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World shocks and commodity price fluctuations: evidence from resource-rich economies

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Abstract

We identify world shocks driving up real commodity prices in a Bayesian dynamic factor model setting using a minimum set of sign restrictions complemented with constrained short-run responses. We find that a world trade shock explains the lion's share of commodity price and commodity currency fluctuations, besides shaping the real business cycle in resource-rich economies. However, according to the asymmetric level of economic development of countries and to the intensity of trade activities, different reactions to global disturbances are estimated. We also show that shortage of energy products in exports is responsible for small effects of world commodity shocks on the domestic economy. Finally, our findings suggest that the non-tradable sector benefits from resource price boosts, in line with the Dutch disease theory linked to this type of economies.

Keywords: Real commodity price; world shocks; resource-rich economies; business cycle; dynamic factor model.

JEL Classification: C32, Q02, E32.

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1 Introduction

Not all real commodity price surges are alike! Indeed, though primary commodity dynamics play a significant role to outline the effects of world fluctuations on the economy, consequences from real resource price disturbances can be different for several reasons. For example, the nature of real commodity price movements might be a key point behind specific variations: real commodity price adjustments dragged by international demand shocks or by global commodity shocks usually generate distinct impulses; therefore, considering only commodity-specific shocks as drivers of real resource prices can be restrictive from an analytical and from a policy point of view.

The objective of the paper is to study the different sources of real commodity price[1] movements originating at global level (henceforth, 'world' and 'global' are used interchangeably) and their effects on resource-rich economies (henceforth, RREs), using Australia and South Africa as illustrative instances. The identification of world shocks is performed through the employment of a minimum set of sign restrictions. The decision to use various shocks is substantiated by two reasons: first, it helps to reliably approximate the state of the global economy with the aim to capture core and meaningful events; second, it enables to clearly manage the problem of non-uniqueness of the identified shocks that arises when sign restrictions methodology is applied (cf. Fry and Pagan, 2011). In fact, whilst notably relevant when only one shock is identified, the so-called "multiple shock problem" is arguably less serious with numerous shocks (see also Furlanetto et al., 2019).

The two case studies, i.e. Australia and South Africa, appear to be particularly insightful when research questions on the effects of world fluctuations are addressed; some facts undeniably justify this choice. First, their leading position as exporters of commodity products over the last decades makes their business cycle tremendously connected to episodes that take place on international (commodity) markets. Second, the recent and rapid growth of many trading partners, especially emerging countries like China, can be source of a number of global fluctuations which effectively impact the domestic economy; more precisely, exports to China represent 33%

[1] For the rest of the paper, commodity price refers to real commodity price, if not otherwise specified.

of Australia and 18% of South Africa's exports in 2016.[2] It is worth to additionally consider that, since the beginning of the 2000s, the contribution of trading activities to the overall GDP (openness) and the terms-of-trade have risen by more than 40% and 30%, respectively, in the two countries, thereby enhancing their dependence on the global business cycle.[3] Figure 1 plots the degree of openness together with the exported commodities as share of total exports over the sample periods; the uphill path depicted by the degree of openness displays a positive correlation with the trajectory of the percentage of coal and (mostly) iron exported for Australia and platinum exported for South Africa.[4] Another remarkable feature of the resource-trade activities relies on the negligible fraction of oil exported, which we show to be of vital importance to interpret a good portion of empirical findings. Motivated by these elements, we specifically examine the propagation mechanism of world commodity price movements on a sizeable group of macroeconomic variables in the two RREs, distinguishing appropriately the underlying global shock which triggers spikes in real resource prices.

This paper proceeds following two consecutive stages, i.e. methodological and analytical. In the first methodological stage we build the econometric framework. Consistently with the literature and the reliability of the approach, the econometric scheme is developed borrowing from the general structural VAR (SVAR) setup. The challenge of identication of world shocks is specifically faced through the employment of a two-blocks dynamic factor model (Boivin and Giannoni, 2009; Mumtaz and Surico, 2009), which, by construction, enables to manage massive datasets; this framework, combined with a set of sign restrictions associated with additional constraints imposed on the impact matrix, allows to identify four world shocks pushing up real commodity prices:[5]

- A *world demand shock* can be intended as a collection of circumstances which stimulate or depress the economy as a whole. A positive world demand shock is associated with a

[2]Exports to China together with exports to Japan, Korea and Hong Kong, represent more than 50% and 30% of, respectively, Australian and South African exports. Details concerning trading partners can be found on the Observatory of Economic Complexity (OEC) website.

[3]Data on trade openness are gathered from the Penn World Table; statistics related to terms-of trade can be downloaded from the OECD website.

[4]The correlation between percentage of platinum exported and openness is 0.80 in the period 1993-2010. The correlation falls to 0.51 when the whole sample period is considered. The uncorrelated dynamics of the two series after 2010 can be easily noted by observing Figure 1.

[5]It is worth mentioning that to provide a robust comparison, all the shocks will be then standardized such that they increase real commodity price by one standard deviation.

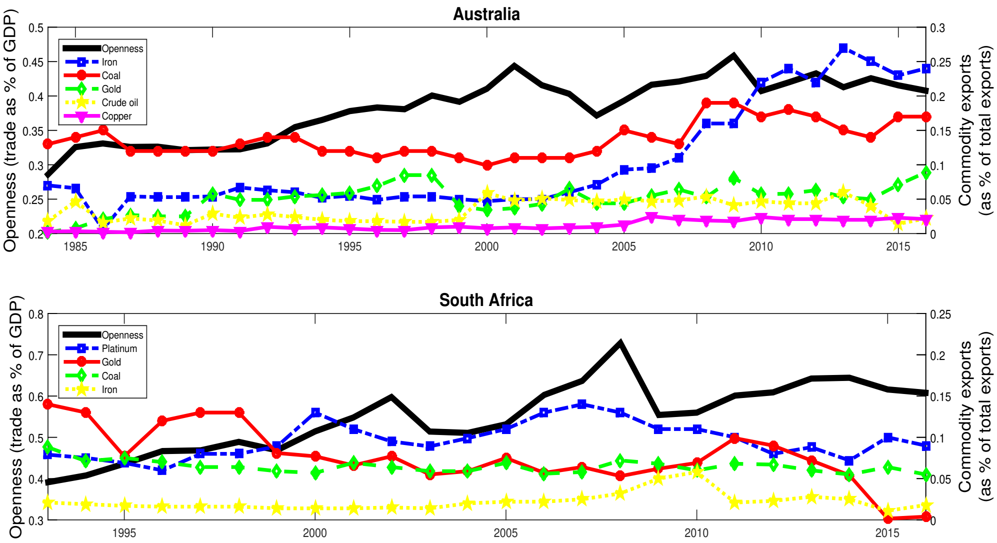

Figure 1: Openness (left y-axis) and commodity procuts exports (right y-axis) for Australia (1984-2016) and South Africa (1993-2016).

Source: Penn World Table (openness) and OEC (commodity exports).
Notes: Yearly data.

surge in global real activities, real commodity prices, inflation rates and interest rates.

- A *world commodity shock* driving up real commodity prices is considered as an event which takes place in commodity markets and increases demand for commodities (speculative or protective strategies), while reduces supply; alternatively, it can be seen as an episode taking place in commodity-producing countries that decreases the stock of resources (commodity-specific industries slowdown, conflicts, weather and environmental catastrophes). A commodity price boom produces negative effects on world real activities and boosts inflation. This shock can be interpreted as a commodity-specific shock.

- A *world trade shock*, induced by a decrease in trade tariffs and weaker market regulation, increases commodity products' circulation and price; a positive reaction of world industrial production puts downward pressure on inflation.

- A *world monetary shock* consists of a general reduction in international interest rates to stimulate economic growth that encourages real commodity price dynamics and inflation.

In the second (analytical) stage we deal with the economic analysis of the identified structural model. Starting from the estimated world factors, moving to highlight the role of shocks to explain international and, mostly, domestic fluctuations, the paper develops providing interesting and consistent evidence on RREs.

In particular, our results overall show that a considerable share of volatility in domestic business cycle(s) has to be attributed to world shocks (Aastveit et al., 2016); asides from that, identification of world trade shocks proves to be a key point of the empirical analysis, being the main drivers of real commodity prices and commodity currencies fluctuations. We estimate that world trade shocks give rise to other relevant responses at real level, albeit large domestic macro variables reactions are also detected subsequently to a world demand shock. This holds true especially for Australia, which actually reaps benefits mostly after a world demand shock and, to a lesser extent, a world trade shock. World commodity shocks are found (1) to explain the smallest share of fluctuations and (2) to have asymmetric effects on the two RREs; the former is due to the meaningless presence of oil products in exports of the two economies; the latter is connected to the fact that a world commodity shock reducing resources supply is positively correlated with domestic improvements mainly (only) in developing countries (Aastveit et al., 2015; Caldara et al., 2019); in fact, for Australia, non-positive effects are estimated. As it is common to verify the presence of Dutch disease effects inside a RRE when structural shocks take place, the empirical discussion ends with this focus. In Australia, after a world commodity shock, non-tradable industries improve, whereas tradable sectors contract as predicted by the Dutch disease theory; commodity-related sectors' worsening confirms the presence of a mining boom which depresses trading activities (Corden, 2012); however, for South Africa, no Dutch disease effect arises since sectors expand, corroborating general advantages stemming from world fluctuations. As our findings suggest, distinguishing between commodity and non-commodity tradables is crucial to highlight contrasting reactions which world shocks trigger on sectors, stressing the relevance of the commodity channel to shape specific impulses. Finally, the validity of the results is tested through a number of robustness checks.

