Economic Modelling 32 (2013) 190–202

Contents lists available at SciVerse ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Trade shocks from BRIC to South Africa: A global VAR analysis ☆

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ARTICLE INFO

Article history:
Accepted 5 February 2013

JEL classification:
C32
C51
F15

Keywords:
BRICS
Trade linkages
Global VAR
Trade shocks

ABSTRACT

This paper studies the trade linkages between South Africa and the BRIC (Brazil, Russia, India and China) countries. We apply a global vector autoregressive model (global VAR) to investigate the degree of trade linkages and shock transmission between South Africa and the BRIC countries over the period 1995Q1–2009Q4. The model contains 32 countries and has two different estimations: the first one consists of 24 countries and one region, with the 8 countries in the euro area treated as a single economy; and the second estimation contains 20 countries and two regions, with the BRIC and the euro area countries respectively treated as a single economy. The results suggest that trade linkages exist between our focus economies; however the magnitude differs between countries. Shocks from each BRIC country are shown to have considerable impact on South African real imports and output.

1. Introduction

Increasing globalisation and economic integration raise a number of important issues. Particularly, it makes countries vulnerable to external shocks. In order to assess these external shocks there is a growing need to model the sources of foreign influence on domestic economies. The global vector autoregressive (global VAR) framework is a powerful tool that is able to assess these shocks through trade linkages, financial linkages and so on. The global VAR model proposed by Pesaran et al. (2004, henceforth PSW), Dees et al. (2007a, henceforth DdPS) and Dees et al. (2007b, henceforth DHPS) combines country-specific models into a global framework and allows for the analysis of interactions between countries/regions in the study, while avoiding any dimensionality problems. This model yields results that are invariant to country and to the ordering of the variables.

Our interest in this paper is to model a small open economy, South Africa (SA), and its trade linkages with the economies of Brazil, Russia, India and China, the so called BRICs. SA's integration into the global economy is characterized mainly by high export growth (Petersson, 2005). A significant growth in exports has been accompanied by a change in SA's direction of trade. In particular, there has been a shift in its major markets from the European Union (EU) and the United States (US) towards the southern engines. We therefore apply a global VAR model to investigate the degree of trade linkages and shock transmission between SA and the BRIC countries over the period 1995Q1–2009Q4.

The rationale for assessing the impact of trade between SA and the BRIC countries is based on the perception, as articulated in Goldman Sachs' report (Wilson and Purushothaman, 2003), that the BRIC countries are developing fast and by the year 2050 they will surpass the level of development in most of the current developed countries. The BRICs does not originate because of its influence as a formal trading bloc or a political alliance. Instead, it is a forum that provides its members with opportunities to network and to initiate economic arrangements. The BRICs represents a model of economic development exemplified by strong economic growth and an enormous capacity to compete in a globalised world. In 2011, SA joined the BRIC group, hence the creation of the BRICS. The BRIC member countries are representatives of their regions and SA represents the African continent as it is the largest economy in the continent. There are papers that look at the syncronisation between SA and the other countries, such as Kabundi and Loots (2007), but based on our knowledge this paper is the first attempt to investigate the response of SA trade and output to shocks originating from the BRICs as a bloc and from individual countries.

Trade linkage is an important feature of economic integration between countries. However, there is no common view on whether more intense trade linkages lead to more or less business cycle synchronisation. Frankel and Rose (1997, 1998) point out that the countries

☆ We would like to thank Isral Kisla, Alfredo Cuevas, Lumengo Bonga-Bonga, Stephen Gelb, and the participants of the ERSA workshops for their comments and suggestions, and we gratefully acknowledge the financial support from the Economic Research Southern Africa.
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0264-9993/$ – see front matter
http://dx.doi.org/10.1016/j.econmod.2013.02.010

which have strong trade linkages have somewhat similar business cycles.[2] In addition, Frankel and Rose (1998) demonstrate that trade linkages foster transmission of aggregate shocks across countries. For example, a positive export shock in one country may lead to a rise in demand for goods produced in the recipient countries. The magnitude of such effects depends on the intensity of trade linkages between the countries in question.[3] According to Forbes and Chinn (2004), direct trade between countries seems to be one of the main determinants of cross-country linkages. However, Krugman (1993) indicates that intense trade linkages across countries actually may have reverse effect since countries specialise more as they become more integrated. The current international trade dynamics are leading to important changes in the structure of global trade. There is a growing argument that some specific emerging economies are playing important roles and are at the centre of the realignment of the world trade structure (Akin and Kose, 2008; Athukorala and Yamashita, 2006; Evenett, 2007).

The BRICS economies have been integrating with the global economy through trade and financial activities. The share of total trade in the world market increased for all its member countries. China's share increased from 3.4% to 9%, Brazil's from 0.9% to 1.2%, India's from 0.6% to 1.1%, Russia's from 1.3% to 2.9% and SA's increased from 0.3% to 0.4%, between 1998 and 2008. The world market share of the BRICS' total trade increased from 6.7% in 1998 to 14.8% in 2008 (OECD, 2010). Moreover, these countries are different from one another in their culture, background, language, the structure of their economies and the integration with the world market. On the one hand, China and India are rapidly growing economies with limited availability of natural resources. They also have a common economic growth performance, such that the growth rate of China and India averaged 11.3% and 8.1% per annum between 2005 and 2010 (WB, 2010). China's economic growth is stimulated mainly by manufacturing and India's by software services and call centres. They are net importers of commodities and emerge as dominant global suppliers of manufactured goods and services. On the other hand, Brazil, Russia and SA experienced significantly lower economic growth with an average of 4.2%, 4.1% and 4% per annum between 2005 and 2010, respectively (WB, 2010). They have an abundance of natural resources and export mainly raw materials. Brazil is the largest exporter in Latin America and the key driver of its economic growth is the exploitation of raw materials. The industrial sector is also developing strongly, led by machinery and transport equipment. The exploitation of energy resources has boosted Russia's economic growth in recent years (MacBeath, 2007). For instance, in 2009, Russia became the biggest oil producer in the world with its share of 12.9% of world oil production, followed by Saudi Arabia with 12%.[4] SA's exports consist mainly of basic commodities and natural resources such as gold, diamond, platinum, iron and steel products, mineral fuels and motor vehicles. It is the largest economy in the African continent and occupies a strategic position in the continent. According to Arora and Vamvakidis (2005) South African economic growth has a significant positive effect on growth in the continent.

In addition to the increased trade flows with the global economy, trade among these countries is also increasing. Within the BRICS countries, Russia was the top Chinese export destination and source of imports until 2009. In 2009, India and Brazil took over and became China's top export partner and source of imports, respectively. Chinese exports to India, Russia, Brazil and SA valued at 29, 17, 14 and 7 billion US dollars, while its imports from Brazil, Russia, India and SA valued at 28, 21, 13 and 8 billion US dollars, respectively. Hence, as a group, they are China's fourth largest trading partner after Japan, the largest trading partner of China, the US and euro area (IMF, 2010). However, none of these countries is as significant to China in the global market as China is to them. All of these statistics imply that there are significant interactions within and between these countries and the world.

The recent and current economic performance as well as the forecast for coming years has increased interest in these countries.[5] There is considerable attention paid to research on, on the one hand, the importance of the BRICS countries in the world economy and, on the other hand, the pace of development achieved by these countries. The rise of the BRICS is fast attaining a visible role on the international scene and certainly impacting on the process and direction of growth of the global economy. Due to their high economic growth and sheer geographical size, these countries have emerged as important powers at both regional and global levels. Economic performance of these countries in the last decade was quite impressive. According to Gross Domestic Product (GDP) Purchasing Power Parity (PPP) China, India, Russia and Brazil, in that order, ranked as the 2nd, 4th, 6th and 7th world's largest economies in 2010 (IMF, 2010). In the second quarter of 2010, China surpassed Japan, becoming the second-largest economy in the world. This contrasts with the situation only a decade ago when China was the 7th, Brazil the 10th, Russia the 15th and India the 16th largest economies. Over the last decade the Chinese, Indian, Russian and Brazilian economies grew at average rates of 10%, 7%, 6% and 3% respectively (WB, 2010). Even with the current economic crisis that started in 2007, these countries' growth continues to lead the rest of the world. In 2009, the economic growth rate of developed countries, such as Japan and Germany, dropped by around 6%, while that of China grew by 9.1% and India by 7.6%. However, the Brazilian and Russian economies contracted by 0.1% and 7.9%, respectively (OECD, 2010). SA's economic performance was lower than that of the BRIC grouping, despite its robust economic growth averaging 4% in the last decade. The economic growth of SA dropped to around 1.8% in 2009 and according to the IMF's GDP (PPP) it is ranked as the 25th largest economy in the world in 2010.

O'Neill et al. (2004) argue that BRIC economies altogether could be larger than the G-6's (France, Germany, Italy, Japan, the UK, and the US) in less than 40 years and, by 2025, they could account for over half the size of the G-6. China is expected to surpass the US as the world's largest economy by 2041. In 30 years, India's economy would be larger than all but the US and China and move to the third position by 2050, given that it is predicted to continue being one of the fastest-growing economies over the next 30 to 50 years. Brazil will be larger than Germany by 2036 and, hence, it will be the world's fifth largest economy by 2050. Russia will overtake Germany, France, Italy and the UK by 2030 and will become the world's sixth largest economy by 2050 (Wilson and Purushothaman, 2003). Consequently, among the G-6 countries, only the US and Japan will remain among the six largest economies in the world. These predictions reflect the increasingly important role that these economies are expected to play in the coming years. However, some researchers observe that certain factors could obscure this optimistic view. For instance, Jensen and Larsen (2004) and Georgieva (2006) emphasise the specific risks and challenges in each country and indicate that the sustainability of high economic growth, witnessed so far depends on several important factors, such as sound and stable macroeconomic and development policies, development of strong and capable institutions, human development, as well as an increasing degree of openness. These predictions reflect the increasingly important role this bloc is expected to play as an economic powerhouse and political leader, and it is aberrant for any country to ignore this switch in power. This paper bridges the gap in the literature in analysing empirically the response of South African economic variables to shocks from the BRIC countries.

