RODRIGO DA SILVA SOUZA

ESSAYS ON COMMODITY PRICE SHOCKS AND MACROECONOMIC VARIABLES

Tese apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduacão em Economia Aplicada, para obtenção do título de *Doctor Scientiae*.

VIÇOSA
MINAS GERAIS – BRASIL
2019

Ficha catalográfica preparada pela Biblioteca Central da Universidade Federal de Viçosa - Câmpus Viçosa

T

Souza, Rodrigo da Silva, 1988-

S729e Essays on commodity price shocks and macroeconomic
2019 variables / Rodrigo da Silva Souza. – Viçosa, MG, 2019.

xii, 132 f. : il. ; 29 cm.

Texto em inglês.

Inclui apêndice.

Orientador: Leonardo Bornacki de Mattos.

Tese (doutorado) - Universidade Federal de Viçosa.

Referências bibliográficas: f. 74-82.

1. Taxas de Câmbio. 2. Economia - Países em desenvolvimento. 3. China. I. Universidade Federal de Viçosa. Departamento de Economia Rural. Programa de Pós-Graduação em Economia Aplicada. II. Título.

CDD 22 ed. 332.456091724

RODRIGO DA SILVA SOUZA

ESSAYS ON COMMODITY PRICE SHOCKS AND MACROECONOMIC VARIABLES

Tese apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduação em Economia Aplicada, para obtenção do título de *Doctor Scientiae*.

APROVADA: 05 de julho de 2019.

Fernanda Aparecida Silva

Luciano Dias de Carvalho

Fabrício de A. C. Vieira

Fabrício de Assis Campos Vieira

Cláudia Maria Sonaglio

Leonardo Bornacki de Mattos
(Orientador)

Contents

List of Figures iv

List of Tables ix

Abstract xi

Resumo xii

1 INTRODUCTION 1

2 COMMODITY PRICES AND THE BRAZILIAN REAL EXCHANGE RATE 4

2.1 Introduction 5

2.2 A theoretical framework on structural factors affecting the link between commodity prices and real exchange rate 10

2.3 Empirical framework 14

2.3.1 Long-run estimation strategies 14

2.3.2 Short-run estimation strategies 16

2.3.3 Alternative specification 18

2.3.4 Data 19

2.4 Results 20

2.4.1 Evolution of the variables 20

2.4.2 Unit root, cointegration and weak exogeneity 23

2.4.3 Effects of structural factors on the link between commodity prices and real exchange rate 26

2.4.4 Effects of financial factors on the link between commodity prices and real exchange rate 28

2.4.5 Alternative specification 31

2.5 Conclusion 37

3 CHINESE RESOURCE DEMAND AND COMMODITY PRICE SHOCKS: MACROECONOMIC EFFECTS ON AN EMERGING MARKET ECONOMY 39

3.1 Introduction 40

3.2 Stylized facts 43

3.3 Empirical framework 47

3.3.1 The SVAR model and identification 47

3.3.2 Data and sample . . . 49

3.4 Chinese resource demand effects an EME . . . 51

3.4.1 Shock to Chinese resource demand . . . 52

3.4.2 Shock to commodity prices . . . 53

3.4.3 Shock to foreign output . . . 55

3.4.4 Forecast error variance decomposition . . . 56

3.5 Alternative specifications . . . 59

3.5.1 Alternative measures of Chinese resource demand . . . 59

3.5.2 Alternative measures of real commodity price indexes . . . 63

3.5.3 Long sample period . . . 66

3.5.4 Commodity prices boom period . . . 67

3.5.5 Detrending . . . 69

3.5.6 Additional robustness tests . . . 69

3.6 Conclusion . . . 70

4 CONCLUDING REMARKS . . . 72

BIBLIOGRAPHY . . . 74

.1 Data appendix . . . 83

.2 Appendix of alternative model specifications . . . 85

List of Figures

Figure 1 – Brazilian real effective exchange rate, real commodity price index and real non-oil commodity price index, from January 1999 to January 2018 20
Figure 2 – Volatility in international financial market (vix_t) and country risk ($embi_t$), from January 1999 to January 2018 21
Figure 3 – Trade openness (xto_t), commodity export dependency ($xced7_t$) and non-oil commodity export dependency ($xced6_t$), from January 1999 to January 2018 23
Figure 4 – Change in the country risk and the highest weights (higher than 0.90) of the transition function 30
Figure 5 – The Brazilian interest rate (right axis) and real commodity prices (left axis), 1999Q1 to 2017Q1. 46
Figure 6 – Chinese resource demand (left axis) and Brazilian GDP (right axis), 1999Q1 to 2017Q1. 46
Figure 7 – Commodity and manufacturing exports relative to total exports (left axis) and commodity and manufacturing exports relative to GDP (right axis), 1999Q1 to 2017Q1. 47
Figure 8 – Impulse response functions to a shock to Chinese steel production, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 53
Figure 9 – Impulse response functions to a shock to commodity prices, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 54
Figure 10 – Impulse response functions to a shock to foreign output, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 55
Figure 11 – Robustness of impulse response functions for shocks to Chinese resource demand for models with alternative measures of Chinese resource demand, 1999Q1 to 2017Q1. 61
Figure 12 – Robustness of impulse response functions for shocks to real commodity prices for models with alternative measures of Chinese resource demand, 1999Q1 to 2017Q1. 62
Figure 13 – Robustness of impulse response functions for shocks to foreign output for models with alternative measures of Chinese resource demand, 1999Q1 to 2017Q1. 63
Figure 14 – Robustness of impulse response functions for shocks to Chinese resource demand for models with alternative measures of real commodity prices, 1999Q1 to 2017Q1. 64

Figure 15 – Robustness of impulse response functions for shocks to real commodity prices for models with alternative measures of real commodity prices, 1999Q1 to 2017Q1. 65
Figure 16 – Robustness of impulse response functions to shocks to foreign output for models with alternative measures of real commodity prices, 1999Q1 to 2017Q1. 66
Figure 17 – Robustness of impulse response functions to shocks to Chinese resource demand for models with alternative sample period definitions and variables in levels. 67
Figure 18 – Robustness of impulse response functions to shocks to real commodity prices for models with alternative sample period definitions and variables in levels. 68
Figure 19 – Robustness of impulse response functions to shocks to foreign output for models with alternative sample period definitions and variables in levels. 69
Figure 20 – Impulse response functions to a shock to Chinese manufacturing exports for the model with Chinese manufacturing exports, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 85
Figure 21 – Impulse response functions to a shock to commodity prices for the model with Chinese manufacturing exports, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 98
Figure 22 – Impulse response functions to a shock to foreign output for the model with Chinese manufacturing exports, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 99
Figure 23 – Impulse response functions to a shock to Chinese industrial production for the model with Chinese industrial production, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 100
Figure 24 – Impulse response functions to a shock to commodity prices for the model with Chinese industrial production, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 101
Figure 25 – Impulse response functions to a shock to foreign output for the model with Chinese industrial production, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 102
Figure 26 – Impulse response functions to a shock to Chinese GDP for the model with Chinese GDP, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 103
Figure 27 – Impulse response functions to a shock to commodity prices for the model with Chinese GDP, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 104

Figure 28 – Impulse response functions to a shock to foreign output for the model with Chinese GDP, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 105
Figure 29 – Impulse response functions to a shock to Chinese steel production for the model with broad basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 106
Figure 30 – Impulse response functions to a shock to commodity prices for the model with broad basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 107
Figure 31 – Impulse response functions to a shock to foreign output for the model with broad basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 108
Figure 32 – Impulse response functions to a shock to Chinese steel production for the model with non-oil basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 109
Figure 33 – Impulse response functions to a shock to commodity prices for the model with non-oil basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 110
Figure 34 – Impulse response functions to a shock to foreign output for the model with non-oil basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 111
Figure 35 – Impulse response functions to a shock to Chinese steel production for the model with commodity terms of trade, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 112
Figure 36 – Impulse response functions to a shock to commodity prices for the model with commodity terms of trade, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 113
Figure 37 – Impulse response functions to a shock to foreign output for the model with commodity terms of trade, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 114
Figure 38 – Impulse response functions to a shock to Chinese steel production for the model with long sample period, 1996Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 115
Figure 39 – Impulse response functions to a shock to commodity prices for the model with long sample period, 1996Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 116
Figure 40 – Impulse response functions to a shock to foreign output for the model with long sample period, 1996Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 117

Figure 41 – Impulse response functions to a shock to Chinese steel production for the model with commodity boom period, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 118
Figure 42 – Impulse response functions to a shock to commodity prices for the model with commodity boom period, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 119
Figure 43 – Impulse response functions to a shock to foreign output for the model with commodity boom period, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 120
Figure 44 – Impulse response functions to a shock to Chinese steel production for the model without restriction in the interest rate, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 121
Figure 45 – Impulse response functions to a shock to commodity prices for the model without restriction in the interest rate, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 122
Figure 46 – Impulse response functions to a shock to foreign output for the model without restriction in the interest rate, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 123
Figure 47 – Impulse response functions to a shock to Chinese steel production for the model with domestic output minus primary commodity sector, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 124
Figure 48 – Impulse response functions to a shock to commodity prices for the model with domestic output minus primary commodity sector, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 125
Figure 49 – Impulse response functions to a shock to foreign output for the model with domestic output minus primary commodity sector, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 126
Figure 50 – Impulse response functions to a shock to Chinese steel production for the model with domestic output in dollar, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 127
Figure 51 – Impulse response functions to a shock to commodity prices for the model with domestic output in dollar, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 128
Figure 52 – Impulse response functions to a shock to foreign output for the model with domestic output in dollar, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 129
Figure 53 – Impulse response functions to a shock to Chinese steel production for the model with variables non-detrended, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 130

Figure 54 – Impulse response functions to a shock to commodity prices for the model with variables non-detrended, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 131
Figure 55 – Impulse response functions to a shock to foreign output for the model with variables non-detrended, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals. 132

List of Tables

Table 1 – Augmented Dickey–Fuller unit root test . . . 24
Table 2 – Zivot-Andrews unit root test . . . 24
Table 3 – Engle-Granger (EG) and Phillips-Ouliarius (PO) cointegration tests - Dependent variable = $reer_t$ . . . 24
Table 4 – Johansen cointegration test summary - Variables: $reer_t$ e br_7 . . . 25
Table 5 – Johansen cointegration test summary - Variables: $reer_t$ e br_6 . . . 25
Table 6 – Weak exogeneity test . . . 26
Table 7 – Effects of trade openness and commodity export dependency on the long-run link between commodity prices and real exchange rate . . . 27
Table 8 – Linearity test . . . 29
Table 9 – Effects of volatility and country risk on the link between commodity prices and real exchange rate . . . 30
Table 10 – Augmented Dickey–Fuller unit root test - Alternative specification . . . 32
Table 11 – Zivot-Andrews unit root test - Alternative specification . . . 32
Table 12 – Engle-Granger (EG) and Phillips-Ouliarius (PO) cointegration tests - Dependent variable = $reer_t$; Control variables = dif_t e res_t - Alternative specification . . . 32
Table 13 – Johansen cointegration test summary - Variables: $reer_t$, br_7, dif_t and res_t - Alternative specification . . . 33
Table 14 – Johansen cointegration test summary - Variables: $reer_t$, br_6, dif_t and res_t - Alternative specification . . . 34
Table 15 – Effects of trade openness and commodity export dependency on the long-run link between commodity prices and real exchange rate - Alternative specification . . . 35
Table 16 – Effects of volatility and country risk on the link between commodity prices and the real exchange rate - Alternative specification . . . 36
Table 17 – Sectoral composition of the Brazilian economy and the correlation of key variables with Chinese resource demand, real commodity prices and Brazilian output, 1999Q1 to 2017Q1. . . . 44
Table 18 – Forecast error variance decomposition (in per cent), 1999Q1 to 2017Q1 . 57
Table 19 – Robustness analysis: Forecast error variance decomposition of output for models with alternative specifications (in per cent). . . . 60
Table 20 – Forecast error variance decomposition for the model with Chinese manufacturing exports (in per cent). . . . 86
Table 21 – Forecast error variance decomposition for the model with Chinese industrial production (in per cent). . . . 87

Table 22 – Forecast error variance decomposition for the model with Chinese GDP (in per cent). 88
Table 23 – Forecast error variance decomposition for the model with broad basket (in per cent). 89
Table 24 – Forecast error variance decomposition for the model with non-oil basket (in per cent). 90
Table 25 – Forecast error variance decomposition for the model with commodity terms of trade (in per cent). 91
Table 26 – Forecast error variance decomposition for the model with long sample period (in per cent). 92
Table 27 – Forecast error variance decomposition for the model with commodity boom period (in per cent). 93
Table 28 – Forecast error variance decomposition for the model without restriction in the interest rate (in per cent). 94
Table 29 – Forecast error variance decomposition for the model with domestic output minus primary commodity sector (in per cent). 95
Table 30 – Forecast error variance decomposition for the model with domestic output in dollar (in per cent). 96
Table 31 – Forecast error variance decomposition for the model with variables non-detrended (in per cent). 97

Abstract

SOUZA, Rodrigo da Silva, D.Sc., Universidade Federal de Viçosa, July, 2019. **Essays on Commodity Price Shocks and Macroeconomic Variables**. Advisor: Leonardo Bornacki de Mattos.

Swings in world commodity prices are an important driver of macroeconomic variables in commodity-exporting emerging market economies, such as output, real exchange rate and inflation. In this thesis, we look at the Brazilian case. The first essay addresses the relationship between world commodity prices and the Brazilian real exchange rate, focusing on factors that potentially change the intensity of this relationship, such as trade openness, commodity export dependency, international financial market volatility and country risk situation. The main result shows that the real exchange rate response to real commodity price shocks depends on the trade openness and the country risk situation. The second essay empirically addresses the hypothesis of that in the external commodity based sector, Chinese resource demand is the most important driver of emerging market economies' business cycles, using Brazil as a representative case. Specifically, we examine the effects of Chinese resource demand, world commodity prices and foreign output on domestic macroeconomic variables. Our key findings show that shocks to Chinese demand induce an expansion in the Brazilian resource exports, in the non-tradeable primary commodity sector and in other domestic activity. Commodity price shocks are less favourable than Chinese resource demand shocks. Our findings identify the important role of the interest rate in amplifying the real effects of the commodity sector boom, in contrast to the role of the interest rate in developed countries. When both Chinese resource demand and commodity prices are incorporated into the model, commodity prices play a smaller role in explaining the variance of domestic output than that found in the previous literature.

Resumo

SOUZA, Rodrigo da Silva, D.Sc., Universidade Federal de Viçosa, julho de 2019. **Ensaios sobre choques nos preços de *commodities* e variáveis macroeconômicas**. Orientador: Leonardo Bornacki de Mattos.

Flutuações nos preços internacionais de *commodities* desempenham um importante papel na determinação de variáveis macroeconômicas em países emergentes exportadores de *commodities*, como: produto, taxa de câmbio real e inflação. Nesta tese, investiga-se o caso brasileiro. O primeiro ensaio aborda a relação entre preços internacionais de *commodities* e a taxa de câmbio real brasileira, focando em fatores que potencialmente alteram a intensidade desta relação, tais como abertura comercial, dependência em relação às exportações de *commodities*, volatilidade no mercado financeiro internacional e situação do risco país. O resultado principal sugere que a resposta da taxa de câmbio real aos choques nos preços de *commodities* depende da abertura comercial e da situação do risco país. O segundo ensaio empiricamente aborda a hipótese de que considerando o setor externo baseado em *commodities*, a demanda chinesa por *commodities* é o principal determinante dos ciclos de negócios de economias emergentes, usando o Brasil como um caso representativo. Especificamente, este trabalho examina os efeitos da demanda chinesa por *commodities*, dos preços internacionais de *commodities* e do produto mundial sobre variáveis macroeconômicas domésticas. Os principais resultados mostram que os choques na demanda chinesa provocam uma expansão nas exportações brasileiras de *commodities*, no setor de *commodities* não transacionáveis e em outras atividades domésticas. Choques nos preços de *commodities* são menos favoráveis do que choques na demanda chinesa por *commodities*. Os resultados também identificam o importante papel da taxa de juros na ampliação dos efeitos reais do *boom* no setor de *commodities*, em contraste com o papel da taxa de juros em países desenvolvidos. Quando a demanda chinesa por *commodities* e os preços de *commodities* são incorporados no modelo, preços de *commodities* desempenham um papel menos importante na explicação da variância do produto doméstico do que a literatura anterior tem mostrado.

1 Introduction

The emergence of China as a powerhouse has contributed substantially to the leading role of the global commodity markets in debates on international macroeconomics in various spheres of society. The rapid industrialisation and urbanisation process in China has triggered a huge demand for commodities and has consolidated China as the major player in the sector. The spillover effect of the global commodity markets on resource-rich countries is an important and complex topic of international macroeconomics, especially on commodity-exporting emerging market economies which are historically vulnerable to external shocks. On the one hand, commodity-exporting countries benefit from the increase in the revenue caused by the rising prices of their exported goods. On the other hand, the opposite effect hold in the case of downward trend of the prices. In addition, the link between commodity prices and real exchange rates has been related to the overvaluation of the real exchange rates of commodity-exporting countries during the booming phase of the prices, which eventually has consequences on the international competitiveness of the non-commodity sectors.

This thesis presents two essays on commodity prices and macroeconomic variables considering the Brazilian case. Indeed, Brazil has a large share of its exports concentrated in commodities, such as soybeans, oil and iron ore. Thus, the prices of the main commodities exported by Brazil likely influence the terms of trade, which has long been associated with domestic variables such as real exchange rate, investment, output, inflation etc. In addition, domestic sectors such as agriculture, livestock and mining contributed approximately 7 per cent to the Gross Domestic Product (GDP) from 1999 to 2017. From the demand side, China overtook the U.S. as the largest trading partner of Brazil, which had been its most important economic partner for the previous eighty years. Hence, Brazil is potentially susceptible to the global commodity markets swings, especially those related to Chinese resource demand.

The first essay aims to provide empirical evidence to support foreign exchange policy decisions in Brazil. Since the floating exchange rate regime adoption in 1999, the exchange rate has been an important macroeconomic price, either because of its role in the inflation targeting regime or because it influences the international competitiveness of domestic sectors. Thus, a challenge for policymakers is to reconcile the real exchange rate swings with the objectives of the domestic macroeconomic policy. This can be a complex issue because of the exogenous (internationally determined) and volatile nature of the commodity prices.

Specifically, we analysed the Brazilian real exchange rate and the prices of the main commodities exported by Brazil paying attention to the concepts of stationarity, cointegration and exogeneity in order to better understand the stochastic behaviour of these variables over time. We also investigated the link between real exchange rate and commodity prices taking into account the non-linearity on both long and short-run. Two structural factors are addressed in line with the literature on the subject: trade openness and commodity export dependency. Concerning the first factor, theoretical frameworks show that a country with high degree of trade openness has a relatively smaller share of nontraded goods in the domestic consumption basket and therefore a lower commodity price elasticity of real exchange rate. In turn, the larger share of commodities in the Brazilian exports means a larger influence of world commodity prices on the terms of trade and consequently on the real exchange rate.

Additionally, we also consider the hypothesis of that in times of uncertainty, characterised by the volatility in the international financial market and the country risk situation, the short-run relationship between the real exchange rate and commodity prices becomes narrower. The hypothesis is that once risk aversion rises, carry trade operations are unwound, reinstalling the real exchange rate with its fundamentals. The motivation is that the Brazilian real exchange rate has been excessively exposed to the external sector due to the characteristics of the foreign exchange market in Brazil.

The first essay makes three main contributions. First, we only consider the floating exchange rate regime to avoid confounding effects from different monetary regimes. Second, we make a clear distinction between commodity prices and non-oil commodity prices, considering that Brazil exports a broad basket of commodities, instead of defining Brazil as oil exporter or commodity exporter as is usually made. Third, we investigate the short-run non-linearity between world commodity prices and real exchange rate depending on the country risk situation, an indicator available for emerging markets.

The second essay evaluates the effects of global commodity market shocks on commodity-exporting emerging market economies, using the Brazilian economy as a representative case. One of the challenges for policy-makers is to identify what is determining the shock. Shocks to Chinese demand for commodities and shocks to commodity prices are probably transmitted differently for commodity-exporting countries. The setup of the model enables to analyse the impacts of three external shocks, as follows: (*i*) a shock to Chinese resource demand; (*ii*) a shock to world commodity prices; and (*iii*) a shock to foreign output. The configuration of the domestic sector of the model enables the assessment of the transmission of these shocks through the domestic activity that is directly linked to resource demand (real resource exports and the non-tradeable primary commodity sector) and to other domestic activity. In addition, the domestic sector includes inflation, real exchange rate and interest rate. The last variable is the cost of borrowing faced in international financial markets, which has emerged as a salient mechanism amplifying the real effects of the commodity sector boom.

The second essay makes three main contributions. First, we construct a country-specific commodity price index and a measure of Brazilian resource exports, using the historical export weights. Second, we model the effects of both the Chinese resource demand and world commodity prices on the Brazilian economy. Third, we investigate the effects of the Chinese resource demand, instead of only commodity price shocks, on the interest rate, which has been neglected by the literature.

The starting point of the two essays is January 1999, period which the floating exchange rate regime has been adopted by the Brazilian monetary authority. As a floating exchange rate is a likely absorber of terms of trade shocks, this year represents an important break in the exchange rate data for the questions under consideration. The adoption of this starting point also attenuates the bias associated with the heterogeneity of macroeconomic policy, since from this year the Brazilian macroeconomic policy is based on the tripod regime characterised by the floating exchange rate, inflation target and primary surplus target.

The essays are independent, despite them being linked to each other regarding the research topic - the effects of commodity price shocks on macroeconomic variables.

2 Commodity prices and the Brazilian real exchange rate

Rodrigo da Silva Souza[1], Leonardo Bornacki de Mattos[2] and João Eustáquio de Lima[3]

Abstract

World commodity prices are an important driver of macroeconomic variables in commodity-exporting countries, such as output, real exchange rate and inflation. In this essay, we address the relationship between world commodity prices and the Brazilian real exchange rate, focusing on factors that potentially change the intensity of this relationship. Our empirical approach allows that structural factors, such as trade openness and commodity export dependency, may change the long-run relationship between world commodity prices and the Brazilian real exchange rate, and factors related to the financial market, such as international financial market volatility and country risk situation, may change the short-run relationship. The analysis involves only the floating exchange rate regime, from January 1999 to January 2018. The key result shows that the real exchange rate response to real commodity price shocks depends on the trade openness and the country risk situation.

Keywords: Commodity Currency, Brazilian Real Exchange Rate, Commodity Exports.
JEL Classifications: C24; F41; F62; Q02.

[1] Doctoral student in the Graduate Program in Applied Economics, Federal University of Viçosa. Email: souzarodrigodasilva@gmail.com
[2] Professor at the Department of Rural Economics of the Federal University of Viçosa. CNPq Research Productivity Scholarship. E-mail: lbmattos@ufv.br.
[3] Professor at the Department of Rural Economics of the Federal University of Viçosa. CNPq Research Productivity Scholarship. E-mail: jelima@ufv.br.

2.1 Introduction

The term "commodity currency" has been used to describe the commodity-exporting countries' real exchange rates influenced by world commodity prices, as defined by Chen e Rogoff (2003) and Cashin, Céspedes e Sahay (2004). Cashin, Céspedes e Sahay (2004) found evidence of a long-run relationship between real exchange rates and world commodity prices for about one-third of the 58 commodity-exporting countries in the sample. The link between macroeconomic variables and real exchange rates is a recurring research topic in international macroeconomics since it is a prominent transmission channel between external shocks and domestic economy (AIZENMAN; BINICI, 2016). Emerging economies are historically vulnerable to external shocks, such as those triggered by disruptions in the global commodity markets, which cause concerns for policymakers of this group of countries.[4]

Several mechanisms explain the interdependence between world commodity prices and real exchange rates. In the short-run, the higher (lower) the price, the higher (lower) the supply of foreign exchange, triggering an appreciation (depreciation) of the exchange rate (KOHLSCHEEN; AVALOS; SCHRIMPF, 2017). In the long-run, the rise (fall) of terms of trade[5] brings more (less) income and wealth to commodity-exporting countries, causing the real exchange rate to appreciate (depreciate) (GREGORIO; WOLF, 1994; RICCI; MILESI-FERRETTI; LEE, 2013; NEARY, 1988). Even being long-run effects, the market participants anticipate the movements and the real exchange rate appreciates (depreciates) as soon as commodity prices rise (fall) (COUDERT; COUHARDE; MIGNON, 2015). Moreover, the rise (fall) of terms of trade tend to increase (decrease) the international attractiveness of domestic assets. Consequently, the exchange rate appreciates (depreciates) through the capital flow channel (BACEN, 2015; CHEN; LEE, 2014).

The key issue surrounding the effects of the world commodity price shocks on domestic economy lies on economic growth implications. Whether the revenues from natural resources are translated into a blessing or a curse is not clear in the literature. On the one hand, an increase in the world commodity prices is associated with expansion in consumption, investment and output of commodity-exporting countries (DRECHSEL; TENREYRO, 2018; FERNáNDEZ; GONZáLEZ; RODRIGUEZ, 2018; ZEEV; PAPPA; VICONDOA, 2017; SHOUSHA, 2016). On the other hand, the appreciation of the real exchange rate due to higher incomes from commodity exports tend to mitigate the international competitiveness of non-commodity sectors, such as the manufacturing industry. This phenomenon is known as Dutch Disease and emphasises that in resource-rich countries,

[4] The effects of global cycles on emerging economies are highlighted in the literature since these economies face a reversal in commodity prices and capital inflows simultaneously (sobering reversal of a double bonanza, as labelled by Reinhart, Reinhart e Trebesch (2016)), which is associated with economic crises.

[5] Terms of trade is defined as the ratio of exports value to imports value.

the increases in the commodity prices are associated with the decline of production in technology-intensive sectors (BRESSER-PEREIRA, 2008; FRANKEL, 2012; CORDEN, 1984; CORDEN; NEARY, 1982).

The literature about commodity currency increased significantly with the reversal of the fall in the world commodity prices in the 2000s (CARNEIRO, 2012). The urbanisation and industrialisation processes in China have led to an unprecedented demand for commodities with a substantial spillover effect on resource-rich countries (JENKINS, 2014; DUNGEY; FRY-MCKIBBIN; LINEHAN, 2014). This recent dynamic of the global commodity markets has contributed to the growing number of commodity-dependent developing countries.[6] According to UNCTAD (2017), the value of commodity exports from developing countries increased by about 25% between 2010 and 2015. During the same period, the institution has shown that 9 developing countries joined the group of commodity-dependent developing countries, which account for approximately two-thirds (91 countries) of the 135 developing countries in the sample.

In Brazil, the share of the value of commodity exports in the value of total merchandise exports increased significantly in the late 2000s (NEGRI; ALVARENGA, 2011). The "China Effect" accounted for part of this inflexion, especially with the high demand for commodities due to fiscal stimulus in the aftermath of the financial collapse of 2008.[7] The share of commodity exports in Brazilian merchandise exports remained around 60% between 2010 and 2015 (UNCTAD, 2015; UNCTAD, 2017), consolidating Brazil in the group of commodity-dependent developing countries and the Brazilian Real in the group of commodity currencies.[8] Kohlscheen (2014) conjectures that the important oil discovery in the pre-salt layer suggests that commodity prices will continue to influence the Brazilian currency in the future. Using simulation methods for the year 2020, the results in Magalhães e Domingues (2014) showed that the pre-salt layer discovery will increase the expansion of oil exports in detriment of manufacturing exports. The authors also showed that the change in the productive structure of the economy will favour sectors related to mining activities. The outlook for the soybean market (2027/28 relative to 2017/18) indicates an increase of 37.9% in exports (MAPA, 2018). This potential to expand commodity exports makes Brazil a special case in the world.

The literature often brings up the idea that the Brazilian economy has been undergoing a process of deindustrialisation, characterised mainly by the relative decline of the transformation sector in the Gross Domestic Product (GDP). This process is

---

[6] According to the United Nations Conference on Trade and Development (UNCTAD), a country belongs to the group of commodity-dependent developing countries when the ratio of the value of commodity exports to the value of total merchandise exports exceeds 60%.

[7] For empirical analysis of the increasing effects of China's economy fluctuations on a typical Latin American country since the mid-1990s, see Cesa-Bianchi et al. (2012).

[8] For evidences of commodity currency in Brazil, see Veríssimo e Xavier (2013), Veríssimo, Xavier e Vieira (2012), Branco (2016) and Kohlscheen (2014).

mainly attributed to the increase in commodity exports at the detriment of manufactured exports. The overvaluation of the Brazilian Real and the intensification of the competition with China over manufactured goods are among the reasons.[9] Although evidences of sectoral reallocation of non-commodity sectors to the commodities sector (a symptom of Dutch Disease) are not conclusive (for example, see Nassif, Feijó e Araújo (2014)), many economists seem to converge towards the need for reindustrialisation of the country. In this case, exchange rate policy plays a crucial role (OREIRO; BASILIO; SOUZA, 2014; MATTEI, 2016). Thus, exploring mechanisms that help in the management of the exchange rate policy in Brazil is an important research topic.

The various magnitudes of the real exchange rate responses to the commodity price fluctuations have encouraged investigations about the potential factors that determine this heterogeneity of results. Bodart, Candelon e Carpantier (2015) and Chen e Lee (2014) showed that structural factors such as trade openness and commodity export dependency potentially influence the magnitude of the commodity price elasticities. However, Chen e Lee (2014) found no long-run relationship between commodity prices and the Brazilian real exchange rate as the authors examined a long sample (between 1980 and 2010), encompassing the period which the Brazilian Real was not allowed to float. In turn, Bodart, Candelon e Carpantier (2015) only examined countries specialised in the export of a major commodity, which is not the case of the Brazilian export basket.

Coudert, Couharde e Mignon (2015) addressed the short-run relationship between world commodity prices and real exchange rate taking into account the hypothesis of that commodity prices are more tightly linked to the real exchange rate in periods of uncertainty. These periods are characterised by high volatility on commodity and financial markets. The authors argue that carry trade operations during periods of low risk aversion tend to drive the exchange rates away from its fundamentals. Thus, once risk aversion rises, carry trade operations are massively unwound, reinstalling the real exchange rate with the uncovered parity as well as other fundamentals (CLARIDA; DAVIS; PEDERSEN, 2009). Coudert, Couharde e Mignon (2015) found that volatility does not affect the relationship between world commodity prices and the real exchange rates in developing countries, including Brazil in the sample. The rationale is that many emerging and developing countries have either fixed exchange rates or strong intervention in the foreign exchange market when they adopt the floating exchange rate regime. However, the Brazilian Real has been volatile during the period at which it has been allowed to float and it is one of the most traded emerging market currencies in the world (KALTENBRUNNER, 2011; ROSSI, 2010).

Two aspects of the foreign exchange market in Brazil make the Brazilian Real

[9] For evidences of deindustrialisation in Brazil caused by the overvaluation of the Brazilian Real during the boom phase of the last commodity cycle, see Oreiro, Basilio e Souza (2014), Bresser-Pereira (2013) and Sonaglio, Campos e Braga (2016). Jenkins (2015) and Hiratuka e Sarti (2017) address the issue of deindustrialisation with a focus on competition with China over manufactured goods.

excessively exposed to disruptions in the international markets. First, the foreign exchange derivatives market in Brazil is larger than the spot exchange market compared to other countries (PRATES, 2009; ROSSI, 2014). The constraints inherent to the spot exchange market and the easy access to the futures exchange market make the derivatives of dollar the preferred instrument to foreign investors who want to speculate on the Brazilian Real.[10] Second, the surging exposure of foreign investors in a set of short-term domestic currency assets (NOIJE; CONTI, 2016). According to Kaltenbrunner e Painceira (2014), this process has two important implications: (*i*) the exchange rate movements become exacerbated and (*ii*) the exchange rate becomes more vulnerable to external conditions. The reason is that foreign investors finance their positions in the international financial market and quickly reverse their positions in times of uncertainty.

Regarding exchange rate policy, the Central Bank of Brazil (BACEN) is an important player in the foreign exchange market. According to Prates (2009), BACEN's intervention strategy in the spot exchange market has coincided with the objectives of the inflation targeting regime and the accumulation strategy of foreign exchange reserves. According to the author, at the peak of the international liquidity cycle, BACEN's interventions at the buying end of the foreign exchange market aimed to reduce exchange rate volatility, without seeking to influence in appreciation trend.

Since Brazil is an emerging economy, the country risk situation is potentially important in the context of the analysis of Coudert, Couharde e Mignon (2015) due to its characteristic of reflecting both aspects of the domestic economy and the uncertainty in the international financial market (ORNELAS, 2017; BELLAS; PAPAIOANNOU; PETROVA, 2010). The literature has documented that although external factors determine the capital flow towards developing countries, domestic indicators influence the distribution of these resource among these countries (AKYÜZ, 2011). This variable is not included in the prior literature since, to our best knowledge, there are no papers specifics for a emerging economy. The hypothesis is that the perception of risk from international investors regarding the domestic economy affects the relationship between commodity prices and the real exchange rate of an emerging economy.

The aim of this essay is to better understand the relationship between the Brazilian real exchange rate and the prices of the main commodities exported by Brazil (soybean, oil, iron ores, coffee, sugar, chicken meat and beef), focusing on factors that potentially change the intensity of this relationship. The analysis of this essay addresses both the short and long-run in accordance with the features of the factors. Structural factors, such

[10] One of the main reasons for this liquidity asymmetry is that only banking institutions and brokerage firms authorised by the National Monetary Council are allowed to invest in foreign currency. In turn, the financial derivative market in Brazil can be accessed by any agent interested to invest in dollar future contract (consequently in Brazilian Real). As a result, the Brazilian Real is one of the most traded currencies among the emerging markets (KALTENBRUNNER, 2011; ROSSI, 2010).

as (i) trade openness and (ii) commodity export dependency, may change the long-run relationship between world commodity prices and the Brazilian real exchange rate, and factors related to financial market, such as (i) international financial market volatility and (ii) country risk situation, may change the short-run relationship.

We carry out the empirical analysis of this essay in two steps. First, we estimate the long-run relationship between real commodity prices and the Brazilian real exchange rate, allowing that the elasticity of this relationship may be changed by the structural factors. Second, we estimate the short-run adjustment process through a smooth transition regression (STR) which may explain the non-linearity depending on the factors related to financial market. Our sample covers the period in which the exchange rate is allowed to float by the Brazilian monetary authority, from January 1999 to January 2018. A longer sample would inevitably capture the potential effects of the change of exchange rate regime on the elasticity (CHEN; ROGOFF, 2003; BODART; CANDELON; CARPANTIER, 2015). The choice of the sample period matters for the issue under analysis since several studies have not found long-run relationship between world commodity prices and the Brazilian real exchange rate taking into account mixed regimes for the exchange rate (CHEN; LEE, 2014; CASHIN; CéSPEDES; SAHAY, 2004; VERÍSSIMO; XAVIER; VIEIRA, 2012). Adopting this starting point also attenuates the bias associated with the heterogeneity of the macroeconomic policy since it has been officially based on the tripod regime (floating exchange rate, inflation target and primary surplus target) in 1999.

The literature has often made distinction between oil and non-oil commodities (COUDERT; COUHARDE; MIGNON, 2011; CHEN; ROGOFF, 2003) since energy prices have a particular dynamics on the economy. For instance, oil is a non-renewable fossil resource with demand rather inelastic and it is widely used as a production factor (AROURI; NGUYEN, 2010; DAUVIN, 2014). Besides, it has been well documented that oil is the commodity most related to the financial market, from the standpoint of the oil speculation phenomenon (CRETI; JOËTS; MIGNON, 2013; FILIS; DEGIANNAKIS; FLOROS, 2011). Hence, we constructed a real commodity price index and a real non-oil commodity price index, using historical export weights specifics for Brazil since the Brazilian natural resource exports encompass agricultural, livestock and mining goods, including oil in the mining category.

This essay is closely related to previous literature about potential factors that change the relationship between world commodity prices and real exchange rates (CHEN; LEE, 2014; COUDERT; COUHARDE; MIGNON, 2015; DAUVIN, 2014). Our contribution is threefold. First, we only consider the floating exchange rate regime to avoid confounding effects from different monetary regimes. Second, we make a clear distinction between commodity prices and non-oil commodity prices, considering that Brazil exports a broad basket of commodities, instead of defining Brazil as oil exporter (FILIS; DEGIANNAKIS;

FLOROS, 2011) or commodity exporter (DAUVIN, 2014) as is usually made. Third, we investigate the short-run non-linearity between world commodity prices and real exchange rate depending on the country risk situation, an indicator available for emerging markets.

The remainder of this essay proceeds as follows. Section 2.2 presents the theoretical framework on structural factors affecting the link between commodity prices and real exchange rate. Section 2.3 describes the empirical framework. Section 2.4 presents the results. Section 2.5 concludes.

2.2 A theoretical framework on structural factors affecting the link between commodity prices and real exchange rate

World commodity prices are potential determinants of the real exchange rates of commodity-exporting countries since the terms of trade of these countries are heavily composed of primary commodities. The long-run relationship between terms of trade and real exchange rates was investigated during the 1980s in order to analyse the perverse effects that a booming sector could have on the economy from a framework known as "Dutch Disease". This term refers to the harmful effect on the Dutch transformation industry triggered by natural gas discoveries of the nineteen sixties through the appreciation of the Dutch real exchange rate (CORDEN, 1984; CORDEN; NEARY, 1982).

The real exchange rate can be defined from an internal perspective as the relative price of nontraded and traded goods, taking into account the validated of the law of one price for traded goods.[11] It appreciates when the prices of nontraded goods increase relative to those of the traded goods. With regard to this perspective, the changes in the world commodity prices and therefore in the terms of trade influence the real exchange rates through both income and substitution effects (NEARY, 1988). The income effect refers to the increase in the demand for nontraded goods (assumed as normal goods) arising from the increase in income due to terms of trade improvement. Thus, the prices of nontraded goods relative to traded goods rise, so pushing up the real exchange rate. The substitution effect yields a shrinkage in the supply of nontraded goods, increasing their prices relative to those of the traded goods, reinforcing the income effect. If the commodity sector has links with the rest of the economy, the real appreciation may be avoidable; the boom, for example, may encourage more production of nontraded goods. However, the natural

[11] In Ouyang e Rajan (2013), the real exchange rate swings are decomposed into two sub-components. First, the relative price of traded goods between the countries (external prices) expressed in the same currency, with implications for international competitiveness. Second, the relative price of traded goods and nontraded goods within each country (internal prices), influencing the internal sectoral resource allocation. If Purchasing Power Parity (PPP) holds for traded goods, the movements in the real exchange rates are due to changes in the relative prices of traded and nontraded goods. Thus, when the prices of the nontraded goods increase in relation to the traded goods, the real exchange rates tend to appreciate.

resource sector is assumed to have weak links with the rest of the economy.

During the 2000s some studies focused directly on the long-run relationship between real exchange rate and world commodity prices (CASHIN; CéSPEDES; SAHAY, 2004; CHEN; ROGOFF, 2003). The Cashin, Céspedes e Sahay (2004)'s theoretical framework considers a small open economy that produces two types of goods (a nontraded good and a traded good). In general terms, an increase in the world commodity prices likely will increase wages in the commodity sector and consequently in the nontraded sector due to the premise that wages will tend to equalise insofar as labour can move freely between the sectors. The outcome is an increase in the prices of nontraded goods. The final effect is an appreciation of the real exchange rate since world commodity prices are exogenous. The Chen e Rogoff (2003)'s model produces similar results. In both studies, the income effect is neglected, and Tokarick (2008) argues that this is a serious omission because the literature about "Dutch Disease" emphasised the importance of the spending effects.

Despite the literature to highlight the robust relationship between real exchange rates and commodity prices, some recent studies noticed that the magnitude of the elasticities varies widely among countries and over time (BODART; CANDELON; CARPANTIER, 2015; CHEN; LEE, 2014). These studies consider a small open economy that produces threes types of goods (an exportable commodity, an exportable manufacture, and a non-traded good). The two tradable goods are necessary in the model to investigate how the commodity export dependency is able to affect the relationship between world commodity prices and real exchange rate. The adjustment of the models also goes thought free mobility of labour across the sectors and the consequent equalisation of the wages. In this essay, we detail the Chen e Lee (2014)'s model, which highlights the real exchange rate response to world commodity price shocks, allowing that structural factors affect the link between these two variables. Another option would be the theoretical framework of Bodart, Candelon e Carpantier (2015), who investigate structural factors that influence the relationship between real exchange rates and commodity prices in developing countries specialised in the export of a leading commodity. We chose the framework of Chen e Lee (2014) because it considers a commodity price index composed by a group of commodities. The Brazilian exports are composed of a group of primary commodities (even if small) rather than a leading commodity.

Chen e Lee (2014) consider a small open economy at competitive market that produces exportable commodities (xc), exportable manufactures (xm) and non-traded (n) whose production functions for each sector are:

$$Y_{xc} = A_{xc} L_{xc}^{\alpha_{xc}} H_{xc}^{\beta_{xc}} K_{xc}^{1-\alpha_{xc}-\beta_{xc}} \tag{2.1}$$

$$Y_{xm} = A_{xm} L_{xm}^{\alpha_{mc}} H_{mc}^{\beta_{xm}} K_{xm}^{1-\alpha_{xm}-\beta_{xm}} \tag{2.2}$$

$$Y_{n} = A_{n} L_{n}^{\alpha_{n}} K_{n}^{1-\alpha_{n}} \tag{2.3}$$

where A_i, L_i, H_i and K_i are productivity shocks, unskilled labor, skilled labor, and capital stock used in sectors $i = xc, xm$ e n, respectively; α_i and β_i are the shares of the unskilled and skilled labor in the production of the sector i. There is constant-returns-to-scale technology and the skilled labor is necessary to produce exportable goods. Chen e Lee (2014) embrace the following assumptions: (i) capital can move between sectors of the country and internationally, resulting in marginal product of capital of the domestic country given by the world interest rate (r^*); (ii) labor can migrate among sectors of the country, ensuring wages equalisation across unskilled and skilled sectors (w_L and w_H, respectivaly); and (iii) the total domestic labor supply is inelastic and given by $L = L_{xc} + L_{xm} + L_n$ and $H = H_{xc} + H_{xm}$.

Commodity prices (P_{xc}) are assumed to be exogenous in a small open economy and exportable manufactures (xm) are taken as numeraire. Thus, domestic prices of non-traded goods (P_n) and prices of exportable commodities (P_{xc}) are measured in terms of exportable manufactures. In addition, the Law of One Price (LPU) is valid for the exportable goods ($i = xc, xm$), so that:

$$EP_i = P_i^* \tag{2.4}$$

where E is the nominal exchange rate, which is defined as the price of the domestic currency in terms of the foreign currency.[12] And the asterisk denotes a foreign variable.

Defining $P_{xm} = 1$ and by combining the first order conditions from profit-max problem composed by the Equations 2.1, 2.2 and 2.3, one can find the conditions of zero-profit for each exportable sector.[13]

To simplify the resolution, Chen e Lee (2014) assume the following suppositions for the exportable sectors ($i = xc, xm$): (i) both sectors share a common rate of productivity shock ($\hat{A}_x = \hat{A}_{xm} = \hat{A}_{xc}$); ($ii$) the share of capital income in output ($\mu_{k,i} = rK_i/P_iY_i$) are equal $\mu_{k,xc} = \mu_{k,xm}$; and (iii) the share of skilled and unskilled labor in the income are $\mu_{H,i} = w_H H_i/P_iY_i$ and $\mu_{L,i} = w_L L_i/P_iY_i$. Taking account these suppositions and the first order conditions, the log-differentiation of the conditions of zero-profit for the exportable sectors results in the following equation:

$$\hat{w}_L = \frac{\varphi \hat{P}_{xc} + \hat{A}_{xc}}{\mu_{L,xc} + \mu_{H,xc}} \tag{2.5}$$

where, $\varphi = \mu_{H,xm}/\mu_{H,xm} - \mu_{H,xc}$. Since the exportable manufacures are relatively more skilled-labor intensive than exportable commodities, it's likely that $\varphi > 0$.

From the condition zero-profit in the non-traded good sector is possible to obtain:

$$\hat{P}_n = \mu_{L,n}\hat{w}_L - \hat{A}_n \tag{2.6}$$

[12] For example, the bilateral nominal exchange rate between Brazil and United States is US\$/R\$. Thus, an increase in the nominal exchange rate means a nominal appreciation of the Brazilian exchange rate. This setting is different from that found in textbooks.

[13] See algebraic details in Chen e Lee (2014).

Combining the Equations 2.5 and 2.6, one can to obtain:

$$\hat{P}_n = \frac{\mu_{L,n}}{\mu_{L,xc} + \mu_{H,cx}}(\varphi \hat{P}_{xc} + \hat{A}_{xc}) - \hat{A}_n \tag{2.7}$$

According to Chen e Lee (2014), the non-traded goods tend to be more labor-intensive than exportable goods, so that $\mu_{L,n}/\mu_{L,xc}+\mu_{H,xc} \geq 1$. The Equation 2.7 shows that the price of non-traded good is a positive function of the price of exportable commodities and there is a positive relationship between productivity in the commodity sector and the price of the non-traded good, as defined in the Balassa-Samuelson effect.

Identical individuals supply production inputs and consume four types of goods: non-traded (n), imported (m), exportable commodities (xc) and exportable manufactures (xm). Home residents derive utility by consuming (θ_n) share of non-traded goods, (θ_m) share of imported, (θ_{xc}) share of exportable commodities and ($1 - \theta_n - \theta_m - \theta_{xc}$) share of exportable manufactures. The utility function in the Cobb-Douglas form is:

$$U = C_n^{\theta_n} C_m^{\theta_m} C_{xc}^{\theta_{xc}} C_{xm}^{1-\theta_n-\theta_m-\theta_{xc}} \tag{2.8}$$

where C_i is the consumption of the good $i = n, m, xc, xm$. Using a consumption-based price index for domestic and foreign countries and the Equation 2.7, one can to write the real exchange rate as follows:

$$Q = \frac{EP}{P^*} = \frac{EP_n^{\theta_n} P_m^{\theta_m} P_{xc}^{\theta_{xc}}}{(P_n^*)^{\theta_n^*}(P_m^*)^{\theta_m^*}(P_{xm}^*)^{1-\theta_n^*-\theta_m^*}} = (E\frac{P_n}{P_n^*})^{\theta_n} P_{xc}^{\theta_{xc}} = (E\frac{f(P_{xc})}{P_n^*})^{\theta_n} P_{xc}^{\theta_{xc}} \tag{2.9}$$

where Q is the real exchange rate,[14] P e P^* are consumption-based price indexes for domestic and foreign countries, respectively. The Equation 2.9 shows that taking P_n^* as given, the real exchange rate of the home country appreciates in response to an increase in the world commodity prices, and the magnitude of the appreciation depends on the parameters θ_n e θ_{xc}; that is, the real exchange rate is more sensitive to commodity price fluctuations the larger is the share of non-traded and commodities in the basket of domestic consumption. Given this theoretical framework, Chen e Lee (2014) propose the following structural variables:

(a) Trade openness: *Ceteris Paribus*, a country with high degree of trade openness has a relatively smaller share of non-traded goods in the domestic consumption basket (smaller θ_n) and therefore a lower real exchange rate response to commodity prices shocks.

(b) Commodity export dependency: *Ceteris paribus*, the larger the share of commodities in the basket of domestic consumption (θ_{xc}), the higher the real exchange rate response to commodity price shocks.

[14] According to this definition, an increase in Q means an appreciation of the real exchange rate.

The Cashin, Céspedes e Sahay (2004)'s model also shows that the share of nontraded goods in the domestic consumption basket changes the real exchange rate response to commodity price shocks, but this issue is not included in the empirical framework. Bodart, Candelon e Carpantier (2015) also make the link between the share of nontraded goods in the domestic consumption basket and the degree of trade openness. In turn, the commodity export dependency is an obvious structural factor since the larger dependency is associated with a larger portion of the terms of trade composed by primary commodities. This issue was directly analysed in the Bodart, Candelon e Carpantier (2015)'s theoretical framework, who included in the empirical model only data for countries specialised in a leading commodity.

2.3 Empirical framework

To assess the effects of the real commodity prices on the Brazilian real exchange rate taking into account structural and financial factors that potentially change the intensity of this relationship, the empirical framework is divided in two parts. First, we rely on long-run equation estimation techniques to account for the relationship between real exchange rate and real commodity prices. In addition, we allow that the structural factors defined in the Section 2.2 (trade openness and commodity export dependency) change the real exchange rate response to commodity price shocks. Second, we use short-run equation estimation techniques to analyse the potential non-linearity in the link between real exchange rate and real commodity prices according to the financial factors (volatility in international financial market and the country risk situation).

2.3.1 Long-run estimation strategies

Empirically, the long-run relationship between real exchange rate and real commodity prices is given by:

$$reer_t = \beta_0 + \beta_1 br(i)_t + \epsilon_t \tag{2.10}$$

where $t = 1, ..., T$ denotes the time (from January 1999 to January 2018). $reer_t$ is the real effective exchange rate (in log) and $br(i)_t$ denotes the real commodity price indexes (in log), where i assumes 7 or 6; when $i = 7$, the real commodity price index contains the seven major commodities exported by Brazil ($br7_t$: soybean, iron ore, oil, sugar, chicken meat, beef and coffee) and when $i = 6$ the real non-oil commodity price index contains the same seven commodities except by oil prices ($br6_t$). ϵ_t is the error term $i.i.d.$

The real effective exchange rate[15] ($reer_t$) is a trade-weighted index and based on consumer prices, according to International Monetary Fund's methodology. A rise in the

[15] Unless otherwise noted, real effective exchange rate and real exchange rate are interchangeable terms and signify the logarithm of the real effective exchange rate.

real exchange rate, or a real appreciation, means that a basket of domestic consumption becomes more expensive than a basket of foreign consumption; therefore, an increase means a loos in trade competitiveness.[16]

The calculation of the real commodity price index ($br7_t$) follows methodology used in Cashin, Céspedes e Sahay (2004). Specifically, the weights of the index are the average value of each major commodity exported by Brazil divided by the average value of Brazil's commodity exports over the period from 1999 January to 2018 January. The weights are used into the calculation of the geometrically weighted index of monthly nominal commodity export prices. Finally, the nominal commodity price index is deflated by the U.S. import price of manufactured articles from industrialised countries, in line with Shousha (2016), so that the index can also be interpreted as commodity terms of trade, such as in Bodart, Candelon e Carpantier (2012), Cashin, Céspedes e Sahay (2004) and Zeev, Pappa e Vicondoa (2017). The calculation of the real non-oil commodity price index ($br6_t$) only does not include the oil prices.[17]

The theoretical framework presented in Section 2.2 addresses structural factors that potentially change the link between real exchange rate and real commodity prices. Empirically, to gauge the effects of the structural factors on the Brazilian real exchange rate elasticity to commodity price shocks the following equation is estimated:

$$reer_t = \phi_0 + \phi_1 br(i)_t + \phi_2 br(i)_t \times x(j)_t + \nu_t \tag{2.11}$$

where $x(j)_t$ contains the factors presented in Section 2.2. j assumes to and $ced(i)$; when $j = to$, the trade openness factor (xto_t) is analyzed and when $j = ced(i)$ the commodity export dependency factor is analyzed ($xced(i)_t$), with $i = 7$ ($xced7$) and 6 ($xced6$), according to the value assumed by $br(i)_t$. Both xto_t and $xced(i)_t$ were transformed into dummy variables by the median method (1 for the observations greater than the median and 0, otherwise) and investigated as interaction terms jointly with $br(i)_t$, in line with Chen e Lee (2014) and Bodart, Candelon e Carpantier (2015). The commodity price elasticity (w_1) of real effective exchange rate is $w_1 = \phi_1$, when $x(j)_t = 0$, and $w_2 = \phi_1 + \phi_2$ when $x(j)_t = 1$. Finally, ν_t is the $i.i.d$ error term.

The trade openness (xto_t) factor is the degree of dependence on foreign trade. This variable is measured as imports and exports divided by the GDP. In turn, the commodity export dependency ($xced(i)_t$) factor is the degree of dependence on commodity exports. This variable is defined as the average value of the main commodities exported by Brazil

[16] Real exchange rate is defined by $Q = EP/P^*$, where the nominal exchange rate (E) is the price of the domestic currency in terms of the foreign currency, in accordance with Equations 2.4 and 2.9. P and P^* are domestic and foreign consumer price indexes, respectively (IMF, 2018b).

[17] The weights for the real commodity price index are: soybean (0.280), iron ore (0.253), oil (0.159), sugar (0.119), coffee (0.063), beef (0.053) and chicken meat (0.073). In turn, the weights for the real non-oil commodity price index are: soybean (0.333), iron ore (0.301), sugar (0.141), coffee (0.075), meat (0.063) and chicken meat (0.087).

divided by the average value of the merchandise exports over the period from January 1999 to January 2018. Two variables are constructed: commodity export dependency ($xced7_t$) and non-oil commodity export dependency ($xced6_t$). Data used in the calculation of $br(i)_t$, xto_t and $xced(i)_t$ are expressed in U.S dollar.

The literature on commodity currency has often shown that real exchange rate and real commodity prices are cointegrated in the sense of Engle e Granger (1987).[18] Despite the unit root in the real exchange rate to entail the rejection of the Purchasing Power Parity (PPP), the cointegration between real exchange rate and real commodity prices means that the fluctuations in the prices may be important sources of real shocks that explain the parity deviations (CASHIN; CéSPEDES; SAHAY, 2004).