This paper is part of the literature related to the study of world shocks and real commodity price fluctuations, and their effects. The dynamics displayed by resource prices during the 2008 financial crisis and other significant periods (the oil glut in the second half of the 1980s and the East Asian financial crisis, among the others) connotes them as important indicators to monitor global and national economic activities. Indeed, a considerable bulk of contributions which takes into account commodity price movements is entering the literature on SVAR. Most of the research is connected to the identification of shocks originating in the energy market - especially oil - together with shocks from other international contexts. While most of the studies are concentrated on resource-importing countries, like the US (Kilian, 2009; Kilian and Murphy, 2012; Lippi and Nobili, 2012), a strand of the literature focuses on oil-exporting economies. To this aim, some applications are provided for Canada, a textbook example of commodity economy, whose energy products dominate export activities (Maier and Vasishtha, 2013; Charnavoki and Dolado, 2014). A more recent contribution by Bjørnland and Thousrud (2016) highlights the difference of a resource supply boom with respect to a negative commodity shock in Australia and Norway, showing that the weight of the domestic oil sector is a factor that should not be neglected. The rest of the literature concentrates on oil-specific shocks; Peersman and Van Robays (2012) study the effects of different oil shocks (price, demand, supply) on a set of oil-importing and oil-exporting economies; Aastveit et al. (2015) analyze the economic fluctuations of oil demand and oil supply shocks on a number of developed and developing economies; similarly, Caldara et al. (2019) observe the impulse induced by oil demand and supply shocks on advanced and emerging markets, estimating a positive reaction of industrial production in the latter (in line with Aastveit et al., 2015).[6] Van Robays (2016) highlights that the presence of nonlinearities in uncertainty is responsible for asymmetric effects of oil shocks. Kilian et al. (2009) show the reactions of several external balance variables, i.e. the oil trade balance, non-oil trade balance, current account and changes in net foreign assets, for a number of countries, including controls for regional aggregates. Since the introduction of Factor-Augmented VAR (FAVAR) models by Bernanke et al. (2005), the employment of dynamic factor models to study the transmission mechanism of international shocks has been getting increasing attention. Given their economic structure, business cycles for small open economies are investigated using *ad hoc* specifications of global dynamic factor models. Initially, Mumtaz and Surico (2009), Boivin and Giannoni (2009), and Liu et al. (2014) specify a two-blocks dynamic factor models to identify common global factors and their contributions to domestic fluctuations. Aastveit et al. (2016) extend the model to include an additional block containing common sub-global

[6] Oil demand and oil supply shocks in Caldara et al. (2019) are identified using an instrumental variable approach.

factors to emphasize the dependence of small open economies on regional events.

The rest of the paper is organized as follows. Section 2 illustrates the methodological approach, which consists of the description of the empirical framework, the data, the estimation procedure and the identification of structural world shocks. Section 3 concerns the analytical stage and reports the results for the global economy and the effects of world shocks on the two RREs. Section 4 describes the outcomes for a number of robustness checks. Section 5 concludes.

2 Methodology

2.1 Dynamic factor model

The empirical model is built upon a two-blocks dynamic factor model (Boivin and Giannoni, 2009; Mumtaz and Surico, 2009; Charnavoki and Dolado, 2014): the first block outlines the global business cycle, whereas the second one refers to the domestic economy. Therefore, one model for each RRE is estimated. A number of latent factors is extracted from a panel of series related to the two blocks and they aim to empirically cover the main developments occurred over the sample period. In particular, the two blocks of latent variables are $(\mathbf{F}_t^{W'}, \mathbf{F}_t^{D'})$, where the superscripts W and D indicate world and domestic economy, respectively. On one hand, the vector of the global economy, $\mathbf{F}_t^{W'}$, comprises four world factors, namely a world economic activity factor, $F_{Y,t}^{W'}$, which captures the occurrences of the global real activity; a world real commodity price factor, $F_{C,t}^{W'}$, describing the global commodity market dynamics; a world inflation factor, $F_{\Pi,t}^{W'}$, which depicts world prices evolution; a world interest rate factor, $F_{IR,t}^{W'}$, used as item for expansionary or restrictive monetary policies. On the other hand, the vector for the RRE, $\mathbf{F}_t^{D'}$, is built on a number of factors extracted from national series (e.g. output, consumption and price-related series, among the others) and employed to get a reliable picture of the business cycle in Australia and South Africa. Specifically, two domestic factors are extracted, according to the outcomes of the IC_{p2} criterion by Bai and Ng (2002).[7] Given the small number of domestic factors extracted, it is convenient to consider the first factor as a good approximation of the real domestic business cycle.

[7]The criterion by Bai and Ng (2002) suggests to consider two domestic factors for each country.

The model is composed by two equations: an observation equation, which describes the relation between the unobserved factors and the different sets of variables, and a transition equation that connotes the dynamics of the latent factors. Respectively

$$\begin{pmatrix} \mathbf{X}^W_{Y,t} \\ \mathbf{X}^W_{C,t} \\ \mathbf{X}^W_{\Pi,t} \\ \mathbf{X}^W_{I,t} \\ \mathbf{X}^D_t \end{pmatrix} = \begin{bmatrix} \Lambda^W_Y & 0 & 0 & 0 & 0 \\ 0 & \Lambda^W_C & 0 & 0 & 0 \\ 0 & 0 & \Lambda^W_\Pi & 0 & 0 \\ 0 & 0 & 0 & \Lambda^W_I & 0 \\ \Lambda^D_Y & \Lambda^D_C & \Lambda^D_\Pi & \Lambda^D_I & \Lambda^D \end{bmatrix} \begin{pmatrix} F^W_{Y,t} \\ F^W_{C,t} \\ F^W_{\Pi,t} \\ F^W_{I,t} \\ \mathbf{F}^D_t \end{pmatrix} + \begin{pmatrix} \mathbf{e}^W_{Y,t} \\ \mathbf{e}^W_{C,t} \\ \mathbf{e}^W_{\Pi,t} \\ \mathbf{e}^W_{I,t} \\ \mathbf{e}^D_t \end{pmatrix} \tag{1}$$

and

$$\begin{pmatrix} \mathbf{F}^W_t \\ \mathbf{F}^D_t \end{pmatrix} = \begin{bmatrix} \beta^W(L) & 0 \\ \beta^D_W(L) & \beta^D(L) \end{bmatrix} \begin{pmatrix} \mathbf{F}^W_{t-p} \\ \mathbf{F}^D_{t-p} \end{pmatrix} + u_t \tag{2}$$

In equation (1) X^W_t and X^D_t refer to world and domestic series; F^W_t and F^D_t indicate the latent factors extracted from world and domestic data, related to the observable series through the loadings $\Lambda^W$and Λ^D; $e^W_t$and e^D_t are i.i.d. errors such that $E(e^W_t) = E(e^D_t) = E(e'_t F_t) = 0$. The restricted structural VAR in equation (2) consists of latent factors, its lags up to finite order p loaded by respective lag polynomials $\beta^{W,D}(L)$ and reduced-form residuals u_t, which are assumed to be $u_t \sim N(0, \Omega)$ with $u_t = B_0 \epsilon_t$, where $\Omega = B_0 B'_0$ and ϵ_t is a normally distributed structural shock with zero mean and variance I. What is worthwhile to be noticed is that the global factors are included in the last row of equation (1) to explicitly be considered, together with the domestic factors, as drivers of the business cycle in the RRE; conversely, domestic shocks in equation (2) are assumed to have delayed effects on world factors.

2.2 Data

In this section we provide details about the data employed. The data are collected at quarterly frequency and they span the period comprised between 1984:II and 2016:II for Australia and 1993:I and 2016:II for South Africa; the series are gathered from different databases (International Monetary Fund, World Bank, OECD, FRED, Australian Bureau of Statistics, Reserve Bank of Australia and South African Reserve Bank). The data depicting the world block refer to the international economy via world and country aggregates (OECD, European Union and G7), next to single economies that are large enough to impact the global business cycle, i.e. the US. As shown in the empirical model section, the series collected for the foreign block allow to extract four factors: the world real activity factor is extracted from data on GDP, industrial production index, exports and imports; the world real commodity price factor is obtained from a group of five indices of commodity price aggregates, namely oil, metals, industrial, agriculture and beverage; the world inflation factor is measured by consumer price indices and GDP deflators and the world interest rate factor included in the model to control for global monetary policy is extracted from the US federal funds rate and the EU overnight rate (due to the short availability of data on world interest rates, especially in terms of time observations). Data for the RREs are not collected according to the "the more, the best logic": as suggested by Boivin and Ng (2006) and Caggiano et al. (2011), we pick the most representative (to our knowledge) series featuring and capturing the Australian and South African state of the economy; they range from real activity indicators to consumer and producer prices and interest rates, presumably allowing for a reliable approximation of the domestic business cycle. Before estimating the model, we difference non-stationary variables and we demean and standardize all the variables.[8]

2.3 Estimation strategy

The estimation procedure is conducted through a two-step principal component analysis, where, in the first step, the main principal components are extracted from the global and domestic series and, in the second step, factors are employed in the restricted VAR. The two-step principal component analysis is borrowed from previous works by, among the others, Boivin and Giannoni (2009) and Mumtaz and Surico (2009). In particular, in the first step, an iterative procedure is performed: starting from an initial estimate of the domestic principal component F_t^D, extracted from the domestic observed series and denoted by $F_t^{D,0}$, the iteration procedure advances as follows:

1) we regress the domestic variables X_t^D on $F_t^{D,0}$ and on estimates of the global factors

[8]The variables are taken in log difference $[\log(X_t) - \log(X_{t-1})]$; only the trade balance (as % of GDP), the current account balance (as % of GDP) for the domestic block and the interest rates at global and domestic level are not differenced or taken in log.

to obtain the foreign and domestic loading matrices;

2) we compute $X_t^{D,0}$as the residuals vector from the regression;

3) we estimate $F_t^{D,1}$ as the first domestic principal component of $X_t^{D,0}$;

4) we repeat steps 1), 2) and 3) until achieving convergence in $F_t^{D,j}$.

This approach allows to verify that the international factors are truly common components since they should be captured by the principal component of the domestic series. This is connected to the model specification, where the international factors are imposed to be included in the principal component for the domestic block of the model. The second step of the procedure regards the Bayesian estimation of the restricted VAR with 6 variables (4 world factors and 2 domestic factors). Following Furlanetto et. al (2019), a Normal-Wishart posterior distribution for the OLS estimates of the VAR parameters is assumed; as suggested by the AIC criterion, the sufficient number of lags p to properly control for factors dynamics is $p = 2$.[9] Concerning the measurement equation's parameters, we assume an Inverse-Normal-Gamma distribution. Additional details concerning the estimation procedure are provided in Appendix.