[2] Many other seminal studies have supported this argument, such as Baxter and Kouparitsas (2005) and Inklaar et al. (2007).

[3] Further evidence on the effect of international trade linkages on the business cycle can be found in Yi (2003), Abeysinghe and Forbes (2005), Kose and Yi (2006) and Burstein et al. (2008).

[4] See BP Statistical Review (2010).

[5] For instance, Jensen and Larsen (2004), O'Neill et al. (2005), Georgieva (2006), Jenkins and Edwards (2006), Winters and Yusuf (2007), Gu et al. (2008), McDonald et al. (2008), Nayyar (2009), OECD (2009), and Santos-Paulino and Wan (2010).

The paper is organised as follows. Section 2 describes the current patterns of South African foreign trade with the BRIC countries. Section 3 explains the model, while Section 4 describes the data, outlines the specification and the estimation of the model. Section 5 reports the empirical results and their interpretation. Section 6 concludes the paper.

2. South African foreign trade with the BRIC countries

SA experienced total export growth of around US$ 29 billion in 2000 and US$ 60 billion in 2009. The significant growth in exports has been accompanied by a change in SA's direction of trade, with a shift in its major markets away from the EU and the US towards the southern engines. Thus, the geographical composition of SA's export market has become much more diversified over the last decade, whereby including a set of emerging markets as major trading partners.

Trade between SA and the BRIC jumped from 5% in 2000 to 16% in 2009, whereas trade between SA and the world grew from 10% to 32% in the same period. Since 2000, trade between SA and China grew the most among the BRIC countries (Fig. 1). SA has also managed to maintain and accelerate its trade ties with India, Brazil and Russia. In 2009, China, India, Brazil and Russia ranked as SA's 1st, 8th, 17th and 40th largest trade partners, respectively. Fig. 1 shows that China dominates the SA-BRIC trade flows, accounting for around two-thirds of the SA-BRIC trade.

2.1. Foreign trade by country

Table 1 shows the percentage of SA's top export destinations between 2000 and 2009. It shows that in 2000, SA's top export destinations were the US followed by the UK and Japan. In 2005, Japan became the top SA's export destination, followed by the UK, the US and Germany. However, in 2009, China overtook the US, Japan, Germany and the UK, and became SA's leading export destination, registering 53.9% annual growth. China received 9.4% of total South African exports in 2009. According to the Department of Trade and Industry's Trade Statistics (DTI), SA's exports to China experienced particularly rapid growth from less than US$ 600 million in 2000 to around US$ 6 billion in 2009.

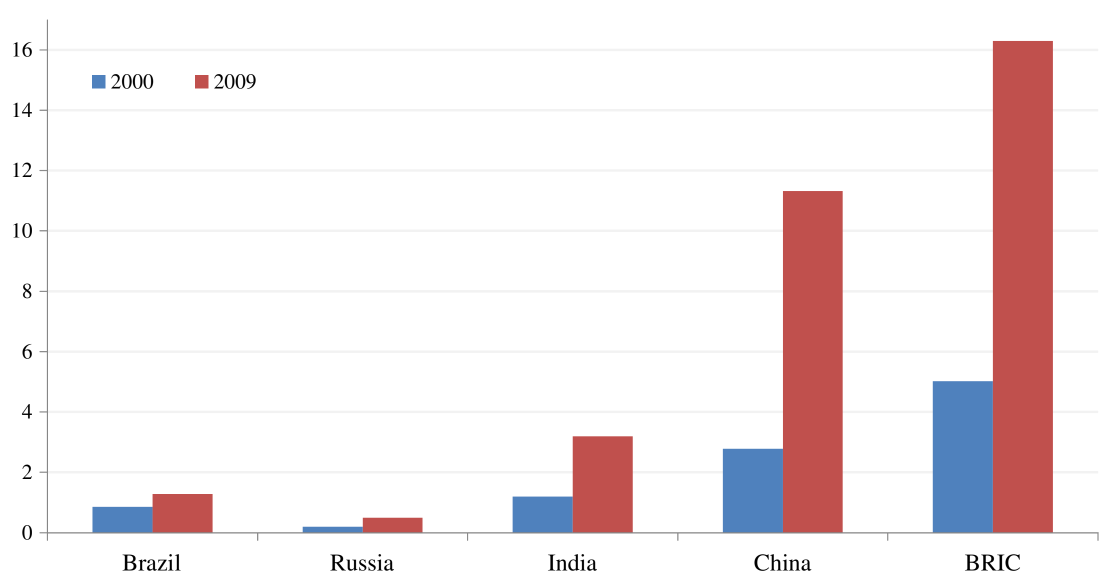
On the import side, Table 2 depicts the percentage of SA's top source of imports over the period 2000 and 2009. Developed countries such as Germany, the US, Japan and the UK have been among SA's top source of imports. Germany was the dominant supplier of imports to SA from 2000 to 2009. But in 2009, China became the biggest import market, overtaking Germany, and supplied 13% of total SA's imports, while imports from Germany were 11.5%. Imports from India, Brazil and Russia increased from 0.9%, 1%, and 0.3% of total imports in 2000, to 2.9%, 1.9% and 0.6% in 2009, respectively. Meanwhile, India currently is the 8th largest import source to SA. It is notable that some developing countries, such as Saudi Arabia and Iran, occupy the 5th and 6th positions of SA's biggest source of imports.

2.2. Foreign trade by product group

Table 3 lists the top five most important South African export products to the BRIC countries. It shows that SA's exports to the BRIC countries generally consist of basic commodities. In addition, China and India import significant amounts of precious stones, for instance platinum, gold and diamonds. According to Sandrey and Jensen (2007) around 46% of China's platinum and 26% of its diamonds come from SA.

Looking more deeply, SA's exports to China comprise of natural resources such as coal, gold and uranium (62.5%), iron and steel (18%) and non-ferrous metals (7.3%). As is the case with China, SA's exports to India also consist mainly of basic commodities, coal (57.5%), chemicals (15.9%), iron and steel (8.5%) and non-ferrous metals (4.4%). SA's main exports to Brazil include coal (11.6%), chemical products (31.6%), motor vehicles, parts and accessories (15.8%), non-ferrous metals (4.9%) and iron and steel (14.6%). Together these products constitute 78.7% of SA's exports to Brazil. SA's exports to Russia is different from the product grouping that it exports to other BRIC countries and mainly consist of agricultural products, such as forestry, fish, food and beverages, which account for 50%, 10% and 3%, respectively. SA also exports machinery and equipment (10%) and mining products (15%) to Russia.

On the import side, Table 4 illustrates the top five SA's imports by categories from the BRICs. It shows that SA's imports from China commonly consist of machinery and electrical equipment, textiles, clothing and footwear. Coke and refined petroleum, fibres, electrical equipment,



Source: South African International Trade Indicators, 2010

Fig. 1. SA's foreign trade with the BRIC countries (percentage).

Table 1
SA's top export destinations, 2000–2009 (percentage).

Rank	Exports to:	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	China	1.96	1.74	1.70	2.57	2.21	2.64	3.52	5.17	5.48	9.47
2	US	11.98	8.96	9.00	9.22	10.03	9.52	10.54	10.96	10.33	8.15
3	Japan	8.04	5.02	5.59	7.81	9.08	10.24	10.70	10.55	10.24	6.70
4	Germany	7.77	7.29	6.69	6.30	6.88	6.48	6.87	7.17	7.24	6.46
5	UK	8.86	9.74	9.18	8.81	9.46	10.00	8.18	7.21	6.25	4.94
6	Switzerland	1.78	0.80	0.87	1.54	2.42	2.04	2.64	1.86	1.93	4.19
7	Netherlands	3.32	4.37	4.45	4.41	4.12	4.45	4.54	4.13	4.21	3.59
8	India	1.42	1.43	1.35	1.15	1.25	1.82	1.35	1.95	2.80	3.48
24	Brazil	0.65	0.83	0.64	0.52	0.53	0.62	0.71	0.72	0.83	0.59
40	Russia	0.10	0.12	0.15	0.23	0.22	0.14	0.17	0.21	0.26	0.31

[1] Source: South African International Trade Indicators, 2010.

Table 2
SA's top source of imports, 2000–2009 (percentage).

Rank	Imports from:	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	China	3.68	4.19	5.21	6.46	7.53	8.95	9.99	10.73	11.17	13.09
2	Germany	13.27	14.95	15.58	14.79	14.18	14.03	12.48	11.64	11.36	11.58
3	US	11.76	11.92	11.62	9.70	8.45	7.79	7.55	7.66	7.84	7.50
4	Japan	7.94	6.86	6.90	7.03	6.83	6.77	6.55	6.58	5.62	4.89
5	S.Arabia	7.41	7.03	4.59	5.83	5.65	5.53	5.28	4.53	6.39	4.99
6	Iran	4.28	4.10	3.61	3.63	5.01	4.10	3.97	3.70	3.81	4.15
7	UK	8.60	8.47	9.07	8.70	6.85	5.55	4.98	4.84	4.10	4.01
8	India	0.94	0.97	1.07	1.22	1.49	2.00	2.33	2.22	2.61	2.92
17	Brazil	1.09	1.53	1.78	2.07	2.10	2.37	2.02	2.08	1.89	1.95
53	Russia	0.30	0.16	0.35	0.11	0.08	0.18	0.39	0.70	0.36	0.66

[2] Source: South African International Trade Indicators, 2010.

motor vehicles and chemicals are the main imports from India. SA's major imports from Brazil are motor vehicles, parts and accessories, machinery and equipment, and electrical machinery, as well as agricultural goods. SA mainly imports mining, iron and steel, non-ferrous metals and agricultural goods from Russia.

