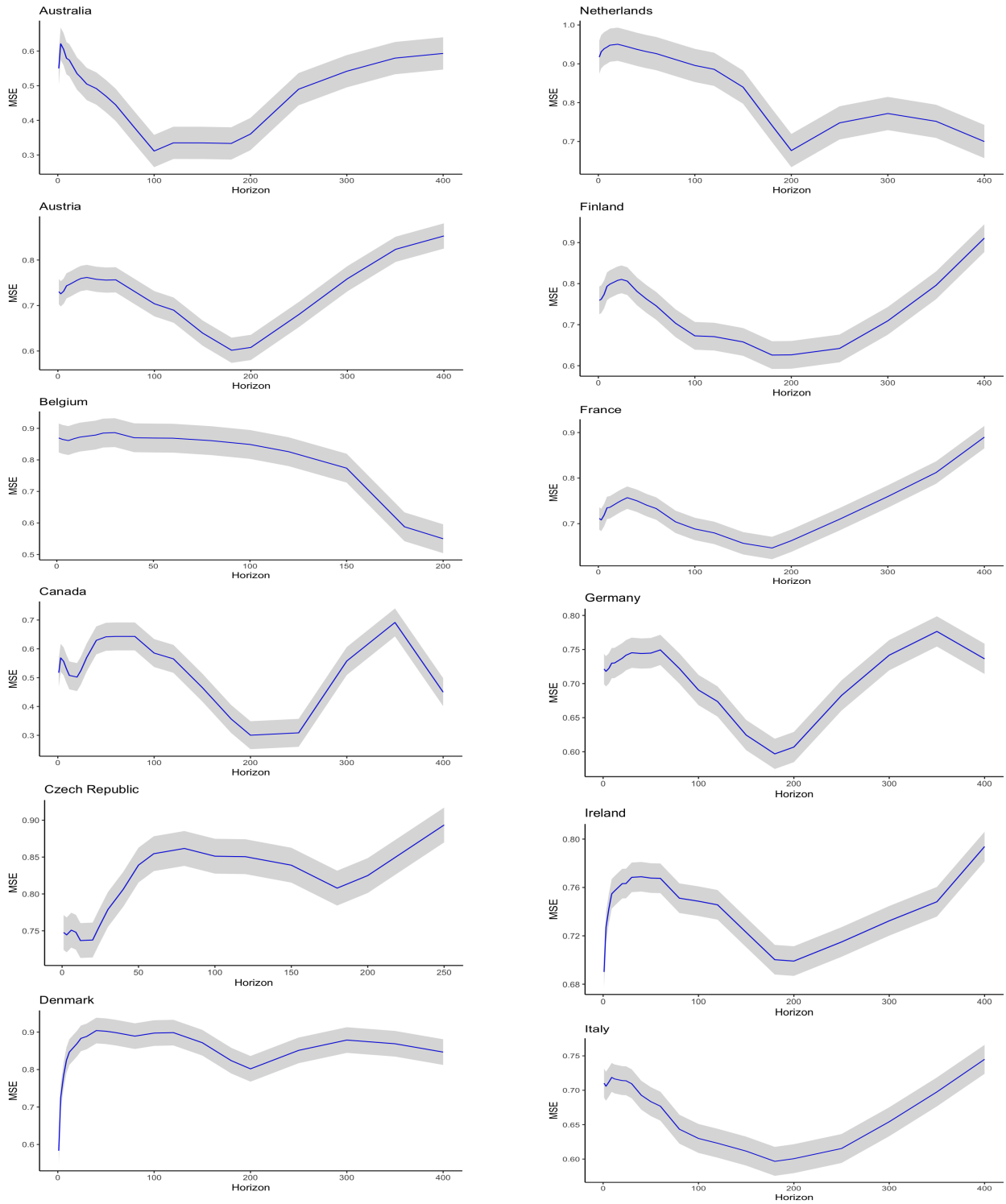
**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) and estimated for the cyclical components of the variables obtained using the Hamilton filter. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 16 ( $T=2240$ ;  $N=16$ ). The CI's are constructed with  $\alpha = 0.05$  and  $0.10$ .

