The Magnitude of the macroeconomic impact of oil price: the case of BRICS

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Abstract:

This paper aims to investigate the importance of the macroeconomic impact of oil prices variations on Brazil, Russia, India, China and South Africa (BRICS). The topic was selected due to the significance of those leading emerging economies in global markets and to the determining role of oil in the current economy of the BRICS. The research was built upon on the Granger causality test, the impulse response function and the Cholesky variance decomposition by fitting both linear and non-linear multivariate VAR models. The model includes oil price inflation and consumer price inflation, interest rates, unemployment rates, exchange rates, imports and exports, and total industrial production. The results showed a significant impact of oil prices on the BRICS economies mainly in terms of total industrial production, exports and imports, and evidence of asymmetry was found. The remaining outcomes showed different results depending on whether the country is oil-exporting or oil-importing.

1. Introduction:

Since the oil shock crises in the 1970s, understanding the impact of oil price variations has been at the heart of research. The importance of this topic is first due to the continual growth of the world oil demand, from 73,38 Million Barrels per Day (Mb/d) in 1997 to more than 100 Mb/d expected by 2018. (International Energy Agency, 2017). Specifically, this increase seems to be sharper for the BRICS countries as they are at a differing level of industrialisation, therefore needing considerable energy supply. China is now the second largest oil-consuming country in the world after the United States (IEA, 2017). India occupies the third position, and because of the economic development the country is experiencing, its demand for oil continues to escalate (IEA, 2015). With regard to the African continent, South Africa is the leader in terms of oil consumption, especially since the country has been witnessing rapid growth since 1994. The oil supply becomes even more important if one considers the limited oil reserves South Africa has (IEA, 2015). Moreover, Brazil is not only a large producer of oil in the world, but also one of the highest oil-consuming countries in the American continent after the United States and Canada. The only net-exporting country in the BRICS is Russia (Fattouh et al., 2015), where the revenues from oil and gas account for half of the budget earnings (EIA, 2015). Importantly, Cheng et al. (2007) and Singh and Dube (2014) confirmed the escalating weight of the BRICS in the global economy, forecasting it to become “the largest global economic group by the middle of the century”. This represents one motive for investigating the oil price impact on inflation for the BRICS. Another motive is the limited number of research papers on this association. The majority of papers discussed the effect of oil price fluctuation in the United States (i.e. Hooker, 1999; Castillo, Montoro and Tuesta, 2010; Blanchard and Riggi, 2013). Other papers have focused on European countries (i.e. Alvarez et al., 2010; Filis, 2010; Chatziantoniou et al., 2012) and less commonly the Asian countries (i.e. Cunado and De Gracia, 2004, Rafiq and Salim, 2014).

2. Literature Review

Among the first studies which focused on inflation, Hooker (1999) found that before 1980, econometric findings suggest that variations of oil prices have considerably contributed to inflation increases, an impact that decreases from the early eighties. This research is cited by Cunado and De Gracia (2004), who found that this effect is limited to the short-run. The difference is likely due to the time lag between the two papers. Castillo, Montoro and Tuesta

(2010) have been more precise by asserting that, although the relationship between inflation and oil price experienced weakness from the 2000s in the US, the greater the oil prices volatility, the higher are the inflation levels. Those findings were shared by Wu and Ni (2011) and Blanchard and Gali (2007). Notwithstanding a change across time, those latter remarked that 61% of inflation variation in the US is due to oil price changes. However, one question that needs to be considered is whether the log-linear approximation employed is valid with extreme oil price volatility; as only the mean would be considered and not the variance (Zietz, 2006). Cologni and Manera (2008) provided both long term and short term analysis when reviewing the impact on the G-7 countries. They concluded that oil price shocks lead not only to higher inflation and lower output, but also have a significant impact on interest rates. The latter would be the central banks' response for absorbing the shock through its monetary policy. Likewise, Filis (2010) affirmed the short run positive relationship between oil prices and inflation in Greece as well as a negative long run relationship with regards to the Athens Stock Exchange. By contrast, Leblanc and Chinn (2004) affirmed that oil price impact is limited, as did Blanchard and Riggi (2013). Alvarez et al. (2010) reviewed the impact of oil price volatility on unemployment and found that with extreme oil price volatility, unemployment rates tends to increase especially in industrialised countries that need a high energy supply. Lastly, they observed that the macroeconomic transmission mechanism of oil price variation tends to lack a deep understanding and is comparatively poorly developed.

Among the limited number of studies which focused on the macro-economy of countries from the BRICS, Rafiq and Salim (2014) found that oil price volatility had a significant impact on Chinese GDP as well as on Indian GDP and inflation. However, this paper presented some limitations especially regarding the small data set which did not allow adding more variables to the model. Izatov (2015) affirmed this considerable effect on the Russian GDP. With regards to Brazil, Cavalcanti and Jalles (2013) asserted that this impact is limited and unclear, by contrast with South Africa which is highly influenced by its fluctuations, as revealed by Kin and Courage (2014) and Niyimbanira (2013).