It is evident that most of SA's export products face little competition from China, Brazil and India. For instance, Brazil exports mainly vehicles, machinery, iron and steel, and ores as well as agricultural products, while China exports machinery and electrical equipment, clothing, textiles and footwear, and chemicals (Naude, 2009). India mainly exports precious metals and stones, mineral fuels, clothing and organic chemicals (Sandrey and Jensen, 2007).

3. Methodology

Since the seminal work of Sims (1980) there has been an increase in popularity of the vector autoregressive (VAR) models, especially in empirical macroeconomics. However, these models can only deal with a relatively small number of variables and are often estimated using data for a cross-sectional unit, ignoring possible international linkages. When international linkages are present in a VAR model, then the model would have to include either higher-order time lags or have to include half a dozen domestic variables so as to capture the complicated international linkages. Moreover, the coefficient estimates of the model would not have the same interpretation as in a closed-economy model since all economies are now open, and therefore the impact of foreign variables should be taken into account. In a standard VAR model, each variable is allowed to have an independent effect on the dependent variables. Panel VAR models have also been applied to construct multi-country models (Ballabriga et al., 1999).[6] These models combine several VAR coefficients and assume that the regressors do not include any contemporaneous endogenous variables and thus, they suffer from the same criticism (Assenmacher-Wesche and Gerlach, 2008).

To answer these issues, PSW, DdPS and DHPS develop a global VAR model to examine the global interactions and to simplify the analysis of country shocks on the world economy. They combine several VAR models and take a slightly different approach by allowing unrestricted coefficients for the domestic variables and carefully construct country-specific foreign variables for use in each of the separate country-specific models. The country-specific foreign variables are treated as weakly exogenous when estimating the model for each country.[7] The country-specific vector error-correcting models are estimated individually for each country/region, where domestic variables are related to the corresponding foreign variables. The country-specific models are then combined to simultaneously generate impulse response functions for all variables in the world economy. The aim of the global VAR model is to provide a flexible structure for use in a variety of applications (PSW, 2004). For instance, DdPS (2007) use a global VAR model to analyse the international linkages of the euro area, which treats the euro area as a single economy. Pesaran et al. (2007) use it to examine the decision of UK and Sweden not to join the Euro and Smith (2009) uses it to evaluate the success of European Monetary Union (EMU) considering whether the UK and Sweden would have been better off if they had joined the Euro or whether Germany and Italy would have been better off had they not joined. Finally, Pesaran et al. (2009) use the global VAR model to forecast economic and financial variables across 33 countries.

The global VAR approach also allows for the interdependencies between countries and/or regions at a variety of levels in a transparent manner that can be evaluated empirically, including long-run relationships consistent with the theory and data. The interdependencies between countries can be summarised in three transparent ways. Firstly, it combines the individual country VAR models where domestic variables are related to country-specific foreign variables in a rational way, to match the international trade pattern of the country under

[6] For more detail on multi-country models see Canova and Cicarelli (2006).

[7] In a global VAR, each of the country/region-specific models is estimated using a range of country-specific domestic and foreign variables which are constructed as a weighted average of endogenous variables in other countries. The weighting matrix is derived from the trade pattern.

Table 3
SA's exports by product group (USD in millions).

Country	Products	2003	2004	2005	2006	2007	2008	2009
Brazil	Chemicals	44.1	53.9	62.4	79.6	96.1	135.6	113.0
	Motor vehicles and parts	16.3	15.1	19.9	27.4	45.0	77.8	56.5
	Iron and steel	29.8	57.8	81.2	99.2	136.4	194.6	52.2
	Coal mining	22.4	26.9	29.1	51.8	43.5	66.9	41.7
	Non-ferrous metals	16.8	19.2	28.7	48.3	47.6	23.2	17.8
China	Mining	221.9	311.9	505.4	1028.0	1904.6	2568.1	3,610.1
	Iron and steel	279.2	262.6	272.3	336.1	880.3	654.6	1,041.7
	Non-ferrous metals	100.0	109.4	173.7	180.4	121.4	373.4	420.8
	Chemicals	64.2	114.6	124.9	114.9	159.0	199.3	205.9
	Agriculture, forestry and fishing	12.6	12.7	22.8	39.9	69.5	77.0	128.5
India	Coal mining	32.7	18.8	154.6	94.9	426.3	608.1	1,217.1
	Chemicals	127.4	202.6	212.9	227.8	253.3	778.8	336.6
	Iron and steel	41.7	73.1	171.3	113.2	137.1	256.7	181.2
	Mining	6.2	14.3	13.0	16.2	57.0	177.0	96.7
	Non-ferrous metals	29.6	51.0	170.9	67.1	183.8	129.3	93.9
Russia	Agriculture, forestry and fishing	37.7	45.9	33.5	52.8	72.5	100.1	94.5
	Machinery and equipment	3.0	13.9	7.8	5.8	14.0	17.3	28.3
	Food	14.9	4.9	4.0	11.4	8.2	8.9	19.7
	Mining	0.2	1.3	0.1	2.7	8.7	13.2	18.9
	Beverages	0.9	1.9	2.6	4.5	6.3	14.0	6.8

[3] Source: South African International Trade Indicators, 2010.

consideration. Secondly, non-zero pair-wise correlations in residuals between countries and equations are allowed to capture a certain amount of dependence in idiosyncratic shocks. Lastly, it allows dependence of country-specific variables on common global shocks that can affect all countries simultaneously such as oil prices (DdPS, 2007).

3.1. Country-specific models

Let us consider the global VAR model as proposed by PSW (2004) and further developed by DdPS (2007). Assume that there are $N+1$ countries in the global economy, indexed by $i=0, 1, 2, \ldots, N$, where 0 serves a reference country and denoting each country i modelled as a VARX*:

$$x_{it}=c_{i0}+c_{i1}t+\Phi_i x_{i,t-1}+\Lambda_{i0}x^*_{it}+\Lambda_{i1}x^*_{i,t-1}+\Psi_{i0}d_t+\Psi_{i1}d_{t-1}+\varepsilon_{it} \quad (1)$$

where $t=0, 1, 2, \ldots, T$, x_{it} indicates a $(k_i\times 1)$ vector of domestic variables belonging to country i, at time t, x^*_{it} is a $(k^*_i\times 1)$ vector of foreign variables specific to country i, c_{i0} is a $(k_i\times 1)$ vector of fixed intercept coefficients, c_{i1} is a $(k_i\times 1)$ vector of coefficients of the deterministic time trend, Φ_i is a $(k_i\times k_i)$ matrix of coefficients associated to lagged domestic variables, while Λ_{i0} and Λ_{i1} are $(k_i\times k^*_i)$ matrices of coefficients related to contemporaneous and lagged foreign variables respectively, d_t is a set of common global variables assumed to be weakly exogenous to the global economy, such as oil prices and Ψ_{i0} and Ψ_{i1} are the matrices of fixed coefficients. The error term, ε_{it}, is a $(k_i\times 1)$ vector of idiosyncratic, serially uncorrelated, country-specific shocks, where $\varepsilon_{it}\sim i.i.d.(0,\Sigma_{ii})$ and is non-singular for $i=0, 1, 2, \ldots, N$, and $t=0, 1, 2, \ldots, T$. The global VAR approach allows for non-zero contemporaneous dependence of shocks across countries through cross-country covariances:

$$\Sigma_{ij}=Cov\left(\varepsilon_{it},\varepsilon_{jt}\right)=E\left(\varepsilon_{it}\varepsilon'_{jt'}\right),\ \text{ for } i\neq j$$

A standard component of Σ_{ij} will be indicated by $\sigma_{ij,ls}=Cov(\varepsilon_{ilt},\varepsilon_{jst})$, which is the covariance of the l^{th} variable in country i with the s^{th} variable in country j. The set of country specific-foreign variables, x^*_{it}, are built using fixed trade weights. The weights are computed using cross-country trade weighted averages of the corresponding variables given by trade shares, such that w_{ij} is the share of country j in the total trade (exports plus imports) of country i measure in US dollar. Therefore:

$$w_{ii}=0,\ \ \forall\ i=0,1,2,\ldots,N$$

and

$$\textstyle\sum_{j=0}^N w_{ij}=1,\ \ \forall\ i,j=0,1,2,\ldots,N$$

Specifically, the set of foreign specific variables for country i, x^*_{it} defined as:

$$x^*_{it}=\textstyle\sum_{j=0}^N w_{ij}x_{jt} \quad (2)$$

where $w_{ij}\geq 0$ are the weights attached to the foreign variables. The foreign variables, x^*_{it}, and global variables (in this study the oil price), p^{oil}_{it}, are treated as weakly exogenous. PSW (2004) provide theoretical arguments and empirical evidence of the weak exogeneity assumption that allows country/region-specific models to be estimated consistently. This considers each economy as small when compared to the rest of the world. The weights, w_{ij}, capture the importance of country j for country i. The weights used in this paper are based on cross-country trade flows. They are computed using the annual trade averages over the period 2006–2008. We allow country-specific shocks to be weakly correlated with shocks in other countries or regions through the link between domestic and foreign variables. These shocks are serially uncorrelated and cross-sectionally weakly dependent, such that for each t:

$$\varepsilon^*_{it}=\textstyle\sum_{j=0}^N w_{ij}\varepsilon_{jt}\rightarrow 0$$

The idiosyncratic shocks, ε_{it}, are correlated across countries or regions such as:

$$E\left(\varepsilon_{it}\varepsilon'_{jt'}\right)=\begin{cases}\Sigma_{ij} & \text{for } t=t'\\ 0 & \text{for } t\neq t'\end{cases}$$

Therefore, the global VAR model allows for interdependence between countries or regions through three separate but interrelated channels: (1) the direct dependence of domestic variables, x_{it}, with foreign variables, x^*_{it}, and with their lagged values; (2) the dependence of the country-specific domestic variables, x_{it}, on common global exogenous variables, d_t, such as oil prices and their related lagged values; (3) the contemporaneous dependence of the idiosyncratic shock in country i on the shocks in country j, measured via the cross-country covariances, as Σ_{ij} indicated above.