The estimation of the cointegrating equation uses the technique of Stock e Watson (1993), denominated dynamic ordinary least squares (DOLS). This estimator is often used in the literature on commodity currency and other applications encompassing determinants of the real exchange rate.[19] DOLS consists of assigning *leads* and *lags* of the first difference of the regressors to minimize possible endogeneity and feedback effect. DOLS is efficient in the estimation of cointegration vectors that include deterministic components, that accommodate variables of different integration orders as well as possible simultaneity between the variables (STOCK; WATSON, 1993). In addition, the DOLS is asymptotically equivalent to the maximum likelihood estimator (CHOI; OH, 2003; STOCK; WATSON, 1993). However, in the presence of serial correlation, the variance-covariance matrix of the disturbances may be biased. Thus, in this essay, all the estimates use the method of Newey e West (1987), which estimates the variance-covariance matrix consistently in the presence of heteroskedasticity and autocorrelation when their forms are unknown.

2.3.2 Short-run estimation strategies

To check whether the volatility in international financial market and the country risk situation are sources of non-linearity between real exchange rate and real commodity prices we rely on the smooth transition regression (STR) model, which is often used in the literature on exchange rate (COUDERT; MIGNON, 2016; COUDERT; COUHARDE; MIGNON, 2011). According to Teräsvirta (1996), the switching regression models may be generalised such that the transition from one regime to another is smooth rather than abrupt, giving rise to the STR model. Our specification relies on the smooth transition error correction model, similar to the strategy used by Coudert, Couharde e Mignon (2015) and Dauvin (2014), since that it allows the short-term relationship to be non-linear,

[18] For example, see Bodart, Candelon e Carpantier (2012), Cashin, Céspedes e Sahay (2004), Chen e Lee (2014), Chen e Rogoff (2003) and Kohlscheen (2014).

[19] For example, see Chen e Lee (2014), Coudert, Couharde e Mignon (2015), Bodart, Candelon e Carpantier (2015), Bodart, Candelon e Carpantier (2012), Chen e Rogoff (2003), Dauvin (2014) and Ricci, Milesi-Ferretti e Lee (2013).

depending on the transition variable. Both long-term and short-term relationships are expressed in the following specification:

$$\Delta reer_t = \Phi_0 + \Phi_1 \Delta br(i)_t + \Phi_2 \Delta br(i)_t \times G(\gamma, c, s_t) + \Phi \epsilon_{t-1} + \varepsilon_t \tag{2.12}$$

where $\Delta reer_t$, $\Delta br(i)_t$ are the monthly change in $reer_t$ and in $br(i)_t$, respectively. $\epsilon_t = reer_t - \beta_0 - \beta_1 br(i)_t$. $G(.)$ is the transition function, which defines as occurs the transition between the regimes.

The logistic STR (LSTR) model uses the Equation 2.12 jointly with the following equation:

$$G(\gamma, c, s_t) = (1 + exp\{-\gamma(s_t - c)\})^{-1}, \gamma > 0 \tag{2.13}$$

The transition function $G(\gamma, c, s_t)$ is a limited function of the continuous transition variable (s_t) and assumes values between 0 and 1 (TERÄSVIRTA, 1994; TERÄSVIRTA, 1996). The slope parameter (γ) determines the speed of transition from one regime to another and the location parameter (c) indicates where occurs the transition. Specifically, $s_t \to -\infty$, $G(.) \to 0$ so that the real exchange rate equation is given by $\Delta reer_t = \Phi_0 + \Phi_1 \Delta br(i)_t + \Phi \epsilon_{t-1} + \varepsilon_t$. Similarly, when $s_t \to \infty$, $G(.) \to 1$, the equation is given by $\Delta reer_t = \Phi_0 + (\Phi_1 + \Phi_2)\Delta br(i)_t + \Phi \epsilon_{t-1} + \varepsilon_t$. Thus, the model allows characterising the non-linearity associated with small and large values of the transition variables regarding the location parameter or threshold (c).

In turn, the exponential STR (ESTR) model uses the equation 2.12 jointly with the following equation:

$$G(\gamma, c, s_t) = (1 - exp\{-\gamma(s_t - c)^2\}, \gamma > 0 \tag{2.14}$$

The main characteristic of this function is being symmetric around $s_t = c$. Wen s_t approaches c, $G(.)$ approaches 0 and the real exchange rate equation is given by $\Delta reer_t = \Phi_0 + \Phi_1 \Delta br(i)_t + \Phi \epsilon_{t-1} + \varepsilon_t$. At the other end, when s_t departs from c, $G(.)$ approaches 1 so that the model becomes $\Delta reer_t = \Phi_0 + (\Phi_1 + \Phi_2)\Delta br(i)_t + \Phi \epsilon_{t-1} + \varepsilon_t$. Note that when the parameter γ approaches 0 or infinity, the model approaches the linear form, since $G(.)$ is constant. This function displays the cases where the asymmetry occurs at the extremes of the transition variables, so that there are intermediate values (for example, around 0) that reflect the first regime, and extreme values that reflect the second regime.

We run the STR model using two transition variables successively. First, we use the VIX index (vix_t) - implied volatility on the S&P500 index. This index is a measure of the market's expectation based on options on the S&P500 index (CBOE, 2018). The VIX has been usually used as a proxy of uncertainty about the international financial market (SILVENNOINEN; THORP, 2013), global risk perception (KOHLSCHEEN, 2014) and risk aversion (MOREIRA; ROCHA; SILVEIRA, 2015). Second, we use the change of the JP

Morgan's Emerging Markets Bond Index - EMBI+ Brazil ($\Delta embi_t$). The EMBI+ gauges the risk premium of the Brazilian sovereign bonds in relation to the U.S. Treasury bonds. This index is calculated with bond traded actively and denominated in U.S dollars. The daily data of the VIX and of the EMBI+ were transformed into the monthly frequency by the simple average. The EMBI+ is in log form, as is often in the literature (FERNANDEZ; SCHMITT-GROHE; URIBE, 2017; URIBE; YUE, 2006).

Concerning the specification and estimation, we rely on the linearity test depicted in Teräsvirta (1994) and Teräsvirta (1996) and on the BRGS algorithm (Broyden-Fletcher-Goldfarb-ShannoBroyden) to maximise the logarithm of likelihood.

2.3.3 Alternative specification

As in Chen e Lee (2014) and Cashin, Céspedes e Sahay (2004), we assume that commodity prices are the most important determinant of the real exchange rate of a commodity-dependent country. Indeed, Kohlscheen (2014) found that commodity prices are the most important long-run determinant of the Brazilian real exchange rate, but in the short-run other factors play a nontrivial role in determining the real exchange rate. This aspect is reinforced by the institutional aspects of the foreign exchange market in Brazil. Therefore, control variables are included in the Equations 2.10 and 2.12 as a sensitivity analysis of empirical results.

The literature stresses several determinants of the real exchange rate (RICCI; MILESI-FERRETTI; LEE, 2013; MACDONALD, 1997). While the fundamentals change according to the characteristics of the country (development level, for example), some variables are often used in the literature. Additionally to the prices of the major commodities exported by Brazil, we also consider the logarithm of the real interest differential (dif_t) between Brazil and the United States. The nominal interest differential is Brazil's interest rate (SELIC) minus the United States' interest rate (Fed Funds Effective). The first interest rate is deflated by the Broad National Consumer Price Index (IPCA) of Brazil and the second interest rate by the U.S Consumer Price Index (CPI). An appreciation of the real exchange rate is expected in response to an increase in the real interest differential due to the rise in attractiveness of domestic financial assets.

The alternative specification also includes international reserves (res_t) as this policy variable can help to stabilise the exchange rate, providing liquidity for the foreign exchange market. In this sense, Aizenman, Edwards e Riera-Crichton (2012) show that active international reserve management effectively lowers the volatility of the real exchange rates in commodity-exporting Latin American economies. This variable is measured as a proportion of the GDP.

The literature on determinants of the real exchange rate normally includes measures of relative productivity to capture the Balassa-Samuelson effect. However, when considering a Brazilian manufacturing productivity index comparing to U.S productivity, Kohlscheen (2014) did not find any trend. The author concludes that is difficult to attribute the appreciation of the Brazilian Real occurred in the 2000s to the Balassa-Samuelson effect. In addition, some studies confirm the non-evidence of the Balassa-Samuelson effect for the Brazilian economy (for example, see Vasconcelos (2004)).

2.3.4 Data

This section presents the dataset used in this article. Items (1) to (5) contain the data used in the benchmark model and items (6) and (7) the data used in the alternative specification.

(1) Real effective exchange rate ($reer_t$): Monthly data from the International Monetary Fund (IMF, 2018a).

(2) Real commodity prices indexes ($br(i)_t$): Nominal prices were obtained from the World Bank's Global Economic Monitor Commodities (WB, 2018) and the export data used to calculate the weights are from Brazilian foreign trade dataset of the Ministry of Industry, Foreign Trade and Services (COMEXSTAT, 2018).[20] The deflator is from Federal Reserve Bank of St. Louis (FED, 2018).

(3) Trade openness (xto_t) and commodity export dependency ($xced(i)_t$): The monthly data of exports were obtained from the Brazilian foreign trade dataset of the Ministry of Industry, Foreign Trade and Services (COMEXSTAT, 2018). These data are the same goods used to calculate the weights of the real commodity price indexes. Monthly GDP data (code: 4385) are from the Central Bank of Brazil's dataset (BACEN, 2018). All the foreign trade data were seasonally adjusted using the ARIMA X13 method.

(4) VIX index (vix_t): Data from the Chicago Board Options Exchange (CBOE, 2018).

(5) JP Morgan's Emerging Markets Bond Index ($embi_t$): The data are in point basis and the source is the Brazilian Institute of Applied Economic Research (IPEA, 2018).

(6) Real interest differential (dif_t): The SELIC rate (code: 4189) were obtained from the Central Bank of Brazil's dataset (BACEN, 2015) and the IPCA at the Brazilian

[20] We used the products related to the following NCM (Common Nomenclature of MERCOSUL South American trade bloc) codes: soybean (12010010, 12010090, 12011000, 12019000, 15071000, 23040010 and 23040090), iron ores (26011100, 26011200, 26012000, 26011210 and 260112900), oil (27090010), beef (2011000, 02012010, 02012020, 02012090, 02013000, 02021000, 02022010, 02022020, 02022090 and 02023000), chicken meat (02071100, 02071200, 02071300 and 02071400), sugar (17011100, 17011300, 17011400 and 17019900), coffee (09011110).

Institute of Geography and Statistics (IBGE, 2018). The Fed Funds Effective and the CPI were obtained from the Federal Reserve Bank of St. Louis (FED, 2018).

(7) International reserves (res_t): Reserves (code: 3546) were obtained from the Central Bank of Brazil's dataset (BACEN, 2018) as well as the Monthly GDP data.

2.4 Results

2.4.1 Evolution of the variables

Figure 1 plots the real exchange rate against the real commodity price indexes. This Figure shows that an appreciation of the real exchange rate is associated with an increase in the real commodity prices, which is particularly clear from 2003 to 2011. The exception is the financial collapse of 2008. Real commodity prices declined from 2012 to 2016, when China reoriented its growth domestically (CASHIN; MOHADDES; RAISSI, 2017) and the Brazilian real exchange rate followed closely this decline.

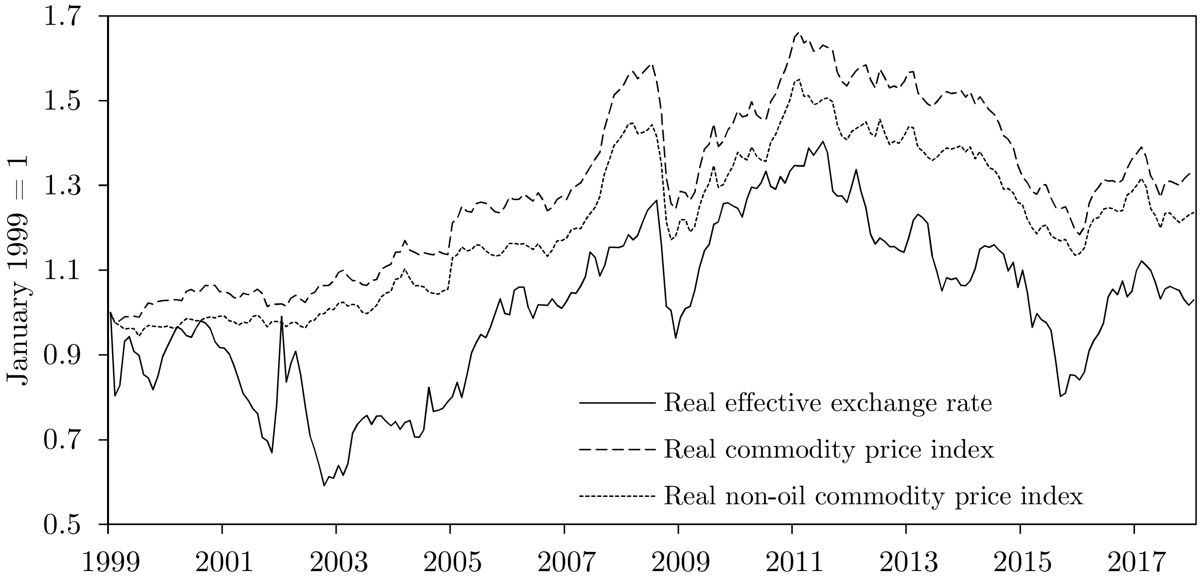

Figure 1 – Brazilian real effective exchange rate, real commodity price index and real non-oil commodity price index, from January 1999 to January 2018

Note: The Figure plots Brazilian real effective exchange rate ($reer_t$), real commodity price index ($br7_t$) and real non-oil commodity price index ($br6_t$), defined in Section 2.3.1, without transformation in log form.

The country risk of an emerging economy reflects the international financial market conditions since these countries are vulnerable to external shocks, as well as domestic events. Figure 2 shows high values for both country risk and volatility in international financial market at the begin of the sample period of this essay. The speculative attack that gave rise to the Asian crisis, in 1997, triggered an increase in the risk aversion and an inversion in the capital flows, starting the currency crisis in Brazil in 1999, and, consequently, leading the country to adopt the floating exchange rate regime. The early years of the 2000s were a test for the new regime as is indicated through extreme values for both country risk and volatility in international financial market. For instance, there was a spillover of uncertainty on emerging markets from the collapse of Argentina in 2001 (FARHI, 2006). Furthermore, took place in 2002 a confidence crisis caused by uncertainty about the future of economic policy thanks to the presidential elections in Brazil. Consequently, the capital flows towards Brazil were interrupted due to the high level of country risk (SOUZA; HOFF, 2006).

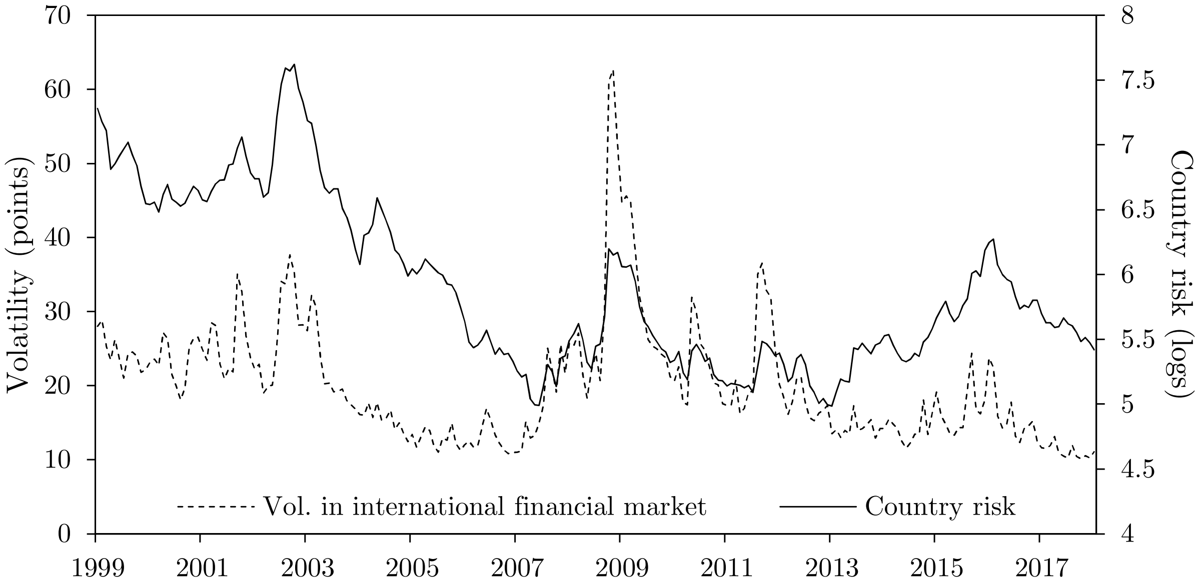

Figure 2 – Volatility in international financial market (vix_t) and country risk ($embi_t$), from January 1999 to January 2018

The financial collapse of 2008 explains a sharp depreciation of the real exchange rate and the decline in the real commodity prices shown in Figure 1. In the aftermath of the crisis, the European sovereign debt crisis was reflected more in the vix_t than in the $embi_t$ since the commodity-exporting emerging market economies faced a bonanza period due to increase in the commodity prices. In 2016, the vix_t displayed high values reflected by decision of United Kingdom of leaving the European Union (BREXIT). According to the Getúlio Vargas Foundation's Business Cycle Dating Committee (CODACE, 2018), Brazil was in recession from the second quarter of 2014 to the fourth quarter of 2016, justifying the increase in the country risk during this period. The literature brings several justifications for the crisis,[21] but there isn't consensus due to lack of historical distancing.

[21] The decline in the commodity prices was accompanied by a slowdown in the growth of emerging economies and developing countries, many of which presented high growth rates during the boom phase of the prices (ASLAM et al., 2016). Rossi e Mello (2016), attempting to contribute for the debate on the Brazilian crisis, argue that several factors that contributed positively to the constitution of the mass consumer market also negatively impacted the productive structure, among them the improvement in the terms of trade and the real exchange appreciation. In turn, Filho (2017) argues

In general, the Brazilian real exchange rate showed a depreciation trend from mid-2014, closely following the downward trend in the commodity prices and the increase in the country risk.[22]

The structural factors that potentially change the relationship between real exchange rate and commodity prices are shown in Figure 3. Both trade openness and commodity export dependency revealed an inflexion in the aftermath of the financial collapse of 2008. The measure of trade openness is gauged with exports and imports in the numerator and GDP in the denominator. Exports and imports dropped sharper and recovered slower than Brazil's GDP due to the impact of the crisis on global trade, which explains the lower values for the post-crisis measure of trade openness. Regarding commodity export dependency, the investment strategy in emerging economies, especially in China in response to the crisis, explains the commodity price boom in the post-crisis and the larger share of commodities in the trade balance of commodity-exporting countries.

that the set of policies adopted from 2011/2012, known as the New Economic Matrix, has reduced the productivity of the Brazilian economy and consequently the potential output.

22 For examples of the inverse relationship between commodity prices and country risk of commodity-exporting emerging market economies, see Fernández, González e Rodriguez (2018) e Shousha (2016).

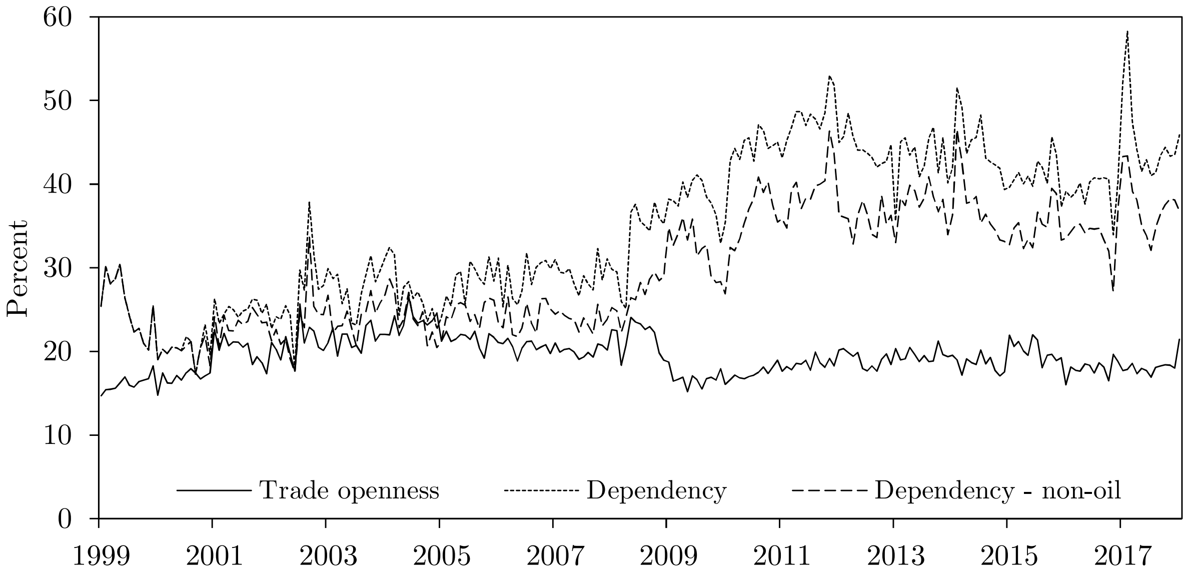

Figure 3 – Trade openness (xto_t), commodity export dependency ($xced7_t$) and non-oil commodity export dependency ($xced6_t$), from January 1999 to January 2018

2.4.2 Unit root, cointegration and weak exogeneity

To analyse the main stochastic characteristics of the real commodity price indexes and of the Brazilian real exchange rate, this section presents the unit root, cointegration and weak exogeneity tests.

Table 1 reports the results of the Augmented Dickey-Fuller (ADF) test, showing that the Brazilian real exchange rate and the real commodity price indexes have a unit root, considering the specification with intercept and with intercept and trend. Macroeconomic variables are subject to structural breaks, such as occurred in the financial collapse of 2008. The Zivot-Andrews (ZA) test considers this issue allowing an endogenous structural break in the intercept. The results are shown in Table 2, confirming the findings of the ADF test after considering a structural break. Despite both variables have a unit root, they can present a comovement over time so that they are labelled of cointegrated variables.

The results of the cointegration tests of Engle e Granger (1987) and Phillips e Ouliaris (1990) are summarized in Table 3. All test statistics (τ and z) provide evidence for the rejection of the null hypothesis of non-cointegration. In turn, the results of Johansen's cointegration test[23] are summarised in Tables 4 and 5. The tests confirm that the real commodity price indexes and the Brazilian real exchange rate have a cointegrated vector when the tests are specified with intercept. Thus, the hypothesis that there is a long-run relationship between the Brazilian real exchange rate and the world prices of the major commodities exported by Brazil is not rejected. These findings are consonant with

[23] For details of the Johansen cointegration test, see Johansen (1998), Johansen (1991) and Enders (2015).

Table 1 – Augmented Dickey–Fuller unit root test

Variable	p	Model 1	p	Model 2	Variable	p	Model 1	p	Model 2
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
$reer_t$	0	$-1,632^{ns}$	0	$-2,063^{ns}$	$\Delta reer_t$	2	$-8,000^{***}$	2	$-7,983^{***}$
$br7_t$	1	$-1,970^{ns}$	1	$-1,673^{ns}$	$\Delta br7_t$	4	$-5,664^{***}$	1	$-8,330^{***}$
$br6_t$	1	$-1,698^{ns}$	1	$-1,581^{ns}$	$\Delta br6_t$	5	$-5,300^{***}$	5	$-5,403^{***}$

Notes: (1) Null hypothesis: the variable has a unit root. (2) Columns 2 and 6 report the test statistic of the version with intercept and Columns 4 and 8 report the test statistic of the version with intercept and linear trend. (3) Lags (p) are chosen by the Modified Schwarz information criteria (p max = 14). (4) Critical values based on MacKinnon (1996). (5) ***, **, * and *ns* stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Table 2 – Zivot-Andrews unit root test

Variable	p	Model 1	p	Model 2	p	Model 3
	(1)	(2)	(3)	(4)	(5)	(6)
$reer_t$	1	-4.087^{ns} [2005M01]	1	-3.316^{ns} [2010M08]	1	-4.126^{ns} [2005M04]
$br7_t$	1	-3.898^{ns} [2014M05]	1	-3.896^{ns} [2011M02]	1	-4.060^{ns} [2010M08]
$br6_t$	1	-3.768^{ns} [2014M05]	1	-3.101^{ns} [2011M01]	1	-4.279^{ns} [2010M08]

Notes: (1) Null hypothesis: the variable has a unit root with a structural break in the intercept. (2) Columns 2, 4 e 6 report the test statistic of the versions with intercept, linear trend and both, respectively. (3) Dates of structural breaks are in [ ]. (4) p max = 8. (5) ***, **, * and *ns* stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Kohlscheen (2014) and Veríssimo, Xavier e Vieira (2012). According to Cashin, Céspedes e Sahay (2004), the cointegration relationship between world commodity prices and real exchange rate is a result of higher wages caused by higher commodity prices. It puts upward pressure on prices of nontraded good and eventually causes an appreciation of the real exchange rate. Kohlscheen (2014) suggests that this mechanism is in line with the recent dynamics of these variables in Brazil. Moreover, evidence of cointegration rules out the possibility of "spurious regression".

Table 3 – Engle-Granger (EG) and Phillips-Ouliarius (PO) cointegration tests - Dependent variable = $reer_t$

Variable	Model 1 (τ)		Model 1 (z)		Model 2 (τ)		Model 2 (z)	
	E-G	PO	E-G	PO	E-G	PO	E-G	PO
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$br7_t$	$-3,971^{**}$	$-4,367^{***}$	$-23,977^{**}$	$-33,148^{***}$	$-3,969^{***}$	$-4,368^{**}$	$-20,22^{**}$	$-33,230^{**}$
$br6_t$	$-3,88^{**}$	$-3,335^{***}$	$-26,899^{**}$	$-34,342^{***}$	$-3,888^{**}$	$-4,356^{**}$	$-27,221^{**}$	$-34,884^{***}$

Notes: (1) Null hypothesis: the series are not cointegrated. (2) Columns 1 and 3 report the test statistic (τ e z) of the Engle-Granger test at the version with intercept and Columns 5 and 7 report the test statistic at the version with intercept and linear trend. (3) Columns 2 and 4 report the test statistic (τ e z) of the Phillips-Ouliaris test in the version with intercept and Columns 6 and 8 report the test statistic of the version with intercept and linear trend. (4) Lags (p) of the Engle-Granger test are chosen by the Modified Schwarz information criteria (p max = 14). (5) Critical values based on MacKinnon (1996). (6) ***, **, * and *ns* stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Table 4 – Johansen cointegration test summary - Variables: $reer_t$ e br_7

(a) *Number of cointegrating relations*		
Test type	No trend and intercept	Linear trend and intercept
Trace	1	0
Maximum Eigenvalue	1	0

(b) *Unrestricted cointegration rank test (trace)*

Hypothesis		Eigenvalue	Trace statistic	Critical value	Prob.˙
Null	Alternative				
$r = 0$	$r \geq 1$	0,065	$19,199^{**}$	15,494	0,013
$r \leq 1$	$r \geq 2$	0,016	$3,778^{ns}$	3,841	0,052

(c) *Unrestricted cointegration rank test (maximum eigenvalue)*

Hypothesis		Eigenvalue	Max-Eigen statistic	Critical value	Prob.
Null	Alternative				
$r = 0$	$r = 1$	0,065	$15,420^{**}$	14,264	0,032
$r = 1$	$r = 2$	0,016	$3,778^{ns}$	3,841	0,052

Notes: (1) Part (a) reports the number of cointegrating relations chosen by the trace and maximum eigenvalue tests at the 5% confidence level when the test is specified with intercept and with linear trend and intercept. (2) Parts (b) e (c) report the results for the version with intercept. (3) One lag is chosen since the model selection criteria of a VAR indicated two lags. (5) Critical values based on MacKinnon, Haug e Michelis (1999). (6) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Table 5 – Johansen cointegration test summary - Variables: $reer_t$ e br_6

(a) *Number of cointegrating relations*		
Test type	No trend and intercept	Linear trend and intercept
Trace	1	0
Maximum Eigenvalue	1	0

(b) *Unrestricted cointegration rank test (trace)*

Hypothesis		Eigenvalue	Trace statistic	Critical value	Prob.˙
Null	Alternative				
$r = 0$	$r \geq 1$	0,070	$19,426^{**}$	15,494	0,012
$r \leq 1$	$r \geq 2$	0,013	$2,924^{ns}$	3,841	0,087

(c) *Unrestricted cointegration rank test (maximum eigenvalue)*

Hypothesis		Eigenvalue	Max-Eigen statistic	Critical value	Prob.
Null	Alternative				
$r = 0$	$r = 1$	0,065	$16,501^{**}$	14,264	0,021
$r = 1$	$r = 2$	0,016	$2,924^{ns}$	3,841	0,087

Notes: (1) Part (a) reports the number of cointegrating relations chosen by the trace and maximum eigenvalue tests at the 5% confidence level when the test is specified with intercept and with linear trend and intercept. (2) Parts (b) e (c) report the results for the version with intercept. (3) One lag is chosen since the model selection criteria of a VAR indicated two lags. (5) Critical values based on MacKinnon, Haug e Michelis (1999). (6) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

An important issue to be addressed in an integrated system is the information flow between the variables. A variable that doesn't adjust to restore the long-run equilibrium is called weakly exogenous. The Table 6 reports the results of the weak exogeneity test.[24] The results suggest that the Brazilian real exchange rate adjusts to discrepancy from the long-run equilibrium relationship, but the real commodity price indexes do not, so that the world commodity prices are weakly exogenous. These findings are in accordance with the fact that commodity prices are taken on the international market with limited influence from small commodity-exporting countries. Cashin, Céspedes e Sahay (2004) found that commodity prices are weakly exogenous for 10 out of 19 commodity currencies. The authors did not include the Brazilian real exchange rate in the exogeneity test because the hypothesis of non-cointegration between real commodity prices and the Brazilian real exchange rate was not rejected for the period from 1980 to 2002. The results of this essay contribute to the literature by showing evidence for the Brazilian economy during the floating exchange regime period.

Table 6 – Weak exogeneity test

Test statistic	Between $reer_t$ e $br7_t$				Between $reer_t$ e $br6_t$			
	$\Delta reer_t$	Prob.	$\Delta br7_t$	Prob.	$\Delta reer_t$	Prob.	$\Delta br6_t$	Prob.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
χ^2	$7,586^{***}$	0,005	$1,557^{ns}$	0,212	10.761^{***}	0,001	0.767^{ns}	0,381

Notes: (1) Columns 1 to 4 report the results of the weak exogeneity test between $reer_t$ e $br7_t$ and Columns 5 to 8 report the results between $reer_t$ e $br6_t$. (2) The likelihood ratio test is used to test whether the adjustment coefficients of a VEC model are statistically equal to zero. (3) The variables in difference form (with Δ) are the dependent variables of the respective VEC model. (4) One lag is chosen since the model selection criteria of a VAR indicated two lags. (5) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

2.4.3 Effects of structural factors on the link between commodity prices and real exchange rate

To disentangle the long-run relationship between the variables under question in this essay, this section presents the estimates for the DOLS specification.

The results in Table 7 indicate a robust and strong relationship between the Brazilian real exchange rate and the commodity price indexes during the floating exchange rate regime in Brazil. Thereby, the specialisation of the Brazilian exports occurs in such a way that the prices of these goods are an important source of the terms of trade and

[24] This essay follows the definition of weak exogeneity of Johansen (1998). If the line i of the matrix α (the matrix of adjustment coefficients) is zero, it's said that the variable i is weakly exogenous relating to the parameter β. This is done by imposing restrictions on the matrix of adjustment coefficients of a VEC. According to Enders (2015), for practical purposes, this means that weakly exogenous variables do not experience the *feedback* that requires the use of a VAR.

consequently of the real exchange rate fluctuations. Specifically, the results in Column 1 indicate that a 1% increase in the real commodity prices leads to a real exchange rate appreciation of 1.222%. In the similar way, the results in Column 4 show that a 1% increase in the real non-oil commodity prices leads to a real exchange rate appreciation of 1.308%.[25] The sign and the size of the coefficients are in line with the prior literature (BRANCO, 2016; KOHLSCHEEN, 2014; VERÍSSIMO; XAVIER; VIEIRA, 2012; CHEN; LEE, 2014).

Table 7 – Effects of trade openness and commodity export dependency on the long-run link between commodity prices and real exchange rate

Dependent variable = $reer_t$	Models with real commodity price index			Models with real non-oil commodity price index		
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	$-0,227^{***}$	$-0,218^{***}$	$-0,226^{***}$	$-0,155^{***}$	$-0,152^{***}$	$-0,156^{***}$
	(-7,275)	(-7,162)	(-6,824)	(-6,03)	(-5,897)	(-5,910)
$br7_t$	$1,222^{***}$	$1,300^{***}$	$1,213^{***}$			
	(13,450)	(14,474)	(10,490)			
$br6_t$				$1,308^{***}$	$1,353^{***}$	$1,329^{***}$
				(14,067)	(14,582)	(11,563)
$br7_t \times xto_t$		$-0,246^{***}$				
		(-3,879)				
$br7_t \times xced7_t$			$0,010^{ns}$			
			(0,174)			
$br6_t \times xto_t$					$-0,142^{**}$	
					(-2,148)	
$br6_t \times xced6_t$						$-0,032^{ns}$
						(-0,447)
leads	0	0	0	0	0	0
lags	0	1	0	0	0	0
adjusted R^2	0,797	0,811	0,798	0,805	0,809	0,805
observations	228	227	228	228	228	228
Lc statistic	$0,002^{ns}$	$0,004^{ns}$	$0,003^{ns}$	$0,002^{ns}$	$0,004^{ns}$	$0,003^{ns}$

Notes: (1) Columns 1 and 4 report the estimation of Equation 2.10: $reer_t = \beta_0 + \beta_1 br(i)_t + \epsilon_t$. (2) Columns 2, 3, 5 and 6 report the estimation of Equation 2.11: $reer_t = \phi_0 + \phi_1 br(i)_t + \phi_2 br(i)_t \times x(j)_t + \nu_t$. (3) The interaction terms are: trade openness (xto_t) and commodity export dependency ($xced7_t$ and $xced6_t$). (4) Lags and Leads (max = 8) are chosen by the Akaike information criteria. (5) The t-statistics are in ( ) and the standard error are the of Newey-West (*HAC)*. (6) The Lc statistics of the Hansen test of parameter stability are shown in all columns (null hypothesis: cointegrating parameters are constant). (7) Hansen test's critical values are based on Hansen (1992). (8) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

[25] The cointegration vectors estimated from a model VEC used in the cointegration tests presented in Tables 4 and 5 yield the following cointegrating equation: $reer_t = 0.246 + 1.298br7_t$; with the coefficient of $br7_t$ significant at the conventional levels of significance. In turn, the test of Table 5 provides the following cointegrating equation: $reer_t = 0.161 + 1.337br6_t$; with the coefficient of $br6_t$ also significant. These results are in accordance with Stock e Watson (1993), which state that in case of $I(1)$ variables with a cointegration vector, the DOLS method is asymptotically equivalent to the Johansen's method. The complete results of the cointegration vectors estimated by the Johansen's method are available upon request.

The results in Columns 2 and 5 report the effects of the trade openness on the commodity price elasticities of the real exchange rate. The negative coefficient estimate for $br7_t \times xto_t$ show that the commodity price elasticity of the real exchange rate is smaller for the periods which the trade openness is higher in Brazil. A very similar outcome is found for the non-oil commodity price elasticity ($br6_t \times xto_t$). Such findings are in line with the prior literature for both oil exporters and commodity exporters (BODART; CANDELON; CARPANTIER, 2015; CHEN; LEE, 2014). According to Section 2.2, the larger the trade openness, the lower the share of nontraded goods in the domestic consumption basket, which eventually reduces the commodity price elasticity of the real exchange rate. Our results show that this mechanism has been working for Brazil during the floating exchange rate regime.

Finally, the results in Columns 3 and 6 report the effects of the commodity export dependency on the commodity price elasticities. The coefficient estimate for $br7_t \times xced7_t$ and $br6_t \times xced6_t$ are not statistically significant. Even though has been predicted in theoretical models, the empirical evidences have not been clear about this issue. For example, Bodart, Candelon e Carpantier (2015) found that the degree of export diversification has a negative impact on the commodity price elasticity of the real exchange rate for oil-producing countries while Chen e Lee (2014) found no evidence for the sample of oil exporters. The latter authors found a positive impact of the commodity export dependency on the commodity price elasticity of the real exchange rate for non-oil commodity exporters. Our findings point out that the link between commodities prices and the Brazilian real exchange rate is not sensitive to the share of the commodities in the Brazilian export basket even in an environment of floating exchange rate.

2.4.4 Effects of financial factors on the link between commodity prices and real exchange rate

This section presents the results of the smooth transition error correction model, whose transition variables are the volatility in international financial market (vix_t) and the country risk situation ($\Delta embi_t$).

We start by testing for the hypothesis of linearity against the LSTR and ESTR specifications. Three findings stand out in Table 8. First, the volatility in international financial market does not change the relationship between the Brazilian real exchange rate and the prices of the main commodities exported by Brazil. Second, the country risk situation does change the relationship between Brazil's real exchange rate and the real commodity price index, including oil ($br7_t$). Third, the most suitable functional form for the transition function is exponential, giving rise to an ESTR model. Hence, Regime 1 includes the intermediate values of the country risk situation and Regime 2 the extreme values.

Table 8 – Linearity test

Model	Transition variable	H_0	H_3	H_2	H_1	Conclusion
		(1)	(2)	(3)	(4)	(5)
$br7_t$	vix_t	0.337^{ns}				Linear
	$\Delta embi_t$	0.050^{**}	0.09^{*}	0.063^{*}	0.227^{ns}	ESTR
$br6_t$	vix_t	0.259^{ns}				Linear
	$\Delta embi_t$	0.208^{ns}				Linear

Notes: (1) Columns 1 and 4 report the p-values (test F) related to the coefficients of the test equation for linearity and Column 5 reports the functional form of the transaction function (linear, LSTR or ESTR). (2) The rejection of H_0 concludes towards linear form. (3) The rejection of H_3 indicates an LSTR model and the rejection of H_2 concludes towards ESTR model. (4) p-value associated to H_2 lower than H_3 concludes towards to ESTR. (5) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Some key results stand out from the estimates of ESTR model (Table 9). The Regime 1 occurs when the country risk variations are around $\hat{c} = 0.015$, or close to zero, while the Regime 2 occurs when the country risk variations are far from $\hat{c}$. In Regime 1, real commodity prices do not affect the Brazilian real exchange rate since the coefficient is not significant (Column 1). In turn, in Regime 2, other things being equal, 1% increase in the real commodity prices leads to a real exchange rate appreciation of 0.979% (Column 2). On the last regime, the coefficient is significant at the confidence level of 1%.

To better understand what the econometric model has included in the Regime 2, Figure 4 plots the largest weights (above 0.90) returned by the transition function in order to examine closer the events captured by the econometric model. Remarkably, the model captured the main periods of crisis that the Brazilian economy witnessed since the adoption of the floating exchange rate regime as the largest weights occurred on April 1999, June and July 2002, October 2008, June 2013 and March 2016 (all these events were previously discussed in Section 2.4.1). The exception is June 2013, period of deterioration of the international liquidity conditions towards emerging economies following the pronouncement of easing the quantitative easing policy of the Federal Reserve (Fed).[26]

Our findings show that the econometric model effectively captured moments of crisis in the Brazilian economy when the country risk presented the highest values during the floating exchange rate regime. Even when the weight of 0.90 or above is associated with a negative change in the country risk, as in 1999 and 2016, this variation occurs on a high level of the country risk, or high risk aversion related to the Brazilian economy. In the situations where the country risk is high, carry trade operations are abruptly unwound, which restores the real exchange rate with its fundamentals (CLARIDA; DAVIS; PEDERSEN, 2009). These results contribute to prior literature (COUDERT; COUHARDE; MIGNON, 2015) by showing that the country risk situation captures the non-linearity

[26] See Prates e Cunha (2014) for a detailed explanation on the dynamics of capital flows in Brazil from 2012 to 2013.

Table 9 – Effects of volatility and country risk on the link between commodity prices and real exchange rate

Dependent variable = $\Delta reer_t$	Regime 1 (1)	Regime 2 (2)
Intercept	$0,000^{ns}$	
	(0,227)	
$\Delta br7_t$	$0,295^{ns}$	$0,979^{***}$
	(1,534)	(4,734)
ϵ_{t-1}	$-0,092^{***}$	
	(-2,651)	
$\hat{\gamma}$	49,646	
$\hat{c}$	0,015	
adjusted R^2	0,144	
F-statistic	$7,473^{***}$	
observations	227	
B-G test	$18,065^{ns}$	
B-P-G test	$0,096^{ns}$	

Notes: (1) Estimation of Equation 2.12 with Equation 2.14: $\Delta reer_t = \Phi_0 + \Phi_1 \Delta br(i)_t + \Phi_2 \Delta br(i)_t \times (1 - exp\{-\gamma(\Delta embi_t - c)^2\} + \Phi\epsilon_{t-1} + \varepsilon_t$. (2) Column 1 reports the results for the linear part of equation and the Column 2 the results for the non-linear part. (3) The t-statistics are in ( ) and the standard errors are the of Newey-West. (4) Null hypothesis of the Breusch-Godfrey (B-G) Serial Correlation LM test (max lag = 12): no residual autocorrelation. (5) Null hypothesis of the Breusch-Pagan-Godfrey (B-P-G) Heteroskedasticity test: homocedasticity. (6) $\hat{\gamma}$ and $\hat{c}$ denote the estimates for the slope parameter and the threshold, respectively. (7) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

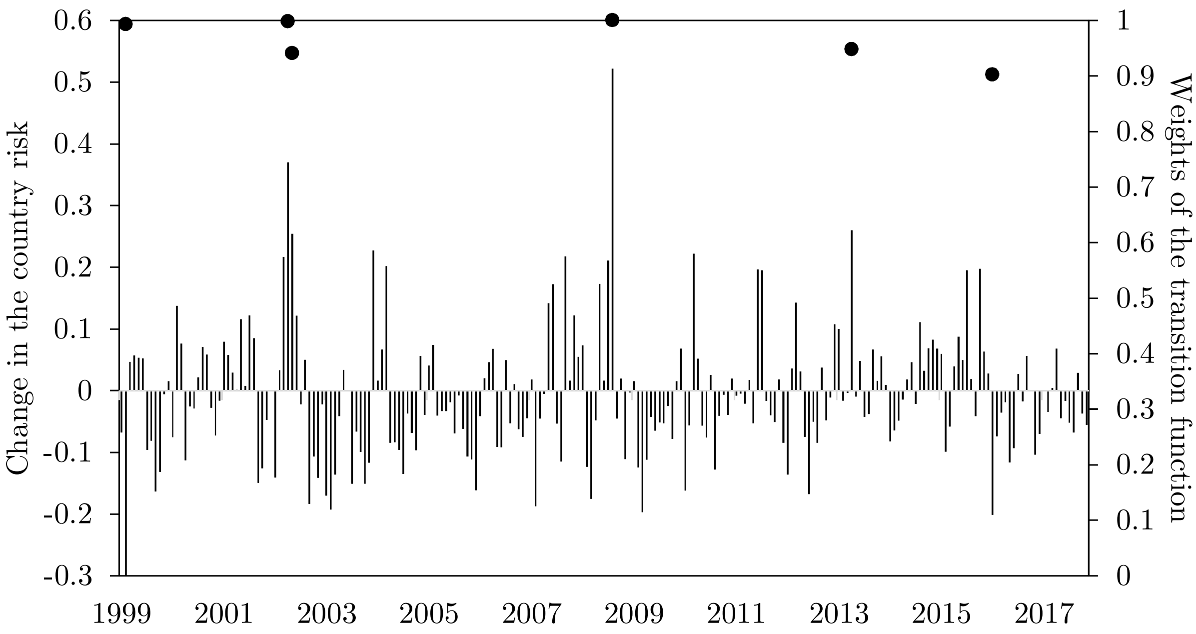

Figure 4 – Change in the country risk and the highest weights (higher than 0.90) of the transition function

between commodity prices and real exchange rate of a commodity-exporting emerging market economy with floating exchange rate regime. This is due to the characteristics of the country risk, which reflects global aspects affecting emerging economies, as well as aspects of the domestic economy. Although external factors determine the allocation of resources towards emerging economies, country-specific factors determine the distribution of resources among the countries (AKYÜZ, 2011). We also show the role of the oil prices in influencing the sensibility of Brazil's real exchange rate response to the real commodity price shocks in the short-run. Coudert, Couharde e Mignon (2015) confirm this role, but for advanced countries.

2.4.5 Alternative specification

The results of Section 2.4 confirm that commodity prices drive the Brazilian real exchange rate. However, other variables may have a non-trivial role in the determination of the real exchange rate. This section investigates the sensitivity of the results when the real interest differential (dif_t) and the international reserves (res_t) are included in the Equations from 2.10 to 2.12.

The ADF and ZA tests are depicted in Tables 10 and 11. These tests indicate that res_t has a unit root. The ADF test indicates that dif_t does not have a unit root considering a linear trend, but this hasn't been confirmed by the ZA test. The results of the EG and PO tests are reported in Table 12, showing that there is cointegration even when other variables are inserted into the model. In turn, the Johansen's test is presented in Tables 13 and 14. The Trace and Maximum eigenvalue tests indicate a cointegration vector for the model with the real commodity price index. The same tests indicate a cointegration vector for the model with the real non-oil commodity price index taking account intercept and linear trend in the specification. The Trace test indicates a cointegration vector for the model with the latter index considering intercept and the Maximum eigenvalue test do not. We didn't include a linear trend in the cointegration vector as it does not change our main results.[27]

[27] The results of the cointegration vector with a linear trend in the specification are available upon request.

Table 10 – Augmented Dickey–Fuller unit root test - Alternative specification

Variable	p	Model 1	p	Model 2	Variable	p	Model 1	p	Model 2
	(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)
dif_t	4	$-0,053^{ns}$	1	$-4,258^{***}$	Δdif_t	2	$-5,330^{***}$	2	$-5,2911^{***}$
res_t	1	$-0,376^{ns}$	2	$-2,569^{ns}$	Δres_t	4	$-5,968^{***}$	1	$-6,001^{***}$

Notes: (1) Null hypothesis: the variable has a unit root. (2) Columns 2 and 6 report the test statistic of the version with intercept and Columns 4 and 8 report the test statistic of the version with intercept and linear trend. (3) Lags (p) are chosen by the Modified Schwarz information criteria (p max = 14). (4) Critical values based on MacKinnon (1996). (5) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Table 11 – Zivot-Andrews unit root test - Alternative specification

Variable	p	Model 1	p	Model 2	p	Model 3
	(1)	(2)	(3)	(4)	(5)	(6)
dif_t	6	-4.786^{ns} [2005M07]	6	-3.302^{ns} [2006M06]	6	$-3,779^{ns}$ [2005M07]
res_t	7	$-4,466^{*}$ [2003M12]	7	$-3,992^{ns}$ [2006M01]	7	-4.785^{ns} [2015M08]

Notes: (1) Null hypothesis: the variable has a unit root with a structural break in the intercept. (2) Columns 2, 4 e 6 report the test statistic of the versions with intercept, linear trend ans both, respectively. (3) The structural break dates are in [ ]. (4) p max = 8. (5) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Table 12 – Engle-Granger (EG) and Phillips-Ouliarius (PO) cointegration tests - Dependent variable = $reer_t$; Control variables = dif_t e res_t - Alternative specification

Variable	Model 1 (τ)		Model 1 (z)		Model 2 (τ)		Model 2 (z)	
	EG	PO	EG	PO	EG	PO	EG	PO
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$br7_t$	$-4,171^{**}$	$-4,555^{**}$	$-28,174^{*}$	$-35,028^{**}$	$-4,100^{ns}$	$-4,532^{**}$	$-27,528^{ns}$	$-35,135^{*}$
$br6_t$	$-4,211^{**}$	$-4,653^{**}$	$-30,33^{*}$	$-38,141^{**}$	$-4,141^{ns}$	$-4,622^{**}$	$-29,602^{ns}$	$-38,056^{**}$

Notes: (1) Null hypothesis: the series are not cointegrated. (2) Columns 1 and 3 report the test statistic (τ e z) of the Engle-Granger test at the version with intercept and Columns 5 and 7 report the test statistic at the version with intercept and linear trend. (3) Columns 2 and 4 report the test statistic (τ e z) of the Phillips-Ouliaris test in the version with intercept and Columns 6 and 8 report the test statistic of the version with intercept and linear trend. (4) Lags (p) of the Engle-Granger test are chosen by the Modified Schwarz information criteria (p max = 14). (5) Critical values based on MacKinnon (1996). (6) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Table 13 – Johansen cointegration test summary - Variables: $reer_t$, br_7, dif_t and res_t - Alternative specification

(a) *Number of cointegrating relations*		
Test type	No trend and intercept	Linear trend and intercept
Trace	1	1
Maximum Eigenvalue	1	1

(b) *Unrestricted cointegration rank test (trace)*					
Hypothesis		Eigenvalue	Trace statistic	Critical value	Prob.˙
Null	Alternative				
$r = 0$	$r \geq 1$	0,117	$50,005^{**}$	47,856	0,031
$r \leq 1$	$r \geq 2$	0,068	$21,684^{ns}$	29,797	0,316
$r \leq 2$	$r \geq 3$	0,022	$5,476^{ns}$	15,494	0,756
$r \leq 3$	$r \geq 4$	0,001	$0,246^{ns}$	3,841	0,619

(c) *Unrestricted cointegration rank test (maximum eigenvalue)*					
Hypothesis		Eigenvalue	Max-Eigen statistic	Critical value	Prob.
Null	Alternative				
$r = 0$	$r = 1$	0,117	$28,321^{**}$	27,584	0,040
$r = 1$	$r = 2$	0,068	$16,207^{ns}$	21,131	0,213
$r = 2$	$r = 3$	0,022	$5,230^{ns}$	14,264	0,712
$r = 3$	$r = 4$	0,001	$0,246^{ns}$	3,841	0,619

Notes: (1) Part (a) reports the number of cointegrating relations chosen by the trace and maximum eigenvalue tests at the 5% confidence level when the test is specified with intercept and with linear trend and intercept. (2) Parts (b) e (c) report the results for the version with intercept. (3) One lag is chosen since the model selection criteria of a VAR indicated two lags. (5) Critical values based on MacKinnon, Haug e Michelis (1999). (6) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Table 14 – Johansen cointegration test summary - Variables: $reer_t$, br_6, dif_t and res_t - Alternative specification

(a) Number of cointegrating relations		
Test type	No trend and intercept	Linear trend and intercept
Traçe	1	1
Maximum Eigenvalue	0	1

(b) Unrestricted cointegration rank test (trace)

Hypothesis		Eigenvalue	Trace statistic	Critical value	Prob.˙
Null	Alternative				
$r = 0$	$r \geq 1$	0,113	$50,932^{**}$	47,856	0,025
$r \leq 1$	$r \geq 2$	0,078	$23,608^{ns}$	29,797	0,217
$r \leq 2$	$r \geq 3$	0,020	$5,090^{ns}$	15,494	0,799
$r \leq 3$	$r \geq 4$	0,001	$0,282^{ns}$	3,841	0,595

(c) Unrestricted cointegration rank test (maximum eigenvalue)

Hypothesis		Eigenvalue	Max-Eigen statistic	Critical value	Prob.
Null	Alternative				
$r = 0$	$r = 1$	0,113	$27,324^{*}$	27,584	0,053
$r = 1$	$r = 2$	0,078	$18,517^{ns}$	21,131	0,111
$r = 2$	$r = 3$	0,020	$4,808^{ns}$	14,264	0,765
$r = 3$	$r = 4$	0,001	$0,282^{ns}$	3,841	0,595

Notes: (1) Part (a) reports the number of cointegrating relations chosen by the trace and maximum eigenvalue tests at the 5% confidence level when the test is specified with intercept and with linear trend and intercept. (2) Parts (b) e (c) report the results for the version with intercept. (3) One lag is chosen since the model selection criteria of a VAR indicated two lags. (5) Critical values based on MacKinnon, Haug e Michelis (1999). (6) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Tables 15 to 16 present the results of the alternative specification. Remarkably, the coefficients are similar to those from the benchmark model (Tables 7 and 9). Hence, the main results remain unchanged, even when other determinants of the real exchange rate are included in the model. Contrary to the expected, the coefficient of dif_t has a negative sign, indicating that an increase in the real interest differential is associated with a real exchange rate depreciation. This result may be related to the fact that an increase in interest rates in emerging economies is often associated with capital outflow, which induces to a depreciation of the exchange rate (SHOUSHA, 2016). In addition, Kohlscheen (2014) points out that the long period of appreciation of the Brazilian Real in the 2000s coincided with a period of unprecedented reduction of the interest rate differential.