2.4 Identification of shocks

The identification of shocks always represents an issue to be convincingly discussed. The procedure adopted here is twofold. It relies on the employment of the rotation procedure which allows to impose sign restrictions on the estimated impulse-response functions of world factors (Rubio-Ramirez et al., 2010) and coupled with additional quantitative short-run constraints. The procedure starts with drawing a non-singular parameter matrix B_0; we then apply the Choleski decomposition, so that B_0 is taken to be lower triangular; being K the number of global factors, we draw a $K \times K$ independent normal standard matrix Z with distribution $Z \sim MN(0, I_{K^2})$; a QR decomposition is performed on Z, such that $Z = QR$; therefore, a set of candidate impulse-response functions (henceforth, IRFs) is obtained from B_0Q and β and discarded if they do not satisfy sign restrictions imposed; if so, a new matrix Z is drawn and the procedure is repeated until signs are matched (additional details are reported

[9]AIC criterion is checked for both models.

in Appendix). Sign restrictions are displayed in Table 1 and they are imposed to be satisfied along the first year (Kilian, 2009; Charnavoki and Dolado, 2014); signs imposed replicate those coming from the relevant literature (Peersman, 2005; Peersman and Straub, 2006; Charnavoki and Dolado, 2014). As anticipated in the previous sections, a world demand shock increases real activities, real commodity prices, inflation and interest rates; a world commodity shock leads to a contraction of real activities[10], while it boosts real commodity prices and inflation; the latter, instead, contracts when a world trade shock occurs, driving up the real activity factor and the real commodity price factor; finally, a world monetary shock is associated with a reduction in interest rates which pushes real activities, real commodity prices and accelerates inflation. A classical problem associated with this identification procedure is that it does not produce point estimates of the IRFs; instead, it generates results which derive from several different structural models. A further restriction is imposed as follows. Functions that do not fail the signs test are also evaluated according to a supplementary limitation to which the elements of the impact matrix B_0 are constrained; in particular, combining Hamilton (2009) and Kilian and Murphy (2012),[11] we assume a small negative elasticity (between -10% and 0%) of the world real activity factor to a world commodity shock in the short term; hence, those models which generate functions not complying with this additional constraint are also rejected.

3 Empirical results

The empirical findings are organized in two main sections. The first concerns the evidence related to the global economy to verify the reliability of the estimated global environment, before proceeding towards the analysis of the transmission mechanism of world shocks on RREs. Precisely, the second section reports the effects of world shocks on domestic business cycles for RREs. The results are focused on their real effects and highlight the reaction of (1) GDP and its components, (2) additional relevant variables, e.g. inflation and current account, and (3) individual industries in terms of GDP and employment. The reactions of the different

[10] A world commodity shock driving up real resource prices and reducing resources supply induces a worsening in advanced economies' real activities (Aastveit et al., 2015; Caldara et al., 2019), which are assumed to be the main drivers world real activities in the two models.

[11] To be precise, Hamilton (2009) finds a negative correlation between commodity price and real activities, while Kilian and Murphy (2012) assume a small reaction of world real activities to a commodity shock.

	Demand	Commodity	Trade	Monetary
Real activity	+	-	+	+
Real commodity price	+	+	+	+
Inflation	+	+	-	+
Interest rate	+	NR	NR	-

Table 1: Sign restrictions imposed on the IRFs of world factors.

Notes: The table shows the response of each world factor (rows) to world shocks (columns). NR indicates that no restrictions are imposed on the response of the factor to the specific shock.

factors and variables to world shocks are studied through the observation of IRFs for horizons $h = 1, ..., 32$; the IRFs graphs contain the median variable response and, when applicable, an interval of acceptability of 68%.

3.1 Evidence from the global economy

Estimated world principal components. The empirical analysis begins with the chart of the estimated principal components depicting the global economy. Figure 2 reports the world real activity, real commodity price, inflation and interest rate principal components together with main the global economic downturns as classified by the OECD. It is evident that the estimated principal components (1) closely match global specific events and (2) are shaped according to their own and distinctive dynamics. For example, as for the latter, the Great Recession represents the main downturn for world economic activities (Boivin and Giannoni, 2009, among the others), whereas world inflation, as well as world interest rate, has strictly decreased since the 1980s.

World shocks and world reactions. Figure 3 summarizes the responses of the global factors to world shocks for the Australia and South Africa's estimated model. The IRFs present (1) statistically significant reactions of the factors[12] and (2) either qualitatively and quantitatively very similar responses from the two models. It is worth highlighting that a world demand shock

[12] Only world trade shocks appear to have a negligible effect on the world interest rate factor.

is beneficial for the economy as a whole because it generates a stimulating environment where economic activities proliferate, real commodity prices boost and world interest rates increase to cool down inflation. World monetary shocks produce positive effects for the economy, while a world commodity shock significantly curbs real activities. A world trade shock appears the real brake for world prices: it unsurprisingly raises real activities and commodity prices and lowers inflation.

3.2 The effects of world shocks on RREs

As mentioned before, the results on RREs are reported in this second section of empirical findings. The IRFs connected to world shocks and domestic business cycles adjustments are displayed after the shocks have been standardized such that on impact response of the world real commodity price factor corresponds to one standard deviation increase.

Commodity price and commodity currency. The first results on this section concern the reaction of the real commodity price factor and the exchange rates in both models and for the two RREs. As shown in the first column of Figure 4, all the world shocks raise the real commodity price factor[13] and this effect is very persistent. Furthermore, thanks also to the forecast error variance decomposition (henceforth, FEVD) reported in Table 2, it turns out clearly that a trade shock is the main driver of real commodity price fluctuations: it explains more than 40% and more than 50% of the forecast error variance of the real resource price factor in the model for Australia and South Africa, respectively. The second and the third column of Figure 4 show a stylized fact that is commonly documented in the literature on commodity-rich countries (Chen and Rogoff, 2003; Cashin et al., 2004; Bodart et. al., 2012): an increase in real commodity prices triggers the appreciation of the two commodity currencies, either in nominal and real terms (Charnavoki and Dolado, 2014).[14] The response to world shocks is quite homogeneous across shocks for Australia, whilst South African currency reaction is very long lasting after a world trade shock. However, the FEVD suggests that a world trade shock is actually the main contributor to exchange rate deviations for both RREs.

[13] As it is assumed by the identification of world shocks.

[14] Exchange rates unsurprinsingly also appreciate on impact after a world monetary shock. A decrease in the global interest rate factor, mainly driven by the US Fed rate, induces a (temporaneous) appreciation of the other currencies.

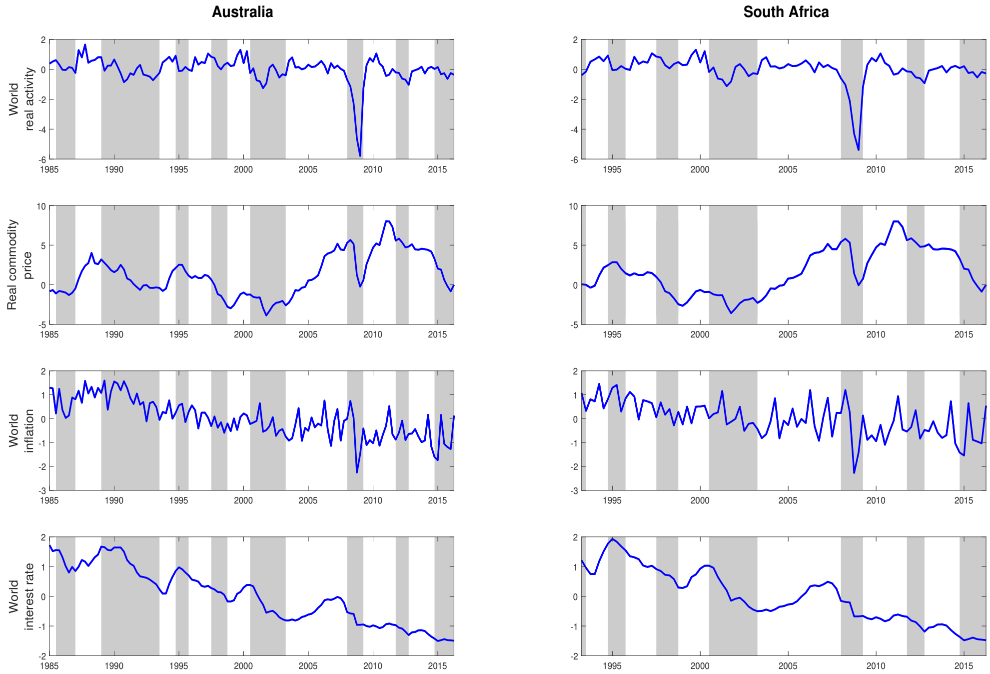

Figure 2: Estimated world principal components for Australia (left column) and South Africa (right column). Shaded areas indicate global downturns as identified by the OECD.

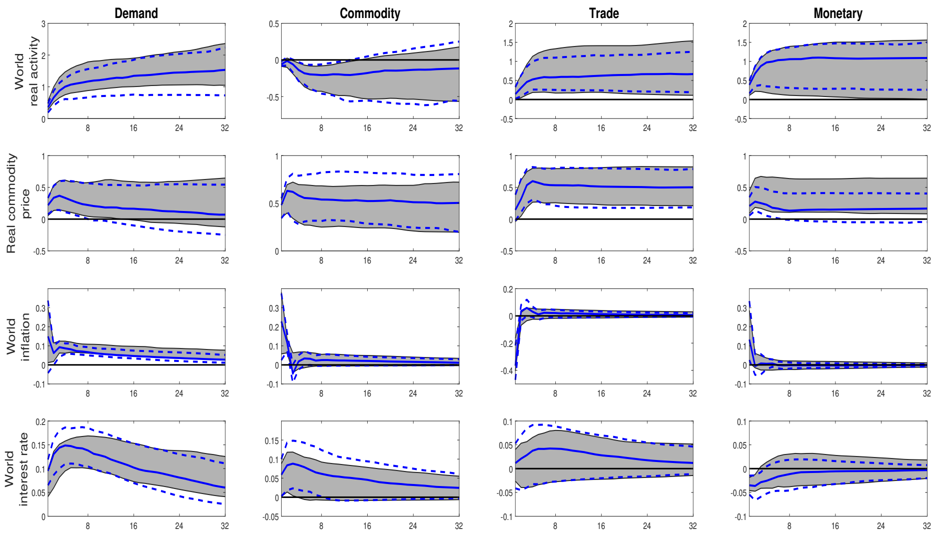

Figure 3: IRFs of world factors to world shocks. Shaded area represents the 68% credible interval for Australia model; dashed lines contain 68% credible interval and median (solid line) for South Africa model.