Iwayemi and Fowewe (2011) analysed the impact of oil shocks on African exporting countries. They claimed that three factors explain why oil prices do not have a significant macroeconomic impact: the decrease of oil dependency in the majority of countries, the important impact of monetary policies in absorbing the shocks, and lastly the asymmetrical impact of those shocks. Numerous papers have confirmed the existence of this latter asymmetric effect of oil price variations on the economy. Du, He and Wei (2010) analysed the asymmetric impact of oil prices on China and concluded that the positive shocks do not have a considerable influence on Chinese economic growth, by contrast with negative shocks which have led to decline. Furthermore, Farzanegan and Markwardt (2009) identified that both oil prices increases and decreases were important for the Iranian inflation.

Interestingly, the majority of the papers considering the asymmetric impact, namely Curnado and De Gracia (2003); Jimenez-Rodriguez and Sanchez (2005); Jbir and Zouari Ghorbel (2008), Mehrara (2008), Du, He and Wei (2010); Berument, Ceylan and Dogan (2010); and Iwayemi and Fowowe (2010; 2011) followed Lee et al. (1995)'s paper. Remarkably, Lee et al. (1995)'s model, with Mork (1989)'s and Hamilton (1996)'s, seem to be one of the most appropriate in modelling the asymmetry of oil prices impact. Nevertheless, it is argued that Mork's (1989) model isolates each of the positive and negative repercussions which may conceal the substantial impact of oil prices variations (Farzanegan and Markwardt, 2009). In contrast, Lee et al. (1995)'s model was distinguished by its ability to examine the environment in which oil price fluctuations occur through a GARCH model. Hamilton (2008) justified the use of ARCH models in such macroeconomic analysis for two reasons: The first argument being the inaccurate standard errors or the spurious regression where "a true null hypothesis is asymptotically rejected with probability one", from the OLS method. The other reason is the outliers and the "high-variance episodes" that may mislead any interpretations of the outcomes. As Jimenez-Rodriguez and Sanchez (2005) pointed out, an oil price shock would be of a higher weight in a steady environment compared to its weight in unstable circumstances, which explains the scaled transformation of oil prices.

The remainder of this paper is organised as follows: the next section explains the methodology, after which the results are elaborated with a discussion specific to every country. Finally, concluding remarks are presented.

3. Methodology

3.1 Variable choice

This paper is built upon the following set of variables: nominal crude oil prices expressed in US dollar (OilP), total industrial production (TIP) used as a proxy for GDP, consumer price indexes (CPI, 2010=100) to measure inflation, interest rates (IR) as monthly data of 3-months governmental treasury bills, unemployment rates (UR), exchange rates (EXR) expressed in the national currency to US Dollar spot exchange rate; and lastly exports (EXP) and imports (IMP) defined as the total value goods in US Dollars. The rationale behind this selection is the availability of monthly data for the BRICS. The data was collected from the Federal Reserve Bank of St Louis, the OECD database, the World Bank, the International Energy Agency and Thomas Reuters DataStream. The only variable unavailable was the monthly unemployment rate for India.

Variables were subject to changes and the VAR included oil price inflation, CPI inflation, changes in interest rates, in unemployment rates and exchange rates, and exports and imports growth.

With regards to the choice of oil prices, their specification in nominal or real terms presented certain discrepancies (Kilian and Vigfussion, 2010). Although Hamilton (2005) argued that there is no difference in testing oil shocks when using nominal or real prices, it has been suggested that nominal prices would be more suitable as it is an explanatory variable. More clearly, it is claimed that real oil prices are influenced by major events or adjusted by inflation or deflation, which makes it “endogenous with respect to the economy” (Hamilton (2005). Therefore, the choice of nominal oil price is based on the need for “exogeneity” in the interpretation of empirical results. Moreover, Hamilton (2010) argued that the producers’ crude oil price is a “better proxy” than the refiners’ price, as it allows less correlation with gasoline’s price.

Finally, as the BRICS contains oil-importing and oil-exporting countries, the analysis will be at the country level which preserves every country’s specifications.

3.2 Unit root and cointegration tests

To test for stochastic stationarity, and following the confirmatory data analysis process, both augmented Dickey-Fuller (ADF) and KPSS tests were employed[*]. All the variables turned out to be stationary by differencing in the first level.

The optimal lag length was selected through the Schwarz’s Bayesian Information Criterion (SBIC), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQIC)

[*] The results are available in the online appendix

(Table 1). Following the finding of Lutkephol (2005) who demonstrated that SBIC procures an appropriate estimation of the actual lag order, it was selected when results were heterogeneous.

Table 1: Order Criteria Selection

	Brazil		Russia		India		China		South Africa	
AIC	2	-25.8811	4	-23.6099	2	-27.7056	2	-21.5198	2	-20.7172
HQIC	1	-24.4113	1	-22.5838	1	-27.3213	1	-20.7224	1	-20.1158
SBIC	**1**	**-24.7787**	**1**	**-21.5120**	**1**	**-26.8292**	**1**	**-19.8865**	**1**	**-19.6238**

3.3 VAR model

The VAR (p) model used is the following (based on Jimenez-Rodriguez and Sanchez, 2005):

$$\underset{[N*1]}{Y_t} = \underset{[N*1]}{C} + \sum_{i=1}^{n} \underset{[N*N]}{A_i} \; Y_{t-i} + \underset{[N*1]}{\varepsilon_i} \qquad (1)$$

$cov\ (\varepsilon_i) = \Omega = UU^T$, the Cholesky decomposition

After checking for the coefficients significance with the Wald test, it is informative to employ the Granger causality test in order to confirm on which variables oil prices changes have a direct impact.