PSW (2004) proposes that the country-specific models be estimated separately to accommodate the weak exogeneity assumption of foreign variables rather than to estimate directly the complete system of $N+1$ country-specific models (1) together with the relations linking the foreign variables (2). In practice, this exogeneity assumption should hold for small open economies where the impact of global markets and/or regions is generally exogenously given. Therefore, such an assumption seems reasonable to a small player in the global economy such as SA.

3.2. Building the global VAR

This section illustrates the process of combining the country-specific models into a global VAR model. The estimated parameters from the

Table 4
SA's imports by product group (USD in millions).

Country	Products	2003	2004	2005	2006	2007	2008	2009
Brazil	Motor vehicles and parts	255.3	324.8	468.9	513.2	550.4	510.3	368.2
	Food	109.5	206.7	288.5	224.5	342.4	389.7	290.5
	Machinery and equipment	80.3	144.5	156.2	149.0	199.6	227.7	117.8
	Agriculture, forestry and fishing	22.4	46.6	25.3	38.5	35.9	29.5	104.0
	Electrical machinery	19.3	27.1	38.1	51.7	99.7	118.6	71.0
China	Machinery and equipment	509.6	845.1	1237.7	1770.6	2183.2	2,402.4	2030.7
	TV and communication equipment	234.1	385.0	560.9	762.2	1,090.0	1246.5	1135.8
	Wearing apparel	227.8	452.6	606.1	859.9	623.9	623.4	744.8
	Electrical machinery	96.4	146.6	215.9	349.9	454.5	806.5	458.8
	Other industries	126.8	194.7	265.2	334.5	390.0	425.7	425.1
India	Coke and refined petroleum products	0.3	77.3	140.6	259.4	451.4	762.2	519.0
	Chemicals and man-made fibres	44.1	60.4	81.0	104.8	121.7	212.9	225.1
	Motor vehicles and parts	21.1	49.3	212.8	318.8	235.1	196.5	178.3
	TV and communication equipment	1.3	3.1	4.3	6.5	26.3	120.1	119.7
	Chemicals	31.4	54.5	79.4	99.2	93.7	116.5	115.7
Russia	Mining	0.0	0.0	57.4	115.3	468.2	157.6	342.5
	Agriculture, forestry and fishing	4.3	0.0	0.0	0.0	0.0	0.0	20.9
	Other industries	0.1	0.1	0.1	0.2	0.1	32.3	20.3
	Non-ferrous metals	19.5	11.4	0.9	101.0	39.2	17.8	10.3
	Iron and steel	0.9	1.9	8.3	20.1	28.0	21.7	8.9

[4] Source: South African International Trade Indicators, 2010.

country-specific models are then stacked together to build a global VAR. In view of the simultaneous dependence of the domestic variables, x_{it}, on the foreign variables, x_{it}^*, the country-specific VARX* models (1) are solved simultaneously for all the domestic variables, x_{it}, $i = 0, 1, 2, \ldots, N$. Let us consider the general country-specific model (1) without the set of global variables, because these variables are considered endogenous for the US model, as it is the dominant economy in the model, while weakly exogenous for the remaining country-specific models. Thus, Eq. (1) becomes:

$$x_{it} = c_{i0} + c_{i1}t + \Phi_i x_{i,t-1} + \Lambda_{i0} x_{it}^* + \Lambda_{i1} x_{i,t-1}^* + \varepsilon_{it} \quad (3)$$

The global variables are included as foreign variables for all countries except the US model. To construct the global VAR model from the individual country-specific models, firstly we group together domestic and foreign variables for each country as:

$$z_{it} = \begin{pmatrix} x_{it} \\ x_{it}^* \end{pmatrix}$$

Therefore, Eq. (3) becomes:

$$A_i z_{it} = c_{i0} + c_{i1}t + B_i z_{i,t-1} + \varepsilon_{it} \quad (4)$$

where $A_i = (I_{ki} - \Lambda_{i0})$, $B_i = (\Phi_i - \Lambda_{i1})$. The dimensions of A_i and B_i are $k_i \times (k_i + k_i^*)$ and A_i has a full row rank, that is $rank(A_i) = k_i$.

Secondly, we collect all country/region-specific domestic variables together to create a global vector, g_t, with dimension $k \times 1$, where $k = \sum_{i=0}^{N} k_i$, denote the total number of endogenous variable in the system: $g_t = (g'_{0t}, g'_{1t}, \ldots, g'_{Nt})'$. We start by assuming that all country-specific variables in the global economy are endogenously determined. However, there are complex trade linkages between countries, for instance in the case of trade flow variables. Endogeneity is implicit in the construction of aggregate exports and imports as the exports from country i_1 to country i_2 are the imports from country i_2 to country i_1 and vice-versa. We can now write country-specific variables in terms of the global variable vector, g_t, to obtain the following identity:

$$z_{it} = L_i g_t \text{ for } \forall\ i = 0, 1, 2, \ldots, N \quad (5)$$

where L_i is the $(k_i + k_i^*) \times k$ matrix collecting the trade weights w_{ij}, $\forall\ i,j = 0,1,2,\ldots,N$. PSW (2004) defines L_i as the *link* matrices which allows the country-specific models to be written in terms of the global variable vector, g_t.

Furthermore, using the identity in Eq. (5) in each country-specific model (4), it follows that:

$$A_i L_i g_t = c_{i0} + c_{i1}t + B_i L_i g_{t-1} + \varepsilon_{it} \quad (6)$$

where $A_i L_i$ and $B_i L_i$ are both $k_i \times k$ dimensional matrices.

Finally, by stacking each country-specific model in Eq. (6), we obtain the global VAR for all the endogenous variables in the system, g_t,

$$K g_t = c_{i0} + c_{i1}t + M g_{t-1} + \varepsilon_{it} \quad (7)$$

where $K = \begin{pmatrix} A_0 L_0 \\ A_1 L_1 \\ \vdots \\ A_N L_N \end{pmatrix}, M = \begin{pmatrix} B_0 L_0 \\ B_1 L_1 \\ \vdots \\ B_N L_N \end{pmatrix}, c_0 = \begin{pmatrix} c_{00} \\ c_{10} \\ \vdots \\ c_{N0} \end{pmatrix}, c_1 = \begin{pmatrix} c_{01} \\ c_{11} \\ \vdots \\ c_{N1} \end{pmatrix}, \varepsilon_t = \begin{pmatrix} \varepsilon_{0t} \\ \varepsilon_{1t} \\ \vdots \\ \varepsilon_{Nt} \end{pmatrix}$

The K matrix has dimensions $k \times k$ and if it is non-singular, such as of full rank, then we can invert it. By inverting the K matrix we get the global VAR model in its reduced form:

$$g_t = b_0 + b_1 t + H g_{t-1} + \mu_t \quad (8)$$

where g_t is the global $k \times 1$ vector, where $k = \sum_{i=0}^{N} k_i$ is the total number of the endogenous variables in the global model, containing the macroeconomic variables for all the countries, g_t is a function of time, the lagged values of all macroeconomic variables g_{t-1}, and the exogenous variables common to all countries and their lags. b_0 and b_1 are vectors $k \times 1$ of coefficients, H is a $k \times k$ matrix of coefficients, and μ_t is a $k \times 1$ vector of reduced-form shocks that are linear functions of the country-specific shocks, ε_t; particularly, $\mu_t = K^{-1}\varepsilon_t$, where $\varepsilon_t = \left(\varepsilon'_{0t},\ \varepsilon'_{1t},\ \ldots,\ \varepsilon'_{Nt}\right)'$, $var(\mu_t) = K^{-1}\Sigma\varepsilon K'^{-1}$, and $\Sigma\varepsilon = var(\varepsilon_t)$.

Since the country-specific weights convince the adding-up restrictions, $k = \sum_{i=0}^{N} k_i = 1$, the link matrices must be of full rank and allow the link matrix to be non-singular as well. The model in Eq. (8) is solved recursively and used to construct generalised impulse response analysis in the usual manner. There are no restrictions placed on the covariance matrix, $\Sigma\varepsilon = E(\varepsilon_t \varepsilon'_t)$.

Briefly, the global VAR model can be described in two stages. In the first stage, country-specific VARX* models, namely VAR models augmented by weakly I(1) variables (such as domestic variables and cross-section averages of foreign variables) are estimated for each country/region individually. In the second stage, the estimated coefficients from the country/region-specific models are stacked and solved in one big system such as global VAR. This model is a useful framework in this instance, given its ability to model the international transmission of shocks. In this paper, we build a global VAR model, following PSW (2004) and DdPS (2007), to assess the importance of trade linkages between SA and the BRICs.

4. Data and estimation of the model

In this paper, the global VAR model[8] contains 32 countries from different regions of the world. Table 5 presents countries and regions included in the model. We have two different estimations in our model. Firstly, the 8 countries in the euro area are grouped together and treated as a single economy, while the remaining 24 countries are modelled individually. Secondly, the BRIC countries and the euro area are modelled separately as a single economy, while the remaining 20 countries are estimated individually. Therefore, the global VAR model contains 24 countries and one region in the first and 20 countries and two regions in the second estimation. The models are estimated for the period 1995Q1–2009Q4.