Table 15 – Effects of trade openness and commodity export dependency on the long-run link between commodity prices and real exchange rate - Alternative specification

Dependent variable = $reer_t$	Models with real commodity price index			Models with real non-oil commodity prince index		
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	$-0,132^{*}$	$0,174^{ns}$	$-0,131^{*}$	$-0,006^{ns}$	$0,039^{ns}$	$-0,009^{ns}$
	(-1,965)	(1,589)	(-1,684)	(-0,112)	(0,620)	(-0,253)
$br7_t$	$1,208^{***}$	$1,223^{***}$	$1,203^{***}$			
	(13,765)	(12,694)	(10,424)			
$br6_t$				$1,316^{***}$	$1,384^{***}$	$1,324^{***}$
				(15,119)	(15,962)	(20,234)
$br7_t \times xto_t$		$-0,484^{***}$				
		(-4,658)				
$br7_t \times xced7_t$			$0,004^{ns}$			
			(0,068)			
$br6_t \times xto_t$					$-0,206^{**}$	
					(-2,486)	
$br6_t \times xced6_t$						$-0,009^{ns}$
						(-0,219)
dif_t	$-0,033^{ns}$	$-0,129^{***}$	$-0,034^{ns}$	$-0,047^{**}$	$-0,060^{**}$	$-0,046^{***}$
	(-1,308)	(-3,421)	(-1,256)	(-2,195)	(-2,548)	(-3,547)
res_t	$-0,028^{ns}$	$-0,093^{***}$	$-0,028^{ns}$	$-0,053^{***}$	$-0,068^{***}$	$-0,053^{***}$
	(-1,549)	(-4,164)	(-1,472)	(-3,093)	(-3,565)	(-5,344)
leads	0	3	0	0	0	0
lags	0	4	0	0	1	0
adjusted R^2	0,827	0,860	0,827	0,840	0,847	0,838
observation	228	221	228	228	227	228
Lc statistic	$0,005^{ns}$	$0,007^{ns}$	$0,006^{ns}$	$0,005^{ns}$	$0,007^{ns}$	$0,002^{ns}$

Notes: (1) Columns 1 and 4 report the estimation of Equation 2.10: $reer_t = \beta_0 + \beta_1 br(i)_t + \epsilon_t$. (2) Columns 2, 3, 5 and 6 report the estimation of Equation 2.11: $reer_t = \phi_0 + \phi_1 br(i)_t + \phi_2 br(i)_t \times x(j)_t + \nu_t$. (3) The interaction terms are: trade openness (xto_t) and commodity export dependency ($xced7_t$ and $xced6_t$). (4) Lags and Leads (max = 8) are chosen by the Akaike information criteria. (5) The t-statistics are in ( ) and the standard error are the of Newey-West (*HAC)*. (6) The Lc statistics of the Hansen test of parameter stability are shown in all columns (null hypothesis: cointegrating parameters are constant). (7) Hansen test's critical values are based on Hansen (1992). (8) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Table 16 – Effects of volatility and country risk on the link between commodity prices and the real exchange rate - Alternative specification

Dependent variable = $\Delta reer_t$	Regime 1 (1)	Regime 2 (2)
Intercept	$-0,000^{ns}$	
	(-0,074)	
$\Delta br7_t$	$0,311^{*}$	$0,875^{***}$
	(1,653)	(4,216)
ϵ_{t-1}	$-0,092^{**}$	
	(-2,354)	
Δdif_t	$-0,036^{ns}$	
	(-0,936)	
Δres_t	$0,071^{**}$	
	(2,416)	
$\hat{\gamma}$	60,189	
$\hat{c}$	0,006	
adjusted R^2	0,133	
F-statistic	$5,958^{***}$	
observations	227	
B-G test	$20,173^{*}$	
B-P-G test	$2,517^{ns}$	

Notes: (1) Estimation of Equation 2.12 with Equation 2.14: $\Delta reer_t = \Phi_0 + \Phi_1 \Delta br(i)_t + \Phi_2 \Delta br(i)_t \times (1 - exp\{-\gamma(\Delta embi_t - c)^2\} + \Phi \epsilon_{t-1} + \varepsilon_t$. (2) Column 1 reorts the results for the linear part of equation and the Column 2 the results for the non-linear part. (3) The t-statistics are in ( ) and the standard errors are the of Newey-West. (4) Null hypothesis of the Breusch-Godfrey (B-G) Serial Correlation LM test (max lag = 12): no residual autocorrelation. (5) Null hypothesis of the Breusch-Pagan-Godfrey (B-P-G) Heteroskedasticity test: homocedasticity. (6) $\hat{\gamma}$ and $\hat{c}$ denote the estimates for the slope parameter and the threshold, respectively. (7) ***, **, * and ns stand for significant coefficients at the 1%, 5%, 10% statistical level and no significant, respectively.

Finally, the results in Table 15 report a negative coefficient for res_t in the long-run model, indicating that an increase in the international reserves is associated with a real exchange rate depreciation. Conversely, res_t remained positive in the short-run model (Table 16). This result can be explained by the dynamics of obtaining foreign exchange during the last commodity price boom. According to Prates (2009), who analysed the strong appreciation of the Brazilian Real from 2004 to 2007, both current account surpluses and capital flows were absorbed by the government (Central Bank of Brazil and National Treasury). During that period, the government acquired about USD183bn dollars, which was channelled towards reducing external debt and international reserves.

2.5 Conclusion

Approximately half of the Brazilian exports are composed of commodities. Therefore, commodity price shocks are potential sources of the exogenous changes in the terms of trade and consequently of the exchange rate fluctuations.

The results of this essay show that the Brazilian Real and the prices of the main commodities exported by Brazil have a cointegrating relation. In addition, the real exchange rate adjusts to restore the long-run equilibrium instead of real commodity prices. There is also a positive relationship between the series on focus. Thus, our results show that is possible to associate an appreciation of the Brazilian Real with the increase in the prices of the main commodities exported by Brazil during the floating exchange rate regime period. Consistently with the theoretical model, periods of larger trade openness are associated with the lower elasticity of the real exchange rate to the commodity price shocks. In addition, the results suggest that the relationship between real exchange rates and commodity prices is not sensitive to commodity export dependency.

The findings also suggest that the short-run relationship between commodity prices and the Brazilian real exchange rate is associated with the country risk situation. Periods of large variation of country risk occurred during the main moments of crisis faced by the Brazilian economy taking into account the floating exchange rate regime period. During crisis periods, the elasticity of the real exchange rate to commodity price shocks is larger. The interpretation of this result is based on evidence of which carry trade operations are unwound at times of risk aversion, and the real exchange rate, therefore, restores its link to the fundamentals.

The findings of this essay provide important insights for the appropriated design of foreign exchange policy in Brazil. Whether exogenous shocks significantly affect the real exchange rate, the competitiveness of domestic sectors not based on commodities depend on external factors, which are not necessarily in line with the objectives of the economic development of the country. As a result, the investigation of factors that effectively influence the relationship between commodity prices and real exchange rate is essential for the policy makers. Globalisation strategies can be elaborated in order to better manage the export revenues. Specifically, according to our findings, foreign trade strategies that increase trade openness lead to the lesser connection between the Brazilian real exchange rate and the commodity price shocks. To conclude, the relationship between commodity prices and the Brazilian real exchange rate should be reformulated to consider trade openness in the long-run and the country risk situation in the short-run.

3 Chinese Resource Demand and Commodity Price Shocks: Macroeconomic Effects on an Emerging Market Economy

Rodrigo da Silva Souza[1] and Renée Fry-McKibbin[2]

Abstract

This essay empirically addresses the hypothesis that in the external commodity based sector, Chinese resource demand is the most important driver of emerging market economies' business cycles, using Brazil as a representative case. Using a structural VAR to examine the effects of Chinese resource demand, world commodity prices and foreign output on domestic macroeconomic variables, we show that shocks to Chinese demand induce an expansion in Brazilian resource exports, the non-tradeable primary commodity sector and other domestic activity. Commodity price shocks are less favourable than Chinese resource demand shocks. Our findings identify the important role of the interest rate in amplifying the real effects of the commodity sector boom, in contrast to the role of the interest rate in developed countries. When both Chinese resource demand and commodity prices are incorporated into the model, commodity prices play a smaller role in explaining the variance of domestic output than that found in the previous literature.

Keywords: Brazil; EME business cycles; Commodity exports.
JEL Classifications: C51; E32; F43; F62.

[1] Doctoral student in the Graduate Program in Applied Economics, Federal University of Viçosa. Email: souzarodrigodasilva@gmail.com
[2] Professor at the Crawford School of Public Policy of the Australian National University. Email: renee.mckibbin@anu.edu.au

3.1 Introduction

The emergence of China as an economic powerhouse has contributed to the rapid transformation of the structure of the global economy (JENKINS, 2014). In particular, the unprecedented demand for natural resources for purposes of industrialization and urbanization has led to potentially substantial spillover effects for commodity-exporting countries (CESA-BIANCHI et al., 2012; DUNGEY; FRY-MCKIBBIN; LINEHAN, 2014; DUNGEY et al., 2017). The empirical evidence suggests that the impacts of Chinese economic shocks on a typical Latin American economy have tripled since mid-1990 (CESA-BIANCHI et al., 2012). On the one hand, the benefits of high Chinese demand for most Latin American economies include rapid growth in the exports of mineral and agricultural inputs, and the fast recovery of Latin American and other developing economies in the aftermath of the global financial crisis is related to trade linkages with China. On the other hand, a slowdown in the growth of China represents a key risk (GRUSS, 2014). More specifically, the contraction in the value of China's imports since 2014 compounds concerns of negative spillovers from China to commodity-exporting economies as China reorients its growth domestically (CASHIN; MOHADDES; RAISSI, 2017). The effects of global economic cycles on commodity-exporting emerging market economies (EMEs) has emerged as an important topic in international macroeconomics as these economies face a reversal in primary commodity prices and capital inflows simultaneously, which is labeled a "sobering reversal of a double bonanza" by Reinhart, Reinhart e Trebesch (2016).

This essay empirically evaluates the effects of Chinese resource demand on EMEs. We do so through a structural VAR (SVAR) framework closely following Dungey, Fry-McKibbin e Linehan (2014) and using Brazil as a representative case. The model contains an external sector consisting of Chinese resource demand, world commodity prices, foreign output and real resource exports and a domestic sector consisting of the non-tradeable primary commodity sector, domestic output, inflation, the interest rate and the real exchange rate. The set up of the model enables the examination of the impacts of three external shocks on Brazil. These shocks include the following: (*i*) a shock to Chinese resource demand; (*ii*) a general shock to world commodity prices; and (*iii*) a general shock to foreign output. The configuration of the domestic sector of the model enables the assessment of the transmission of these shocks through domestic activity that is directly linked to resource demand (real resource exports and the non-tradeable primary commodity sector) and to other domestic activity such as domestic output. The data frequency is quarterly, and the sample period extends from 1999 Quarter 1 to 2017 Quarter 1, encompassing the period which the Brazilian currency is allowed to float as well as the entirety of the last commodity price boom and the aftermath period.

A widespread feature of business cycles in EMEs is the countercyclical nature of the cost of borrowing faced in international financial markets. While in developed economies interest rates are mildly pro-cyclical, in EMEs, periods of low (high) interest rates are associated with economic expansion (contraction) due to the relatively large country-specific risk spread included in these rates (FERNáNDEZ; GULAN, 2015; SHOUSHA, 2016). According to Neumeyer e Perri (2005) and Uribe e Yue (2006), the interest rate reacts to EME fundamentals and vice versa, consequently exacerbating business-cycle fluctuations caused by real shocks. The recent literature includes world commodity prices among the fundamentals able to influence interest rates in EMEs, arguing that the negative relationships between these variables cause a further expansion that would not otherwise occur (SHOUSHA, 2016; DRECHSEL; TENREYRO, 2018; FERNáNDEZ; GONZáLEZ; RODRIGUEZ, 2018; ZEEV; PAPPA; VICONDOA, 2017). Shousha (2016) argues that world commodity price shocks drive the business cycle fluctuations of small open commodity exporters, with stronger effects on the real activity of emerging economies rather than that of developed economies, which is largely due to the response of the interest rate.[3] However, the literature has been silent about the influence of resource demand shocks, rather than commodity price shocks, on the interest rate of EMEs, namely the cost of borrowing faced by these economies in international financial markets, which eventually may have flow-on effects on the domestic economy.

A first look at the data in Section 3.2 strongly supports the use of the Brazilian economy as a representative case. Similar to other EMEs, Brazil's primary commodity exports are approximately 50% of total Brazilian exports. China overtook the U.S. as the largest trading partner of Brazil in 2009; the U.S. had been Brazil's most important economic partner for the previous eighty years (CARDOSO, 2013). The primary sector in Brazil contributes approximately 7 percent to GDP, making it susceptible to commodity market swings. As expected, in an EME (FERNáNDEZ; GONZáLEZ; RODRIGUEZ, 2018), both world commodity prices and Chinese resource demand relate positively to output and investment and negatively to the real exchange rate and the interest rate.

Our findings highlight the mechanisms through which the external commodity sector acts as an important driver of business cycles in the Brazilian economy. Shocks to Chinese resource demand induce an expansion in the real value of resource exports,

[3] Specifically, using a DSGE framework, Shousha (2016) finds that an increase in commodity prices reduces foreign country indebtedness due to an increase in exports, which consequently lowers the interest rate. Since EMEs face financial frictions, the interest rate falls further due to lower country risk, which, in turn, directly relates to capital flows. Similarly, Drechsel e Tenreyro (2018), suggest that the negative relationship between the interest rate spread and commodity prices may come from creditors decreasing the required interest rate premium during the commodity price boom phase, as the collateral value of the economy depends directly on commodity prices through export earnings. For examples of the negative relationship between world commodity prices and country risk, see Bastourre et al. (2012), Aslam et al. (2016), Hilscher e Nosbusch (2010), Bouri, Boyrie e Pavlova (2016) and Barone e Descalzi (2012). For an example of the pro-cyclical nature of capital inflows in developing economies, see Kaminsky, Reinhart e Végh (2004); and for an example of the link between large capital inflows and an increase in consumption, investment and private credit, see Benigno, Converse e Fornaro (2015). See Ornelas (2017) for an investigation of the influence of gross debt on the country spread.

the non-tradeable primary commodity sector and domestic output for approximately six years, as well as an appreciation of the real exchange rate and a decline in the interest rate. Shocks to world commodity prices not resulting from resource demand also produce an expansionary effect on the Brazilian economy. However, the effects are less persistent than the shocks from Chinese resource demand. Shocks to world output are the least important. We contribute to the literature highlighting the role of commodity prices as a source of business cycles in EME's (FERNáNDEZ; GONZáLEZ; RODRIGUEZ, 2018; SHOUSHA, 2016; DRECHSEL; TENREYRO, 2018). These works found that commodity price shocks explain approximately one-third of business cycle fluctuations. In contrast, an historical decomposition of the variance of domestic output over the sample period attributes a remarkable 35% to Chinese resource demand shocks and 9% to shocks to world commodity prices over the longer time horizon. Our contribution shows the bulk of the influence of the commodity sector on economic fluctuations in EMEs comes from Chinese demand rather than commodity price shocks or general world output shocks.

Another important result confirms the findings of Shousha (2016), who showed that the inclusion of commodity price shocks in the model dampens the contribution of interest rate shocks on domestic output, which is often found to be crucial in accounting for EME business cycles (URIBE; YUE, 2006). We add to this literature by showing the contribution of resource demand on variances in Brazil's interest rate. By including Chinese resource demand in the model, the contribution of world commodity prices in explaining the variance in the interest rate is lower than that found in the previous literature. For example, using data from 1995Q1 to 2014Q3, Zeev, Pappa e Vicondoa (2017) found that approximately 26% of the variance in the interest rate spread in Brazil is explained by world commodity price fluctuations. Our results show the equal importance of shocks to Chinese resource demand and shocks to world commodity prices (approximately 15% each) in explaining the variance in the interest rate. In turn, the interest rate plays a smaller role in explaining the variance in domestic output than that found in previous literature.

This article further contributes to the literature on the spillover effects of Chinese activity on small open economy commodity exporters. Dungey, Fry-McKibbin e Linehan (2014) found that shocks to Chinese resource demand and commodity prices led to lower Australian output after the first year due to falls in non-resource sector output, which was not offset by an increase in the resource output sector, which is consistent with the symptoms of Dutch disease. Subsequently, Dungey et al. (2017) found reduced evidence of Dutch disease in the Australia economy in the aftermath of the end of the commodity price boom. The authors showed that Chinese resource demand explains less than 4% of the variance in Australian output, and commodity prices explain less than 6% in the longer time horizon. As we show in this article, resource demand and world commodity prices exhibit relatively much stronger effects on the domestic output of Brazil, supporting the high relevance of global commodity cycles for EMEs.

The remainder of this essay proceeds as follows. Section 2 presents some stylized facts on the features of the Brazilian economy that show it is an appropriate example of a commodity exporting EME. Section 3 describes the SVAR framework, the data and the sample. Section 4 presents the results from the benchmark model, while Section 5 reports the results from alternative specifications and the robustness exercises. Section 6 concludes.

3.2 Stylized facts

The empirical features of the Brazilian economy summarized in Table 17 indicate that Brazil is an appropriate country to use for the model of commodity resource demand for an EME. The table summarizes data on the sectoral composition of the Brazilian economy and the correlation of key Brazilian variables with Brazilian output, Chinese resource demand and real commodity prices over the period of the analysis (1999Q1 to 2017Q1). The first column of the table shows the mostly domestic composition of the economy, with 78.2% of GDP coming from the non-tradeable sector. The contributions of the commodity and non-commodity tradeable sectors reveal a reasonable degree of diversification of the Brazilian economy at 7.5% and 14.3% of GDP, respectively and the likely susceptibility to world commodity price fluctuations.

The characteristics of the Brazilian economy shown in Table 17 align with those expected for a commodity exporting EME (FERNáNDEZ; GONZáLEZ; RODRIGUEZ, 2018; FERNáNDEZ; GULAN, 2015), including a positive association of world commodity prices with domestic consumption, investment and output and a negative association with the real exchange rate and the interest rate. The positive association of Chinese resource demand with Brazilian output, all of the domestic sectors and investment, as well as the negative association with the real exchange rate and the interest rate variable, unsurprisingly reflects the prominent role of China in commodity markets. Most notable is the strong negative association between Chinese resource demand (-68.9%) and world commodity prices (-74.9%) and the interest rate, which, in turn, has a non-trivial role for Brazilian output compared to other EMEs through the considerably large stock of external debt (FERNáNDEZ; GONZáLEZ; RODRIGUEZ, 2018).[4]

[4] For analyses of the external vulnerability indicators of the Brazilian economy during the period of 2001 to 2010, see Noije e Conti (2016), and during the period of 2007 to 2013, see Prates (2014). For an analysis of Brazilian financial integration and new forms of external vulnerability, see Kaltenbrunner (2011).

Table 17 – Sectoral composition of the Brazilian economy and the correlation of key variables with Chinese resource demand, real commodity prices and Brazilian output, 1999Q1 to 2017Q1.

Sector/variable	Value added (% of GDP) (1)	Correlation with: Chinese resource demand (2)	Real commodity prices (3)	Domestic output (4)
Sector				
Primary commodity	7.50	53.56	40.68	34.88
Non-commodity tradables	14.30	84.87	90.31	86.35
Non-tradables	78.20	51.26	80.22	98.20
Variables				
Real commodity prices		78.06	100.00	86.88
Resource exports		68.72	85.84	82.26
Investment		35.91	72.98	93.18
Consumption		25.54	61.18	85.96
Domestic output		63.12	86.88	100.00
Interest rate		-68.91	-74.93	-65.37
Real exchange rate		-38.53	-65.26	-63.96

Notes: All variables are linearly detrended and expressed in log form. Column (1) summarizes the sectoral composition of the Brazilian economy for the following: primary commodities (crops, livestock and mining); non-commodity tradables (manufacturing); and non-tradables (services, building industry, public utilities). Chinese resource demand is proxied by Chinese steel production; the real commodity price variable is a trade-weighted index containing prices of Brazil's three primary commodity exports (soybeans, iron ore and oil); Brazilian resource exports are the sum of soybeans, iron ore and oil; the real exchange rate is a trade-weighted index defined in terms of a basket of foreign goods such that a decrease is a real appreciation of the Brazilian real; and the interest rate is the sum of the JP Morgan EMBI+ sovereign spread and the U.S. real interest rate. For complete details on data construction and sources see Section 3.3.2 and Appendix .1.

To further explore the relationship between commodity prices and the cost of issuing debt faced by the Brazilian economy in international financial markets, Figure 5 plots real commodity prices against the interest rate. An inspection of Figure 5 shows a reduction in the cost of issuing debt when commodity prices rise, which is particularly evident at the peak of the commodity price cycle in 2007-2008 and again from 2010. From mid-2012, the interest rate variable increases as world commodity prices decline. In turn, Figure 6 shows a positive relationship between Chinese resource demand and Brazilian output. By 2016, after the slowdown in the rate of growth of both Brazilian output and Chinese resource demand, the Brazilian economy appears to recover, seemingly coinciding with the recovery in Chinese resource demand.

Since 1999, the share of commodity exports in terms of total Brazilian exports and GDP increased by approximately 15 and 3%, respectively, as shown in Figure 7. According to the AliceWeb dataset, the exports of soybeans, iron ore and oil accounted for 50.6% of primary commodity exports and 26.2% of total exports in Brazil during the sample period from 1999Q1 to 2017Q1.[5] This export demand mostly comes from China, which has been the leading importer of Brazilian soybeans since 2002 and iron ore since 2001.[6] The three largest importers of Brazilian oil since 2005 include China in all years apart from in 2007.[7]

The decline in the share of manufactured goods in total Brazilian exports and in GDP coincides with an increase in the relative size of the commodity export market in Brazil, which is also shown in Figure 7. These numbers depict the challenges of the rapid growth in China faced by Brazil and several Latin American economies, particularly as the growth in global demand for imports from China means a loss of export markets for local producers (JENKINS; BARBOSA, 2012; HIRATUKA; SARTI, 2017). The debate abounds in Brazil about relative de-industrialization, which is mainly attributed to the maintenance of the overvalued Brazilian currency during the boom phase of the commodity price cycle (OREIRO; BASILIO; SOUZA, 2014; BRESSER-PEREIRA, 2013; SONAGLIO; CAMPOS; BRAGA, 2016; JENKINS, 2015). Despite this debate, evidence of sectoral reallocation in the Brazilian economy from the commodity sector to the non-commodity sector is difficult to find.[8]

---

5 The System of Analysis of Foreign Trade Information (AliceWeb) is the main dataset used for Brazilian foreign trade. The platform obtains data from the Integrated Foreign Trade System of the Ministry of Industry, Foreign Trade and Services (MDIC). The data are available at <http://aliceweb.mdic.gov.br/>. The AliceWeb system was deactivated in 2018 and replaced by a new platform available at <http://comexstat.mdic.gov.br>.

6 Unless otherwise specified, soybeans refers to soybean complex: soybeans, soybean oil and soybean meal.

7 For perspective, China accounted for 57.5% of soybean exports, 55% of iron ore exports and 38.8% of oil exports by Brazil in 2016. China imported USD14.4bn of Brazilian soybeans (in grain) in 2016, while the second largest importer imported around USD600mn. China imported USD7.3bn of iron ore in 2016, which is seven times more than the second largest importer. China imported USD5.8bn of Brazilian oil between January and September 2017, which is twice that of the second largest importer.

8 Nassif, Feijó e Araújo (2014) showed that there was a shift in the workforce from agriculture to the service sector, while there was a small increase in the share of manufacturing employment relative to

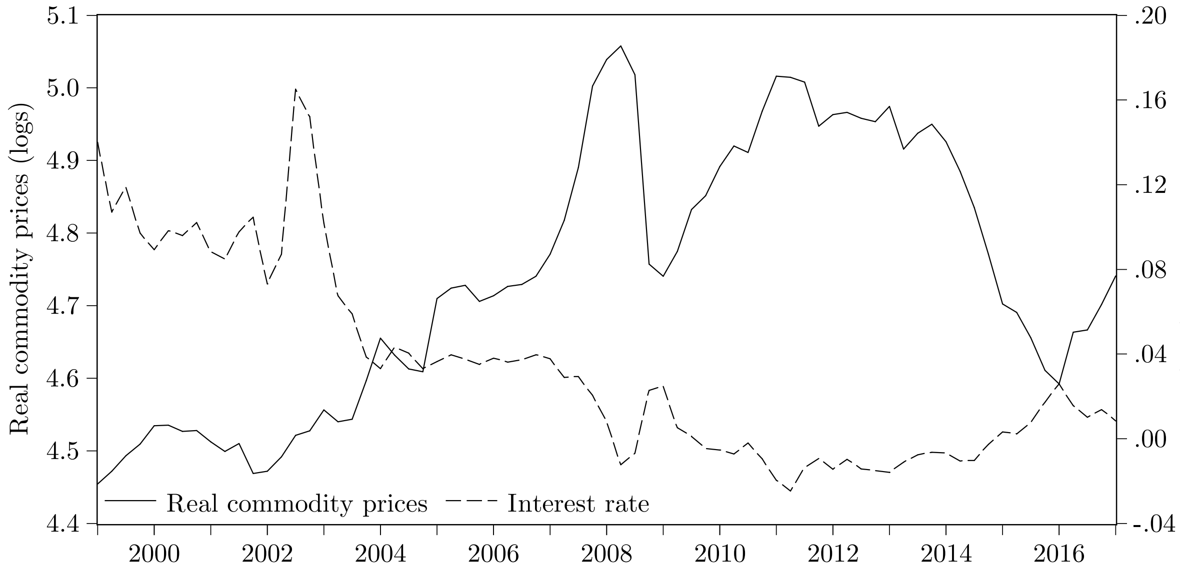

Figure 5 – The Brazilian interest rate (right axis) and real commodity prices (left axis), 1999Q1 to 2017Q1.

Notes: The real commodity price variable is a trade-weighted index containing prices of Brazil's three primary commodity exports (soybeans, iron ore and oil). The interest rate is the sum of the JP Morgan EMBI+ sovereign spread and the U.S. real interest rate. For details on data construction and sources, see Section 3.3.2 and Appendix .1.

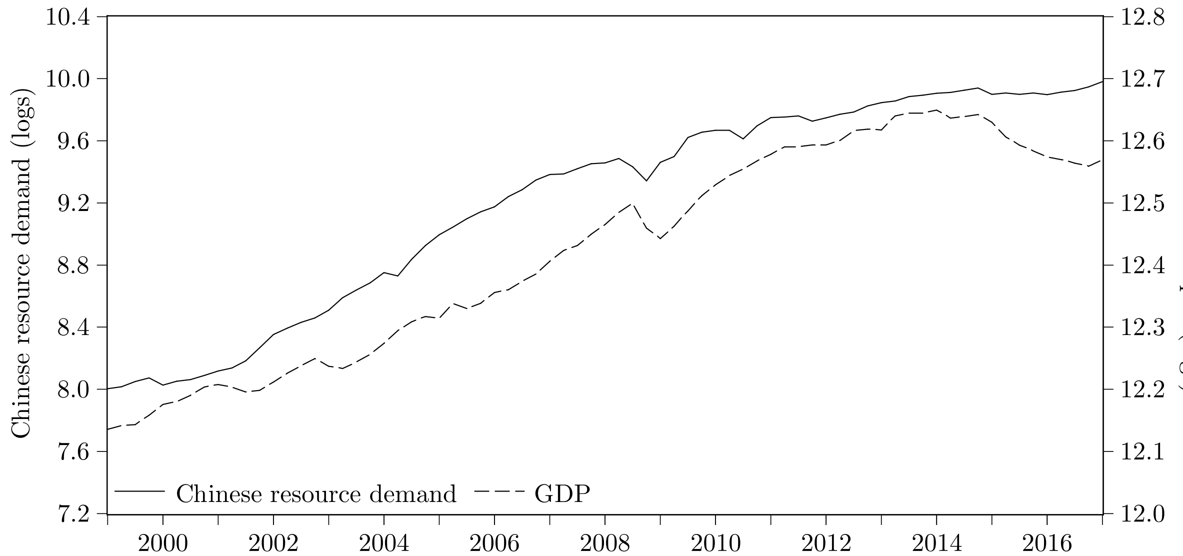

Figure 6 – Chinese resource demand (left axis) and Brazilian GDP (right axis), 1999Q1 to 2017Q1.

Notes: Chinese resource demand is proxied by Chinese steel production. For complete details on data construction and sources, see Section 3.3.2 and Appendix .1.

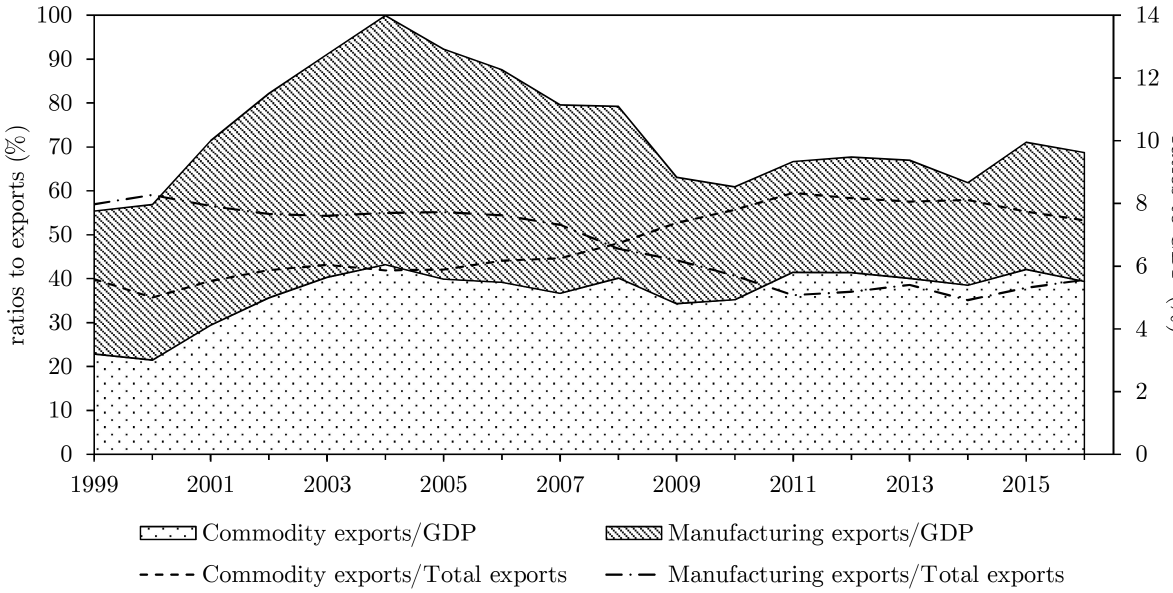

Figure 7 – Commodity and manufacturing exports relative to total exports (left axis) and commodity and manufacturing exports relative to GDP (right axis), 1999Q1 to 2017Q1.

Notes: All data are in U.S. dollars, and the definition of commodities follows MDIC (2016). Sources: Central Bank of Brazil and AliceWeb.

3.3 Empirical framework

Gauging the effects of Chinese resource demand on Brazil involves specifying a SVAR model of the Brazilian economy interacted with a sector specifically modeling Chinese demand, global commodity and general international shocks. This section outlines the SVAR model and identification assumptions and then describes the data and the sample period.

3.3.1 The SVAR model and identification

The SVAR model for the set of variables X_t in (3.1) follows

$$B(L)X_t = \epsilon_t, \tag{3.1}$$

total employment during the period from 2000 to 2009. However, the slowdown in labour productivity gains increased the technological gap in the Brazilian economy in the late 1990s. The authors concluded that Brazil has entered into a trajectory of falling behind due to an increase in the technological gap and a drop in manufactured exports, despite a relatively large and diversified Brazilian manufacturing industry. Benigno, Converse e Fornaro (2015) provided empirical evidence of a reallocation of productive resources out of manufacturing, presumably into the non-tradable sector when there are large capital inflows into Latin America. There was one exception in the Brazilian economy. While Brazil did experience a consumption boom during the large capital inflows in the late 1990s, the share of employment dedicated to manufacturing sector was steady or rising.

with $B(L) = B_0 - B_1L - B_2L^2 - ... - B_pL^p$, lag operator L, the order of the matrix polynomial p, and with deterministic terms suppressed for convenience. In the application, X_t contains a 9×1 vector of endogenous macroeconomic variables. Formally, $X_t = [x_t^*, x_t]'$, with external variables denoted by x_t^* and domestic variables by x_t. The foreign variables in x_t^* consist of Chinese resource demand (csp_t), world commodity prices (pc_t), foreign output (yw_t) and Brazilian resource exports ($resx_t$). The domestic macroeconomic variables in x_t consist of the non-tradeable primary commodities sector in Brazil ($comm_t$), Brazilian output (yd_t), the inflation rate (pd_t), the interest rate (rd_t) and the real exchange rate (q_t). B_0 represents the contemporaneous relationships between the variables and is nonsingular and normalized to have unit values on the diagonal; ϵ_t denotes the 9×1 vector of normally distributed structural shocks with $E(\epsilon_t \epsilon_t') = D$ and $E(\epsilon_t \epsilon_{t+s}') = 0$, for all $s \neq 0$.The diagonal matrix D contains the variances in the structural innovations.

Model estimation begins with the reduced form representation

$$A(L)X_t = u_t, \tag{3.2}$$

where $A(L) = B_0^{-1}B(L) = I - A_1L - A_2L^2 - ...A_pL^p - ...A_pL^p$, and u_t represents a 9×1 vector of serially uncorrelated reduced form innovations with the characteristics $E(u_t) = 0$, $E(u_t u_t') = \sum$ and $E(u_t u_{t+s}') = 0$ for all $s \neq 0$. The reduced form residuals relate to the structural residuals through $u_t = B_0 \epsilon_t$. The estimation follows the AB form of the SVAR of Amisano e Giannini (1997). In this specification, $Au_t = B\epsilon_t$, where matrix A contains the contemporaneous parameters and matrix B controls the variance-covariance matrix of the structural innovations.

The identification of the structural shocks in the SVAR mainly takes place through lower triangular restrictions on the contemporaneous impact matrix B_0. Using the rationale of Dungey, Fry-McKibbin e Linehan (2014), the recursive ordering is as follows: csp_t, pc_t, yw_t, $resx_t$, $comm_t$, yd_t, pd_t, rd_t and q_t. We assume that the external variables in x_t affect all domestic variables contemporaneously. The Chinese resource demand variable comes first given its flow-on effect to world commodity prices and foreign output (DUNGEY; FRY-MCKIBBIN; LINEHAN, 2014). World commodity prices come before foreign output, following Berkelmans (2005). The domestic variables do not affect the external variables contemporaneously as Brazil is a small open economy. However, the domestic variables are able to affect the external sector with a lag. There is evidence of some market power of commodity-exporting economies in commodity markets, so this assumption allows for this channel if, in fact, this occurs in the data for the case of Brazil (CLEMENTS; FRY, 2008; DUNGEY et al., 2017).

As in Uribe e Yue (2006), the identification presupposes that changes in the interest rate influence domestic variables with one lag, but domestic shocks affect financial markets contemporaneously.[9] According to Shousha (2016), interest rate determination follows the domestic variables and precedes the real exchange rate for emerging market economies. Berkelmans (2005) argue that domestic monetary policy and inflation do not react contemporaneously to shocks to foreign output, and Dungey, Fry-McKibbin e Linehan (2014) extend that argument to the Chinese resource demand variable and real resource exports. We follow these same restrictions. Relaxing the restriction that external variables affect Brazil's interest rate with a lag and assuming that they affect the interest rate contemporaneously does not change the results very much, as shown in Section 3.5.

The identification restrictions are summarized by

$$B_0 X_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 & 0 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 & 0 & 0 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 & 0 & 0 & 0 \\ 0 & b_{72} & 0 & 0 & b_{75} & b_{76} & 1 & 0 & 0 \\ 0 & b_{82} & 0 & 0 & b_{85} & b_{86} & b_{87} & 1 & 0 \\ b_{91} & b_{92} & b_{93} & b_{94} & b_{95} & b_{96} & b_{97} & b_{98} & 1 \end{bmatrix} \begin{bmatrix} csp_t \\ pc_t \\ yw_t \\ resx_t \\ comm_t \\ yd_t \\ pd_t \\ rd_t \\ q_t \end{bmatrix}$$

3.3.2 Data and sample

External variables Chinese economic growth and urbanization has directly led to the demand for resources, particularly energy and mining products (ZHANG; ZHENG, 2008), and for food products such as meat and feed grains such as soybeans as Chinese diets shift towards higher meat consumption (COATES; LUU, 2012).[10] As in Dungey, Fry-McKibbin e Linehan (2014), the difficulty in sourcing a time series of overall Chinese resource demand necessitates using Chinese steel production (csp_t) as a proxy, which is a reasonable choice. The sensitivity analysis in Section 3.5 explores the use of alternative measures to Chinese steel production such as Chinese manufacturing exports (ROBERTS; RUSH, 2010), Chinese industrial production and Chinese GDP.

The calculation of the real commodity price index for Brazil (pc_t) follows the method proposed by Deaton e Miller (1996) and Cashin, Céspedes e Sahay (2004). First, to calculate the weights of the index, the average value of each principal commodity export of Brazil (soybeans, iron ore and oil) is divided by the average total value of

[9] According to Uribe e Yue (2006) financial markets react quickly to news about the business cycles in emerging economies. Moreover, decisions about real activity such as employment and spending on investment goods take time to implement.

[10] China accounted for nearly 63% of global imports of soybeans in 2016, according to the dataset of the Food and Agriculture Organization of the United Nations (FAOSTAT). The data are available at <http://www.fao.org/faostat/en>.

Brazil's commodity exports over the period 1996Q1 to 2017Q1. Second, the weights from step one are input into the calculation of the geometrically weighted index of monthly nominal commodity export prices expressed in U.S. dollars. Finally, dividing the nominal commodity price index (CPI) by the nominal price index of the U.S. CPI for all urban consumers results in the real commodity price index used in the empirical application. Dungey, Fry-McKibbin e Linehan (2014) also use the U.S. CPI to deflate the nominal price index, while Shousha (2016) and Zeev, Pappa e Vicondoa (2017) use the U.S. import price of manufactured goods from industrialized countries to calculate the commodity terms of trade. To assess the propagation of commodity price shocks to the general macroeconomy, we retain the CPI-based deflator. The weights of the commodities in step one are soybeans (40.60%), iron ore (37.29%) and oil (22.11%).

The foreign output variable (yw_t) consists of a weighted measure of the real GDP of Brazil's eighteen most important trading partners in terms of the value of exports, with the weight calculated as the arithmetic average of export values from 1996Q1 to 2017Q1.[11] The measure of the real value of Brazilian resource exports ($resx_t$) contains the same products included in the real commodity price index.

Domestic variables The primary non-tradable commodity sector ($comm_t$) variable contains the sum of the value added of the crop and livestock sector and the mining sector and accounts for the direct effects of the variables in the commodity sector on the non-tradable commodity sector. The crop and livestock sector has a strong relationship with exported agricultural goods (soybeans), and the mining sector has a strong relationship with exported mineral goods (iron ore and oil). Domestic output (yd_t) consists of Brazilian real GDP, and the inflation rate (pd_t) is the Broad National Consumer Price Index (IPCA) and the main indicator of the inflation target of the Central Bank of Brazil.

The interest rate (rd_t) construction follows Uribe e Yue (2006) and Shousha (2016), and is the sum of JP Morgan's EMBI+ sovereign spread and the U.S. real interest rate. The three-month U.S. Treasury bill minus a measure of U.S. expected inflation measures the latter. The weighted index is composed of foreign debt instruments from the governments of emerging countries, which are actively traded and denominated in U.S. dollars.

The real effective exchange rate variable[12] (q_t) is the Central Bank of Brazil's trade weighted index. According to the Central Bank of Brazil's methodology, the index is expressed in real terms using the Broad National Consumer Price Index (IPCA) in relation to the Consumer Price Index of its main trading partners. In addition, an decrase in the index means an appreciation of the real exchange rate and consequently

[11] The trading partners are Belgium, Spain, Netherlands, China, Chile, Germany, India, United States, United Kingdom, Italy, Japan, Argentina, Mexico, France, Russian Federation, Canada, Paraguay and the Korea Republic. Foreign output calculated using export and import shares is similar to that calculated using only export shares. The results are available upon request.

[12] Real effective exchange rate and real exchange rate are used as interchangeable terms in this essay.

a loss of international competitiveness. The inclusion of the real exchange rate links with the literature on the influence of external shocks on EMEs (SHOUSHA, 2016; FERNáNDEZ; GONZáLEZ; RODRIGUEZ, 2018; ZEEV; PAPPA; VICONDOA, 2017; DRECHSEL; TENREYRO, 2018) and also to the literature on the impact of commodity booms on commodity-exporting economies (DUNGEY; FRY-MCKIBBIN; LINEHAN, 2014; DUNGEY et al., 2017; CORDEN, 1984; CORDEN; NEARY, 1982; FRANKEL, 2012; WIJNBERGEN, 1984). Appendix A contains full details of the data and data sources.

Sample and treatment of the data The data frequency is quarterly, and the benchmark model's sample period extends from 1999 Quarter 1 to 2017 Quarter 1.[13] The start date of 1999 coincides with the floating of the Brazilian exchange rate following the pressure of the Russian default in late 1998. Although it is common for SVAR papers on the Brazilian economy to begin their sample period in 1996 or before (for example, see Zeev, Pappa e Vicondoa (2017)), a floating currency is likely to be a major shock absorber in of terms of trade shocks on the domestic economy (ASLAM et al., 2016) and hence represents an important break in the exchange rate data for the questions under consideration. The sample period encompasses the entirety of the last commodity price boom and the aftermath period. Adopting 1999 as a starting point also attenuates the bias related to the heterogeneity of the macroeconomic policy as it has been based on floating exchange rate, inflation target and primary surplus target, namely tripod regime, since 1999. The sensitivity analysis in Section 3.5 explores the use of a longer sample period, from 1996 Quarter 1 to 2017 Quarter 1.

The data are transformed with all non-stationary variables linearly detrended and expressed in log form. The exception is the inflation rate, which is a percentage. The VAR lag order selection tests indicate either one (Schwartz Bayesian Information Criterion and Hannan-Quin Information Criteria) or two (Akaike Information Criteria and Likelihood Ratio) *lags* (using a maximum lag length of $pmax = 4$). The lag length of $p = 2$ ensures no serial correlation, and the SVAR satisfies the stability condition.

3.4 Chinese resource demand effects an EME

To disentangle the effects of the external shocks to Chinese resource demand (csp_t), real commodity prices (pc_t) and foreign output (yw_t) on the dynamic relationships between the external variables and the economy of Brazil, Sections 3.4.1 to 3.4.4 present the impulse response functions to shocks for each of these variables, followed by the forecast error variance decompositions for all variables in the model.

[13] The Brazilian System of National Accounts (reference series 2010) is integrated with the National Classification of Economic Activities (CNAE). Taking into account the current classification of products and activities released in 2007, the Brazilian Institute of Geography and Statistics (IBGE) provides quarterly and chain-weighted data from the first quarter of 1996 expressed in 1995 prices.

3.4.1 Shock to Chinese resource demand

A one standard deviation shock to Chinese steel production (or 3.76%), as shown in Figure 8, results in rising real commodity prices received by Brazilian exporters, indicating that the shock coming from China is a commodity demand shock. Real commodity prices peak at 3.43% above the baseline in the third quarter. Steel production in China and real commodity prices converge to their initial values approximately six years after the shock. The characteristics of the shock are akin to those of a demand shock, and the duration of the shock is the same as in Dungey et al. (2017).

Brazilian resource exports and the primary commodity sector expand in response to the commodity demand shock, peaking at 6.81% and 1.09% above the baseline level in the fourth and third quarters, respectively. Consistent with Veríssimo e Xavier (2013), the rise in the real value of Brazilian resource exports occurs despite an appreciation of the real exchange rate, reflecting the high profitability of resource exports from EMEs. Higher Chinese resource demand and the resultant commodity price boom translate into an expansion of output in Brazil. Domestic output peaks at 1.05% in the third quarter and remains above the baseline for approximately eight years. The expansion occurs in both the resource sector and the non-resource sector of the Brazilian economy, suggesting that there is no evidence of Dutch disease.

Chinese resource demand and the resulting commodity price boom puts downward pressure on the interest rate available to Brazil in foreign capital markets as investors react to the improvement in Brazil's terms of trade. The interest rate remains below the baseline level for six years in response to a Chinese resource demand shock. This channel contributes to the explanation of the overall expansionary effect of the shock to Chinese resource demand on the domestic economy. Both increased commodity exports and the decline in the interest rate lead to an appreciation of the real exchange rate. Remarkably, all variables regarding domestic activity remain above the baseline level for nearly six years, which is similar to the duration of the shock to Chinese resource demand. The exception is inflation, which is neutralized by the appreciation of the real exchange rate.

The results for a shock to Chinese resource demand are more positive for the macroeconomy in Brazil than for the macroeconomy Australia. Unlike our results for Brazil, Dungey, Fry-McKibbin e Linehan (2014) find some evidence of Dutch disease as Australian output drops below the baseline after the first six quarters in response to the Chinese resource demand shock. The main reasons for this identified by the authors include the following: i) tighter monetary policy invoked as the economy expands; ii) the fall in the real value of Australian resource exports in response to the combined effect of the rise in real commodity prices and the appreciation of the real exchange rate; and iii) the movement of factors of production out of the non-resource sector into the expanding resource sector. These mechanisms are in direct contrast to the case of Brazil, where

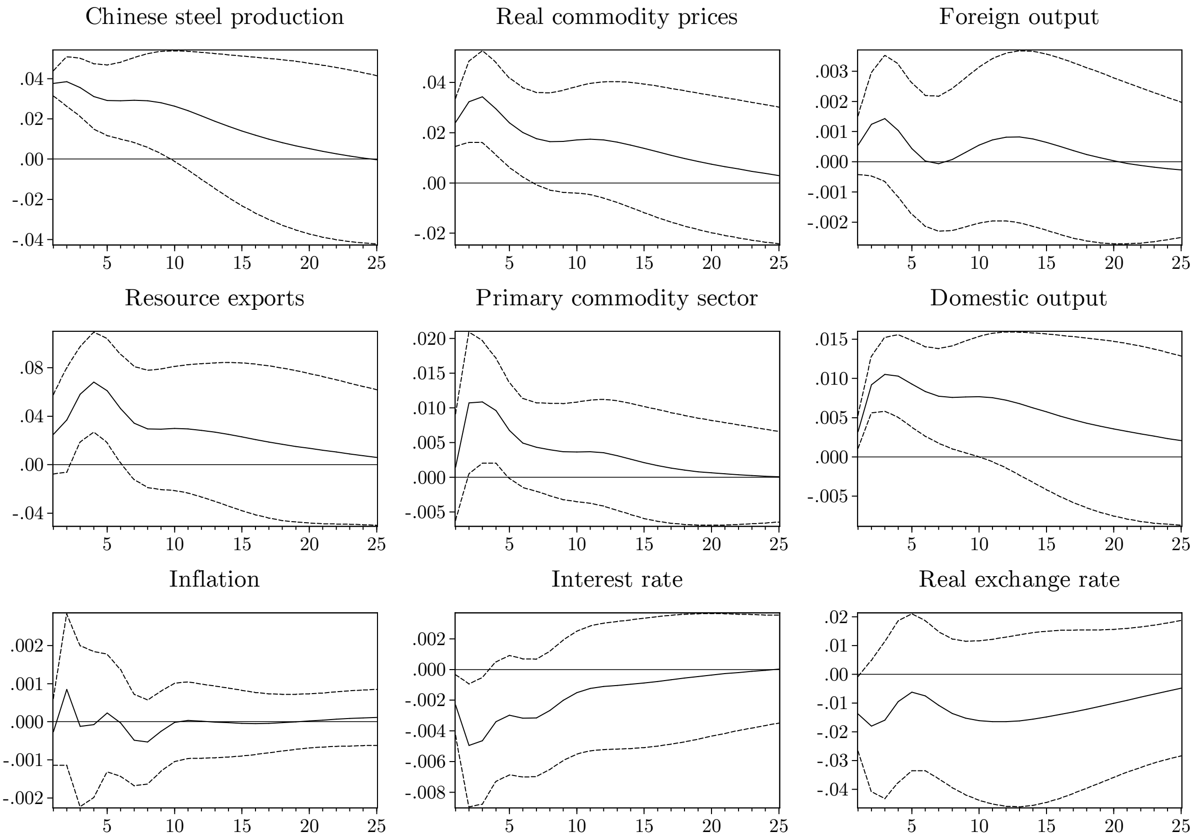

Figure 8 – Impulse response functions to a shock to Chinese steel production, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

the (externally set) cost of borrowing in foreign markets is more favorable, commodity exports rise despite exchange rate appreciation, and both the resources sector and the non-resources sector expand in response to the shock.

3.4.2 Shock to commodity prices

A one standard deviation shock to real commodity prices received by Brazilian exporters, as shown in Figure 9, corresponds to a rise of 3.65%. Real commodity prices peak at 3.97% by the second quarter and remain above their initial level for six quarters. In response to the shock, steel production in China falls and remains below the baseline for approximately ten years. Foreign output reacts positively but eventually falls below the baseline after the first year. These results are consistent with a commodity supply shock, where commodity prices rise and commodity (steel) production falls. The price of goods that use commodities as inputs rise in response to the rupture in the supply of commodities, and subsequently, foreign output falls (JÄÄSKELÄ; SMITH, 2013).

The real value of Brazilian resource exports peaks at 6.56% in the third quarter and remains above the baseline for nine quarters, following the higher world commodity prices

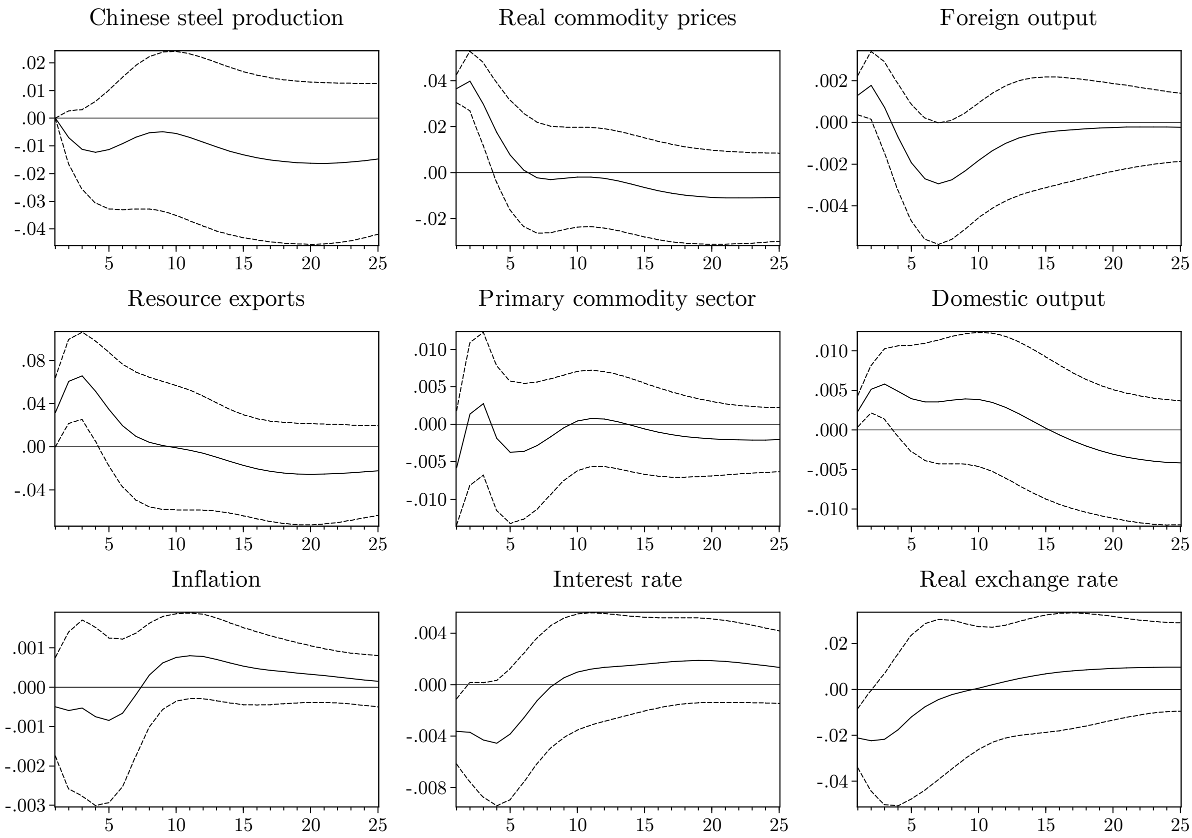

Figure 9 – Impulse response functions to a shock to commodity prices, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

closely. Similar to the shock to Chinese resource demand, Brazilian resource exports rise in response to higher world commodity prices despite a real exchange rate appreciation. The primary commodity sector in Brazil fluctuates around the baseline level in response to a commodity supply shock, reflecting the combined effect of lower steel production in China, lower foreign output, and higher world commodity prices. Resource demand shocks rather than commodity price shocks drive the primary commodity sector in Brazil.

Domestic output peaks at 0.58% above the initial level in the third quarter in response to the commodity supply shock and remains above the baseline for fifteen quarters. Similar to the effect of the Chinese resource demand shock, Brazil's interest rate falls in response to the world commodity price shock and remains below the initial level for two years. The reaction of domestic output and the interest rate confirm the findings reported by Zeev, Pappa e Vicondoa (2017), Shousha (2016), Drechsel e Tenreyro (2018), Fernández, González e Rodriguez (2018), who suggest that world commodity prices are important sources of business cycles in Latin America because they reduce the country's interest rate, causing a further expansion that would not otherwise occur. The spillover effect from commodity prices to the interest rate helps explain the expansionary impact of the shocks to commodity prices on domestic output.