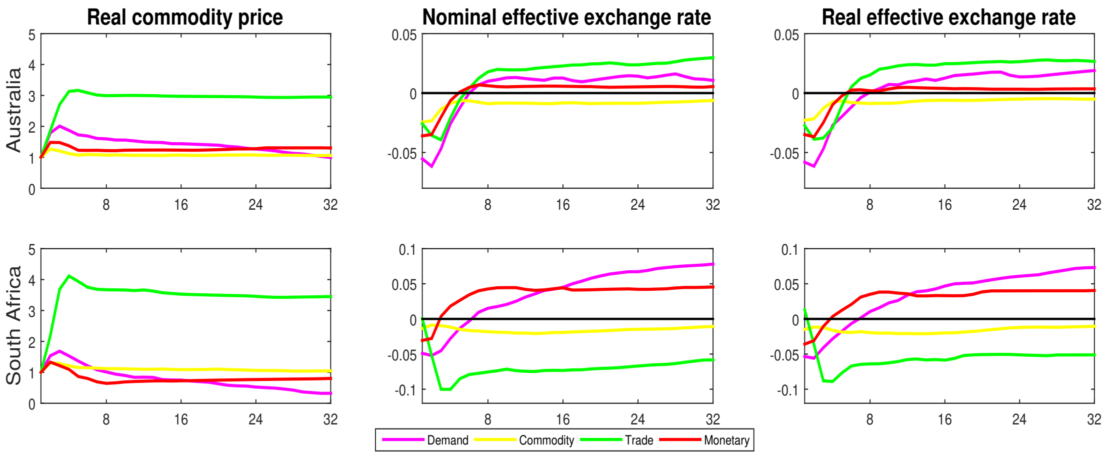

Figure 4: IRFs of the real commodity price factor, nominal and real exchange rate to world shocks. Median response.

Furthermore, it is worthwhile mentioning that the difference of the degrees of openness of the two RREs can explain the heterogeneity in the magnitude of reaction of the real exchange rate to a world commodity shock. According to Bodart et al. (2012), higher trade openness leads to weaker exchange rate elasticity to a commodity shock. In line with Figure 1, it is reasonable to estimate a minor impact of world commodity shocks on the real exchange rate in South Africa with respect to Australia.[15]

The effects of world trade shocks. Since world trade shocks are found to explain the lion's share of real commodity price and exchange rates movements, we start to report the results concerning their (other) real effects on the RREs. The surge of export prices after an exchange rate appreciation drives up the terms-of-trade in this type of countries (Charnavoki and Dolado, 2014; Bjørnland and Thorsrud, 2016). Spatafora and Warner (1999) find that a lasting terms-of-trade shock increases consumption and investment for a panel of developing commodity-exporting economies. Figure 5 reports the response of real GDP and its components.[16] Given the persistent effect of world trade shocks on real commodity price and real exchange rate, we expect South Africa to be generally more sensitive to a world trade shock boosting terms-of-trade with respect to Australia. Indeed, South Africa benefits strongly from a world trade shock in terms of real GDP and consumption; moreover, coherently with its degree of openness, the

[15]The average median response of real exchange rate to a world commodity shock over the first year equals 0.0162 for Australia and 0.0137 for South Africa.

[16]Even if government spending is one of GDP components, this is not here shown because it is not available for South Africa over the entire sample period considered.

	Demand AUS, RSA	**Commodity** AUS, RSA	**Trade** AUS, RSA	**Monetary** AUS, RSA
Real commodity price				
$h = 4$	0.25, 0.19	0.15, 0.15	0.42, 0.52	0.18, 0.14
$h = 12$	0.22, 0.13	0.16, 0.18	0.44, 0.58	0.18, 0.11
Nominal effective exchange rate				
$h = 4$	0.42, 0.18	0.14, 0.07	0.34, 0.63	0.10, 0.12
$h = 12$	0.27, 0.19	0.18, 0.12	0.43, 0.44	0.12, 0.25
Real effective exchange rate				
$h = 4$	0.37, 0.20	0.10, 0.12	0.40, 0.65	0.13, 0.03
$h = 12$	0.20, 0.23	0.16, 0.14	0.53, 0.39	0.11, 0.24

Table 2: Forecast error variance decomposition (FEVD) of commodity price and commodity currency.

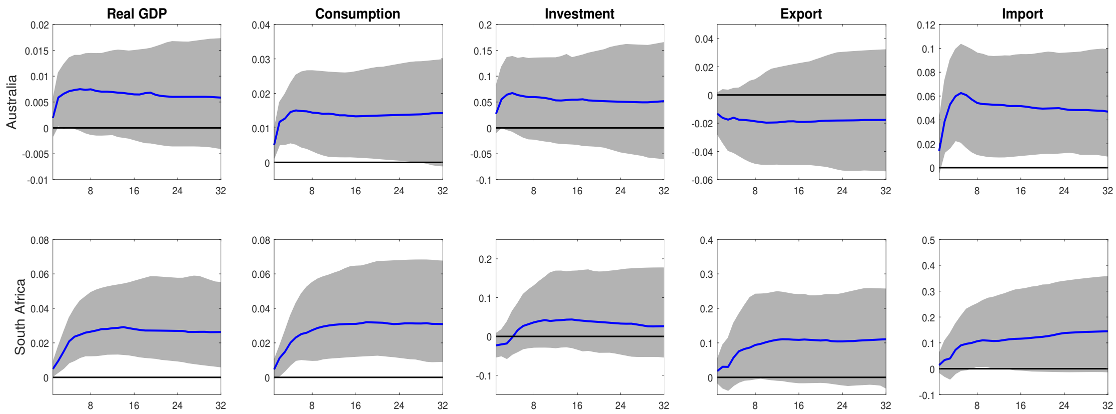

Figure 5: IRFs of real GDP and its components to a world trade shock. Shaded area represents the 68% credible interval.

country enlarges further the number of relationships with foreign markets, widening its trade activities in the medium term. Nevertheless, real imports rise more than real exports in both countries and especially in Australia; an import boom is undoubtedly probable after a real exchange appreciation since most of the domestic demand effectually falls on foreign goods, which are relatively less expensive.

Additional IRFs are reported in Figure 6. As for global inflation, a world trade shock lowers domestic inflation; the reaction is very strong particularly for South Africa. In their application, Aizenman and Riera-Crichton (2008) find that, for developing commodity-exporting countries, managing international reserves is a key solution to deal with terms-of-trade shocks and the subsequent real exchange rate volatility. Here, we are able to reproduce this evidence in the case of a terms-of-trade spike driven by world trade shocks. Accordingly, in South Africa, the international inflow of capital increases. Therefore, the current account increases on impact, whereas, in Australia, the level of reserves is kept constant and the current account heavily deteriorates.

The relevance of world trade shocks has not been sufficiently discussed in the literature on RREs, even if a research agenda to fill this gap in the future should be taken into consideration. Still, as suggested by the FEVD in Table 3, other shocks do explain consistent shares of domestic fluctuations.

The effects of world commodity shocks. As highlighted by the FEVD, a world commodity shock explains the smallest share of domestic fluctuations. Charnavoki and Dolado (2014), conversely, find that a commodity shock strongly affects the Canadian business cycle. The reason for this opposite evidence can be traced into the different composition of resource-related activities: while in Canada energy product exports, especially oil, account for almost one fourth trade of total exports, in Australia and South Africa trading activities rely on other types of commodity products, as shown in Figure 1. In Figure 7 we disentangle the reaction of the observed components of the real commodity price factor to a world commodity shock. It is easy to notice that the reaction of the real price of oil represents the major response. Even though metals and industrial commodity prices go up as well, the difference with the increase in the oil price is large. Hence, it is not surprising that world commodity shocks generate quantitatively greater impulses for oil-rich countries. The same opinion is shared in

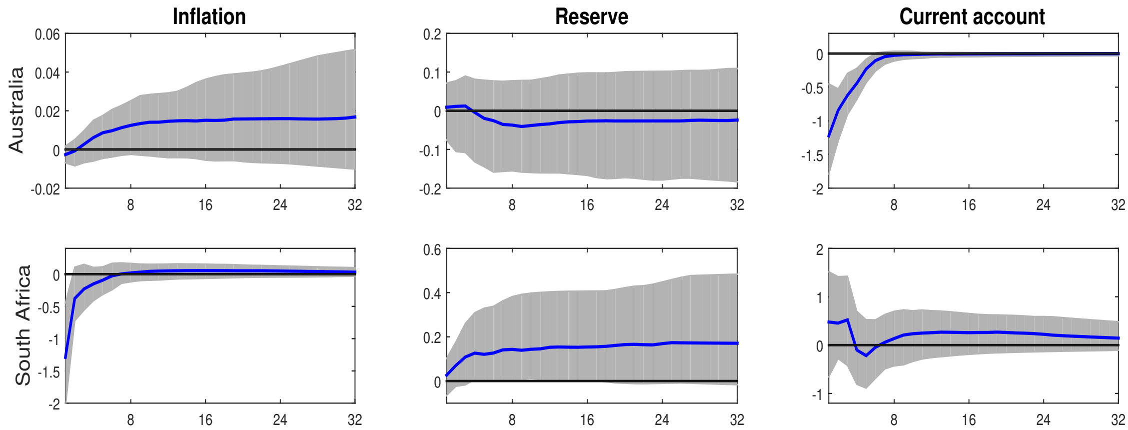

Figure 6: IRFs of additonal variables to a world trade shock. Shaded area represents the 68% credible interval.

other contributions. Detailed IRFs in Aastveit et al. (2015), for example, testify that an oil-price boom driven by supply shortages differently impacts oil-rich economies (Canada, Norway, Mexico) and non-oil resource-rich economies (Australia, Chile, South Africa);[17] especially the former display much more pronounced reactions. Further investigations to explain the puzzle are performed in the robustness section. Additional consistent evidence regarding asymmetric effects of resource shocks on oil-exporting and oil-importing countries can be found in Peersman and Van Robays (2012).

The IRFs for real GDP and its components are plotted in Figure 8. Next to the magnitude, the sign of the functions differs for some variables. As Aastveit et al. (2015) show comparing developed and developing economies, some negative reactions are detected for Australia. In the main argument of their application, Aastveit et al. (2015) and Caldara et al. (2019) prove that negative commodity supply shocks generally depress developed economies, whereas they trigger non-negative effects for developing countries. Several causes are considered to be factors of this asymmetry, including the unequal degree of trade openness: the higher the trade activities as percentage of GDP, the smaller the negative effects of commodity-specific shocks on the real business cycle.[18] As predicted, real GDP and consumption decrease on impact in Australia, while they improve in South Africa. Figure 9 confirms the surge in inflation for both countries

[17] Chile is the world leading exporter of copper. Indeed, it exported 28% of the global copper ore in 2016, according to the Observatory of Economic Complexity (OEC).