The first step in the construction of the model is the selection of variables to include in the analysis. Given the objective of this paper the real output, real exports and real imports are the main variables of interest. In addition, we include the real effective exchange rates and inflation, given their typical effect on trade. Finally, to account for possible common factors we also include the price of oil. Details about the data sources are reported in Appendix A.

We select the following country-specific domestic, x_{it}, and foreign variables, x^*_{it}, for country $i = 1, 2, \ldots, N$:

$$x_{it} = (y_{it},\ ex_{it},\ im_{it},\ rer_{it},\ dp_{it})' \quad \text{and} \quad x^*_{it} = \left(y^*_{it},\ dp^*_{it},\ p^{oil}_t\right)'$$

where y_{it} is the log real output, ex_{it} is the log real exports, im_{it} is the log real imports, rer_{it} is the log real effective exchange rates, dp_{it} is the log of the rate of inflation and p^{oil}_t is the log of the nominal spot price of oil.

The country-specific foreign variables are built using fixed trade weights based on the average trade flows computed over the three years, i.e. 2006–2008, and are defined as follows:

$$y^*_{it} = \sum_{j=0}^{N} w_{ij} y_{it}, \quad dp^*_{it} = \sum_{j=0}^{N} w_{ij} dp_{it}, \quad rer^*_{it} = \sum_{j=0}^{N} w_{ij} rer_{it},$$

where w_{ij}, the weights, are the share of country j in the trade of country i such that $w_{ii} = 0$ and $\sum_{j=0}^{N} w_{ij} = 1$. The motivation behind choosing the trade weights is to accommodate the effects of external shocks that could pass through output in all countries via trade channels. The set of country-specific foreign variables represents the dynamics of the global economic variables, which are assumed to impact and shape SA's macroeconomic variables. The trade shares for the BRICS economies, with a *Rest* category showing the trade shares with the remaining 19 countries in the model, are presented in Table 6.

[8] We would like to thank Vanessa Smith and Alessandro Galesi for making their Matlab codes available to us. These codes can be downloaded from: http://www-cfap.jbs.cam.ac.uk/research/gvartoolbox/index.html.

Table 5
Countries and regions in the global VAR model.

Regions	Countries	Regions	Countries
	Austria		Japan
	Belgium		Australia
	Finland	Developed countries	Canada
Euro area	France		New Zealand
	Germany		United Kingdom
	Italy		United States
	Netherlands		Indonesia
	Spain	Asian countries	Korea
	Norway		Malaysia
Rest of Europe	Sweden		Singapore
	Switzerland		Thailand
	Turkey		Brazil
	Argentina		Russia
Latin America	Chile	BRICS	India
	Mexico		China
	Peru		South Africa

In the case of the US economy, domestic and foreign variables are treated differently because the US is treated as a reference country. The US model is linked to the world through the assumption that exchange rates are determined in the remaining country-specific models. Therefore, we have the following domestic and foreign variables for the US model:

$$x_{0t} = (y_{0t},\ ex_{0t},\ im_{0t},\ rer_{0t},\ dp_{0t})' \quad \text{and} \quad x^*_{0t} = (y^*_{0t},\ dp^*_{0t},\ rer^*_{0t})'$$

Given the importance of the US economy for the global economy, we include the price of oil as an endogenous variable and treat the set of real exchange rates as weakly exogenous for the US model, while the real exchange rates are treated as an endogenous variable and the price of oil is treated as exogenous variable in the models for all other countries. We then aggregate as follows. Firstly, the economies in the euro area are modelled in a single regional model and secondly, the BRIC countries in a single regional VARX* model. The regional variables, such as y_{it}, ex_{it}, im_{it}, rer_{it}, dp_{it} and p^{oil}_t, are constructed from the country-specific variables using the following weighted averages:

$$y_{it} = \sum_{l=1}^{N_i} w^0_{il} y_{ilt}$$

where y_{ilt} indicates output of country l in region i and w^0_{il} are the PPP-GDP weights (Purchasing Power Parity's adjusted GDP series). Specifically, the weights are based on the GDP shares of each country in the euro area and the BRIC region. The weights are constructed by averaging the PPP-GDP for each given country over the period 2006–2008. These weights, which should add up to 1, are then divided by the total PPP-GDP of the euro area and the BRIC region. They are then used to compute regional variables, region-specific shocks, such as shocks to a variable across all countries within a particular region, regional aggregation of impulse responses as well as forecast error-variance

Table 6
Trade weights.

Country	Brazil	China	India	Russia	SA
Brazil	0.0000	0.0222	0.0147	0.0137	0.0204
China	0.1213	0.0000	0.1615	0.1095	0.1158
India	0.0154	0.0266	0.0000	0.0142	0.0278
Russia	0.0483	0.0617	0.0303	0.0000	0.0099
SA	0.0097	0.0092	0.0129	0.0008	0.0000
Rest	0.8053	0.8802	0.7806	0.8618	0.8260

Note: Trade weights are displayed in column by country.
Rest: Accumulates the remaining countries.
Source: Direction of Trade Statistics, 2006–2008, IMF.

decompositions. It is important to note that these weights (PPP-GDP), used to aggregate countries into a region, are not the same as the weights (trade weights) used to build the foreign variables.

The next step is to determine the degree of integration of all the series. We first use the traditional Augmented Dickey-Fuller (ADF) tests on levels, first and second differences for all country-specific domestic and foreign variables in the global VAR model. The lag order of the ADF test statistics is determined by the minimisation of the Akaike Information Criterion (AIC), for which the maximum lag allowed is set to 6. Since the traditional ADF test for unit roots may suffer power problems in small samples, we use the Weighted Symmetric Augmented Dickey-Fuller (WS-ADF) test, which uses the time reversibility of stationary autoregressiveness. The WS-ADF test statistics are also based on the related regressions with the same lag order, in accordance with the AIC. The WS-ADF test results on level and first differences, without trend, for our focus economies are reported in Table 7. The results from the test show that in most countries the hypothesis of the unit roots cannot be rejected for most of the variables and that most of variables are integrated of order 1 or I(1).

After finding that most of the variables in most of the countries have a unit root, the next step is to identify the rank of the cointegration space. We perform a cointegration analysis, in cases where cointegration is found, and individually estimate each country VARX* model in its vector error-correcting VECMX* form. Specifically, we carry out the Johansen's (1992, 1995) reduced-rank procedure. Then, the cointegration rank is derived by employing the trace test statistic at the 95% critical values and the maximum eigenvalue statistics. Table 8 presents the number of cointegrating ranks obtained for each of our focus economy VARX* model and lag orders for each domestic and foreign variable for each of the BRICS country model. We use White's heteroskedasticity-corrected standard errors for testing all hypotheses.

Testing weak exogeneity of foreign and global variables is the key assumption of the global VAR approach. We estimate the parameters of the country-specific models using the reduced-rank approach under a weak exogeneity condition. The reduced-rank approach developed by Johansen (1995) assumes that all variables are endogenously determined and are of the order I(1). Pesaran et al. (2000) propose the method which allows the inclusion for weakly exogenous variables in a reduced-rank estimation procedure. Following DdPS (2007), we employ weak exogeneity tests proposed by Johansen (1992) and Harbo et al. (1998). This test assesses the joint significance of the estimated error-correcting terms in the marginal models for the foreign variables. This amounts to conducting the following regression for each l^{th} element of x_{it}^* in each country i model:

$$\Delta x_{it}^* = \mu_{il} + \sum_{j=1}^{r_i} \gamma_{ij,l} ECM_{i,t-1}^j + \sum_{k=1}^{p_i} \theta_{ik,l} \Delta x_{i,t-k} + \sum_{m=1}^{q_i} \delta_{im,l} \Delta x_{i,t-m}^* + \varepsilon_{it,l} \quad (9)$$

where $ECM_{i,t-1}^j$, $j = 1, 2, \ldots, r_i$, is the estimated error-correcting terms associated with the r_i cointegrating relations, the rank, for the country i model with $j = 1, 2, \ldots, r_i$. $\Delta x_{i,t-k}$ is the set of domestic variables in differences, with $k = 1, 2, \ldots, p_i$, where p_i is the lag order of the domestic component of each country i model, $\Delta x_{i,t-m}^*$ is the set of foreign and global variables in differences with $m = 1, 2, \ldots, q_i$, where q_i is the lag order of the foreign, weakly exogenous, component of each i country model. The test for weak exogeneity consists of verifying, by means of F-test, the joint hypothesis that $\gamma_{ij,l} = 0$ for each $j = 1, 2, \ldots, r_i$, in the above regression. The results of F-statistics for testing the weak exogeneity of each of BRICS country-specific foreign variables and the oil price are reported in Table 9. It shows that most of the weak exogeneity assumptions cannot be rejected.

Table 7
WS-ADF unit root test statistics for domestic, foreign and global variables.

Variables			Brazil	China	India	Russia	SA
Domestic	Real GDP	Level	0.87	1.81	1.13	−0.56	0.21
		First difference	−6.11	−3.71	−6.77	−3.94	−3.57
	Inflation	Level	−1.62	−1.41	−4.28	−1.41	−4.13
		First difference	−8.12	−5.32	−6.63	−4.78	−6.44
	Exchange rates	Level	−1.24	0.40	0.76	−0.68	−1.67
		First difference	−5.23	−2.44	−4.81	−4.22	−5.1
	Real exports	Level	−0.15	0.25	0.54	−0.45	−0.61
		First difference	−5.06	−3.68	0.69	−0.83	−0.63
	Real imports	Level	0.10	0.80	0.69	−0.83	−0.63
		First difference	−3.08	−5.56	−4.89	−4.54	−4.53
Foreign	Real GDP	Level	0.93	0.44	1.16	0.77	1.24
		First difference	−4.58	−4.18	−4.84	−4.71	−4.61
	Inflation	Level	−2.6	−1.54	−2.12	−2.04	−0.94
		First difference	−5.19	−4.43	−5.04	−6.22	−6.21
Global	Oil price	Level	−0.76	−0.76	−0.76	−0.76	−0.76
		First difference	−6.29	−6.29	−6.29	−6.29	−6.29

Note: WS-ADF test statistics are chosen by the modified AIC with 5% significant level. The 95% critical value of the WS-ADF statistics for regressions with trend is −3.24 and without trend is −2.55.