The real exchange rate appreciates in response to higher world commodity prices, remaining below the baseline level for nine quarters, following higher resource exports and lower interest rate closely. As the interest rate measures the cost of borrowing that emerging countries face in international financial markets, a decrease in that rate *leads* to capital inflows, which puts further pressure on the real exchange rate. Indeed, Shousha (2016) argues that the interest rates of EMEs rise when there are capital outflows, while in advanced economies, interest rate rises are mainly due to monetary policy tightening. As in the previous shock, inflation is neutralized by the appreciation of the real exchange rate.

3.4.3 Shock to foreign output

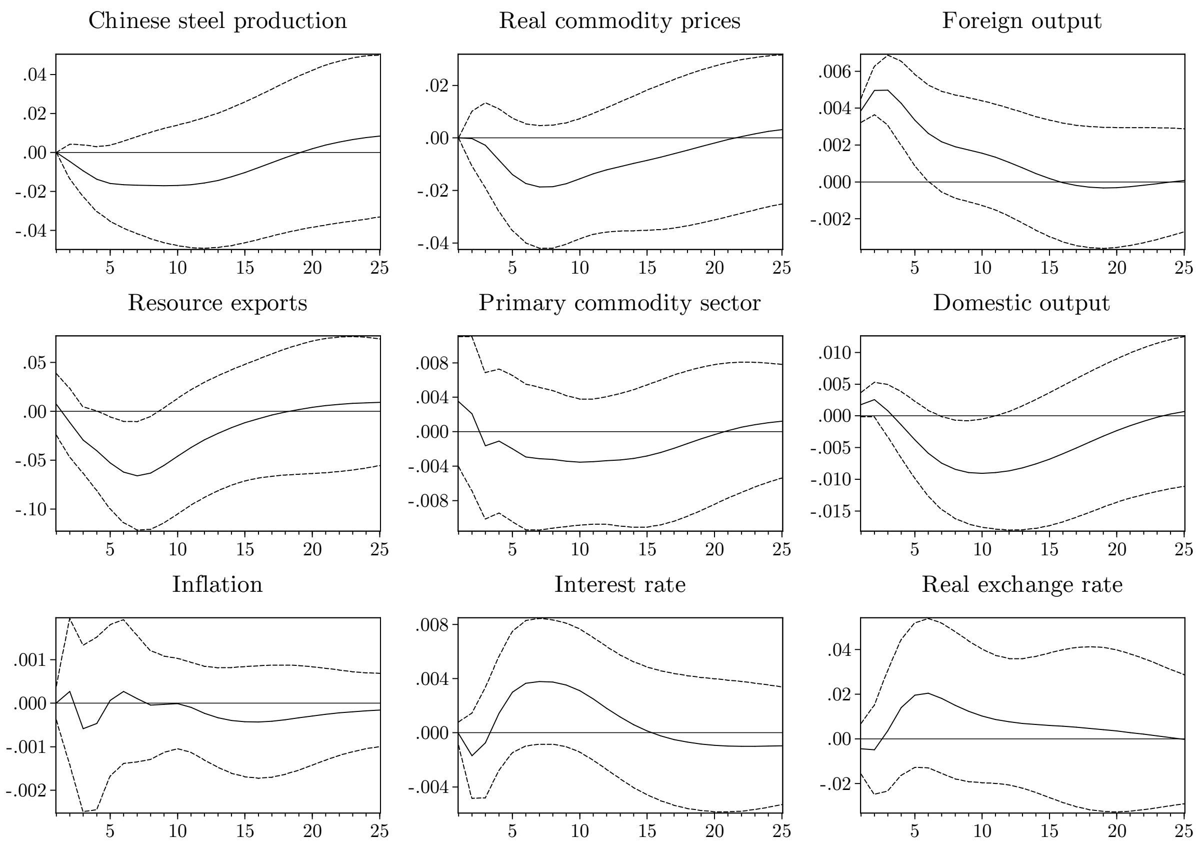

Figure 10 – Impulse response functions to a shock to foreign output, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

Figure 10 shows the responses to a shock to foreign output of 0.38%, which has a long duration but quite insignificant effects compared to the Chinese resource demand and commodity price shocks. By the thirteenth quarter, the effect of the shock on itself is only 0.07%. Chinese steel production falls below the baseline for nineteen quarters, while world commodity prices, Brazilian resource exports and the primary commodity sector (shortly afterwards) fall in response to lower Chinese resource demand. The decrease in resource exports occurs despite the depreciation of the exchange rate. Brazilian resource exports more strongly relate to Chinese resource demand than higher world demand as the latter does not sustain Brazilian resource exports or output.

Brazil's interest rate initially falls in response to the positive external conditions, but after three quarters, it reverses to be above the baseline. The overshooting of the interest rate may be partly responsible for the negative response of the primary commodity sector. Lower commodity prices and Brazilian exports contribute to the real exchange rate depreciation, with the higher interest rate providing additional pressure for depreciation.

3.4.4 Forecast error variance decomposition

Table 18 presents the forecast error variance decomposition of each variable. The decomposition shows the proportionate contribution of each of the shocks in the model to each variable over short (one and four quarters), medium (twelve quarters) and long (24 quarters) horizons.

The variance decompositions for the external sector of Chinese steel production, commodity prices and world output are shown in the first three rows of column one of Table 18. Over the long horizon (24 quarters), almost half of the variance of Chinese steel production comes from a combination of its own shocks (32.84%) and those of world commodity prices (9.18%) and foreign output (8.60%). The contribution to Chinese steel production of Brazilian output (11.97%), the primary commodity sector (14.23%) and the real exchange rate (14.92%) provides evidence of a strong interaction between commodity demand (from China) and supply (represented here by Brazil). Like Australia (DUNGEY et al., 2017), Brazil exhibits some market power in the commodity prices of their exports represented by the contribution of Brazilian output to commodity prices at the 24th quarter (9.88%). The decomposition of world demand falls mainly to the shock itself (46.79%) and commodity prices (18.31%).

The large contribution of the external sector of approximately 70% to the variance of Brazilian exports stands out. This result is expected because of the direct link between resource demand and commodity price fluctuations and Brazilian commodity exports. Brazilian resource exports react to resource demand and commodity prices regardless of the real exchange rate since the latter variable accounts for less than 5% of resource exports. These findings concur with the impulse responses shown in Sections 3.4.1 to 3.4.3.

The top panel in the second column of Table 18 provides evidence of direct links between the external resource sector and the non-tradable primary commodity sector as the second and third largest contributors to the primary commodity sector are Chinese resource demand (17.96%) and the exchange rate (14.21%), respectively. Overall, its own shocks dominate (42.58%), with the remaining quarter of contributions evenly spread between the domestic macroeconomy and the external sector. The commodity sector in

Table 18 – Forecast error variance decomposition (in per cent), 1999Q1 to 2017Q1

		Horizon (qtr)						Horizon (qtr)			
Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	81.18	47.31	32.84		csp_t	0.21	15.58	18.54	17.96
	pc_t	0.00	5.19	3.39	9.18		pc_t	3.22	2.23	3.30	4.09
	yw_t	0.00	4.73	10.71	8.60		yw_t	1.16	0.97	3.87	5.05
	$resx_t$	0.00	4.63	7.30	6.22		$resx_t$	6.62	5.47	5.64	5.34
csp_t	$comm_t$	0.00	0.31	8.05	14.23	$comm_t$	$comm_t$	88.80	53.52	45.24	42.58
	yd_t	0.00	0.75	10.01	11.97		yd_t	0.00	2.91	3.96	5.73
	pd_t	0.00	0.90	0.27	0.30		pd_t	0.00	0.45	0.72	0.68
	rd_t	0.00	0.42	0.78	1.73		rd_t	0.00	4.99	4.39	4.37
	q_t	0.00	1.89	12.18	14.92		q_t	0.00	13.90	14.35	14.21
	csp_t	30.37	43.97	41.69	34.10		csp_t	12.28	49.66	41.30	34.94
	pc_t	69.63	49.02	27.32	23.18		pc_t	6.68	14.30	9.92	9.29
	yw_t	0.00	0.95	14.03	11.44		yw_t	3.77	1.98	25.75	25.60
	$resx_t$	0.00	0.14	1.52	2.79		$resx_t$	0.15	0.21	1.48	1.82
pc_t	$comm_t$	0.00	2.06	4.02	8.67	yd_t	$comm_t$	1.01	2.83	3.67	4.30
	yd_t	0.00	0.14	6.71	9.88		yd_t	76.10	28.22	15.14	18.51
	pd_t	0.00	3.06	2.17	1.53		pd_t	0.00	1.82	1.32	0.92
	rd_t	0.00	0.35	0.46	1.28		rd_t	0.00	0.69	0.69	1.49
	q_t	0.00	0.31	2.07	7.13		q_t	0.00	0.29	0.71	3.12
	csp_t	1.78	4.86	3.13	3.57		csp_t	0.18	0.74	1.17	1.12
	pc_t	9.92	5.67	20.57	18.31		pc_t	0.63	1.33	4.00	5.43
	yw_t	88.30	80.46	54.16	46.79		yw_t	0.00	0.58	0.64	1.62
	$resx_t$	0.00	0.22	4.11	4.70		$resx_t$	0.14	2.88	3.43	3.52
yw_t	$comm_t$	0.00	1.09	7.45	12.78	pd_t	$comm_t$	1.46	13.26	13.18	14.39
	yd_t	0.00	1.55	1.81	2.06		yd_t	0.36	4.59	6.15	5.77
	pd_t	0.00	0.62	0.53	0.50		pd_t	97.22	40.76	37.02	34.73
	rd_t	0.00	0.26	0.39	0.41		rd_t	0.00	29.86	28.79	27.01
	q_t	0.00	5.29	7.86	10.87		q_t	0.00	5.99	5.63	6.40
	csp_t	3.26	20.59	21.76	20.05		csp_t	3.20	14.44	15.65	13.96
	pc_t	5.24	23.94	13.66	15.33		pc_t	7.89	15.18	13.60	15.86
	yw_t	0.25	5.50	25.59	21.05		yw_t	0.00	1.25	12.70	11.86
	$resx_t$	91.25	37.55	18.79	15.92		$resx_t$	0.23	8.56	6.20	5.94
$resx_t$	$comm_t$	0.00	5.61	4.65	7.84	rd_t	$comm_t$	2.16	1.83	2.32	5.53
	yd_t	0.00	3.56	12.50	12.94		yd_t	1.04	3.47	11.77	11.51
	pd_t	0.00	0.52	0.51	0.45		pd_t	0.14	0.61	0.64	0.62
	rd_t	0.00	2.37	1.90	2.23		rd_t	85.34	54.08	35.32	30.69
	q_t	0.00	0.35	0.64	4.19		q_t	0.00	0.58	1.79	4.04
							csp_t	5.31	4.94	9.06	12.38
							pc_t	12.52	9.87	7.75	8.65
							yw_t	0.54	1.45	7.87	6.97
							$resx_t$	1.46	0.57	0.67	2.13
						q_t	$comm_t$	10.79	28.30	28.65	26.34
							yd_t	1.86	2.71	5.33	7.08
							pd_t	0.47	0.46	0.64	0.53
							rd_t	21.00	11.70	8.20	6.92
							q_t	46.04	40.00	31.84	29.00

Notes: External variables: Chinese steel production (csp_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Brazil is driven by demand shocks instead of price shocks.

The second panel of column 2 of Table 18 contains the most important variance decomposition of Brazilian output. The decomposition shows the susceptibility of the Brazilian economy to external shocks. Over the longer horizon, Chinese steel production (34.94%), world commodity prices (9.29%) and world demand (25.60%) combine to contribute around 70% of explaining the variance in domestic output. In comparison, the findings in Dungey et al. (2017) show that Chinese steel production and world commodity prices are responsible, respectively, for a mere 3.36% and 5.11% of Australian output in the long-run. The contrasting results of the two papers align with Shousha (2016), who finds that real commodity prices are responsible for 23% of the movement in the domestic output of EMEs compared with 7% of that in advanced economies. Our findings confirm the idea that Chinese resource demand has a strong role in the business cycles of EMEs and that world commodity prices also have a non-trivial role, even when these prices are orthogonal to resource demand. The interest rate is generally considered essential in accounting for business cycles in EMEs (for example, see Uribe e Yue (2006)) and explains 1.49% of Brazilian output, again confirming Shousha (2016), who argues that, at least for commodity exporters, the interest rate shocks capture commodity price effects when the latter are omitted from the models, leading to an overestimation of the importance of the interest rate for the business cycle.

In turn, shocks in the external sector contribute the bulk of the variance of the interest rate in the long horizon with Chinese steel production (13.96%) and world commodity prices (15.86), following, in magnitude, the effect of the shock itself (30.69%). This result points to strong spillover effects from both Chinese resource demand and world commodity prices to the interest rates of EMEs, again, even when world commodity prices are orthogonal to resource demand. Our findings show that the inclusion of Chinese resource demand in the model dampens the contribution of commodity prices to the interest rate. Considering a two year horizon, Zeev, Pappa e Vicondoa (2017) found that the commodity terms of trade explain 26% of interest rate spread fluctuations in Brazil. The interest rate channel helps to explain the expansionary effect of Chinese resource demand on the non-resource domestic sector.

Apart from its own shocks (29%) and the non-tradeable primary commodity sector in Brazil (26.34%), Chinese steel production (12.38%) and world commodity prices (8.65%) explain the majority of the variance of the real exchange rate. Combined, Chinese steel production and world commodity prices contribute approximately 20 percent to the variance of the real exchange rate in the longer term, confirming the findings of Chen e Rogoff (2003) and Cashin, Céspedes e Sahay (2004) that the real exchange rate in Brazil is associated with commodity market fluctuations in such way that it belongs to the group of commodity currencies.

As expected, the interest rate influences the variance in the exchange rate in the long horizon as the interest rate plays a non-trivial role in the determination of the exchange rate. These results align with the findings in Prates (2009), who argues that the effect of improved terms of trade and the resulting trade surplus on the Brazilian exchange rate was as much direct on the spot exchange rate, as indirect through its impact on the market expectations of the trajectory of Brazilian country and currency risk and hence the Brazilian interest rate available on international markets.[14]

3.5 Alternative specifications

This section sets out some alternative specifications to the benchmark model of Section 3.4 to investigate the model robustness to measures of Chinese resource demand, real commodity price indexes, the sample period, and a detrending of the data. Figures 11 to 19 present the impulse response functions for the shocks to Chinese resource demand, commodity prices and world output for the robustness experiments, while Table 19 contains the forecast error variance decomposition for the most important variable of output in Brazil for each case. The complete set of results are available upon request. Like the model in Section 3.4, the models for the robustness exercises have a lag length of $p = 2$, and all SVARs satisfy the stability condition.

Overall, the model is remarkably robust to the alternative specifications of the model. Table 19 shows that over the longer term horizon of 24 quarters, the contribution of Chinese resource demand shocks to Brazilian output range from 18.17 to 43.89 percent compared to the benchmark model, which was 34.94 percent. The contribution of the commodity price shocks to output ranges from 1.56 to 9.56 percent, compared to the benchmark model, which was 9.29 percent, while the contribution of foreign output shocks to output in Brazil ranges from 10.88 to 42.34 percent compared to the benchmark of 25.60 percent.

3.5.1 Alternative measures of Chinese resource demand

Three alternative proxies of Chinese resource demand of Chinese manufacturing exports, industrial production and GDP are sequentially substituted into the VAR in place of the Chinese steel production (csp_t) variable to examine the sensitivity of the model to the alternative measures. Figures 11 to 13 compare the impulse response functions to each of the shocks to Chinese resource demand, real commodity prices and foreign output

[14] Although not directly modeled, our findings support the view that world commodity price fluctuations influence capital flows to Brazil in terms of both foreign direct investment (FRIZOA; LIMA, 2014) and portfolio investment (BREDOW; LéLIS; CUNHA, 2016). These results also concur with the argument of Forbes et al. (2016), who show that when Brazil implemented its capital controls, investors increased the share of their portfolios allocated to ‘dragon play’.

Table 19 – Robustness analysis: Forecast error variance decomposition of output for models with alternative specifications (in per cent).

	Horizon (qtr)					Horizon (qtr)			
	1	4	12	24		1	4	12	24
Robustness to Chinese resource demand					Robustness to commodity price index				
Chinese manufacturing exports					*Broad basket*				
cme_t	14.65	23.70	17.35	18.17	csp_t	10.54	46.67	40.70	36.09
pc_t	7.82	26.41	15.65	8.67	$pc7_t$	8.37	12.56	10.25	8.38
yw_t	0.58	1.94	39.23	42.34	yw_t	2.36	1.40	24.98	26.13
$resx_t$	0.53	1.90	1.58	2.19	$resx7_t$	0.46	0.35	1.87	1.86
$comm_t$	0.54	5.66	5.70	4.70	$comm_t$	2.18	2.08	2.67	2.76
yd_t	75.87	36.70	17.01	17.91	yd_t	76.09	34.04	14.94	16.84
pd_t	0.00	2.45	1.06	0.64	pd_t	0.00	1.72	1.69	1.19
rd_t	0.00	0.61	1.04	4.44	rd_t	0.00	0.87	1.00	1.14
q_t	0.00	0.63	1.38	0.94	q_t	0.00	0.32	1.91	5.62
Chinese industrial production					*Non-oil basket*				
cip_t	15.47	61.13	44.21	30.16	csp_t	12.07	47.84	46.47	42.52
pc_t	1.63	2.30	2.03	1.56	$pc6_t$	4.34	9.14	7.99	6.52
yw_t	2.37	2.28	19.63	14.37	yw_t	4.03	2.22	21.63	23.05
$resx_t$	0.72	0.69	3.10	3.18	$resx6_t$	0.01	0.55	1.89	1.12
$comm_t$	1.81	0.81	6.05	15.60	$comm_t$	1.24	1.80	1.76	2.90
yd_t	78.00	23.92	16.18	26.24	yd_t	78.30	35.34	14.43	13.48
pd_t	0.00	7.94	6.93	4.59	pd_t	0.00	1.68	1.35	0.85
rd_t	0.00	0.19	1.31	3.99	rd_t	0.00	1.17	1.26	1.28
q_t	0.00	0.73	0.58	0.30	q_t	0.00	0.25	3.20	8.27
Chinese GDP					*Commodity terms of trade*				
$cgdp_t$	12.77	49.87	41.26	30.40	csp_t	11.48	48.60	39.84	34.11
pc_t	5.91	13.71	9.92	6.04	$ctot_t$	6.78	14.90	11.02	9.56
yw_t	2.91	1.72	13.36	10.88	yw_t	3.94	2.08	25.93	26.23
$resx_t$	0.22	0.50	4.71	5.00	$resx_t$	0.14	0.23	1.60	1.47
$comm_t$	1.24	0.42	5.65	11.58	$comm_t$	0.90	2.77	3.71	4.06
yd_t	76.94	26.35	18.33	28.19	yd_t	76.76	28.50	15.13	18.67
pd_t	0.00	5.50	5.13	3.24	pd_t	0.00	1.76	1.28	0.91
rd_t	0.00	0.56	0.54	1.17	rd_t	0.00	0.81	0.91	1.99
q_t	0.00	1.38	1.09	3.50	q_t	0.00	0.36	0.58	3.01
Robustness to sample period					Robustness to detrending				
Boom period									
csp_t	9.50	42.85	40.78	38.19	csp_t	7.00	29.22	43.60	43.89
pc_t	8.23	16.37	13.92	9.16	pc_t	8.18	15.19	6.60	3.21
yw_t	5.15	3.21	21.57	27.64	yw_t	3.16	2.31	6.54	14.06
$resx_t$	0.25	0.58	0.96	0.70	$resx_t$	0.99	1.47	12.12	9.11
$comm_t$	0.89	6.11	7.51	4.58	$comm_t$	2.47	4.45	4.70	3.86
yd_t	75.99	29.72	12.56	12.16	yd_t	78.20	41.75	18.63	12.55
pd_t	0.00	0.11	1.12	5.21	pd_t	0.00	3.48	3.48	2.15
rd_t	0.00	0.56	0.68	0.62	rd_t	0.00	0.92	2.04	1.29
q_t	0.00	0.49	0.90	1.74	q_t	0.00	1.19	2.30	9.88
Long period									
csp_t	8.04	33.59	37.42	32.98					
pc_t	6.63	18.38	10.08	7.73					
yw_t	3.60	2.47	14.22	14.32					
$resx_t$	0.02	0.48	2.07	3.89					
$comm_t$	0.00	7.07	4.87	4.46					
yd_t	81.70	33.92	14.01	8.46					
pd_t	0.00	3.23	5.71	4.76					
rd_t	0.00	0.01	2.13	6.61					
q_t	0.00	0.84	9.49	16.79					

Notes: External variables: Chinese steel production (csp_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

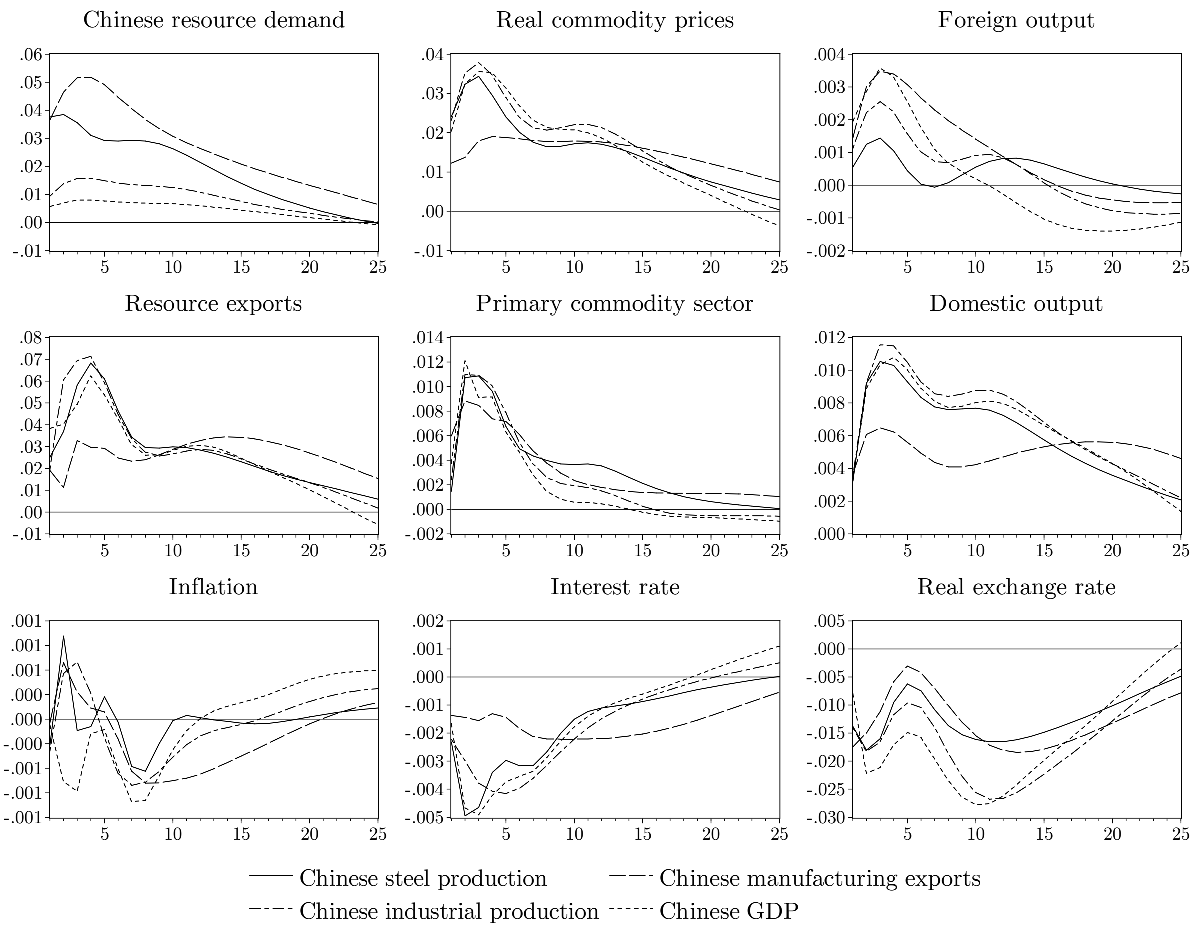

Figure 11 – Robustness of impulse response functions for shocks to Chinese resource demand for models with alternative measures of Chinese resource demand, 1999Q1 to 2017Q1.

shocks for the benchmark model of Chinese steel production (illustrated with the solid line) with the alternatives. In the majority of cases, the impulse response functions follow similar patterns to our benchmark.

Roberts e Rush (2010) show that China's manufacturing exports significantly drive its resource demand, potentially making a good alternative proxy for Chinese resource demand in place of the Chinese steel production variable. Replacing Chinese steel production with manufacturing exports and shocking the exports variable as a proxy for Chinese resource demand results in impulse response functions of a larger magnitude over its duration. However, the quantitative effect on real commodity prices is smaller than that of the original model, with the consequences for the Brazilian variables of resource exports and domestic output being substantially smaller (see Figure 11). The response of manufacturing exports to the real commodity price shock (Figure 12) and foreign output (Figure 13) is the most different of all of the alternatives, with Chinese resource demand changing signs, as shown in Figure 12, for the commodity price shock and increasing in

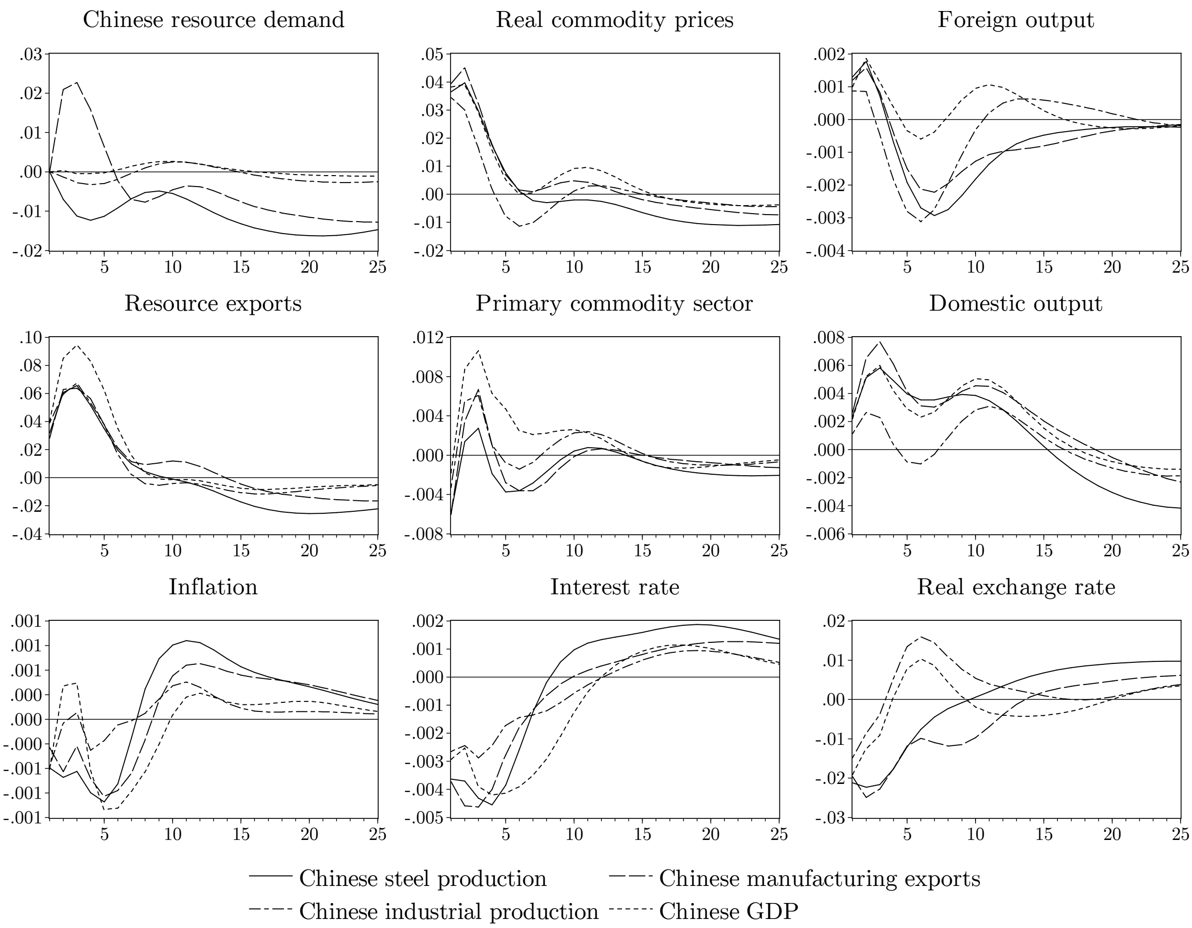

Figure 12 – Robustness of impulse response functions for shocks to real commodity prices for models with alternative measures of Chinese resource demand, 1999Q1 to 2017Q1.

magnitude, as shown in Figure 13, for the foreign output shock.

Replacing the Chinese steel production variable with Chinese industrial production and Chinese GDP, as shown in Figures 11 to 13, results in its own shocks and responses being muted, compared to the benchmark, reflecting the sectors not related to resource demand that these variables capture. Overall the impulse responses of Chinese industrial production and Chinese GDP in the models track each other quite closely but follow dynamics that are similar to those of the impulse response functions of the benchmark model.

The first three panels in the first column of the table show the historical decomposition of output when Chinese manufacturing, industrial production and GDP are substituted into the model for Chinese steel production. The decompositions of Chinese industrial production and the GDP are similar to the results when Chinese steel production is used in the benchmark model with Chinese steel production contribution 34.94 percent to output after six years, compared to 30.16 percent for industrial production, and 30.40

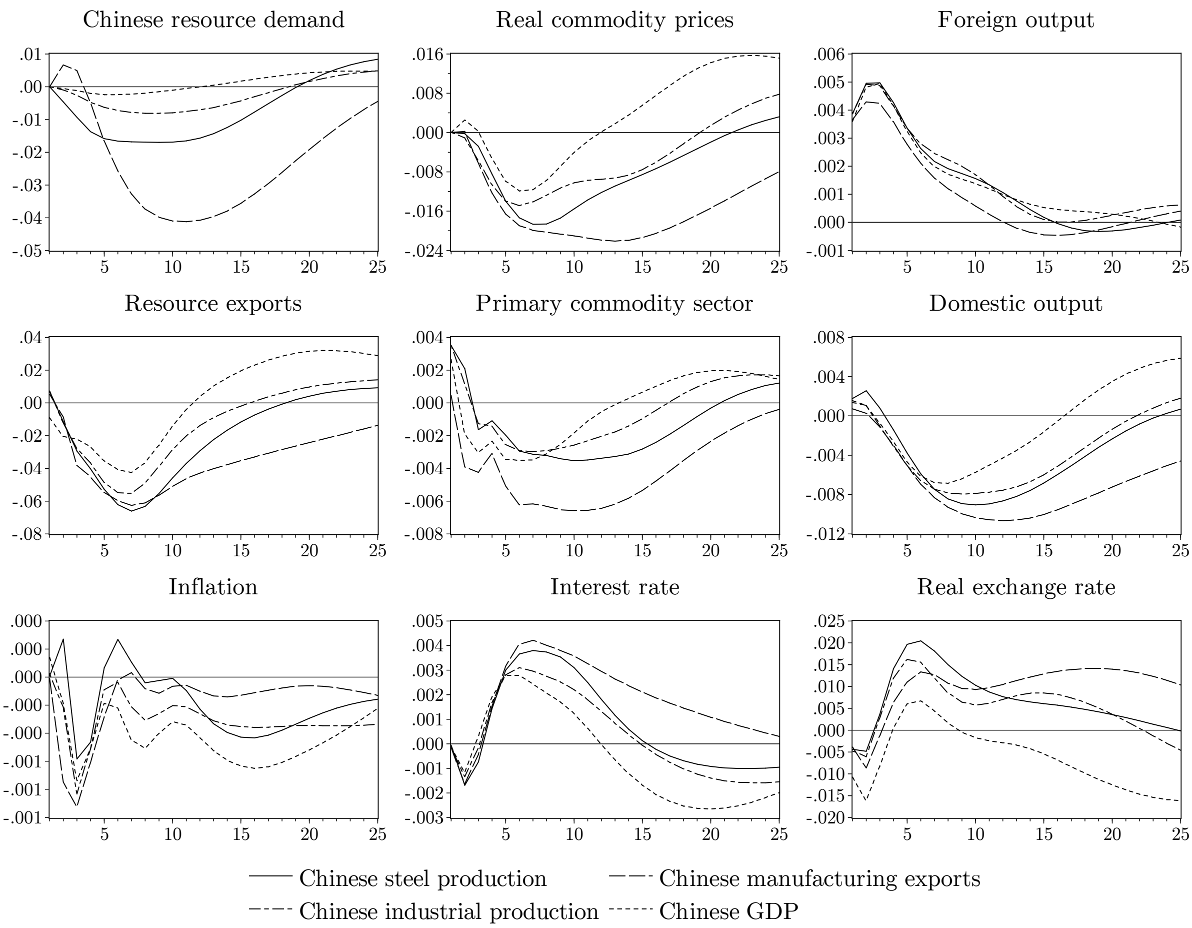

Figure 13 – Robustness of impulse response functions for shocks to foreign output for models with alternative measures of Chinese resource demand, 1999Q1 to 2017Q1.

percent for the GDP. The contribution for manufacturing is lower at 18.17 percent.

In contrast to the Chinese resource demand shocks, the commodity price shocks in the alternative models explain a small percentage of output after six years, ranging from a contribution of 1.56 percent to 8.67 percent, compared to 9.29 percent in the benchmark model. The robustness exercises strongly support the overturning of the premise that world commodity price shocks have an important effect on the Brazilian economy. Instead, Chinese resource demand for primary commodities exported by Brazil is a more important driver of output.

3.5.2 Alternative measures of real commodity price indexes

The index for the benchmark model contains the three main primary commodities exported by Brazil to China: soybeans, iron ore and oil. The second robustness exercise explores alternative definitions of the basket of commodities used in the calculation of the

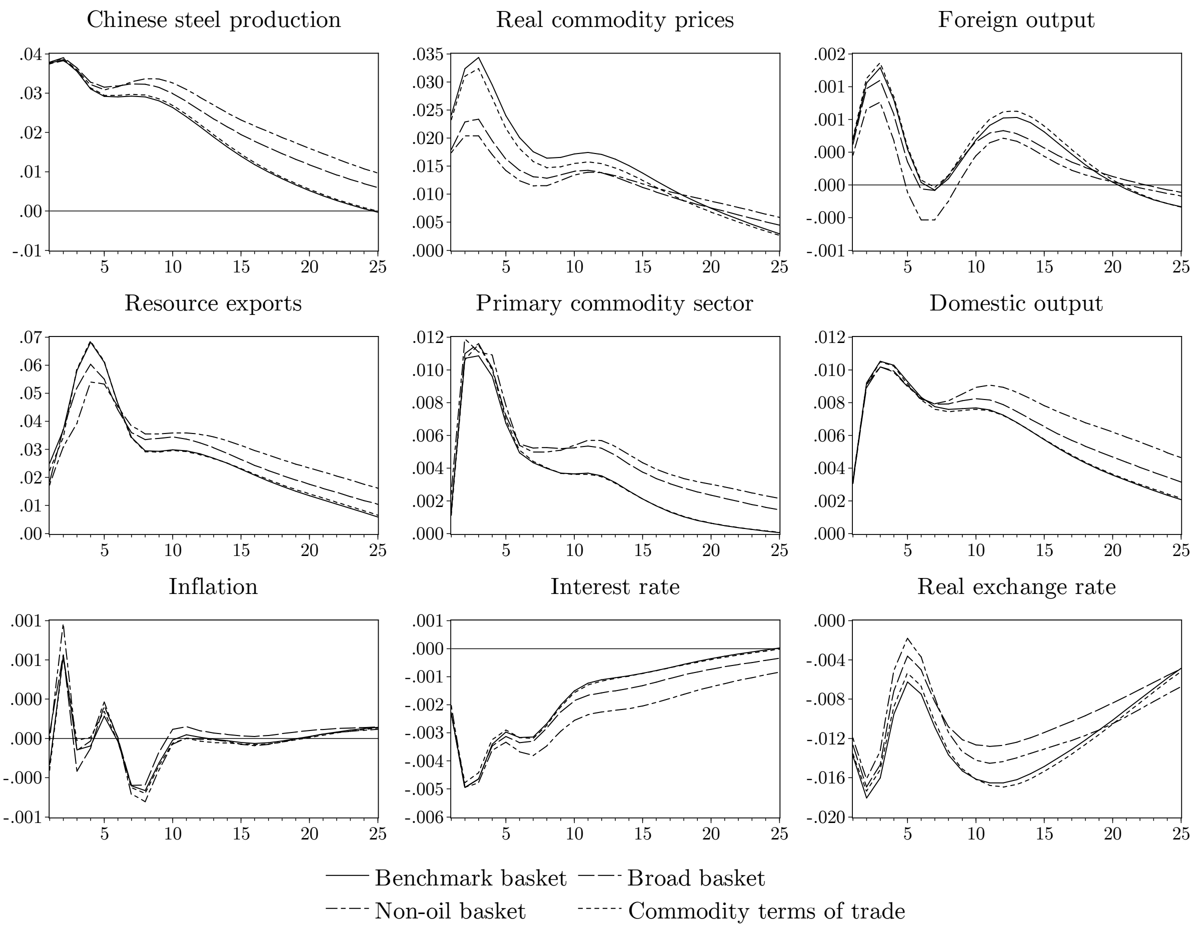

Figure 14 – Robustness of impulse response functions for shocks to Chinese resource demand for models with alternative measures of real commodity prices, 1999Q1 to 2017Q1.

commodity price series and the resource exports variable. Figures 14 to 16 and the first three rows of the second column of the forecast error variance decomposition of output in Table 19 present the results.

First a broader basket of commodities containing the seven most important primary commodities exported by Brazil substitutes into the model. In addition to soybeans, iron ore and oil, the expanded versions of real commodity prices ($pc7_t$) and resource exports ($resx7_t$) contain chicken meat, beef, coffee and sugar. Second, the commodities basket is recalculated to exclude oil since energy prices have a particular growth dynamic that may be different from the other main commodities in the basket. Cashin et al. (2014) and Mohaddes e Pesaran (2016) present evidence on the effects of oil prices on growth. Finally, following Zeev, Pappa e Vicondoa (2017) and Shousha (2016), the commodity terms of trade are substituted into the model in place of the real commodity price index. The series is computed by dividing the commodity price index by the U.S. import price of manufactured goods from industrialized countries.

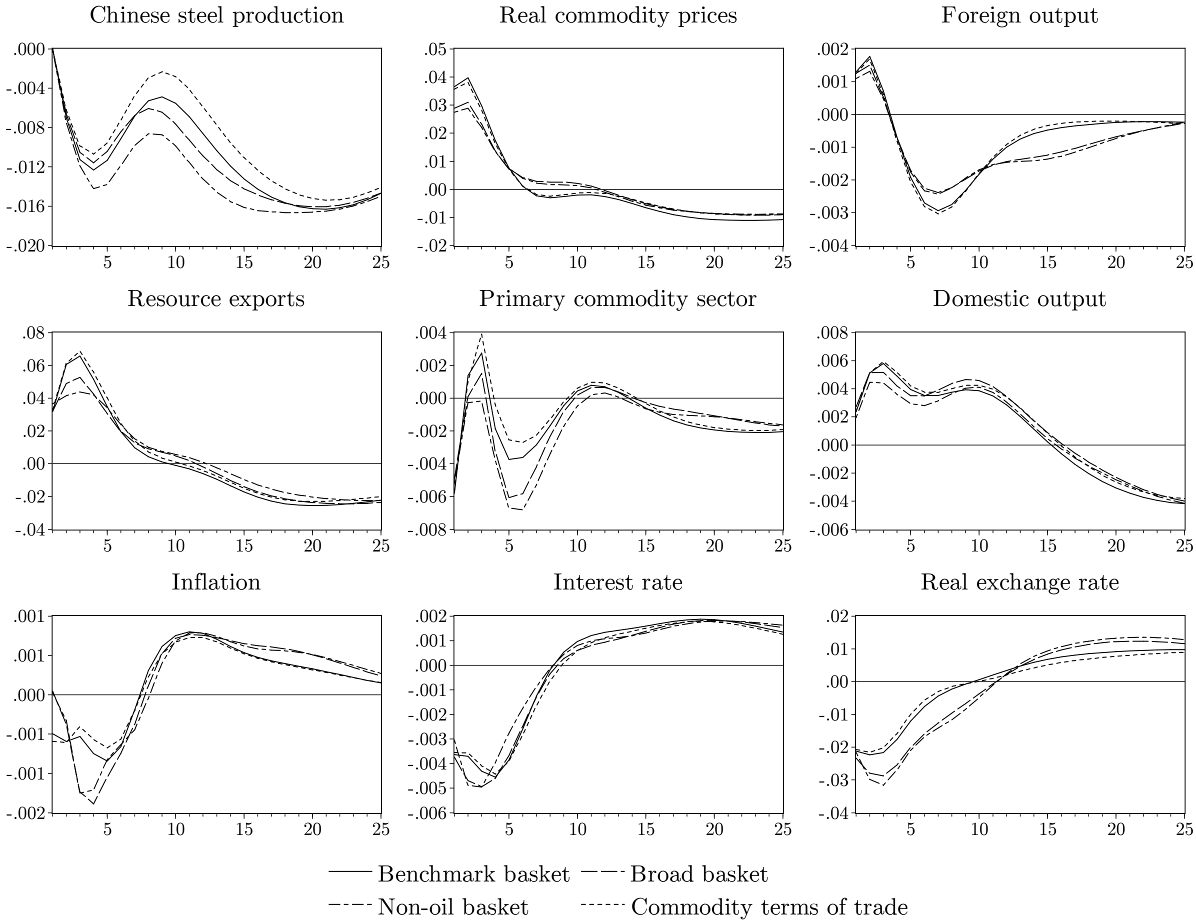

Figure 15 – Robustness of impulse response functions for shocks to real commodity prices for models with alternative measures of real commodity prices, 1999Q1 to 2017Q1.

The benchmark model shows little sensitivity to changes in the definitions of the real commodity price index, as illustrated in Figures 14 to 16 and Table 19. Figure 14 shows that in response to the Chinese resource demand shock, world commodity prices composed of the seven commodities peak at 2.33% in the third quarter, and resource exports peak at 6.03% in the fourth quarter, which is only slightly lower than for the benchmark model. Excluding oil reinforces the results of the Chinese steel production shock. Real commodity prices and Brazilian resource exports peak at a value slightly lower than the benchmark model. Comparing the variance decomposition tables for the output of the benchmark model with the model where the commodities' terms of trade are substituted for the commodity price variable shows only minute differences. In the latter model, the contribution of commodity prices, commodity terms of trade and world output are 34.11, 9.56 and 26.23 percent, respectively, after six years. For the benchmark model the contributions are 34.94, 9.29 and 25.60 percent, respectively. The results are clearly similar enough to the benchmark model to conclude that Brazilian resource exports to

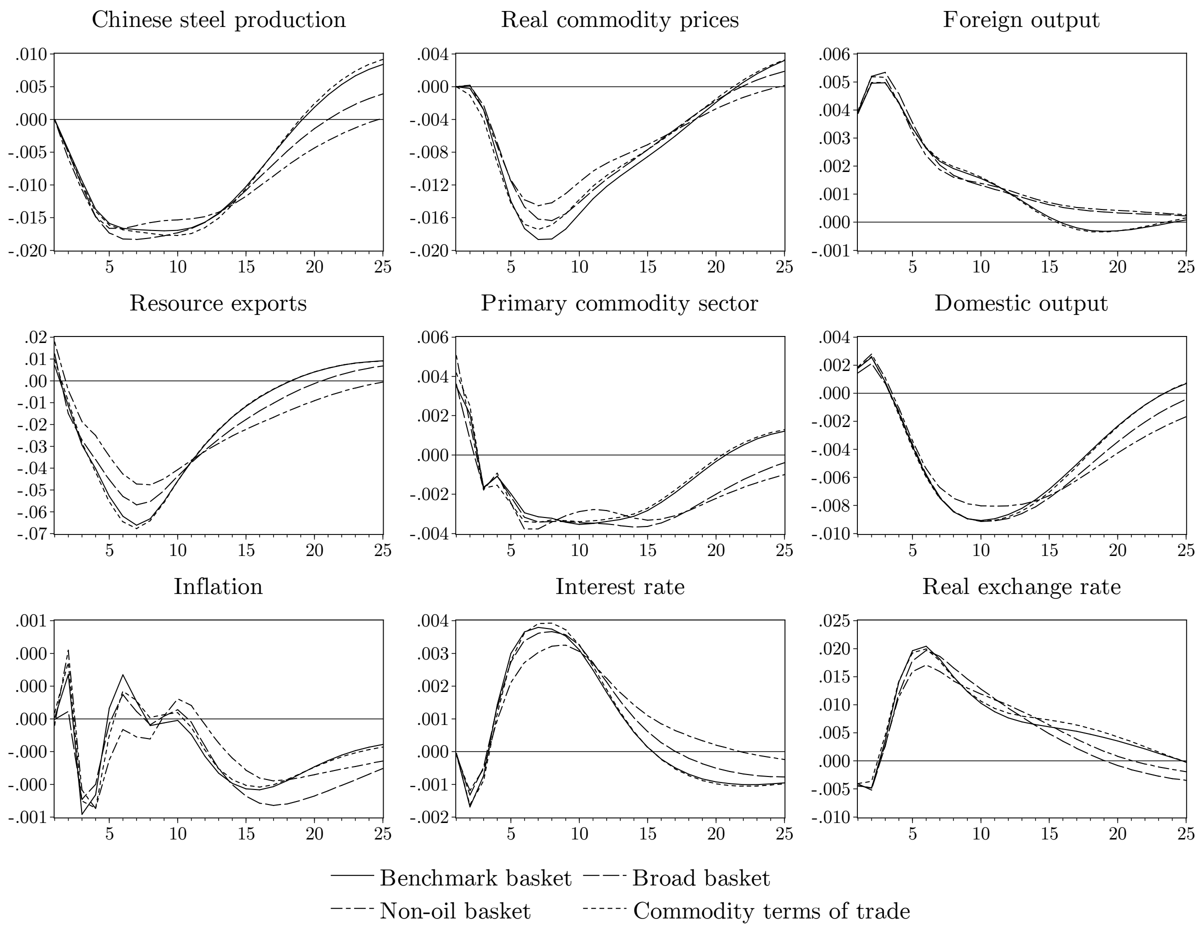

Figure 16 – Robustness of impulse response functions to shocks to foreign output for models with alternative measures of real commodity prices, 1999Q1 to 2017Q1.

China are sufficiently represented by the three main commodities of soybeans, iron ore and oil.

3.5.3 Long sample period

Previous papers in the literature such as Zeev, Pappa e Vicondoa (2017) and Shousha (2016) using a VAR framework for Brazil sometimes use a sample starting point before our chosen starting point of 1999Q1. Zeev, Pappa e Vicondoa (2017) and Shousha (2016) use a starting point of 1995Q1 and 1994Q2, respectively. The earlier starting point inevitably includes a period prior to the adoption of a floating exchange rate regime for Brazil. To assess the sensitivity to the sample period definition we estimated the model encompassing a long sample period beginning in 1996Q1. Figures 17 to 19 present the results, with Figure 17 showing that in response to a shock to Chinese resource demand, the real exchange rate returns to the initial level faster than the benchmark model. As a consequence, the response of domestic output to shocks to Chinese resource demand is still positive in the fiftieth quarter. The historical decompositions show that in the model with

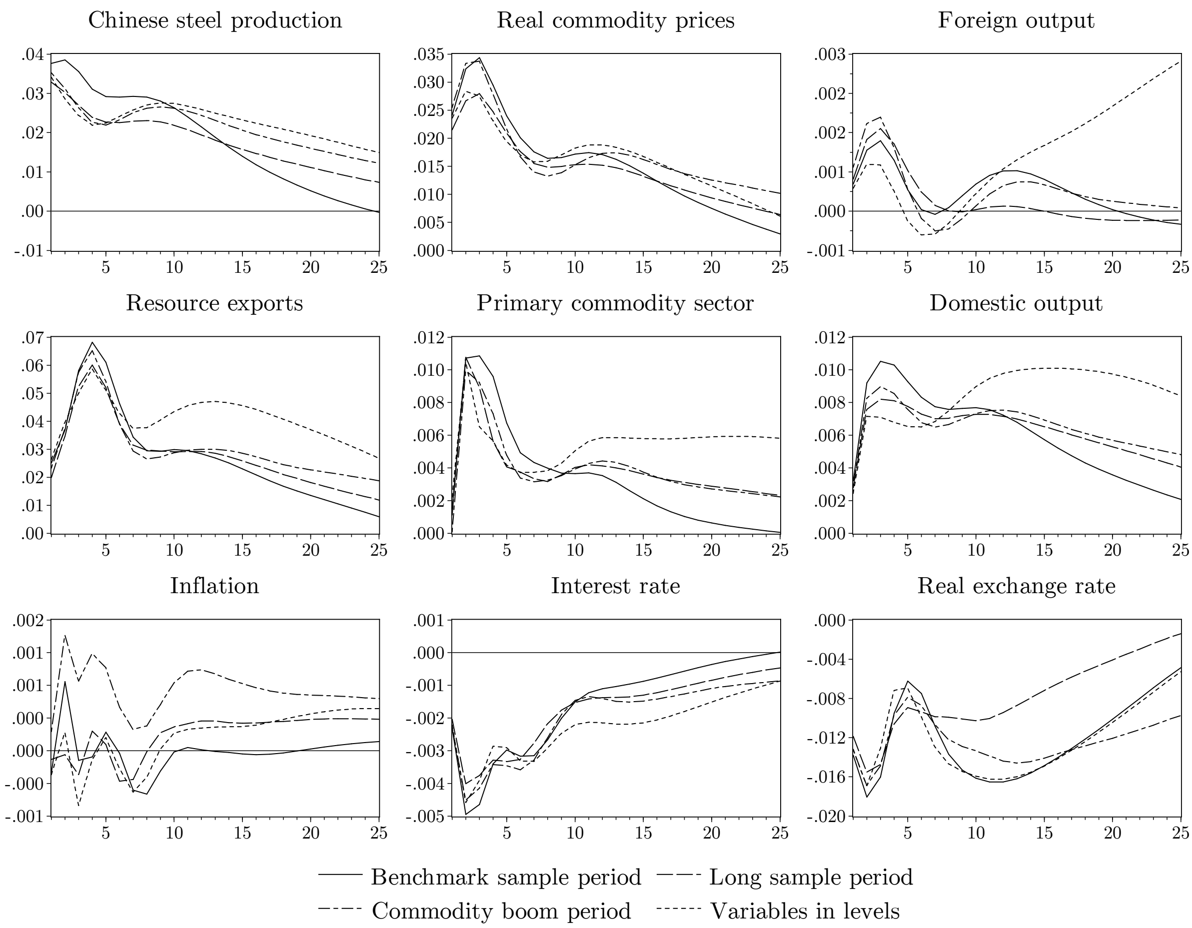

Figure 17 – Robustness of impulse response functions to shocks to Chinese resource demand for models with alternative sample period definitions and variables in levels.

the long sample period, Chinese resource demand explains just over four percent of the exchange rate in comparison to just over twelve percent for the sample period beginning that coincides with the floating of the currency.[15] This alternative specification suggests that the use of data prior to 1999Q1 can overestimate the impact of Chinese resource demand shocks on domestic variables since the real exchange rate is not allowed to dampen those shocks.