[18] Aastveit et al. (2015) also find that the proportion of GDP relative to consumption and investment is a determinant of the sign of the effects of world commodity shocks on domestic economies.

	Demand AUS, RSA	Commodity AUS, RSA	Trade AUS, RSA	Monetary AUS, RSA
Real GDP				
$h = 4$	0.51, 0.34	0.06, 0.07	0.34, 0.32	0.09, 0.27
$h = 12$	0.57, 0.35	0.08, 0.06	0.31, 0.31	0.04, 0.28
Consumption				
$h = 4$	0.44, 0.37	0.04, 0.05	0.43, 0.30	0.09, 0.28
$h = 12$	0.46, 0.38	0.08, 0.05	0.42, 0.29	0.44, 0.28
Investment				
$h = 4$	0.30, 0.49	0.04, 0.05	0.65, 0.02	0.01, 0.44
$h = 12$	0.23, 0.38	0.02, 0.05	0.67, 0.16	0.08, 0.41
Export				
$h = 4$	0.50, 0.36	0.05, 0.04	0.40, 0.18	0.05, 0.42
$h = 12$	0.66, 0.37	0.00, 0.02	0.31, 0.22	0.03, 0.39
Import				
$h = 4$	0.47, 0.36	0.01, 0.06	0.30, 0.20	0.22, 0.38
$h = 12$	0.48, 0.41	0.01, 0.04	0.30, 0.20	0.21, 0.35
Inflation				
$h = 4$	0.38, 0.18	0.22, 0.03	0.21, 0.39	0.19, 0.40
$h = 12$	0.52, 0.60	0.15, 0.11	0.23, 0.17	0.10, 0.12
Reserve				
$h = 4$	0.59, 0.39	0.13, 0.08	0.06, 0.47	0.22, 0.06
$h = 12$	0.42, 0.38	0.12, 0.10	0.35, 0.44	0.11, 0.08
Current account				
$h = 4$	0.33, 0.44	0.01, 0.02	0.58, 0.08	0.08, 0.46
$h = 12$	0.70, 0.58	0.03, 0.12	0.26, 0.21	0.01, 0.09

Table 3: Forecast error variance decomposition (FEVD).

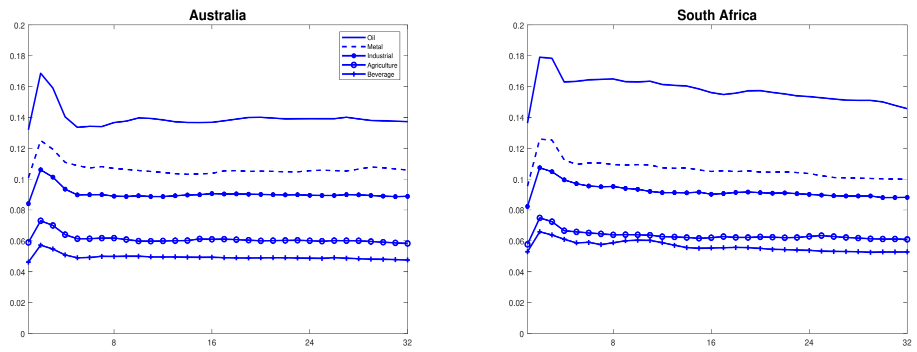

Figure 7: IRFs of commodity price factor components to a world commodity shock. Shaded area represents the 68% credible interval.

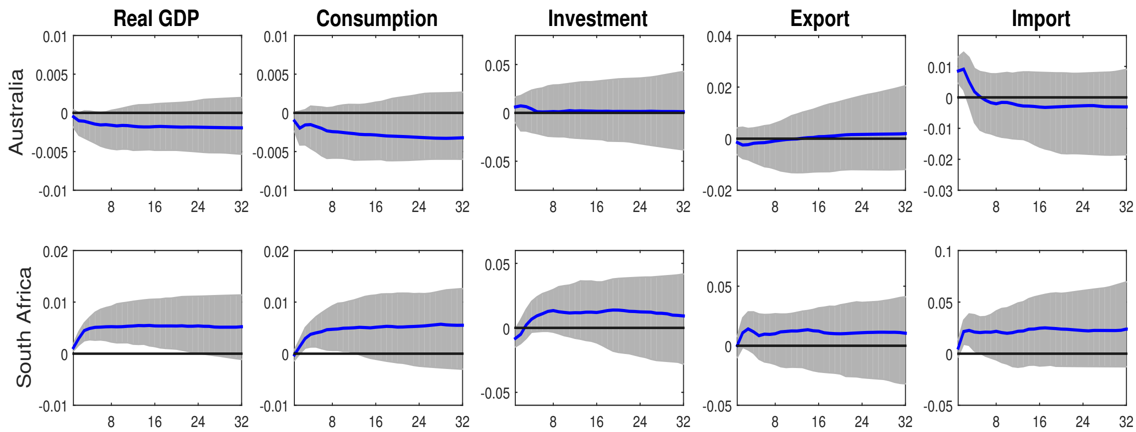

Figure 8: IRFs of real GDP and its components to a world commodity shock. Shaded area represents the 68% credible interval.

and the deterioration of the current account in Australia, although a weaker momentum characterizes the shock transmission.

Additional results. The overall contribution of world shocks to RREs dynamics is summarized in Figure 10, which reports the historical decomposition of the first domestic factor for Australia and South Africa. The evidence provided underlines the importance of world shocks for this type of economies. As Charnavoki and Dolado (2014), Aastveit et al. (2016), and Bjørnland and Thorsrud (2016) document for other RREs, most of the volatility is clearly to be attributed to world demand shocks.[19] World trade shocks begin to gain relevance since

[19]Charnavoki and Dolado (2014), Aastveit et al. (2016), and Bjørnland and Thorsrud (2016) find that, among the other world shocks that they identify, a world demand shock is the main contributor of volatility development in RREs. Aastveit et al. (2016) and Bjørnland and Thorsrud (2016) additionally show that domestic shocks represent the main components of the historical decomposition of domestic business cycles.

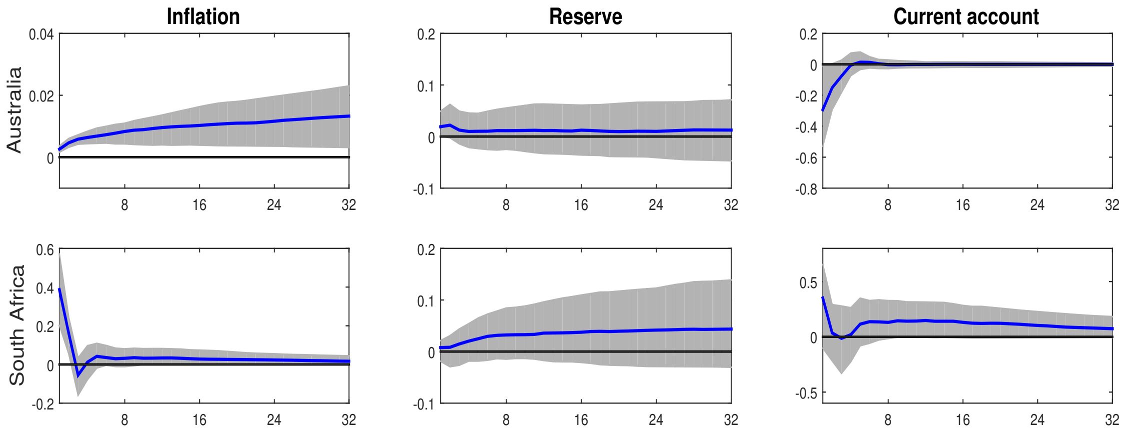

Figure 9: IRFs of additional variables to a world commodity shock. Shaded area represents the 68% credible interval.

the beginning of 2000s, whilst world monetary shocks play a minor role for Australia. The Australian business cycle suffers from world commodity shocks mainly along the time period occupied by the Asian financial crisis and in the early 2000s.

Industries response. Classical investigations for RREs include the analysis of testing for the presence of Dutch disease effects. The Dutch disease effect refers to the different impact of shocks, especially commodity-specific, on individual GDP industries. The Dutch disease theory suggests that a commodity (price) boom and the subsequent real exchange rate appreciation generate beneficial effects for non-tradable sectors but emphasize a contraction for tradables. Recent contributions on RREs concentrate on highlighting different channels through which the effect might arise. Charnavoki and Dolado (2014) and Bjørnland and Thorsrud (2016) show that a commodity shock works in this sense, causing an improvement of non-tradable sectors and a deterioration of tradable sectors. In this exercise, we proceed by aggregating GDP industries into three main categories, namely commodity tradables (CTs), non-tradables (NTs) and non-commodity tradables (NCs).[20] We show that the separation between CTs and NCs is crucial to understand the role of commodity products in shaping Dutch disease effects in RREs. Results are reported in aggregate terms in Figure 11; sectors are grouped according to the categories above and the average median response over 40 quarters is plotted.[21]

[20]Examples of CT sectors are mining and agriculture, forestry and fishing; examples of NT sectors are construction and services; examples NC sectors are manufacturing and retail trade.

[21]Since the number and types of sector are not equally defined in the two countries because of data availability, we aggregate and average the responses over 40 quarters to reduce possible asymmetric comparability.

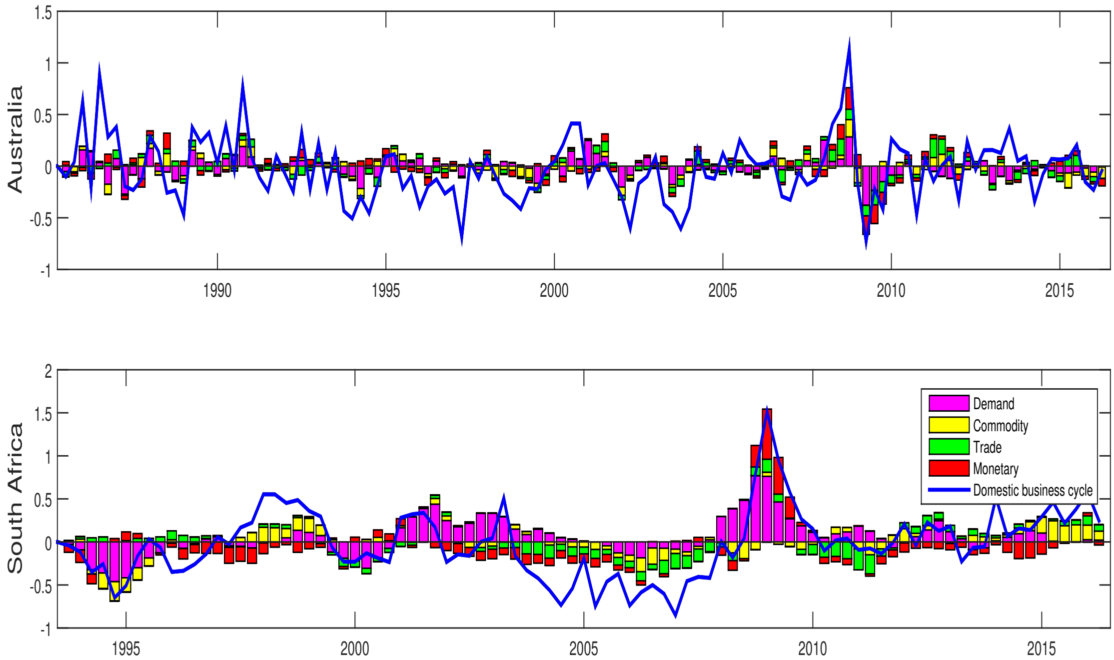

Figure 10: Historical decomposition of domestic business cycle (first domestic factor).