Table 8
VARX* order and cointegrating relationship in the country-specific models.

Country	Lag order of domestic variables	Lag order of foreign variables	Number of cointegrating relations
Brazil	2	1	2
China	1	1	3
India	2	1	2
Russia	2	2	3
SA	1	1	1

Note: The rank of the cointegrating orders for each country/region is computed using Johansen's trace statistics at the 95% critical value level.

5. Empirical results

This section presents the empirical findings based on the dynamic analysis of the global VAR model. We begin by considering the generalised impulse response functions (GIRFs) to assess the time profile of the effects of shocks that we considered. The GIRFs consider the historical correlations between variables, which are summarised by the estimated variance–covariance matrix. Therefore, unlike the traditional IRFs, the result of the GIRFs is invariant to the ordering of the variables in the model, which is important especially in large macroeconomic system. Secondly, GIRFs can provide insights on how shocks spread internationally by revealing linkages between countries (PSW, 2004). This is followed by the generalised forecast error-variance decomposition (GFEVD) for selected variables of interest, given their importance in

Table 9
Weak exogeneity tests of country-specific foreign and global variables.

Country	F test	Critical values	Country-specific foreign and global variables		
			Real GDP	Inflation	Oil prices
Brazil	F(3,38)	2.85	2.95	0.14	0.72
China	F(2,39)	3.24	1.51	1.12	0.15
India	F(2,39)	3.24	1.66	0.15	1.99
Russia	F(4,37)	2.63	0.81	0.77	1.24
SA	F(1,45)	4.05	0.76	1.22	2.04

Note: Critical values are at the 5% level of significance.

the BRICS trade flows. Similarly, the GFEVD has an advantage of being invariant to the ordering of variables in the system. It computes the proportion of the variance of the h-step ahead forecast errors of each variable that is explained by conditioning on contemporaneous and future values of the generalised shocks of the system. It is important to notice that, given the general non-zero correlation between such errors, the individual shock contributions to the GFEVD need not sum to unity (Dees et al., 2007b).

5.1. Generalised impulse response functions

In this section we consider two different types of shocks, namely positive real export and import shocks for 24 periods. The rationale being that, given two countries that are linked through trade, an increase in exports in one country translates to a rise in imports of the other country, and vice-versa. We assess the time profile of the effects of these shocks from Brazil, Russia, India, China and the BRIC as a bloc on the South African economy. Bootstrapped confidence intervals are at the 90% significance level and are calculated using the sieve bootstrap method with 100 replications.

The empirical results are presented in Figs. 2–6. Fig. 2 displays positive real export and import shocks from Brazil. It shows that the export shock from Brazil has a positive impact on South African imports, which means that Brazilian exports trigger imports in SA. The effect is significant and long lasting. However, the effects seem small. South African real imports increase by 1% at the impact, and after one year, it reaches 2% and stays significant for 24 consecutive quarters. The response of South African output to a real export shock is zero at the impact, and gradually becomes positive and significant from second to thirteen quarters, and insignificant thereafter. The results suggest that an export shock not only enhances trade linkages between SA and Brazil, but is also beneficial to the South African economy in that it affects the overall economy, even though the positive effect on output is short lived. In contrast, South African exports and output seem immune to an import shock from Brazil. The impact of this shock seems significant between second and sixth quarters for South African exports, and between second to ninth quarters for South African output. Hence, the results point somewhat to an importance of an export shock relative to an import shock for the South African economy. As shown in Table 1, Brazil is the 24th and 21st largest export destination and import source, respectively, for SA. From Brazil's side, SA is the 26th and 41st most important export destination and import source, respectively (UN, 2009; WB, 2009).

Fig. 3 presents the GIRFs of positive real export and import shocks from Russia. South African real import and output react positively to a real export shock from Russia. This shock has small impact on both South African real imports and output. The effect on real imports is at around 0.01% at impact and reaches to 0.05% after 24 consecutive quarters. In the case of South African output, this is zero at impact, but becomes significant at 12 quarters when the effect increases to 0.05% and at 24 quarters when it reaches 0.08%. A positive real import shock has a positive but insignificant impact on both South African real exports and output. The response of South African real exports to this shock becomes significant at the fifth quarter when the impact is around 0.01%, but this impact fizzles out at the eleventh quarter. These results confirm the observation in Table 1, which ranks Russia at the 40th and 53rd positions as export destination and source of import respectively. From the Russian side, SA is the 104th export destination and 51st import partner (UN, 2009; World Bank, WB, 2009). It implies that trade linkages with SA appear relatively weak, in that an export shock has an impact on the South African economy, but the impact is small, while SA does not react to an import shock.

In Fig. 4, the real export shock from India has a positive and significant effect on South African real imports. At impact, South African real imports increase by 1% and remain high. However, the effect is short-lived in that the shock becomes insignificant after the seventh quarter. Similarly, South African output reacts positively. The effect is zero at the impact and increases gradually and becomes significant after the first quarter and fizzles out after the third quarter. The second shock is the real-imports shock from India. The effect on South African real export increases slowly and becomes significant in the second period following the shock and stays high. Unlike the export

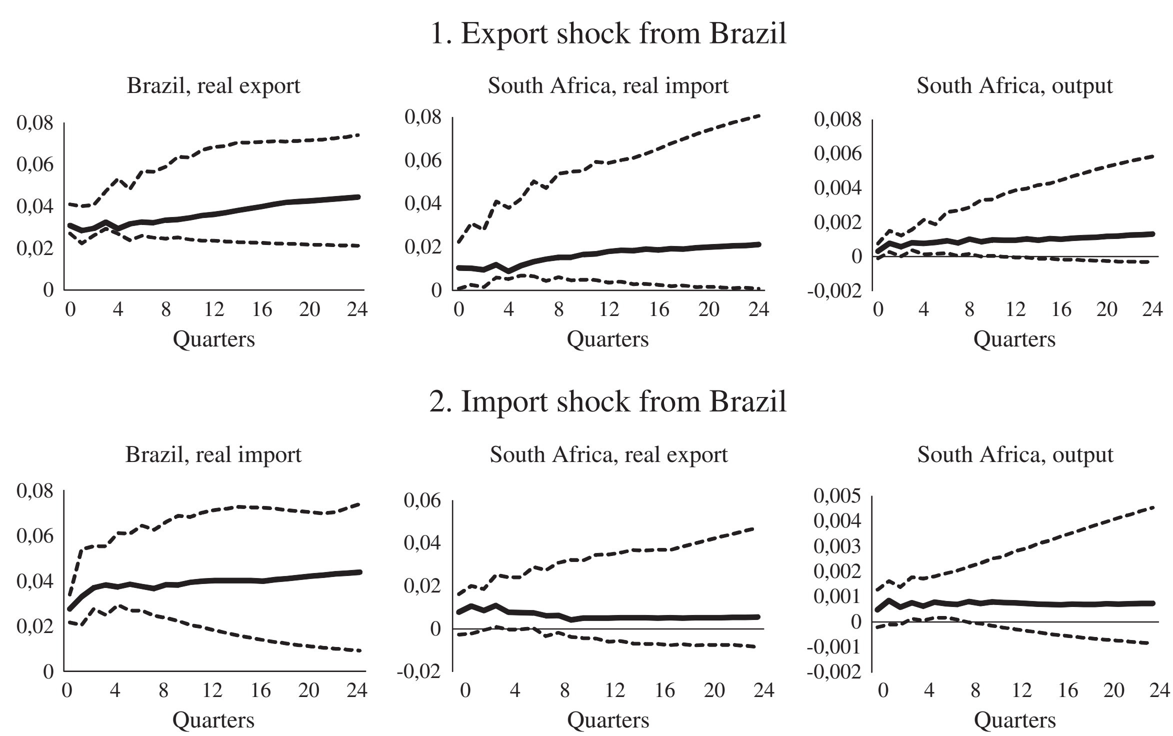


Fig. 2. GIRFs of South African variables to the shocks from Brazil.