3.5.4 Commodity prices boom period

Dungey, Fry-McKibbin e Linehan (2014) estimate a VAR model for the Australian economy taking into account the impact of Chinese resource demand on the domestic economy with a sample spanning 1988Q1 to 2012Q2. The end of 2012Q2 coincides with the end of the commodity price boom for Australia (for example, see Kulish e Rees (2017)). Figure 5 shows that this timing roughly coincides with the end of the boom period for

15 The results of the historical decomposition for the long sample period are available on request.

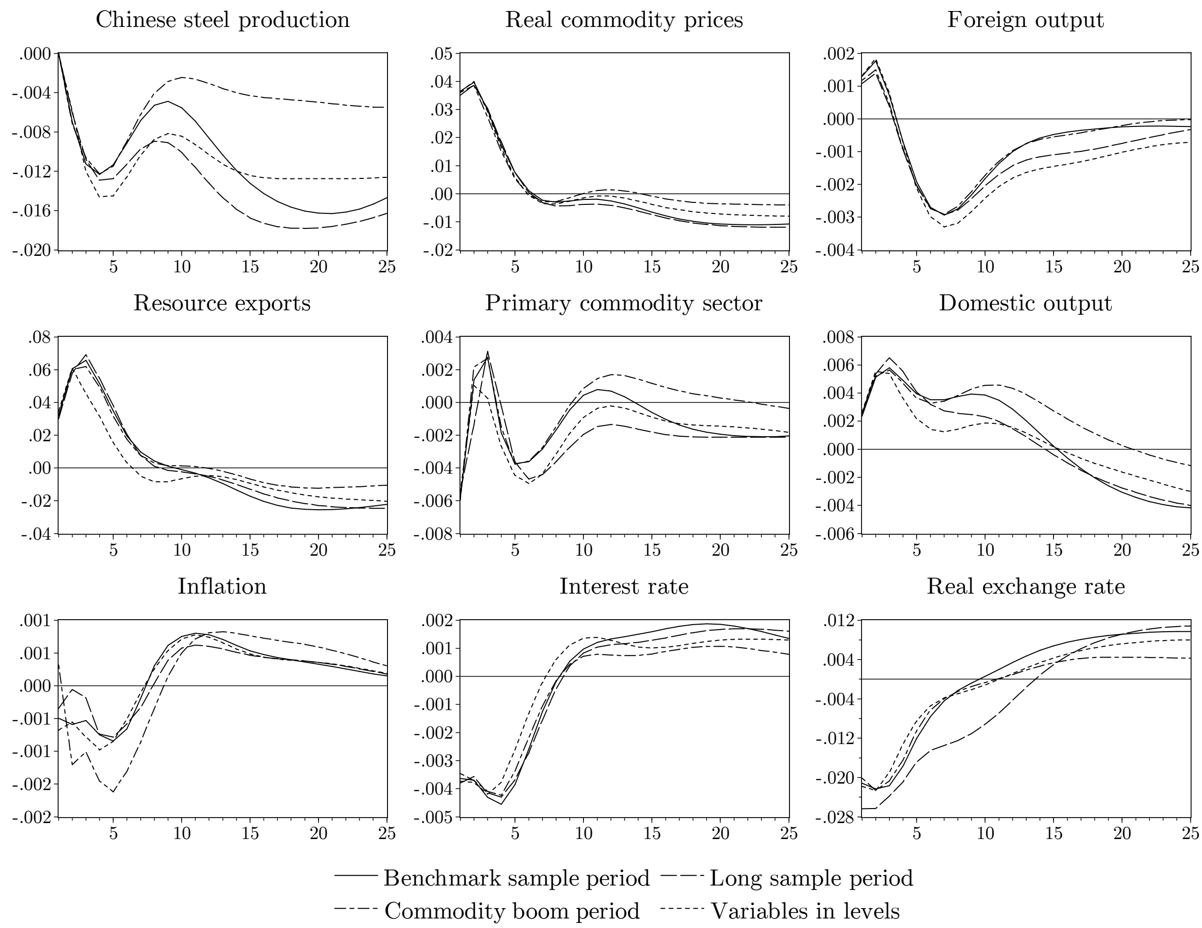

Figure 18 – Robustness of impulse response functions to shocks to real commodity prices for models with alternative sample period definitions and variables in levels.

Brazil. Dungey et al. (2017), which is an extension of Dungey, Fry-McKibbin e Linehan (2014), find reduced evidence of decreased domestic production associated with commodity price shocks (or less evidence of Dutch disease symptoms) for Australia over the longer sample period. The authors argue that despite the longevity of the shock, the Australian economy responded to the commodity boom as though it was temporary rather than permanent. Specifically, commodity prices return to their initial level much faster than in the model with the sample ending in 2012Q1 in response to both Chinese resource demand shocks and commodity price shocks.

To verify the post-boom effects in the benchmark model for Brazil, the model is re-estimated by inserting a dummy variable into all equations of the VAR from 2012Q2 to 2017Q1. Figures 17 to 19 show the impulse response functions taking into account the specification with the dummy variable (the commodity boom period), while the fourth row in column one of Table 19 presents the variance decomposition. Figure 17 shows that in response to a shock to Chinese steel production, commodity prices return to their initial level faster in the benchmark model than in the model where the commodity prices boom

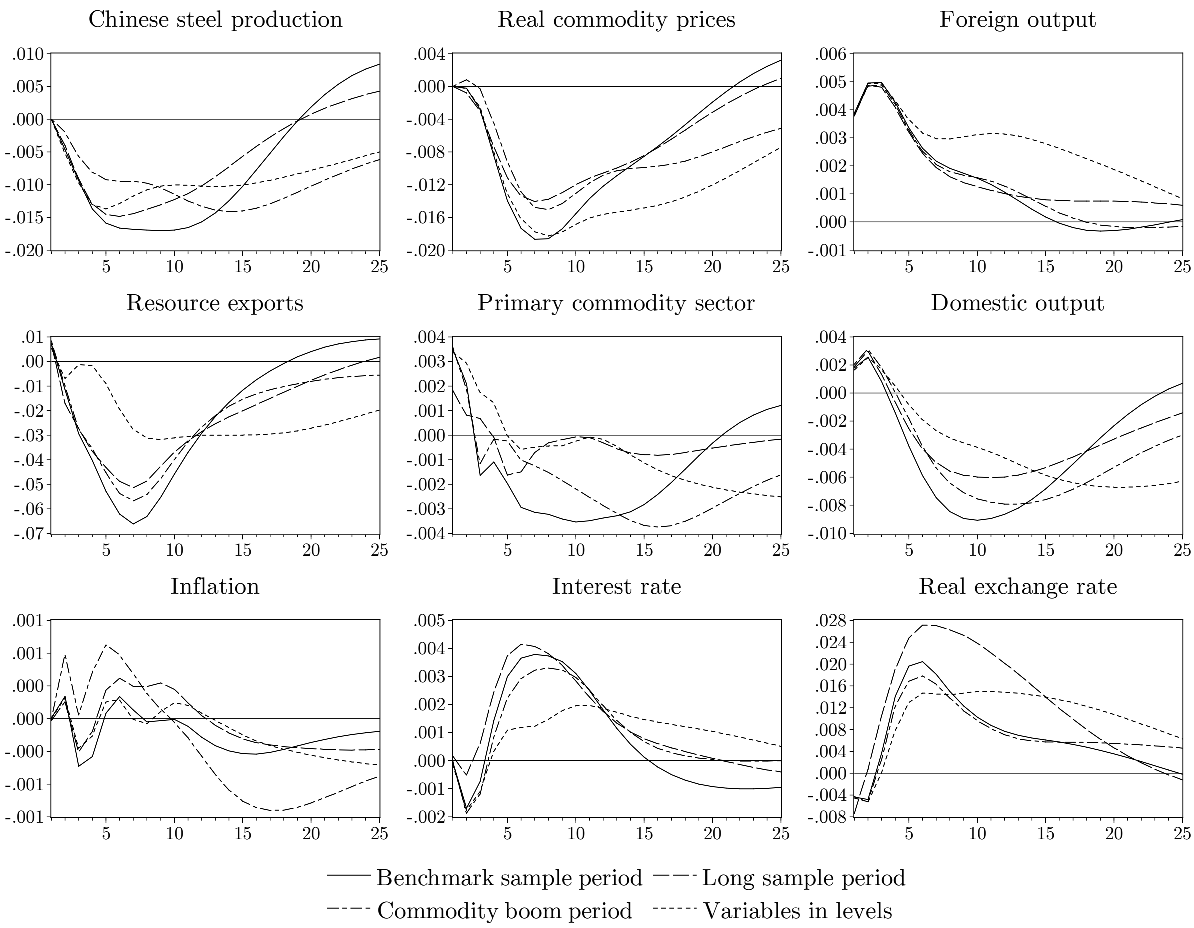

Figure 19 – Robustness of impulse response functions to shocks to foreign output for models with alternative sample period definitions and variables in levels.

period is contained. However, the differential effects are much smaller than that shown for the Australian economy by Dungey et al. (2017).

3.5.5 Detrending

Figures 17 to 19 also present the results of the model's robustness to the detrending of the data. The impulse response functions for the variables in log levels form and the last panel of the variance decomposition where the data is not detrended shows that the model is remarkably resilient to the treatment of the trends in the data.

3.5.6 Additional robustness tests

A range of additional robustness checks were undertaken but did not substantially affect the results. These results are not reported but are available on request including: (*i*) allowing external variables to affect the interest rate contemporaneously in line with Uribe e Yue (2006); (*ii*) removing the primary commodity sector from the domestic output variable; and (*iii*) replacing the domestic sector variables with the series measured in U.S. dollars instead of in local currency terms.

3.6 Conclusion

Unprecedented demand for commodity resources coinciding with the industrialization and urbanization of China may have significant consequences for those with large commodity resources. The effects of global swings in the commodity sector are relevant for emerging markets that have historically been highly vulnerable to the sector. This essay sheds light on the effects of external shocks on EMEs with a case study of Brazil. The demand of China for Brazilian commodity exports of iron ore, soybeans and oil dwarfs the demand of any other country. We carefully identify shocks to Chinese resource demand, general world commodity prices and world output, and our findings support the idea that external forces are substantial sources of aggregate fluctuations in EMEs, with the prominent source being Chinese resource demand. Shocks to the prices of the commodities that Brazil exports also have a non-trivial role in the aggregate fluctuations in EMEs, even with orthogonality between commodity prices and resource demand. More specifically, a shock to Chinese resource demand triggers expansionary effects on domestic output, even when we abstract from the sectors directly linked to resource demand such as real resource exports and the primary *non-traded* commodity sector in Brazil. Commodity price shocks prove less favorable than the price swings driven by resource demand shocks in terms of persistence.

The results of a battery of robustness checks indicate that over the longer term horizon of 24 quarters, the contribution of Chinese resource demand shocks to Brazilian output ranges from 18.17 to 43.89 percent compared to the benchmark model of 34.94 percent. The contribution of the commodity price shocks to output ranges from 1.56 to 9.56 percent compared to the benchmark model of 9.29 percent, while the contribution of foreign output shocks to output in Brazil ranges from 10.88 to 42.34 percent compared to the benchmark of 25.60 percent.

A salient mechanism of adjustment in Brazil is the movement of the interest rate in the opposite direction to both resource demand and commodity prices, amplifying the real effects of the commodity sector boom. The interest rate response to similar shocks in developed economies tends to be opposite that of EMEs, as in emerging countries, the interest rate is influenced by international investors assigning favorable movements in country risk as the commodity sector booms, hence reducing the applicable interest rate, whereas in developed countries interest rates tend to rise as the monetary authority seeks to dampen the inflationary effect of a commodity boom (DUNGEY; FRY-MCKIBBIN; LINEHAN, 2014; DUNGEY et al., 2017).

Although a few questions have been answered in this essay, it worth considering other issues in future researches. We consider Brazil as a representative case for commodity-exporting emerging market economies since Brazil is the largest trade partner of China among the resource-rich emerging economies. A valuable extension would be better understanding the effects of China's resource demand on different groups of countries sorting them by commodity type, such as agricultural and mining goods. The motivation is the reorientation of the Chinese growth towards the domestic market, which can induce fewer imports by mining goods, representing more risk for countries focused on the exports of these goods.

4 Concluding remarks

The essays presented in this thesis have investigated important issues involving global commodity markets and their influence on the Brazilian economy. The essays look at the influence of the commodity markets on the domestic economy in attempting to a deeper understanding of the mechanisms behinds of these effects. They aim to contribute to appropriated macroeconomic management.

Several papers in the Brazilian literature focus on the influence of commodity prices on the real exchange rate, especially about the effects on the domestic economy of the overvaluation of the real exchange rate due to increase in the commodity prices during the last commodity price boom. This issue is important because the real exchange rate is a prominent transmission channel of external shocks to domestic variables. In this context, the first essay brings up a discussion about the relationship between commodity prices and the Brazilian real exchange rate, paying attention to the non-linearity. Our key results show that the real exchange rate response to real commodity price shocks depends on the trade openness and country risk situation. Thus, the relationship between commodity prices and the Brazilian real exchange rate should be reformulated to consider trade openness and the country risk situation. The findings of this essay provide important insights for the appropriated design of foreign exchange policy in Brazil.

China is the major player in the global commodity market due to its huge demand for commodities. The second essay explores the effects of Chinese resource demand on commodity-exporting emerging market economies, using Brazil as a representative case. Our findings point out that (*i*) China's resource demand explains 35% of the variance in Brazilian output, (*ii*) shocks to China's resource demand are more important than shocks to global commodity prices or shocks global demand, and (*iii*) interest rate amplifies the real effects of the commodity sector boom. In this essay, we expand the literature on spillover effects of Chinese activity on commodity-exporting emerging market economies and neatly disentangles demand and supply shocks. Moreover, we explore the interaction of interest rates and commodity prices in these economies. These results add to the concerns about the impact of slower growth in China for the Brazilian economy and other resource-rich economies.

Despite a few questions have been answered in this thesis, it worth considering other questions in future researches. Regarding the first essay, the short-run relationship between commodity prices and the Brazilian real exchange rate depend on the commodity group. The real exchange rate is more sensitive, in the short-run, to real commodity prices taking account oil prices. A valuable extension would be better to explore the short-run relationship between energy prices and the Brazilian real exchange rate since the oil exports are a large share of Brazilian exports. In turn, the second essay we regard Brazil as a representative case for commodity-exporting emerging market economies. A valuable extension would be better understanding the effects of China's resource demand on different groups of countries sorting them by type of commodity, as such agricultural exporters and energy exporters.

These two essays are an effort to answer a few questions on commodity markets and macroeconomic variables. Obviously, there are still a huge number of open questions to explore. Hopefully, the results presented in this thesis represents a positive impact on scientific knowledge on the subject.

Bibliography

AIZENMAN, J.; BINICI, M. Exchange market pressure in oecd and emerging economies: Domestic vs. external factors and capital flows in the old and new normal. *Journal of International Money and Finance*, Elsevier, v. 66, p. 65–87, 2016.

AIZENMAN, J.; EDWARDS, S.; RIERA-CRICHTON, D. Adjustment patterns to commodity terms of trade shocks: the role of exchange rate and international reserves policies. *Journal of International Money and Finance*, Elsevier, v. 31, n. 8, p. 1990–2016, 2012.

AKYÜZ, Y. Capital flows to developing countries in a historical perspective: will the current boom end with a bust? *Research Paper 37*, South Centre, Ginebra, 2011.

AMISANO, G.; GIANNINI, C. From var models to structural var models. In: *Topics in Structural VAR Econometrics*. Berlin: Springer, 1997. p. 1–28.

AROURI, M. E. H.; NGUYEN, D. K. Oil prices, stock markets and portfolio investment: Evidence from sector analysis in europe over the last decade. *Energy Policy*, Elsevier, v. 38, n. 8, p. 4528–4539, 2010.

ASLAM, A. et al. Trading on their terms? commodity exporters in the aftermath of the commodity boom. *IMF Working Paper 16/27*, International Monetary Fund, Research Department, 2016.

BACEN. Influência dos preços de commodities sobre o repasse cambial. In: *Relatório de Inflação, março de 2015*. Brasília: BACEN, 2015. p. 30–32.

BACEN. *Sistema Gerenciador de Séries Temporais do Banco Central do Brasil*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <https://www3.bcb.gov.br/sgspub/localizarseries/localizarSeries.do?method=prepararTelaLocalizarSeries>.

BARONE, S.; DESCALZI, R. Endogenous risk premium and terms of trade shocks: evidence for developing countries. *Revista de economía*, Banco Central del Uruguay, v. 19, n. 2, p. 7, 2012.

BASTOURRE, D. et al. Common drivers in emerging market spreads and commodity prices. *Working Paper 12/57*, Central Bank of Argentina, Economic Research Department, p. 41, 2012.

BELLAS, D.; PAPAIOANNOU, M. G.; PETROVA, I. Determinants of emerging market sovereign bond spreads. *IMF Working Paper 10/281*, International Monetary Fund, Research Department, p. 22, 2010.

BENIGNO, G.; CONVERSE, N.; FORNARO, L. Large capital inflows, sectoral allocation, and economic performance. *Journal of International Money and Finance*, Elsevier, v. 55, p. 60–87, 2015.

BERKELMANS, L. Credit and monetary policy: An australian svar. *Research Discussion Paper 05/06*, Reserve Bank of Australia, Economic Research Department, p. 32, 2005.

BODART, V.; CANDELON, B.; CARPANTIER, J.-F. Real exchanges rates in commodity producing countries: A reappraisal. *Journal of International Money and Finance*, Elsevier, v. 31, n. 6, p. 1482–1502, 2012.

BODART, V.; CANDELON, B.; CARPANTIER, J.-F. Real exchanges rates, commodity prices and structural factors in developing countries. *Journal of International Money and Finance*, Elsevier, v. 51, p. 264–284, 2015.

BOURI, E.; BOYRIE, M. E.; PAVLOVA, I. Volatility transmission from commodity markets to sovereign cds spreads in emerging and frontier countries. *International Review of Financial Analysis*, Elsevier, v. 49, p. 155–165, 2016.

BRANCO, R. Commodity currencies: a real phenomenon in brazil? *Revista de Economia Contemporânea*, SciELO Brasil, v. 20, n. 1, p. 92–112, 2016.

BREDOW, S. M. S.; LéLIS, M. T. C.; CUNHA, A. M. Super cycle of commodity prices and the brazilian economy: an analysis of the external transmission mechanisms between 2002 and 2014. *Economia e Sociedade*, v. 25, n. 3, p. 695–731, 2016.

BRESSER-PEREIRA, L. C. The dutch disease and its neutralization: a ricardian approach. *Revista de economia política*, SciELO Brasil, v. 28, n. 1, p. 47–71, 2008.

BRESSER-PEREIRA, L. C. The value of the exchange rate and the dutch disease. *Brazilian Journal of Political Economy*, SciELO Brasil, v. 33, n. 3, p. 371–387, 2013.

CARDOSO, D. China-brazil: a strategic partnership in an evolving world order. *East Asia*, Springer, v. 30, n. 1, p. 35–51, 2013.

CARNEIRO, R. d. M. Commodities, choques externos e crescimento: reflexões sobre a américa latina. *Serie macroeconomía del desarrollo 117*, CEPAL, Santiago, 2012.

CASHIN, P.; CéSPEDES, L. F.; SAHAY, R. Commodity currencies and the real exchange rate. *Journal of Development Economics*, Elsevier, v. 75, n. 1, p. 239–268, 2004.

CASHIN, P.; MOHADDES, K.; RAISSI, M. China's slowdown and global financial market volatility: Is world growth losing out? *Emerging Markets Review*, Elsevier, v. 31, p. 164–175, 2017.

CASHIN, P. et al. The differential effects of oil demand and supply shocks on the global economy. *Energy Economics*, Elsevier, v. 44, p. 113–134, 2014.

CBOE. *Chicago Board Options Exchange, VIX*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <https://www.cboe.com/vix/>.

CESA-BIANCHI, A. et al. China's emergence in the world economy and business cycles in latin america. *Economía*, JSTOR, v. 12, n. 2, p. 1–75, 2012.

CHEN, Y.; ROGOFF, K. Commodity currencies. *Journal of international Economics*, Elsevier, v. 60, n. 1, p. 133–160, 2003.

CHEN, Y.-c.; LEE, D. What makes a commodity currency? *Working Paper 20*, University of California, Department of Economics, 2014.

CHOI, W. G.; OH, S. A money demand function with output uncertainty, monetary uncertainty, and financial innovations. *Journal of Money, Credit and Banking*, JSTOR, p. 685–709, 2003.

CLARIDA, R.; DAVIS, J.; PEDERSEN, N. Currency carry trade regimes: Beyond the fama regression. *Journal of International Money and Finance*, Elsevier, v. 28, n. 8, p. 1375–1389, 2009.

CLEMENTS, K. W.; FRY, R. Commodity currencies and currency commodities. *Resources Policy*, Elsevier, v. 33, n. 2, p. 55–73, 2008.

COATES, B.; LUU, N. China's emergence in global commodity markets. *Economic Round-up*, Commonwealth of Australia. Department of the Treasury, n. 1, p. 1, 2012.

CODACE. *Comitê de Datação de Ciclos Econômicos (CODACE) da Fundação Getulio Vargas*. 2018. Acessado em 22 de dezembro, 2018. Disponível em: <https://portalibre.fgv.br/main.jsp?lumChannelId=4028808126B9BC4C0126BEA1755C6C93>.

COMEXSTAT. *Base de datos*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <http://comexstat.mdic.gov.br>.

CORDEN, W. Booming sector and dutch disease economics: Survey and consolidation. *Oxford Economic Papers, New Series*, v. 36, n. 3, p. 359–380, 1984.

CORDEN, W. M.; NEARY, J. P. Booming sector and de-industrialisation in a small open economy. *The Economic Journal*, Oxford University Press Oxford, UK, v. 92, n. 368, p. 825–848, 1982.

COUDERT, V.; COUHARDE, C.; MIGNON, V. Exchange rate volatility across financial crises. *Journal of Banking & Finance*, Elsevier, v. 35, n. 11, p. 3010–3018, 2011.

COUDERT, V.; COUHARDE, C.; MIGNON, V. On the impact of volatility on the real exchange rate–terms of trade nexus: Revisiting commodity currencies. *Journal of International Money and Finance*, Elsevier, v. 58, p. 110–127, 2015.

COUDERT, V.; MIGNON, V. Reassessing the empirical relationship between the oil price and the dollar. *Energy Policy*, Elsevier, v. 95, p. 147–157, 2016.

CRETI, A.; JOËTS, M.; MIGNON, V. On the links between stock and commodity markets' volatility. *Energy Economics*, Elsevier, v. 37, p. 16–28, 2013.

DAUVIN, M. Energy prices and the real exchange rate of commodity-exporting countries. *International Economics*, Elsevier, v. 137, p. 52–72, 2014.

DEATON, A.; MILLER, R. International commodity prices, macroeconomic performance, and policies in sub-saharan africa. *Journal of African Economies*, v. 5, n. 3, p. 99–1991, 1996.

DRECHSEL, T.; TENREYRO, S. Commodity booms and busts in emerging economies. *Journal of International Economics*, Elsevier, v. 112, p. 200–218, 2018.

DUNGEY, M.; FRY-MCKIBBIN, R.; LINEHAN, V. Chinese resource demand and the natural resource supplier. *Applied Economics*, Taylor & Francis, v. 46, n. 2, p. 167–178, 2014.

DUNGEY, M. et al. Recovery from dutch disease. *CAMA Working Paper 69/2017*, The Australian National University, Centre for Applied Macroeconomic Analysis, 2017.

ENDERS, W. *Applied econometric time series*. Fourth edition. United States of America: John Wiley & Sons, 2015.

ENGLE, R. F.; GRANGER, C. W. Co-integration and error correction: representation, estimation, and testing. *Econometrica: journal of the Econometric Society*, JSTOR, p. 251–276, 1987.

FARHI, M. O impacto dos ciclos de liquidez no brasil: mercados financeiros, taxa de câmbio, preços e política monetária. *Politica Economica em Foco*, n. 7, p. 152–183, 2006.

FED. *Federal Reserve Bank of St. Louis, Economic Data*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <https://fred.stlouisfed.org/>.

FERNANDEZ, A.; SCHMITT-GROHE, S.; URIBE, M. World shocks, world prices, and business cycles: An empirical investigation. *Journal of International Economics*, Elsevier, 2017.

FERNáNDEZ, A.; GONZáLEZ, A.; RODRIGUEZ, D. Sharing a ride on the commodities roller coaster: common factors in business cycles of emerging economies. *Journal of International Economics*, Elsevier, 2018.

FERNáNDEZ, A.; GULAN, A. Interest rates, leverage, and business cycles in emerging economies: The role of financial frictions. *American Economic Journal: Macroeconomics*, American Economic Association, v. 7, n. 3, p. 153–188, 2015.

FILHO, F. H. B. A crise econômica de 2014/2017. *Estudos Avançados*, SciELO Brasil, v. 31, n. 89, p. 51–60, 2017.

FILIS, G.; DEGIANNAKIS, S.; FLOROS, C. Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries. *International Review of Financial Analysis*, Elsevier, v. 20, n. 3, p. 152–164, 2011.

FORBES, K. et al. Bubble thy neighbour: portfolio effects and externalities from capital controls. *Journal of International Economics*, Elsevier, v. 99, p. 85–104, 2016.

FRANKEL, J. The natural resource curse: A survey of diagnoses and some prescriptions. *Working Paper Series RWP 12-014*, Harvard Kennedy School Research, 2012.

FRIZOA, P.; LIMA, R. A. S. Efeitos da flutuação dos preços das commodities no fluxo de investimento estrangeiro direto no brasil. *Revista de Economia Contemporânea*, v. 18, n. 3, p. 393–408, 2014.

GREGORIO, J. D.; WOLF, H. C. Terms of trade, productivity, and the real exchange rate. *NBER Working Paper 4807*, The National Bureau of Economic Research, 1994.

GRUSS, B. After the boom–commodity prices and economic growth in latin america and the caribbean. *IMF Working Paper 14/154*, Internationial Monetary Fund, Western Hemisphere Department, 2014.

HANSEN, B. E. Tests for parameter instability in regressions with i (1) processes. *Journal of Business & Economic Statistics*, American Statistical Association, v. 10, n. 3, p. 321–335, 1992.

HILSCHER, J.; NOSBUSCH, Y. Determinants of sovereign risk: Macroeconomic fundamentals and the pricing of sovereign debt. *Review of Finance*, Oxford University Press, v. 14, n. 2, p. 235–262, 2010.

HIRATUKA, C.; SARTI, F. Transformações na estrutura produtiva global, desindustrialização e desenvolvimento industrial no brasil. *Brazilian Journal of Political Economy*, v. 37, n. 1, 2017.

IBGE. *Instituto Brasileiro de Geografia e Estatística, Sistema IBGE de Recuperação Automática*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <https://sidra.ibge.gov.br/home/pimpfbr/brasil>.

IMF. *International Monetary Fund, International Financial Statistics (IFS)*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <https://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9-52B0C1A0179B>.

IMF. *International Monetary Fund. Methodology*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <http://datahelp.imf.org/knowledgebase/articles/537472-what-is-real-effective-exchange-rate-reer>.

IPEA. *Instituto de Pesquisa Econômica Aplicada, Base de Dados (IPEADATA)*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <http://www.ipeadata.gov.br/>.

JÄÄSKELÄ, J. P.; SMITH, P. Terms of trade shocks: What are they and what do they do? *Economic Record*, Wiley Online Library, v. 89, n. 285, p. 145–159, 2013.

JENKINS, R. Chinese competition and brazilian exports of manufactures. *Oxford Development Studies*, Taylor & Francis, v. 42, n. 3, p. 395–418, 2014.

JENKINS, R. Is chinese competition causing deindustrialization in brazil? *Latin American Perspectives*, SAGE Publications Sage CA: Los Angeles, CA, v. 42, n. 6, p. 42–63, 2015.

JENKINS, R.; BARBOSA, A. F. Fear for manufacturing? china and the future of industry in brazil and latin america. *The China Quarterly*, Cambridge University Press, v. 209, p. 59–81, 2012.

JOHANSEN, S. Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. *Econometrica: Journal of the Econometric Society*, JSTOR, p. 1551–1580, 1991.

JOHANSEN, S. Likelihood-based inference in cointegrated vector autoregressive models. *Econometric Theory*, Cambridge University Press, v. 14, n. 4, p. 517–524, 1998.

KALTENBRUNNER, A. *Currency internationalisation and exchange rate dynamics in emerging markets: a post Keynesian analysis of Brazil*. Tese (Doutorado) — Department of Economics, School of Oriental and African Studies (SOAS), University of London, 2011.

KALTENBRUNNER, A.; PAINCEIRA, J. P. Developing countries' changing nature of financial integration and new forms of external vulnerability: the brazilian experience. *Cambridge Journal of Economics*, Oxford University Press UK, v. 39, n. 5, p. 1281–1306, 2014.

KAMINSKY, G.; REINHART, C.; VéGH, C. A. When it rains, it pours: procyclical capital flows and macroeconomic policies. *NBER Working Paper 10780*, The National Bureau of Economic Research, 2004.

KOHLSCHEEN, E. Long-run determinants of the brazilian real: A closer look at commodities. *International Journal of Finance & Economics*, Wiley Online Library, v. 19, n. 4, p. 239–250, 2014.

KOHLSCHEEN, E.; AVALOS, F.; SCHRIMPF, A. When the walk is not random: Commodity prices and exchange rates. *International Journal of Central Banking*, v. 13, n. 2, 2017.

KULISH, M.; REES, D. M. Unprecedented changes in the terms of trade. *Journal of International Economics*, Elsevier, v. 108, p. 351–367, 2017.

MACDONALD, R. What determines real exchange rates? the long and the short of it. *IMF Working Paper 97/21*, International Monetary Fund, Research Department, p. 53, 1997.

MACKINNON, J. G. Numerical distribution functions for unit root and cointegration tests. *Journal of applied econometrics*, Wiley Online Library, v. 11, n. 6, p. 601–618, 1996.

MACKINNON, J. G.; HAUG, A. A.; MICHELIS, L. Numerical distribution functions of likelihood ratio tests for cointegration. *Journal of applied Econometrics*, Wiley Online Library, v. 14, n. 5, p. 563–577, 1999.

MAGALHãES, A. S.; DOMINGUES, E. P. Blessing or curse: Impacts of the brazilian pre-salt oil exploration. *Economia*, Elsevier, v. 15, n. 3, p. 343–362, 2014.

MAPA. *Ministério da Agricultura, Pecuária e Abastecimento. Projeções do agronegócio 2017/2018 a 2027/2028*. 2018. Acessado em 15 de novembro, 2018. Disponível em: <http://www.agricultura.gov.br/assuntos/politica-agricola/todas-publicacoes-de-politica-agricola/projecoes-do-agronegocio/banner_site-03-03-1.png/view>.

MATTEI, L. A taxa de câmbio como instrumento do desenvolvimento econômico. *Revista de Economia Política*, v. 36, n. 4, p. 726–747, 2016.

MDIC. *Ministério da Indústria, Comércio Exterior e Serviços. Base de dados do comércio exterior brasileiro*. 2016. Acessado em 12 de abril, 2016. Disponível em: <http://www.mdic.gov.br/comercio-exterior/estatisticas-de-comercio-exterior/base-de-dados-do-comercio-exterior-brasileiro-arquivos-para-download>.

MOHADDES, K.; PESARAN, M. H. Country-specific oil supply shocks and the global economy: A counterfactual analysis. *Energy Economics*, Elsevier, v. 59, p. 382–399, 2016.

MOREIRA, A.; ROCHA, K.; SILVEIRA, M. O fortalecimento do sistema financeiro doméstico e o fluxo de capital para economias emergentes. *Texto para Discussão 2071*, Instituto de Pesquisa Econômica Aplicada, 2015.

NASSIF, A.; FEIJó, C.; ARAúJO, E. Structural change and economic development: is brazil catching up or falling behind? *Cambridge Journal of Economics*, Oxford University Press UK, v. 39, n. 5, p. 1307–1332, 2014.

NEARY, P. Determinants of the equilibrium real exchange rate. *The American Economic Review*, JSTOR, v. 78, n. 1, p. 210–215, 1988.

NEGRI, F. D.; ALVARENGA, G. V. A primarização da pauta de exportações no brasil: ainda um dilema. *Radar - Tecnologia, Produção e Comércio Exterior*, Instituto de Pesquisa Econômica Aplicada, n. 13, p. 7–14, 2011.

NEUMEYER, P. A.; PERRI, F. Business cycles in emerging economies: the role of interest rates. *Journal of Monetary Economics*, Elsevier, v. 52, n. 2, p. 345–380, 2005.

NEWEY, W. K.; WEST, K. D. A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica: Journal of the Econometric Society*, JSTOR, p. 703–708, 1987.

NOIJE, P. V.; CONTI, B. M. de. A vulnerabilidade externa decorrente da posição internacional de investimentos e do fluxo de rendas da economia brasileira no período 2001-2010. *Nova Economia*, v. 26, n. 1, 2016.

OREIRO, J. L.; BASILIO, F. A. C.; SOUZA, G. J. G. Effects of overvaluation and exchange rate volatility over industrial investment: empirical evidence and economic policy proposals for brazil. *Revista de Economia Política*, SciELO Brasil, v. 34, n. 3, p. 347–369, 2014.

ORNELAS, J. Risco, dívida e alavancagem soberana. *Trabalhos para discussão 457*, Central Bank of Brazil, Research Department, p. 37, 2017.

OUYANG, A. Y.; RAJAN, R. S. Real exchange rate fluctuations and the relative importance of nontradables. *Journal of International Money and Finance*, Elsevier, v. 32, p. 844–855, 2013.

PHILLIPS, P. C.; OULIARIS, S. Asymptotic properties of residual based tests for cointegration. *Econometrica: Journal of the Econometric Society*, JSTOR, v. 58, n. 1, p. 165–193, 1990.

PRATES, D. M. Os determinantes das taxas de câmbio nominal e real no Brasil no período 2003-2007. In: *Ensaios sobre Economia Financeira*. Rio de Janeiro: BNDES, 2009. p. 225–286.

PRATES, D. M. A vulnerabilidade externa em tempos de instabilidade: avaliando a liquidez e a solvência da economia brasileira entre 2007 e 2013. *Revista Economia & Tecnologia*, v. 10, n. 3, 2014.

PRATES, D. M.; CUNHA, A. M. A dinâmica dos fluxos de capitais em tempos de instabilidade: o desempenho do brasil no primeiro semestre de 2013. *Indicadores Econômicos FEE*, v. 41, n. 3, 2014.

REINHART, C.; REINHART, V.; TREBESCH, C. Global cycles: Capital flows, commodities, and sovereign defaults, 1815-2015. *American Economic Review*, v. 106, n. 5, p. 574–80, 2016.

RICCI, L. A.; MILESI-FERRETTI, G.; LEE, J. Real exchange rates and fundamentals: A cross-country perspective. *Journal of Money, Credit and Banking*, Wiley Online Library, v. 45, n. 5, p. 845–865, 2013.

ROBERTS, I.; RUSH, A. Sources of chinese demand for resource commodities. *Research Discussion Paper 2010-08*, Reserve Bank of Australia, Economic Group, 2010.

ROSSI, P. O mercado internacional de moedas, o carry trade e as taxas de câmbio. *Observatório da Economia Global*, n. 5, 2010.

ROSSI, P. Institucionalidade do mercado de câmbio e a política cambial no brasil. *Economia e Sociedade*, v. 23, n. 3, p. 645–667, 2014.

ROSSI, P.; MELLO, G. Componentes macroeconômicos e estruturais da crise brasileira: o subdesenvolvimento revisitado. *Brazilian Keynesian Review*, v. 2, n. 2, p. 252–263, 2016.

SHOUSHA, S. Macroeconomic effects of commodity booms and busts: The role of financial frictions. *Unpublished Manuscript*, 2016.

SILVENNOINEN, A.; THORP, S. Financialization, crisis and commodity correlation dynamics. *Journal of International Financial Markets, Institutions and Money*, Elsevier, v. 24, p. 42–65, 2013.

SONAGLIO, C. M.; CAMPOS, A. C.; BRAGA, M. J. Effects of interest and exchange rate policies on brazilian exports. *EconomiA*, Elsevier, v. 17, n. 1, p. 77–95, 2016.

SOUZA, F.; HOFF, C. O regime cambial brasileiro: sete anos de flutuação. *15 anos de Mercosur*, 2006.

STOCK, J. H.; WATSON, M. W. A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica: Journal of the Econometric Society*, JSTOR, p. 783–820, 1993.

TERÄSVIRTA, T. Specification, estimation, and evaluation of smooth transition autoregressive models. *Journal of the american Statistical association*, Taylor & Francis Group, v. 89, n. 425, p. 208–218, 1994.

TERÄSVIRTA, T. Modelling economic relationships with smooth transition regressions. In: *Handbook of Applied Economic Statistics*. New York: Marcel Dekker, 1996.

TOKARICK, S. Commodity currencies and the real exchange rate. *Economics Letters*, Elsevier, v. 101, n. 1, p. 60–62, 2008.

UNCTAD. *State of commodity dependence 2014*. New York and Geneva, 2015. 202 p.

UNCTAD. *State of commodity dependence 2016*. New York and Geneva, 2017. 202 p.

URIBE, M.; YUE, V. Z. Country spreads and emerging countries: Who drives whom? *Journal of international Economics*, Elsevier, v. 69, n. 1, p. 6–36, 2006.

VASCONCELOS, C. R. F. O efeito balassa-samuelson e a paridade do poder de compra na economia brasileira. *Análise Econômica*, v. 22, n. 41, 2004.

VERÍSSIMO, M. P.; XAVIER, C. L.; VIEIRA, F. V. Taxa de câmbio e preços de commodities: uma investigação sobre a hipótese da doença holandesa no brasil. *Revista Economia*, v. 13, n. 1, p. 93–130, 2012.

VERíSSIMO, M. P.; XAVIER, C. L. Taxa de câmbio, exportações e crescimento: uma investigação sobre a hipótese de doença holandesa no brasil. *Brazilian Journal of Political Economy*, v. 33, n. 1, p. 82, 2013.

WB. *World Bank, Global Economic Monitor*. 2018. Acessado em 20 de dezembro, 2018. Disponível em: <https://data.world/worldbank/global-economic-monitor>.

WIJNBERGEN, S. van. The dutch disease: A disease after all? *The Economic Journal*, v. 94, p. 41–55, 1984.

ZEEV, N. B.; PAPPA, E.; VICONDOA, A. Emerging economies business cycles: The role of commodity terms of trade news. *Journal of International Economics*, Elsevier, v. 108, p. 368–376, 2017.

ZHANG, Y.; ZHENG, C. The implications of china's rapid growth on demand for energy and mining products imported from australia. *Economic Papers*, Wiley Online Library, v. 27, n. 1, p. 95–106, 2008.

.1 Data appendix

The following describes the dataset used in this article. Items *(i)* to *(vii)* contain the data used in the benchmark model. Items *(viii)* to *(xii)* contain the data used in the robustness exercises in Section 3.5:

***(i)* Chinese steel production** (csp_t): In thousand tonnes, monthly. The monthly data are converted to quarterly data by summing the values of the quarter; these data are seasonally adjusted using ARIMA X13. The data source is Datastream (code CHVALSTLH). Missing data for 2014M1, 2014M2, 2016M1 and 2016M2 are replaced with estimates from the World Steel Association.

***(ii)* Real commodity prices** (pc_t) **and resource exports** ($resx_t$): Nominal commodity prices in U.S. dollars, monthly. The data are deflated by the U.S. CPI for All Urban Consumers. The sources are The World Bank - Global Economic Monitor Commodities and the Bureau of Labor statistics.

Brazilian exports in U.S. dollars are used to derive the weights to construct the real commodity price index and to calculate the value of Brazilian resource exports. The export data come from the System of Analysis of Foreign Trade Information (AliceWeb). We follow the definitions of commodities proposed by MDIC (2016). Specifically, we use the data since 1997 of the products related to the following NCM (Common Nomenclature of MERCOSUL - South American trade bloc) codes: soybeans (12010010, 12010090, 12011000, 12019000, 15071000, 23040010, and 23040090), iron ore (26011100, 26011200, 26012000, 26011210, and 260112900), crude oil (27090010), beef (2011000, 02012010, 02012020, 02012090, 02013000, 02021000, 02022010, 02022020, 02022090, and 02023000), chicken meat (02071100, 02071200, 02071300, and 02071400), sugar (17011100, 17011300, 17011400, and 17019900) and coffee (09011110). The codes for the data before 1997 are obtained through correlation table available in MDIC (2016). Soybeans encompass all the soybean complexes: soybeans, soybean oil and soybean meal. The export series is deflated by the U.S. CPI and seasonally adjusted using ARIMA X13.

***(iii)* Foreign output** (yw_t): Constant U.S. dollars and seasonally adjusted. The source is the World Bank - Global Economic Monitor.

***(iv)* Non-tradable primary commodity sector** ($comm_t$) **and the Brazilian GDP (domestic output)** (yd_t): The source is the Brazilian System of National Accounts of the Brazilian Institute of Geography and Statistics (IBGE). The data are chain-weighted in 1995 prices and seasonally adjusted.

***(v)* Inflation** (pd_t): The source is the Brazilian Institute of Geography and Statistics (IBGE) (code: 433).

***(vi)* Interest rate** (rd_t): The sum of JP Morgan's Emerging Markets Bond Index

(EMBI+ Brazil) and the U.S. real interest rate. The source of the JP Morgan EMBI+ is the Brazilian Institute of Applied Economic Research (IPEA). The source of data on the three-month U.S. Treasury bill and the measure of U.S. expected inflation is the Federal Reserve Bank of St. Louis.

(*vii*) Real exchange rate (q_t): The source is the Central Bank of Brazil (code 11752).

(*viii*) Chinese manufacturing exports (cme_t): In hundred million U.S. dollars, deflated by the U.S. CPI and seasonally adjusted using ARIMA X13. The source for the data on manufacturing exports is Datastream (code CHEXMANUA). The source for the U.S. CPI for All Urban Consumers: all items is the Bureau of Labor statistics.

(*ix*) Chinese industrial production (cip_t): Constant U.S. dollars and seasonally adjusted. The source is the World Bank - Global Economic Monitor (code: IPTOTSAKD).

(*x*) Chinese GDP $(cgdp_t)$: Constant U.S. dollars and seasonally adjusted. The source is the World Bank - Global Economic Monitor.

(*xi*) Commodity terms of trade $(ctot_t)$: U.S. import prices of manufactured goods from industrialized countries are used to calculate the commodity terms of trade. The source is the Federal Reserve Bank of St. Louis (code: INDUSMANU);

(*xii*) Domestic output denominated in U.S. dollars $(yd(\$)_t)$**:** Constant U.S. dollars and is seasonally adjusted. The source is the World Bank - Global Economic Monitor.

.2 Appendix of alternative model specifications

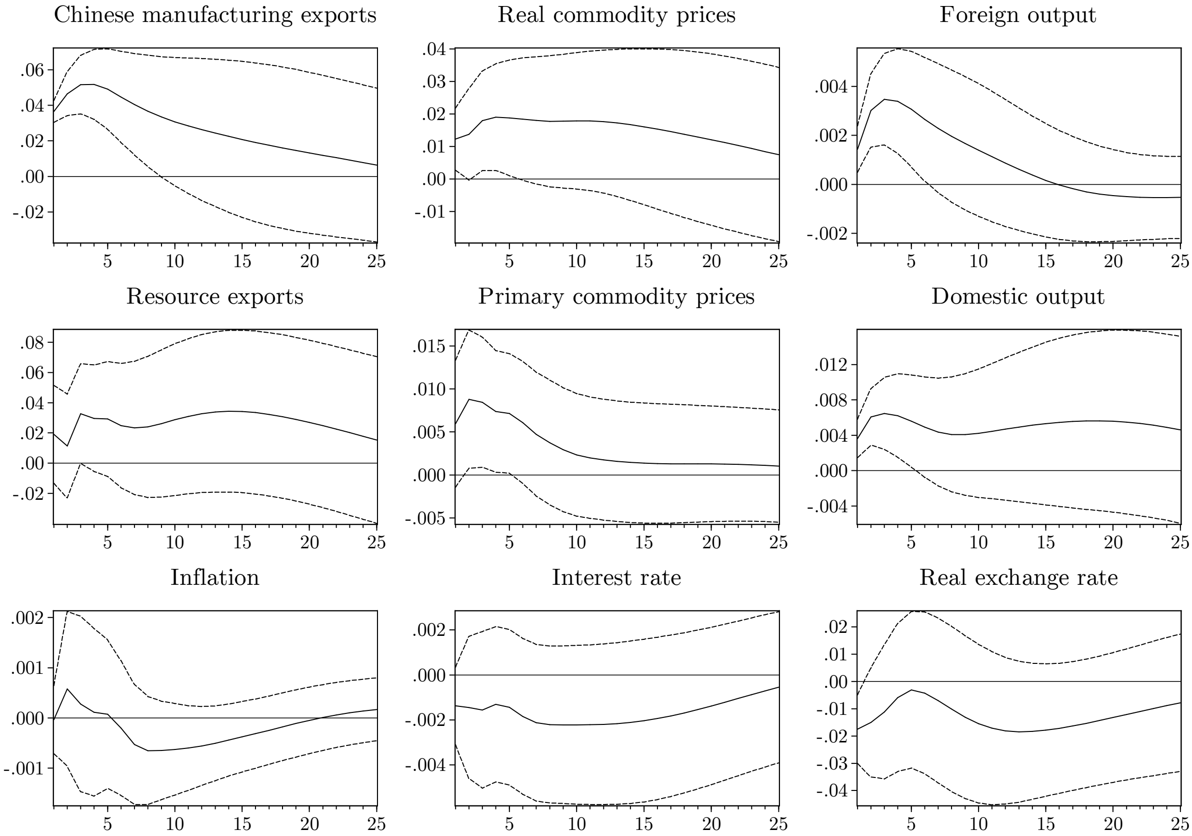

Figure 20 – Impulse response functions to a shock to Chinese manufacturing exports for the model with Chinese manufacturing exports, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

Table 20 – Forecast error variance decomposition for the model with Chinese manufacturing exports (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	cme_t	100.00	83.46	50.59	35.45		cme_t	3.60	12.19	14.44	13.37
	pc_t	0.00	11.37	3.70	4.20		pc_t	3.65	4.77	5.15	4.74
	yw_t	0.00	0.87	25.93	28.48		yw_t	0.02	2.20	13.41	17.55
	$resx_t$	0.00	0.16	0.15	0.42		$resx_t$	5.03	6.32	4.88	4.60
cme_t	$comm_t$	0.00	0.64	6.59	11.47	$comm_t$	$comm_t$	87.71	51.59	41.09	37.20
	yd_t	0.00	1.91	7.00	10.85		yd_t	0.00	6.33	6.03	7.92
	pd_t	0.00	1.03	0.68	0.69		pd_t	0.00	0.33	0.67	0.68
	rd_t	0.00	0.53	3.49	5.29		rd_t	0.00	4.20	3.91	4.41
	q_t	0.00	0.03	1.87	3.15		q_t	0.00	12.06	10.41	9.53
	cme_t	8.81	14.19	23.36	22.34		cme_t	14.65	23.70	17.35	18.17
	pc_t	91.19	68.83	32.79	20.66		pc_t	7.82	26.41	15.65	8.67
	yw_t	0.00	2.66	22.32	27.37		yw_t	0.58	1.94	39.23	42.34
	$resx_t$	0.00	2.64	2.48	1.92		$resx_t$	0.53	1.90	1.58	2.19
pc_t	$comm_t$	0.00	5.93	6.19	8.85	yd_t	$comm_t$	0.54	5.66	5.70	4.70
	yd_t	0.00	0.24	5.38	9.78		yd_t	75.87	36.70	17.01	17.91
	pd_t	0.00	2.89	1.53	1.08		pd_t	0.00	2.45	1.06	0.64
	rd_t	0.00	1.43	2.89	5.00		rd_t	0.00	0.61	1.04	4.44
	q_t	0.00	1.20	3.06	2.98		q_t	0.00	0.63	1.38	0.94
	cme_t	12.23	30.34	30.73	28.34		cme_t	0.00	0.40	2.20	2.74
	pc_t	8.49	4.17	12.20	12.54		pc_t	0.22	0.75	2.59	3.85
	yw_t	79.28	54.69	36.60	33.17		yw_t	0.00	1.67	1.57	1.59
	$resx_t$	0.00	0.22	1.78	1.88		$resx_t$	0.04	2.25	3.21	3.17
yw_t	$comm_t$	0.00	0.86	8.15	12.16	pd_t	$comm_t$	0.50	11.47	11.68	13.07
	yd_t	0.00	0.84	0.89	0.87		yd_t	0.10	6.50	7.88	7.52
	pd_t	0.00	1.78	1.28	1.23		pd_t	99.13	41.92	37.41	35.60
	rd_t	0.00	0.24	0.56	0.54		rd_t	0.00	28.38	27.51	26.26
	q_t	0.00	6.84	7.81	9.28		q_t	0.00	6.64	5.96	6.20
	cme_t	1.93	5.90	9.25	14.21		cme_t	1.12	2.12	6.80	9.46
	pc_t	4.19	28.95	15.68	12.41		pc_t	8.20	18.93	13.64	12.72
	yw_t	0.15	8.78	29.93	28.79		yw_t	0.01	1.36	17.82	18.13
	$resx_t$	93.72	44.67	22.22	16.15		$resx_t$	0.21	5.70	4.60	3.88
$resx_t$	$comm_t$	0.00	4.60	4.48	7.17	rd_t	$comm_t$	1.57	2.02	2.29	6.00
	yd_t	0.00	3.63	12.04	13.21		yd_t	2.48	4.05	11.01	11.87
	pd_t	0.00	0.52	0.35	0.34		pd_t	0.00	0.65	0.55	0.55
	rd_t	0.00	2.15	4.12	5.62		rd_t	86.40	64.59	42.60	36.03
	q_t	0.00	0.79	1.92	2.09		q_t	0.00	0.60	0.68	1.36
							cme_t	8.71	3.86	7.06	13.06
							pc_t	10.98	10.27	9.74	8.17
							yw_t	0.43	0.73	4.02	9.03
							$resx_t$	2.24	1.70	2.38	1.97
						q_t	$comm_t$	10.36	26.86	26.33	23.46
							yd_t	0.95	4.30	7.40	8.38
							pd_t	0.77	0.39	0.32	0.30
							rd_t	19.50	10.20	7.89	7.76
							q_t	46.06	41.70	34.87	27.86

Notes: External variables: Chinese manufacturing exports (cme_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 21 – Forecast error variance decomposition for the model with Chinese industrial production (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	cip_t	100.00	70.47	39.23	27.73		cip_t	0.49	15.14	16.95	16.43
	pc_t	0.00	1.89	1.01	1.14		pc_t	0.93	3.44	3.60	3.80
	yw_t	0.00	2.85	9.15	7.30		yw_t	1.07	0.77	2.68	3.27
	$resx_t$	0.00	2.77	5.53	4.95		$resx_t$	4.45	3.75	4.07	3.93
cip_t	$comm_t$	0.00	6.65	18.22	24.89	$comm_t$	$comm_t$	93.07	61.97	55.66	54.25
	yd_t	0.00	1.72	17.84	25.34		yd_t	0.00	1.50	3.36	4.80
	pd_t	0.00	9.53	5.48	3.85		pd_t	0.00	1.31	2.69	2.61
	rd_t	0.00	2.65	3.05	4.48		rd_t	0.00	3.75	3.53	3.72
	q_t	0.00	1.48	0.51	0.33		q_t	0.00	8.38	7.47	7.20
	cip_t	31.27	54.84	40.29	30.16		cip_t	15.47	61.13	44.21	30.16
	pc_t	68.73	29.36	12.76	8.44		pc_t	1.63	2.30	2.03	1.56
	yw_t	0.00	1.83	6.32	5.22		yw_t	2.37	2.28	19.63	14.37
	$resx_t$	0.00	0.35	3.71	4.08		$resx_t$	0.72	0.69	3.10	3.18
pc_t	$comm_t$	0.00	0.38	12.74	21.19	yd_t	$comm_t$	1.81	0.81	6.05	15.60
	yd_t	0.00	0.49	12.18	20.39		yd_t	78.00	23.92	16.18	26.24
	pd_t	0.00	8.39	6.90	5.01		pd_t	0.00	7.94	6.93	4.59
	rd_t	0.00	3.94	4.50	5.09		rd_t	0.00	0.19	1.31	3.99
	q_t	0.00	0.43	0.60	0.41		q_t	0.00	0.73	0.58	0.30
	cip_t	7.32	15.38	10.24	11.44		cip_t	0.27	0.71	1.99	2.19
	pc_t	4.47	4.46	14.60	14.23		pc_t	0.61	0.34	0.65	0.73
	yw_t	88.21	70.01	48.86	45.80		yw_t	0.00	0.98	1.11	2.17
	$resx_t$	0.00	0.18	5.20	5.41		$resx_t$	0.05	2.19	2.91	3.01
yw_t	$comm_t$	0.00	0.07	11.91	13.15	pd_t	$comm_t$	0.68	11.39	16.58	17.61
	yd_t	0.00	0.28	0.23	0.58		yd_t	0.10	5.65	7.72	7.86
	pd_t	0.00	2.65	2.50	2.59		pd_t	98.29	45.55	38.34	36.84
	rd_t	0.00	1.05	1.77	1.67		rd_t	0.00	27.47	25.87	24.88
	q_t	0.00	5.92	4.70	5.12		q_t	0.00	5.72	4.83	4.70
	cip_t	2.01	25.16	21.28	18.71		cip_t	3.01	11.98	15.22	13.27
	pc_t	8.13	22.55	12.54	10.16		pc_t	4.30	7.30	4.74	4.73
	yw_t	0.28	4.20	14.15	11.31		yw_t	0.01	1.25	7.01	7.64
	$resx_t$	89.57	31.41	15.83	13.31		$resx_t$	0.23	7.03	5.38	5.03
$resx_t$	$comm_t$	0.00	7.94	8.57	16.10	rd_t	$comm_t$	1.63	2.81	14.86	18.38
	yd_t	0.00	4.76	19.58	22.40		yd_t	2.48	4.87	16.71	19.43
	pd_t	0.00	1.87	2.70	2.39		pd_t	0.01	1.39	2.24	1.94
	rd_t	0.00	1.72	4.94	5.25		rd_t	88.34	62.23	32.70	28.60
	q_t	0.00	0.39	0.41	0.37		q_t	0.00	1.14	1.14	0.97
							cip_t	6.25	6.74	16.45	17.30
							pc_t	6.99	2.42	4.65	2.79
							yw_t	0.74	1.50	4.17	3.37
							$resx_t$	1.00	0.67	2.22	3.86
						q_t	$comm_t$	8.66	23.37	20.12	26.33
							yd_t	1.39	7.01	12.81	20.06
							pd_t	0.76	0.97	2.49	2.50
							rd_t	20.45	10.62	8.97	7.32
							q_t	53.77	46.70	28.12	16.47