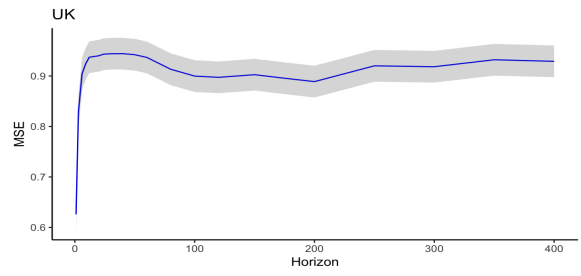
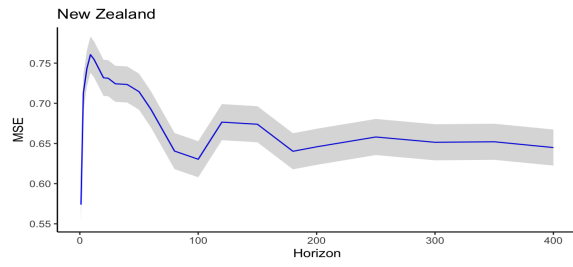
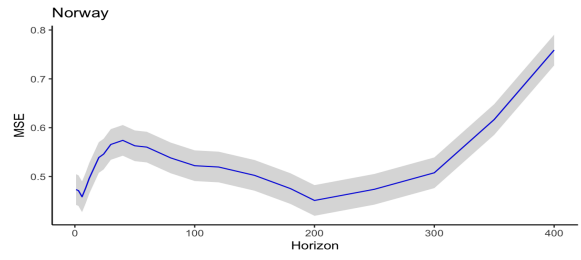
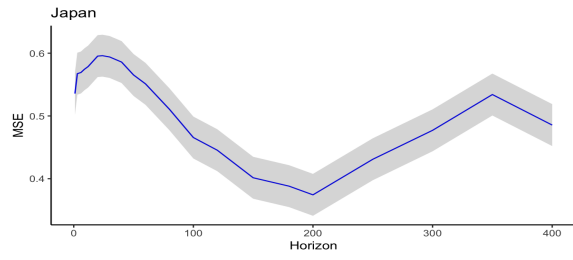
**Figure C2.2 – World Commodity Prices and Real Exchange Rates – EME Sample IRF**



**Notes:** The IRF's are based on the Local Projections approach of Jordà (2005) and estimated for the cyclical components of the variables obtained using the Hamilton filter. RER is measured as national currency per USD but has been normalized to ensure increases imply appreciation. Data is quarterly from 1985q1 -2019q4 and the sample size is 11 ( $T=980$ ;  $N=11$ ). The CI's are constructed with  $\alpha = 0.05$  and  $0.10$ .

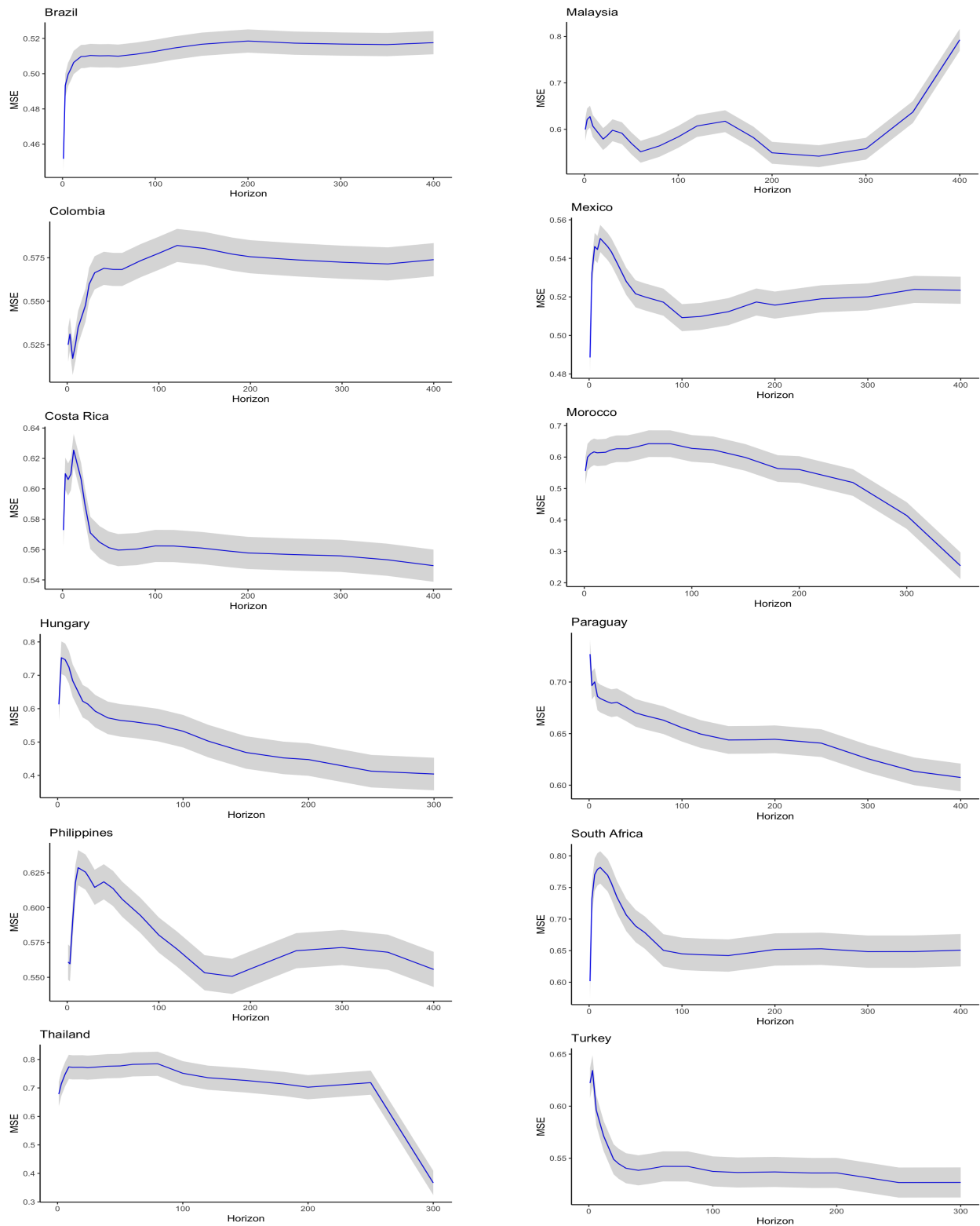
**Figure C2.3 – MSE Decomposition Plots -AE**