The bars show that for South Africa no Dutch disease effect is exactly detected. It can easily be seen that world shocks produce positive effects even for these indicators. However, as Dutch disease would imply, most of the benefits are reaped by NT sectors even if tradable sectors do not deteriorate. In Australia, instead, the story is much different. First, a Dutch disease effect arises after a world commodity shock: both tradable categories contract, while NTs do not. The distinction of tradable sectors into resource and non-resource allows to identify a mining boom which, according to Corden (2012), occurs in Australia after a world commodity shock and depresses trading activities. In line with this evidence, Australia clearly behaves as a three-speed economy (Corden, 2012), considering the different degrees of adjustment of CT, NT and NC sectors. Second, a world trade shock is shown to have opposite effects on CTs and NCs. On one hand, commodity products confirm to suffer from a generalized increase in goods' circulation; on the other hand, weaker marker regulation does not imply unfavourable consequences for non-resource products. Third, albeit world demand shocks softly prevail over the others in South Africa, significantly stronger effects are observed in Australia. In fact, especially for NT sectors, a world demand shock is highly effective.

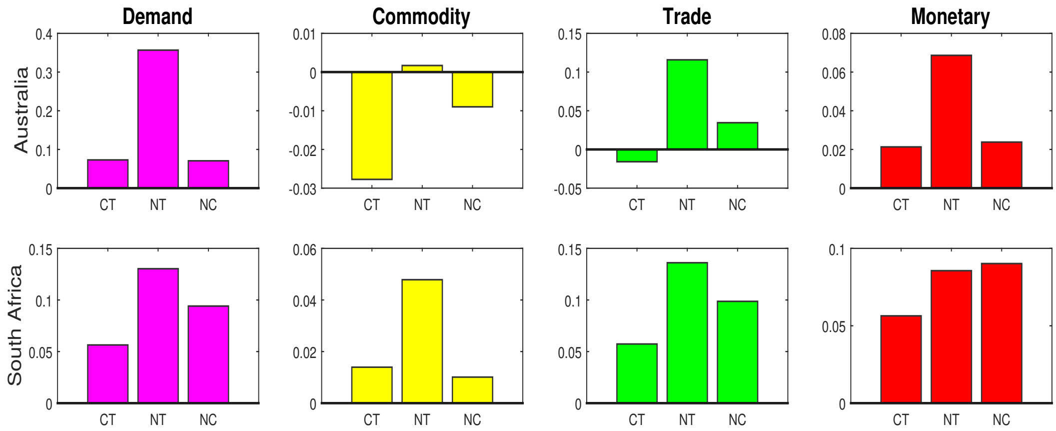

Figure 11: Sectoral IRFs to world shocks. Commodity tradable (CT), non-tradable (NT) and non-commodity tradable (NC) sectors responses are computed as the average median response over 40 quarters.

Employment. Individual GDP industries analysis is enriched by considering dynamics of sectoral employment. Representative sectors are taken into consideration; in line with the previous subsection, a CT, NT and NC sector are considered (Figure 12). Consistently with sectoral GDPs, NT industries reap major benefits from world shocks even in terms of employment. Starting with world trade shocks, in spite of the obvious fact that employment in construction (NT) and manufacturing (NC) show a non-negative response, the number of employed persons in the Australian mining sector (CT) contracts on impact. A surge in employment is extremely evident in manufacturing (especially for Australia); manufacturing is commonly intended as a technology-intensive sector, whose labour demand increases after a decline in market regulation that makes technological applications developed abroad more affordable. A world commodity shock does not stimulate employment dynamics in Australia, while (sectoral) unemployment in South Africa decreases; Corden (2012) points out that a mining boom in Australia does not transmit relevant prompt impulses on the mining labour market for three reasons: a limited movement of labour across sectors, the small share of workers employed in the mining sector, and the time to invest on hiring skilled workers to be used for the elaboration of advanced technical solutions to manage the unexpected boom. Finally, a world demand shock and a world monetary shock predictably boost labour demand and, subsequently, the number of employed workers rises. Even in terms of employment, the transmission mechanism of these two shocks unsurprisingly generates positive effects mostly for NT sectors.

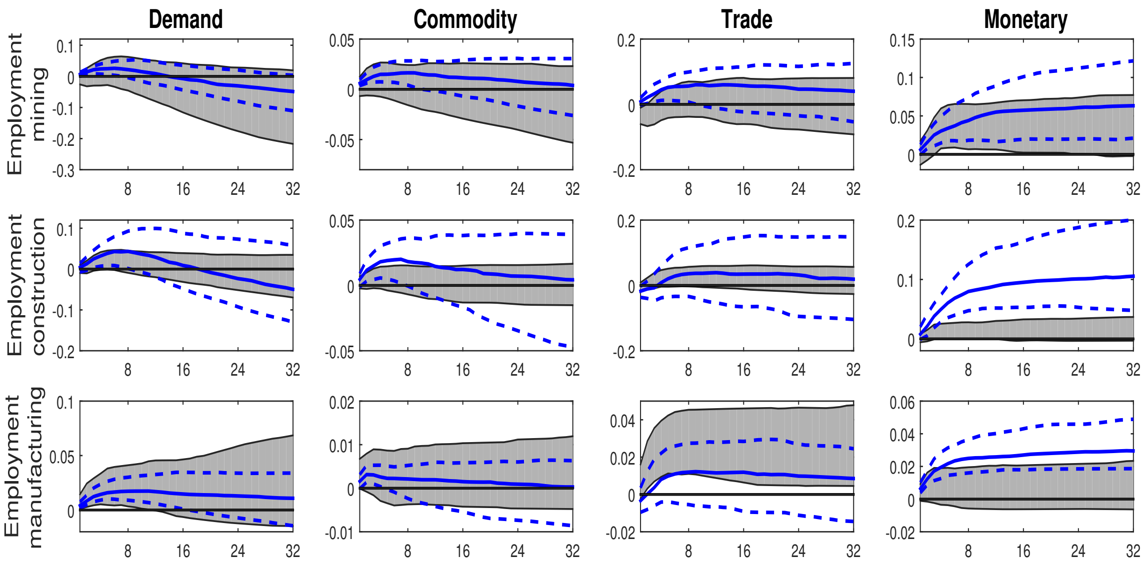

Figure 12: IRFs of sectoral employment to world shocks. Shaded area represents the 68% credible interval for Australia model; dashed lines contain 68% credible interval and median (solid line) for South Africa model.

4 Robustness checks

The outcomes obtained from the baseline model are tested with some robustness exercises implemented along different dimensions. Appendix reports the IRFs related to the checks.

Different number of domestic factors. As reported in Section 2.1, the chosen number of factors to be extracted from the panel of domestic series is selected according to the IC_{p2} criterion by Bai and Ng (2002). A robustness exercise is to reduce the number of domestic factors to verify the validity of the results with respect to this different specification. To be precise, we run the model again for both RREs including only one factor extracted from domestic series. In this first alternative specification the outcomes look stable and in line with the benchmark results.

Changing the number of lags. As stated in Section 2.3, the AIC criterion suggests to include up to 2 lags in the SVAR in (2). The baseline specification and related evidence are compared to another alternative model specification that includes one lag in the SVAR equation. The new results do not show any relevant and qualitative difference with the benchmark outcomes. Hence, the baseline dynamic factor model is independent to the specification in terms of number of lags of the SVAR part.

Oil shocks. The real commodity price factor is replaced with a real oil price factor extracted from three oil price series (Brent, Dubai and WTI). The effects of this new world commodity shock on the two RREs are consistent with our benchmark findings. Oil price is confirmed to be the main driver of commodity price fluctuations. Therefore, the puzzle of resource shocks is again attributable to the composition of exports, or more specifically, to the reliance of exports on energy products.

5 Conclusions

In this paper we estimate a two-blocks Bayesian dynamic factor model for two RREs, i.e. Australia and South Africa. By employing a shock identification strategy based on a set of minimum sign restrictions combined with further short-run constraints, we identify four world shocks driving up real commodity prices, namely a world demand, commodity, trade and monetary shock. Starting from a general analysis of the estimated global business cycle, the discussion proceeds towards the comprehension of the effects of world shocks on RREs. We sucessfully match several findings that we collect from a number of empirical contributions on RREs. We begin finding that a surge in real commodity prices leads to the appreciation of the real exchange rate (Chen and Rogoff, 2003), whose fluctuations are mainly explained by world trade shocks. However, as stated by Bodart et al. (2012), the intensity of trade activities determines the impact of world commodity-specific shocks on exchange rates and, consequently, on domestic business cycles. In line with Aastveit et al. (2015) and Caldara et al. (2019), adverse commodity shocks negatively impact developed economies, whereas they produce reverse effects on developing countries. World commodity shocks are found to play a small role in terms of contributions to domestic deviations; it is reasonable to state that the small dependence to oil-related (trade) activities generates negligible reactions to events taking place on commodity markets. The puzzle is further analyzed with different measures of the real commodity price factor (i.e. an oil price factor). Finally, as commonly detected for this type of economies, a loss in competitiveness due to real exchange rate appreciation induces booms in non-tradable sectors, which is in line with the Dutch disease theory. However, proper Dutch disease effects are estimated only for Australia when an increase in commodity price is triggered by world commodity shocks; in fact, non-tradables expansion is estimated together with tradable sectors contraction. We document remarkable and favourable effects for all sectoral GDPs when an increase of the real commodity price factor is associated with a world demand shock and, to a lesser extent, with a world monetary shock. Furthermore, identifying world trade shocks and disentangling tradable sector between commodity and non-commodity are additional crucial points the enlarge the comprehension of the different channels through which world shocks operate and Dutch disease effects arise.