Notes: External variables: Chinese industrial production (cip_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 22 – Forecast error variance decomposition for the model with Chinese GDP (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	$cgdp_t$	100.00	73.29	45.09	32.22		$cgdp_t$	1.24	14.06	14.85	14.60
	pc_t	0.00	0.20	2.31	1.78		pc_t	0.29	9.99	10.81	10.92
	yw_t	0.00	2.21	2.45	8.26		yw_t	0.63	1.09	3.09	3.96
	$resx_t$	0.00	3.60	7.70	6.74		$resx_t$	3.89	4.24	4.12	4.01
$cgdp_t$	$comm_t$	0.00	5.07	11.39	14.67	$comm_t$	$comm_t$	93.95	60.77	54.82	53.48
	yd_t	0.00	1.49	21.01	26.48		yd_t	0.00	1.61	3.36	4.03
	pd_t	0.00	5.49	3.23	2.19		pd_t	0.00	1.40	2.55	2.52
	rd_t	0.00	0.09	0.32	0.97		rd_t	0.00	1.83	1.71	1.84
	q_t	0.00	8.55	6.51	6.67		q_t	0.00	5.01	4.69	4.64
	$cgdp_t$	22.20	44.81	40.13	31.59		$cgdp_t$	12.77	49.87	41.26	30.40
	pc_t	77.80	46.24	21.46	15.66		pc_t	5.91	13.71	9.92	6.04
	yw_t	0.00	0.39	2.78	7.62		yw_t	2.91	1.72	13.36	10.88
	$resx_t$	0.00	0.43	4.92	4.85		$resx_t$	0.22	0.50	4.71	5.00
pc_t	$comm_t$	0.00	0.44	9.86	12.42	yd_t	$comm_t$	1.24	0.42	5.65	11.58
	yd_t	0.00	0.22	13.56	19.92		yd_t	76.94	26.35	18.33	28.19
	pd_t	0.00	6.55	5.28	3.92		pd_t	0.00	5.50	5.13	3.24
	rd_t	0.00	0.65	0.43	0.98		rd_t	0.00	0.56	0.54	1.17
	q_t	0.00	0.28	1.59	3.04		q_t	0.00	1.38	1.09	3.50
	$cgdp_t$	21.37	26.48	23.44	26.30		$cgdp_t$	0.01	0.95	2.43	3.34
	pc_t	5.59	4.41	4.91	4.53		pc_t	0.66	0.76	2.73	2.81
	yw_t	73.04	57.99	53.72	44.46		yw_t	0.05	0.84	1.56	4.02
	$resx_t$	0.00	0.74	3.74	4.44		$resx_t$	0.04	3.96	4.32	4.21
yw_t	$comm_t$	0.00	0.32	3.09	4.45	pd_t	$comm_t$	1.57	10.94	14.05	13.68
	yd_t	0.00	0.29	0.22	4.78		yd_t	0.43	4.48	7.40	7.86
	pd_t	0.00	1.66	2.13	2.13		pd_t	97.24	43.85	36.48	34.61
	rd_t	0.00	0.13	0.29	0.30		rd_t	0.00	27.01	24.62	23.31
	q_t	0.00	7.97	8.46	8.61		q_t	0.00	7.20	6.41	6.16
	$cgdp_t$	7.91	15.30	16.78	15.36		$cgdp_t$	1.70	15.95	15.37	13.46
	pc_t	8.59	40.13	26.52	20.76		pc_t	5.38	11.47	13.28	12.26
	yw_t	0.45	2.81	7.70	11.69		yw_t	0.01	1.23	4.37	9.87
	$resx_t$	83.05	26.13	15.64	13.11		$resx_t$	0.14	7.87	6.06	5.35
$resx_t$	$comm_t$	0.00	8.13	9.48	10.90	rd_t	$comm_t$	2.04	3.08	12.54	12.51
	yd_t	0.00	4.21	18.52	21.04		yd_t	1.27	2.92	16.15	17.62
	pd_t	0.00	1.15	2.03	1.61		pd_t	0.02	1.36	1.93	1.72
	rd_t	0.00	1.65	2.36	2.18		rd_t	89.43	55.59	29.63	25.54
	q_t	0.00	0.48	0.98	3.34		q_t	0.00	0.53	0.67	1.69
							$cgdp_t$	2.09	9.17	21.93	20.98
							pc_t	12.14	4.30	3.51	2.58
							yw_t	3.85	3.16	2.21	5.22
							$resx_t$	0.12	0.89	4.21	5.23
						q_t	$comm_t$	9.94	20.16	17.25	18.00
							yd_t	0.40	6.25	13.35	20.00
							pd_t	0.02	0.84	1.53	1.36
							rd_t	19.40	9.63	5.89	4.32
							q_t	52.05	45.59	30.12	22.31

Notes: External variables: Chinese GDP ($cgdp_t$), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 23 – Forecast error variance decomposition for the model with broad basket (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	81.73	51.63	39.55		csp_t	0.16	17.21	21.87	22.94
	$pc7_t$	0.00	4.40	3.46	9.13		$pc7_t$	2.41	1.78	4.78	4.64
	yw_t	0.00	5.28	11.29	8.79		yw_t	1.29	0.85	3.73	6.05
	$resx7_t$	0.00	3.40	4.50	3.72		$resx7_t$	5.93	5.87	5.07	4.71
csp_t	$comm_t$	0.00	0.23	5.31	10.12	$comm_t$	$comm_t$	90.22	51.12	40.53	36.69
	yd_t	0.00	0.71	6.06	6.66		yd_t	0.00	4.42	4.24	5.11
	pd_t	0.00	0.76	0.27	0.26		pd_t	0.00	0.21	0.38	0.36
	rd_t	0.00	0.27	0.29	0.72		rd_t	0.00	4.17	3.60	3.30
	q_t	0.00	3.23	17.19	21.05		q_t	0.00	14.37	15.79	16.21
	csp_t	27.91	37.53	34.80	31.27		csp_t	10.54	46.67	40.70	36.09
	$pc7_t$	72.09	53.36	27.18	23.70		$pc7_t$	8.37	12.56	10.25	8.38
	yw_t	0.00	1.11	17.27	14.44		yw_t	2.36	1.40	24.98	26.13
	$resx7_t$	0.00	0.20	1.59	1.94		$resx7_t$	0.46	0.35	1.87	1.86
$pc7_t$	$comm_t$	0.00	3.99	5.28	7.35	yd_t	$comm_t$	2.18	2.08	2.67	2.76
	yd_t	0.00	0.16	8.65	10.21		yd_t	76.09	34.04	14.94	16.84
	pd_t	0.00	2.86	2.02	1.46		pd_t	0.00	1.72	1.69	1.19
	rd_t	0.00	0.18	0.21	0.74		rd_t	0.00	0.87	1.00	1.14
	q_t	0.00	0.61	3.01	8.89		q_t	0.00	0.32	1.91	5.62
	csp_t	1.43	3.63	2.61	2.67		csp_t	0.01	0.80	1.18	1.14
	$pc7_t$	9.22	4.19	17.01	18.49		$pc7_t$	0.01	3.37	5.95	8.22
	yw_t	89.35	83.40	61.23	52.45		yw_t	0.00	0.38	0.37	2.13
	$resx7_t$	0.00	0.43	2.77	2.56		$resx7_t$	0.19	3.57	4.05	3.78
yw_t	$comm_t$	0.00	0.87	6.50	11.08	pd_t	$comm_t$	1.51	12.04	11.36	12.22
	yd_t	0.00	0.84	0.54	0.69		yd_t	0.98	6.06	8.69	8.27
	pd_t	0.00	0.18	0.37	0.46		pd_t	97.31	39.42	35.21	32.66
	rd_t	0.00	0.31	0.65	0.58		rd_t	0.00	28.56	27.35	25.36
	q_t	0.00	6.15	8.32	11.03		q_t	0.00	5.81	5.83	6.22
	csp_t	3.11	25.30	26.46	24.90		csp_t	3.21	13.92	16.62	15.82
	$pc7_t$	9.24	25.10	12.79	14.31		$pc7_t$	8.28	17.88	14.87	16.66
	yw_t	1.38	7.58	27.16	22.01		yw_t	0.00	0.83	11.92	11.07
	$resx7_t$	86.27	30.93	13.85	10.90		$resx7_t$	0.20	7.62	5.77	5.22
$resx7_t$	$comm_t$	0.00	3.17	3.03	5.54	rd_t	$comm_t$	1.40	1.13	1.20	3.47
	yd_t	0.00	2.82	11.89	12.55		yd_t	1.44	2.71	9.36	9.54
	pd_t	0.00	0.93	0.91	0.74		pd_t	0.50	0.97	0.98	0.92
	rd_t	0.00	2.28	1.34	1.58		rd_t	84.98	51.84	34.06	29.79
	q_t	0.00	1.89	2.56	7.47		q_t	0.00	3.12	5.23	7.52
							csp_t	4.69	4.30	6.03	8.28
							$pc7_t$	15.86	16.85	14.48	16.05
							yw_t	0.49	1.17	8.07	7.11
							$resx7_t$	3.20	1.00	1.12	1.52
						q_t	$comm_t$	8.52	24.82	24.28	22.64
							yd_t	2.21	3.93	11.48	11.67
							pd_t	0.84	0.66	0.93	0.82
							rd_t	16.90	8.85	5.99	5.29
							q_t	47.28	38.41	27.63	26.62

Notes: External variables: Chinese steel production (csp_t), real commodity prices - broad basket ($pc7_t$), foreign output (yw_t) and resource exports - broad basket ($resx7_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 24 – Forecast error variance decomposition for the model with non-oil basket (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	80.06	52.79	41.90		csp_t	0.60	18.46	22.96	25.05
	$pc6_t$	0.00	6.16	5.48	10.72		$pc6_t$	2.79	1.98	6.25	5.92
	yw_t	0.00	5.74	9.38	7.55		yw_t	2.64	1.54	3.98	5.99
	$resx6_t$	0.00	3.26	2.54	1.67		$resx6_t$	6.97	9.00	7.09	6.24
csp_t	$comm_t$	0.00	0.16	7.23	11.58	$comm_t$	$comm_t$	87.01	45.86	36.29	32.84
	yd_t	0.00	0.97	4.30	4.28		yd_t	0.00	5.89	5.18	5.18
	pd_t	0.00	0.29	0.09	0.21		pd_t	0.00	0.21	0.33	0.30
	rd_t	0.00	0.36	0.29	0.58		rd_t	0.00	3.88	3.38	3.06
	q_t	0.00	3.00	17.90	21.50		q_t	0.00	13.18	14.55	15.40
	csp_t	28.68	34.93	34.87	32.67		csp_t	12.07	47.84	46.47	42.52
	$pc6_t$	71.32	55.40	29.54	24.98		$pc6_t$	4.34	9.14	7.99	6.52
	yw_t	0.00	1.48	16.39	13.24		yw_t	4.03	2.22	21.63	23.05
	$resx6_t$	0.00	0.13	0.62	0.58		$resx6_t$	0.01	0.55	1.89	1.12
$pc6_t$	$comm_t$	0.00	4.28	4.72	7.81	yd_t	$comm_t$	1.24	1.80	1.76	2.90
	yd_t	0.00	0.11	8.26	8.61		yd_t	78.30	35.34	14.43	13.48
	pd_t	0.00	2.95	1.85	1.33		pd_t	0.00	1.68	1.35	0.85
	rd_t	0.00	0.17	0.30	0.77		rd_t	0.00	1.17	1.26	1.28
	q_t	0.00	0.55	3.45	10.01		q_t	0.00	0.25	3.20	8.27
	csp_t	0.76	2.18	1.71	1.77		csp_t	0.00	1.27	1.90	1.80
	$pc6_t$	7.05	3.49	17.07	19.58		$pc6_t$	0.00	2.90	5.06	7.40
	yw_t	92.19	82.85	57.96	50.74		yw_t	0.00	0.61	0.63	1.50
	$resx6_t$	0.00	2.75	6.63	5.77		$resx6_t$	0.06	6.00	6.05	5.70
yw_t	$comm_t$	0.00	0.57	6.06	9.62	pd_t	$comm_t$	0.59	7.62	8.03	9.06
	yd_t	0.00	0.48	1.24	1.51		yd_t	0.95	7.62	9.48	9.04
	pd_t	0.00	0.18	0.74	0.84		pd_t	98.40	37.66	33.84	31.81
	rd_t	0.00	0.28	0.33	0.29		rd_t	0.00	29.96	28.52	26.76
	q_t	0.00	7.21	8.25	9.88		q_t	0.00	6.36	6.49	6.92
	csp_t	2.43	20.67	29.47	29.72		csp_t	2.52	14.03	20.60	20.88
	$pc6_t$	10.81	24.36	14.23	13.89		$pc6_t$	5.68	15.99	12.80	14.24
	yw_t	2.56	4.75	23.91	20.07		yw_t	0.01	0.57	9.61	8.91
	$resx6_t$	84.20	40.18	17.80	12.47		$resx6_t$	0.10	8.19	5.79	4.84
$resx6_t$	$comm_t$	0.00	1.16	1.22	4.20	rd_t	$comm_t$	0.98	0.90	1.58	4.22
	yd_t	0.00	2.00	7.10	8.38		yd_t	1.54	2.67	5.82	6.11
	pd_t	0.00	0.63	0.78	0.62		pd_t	0.97	0.93	0.80	0.75
	rd_t	0.00	3.30	1.89	1.87		rd_t	88.20	51.76	35.18	29.39
	q_t	0.00	2.95	3.60	8.78		q_t	0.00	4.95	7.83	10.66
							csp_t	4.26	3.86	6.65	10.03
							$pc6_t$	13.89	19.63	17.52	18.78
							yw_t	0.61	1.15	7.03	6.19
							$resx6_t$	1.51	0.90	1.17	1.12
						q_t	$comm_t$	8.10	21.18	19.26	18.58
							yd_t	2.79	4.72	13.35	12.79
							pd_t	1.54	0.90	0.94	0.86
							rd_t	18.27	9.62	6.66	5.60
							q_t	49.02	38.05	27.42	26.05

Notes: External variables: Chinese steel production (csp_t), real commodity prices - non-oil basket ($pc6_t$), foreign output (yw_t) and resource exports - non-oil basket ($resx6_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 25 – Forecast error variance decomposition for the model with commodity terms of trade (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	82.01	48.46	33.97		csp_t	0.12	16.52	19.61	19.01
	$ctot_t$	0.00	3.95	2.11	7.19		$ctot_t$	3.26	2.36	2.79	3.48
	yw_t	0.00	5.03	11.44	9.33		yw_t	1.71	1.39	4.40	5.45
	$resx_t$	0.00	4.02	5.33	4.04		$resx_t$	5.57	5.53	5.17	4.81
csp_t	$comm_t$	0.00	0.27	7.17	12.92	$comm_t$	$comm_t$	89.33	51.38	43.45	40.97
	yd_t	0.00	0.93	11.23	13.11		yd_t	0.00	2.66	3.69	5.38
	pd_t	0.00	1.05	0.35	0.28		pd_t	0.00	0.51	0.86	0.80
	rd_t	0.00	0.56	1.35	3.07		rd_t	0.00	5.76	5.25	5.35
	q_t	0.00	2.18	12.56	16.10		q_t	0.00	13.88	14.78	14.74
	csp_t	29.86	43.23	41.09	34.26		csp_t	11.48	48.60	39.84	34.11
	$ctot_t$	70.14	49.88	28.89	23.73		$ctot_t$	6.78	14.90	11.02	9.56
	yw_t	0.00	1.34	14.03	11.60		yw_t	3.94	2.08	25.93	26.23
	$resx_t$	0.00	0.12	1.23	1.72		$resx_t$	0.14	0.23	1.60	1.47
$ctot_t$	$comm_t$	0.00	1.56	3.32	7.67	yd_t	$comm_t$	0.90	2.77	3.71	4.06
	yd_t	0.00	0.09	6.70	10.04		yd_t	76.76	28.50	15.13	18.67
	pd_t	0.00	3.07	2.26	1.61		pd_t	0.00	1.76	1.28	0.91
	rd_t	0.00	0.48	0.60	1.98		rd_t	0.00	0.81	0.91	1.99
	q_t	0.00	0.23	1.87	7.39		q_t	0.00	0.36	0.58	3.01
	csp_t	1.88	5.29	3.44	4.02		csp_t	0.27	0.72	1.23	1.18
	$ctot_t$	9.20	5.35	20.99	18.45		$ctot_t$	0.90	1.11	3.14	4.50
	yw_t	88.93	81.15	53.91	46.63		yw_t	0.00	0.62	0.62	1.56
	$resx_t$	0.00	0.23	3.40	3.59		$resx_t$	0.11	3.62	4.14	4.04
yw_t	$comm_t$	0.00	0.82	7.45	12.38	pd_t	$comm_t$	1.36	12.68	12.82	13.97
	yd_t	0.00	1.53	1.52	1.95		yd_t	0.24	3.74	5.62	5.29
	pd_t	0.00	0.64	0.53	0.48		pd_t	97.12	40.64	37.02	34.76
	rd_t	0.00	0.28	0.48	0.69		rd_t	0.00	30.82	29.71	28.00
	q_t	0.00	4.71	8.27	11.83		q_t	0.00	6.05	5.71	6.71
	csp_t	2.67	20.12	21.04	19.78		csp_t	3.06	13.30	14.93	13.43
	$ctot_t$	5.66	26.07	15.19	15.78		$ctot_t$	7.45	14.16	13.02	14.90
	yw_t	0.50	5.59	26.14	21.72		yw_t	0.00	1.09	13.04	12.30
	$resx_t$	91.18	36.42	17.83	14.77		$resx_t$	0.19	9.23	6.45	5.82
$resx_t$	$comm_t$	0.00	4.91	4.55	7.44	rd_t	$comm_t$	2.06	1.79	2.09	5.05
	yd_t	0.00	3.75	12.19	12.86		yd_t	1.31	3.30	12.12	11.88
	pd_t	0.00	0.50	0.56	0.47		pd_t	0.08	0.55	0.58	0.53
	rd_t	0.00	2.35	1.86	2.62		rd_t	85.83	56.19	36.44	32.09
	q_t	0.00	0.30	0.64	4.56		q_t	0.00	0.39	1.33	3.98
							csp_t	5.05	4.46	8.62	12.41
							$ctot_t$	11.76	8.75	6.67	7.01
							yw_t	0.45	1.41	7.73	7.20
							$resx_t$	1.11	0.37	0.60	1.41
						q_t	$comm_t$	10.92	27.64	27.73	25.16
							yd_t	2.27	2.10	4.75	7.19
							pd_t	0.36	0.44	0.57	0.47
							rd_t	22.29	13.35	9.37	8.22
							q_t	45.78	41.49	33.96	30.94

Notes: External variables: Chinese steel production (csp_t), commodity terms of trade ($ctot_t$), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 26 – Forecast error variance decomposition for the model with long sample period (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	74.11	38.74	25.68		csp_t	0.09	9.86	10.65	11.79
	pc_t	0.00	7.20	6.91	13.35		pc_t	2.06	1.78	3.84	4.37
	yw_t	0.00	6.05	8.97	5.26		yw_t	0.23	0.19	0.31	0.37
	$resx_t$	0.00	3.50	7.10	6.83		$resx_t$	7.00	5.53	5.06	5.11
csp_t	$comm_t$	0.00	0.45	4.85	7.61	$comm_t$	$comm_t$	90.62	57.68	41.99	35.28
	yd_t	0.00	0.97	2.41	1.48		yd_t	0.00	3.02	5.09	4.71
	pd_t	0.00	2.92	2.12	1.64		pd_t	0.00	1.77	3.62	3.58
	rd_t	0.00	1.67	7.75	11.69		rd_t	0.00	6.72	9.82	11.20
	q_t	0.00	3.13	21.15	26.46		q_t	0.00	13.44	19.61	23.60
	csp_t	27.23	35.77	37.09	29.80		csp_t	8.04	33.59	37.42	32.98
	pc_t	72.77	55.81	32.83	26.11		pc_t	6.63	18.38	10.08	7.73
	yw_t	0.00	0.88	10.33	8.41		yw_t	3.60	2.47	14.22	14.32
	$resx_t$	0.00	0.08	2.46	4.25		$resx_t$	0.02	0.48	2.07	3.89
pc_t	$comm_t$	0.00	3.00	3.64	5.89	yd_t	$comm_t$	0.00	7.07	4.87	4.46
	yd_t	0.00	0.18	2.46	2.77		yd_t	81.70	33.92	14.01	8.46
	pd_t	0.00	3.43	4.86	3.53		pd_t	0.00	3.23	5.71	4.76
	rd_t	0.00	0.60	2.25	6.52		rd_t	0.00	0.01	2.13	6.61
	q_t	0.00	0.25	4.08	12.71		q_t	0.00	0.84	9.49	16.79
	csp_t	2.67	7.62	4.41	3.75		csp_t	0.02	0.14	0.60	1.70
	pc_t	7.39	4.39	25.54	25.36		pc_t	0.24	0.63	2.25	3.43
	yw_t	89.94	81.67	57.59	50.68		yw_t	0.00	0.21	0.94	1.77
	$resx_t$	0.00	0.15	1.97	2.00		$resx_t$	0.26	1.63	1.88	1.78
yw_t	$comm_t$	0.00	0.58	3.72	5.06	pd_t	$comm_t$	3.54	8.83	9.58	9.40
	yd_t	0.00	1.64	1.01	2.41		yd_t	0.38	9.73	15.39	15.49
	pd_t	0.00	0.22	0.66	0.56		pd_t	95.55	52.30	44.63	42.38
	rd_t	0.00	0.35	0.54	2.24		rd_t	0.00	22.34	19.35	18.32
	q_t	0.00	3.37	4.56	7.94		q_t	0.00	4.20	5.39	5.72
	csp_t	1.97	17.52	21.68	20.81		csp_t	2.37	10.28	12.95	12.77
	pc_t	4.52	26.60	17.44	17.07		pc_t	8.21	14.31	13.09	14.79
	yw_t	0.26	5.38	20.85	17.56		yw_t	0.01	1.50	14.09	12.72
	$resx_t$	93.25	43.13	25.31	20.46		$resx_t$	0.18	3.31	2.92	3.48
$resx_t$	$comm_t$	0.00	2.86	2.60	4.50	rd_t	$comm_t$	2.23	2.30	2.28	3.78
	yd_t	0.00	0.36	4.82	5.77		yd_t	0.05	5.12	7.15	7.39
	pd_t	0.00	1.17	2.55	2.15		pd_t	0.00	2.71	3.07	2.69
	rd_t	0.00	1.46	2.32	4.61		rd_t	86.96	59.20	40.61	36.52
	q_t	0.00	1.51	2.42	7.06		q_t	0.00	1.27	3.86	5.86
							csp_t	2.86	3.37	3.95	4.28
							pc_t	14.11	11.34	9.38	9.80
							yw_t	1.11	2.50	14.45	15.25
							$resx_t$	1.36	1.02	0.63	0.93
						q_t	$comm_t$	8.05	8.98	6.02	6.15
							yd_t	0.19	6.96	17.90	21.77
							pd_t	2.64	1.23	0.73	0.66
							rd_t	21.06	21.27	15.57	13.67
							q_t	48.61	43.34	31.37	27.50

Notes: External variables: Chinese steel production (csp_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 27 – Forecast error variance decomposition for the model with commodity boom period (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	78.93	49.15	37.67		csp_t	0.00	11.87	14.88	16.70
	pc_t	0.00	7.24	3.59	2.74		pc_t	3.33	2.48	3.84	3.51
	yw_t	0.00	2.38	6.11	8.13		yw_t	1.20	0.88	1.90	5.67
	$resx_t$	0.00	4.44	6.56	3.98		$resx_t$	6.48	5.44	5.24	4.43
csp_t	$comm_t$	0.00	2.34	6.50	5.57	$comm_t$	$comm_t$	89.00	56.49	48.17	40.61
	yd_t	0.00	0.57	3.07	5.32		yd_t	0.00	2.90	3.02	3.95
	pd_t	0.00	0.76	8.80	22.33		pd_t	0.00	0.40	2.99	7.85
	rd_t	0.00	1.30	0.66	0.58		rd_t	0.00	5.37	4.94	4.18
	q_t	0.00	2.05	15.57	13.68		q_t	0.00	14.16	15.01	13.11
	csp_t	33.21	46.48	45.33	41.72		csp_t	9.50	42.85	40.78	38.19
	pc_t	66.79	47.62	29.92	20.20		pc_t	8.23	16.37	13.92	9.16
	yw_t	0.00	0.26	10.57	11.48		yw_t	5.15	3.21	21.57	27.64
	$resx_t$	0.00	0.35	1.34	1.69		$resx_t$	0.25	0.58	0.96	0.70
pc_t	$comm_t$	0.00	3.88	5.82	5.18	yd_t	$comm_t$	0.89	6.11	7.51	4.58
	yd_t	0.00	0.05	2.78	4.92		yd_t	75.99	29.72	12.56	12.16
	pd_t	0.00	0.58	1.24	8.09		pd_t	0.00	0.11	1.12	5.21
	rd_t	0.00	0.36	0.37	0.55		rd_t	0.00	0.56	0.68	0.62
	q_t	0.00	0.43	2.62	6.18		q_t	0.00	0.49	0.90	1.74
	csp_t	4.79	9.18	4.82	4.68		csp_t	0.07	1.83	2.29	3.26
	pc_t	8.30	4.59	19.98	17.58		pc_t	0.14	2.04	3.01	3.47
	yw_t	86.91	78.12	52.95	45.47		yw_t	0.00	0.41	0.80	3.05
	$resx_t$	0.00	0.17	4.40	4.62		$resx_t$	0.00	3.66	3.48	3.59
yw_t	$comm_t$	0.00	0.88	7.16	11.71	pd_t	$comm_t$	0.03	1.93	2.48	4.35
	yd_t	0.00	1.25	1.38	1.29		yd_t	0.02	2.41	2.30	2.19
	pd_t	0.00	0.39	0.74	3.19		pd_t	99.74	69.94	73.34	69.27
	rd_t	0.00	0.32	0.41	0.36		rd_t	0.00	14.21	9.87	8.13
	q_t	0.00	5.10	8.16	11.09		q_t	0.00	3.56	2.43	2.70
	csp_t	2.82	20.30	22.17	24.21		csp_t	3.14	13.30	17.10	17.33
	pc_t	5.53	23.51	14.56	12.58		pc_t	7.27	14.77	12.80	12.50
	yw_t	0.36	4.69	22.35	19.21		yw_t	0.00	1.37	11.18	10.19
	$resx_t$	91.29	38.90	21.41	17.36		$resx_t$	0.23	7.47	5.51	4.96
$resx_t$	$comm_t$	0.00	5.01	5.80	5.70	rd_t	$comm_t$	2.29	2.49	3.07	3.71
	yd_t	0.00	3.94	9.29	9.25		yd_t	0.59	3.13	8.23	8.21
	pd_t	0.00	0.70	1.70	6.42		pd_t	0.63	1.52	3.01	7.35
	rd_t	0.00	2.58	1.97	1.82		rd_t	85.85	55.33	37.19	32.28
	q_t	0.00	0.37	0.75	3.45		q_t	0.00	0.62	1.91	3.48
							csp_t	4.96	4.39	7.85	12.93
							pc_t	11.50	9.15	7.32	6.66
							yw_t	0.59	1.15	6.51	6.58
							$resx_t$	1.51	0.68	0.78	1.74
						q_t	$comm_t$	10.43	30.61	31.47	27.44
							yd_t	1.21	2.74	4.29	4.76
							pd_t	2.51	0.54	0.51	2.31
							rd_t	20.52	10.68	7.85	6.68
							q_t	46.76	40.06	33.41	30.90

Notes: External variables: Chinese steel production (csp_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 28 – Forecast error variance decomposition for the model without restriction in the interest rate (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	80.35	46.49	32.22		csp_t	0.21	15.12	18.18	17.56
	pc_t	0.00	5.07	3.28	8.90		pc_t	3.22	2.35	3.41	4.16
	yw_t	0.00	5.16	11.50	9.37		yw_t	1.16	1.01	4.00	5.37
	$resx_t$	0.00	5.23	8.19	7.48		$resx_t$	6.62	4.63	5.01	4.88
csp_t	$comm_t$	0.00	0.32	7.85	13.87	$comm_t$	$comm_t$	88.80	54.45	45.80	42.98
	yd_t	0.00	0.69	9.63	11.42		yd_t	0.00	3.06	4.13	5.81
	pd_t	0.00	0.90	0.27	0.29		pd_t	0.00	0.45	0.73	0.68
	rd_t	0.00	0.39	0.71	1.58		rd_t	0.00	4.68	4.10	4.07
	q_t	0.00	1.89	12.09	14.86		q_t	0.00	14.26	14.64	14.47
	csp_t	30.37	43.75	41.17	33.52		csp_t	12.28	50.24	41.92	34.89
	pc_t	69.63	48.98	27.18	22.93		pc_t	6.68	14.18	9.88	9.14
	yw_t	0.00	1.11	14.62	12.18		yw_t	3.77	1.88	25.52	26.16
	$resx_t$	0.00	0.23	1.84	3.62		$resx_t$	0.15	0.19	1.28	2.15
pc_t	$comm_t$	0.00	2.08	4.02	8.49	yd_t	$comm_t$	1.01	2.75	3.60	4.17
	yd_t	0.00	0.14	6.52	9.47		yd_t	76.10	28.03	15.12	18.09
	pd_t	0.00	3.07	2.17	1.53		pd_t	0.00	1.81	1.32	0.92
	rd_t	0.00	0.32	0.42	1.16		rd_t	0.00	0.63	0.64	1.36
	q_t	0.00	0.31	2.06	7.10		q_t	0.00	0.29	0.72	3.12
	csp_t	1.78	4.88	3.15	3.58		csp_t	0.18	0.47	0.96	0.92
	pc_t	9.92	5.58	20.48	18.23		pc_t	0.63	1.15	3.91	5.35
	yw_t	88.30	80.52	53.96	46.65		yw_t	0.00	1.40	1.44	2.32
	$resx_t$	0.00	0.30	4.31	4.94		$resx_t$	0.14	3.67	4.83	4.90
yw_t	$comm_t$	0.00	1.09	7.49	12.79	pd_t	$comm_t$	1.46	12.36	12.24	13.52
	yd_t	0.00	1.52	1.85	2.06		yd_t	0.36	5.32	6.59	6.18
	pd_t	0.00	0.61	0.53	0.50		pd_t	97.22	41.65	37.61	35.27
	rd_t	0.00	0.24	0.35	0.37		rd_t	0.00	27.88	26.71	25.05
	q_t	0.00	5.26	7.87	10.88		q_t	0.00	6.12	5.71	6.49
	csp_t	3.26	20.89	21.52	19.73		csp_t	5.17	16.53	16.59	14.75
	pc_t	5.24	23.91	13.54	15.12		pc_t	6.20	14.04	12.82	15.11
	yw_t	0.25	4.97	26.26	21.74		yw_t	2.42	4.22	15.64	14.34
	$resx_t$	91.25	38.07	19.06	16.59		$resx_t$	6.43	9.63	7.19	7.04
$resx_t$	$comm_t$	0.00	5.55	4.63	7.71	rd_t	$comm_t$	1.36	1.26	1.89	5.08
	yd_t	0.00	3.58	12.12	12.47		yd_t	0.21	3.41	11.28	11.02
	pd_t	0.00	0.51	0.51	0.44		pd_t	0.09	0.63	0.66	0.63
	rd_t	0.00	2.17	1.72	2.03		rd_t	78.12	49.69	32.15	28.00
	q_t	0.00	0.35	0.64	4.17		q_t	0.00	0.59	1.78	4.03
							csp_t	6.37	5.63	9.41	12.47
							pc_t	11.22	9.16	7.27	8.18
							yw_t	2.17	2.18	8.57	7.71
							$resx_t$	4.88	2.21	1.87	3.47
						q_t	$comm_t$	9.65	27.25	27.90	25.66
							yd_t	1.16	2.85	5.33	6.92
							pd_t	0.42	0.47	0.64	0.53
							rd_t	18.89	10.61	7.44	6.28
							q_t	45.25	39.64	31.57	28.78

Notes: External variables: Chinese steel production (csp_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 29 – Forecast error variance decomposition for the model with domestic output minus primary commodity sector (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	81.18	47.18	32.64		csp_t	0.21	15.60	18.58	17.97
	pc_t	0.00	5.19	3.38	9.29		pc_t	3.22	2.23	3.31	4.11
	yw_t	0.00	4.74	10.73	8.65		yw_t	1.16	0.97	3.87	5.08
	$resx_t$	0.00	4.62	7.25	6.13		$resx_t$	6.62	5.47	5.63	5.32
csp_t	$comm_t$	0.00	0.31	8.11	14.27	$comm_t$	$comm_t$	88.80	53.48	45.20	42.50
	yd_t^*	0.00	0.76	10.18	12.19		yd_t^*	0.00	2.92	3.97	5.81
	pd_t	0.00	0.90	0.27	0.30		pd_t	0.00	0.45	0.71	0.67
	rd_t	0.00	0.42	0.81	1.80		rd_t	0.00	5.01	4.40	4.39
	q_t	0.00	1.88	12.09	14.73		q_t	0.00	13.87	14.32	14.15
	csp_t	30.37	43.98	41.57	33.89		csp_t	11.35	46.23	39.61	33.73
	pc_t	69.63	49.01	27.30	23.26		pc_t	8.67	15.03	10.70	9.79
	yw_t	0.00	0.96	14.07	11.47		yw_t	2.80	1.83	25.63	25.66
	$resx_t$	0.00	0.14	1.51	2.73		$resx_t$	0.96	0.25	1.39	1.73
pc_t	$comm_t$	0.00	2.06	4.01	8.68	yd_t^*	$comm_t$	1.26	3.64	4.31	4.66
	yd_t^*	0.00	0.14	6.86	10.10		yd_t^*	74.96	29.58	15.39	18.86
	pd_t	0.00	3.05	2.17	1.54		pd_t	0.00	1.83	1.33	0.93
	rd_t	0.00	0.35	0.47	1.32		rd_t	0.00	1.02	0.85	1.61
	q_t	0.00	0.32	2.05	7.01		q_t	0.00	0.59	0.80	3.04
	csp_t	1.79	4.87	3.15	3.61		csp_t	0.18	0.74	1.15	1.10
	pc_t	9.91	5.67	20.58	18.29		pc_t	0.64	1.34	4.04	5.51
	yw_t	88.30	80.47	54.12	46.73		yw_t	0.00	0.58	0.64	1.69
	$resx_t$	0.00	0.22	4.10	4.70		$resx_t$	0.14	2.88	3.42	3.51
yw_t	$comm_t$	0.00	1.09	7.45	12.79	pd_t	$comm_t$	1.46	13.21	13.12	14.32
	yd_t^*	0.00	1.52	1.82	2.09		yd_t^*	0.33	4.61	6.25	5.87
	pd_t	0.00	0.61	0.53	0.50		pd_t	97.25	40.75	36.97	34.66
	rd_t	0.00	0.26	0.38	0.41		rd_t	0.00	29.89	28.79	26.99
	q_t	0.00	5.29	7.87	10.88		q_t	0.00	5.98	5.60	6.35
	csp_t	3.25	20.56	21.51	19.70		csp_t	3.20	14.44	15.47	13.73
	pc_t	5.25	23.96	13.66	15.46		pc_t	7.89	15.20	13.62	15.97
	yw_t	0.25	5.51	25.62	21.13		yw_t	0.00	1.25	12.75	11.97
	$resx_t$	91.25	37.50	18.71	15.85		$resx_t$	0.23	8.55	6.16	5.88
$resx_t$	$comm_t$	0.00	5.63	4.63	7.83	rd_t	$comm_t$	2.16	1.83	2.32	5.52
	yd_t^*	0.00	3.59	12.80	13.22		yd_t^*	1.03	3.51	12.06	11.76
	pd_t	0.00	0.53	0.52	0.46		pd_t	0.15	0.61	0.65	0.62
	rd_t	0.00	2.36	1.92	2.27		rd_t	85.34	54.04	35.23	30.61
	q_t	0.00	0.35	0.63	4.09		q_t	0.00	0.58	1.74	3.93
							csp_t	5.29	4.91	8.92	12.14
							pc_t	12.56	9.91	7.79	8.74
							yw_t	0.53	1.45	7.88	6.96
							$resx_t$	1.45	0.56	0.65	2.09
						q_t	$comm_t$	10.78	28.23	28.59	26.35
							yd_t^*	1.79	2.78	5.50	7.24
							pd_t	0.48	0.47	0.65	0.54
							rd_t	21.08	11.74	8.23	6.97
							q_t	46.05	39.95	31.79	28.96

Notes: External variables: Chinese steel production (csp_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output minus primary commodity sector (yd_t^*), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

Table 30 – Forecast error variance decomposition for the model with domestic output in dollar (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
csp_t	csp_t	100.00	81.18	47.16	32.63	$comm_t$	csp_t	0.21	15.57	18.52	17.91
csp_t	pc_t	0.00	5.20	3.38	9.26	$comm_t$	pc_t	3.22	2.23	3.30	4.10
csp_t	yw_t	0.00	4.73	10.75	8.66	$comm_t$	yw_t	1.16	0.98	3.89	5.06
csp_t	$resx_t$	0.00	4.61	7.21	6.10	$comm_t$	$resx_t$	6.61	5.43	5.59	5.29
csp_t	$comm_t$	0.00	0.31	8.07	14.25	$comm_t$	$comm_t$	88.81	53.56	45.29	42.63
csp_t	$yd(\$)_t$	0.00	0.76	10.24	12.25	$comm_t$	$yd(\$)_t$	0.00	2.97	4.04	5.84
csp_t	pd_t	0.00	0.90	0.27	0.30	$comm_t$	pd_t	0.00	0.44	0.71	0.67
csp_t	rd_t	0.00	0.42	0.79	1.75	$comm_t$	rd_t	0.00	4.97	4.37	4.36
csp_t	q_t	0.00	1.89	12.13	14.81	$comm_t$	q_t	0.00	13.84	14.29	14.14
pc_t	csp_t	30.37	43.95	41.57	33.92	$yd(\$)_t$	csp_t	12.33	49.62	41.27	34.76
pc_t	pc_t	69.63	49.05	27.34	23.25	$yd(\$)_t$	pc_t	6.84	14.32	9.90	9.30
pc_t	yw_t	0.00	0.96	14.05	11.45	$yd(\$)_t$	yw_t	3.76	1.97	25.74	25.62
pc_t	$resx_t$	0.00	0.14	1.48	2.71	$yd(\$)_t$	$resx_t$	0.10	0.19	1.45	1.76
pc_t	$comm_t$	0.00	2.05	4.02	8.68	$yd(\$)_t$	$comm_t$	1.02	2.82	3.66	4.28
pc_t	$yd(\$)_t$	0.00	0.13	6.83	10.09	$yd(\$)_t$	$yd(\$)_t$	75.96	28.35	15.26	18.79
pc_t	pd_t	0.00	3.05	2.18	1.54	$yd(\$)_t$	pd_t	0.00	1.76	1.30	0.92
pc_t	rd_t	0.00	0.35	0.46	1.29	$yd(\$)_t$	rd_t	0.00	0.68	0.70	1.50
pc_t	q_t	0.00	0.31	2.07	7.07	$yd(\$)_t$	q_t	0.00	0.29	0.72	3.08
yw_t	csp_t	1.79	4.87	3.14	3.59	pd_t	csp_t	0.18	0.74	1.17	1.12
yw_t	pc_t	9.93	5.68	20.57	18.30	pd_t	pc_t	0.63	1.31	3.99	5.43
yw_t	yw_t	88.28	80.48	54.13	46.77	pd_t	yw_t	0.00	0.59	0.64	1.64
yw_t	$resx_t$	0.00	0.21	4.13	4.72	pd_t	$resx_t$	0.14	2.84	3.38	3.48
yw_t	$comm_t$	0.00	1.09	7.46	12.79	pd_t	$comm_t$	1.48	13.30	13.22	14.42
yw_t	$yd(\$)_t$	0.00	1.53	1.81	2.08	pd_t	$yd(\$)_t$	0.37	4.64	6.26	5.87
yw_t	pd_t	0.00	0.60	0.52	0.49	pd_t	pd_t	97.20	40.76	37.00	34.71
yw_t	rd_t	0.00	0.26	0.39	0.41	pd_t	rd_t	0.00	29.85	28.75	26.97
yw_t	q_t	0.00	5.28	7.84	10.85	pd_t	q_t	0.00	5.97	5.60	6.36
$resx_t$	csp_t	3.27	20.49	21.57	19.80	rd_t	csp_t	3.20	14.42	15.50	13.79
$resx_t$	pc_t	5.24	23.95	13.65	15.38	rd_t	pc_t	7.87	15.17	13.58	15.89
$resx_t$	yw_t	0.26	5.51	25.59	21.08	rd_t	yw_t	0.00	1.26	12.73	11.93
$resx_t$	$resx_t$	91.23	37.46	18.70	15.83	rd_t	$resx_t$	0.22	8.50	6.12	5.86
$resx_t$	$comm_t$	0.00	5.64	4.65	7.86	rd_t	$comm_t$	2.18	1.84	2.33	5.54
$resx_t$	$yd(\$)_t$	0.00	3.71	12.77	13.21	rd_t	$yd(\$)_t$	1.08	3.56	12.06	11.77
$resx_t$	pd_t	0.00	0.53	0.53	0.46	rd_t	pd_t	0.14	0.61	0.66	0.63
$resx_t$	rd_t	0.00	2.36	1.90	2.24	rd_t	rd_t	85.30	54.06	35.24	30.62
$resx_t$	q_t	0.00	0.35	0.64	4.14	rd_t	q_t	0.00	0.58	1.77	3.98
						q_t	csp_t	5.33	4.93	9.06	12.34
						q_t	pc_t	12.52	9.85	7.72	8.63
						q_t	yw_t	0.55	1.45	7.84	6.97
						q_t	$resx_t$	1.50	0.59	0.68	2.11
						q_t	$comm_t$	10.85	28.38	28.69	26.36
						q_t	$yd(\$)_t$	1.89	2.77	5.42	7.24
						q_t	pd_t	0.46	0.47	0.65	0.54
						q_t	rd_t	20.93	11.67	8.18	6.91
						q_t	q_t	45.98	39.90	31.75	28.90

Notes: External variables: Chinese steel production (csp_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output in dollar ($yd(\$)_t$), inflation ($pd_t$), interest rate ($rd_t$) and real exchange rate (q_t).

Table 31 – Forecast error variance decomposition for the model with variables non-detrended (in per cent).

Variable	Shock	1	4	12	24	Variable	Shock	1	4	12	24
	csp_t	100.00	70.41	43.23	33.45		csp_t	0.42	9.47	13.44	21.35
	pc_t	0.00	9.03	6.55	7.83		pc_t	2.65	1.95	4.40	3.83
	yw_t	0.00	6.77	6.76	5.43		yw_t	0.98	1.23	0.96	1.86
	$resx_t$	0.00	3.92	10.30	9.69		$resx_t$	13.31	8.92	12.53	14.78
csp_t	$comm_t$	0.00	2.41	8.75	13.28	$comm_t$	$comm_t$	82.64	57.56	46.05	36.55
	yd_t	0.00	0.80	3.51	5.48		yd_t	0.00	2.67	3.70	3.12
	pd_t	0.00	3.33	1.41	0.86		pd_t	0.00	0.73	1.32	1.34
	rd_t	0.00	1.07	0.73	1.15		rd_t	0.00	5.25	4.33	3.24
	q_t	0.00	2.27	18.76	22.83		q_t	0.00	12.21	13.26	13.94
	csp_t	29.65	35.56	36.00	29.34		csp_t	7.00	29.22	43.60	43.89
	pc_t	70.35	54.27	28.80	18.35		pc_t	8.18	15.19	6.60	3.21
	yw_t	0.00	0.95	15.82	17.01		yw_t	3.16	2.31	6.54	14.06
	$resx_t$	0.00	0.29	0.69	0.64		$resx_t$	0.99	1.47	12.12	9.11
pc_t	$comm_t$	0.00	3.73	5.94	6.63	yd_t	$comm_t$	2.47	4.45	4.70	3.86
	yd_t	0.00	0.10	4.98	12.48		yd_t	78.20	41.75	18.63	12.55
	pd_t	0.00	4.30	3.23	1.99		pd_t	0.00	3.48	3.48	2.15
	rd_t	0.00	0.49	0.63	2.04		rd_t	0.00	0.92	2.04	1.29
	q_t	0.00	0.32	3.91	11.51		q_t	0.00	1.19	2.30	9.88
	csp_t	1.28	2.12	1.18	7.10		csp_t	0.23	0.56	0.98	2.39
	pc_t	10.18	6.11	18.43	10.85		pc_t	1.22	2.18	4.29	5.51
	yw_t	88.53	80.17	47.98	30.13		yw_t	0.00	0.22	0.33	1.67
	$resx_t$	0.00	0.66	12.39	24.50		$resx_t$	0.34	3.00	3.97	3.77
yw_t	$comm_t$	0.00	1.16	6.43	9.35	pd_t	$comm_t$	2.41	11.40	10.85	11.30
	yd_t	0.00	2.29	7.91	11.68		yd_t	0.90	6.66	9.90	9.68
	pd_t	0.00	0.72	0.32	0.45		pd_t	94.89	39.54	35.27	32.80
	rd_t	0.00	0.26	0.49	1.37		rd_t	0.00	31.12	29.61	27.70
	q_t	0.00	6.51	4.87	4.57		q_t	0.00	5.32	4.80	5.17
	csp_t	2.82	17.24	29.88	29.65		csp_t	2.92	11.58	18.55	18.51
	pc_t	4.89	16.81	10.95	7.97		pc_t	8.27	14.02	12.91	11.87
	yw_t	0.12	0.17	7.86	10.77		yw_t	0.01	1.05	4.26	5.41
	$resx_t$	92.17	56.13	37.15	22.05		$resx_t$	0.20	12.67	12.04	9.66
$resx_t$	$comm_t$	0.00	6.46	6.19	7.24	rd_t	$comm_t$	1.53	1.42	2.67	5.60
	yd_t	0.00	0.40	2.41	7.92		yd_t	1.68	2.34	5.00	7.84
	pd_t	0.00	0.33	0.97	0.80		pd_t	0.04	0.83	1.05	0.83
	rd_t	0.00	2.17	1.58	1.92		rd_t	85.36	55.79	41.28	31.76
	q_t	0.00	0.29	3.00	11.68		q_t	0.00	0.30	2.25	8.50
							csp_t	4.69	3.88	8.77	11.49
							pc_t	12.87	8.68	6.52	6.16
							yw_t	0.49	0.61	7.00	9.92
							$resx_t$	0.28	0.09	0.16	0.19
						q_t	$comm_t$	8.15	26.92	27.89	22.48
							yd_t	3.96	1.41	3.94	9.10
							pd_t	0.12	0.42	0.67	0.58
							rd_t	22.76	13.73	9.71	8.30
							q_t	46.68	44.26	35.32	31.78

Notes: External variables: Chinese steel production (csp_t), real commodity prices (pc_t), foreign output (yw_t) and resource exports ($resx_t$). Domestic variables: primary commodity sector ($comm_t$), domestic output (yd_t), inflation (pd_t), interest rate (rd_t) and real exchange rate (q_t).