**Notes:** Country Specific MSE Decomposition Plots with 95% Confidence bands. MSE decompositions are estimated from equation 3.1.6 for when Net Export Commodity Price Index was used to estimate tradable goods.

**Figure C2.4 – MSE Decomposition Plots - EME**



**Notes:** Country Specific MSE Decomposition Plots with 95% Confidence bands. MSE decompositions are estimated from equation 3.1.6 for when Net Export Commodity Price Index was used to estimate tradable goods.

#### **4. Summary and Conclusions**

The dynamics of commodity price shocks is of prime interest to macroeconomist and central bankers over the past decade. The high interest in the subject stems from the perceived and documented large role of commodity price shocks in explaining the variations in many macroeconomic variables. To contribute to this body of knowledge, this thesis sets out to investigate the impact of international commodity price variations on different aspects of the macroeconomy of Emerging Market Economies in three separate essays. The first essay examines the link between commodity price shocks and the high levels of corruption in resource rich countries. The second essay conducts an accounting exercise to empirically determine the contribution of tradable and non-tradable goods prices to real exchange rate variations in EME's and the role of world commodity price shocks in explaining international price variations. The final essay empirically examines the dynamic behavior of real exchange rates by providing answers to an age-old disagreement on the relative importance of tradable and non-tradable goods to real exchange rate variations and accesses the component of commodity price variations that drives the effect of commodity price shocks in EME's and AE's.

The first essay contributes to the literature on the resource curse hypothesis by documenting the importance of commodity price variations in determining the level of corruption in resource rich countries and to a large extent EME's. Corruption is rife in every country, rifer in resource rich countries and have been documented as a major source of resource misallocation globally. In the paper, I showed via a theoretically exercise and empirical estimations that commodity price variations is an alternative explanation to the corruption inducing effects of resource windfalls. The findings of the paper shows that positive commodity price shocks results in a significant and noticeable increase in corruption and while episodes of negative commodity price shocks results

in significant and noticeable reduction in the level of corruption in resource rich countries. Further the paper also finds that significance difference exists in the effect of commodity price shocks on corruption in resource rich countries. First the effect is more noticeable in the most corrupt countries and second, the impact depends on the type of commodity exported -more significant impact for exporters of non-energy resources.

In the second essay co-authored with Dr. Yopez, we empirically disaggregate the real exchange rate changes into a tradable and non-tradable component and examine the contribution of each component to real exchange rate fluctuations in EME's, which was an area less examined in the literature. We also empirically document the role of world commodity price shocks in real exchange rate fluctuations in EME's. We find that the relative price of tradable goods accounts for about 90% of the historical variations in the real exchange rates in EME's. We also find that world commodity price shocks explain about 30% of the observed fluctuations in real exchange rates in EME's and that such world commodity price shocks are associated with large and persistent real exchange rate appreciations in EME's.

Finally, a key argument against the observed larger role for the relative price of tradable goods in explaining real exchange rate variations in both EME's and AE's as found in chapter two is that price series such as the PPI and CPI used in measuring the relative price of tradable goods contains large components of non-tradable goods hence overstating the importance of tradable goods to real exchange rate variations. Hence in the final essay, I empirically examine the relevance of the relative price of tradable goods constructed from a purely traded goods price as commodity terms of trade prices to the dynamics of real exchange rates in EME's and AE's. Measuring the relative price of tradable goods using commodity terms of trade prices also allows us to empirically examine the share of the contribution of tradable goods prices to real exchange rate fluctuations

that can be attributed to commodity terms of trade price variations. The paper finds that the relative price of tradable goods variations dominates the variations in real exchange rates even for tradable goods measured using purely traded goods price as the commodity terms of trade prices. This re-affirms the findings in chapter two and in Engel (1999). I also find that the effect of commodity price shocks in EME's and AE's are mainly due to common factors or spillovers in the commodity price shocks.

The findings in this thesis hence underscore the importance of commodity prices for the conduct of monetary and exchange rate policies as well as general economic growth policies in EME' and resource rich countries in general.