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Appendix

Robustness checks

This appendix reports the results obtained from different model specifications and shock identifications to test the robustness of the baseline findings.

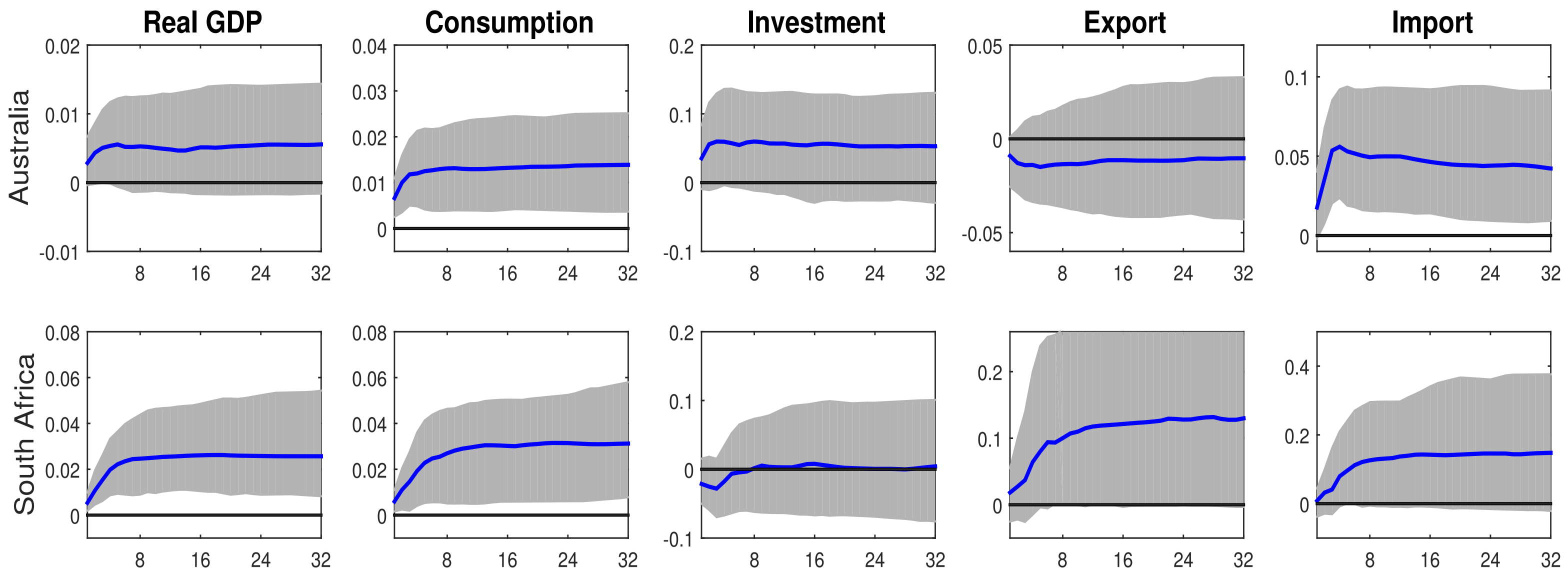

Figure A.1: Robustness. IRFs of real GDP and its components to a world trade shock when one domestic factor is included. Shaded area represents the 68% credible interval.

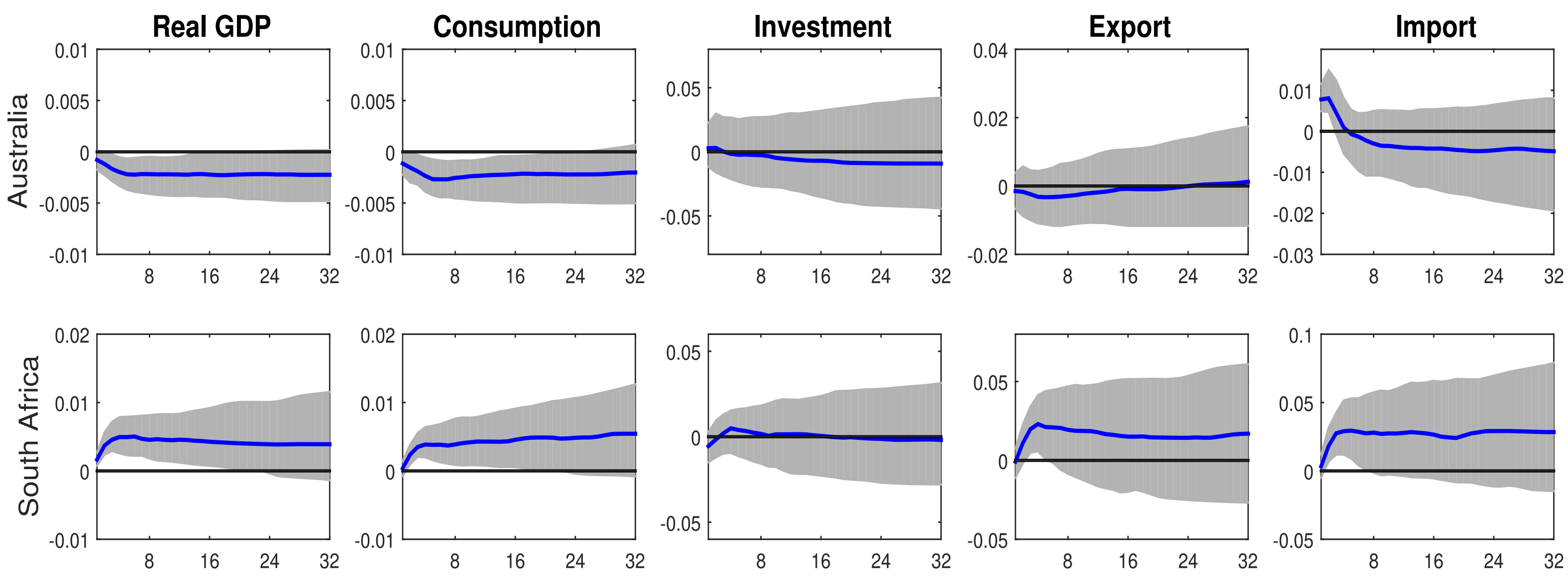

Figure A.2: Robustness. IRFs of real GDP and its components to a world commodity shock when one domestic factor is included. Shaded area represents the 68% credible interval.

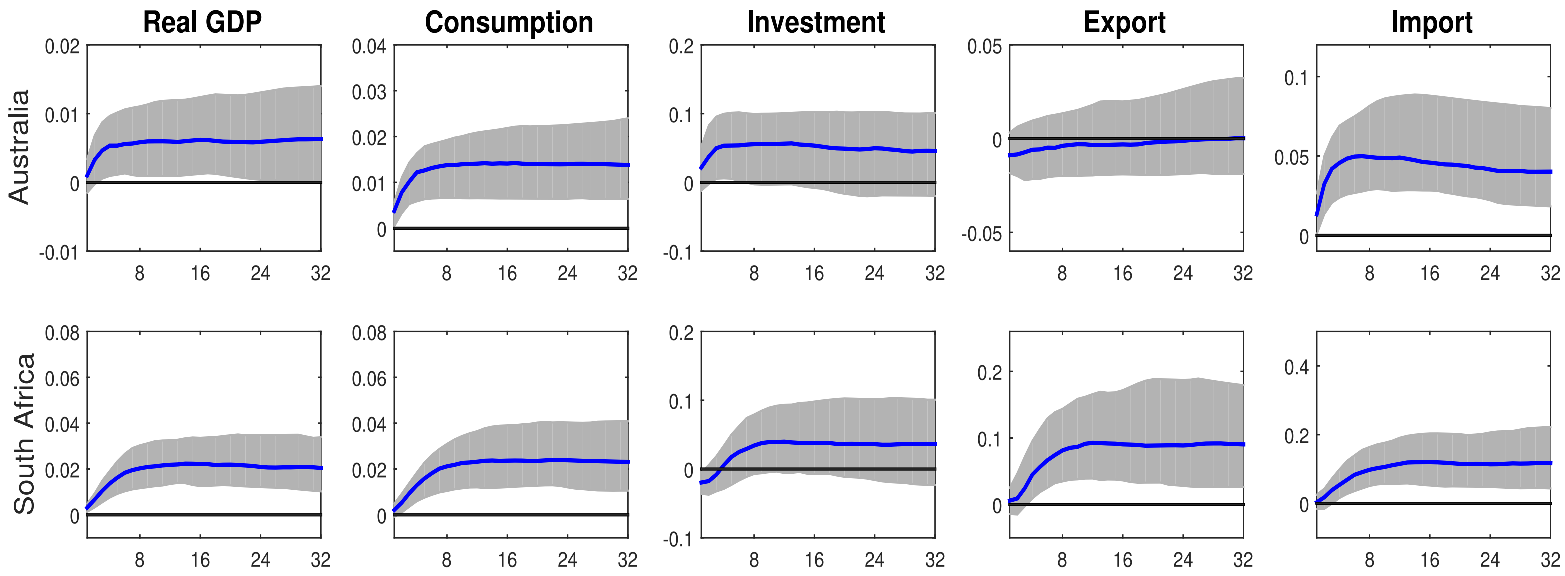

Figure A.3: Robustness. IRFs of real GDP and its components to a world trade shock when a different lag order is selected (one lag). Shaded area represents the 68% credible interval.