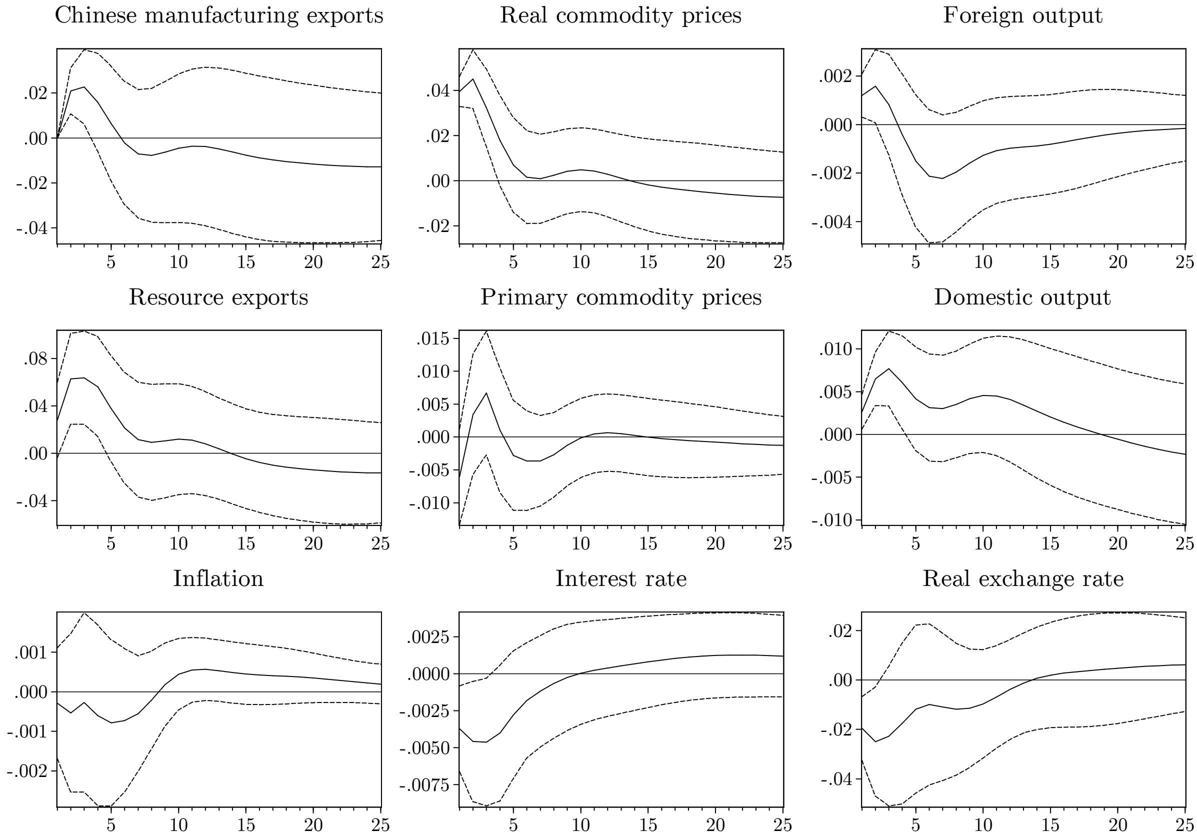

Figure 21 – Impulse response functions to a shock to commodity prices for the model with Chinese manufacturing exports, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

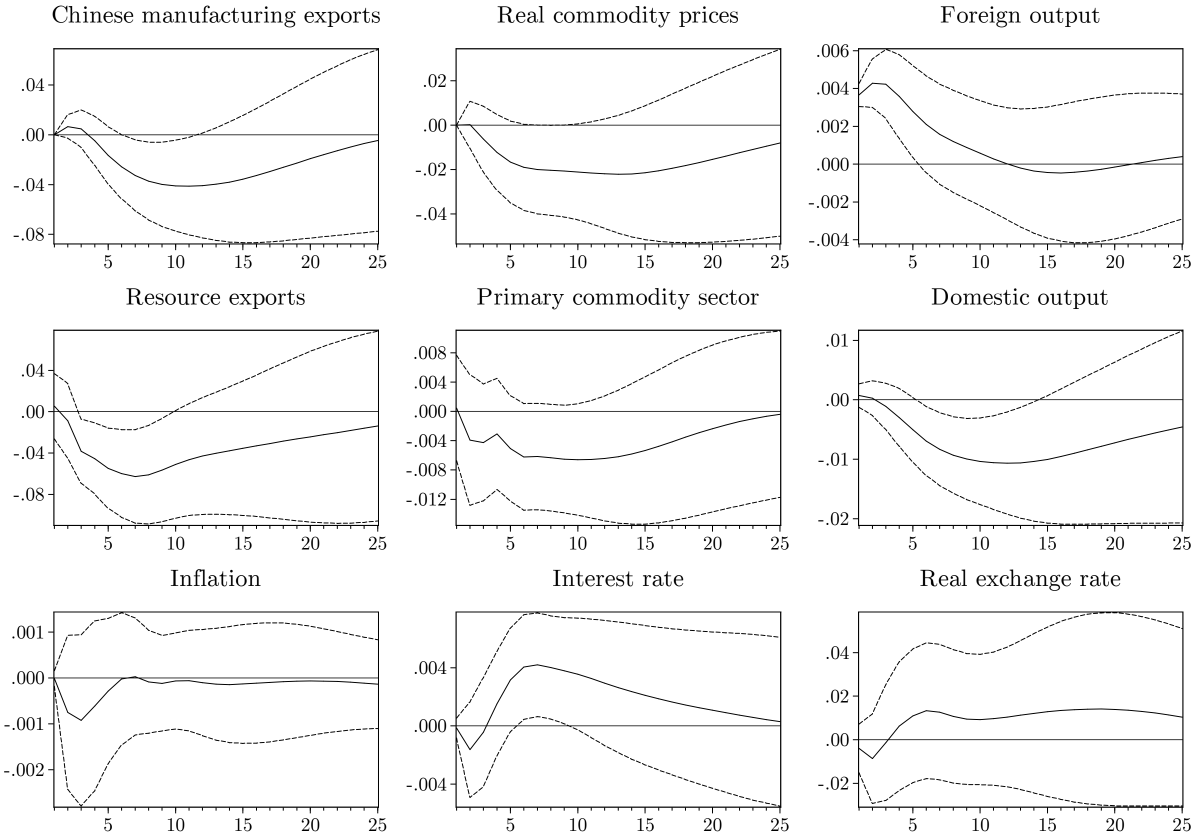

Figure 22 – Impulse response functions to a shock to foreign output for the model with Chinese manufacturing exports, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

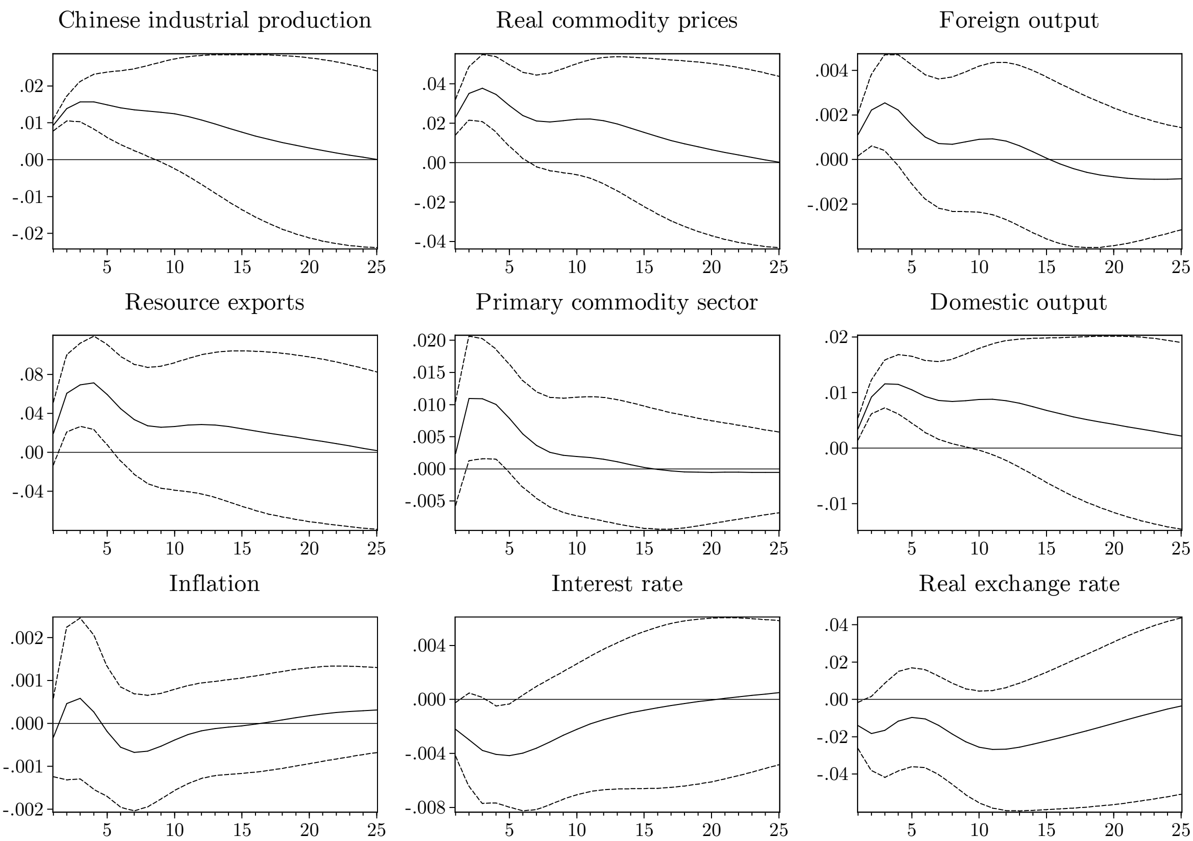

Figure 23 – Impulse response functions to a shock to Chinese industrial production for the model with Chinese industrial production, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

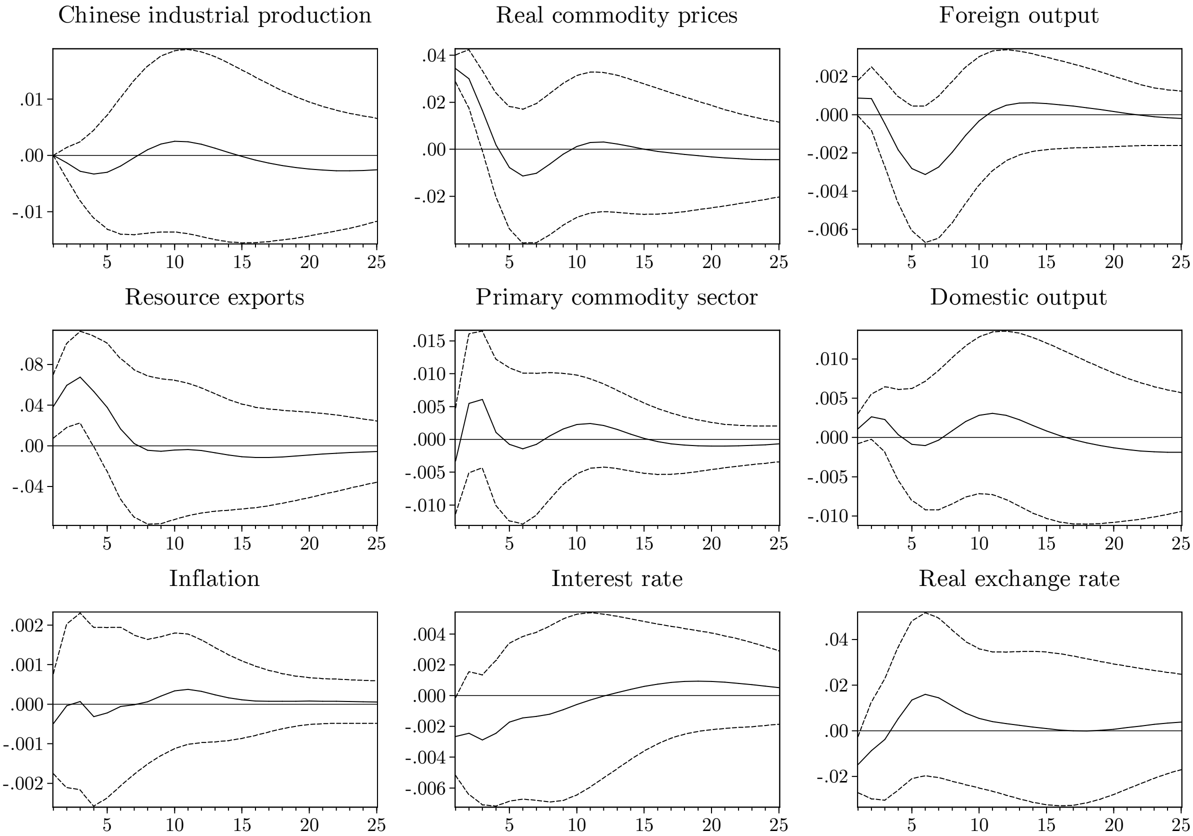

Figure 24 – Impulse response functions to a shock to commodity prices for the model with Chinese industrial production, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

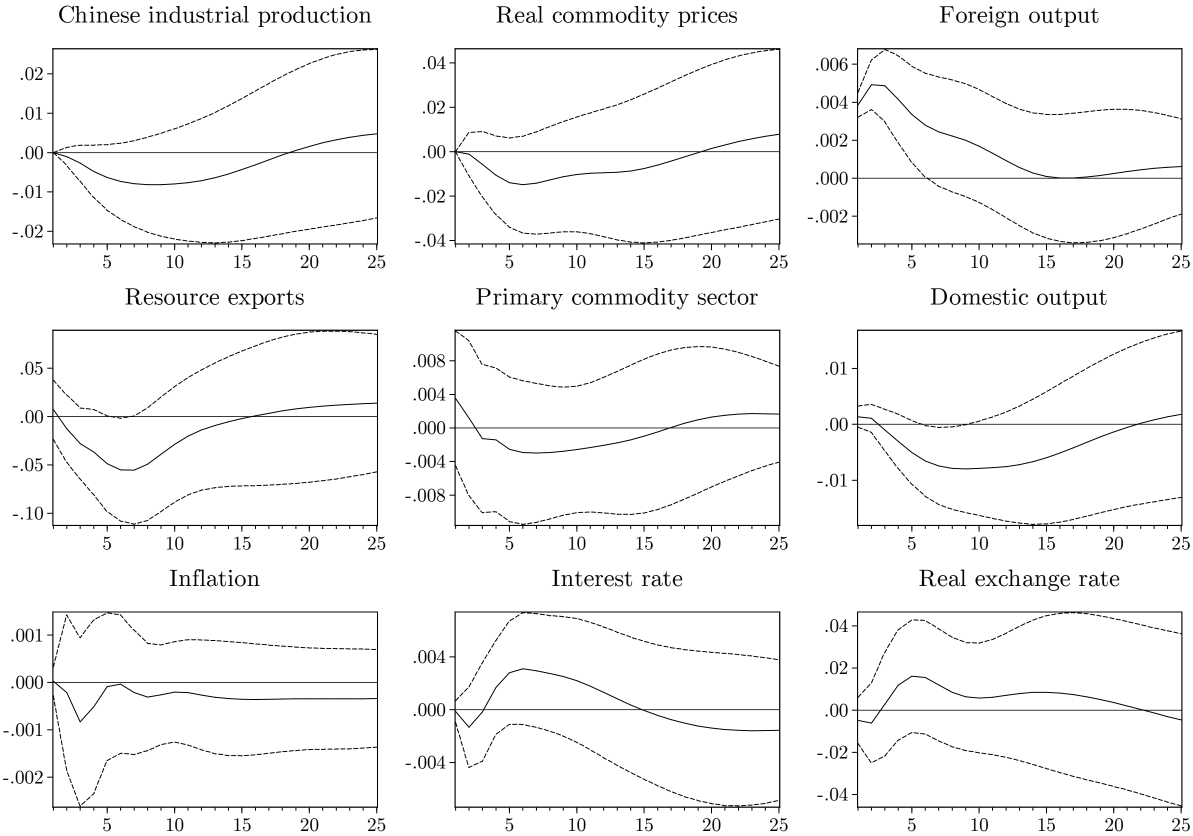

Figure 25 – Impulse response functions to a shock to foreign output for the model with Chinese industrial production, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

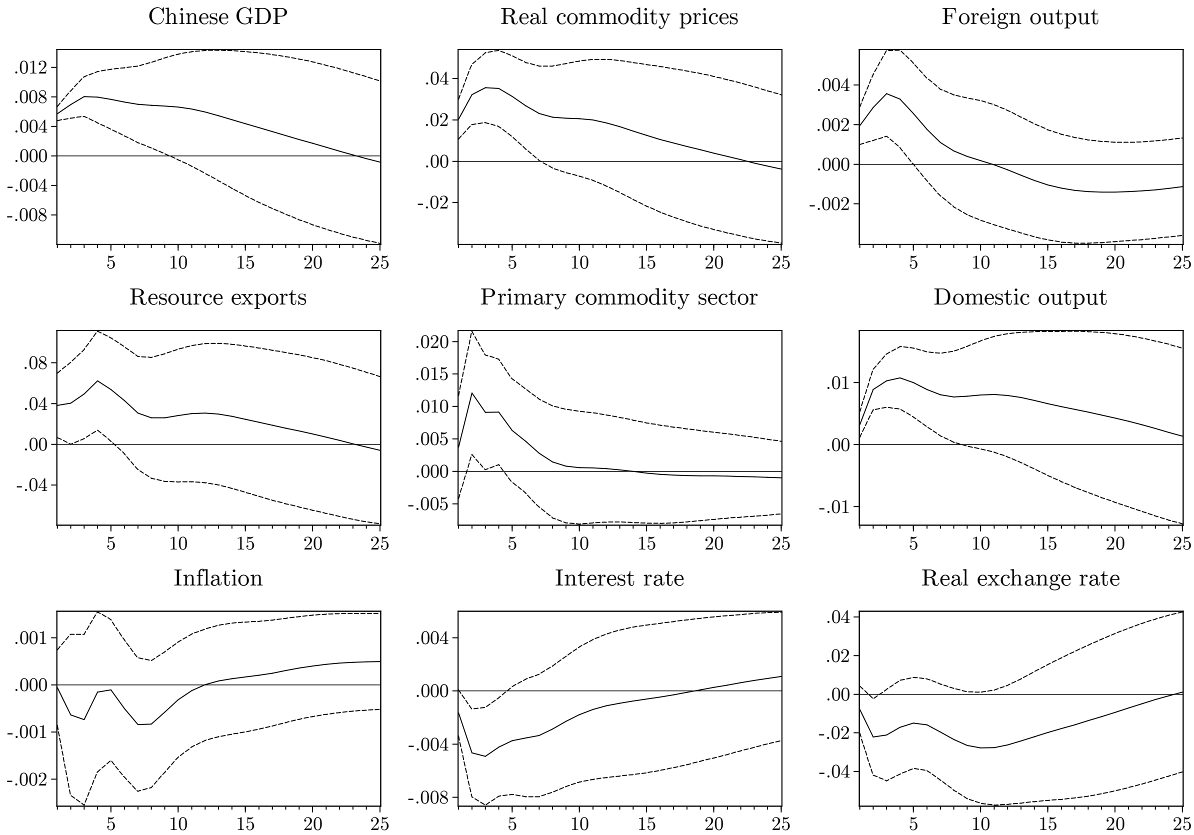

Figure 26 – Impulse response functions to a shock to Chinese GDP for the model with Chinese GDP, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

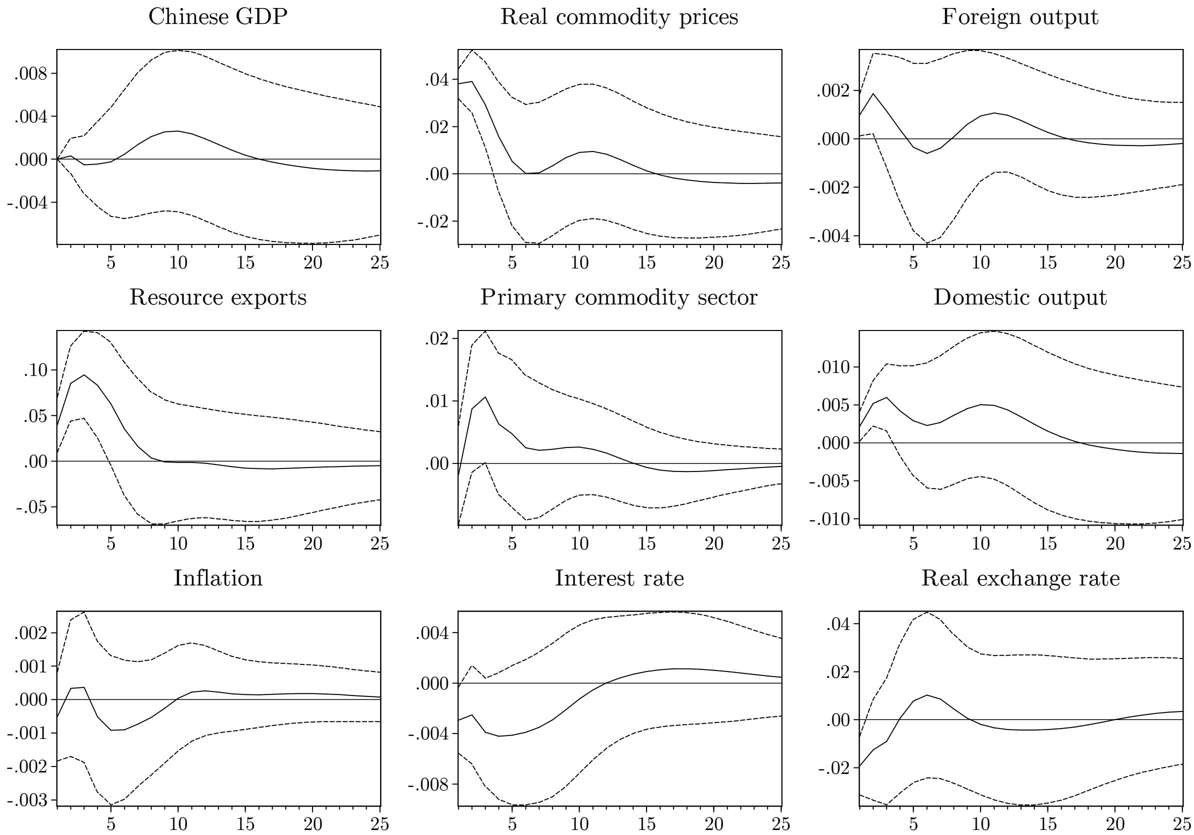

Figure 27 – Impulse response functions to a shock to commodity prices for the model with Chinese GDP, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

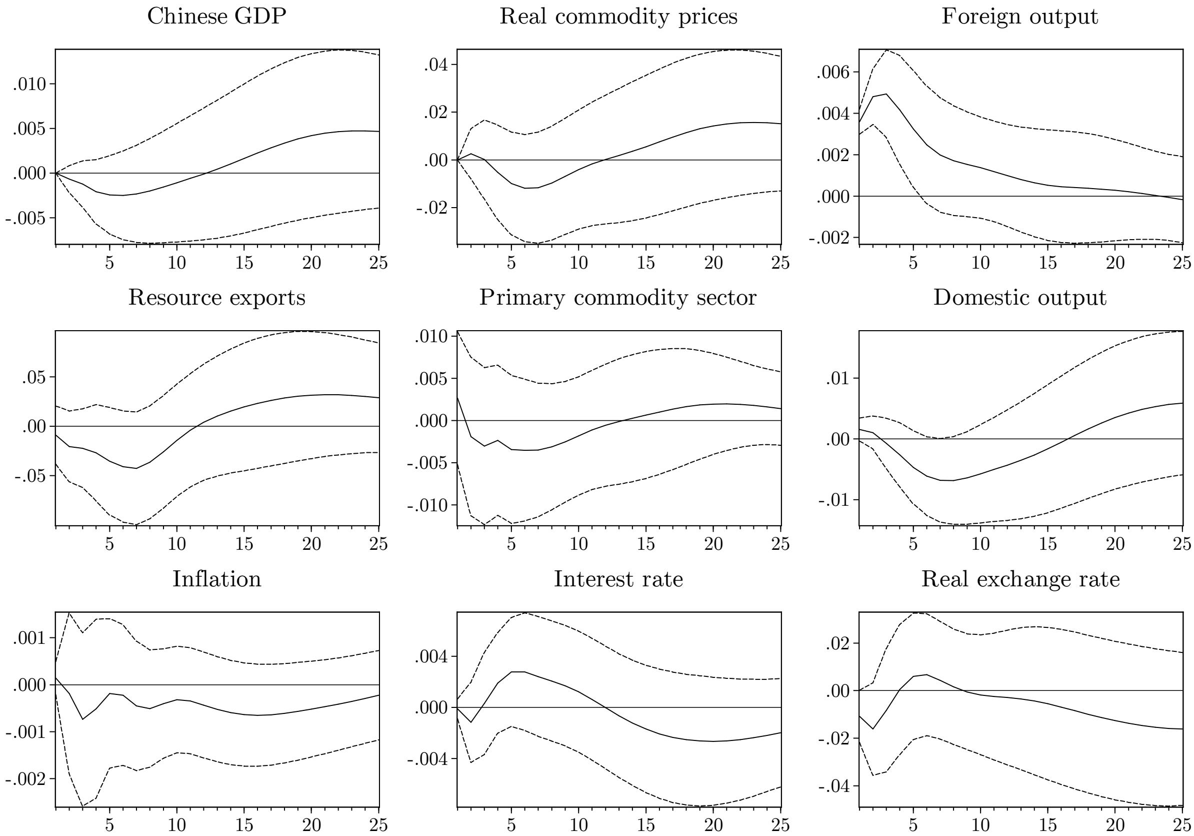

Figure 28 – Impulse response functions to a shock to foreign output for the model with Chinese GDP, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

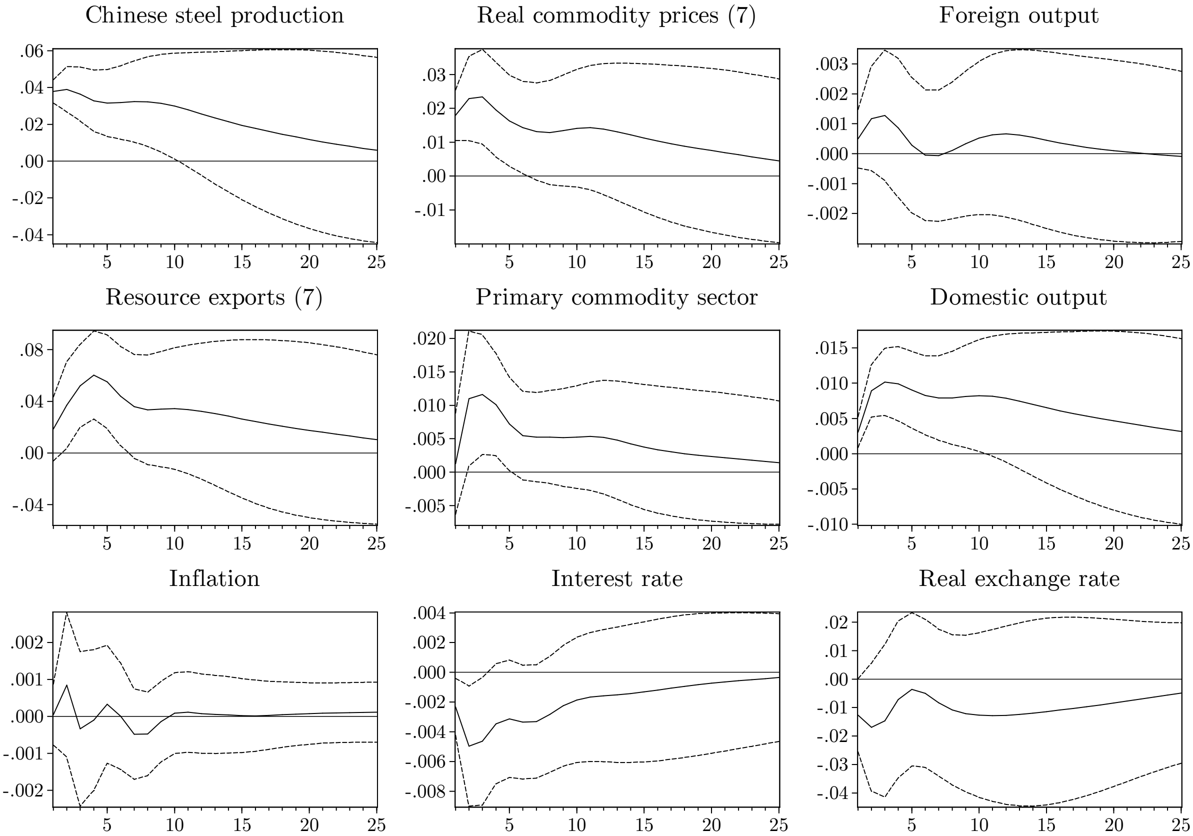

Figure 29 – Impulse response functions to a shock to Chinese steel production for the model with broad basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

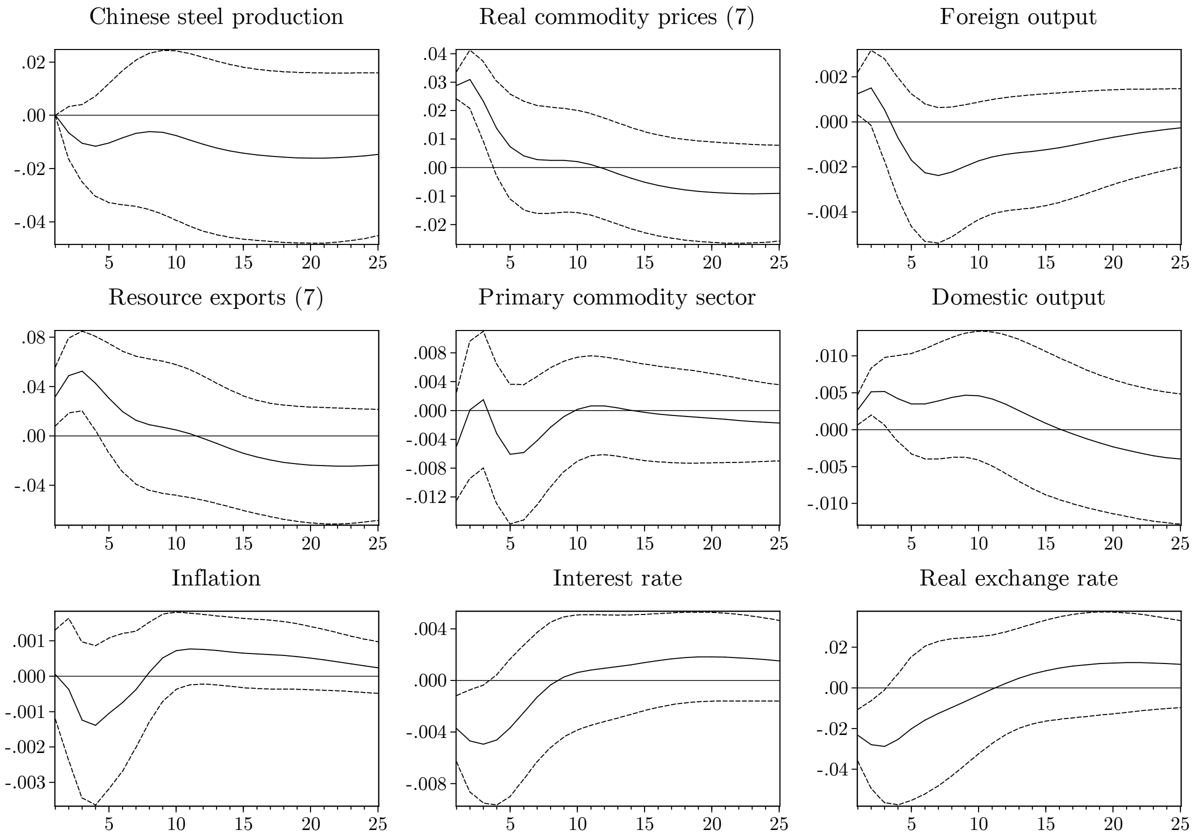

Figure 30 – Impulse response functions to a shock to commodity prices for the model with broad basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

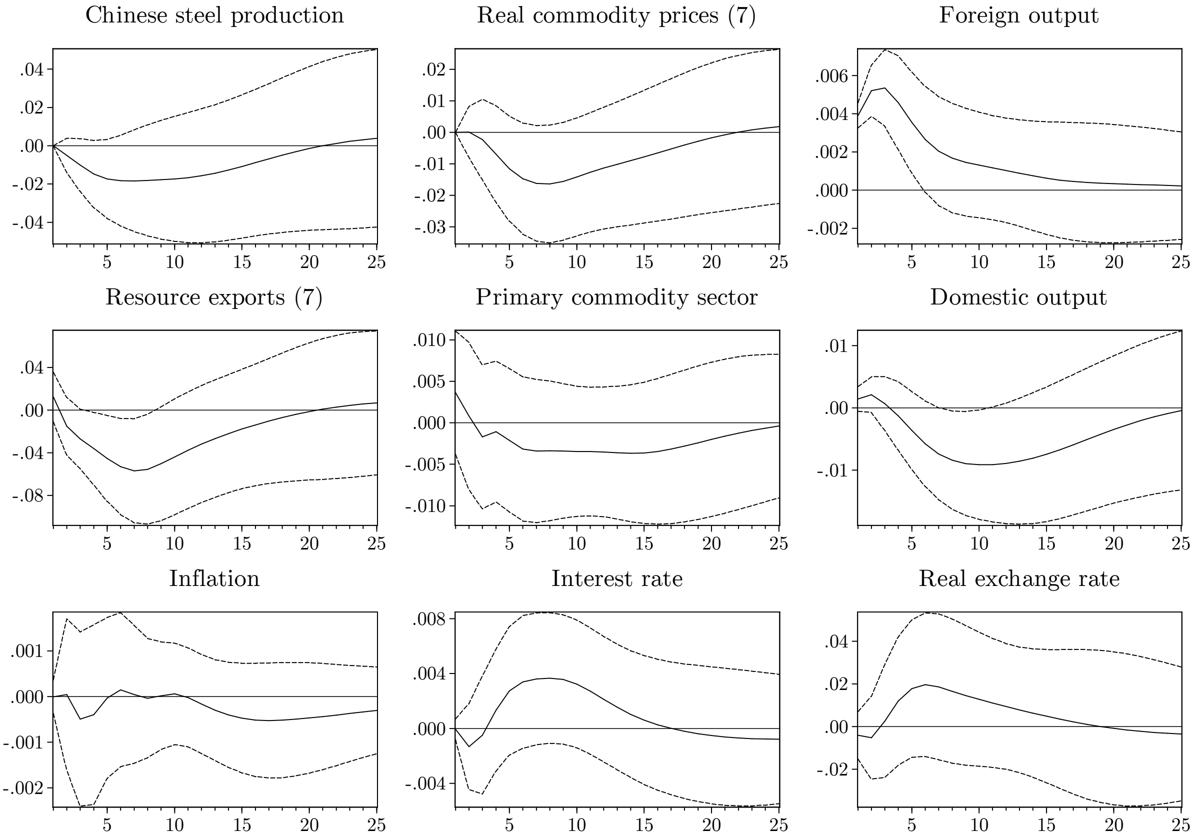

Figure 31 – Impulse response functions to a shock to foreign output for the model with broad basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

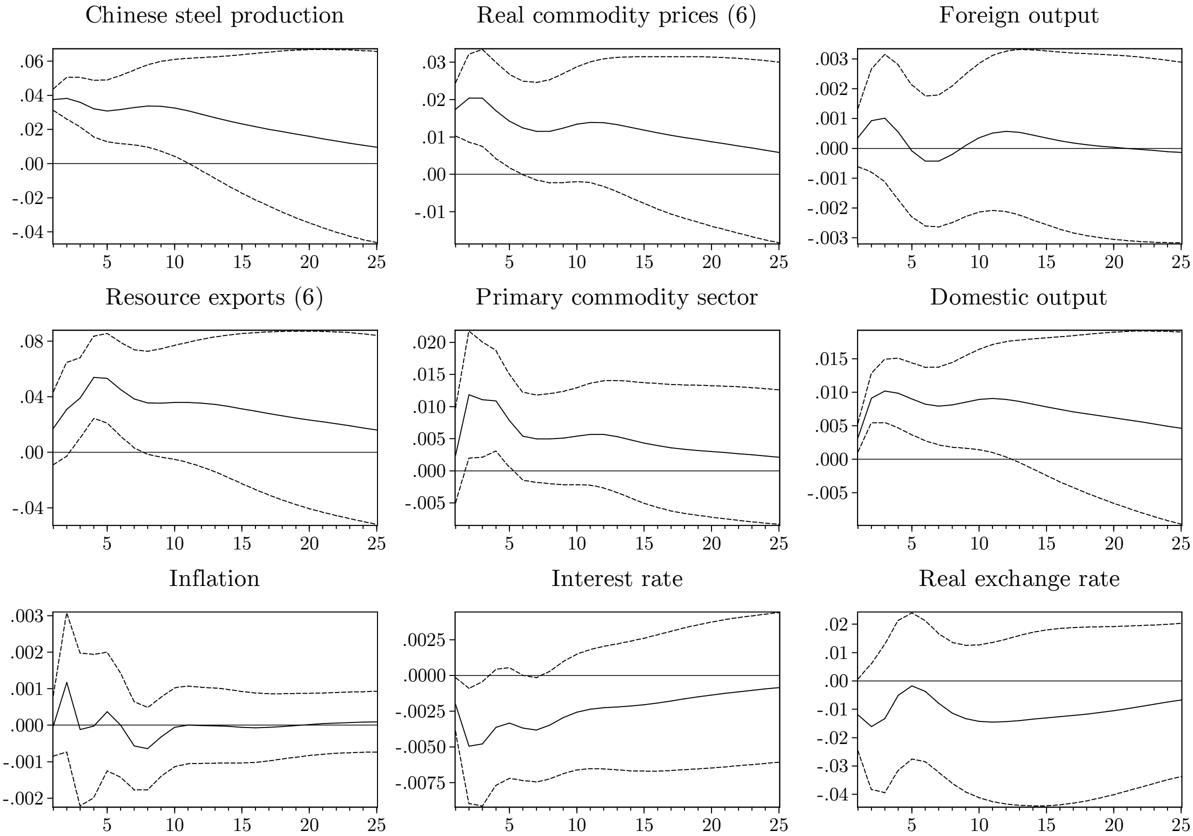

Figure 32 – Impulse response functions to a shock to Chinese steel production for the model with non-oil basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

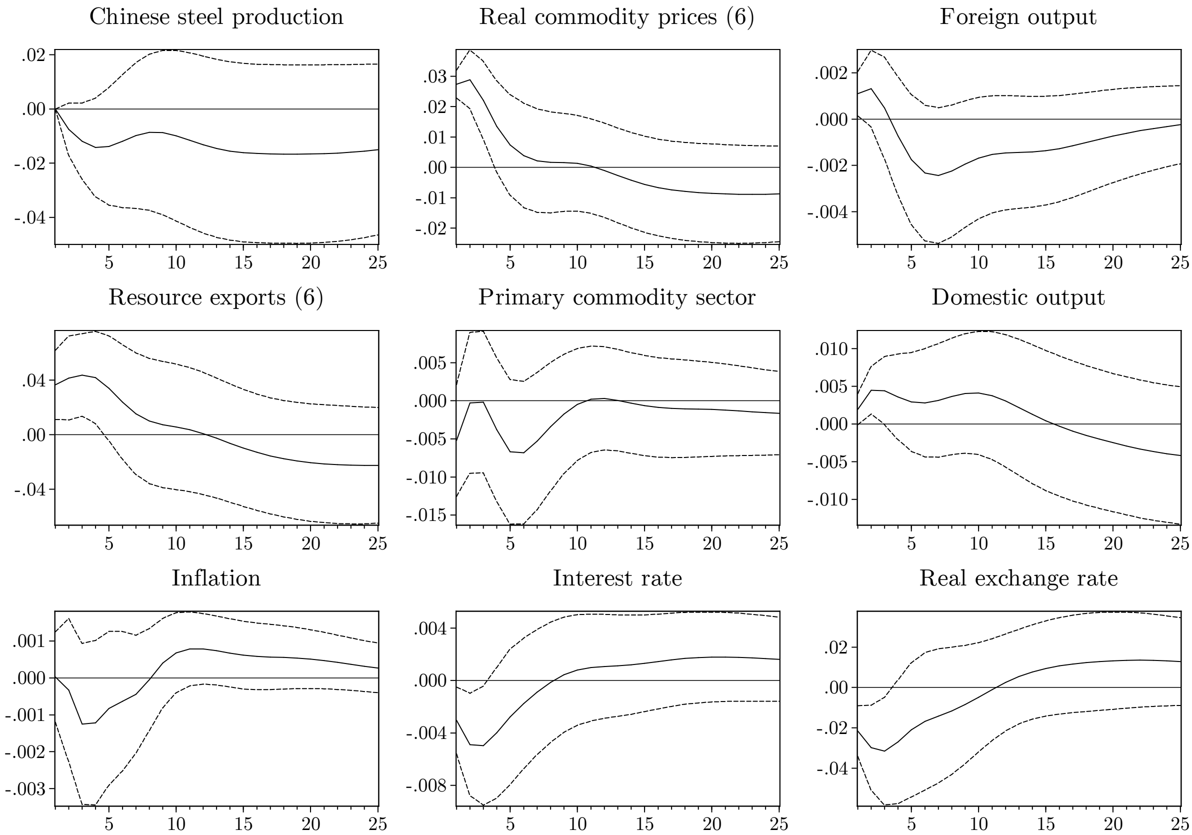

Figure 33 – Impulse response functions to a shock to commodity prices for the model with non-oil basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

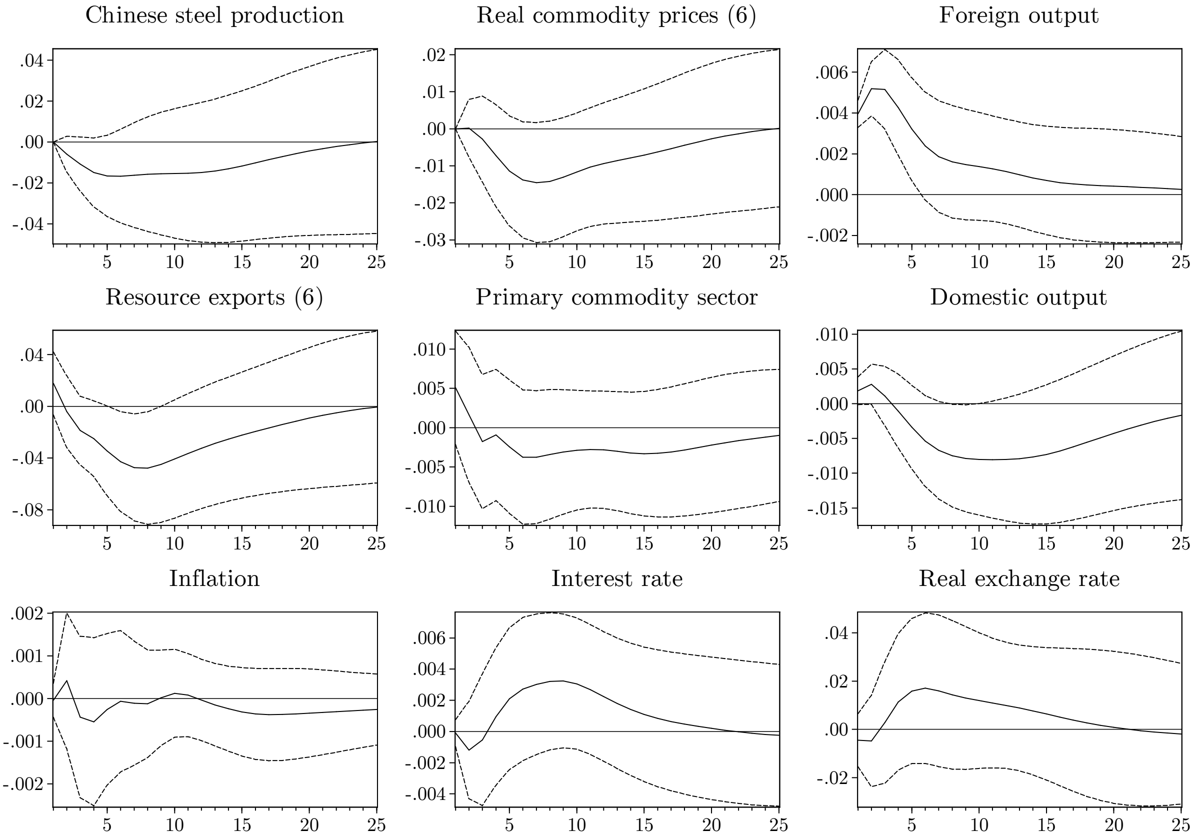

Figure 34 – Impulse response functions to a shock to foreign output for the model with non-oil basket, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

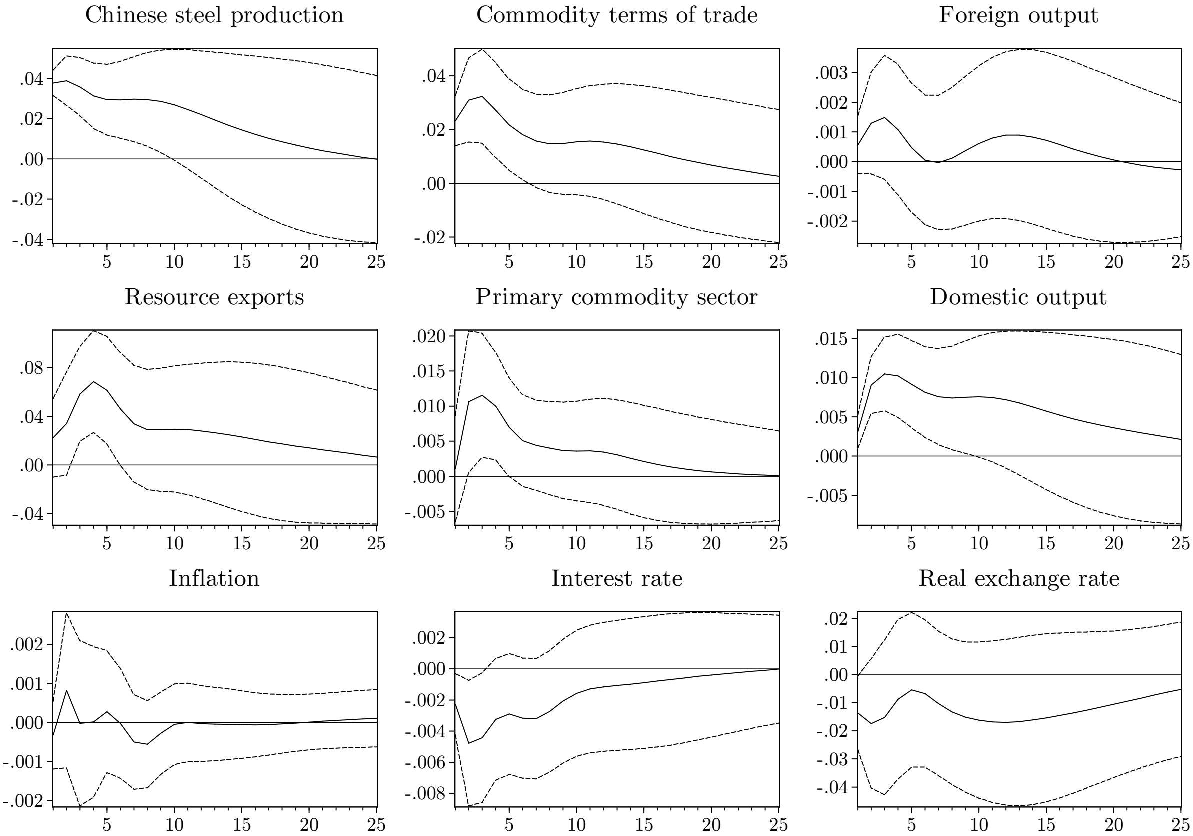

Figure 35 – Impulse response functions to a shock to Chinese steel production for the model with commodity terms of trade, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

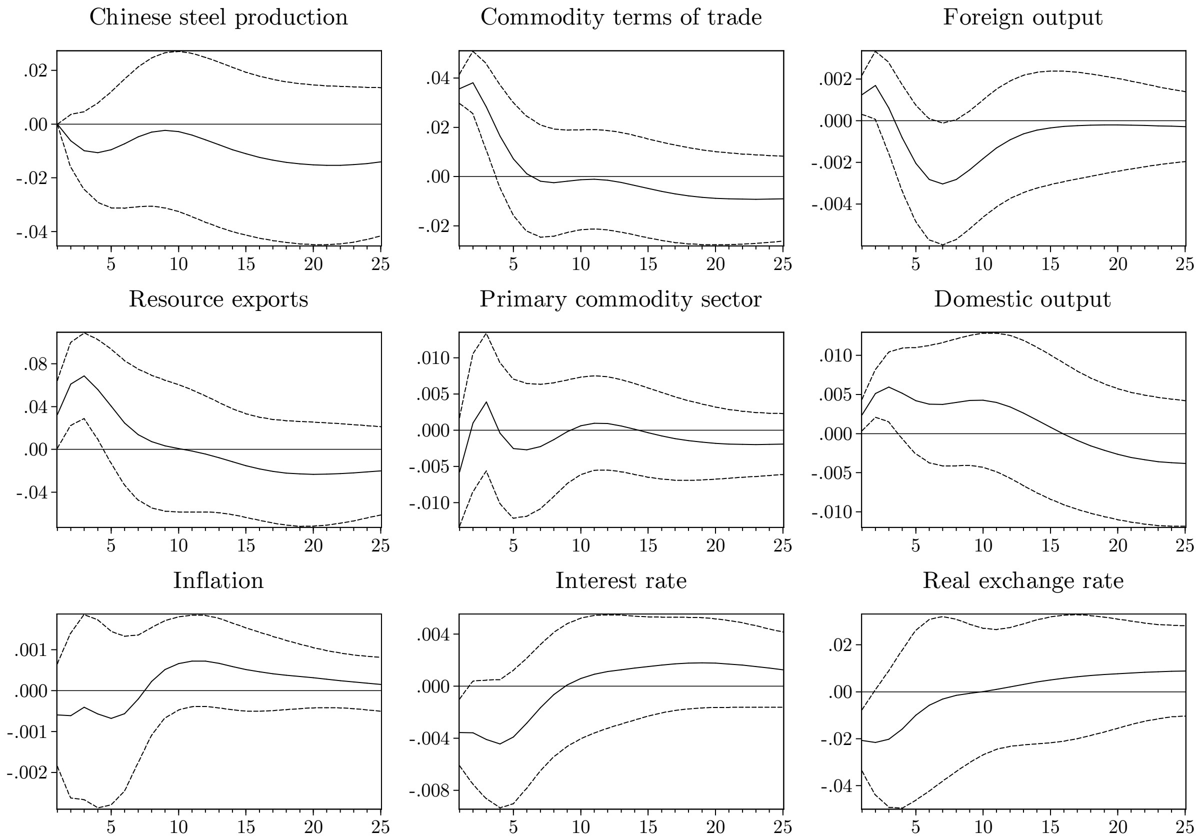

Figure 36 – Impulse response functions to a shock to commodity prices for the model with commodity terms of trade, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

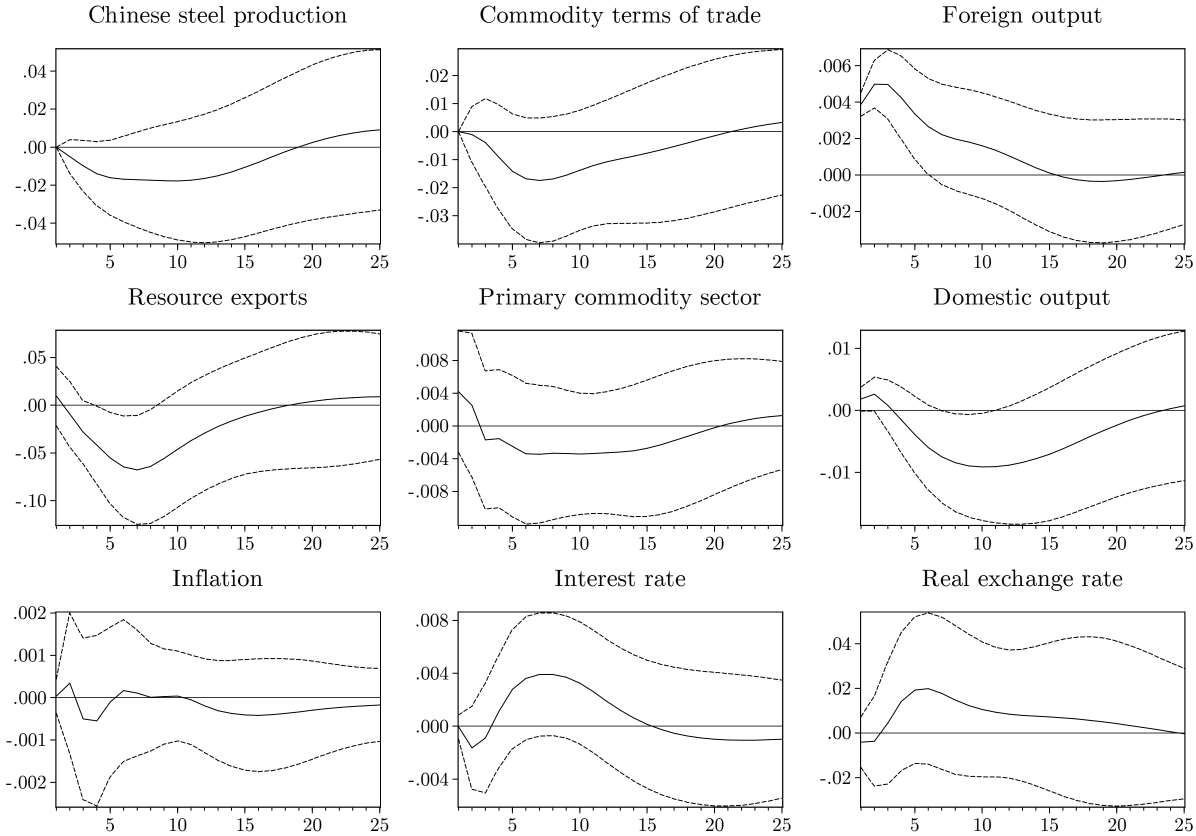

Figure 37 – Impulse response functions to a shock to foreign output for the model with commodity terms of trade, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

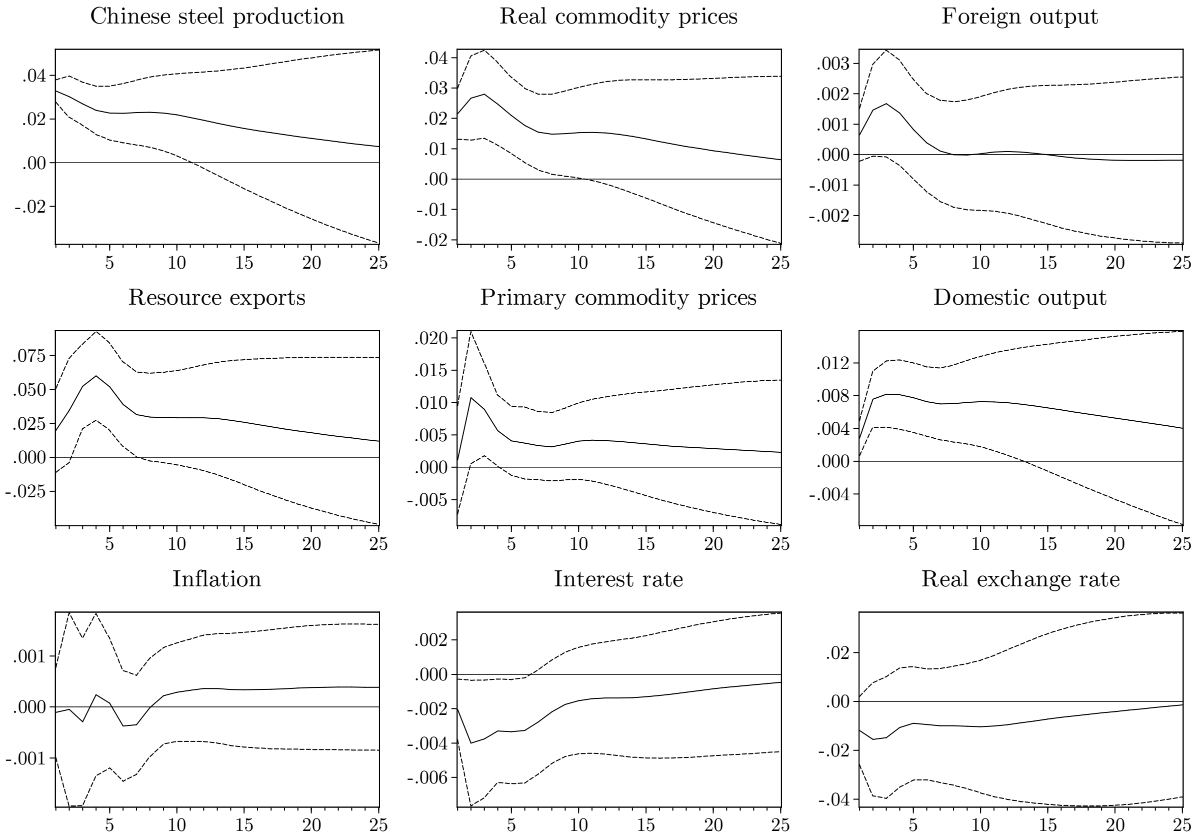

Figure 38 – Impulse response functions to a shock to Chinese steel production for the model with long sample period, 1996Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