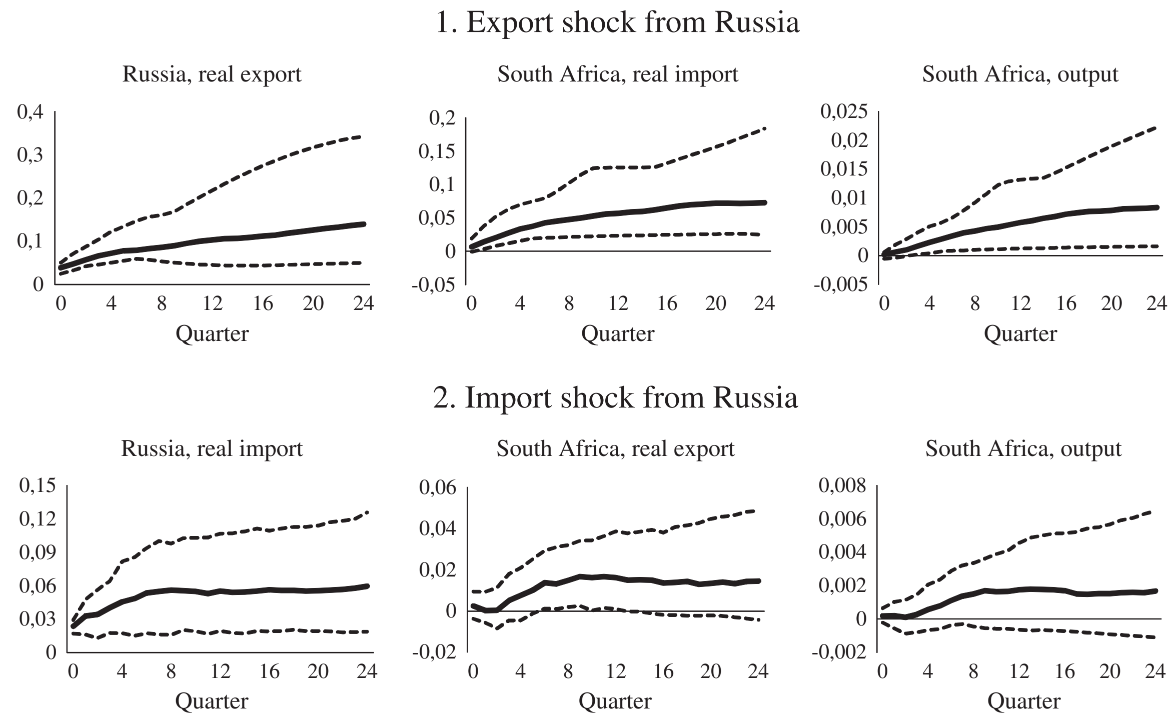


Fig. 3. GIRFs of South African variables to the shocks from Russia.

shock, the import shock has a long-lasting effect. Similarly, output reacts positively and the effect is significant and permanent. Hence, an import shock from India behaves like a supply shock in SA, while the export shock displays characteristics of a demand shock. Notice that India is ranked, in order of importance, in the 8th position in 2009 for both export destination and import resources for SA respectively (see Tables 1 and 2). This makes India one of the major trading partners of SA. SA is also ranked 21st export destination and 24th import trading partner of India (UN, 2009; WB, 2009). These results point to an increasing trade tie between the two countries.

From Fig. 5 we find that a positive real export shock from China increases South African real imports immediately, reaching 1%, and

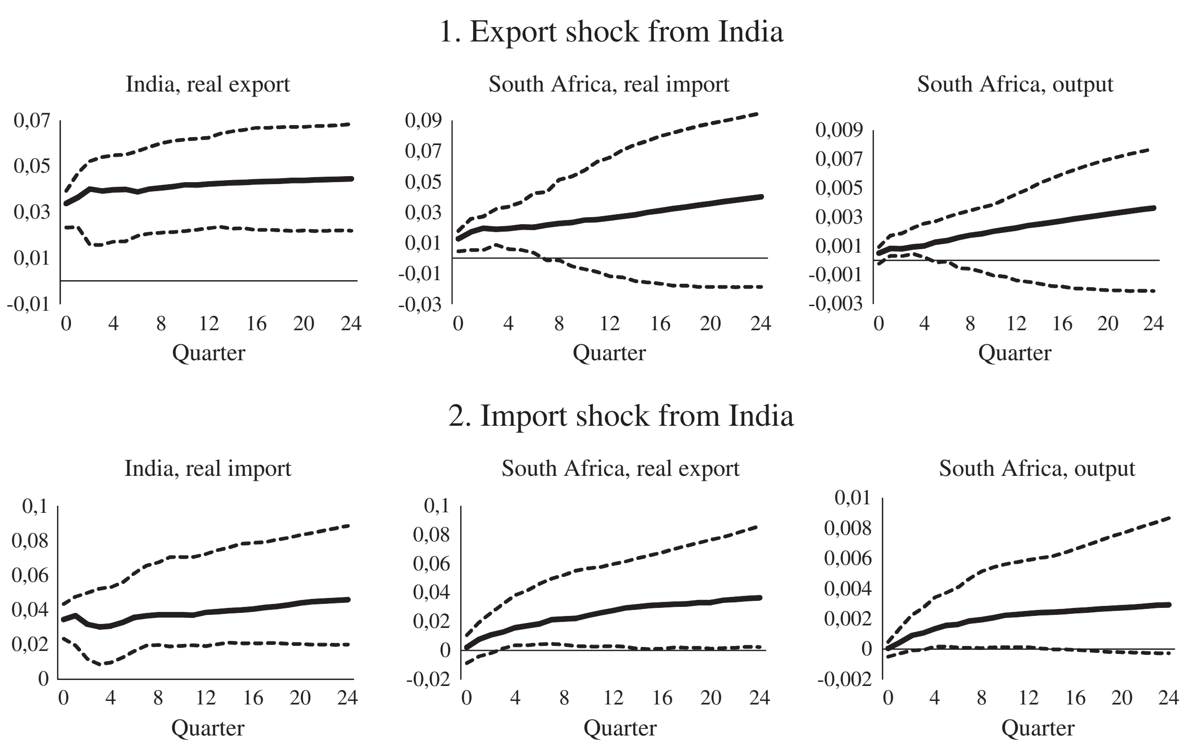


Fig. 4. GIRFs of South African variables to the shocks from India.

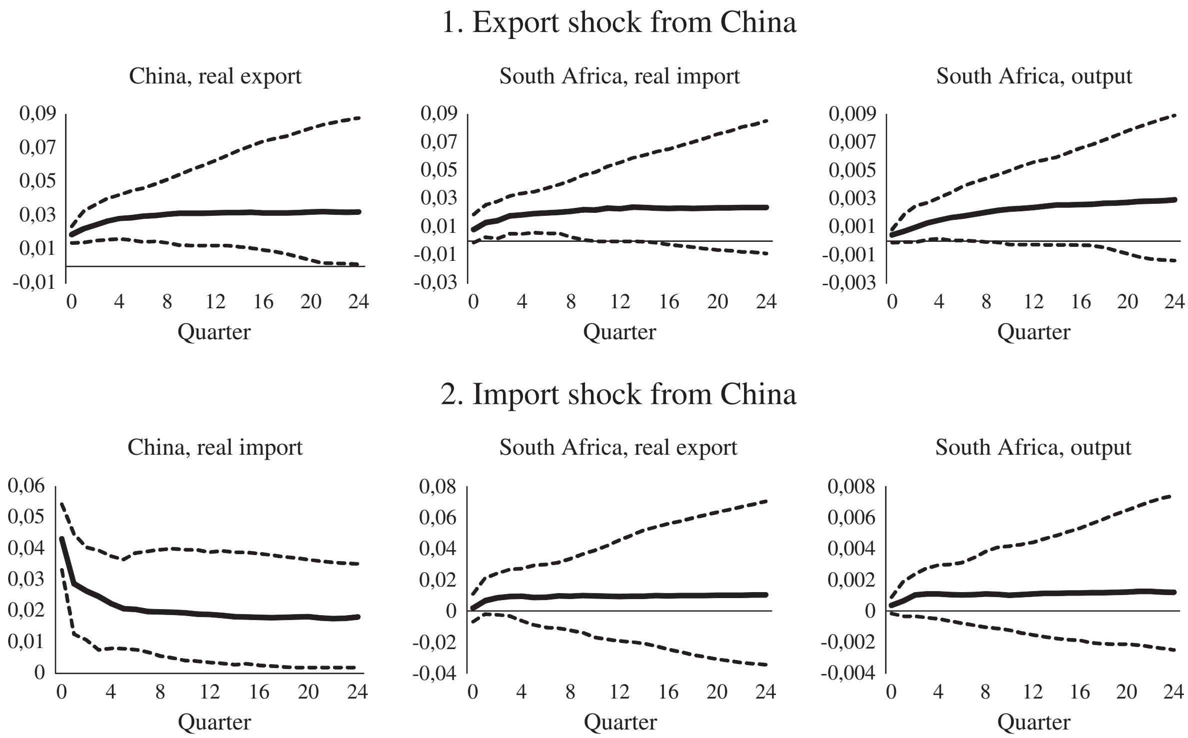


Fig. 5. GIRFs of South African variables to the shocks from China.

gradually rises and attains a maximum of 2% after the ninth quarter and becomes insignificant thereafter. The response of South African real output to this shock is positive, but becomes significant after the third period following the shock and remains significant for approximately three periods. The second shock, the real import shock from China, does not really have an impact on South African real exports and output. Both South African real export and output reacts to this shock positively, but their effects are insignificant. One would expect a positive response of South African exports and output following a Chinese import shock, but the empirical results do not support such expectation. The results