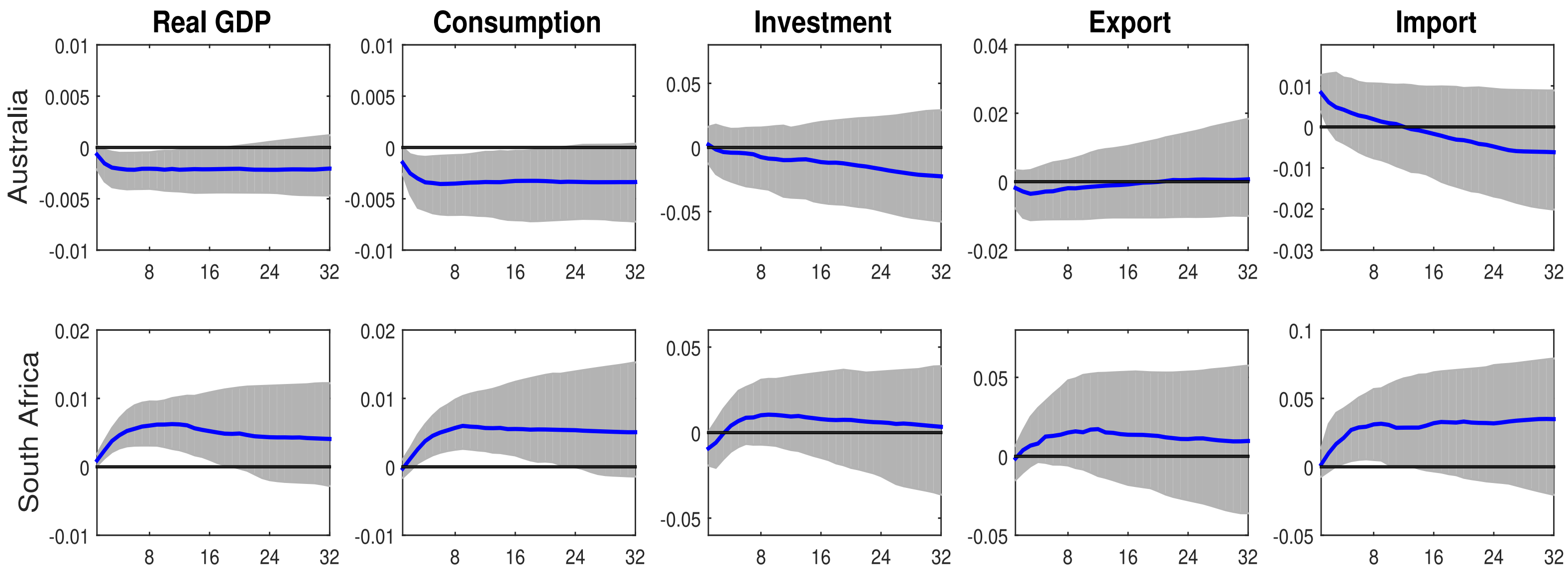

Figure A.4: Robustness. IRFs of real GDP and its components to a world commodity shock when a different lag order is selected (one lag). Shaded area represents the 68% credible interval.

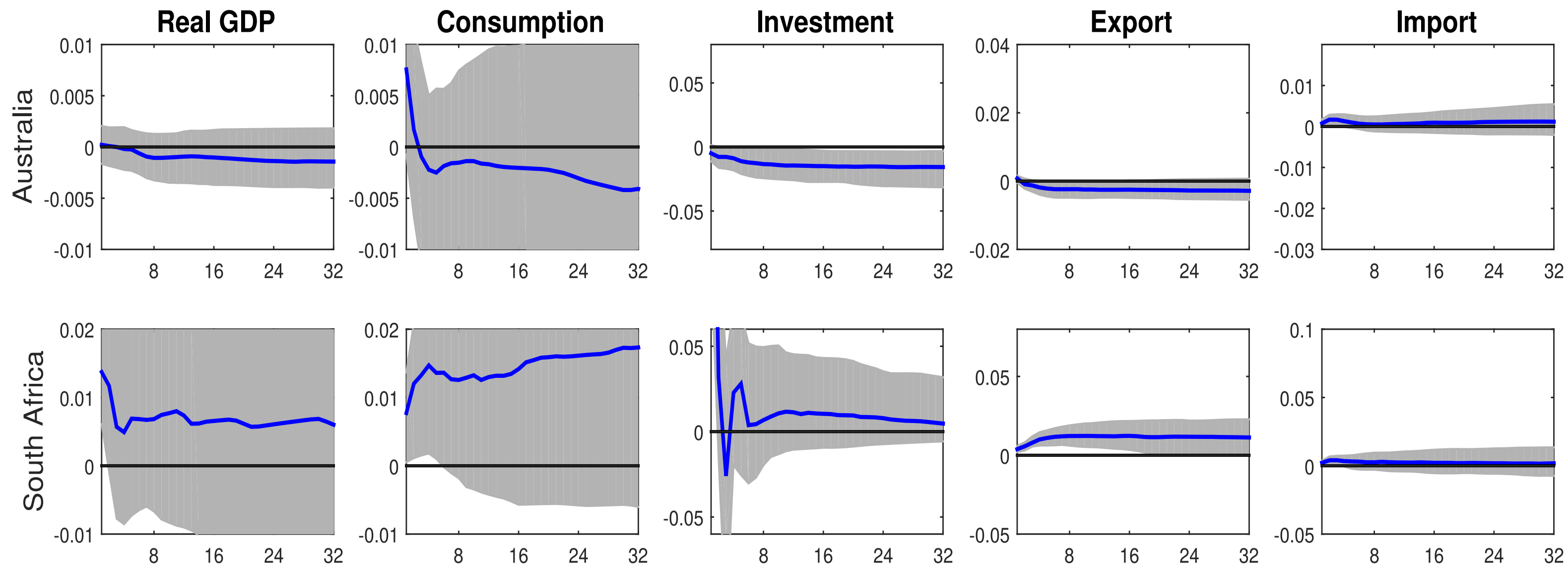

Figure A.5: Robustness. IRFs of real GDP and its components to an oil shock. Shaded area represents the 68% credible interval.

Estimation procedure

We estimate the model in line with Charnavoki and Dolado (2014), which proceed with likelihood estimation by multi-move Gibbs sampling by estimating the parameters of the dynamic factor model by alternatively sampling them from conditional posterior distributions. The factors in the transition equation (2) are modeled as a restricted structural VAR model. Since the model deals with a number of different dependent variables, it can be estimated as a system of seemingly unrelated regression equations (SURE). Specifically, it can be written as follows:

$$y_t = X_t\beta + v_t$$

Where y_t is a vector of dimension $K \times 1$ of dependent variables, $\beta = (\beta_1^{'}, \beta_2^{'}, \ldots, \beta_K^{'})^{'}$ is a vector of parameters, X_t is a block-diagonal matrix with blocks $x_{kt}^{'}$ which contains the current and lagged values of the factors for the k-th variable and $v_t = (v_{1t}, v_{2t}, \ldots, v_{Kt})^{'}$ is a vector of errors such that $v_t \sim N(0, \Sigma)$.

The restricted SVAR is estimated through a Bayesian method borrowed from Koop, Poirier and Tobias (2007). An independent Normal-Wishart prior is used in the model which is largely employed in this type of model. A Normal-Wishart can be written as

$$p(\beta, \Sigma^{-1}) \propto \phi(\beta|\underline{\beta}, \underline{R}) f_W(\Sigma^{-1}|\underline{T}, \underline{v})$$

Where $\phi(\cdot)$ and $f_W(\cdot)$ indicate Normal and Wishart probability density function, respectively. Accordingly, on the one hand, the conditional posterior distribution of restricted SVAR coefficients is

$$\beta|y, \Sigma^{-1} \sim N(\overline{\beta}, \overline{R})$$

With $\overline{R} = (\underline{R}^{-1} + \sum_{t=1}^{T} X_t^{'}\Sigma^{-1}X_t)^{-1}$ and $\overline{\beta} = \overline{R}(\underline{R}^{-1}\overline{\beta} + \sum_{t=1}^{T} X_t^{'}\Sigma^{-1}y_t)$.

While, on the other hand, the posterior for Σ^{-1} conditional on β is

$$\Sigma^{-1}|y, \beta \sim W(\overline{T}, \overline{v})$$

With $\overline{T} = (\underline{T}^{-1} + \sum_{t=1}^{T} (y_t - X_t\beta)(y_t - X_t\beta)')^{-1}$ and $\overline{v} = T + \underline{v}$. The prior is assumed to be uninformative, such that $\underline{R}^{-1} = \underline{v} = \underline{T}^{-1} = 0$. The Gibbs sampler employed sequentially draws from the normal $\phi(\beta y, \Sigma^{-1})$ and $f_W(\Sigma^{-1}|y, \beta)$ in order to approximate the posterior distribution in the model.

Sign restrictions identification scheme

The alternative scheme to identify the structural model is based on imposing sign and bound restrictions on the IRFs following the procedure introduced by Rubio-Ramirez, Waggoner and Zha (2010). Suppose A_0 is the impact matrix obtained by Cholesky decomposing the reduced form variance-covariance matrix Ω and $\tilde{Q}$ is the identity matrix the global block substituted by any rotational orthogonal 4×4 matrix with $\tilde{Q}\tilde{Q}' = I$. A new impact matrix is given by $\tilde{A}_0 = A_0\tilde{Q}$ where $\tilde{A}_0\tilde{A}_0{}' = \Omega$ and a number of structural models is obtained repeatedly drawing from the set of orthogonal rotational matrices. The procedure is articulated as follows:

- Cholesky decompose A_0^k of the posterior draw k of the reduced form variance-covariance matrix Ω^k.
- Suppose $X = QR$ where X is an independent standard normal 4×4, QR its decomposition with the diagonal of R, Q is a rotational matrix uniformly distributed. Substitute the global and regional diagonal block of $\tilde{Q}$ with Q.
- Compute $B_0^k = A_0^k\tilde{Q}$ and check if the model satisfies the sign and bounds constraints otherwise move to the next Gibbs iteration.

Data

We collect around 200 variables in total. In line with Aastveit et al. (2016), we report details of the domestic data which play a key role in the empirical analysis in Table A.1 and in Table A.2 for Australia and South Africa, respectively.

Australia

Name	Transf.	Description
Real GDP	5	Gross Domestic Product - Expenditure approach
Consumption	5	Household Consumption - Expenditure approach
Investment	5	Gross Fixed Capital Formation - General Government
Export	5	Exports of goods and services
Import	5	Imports of goods and services
Inflation	5	Quarter-on-quarter change of national consumer price index
Reserve	5	International reserves excluding gold
Current account	1	Current account balance as % of nominal GDP

Table A.1: Details on selected domestic data. Transformation codes: 1 = no transformation, 5 = log difference.

South Africa

Name	Transf.	Description
Real GDP	5	Gross Domestic Product - Expenditure approach
Consumption	5	Household Consumption - Expenditure approach
Investment	5	Gross Fixed Capital Formation - General Government
Export	5	Exports of goods and services
Import	5	Imports of goods and services
Inflation	5	Quarter-on-quarter change of national consumer price index
Reserve	5	International reserves
Current account	1	Current account balance as % of nominal GDP

Table A.2: Details on selected domestic data. Transformation codes: 1 = no transformation, 5 = log difference.

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