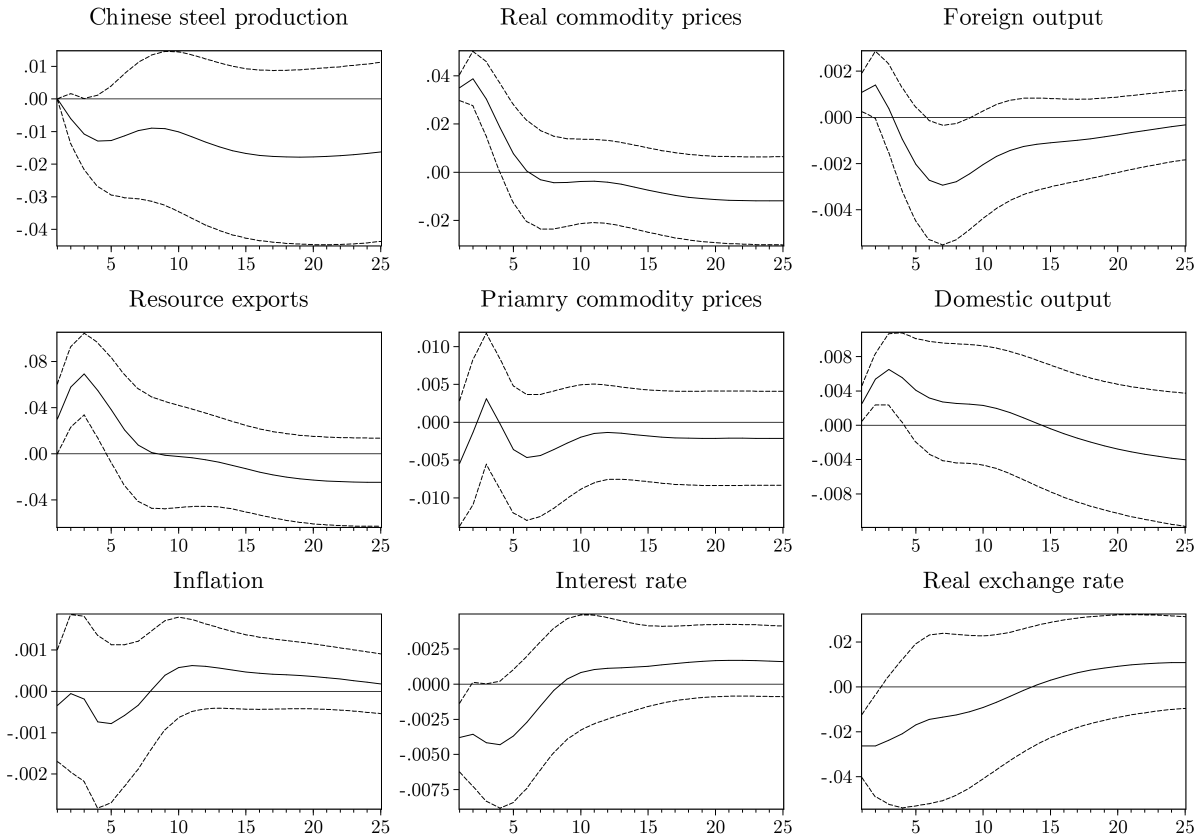

Figure 39 – Impulse response functions to a shock to commodity prices for the model with long sample period, 1996Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

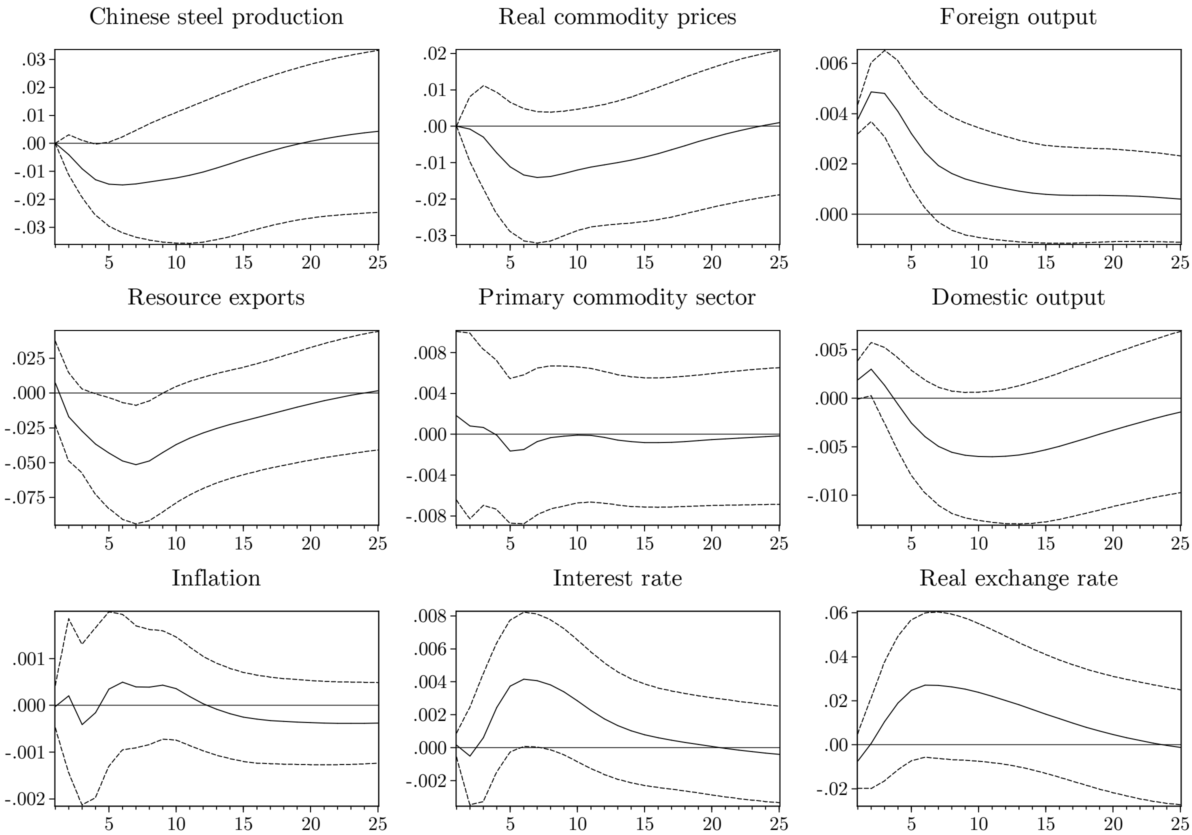

Figure 40 – Impulse response functions to a shock to foreign output for the model with long sample period, 1996Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

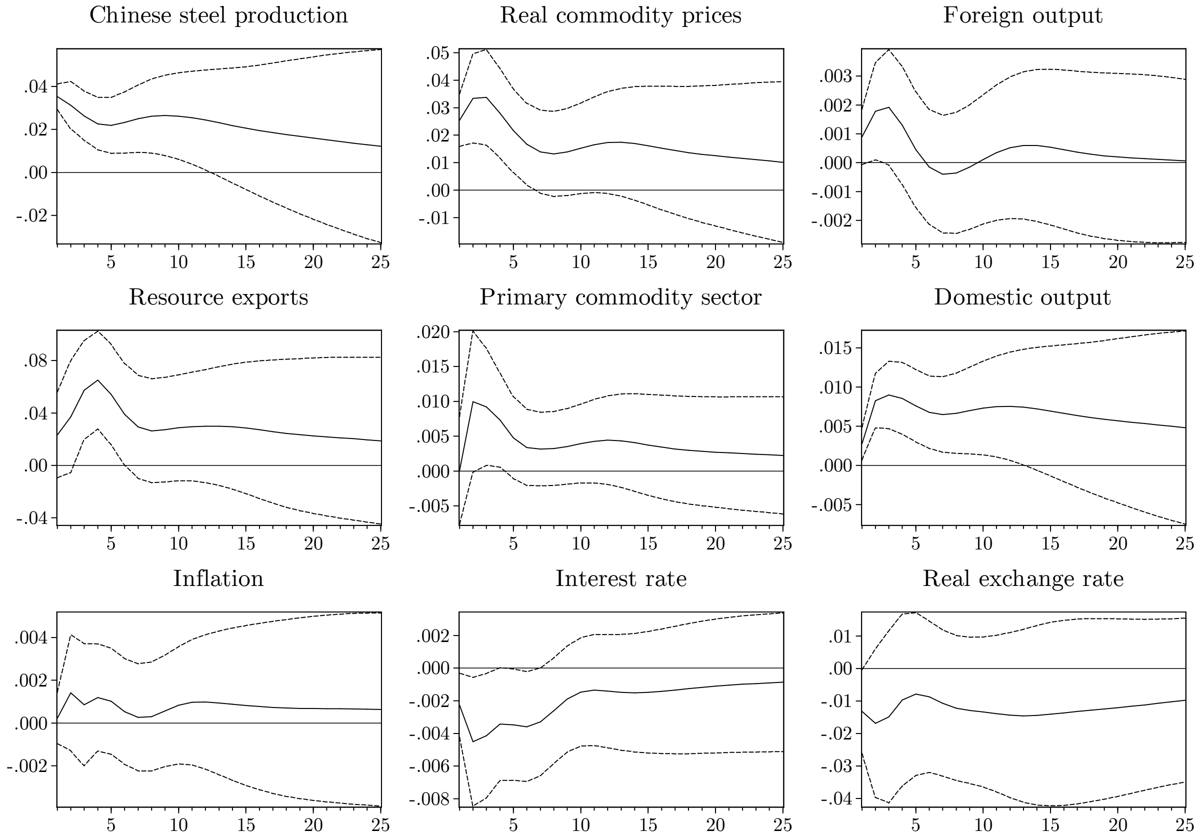

Figure 41 – Impulse response functions to a shock to Chinese steel production for the model with commodity boom period, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

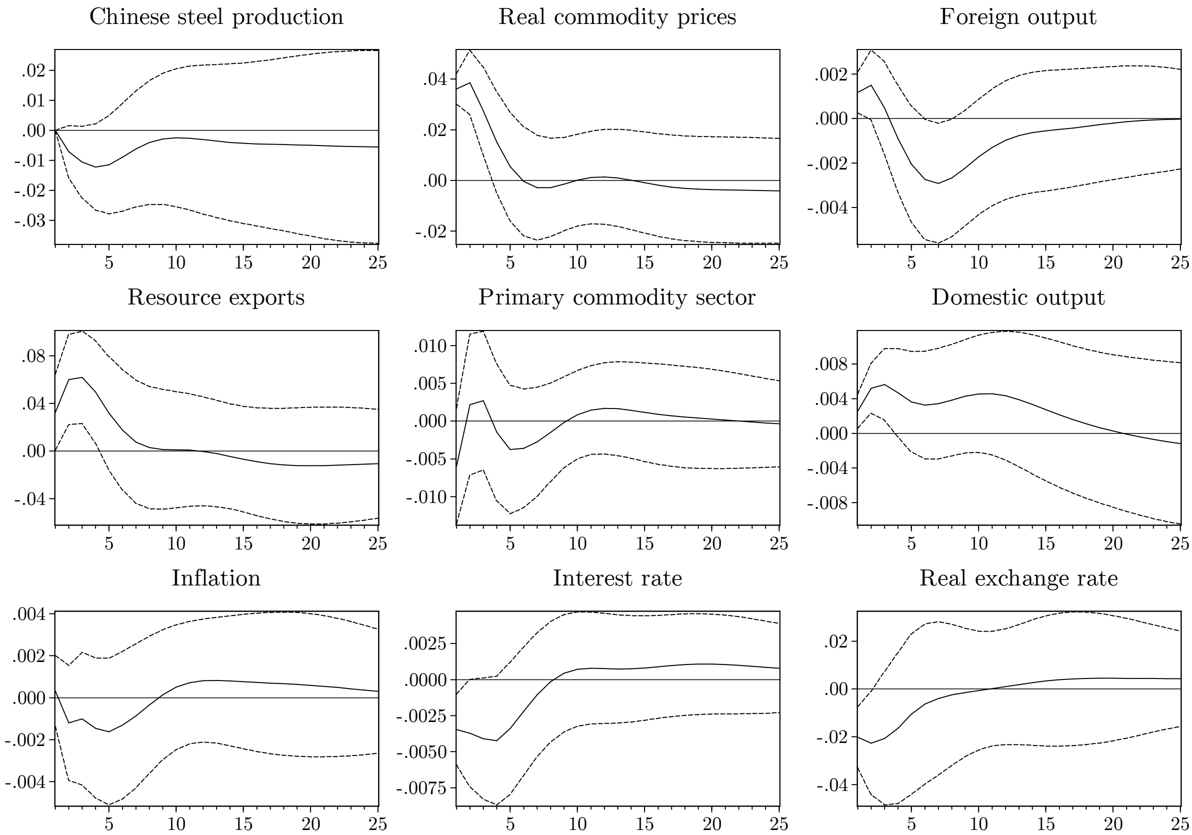

Figure 42 – Impulse response functions to a shock to commodity prices for the model with commodity boom period, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

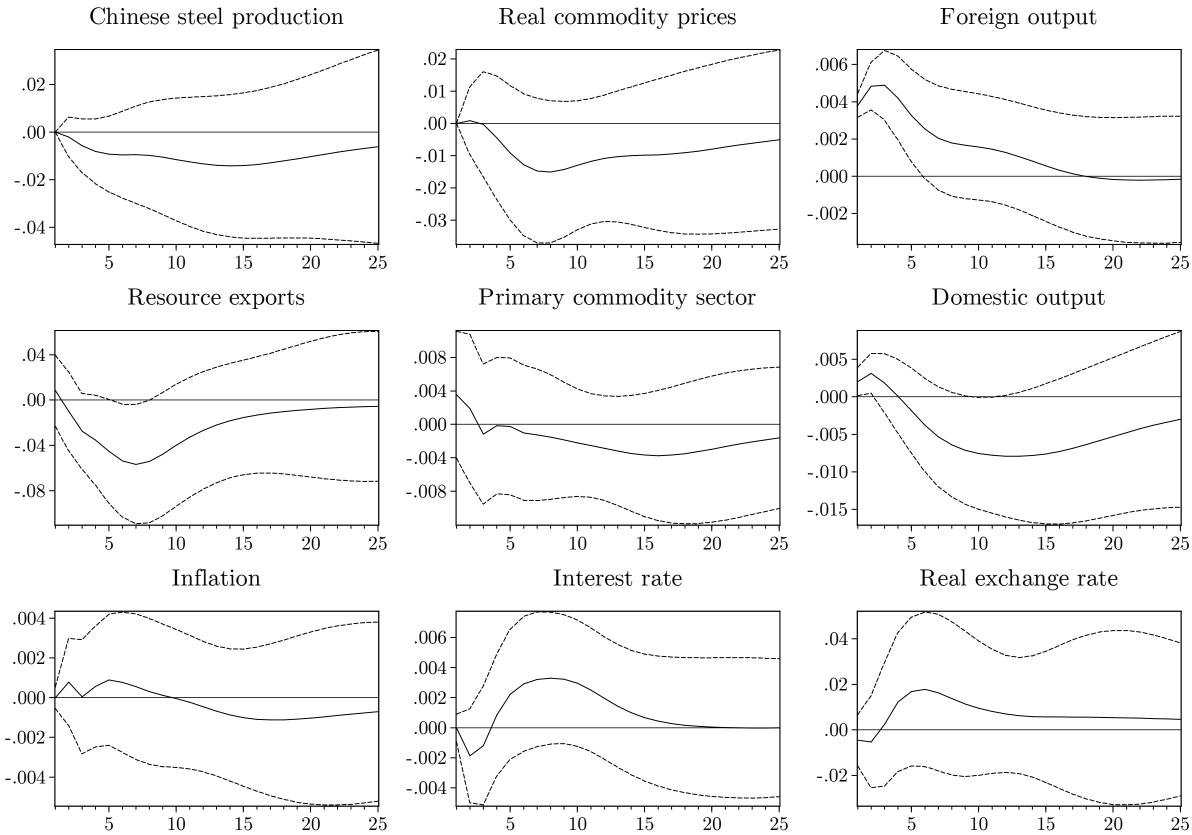

Figure 43 – Impulse response functions to a shock to foreign output for the model with commodity boom period, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

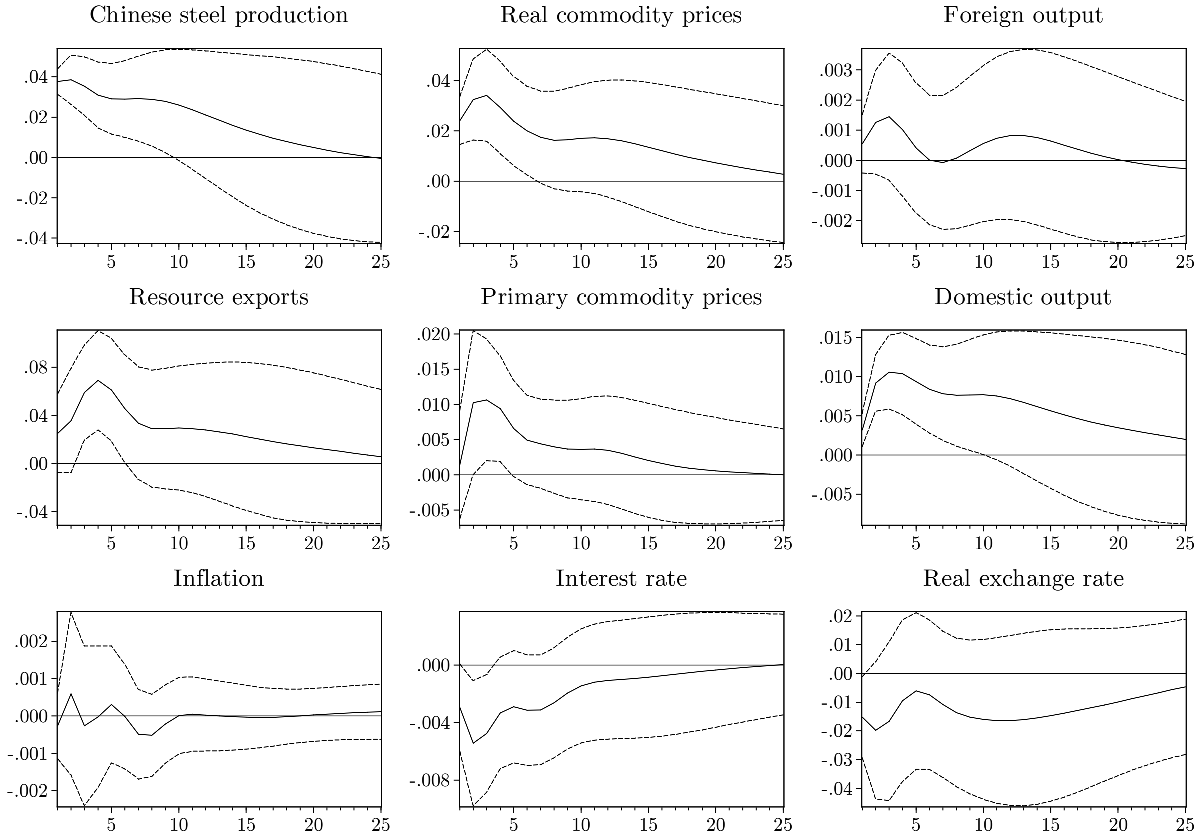

Figure 44 – Impulse response functions to a shock to Chinese steel production for the model without restriction in the interest rate, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

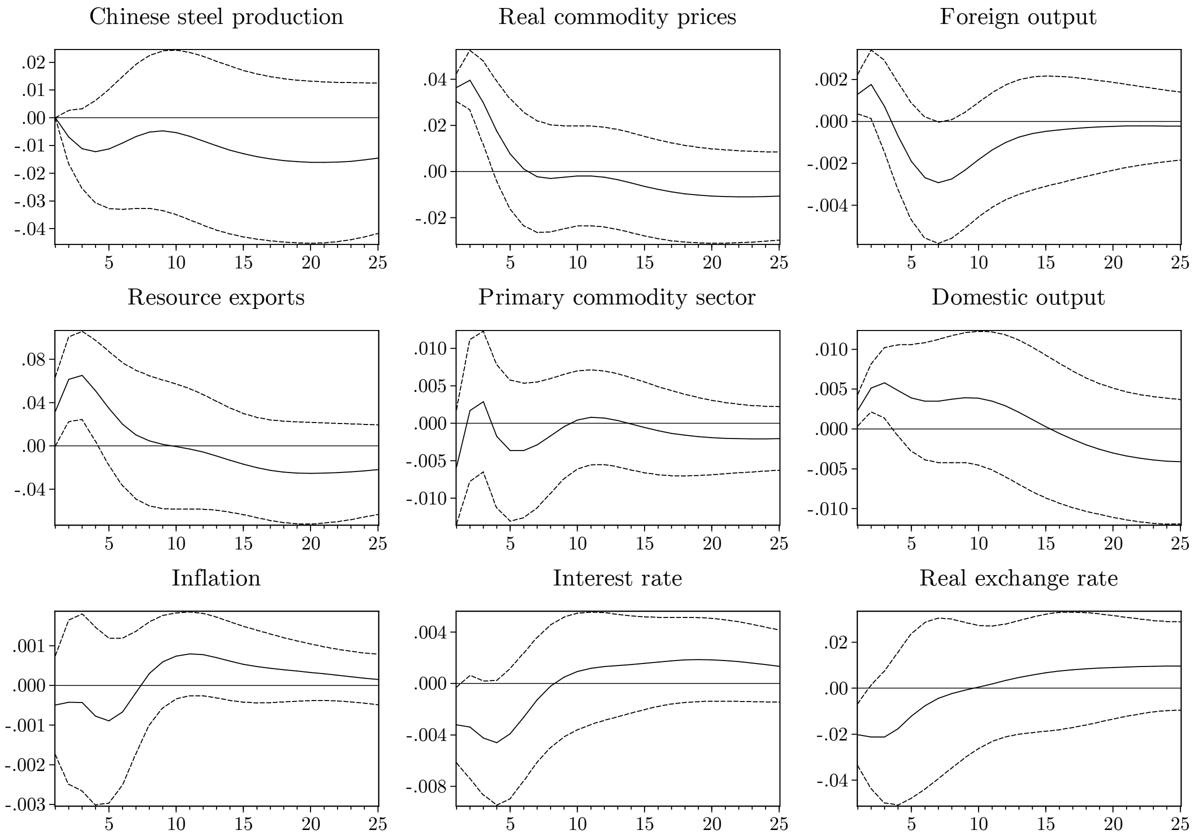

Figure 45 – Impulse response functions to a shock to commodity prices for the model without restriction in the interest rate, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

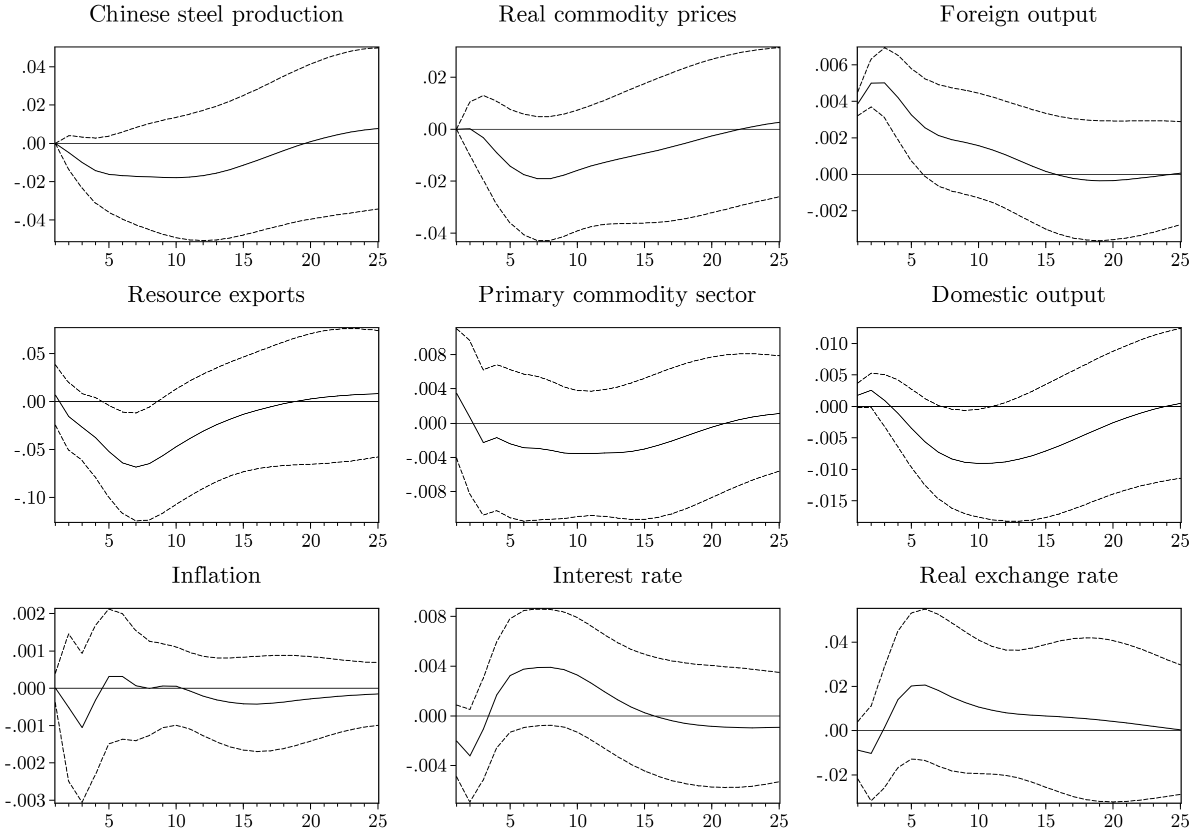

Figure 46 – Impulse response functions to a shock to foreign output for the model without restriction in the interest rate, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

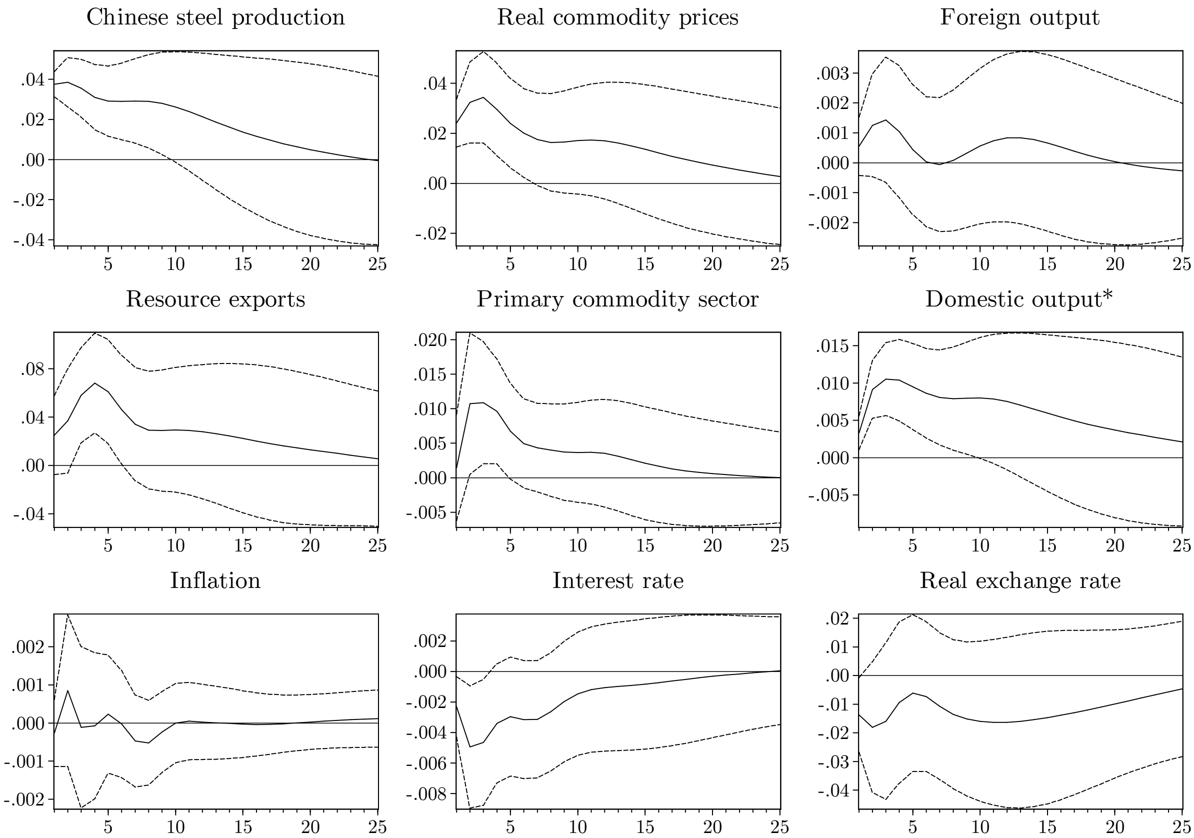

Figure 47 – Impulse response functions to a shock to Chinese steel production for the model with domestic output minus primary commodity sector, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

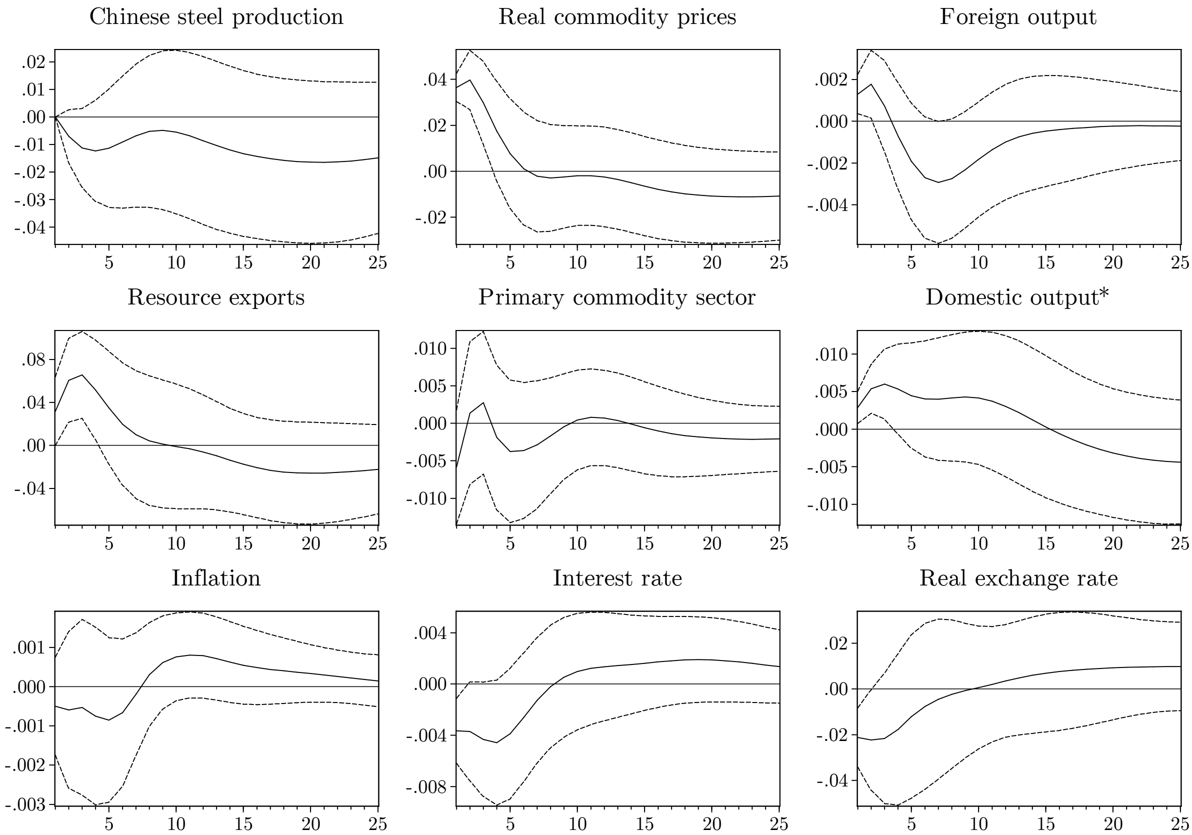

Figure 48 – Impulse response functions to a shock to commodity prices for the model with domestic output minus primary commodity sector, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

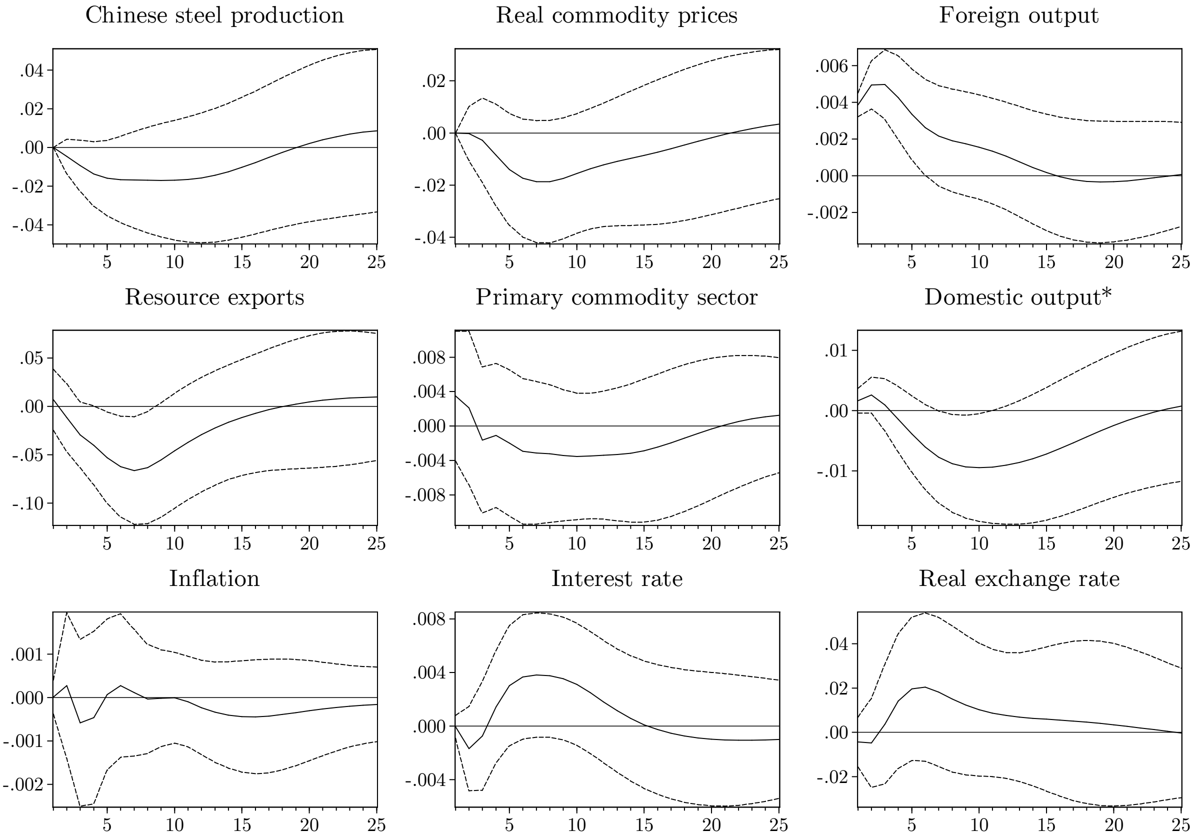

Figure 49 – Impulse response functions to a shock to foreign output for the model with domestic output minus primary commodity sector, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

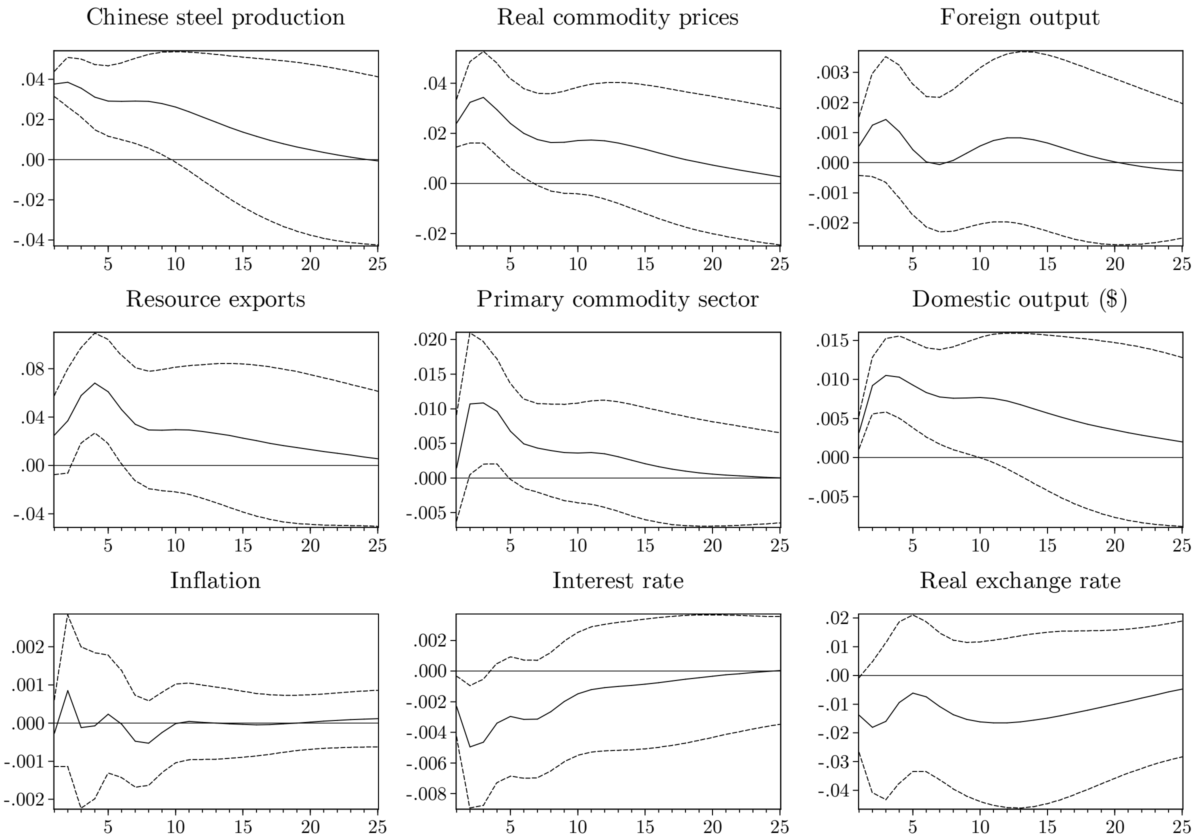

Figure 50 – Impulse response functions to a shock to Chinese steel production for the model with domestic output in dollar, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

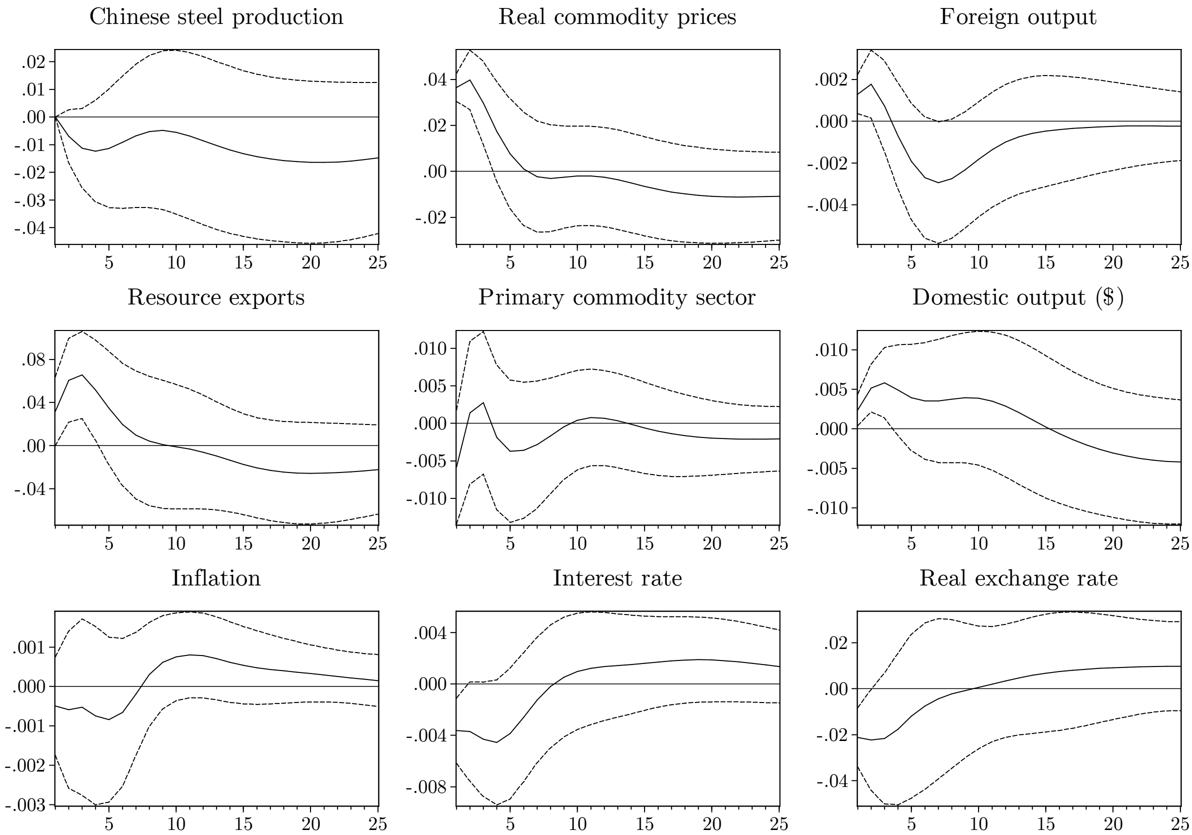

Figure 51 – Impulse response functions to a shock to commodity prices for the model with domestic output in dollar, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

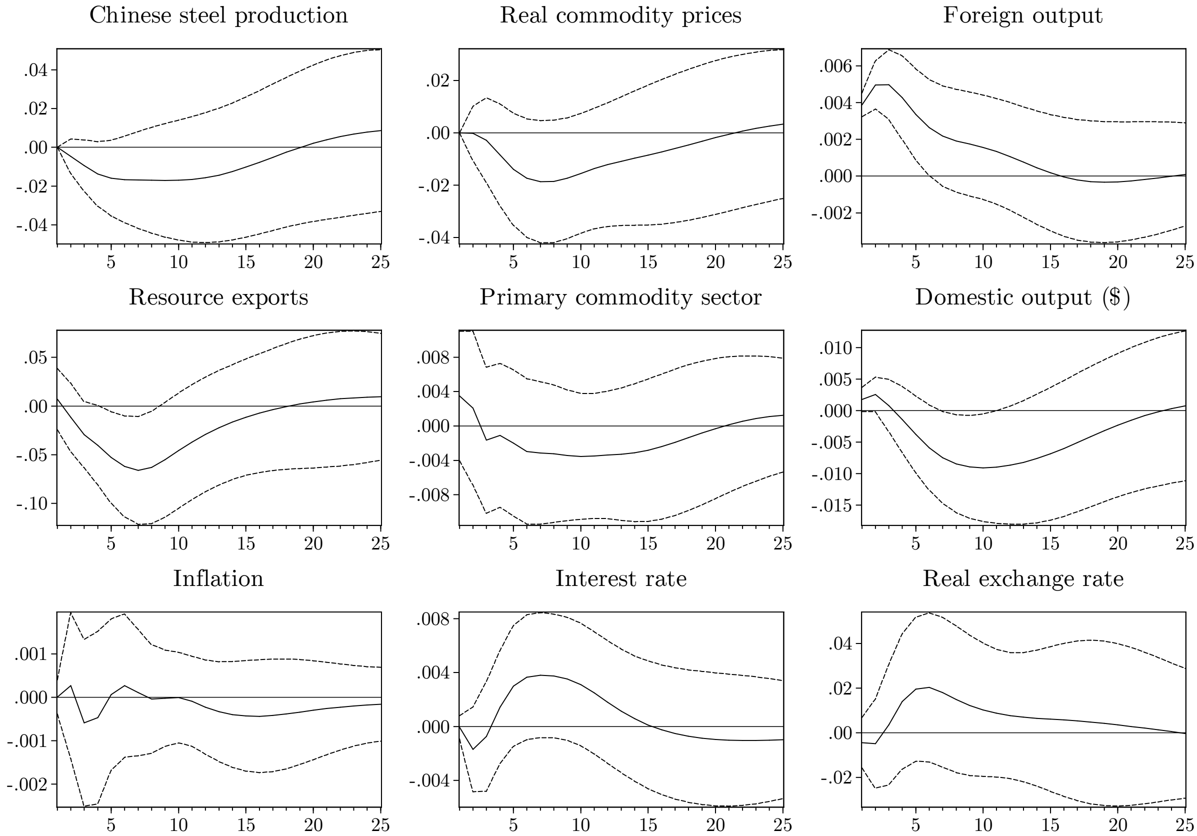

Figure 52 – Impulse response functions to a shock to foreign output for the model with domestic output in dollar, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

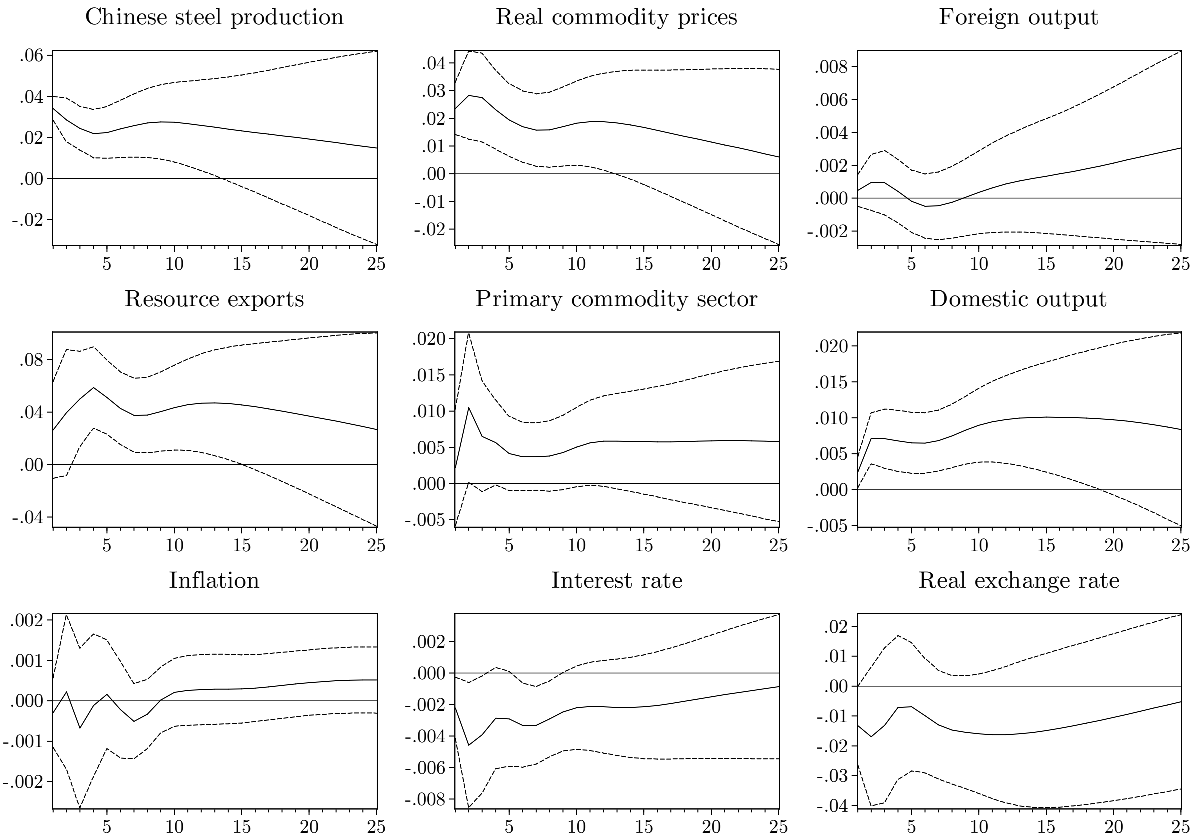

Figure 53 – Impulse response functions to a shock to Chinese steel production for the model with variables non-detrended, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

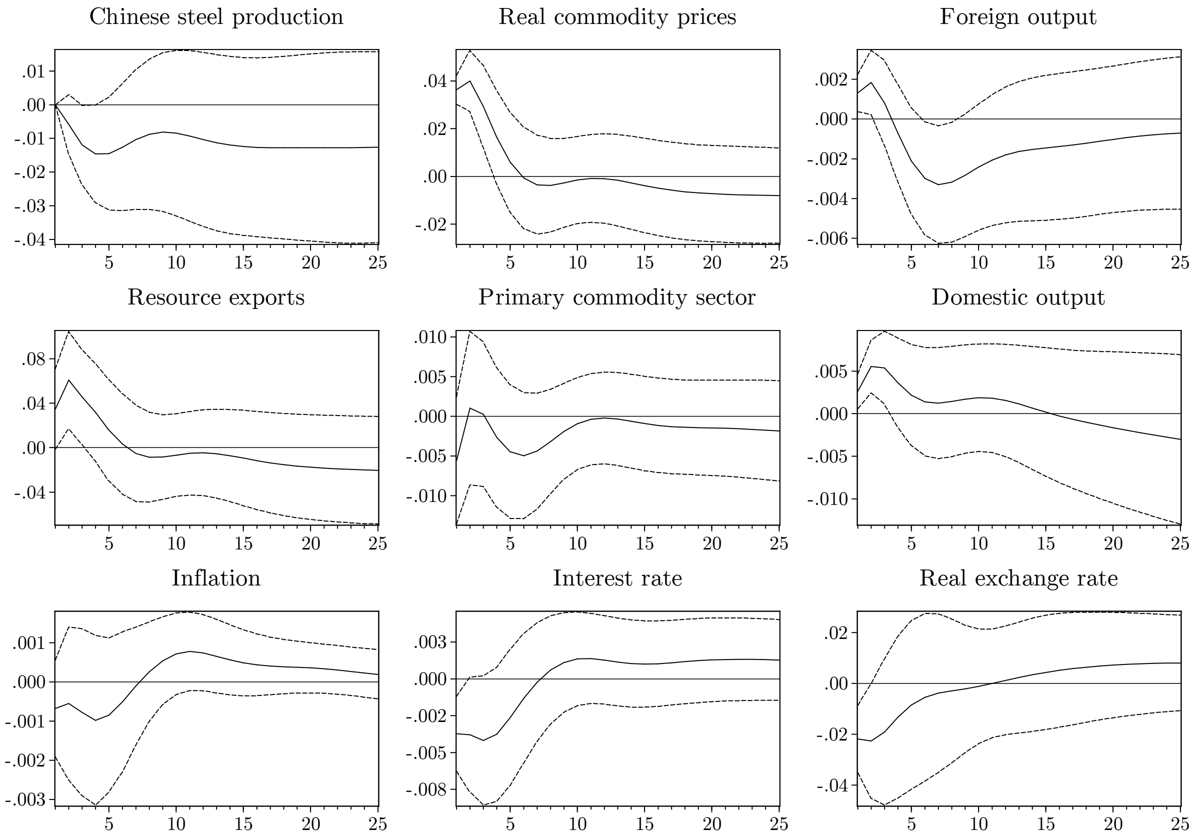

Figure 54 – Impulse response functions to a shock to commodity prices for the model with variables non-detrended, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.

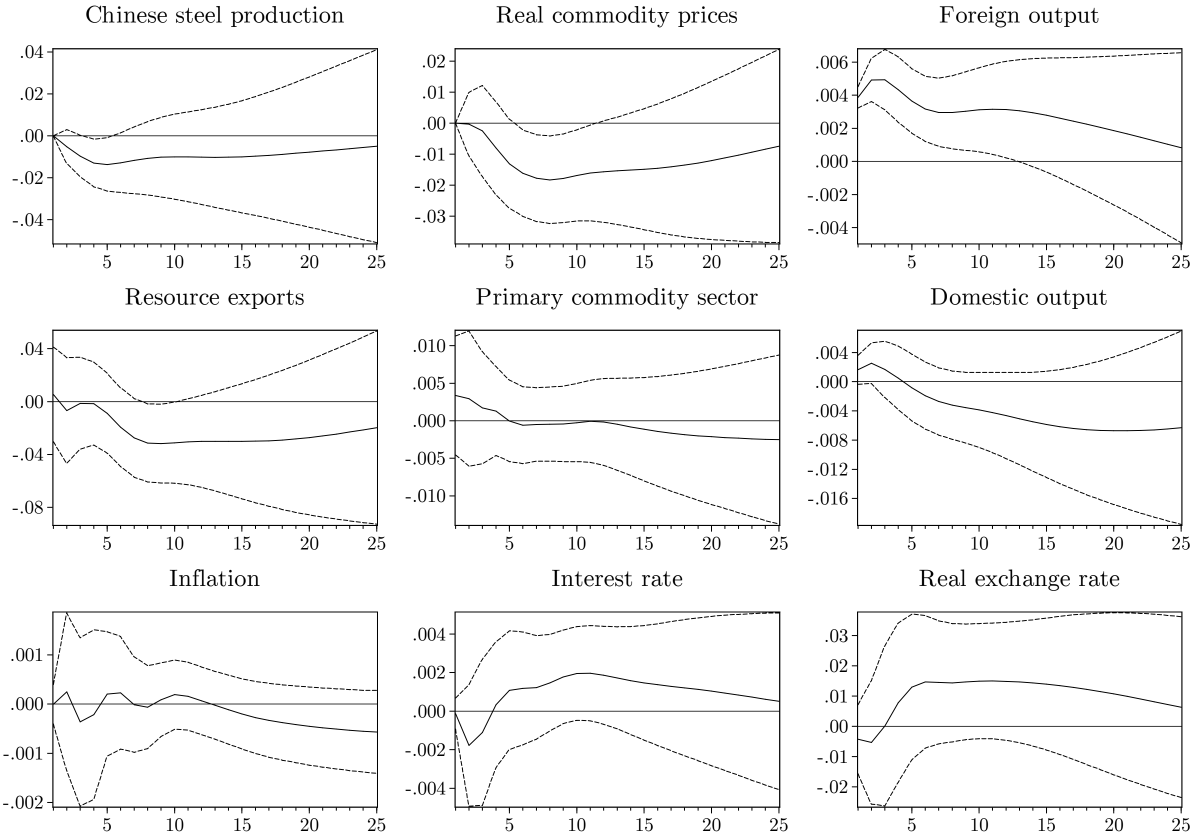

Figure 55 – Impulse response functions to a shock to foreign output for the model with variables non-detrended, 1999Q1 to 2017Q1. Dashed lines are the 90 percent confidence intervals.