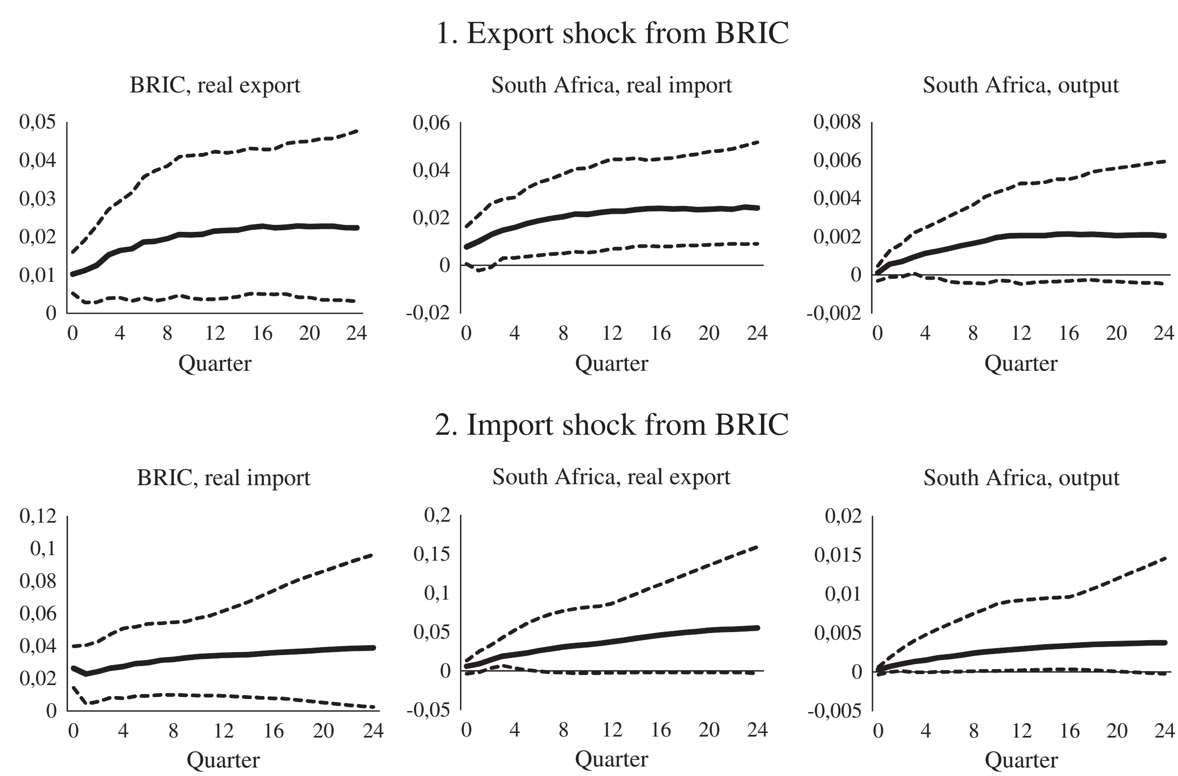


Fig. 6. GIRFs of South African variables to the shocks from the BRIC.

suggest that South African companies are less aggressive in penetrating the Chinese markets, while they have managed to do so in India. China has become SA's number one trading partner in 2009, as shown in Tables 1 and 2, and it is surprising that its overall performance does not translate into tangible performance in SA. Nevertheless, its exports do trigger South African output and import, an indication of the effects of trade links between the two countries.

Lastly, Fig. 6 presents real export and import shocks from the BRIC, as a bloc. A positive export shock from the BRIC has a positive and significant effect on South African imports. The impact is 1% at the impact and reaches 2.4% after 24 quarters. This shock affects South African output only in the short term. Output does not react at impact, but becomes significant after the third quarter following the shock and the effect dies out after the seventh quarter. A real import shock from the BRIC region has a positive but insignificant effect on South African export at impact, but becomes significant after the first quarter and fizzles out after seventh quarters. The response of South African real output to this shock is positive and significant over 20 quarters. It corresponds to an increase of 0.1% at impact, reaches 0.3% at 20 quarters and then becomes insignificant 21 quarters after the impact.

5.2. Generalised forecast error variance decompositions

This section examines the relative contribution of shocks from individual BRIC countries and the BRIC as a region to South African variables. Table 10 presents the generalised forecast error variance decompositions for each of the South African variables explained by the real output, import and export shocks from Brazil, Russia, India, China and the BRIC. The results are on average over a 24-quarter.

From the estimated fraction of the variance decomposition explained by the real export shocks from Brazil, Russia, India, China and the BRIC region, it generally appears to have small effects on South African real output and exports. For example, the export shock from Brazil, Russia, India, China and the BRIC region only explains 1.2%, 0.6%, 0.8%, 0.7% and 0.8% of the variation in real output and 1.0%, 0.8%, 0.9%, 1.3% and 1.3% in real exports respectively. However, the fraction of the variance explained by the real-exports shocks from these countries and the BRIC bloc is estimated to be large for the South African real import and real exchange rates. For instance, the export shock from Brazil, Russia, India, China and the BRIC region only explains 2.1%, 1.1%, 4.1%, 1.7% and 1.6% of the variation in real import and 1.5%, 3.7%, 1.0%, 4.5% and 3.7% in real exchange rates respectively. All of these confirm the results shown through Figs. 2–6. Real export shocks from the individual BRIC countries and the BRIC region have a positive and significant impact on South African real imports.

Looking at the relative contribution of the real import shocks from Brazil, Russia, India, China and the BRIC region, it can be noted that the fraction of the forecast error variances mainly appears to be large for South African real exports and real exchange rates, whereas it appears to be small for real output and real imports, except for the shocks from Brazil and the BRIC region. The import shock from Russia, India and China explains 1.8%, 1.2% and 1.3% of the variation in real exports. It is evident that that the exchange rate is the main channel of transmission of trade shocks, scoring high values of forecast error variance. This finding is also consistent with the previous literature as stated by Friedman (1953) and Mundell (1961), in that the exchange rate acts as a shock absorber, mitigating the effects on the economy of external shocks. However, the real import shock from Brazil mainly explains 2.7% of variation in South African real exports and 2.4% in output, while a real import shock from the BRIC region explains 2.8% of the forecast error variance of South African real imports and 4.5% of the forecast error variance for real exchange rates.

In general, we observe that an Indian real export shock is transmitted more powerfully to South African real imports than the other shocks. Secondly, the real import shock from Brazil plays the biggest role of explaining changes in South African real exports. These results confirm trade linkages between these countries and SA, as in 2009 China ranked SA's number one trading partner, India the 8th, Brazil the 17th and Russia the 40th largest trade partners. The common practice of relying solely on trading with advanced economies can result in the home country being adversely affected by negative shocks from partner countries as observed in the recent global economic crisis. Sources and destinations of imports and exports should be diversified to include a set of emerging markets as well as a number of developing countries. This strategy is equally important for other African countries that rely more on trade with advanced economies.

Table 10
GFEVDs of SA variables explained by the shocks from the BRICs.

Shocks from country and variables		SA variables			
		Real GDP	Real imports	Real exports	Real exchange rates
Brazil	Real export	0.012	0.021	0.010	0.015
	Real import	0.024	0.022	0.027	0.007
Russia	Real export	0.006	0.011	0.008	0.037
	Real import	0.008	0.009	0.018	0.037
India	Real export	0.008	0.041	0.009	0.010
	Real import	0.008	0.012	0.012	0.048
China	Real export	0,007	0.170	0.013	0.045
	Real import	0.010	0.016	0.013	0.046
BRIC	Real export	0.008	0.016	0.013	0.037
	Real import	0.007	0.028	0.012	0.045

Note: Forecast horizon is 24 quarters and forecast error variance of the shock to the real output, export and import of the BRIC countries and the BRIC, as a region, averaged over 24 quarters.

6. Conclusions

This paper investigates trade linkages among South Africa and the BRIC countries as well as the BRIC region, using quarterly data for the 1995Q1–2009Q4 period, in a global VAR framework. The results based on generalised impulse response functions show that export shocks from the BRIC countries, in general, have a significant effect on South African imports and output. Export shocks from China and India have positive, but short-term effects on South African imports and output, whereas Brazil and Russia have a positive and long-term impact on South African imports. Also, real import shocks from the BRIC countries do not have impact on South African real exports and output, except for Brazil and India. These results point to important trade linkages these countries have with SA, especially the importance of export shocks from these countries for SA, but less so for imports. This means that good performance of these economies translate to SA via exports. Similarly, the BRIC as a bloc is closely linked to South African trade variables. Real export and import shocks from the BRIC region have a positive and significant effect on both South African real imports and exports, but not on output. In general, real imports and output react forcefully to shocks from the BRIC region and the exchange rate is the main channel through which these shocks are transmitted in SA. SA's continued and deepened integration into the world economy has been accompanied by trade that targets a variety of emerging markets, thereby mixing the geographical composition of its trade. Such trade strategy is beneficial to South Africa and therefore it is also recommended for the other African countries.

Appendix A. Data sources

Country	GDP	CPI	Exchange rates	Exports	Imports	Oil price
Argentina	IFS	IFS	IFS	DOT	DOT	OECD
Australia	IFS	IFS	IFS	DOT	DOT	OECD
Brazil	IFS	IFS	IFS	DOT	DOT	OECD
Canada	IFS	IFS	IFS	DOT	DOT	OECD
China	GVAR	IFS	IFS	DOT	DOT	OECD
Chile	IFS	IFS	IFS	DOT	DOT	OECD
Euro area	IFS	IFS	IFS	DOT	DOT	OECD
India	GVAR	IFS	IFS	DOT	DOT	OECD
Indonesia	IFS	IFS	IFS	DOT	DOT	OECD
Japan	IFS	IFS	IFS	DOT	DOT	OECD
Korea	IFS	IFS	IFS	DOT	DOT	OECD
Malaysia	IFS	IFS	IFS	DOT	DOT	OECD
Mexico	IFS	IFS	IFS	DOT	DOT	OECD
Norway	IFS	IFS	IFS	DOT	DOT	OECD
New Zealand	IFS	IFS	IFS	DOT	DOT	OECD
Peru	IFS	IFS	IFS	DOT	DOT	OECD
Russia	OECD	IFS	IFS	DOT	DOT	OECD
SA	IFS	IFS	IFS	DOT	DOT	OECD
Singapore	GVAR	IFS	IFS	DOT	DOT	OECD
Sweden	IFS	IFS	IFS	DOT	DOT	OECD
Switzerland	IFS	IFS	IFS	DOT	DOT	OECD
Thailand	IFS	IFS	IFS	DOT	DOT	OECD
Turkey	IFS	IFS	IFS	DOT	DOT	OECD
UK	IFS	IFS	IFS	DOT	DOT	OECD
US	IFS	IFS	IFS	DOT	DOT	OECD

Note: Some of the variables are compiled from the GVAR Toolbox 1.0, where quarterly data are not available. These variables can be downloaded from: http://www-cfap.jbs.cam.ac.uk/research/gvartoolbox/index.html

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