The ordering has been made according to the previous literature, namely the baseline model of Jimenez-Rodriguez and Sanchez, 2005: total industrial production (TIP), nominal oil prices (OilP), CPI, interest rates (IR), unemployment rates (UR), exchange rates (EXR), exports (EXP) and imports (IMP). The latter ordering is explained by earlier studies which presume that GDP does not respond collectively to the other macroeconomic variables. Oil prices are arranged in the way that it has effect on inflation, which would have a contemporaneous effect on the following variables (Jimenez-Rodriguez and Sanchez, 2005).

For robustness, another order has been tested: IR, TIP, UR, EXR, OilP, CPI, EXP and IMP. This is explained by the effect of IR on GDP, and by the argument that oil is a production input. No differences were noticed when comparing the results of the two different orders.

It is also important to mention that all VARs satisfied stability conditions and all eigenvalues lie inside the unit circle. The normality test was rejected for all countries. However, it is argued that normality is not a necessity when it comes to the "validity of statistical procedures related to the VAR" (Lutkepohl, 2001).

3.4 Asymmetric non-linear model:

While the linear VAR model assumes that the oil price impact is symmetric, a non-linear transformation permits to observe how an increase varies from a decrease of a similar magnitude (Jimenez-Rodriguez and Sanchez, 2005). This study followed Iwayemi and Fowowe (2011); with an adjustment added by Jimenez-Rodriguez and Sanchez (2005), based on Lee, Ni and Ratti (1995). The model consists in extracting the conditional variance of oil price fluctuations. The transformation of oil prices through a GARCH (2, 2) as seen in Table 2. This allowed for two new variables: scaled oil prices increase (SOPI) and scaled oil prices decrease (SOPD).

Table 2: GARCH Information Criteria

Lag	HQIC	SBIC
0	2.16938	2.17814
1	-2.13774	-2.12022
2	**-2.19689***	**-2.17061***
3	-2.18647	-2.15143
4	-2.17225	-2.12844

Model Specification:

$$o_t = \delta + \sum_{i=1}^{k} \alpha_i \, o_{t-i} + \varepsilon_t \qquad (2)$$

$$\varepsilon_t = v_t \sqrt{h_t} \sim N(0,1) \qquad (3)$$

$$h_t = \gamma_0 + \gamma_1 \varepsilon^2{}_{t-1} + \gamma_2 h_{t-1} \qquad (4)$$

$$SOPI_t = \max(0, \frac{\varepsilon_t}{\sqrt{h_t}}) \qquad (5)$$

$$SOPD_t = \min(0, \frac{\varepsilon_t}{\sqrt{h_t}}) \qquad (6)$$

Those two latter were included then within a standard VAR model for a Granger causality test, an impulse response function and a variance decomposition in order to compare the findings with the first model.

4 Analysis and findings:

4.1 Brazil:

After fitting the VAR model, running the Wald test for every equation and all the VAR equations jointly is of interest. The null hypothesis of the endogenous variables being zero jointly at specific lags is rejected for all the equations. Since the optimal lag length for Brazil is 1 according to SBIC and HQIC, the results will be restricted then to one lag.

Granger Causality Test

The Granger causality test reveals that oil prices changes have an effective impact on total industrial production, inflation, unemployment rates, exports and imports. With regards to scaled oil price increases and decreases, total industrial production is highlighted, as it is likely Granger-caused by both scaled oil prices increases and decreases. Furthermore, scaled oil price increases Granger-cause exports and imports, whereas scaled oil price decreases Granger-cause unemployment.

Table 3: Granger Causality Test-Brazil

H_0		$\varkappa^2$	DF	P > $\varkappa^2$
TIP is not Granger-caused by	ΔOil	21.157	2	**0.000*** **
	S.Oil+	22.671	2	**0.000*** **
	S.Oil-	4.9703	2	**0.083***
CPI is not Granger-caused by	ΔOil	7.0805	2	**0.029** **
	S.Oil+	4.3111	2	0.116
	S.Oil-	4.0865	2	0.130
IR is not Granger-caused by	ΔOil	0.0097	2	0.995
	S.Oil+	0.22552	2	0.893
	S.Oil-	0.24955	2	0.883
UR is not Granger-caused by	ΔOil	8.1692	2	**0.017** **
	S.Oil+	0.2.0727	2	0.355
	S.Oil-	21.612	2	**0.000*** **
ExR is not Granger-caused by	ΔOil	2.6326	2	0.268
	S.Oil+	3.949	2	0.139
	S.Oil-	0.61249	2	0.736
EXP is not Granger-caused by	ΔOil	8.8535	2	**0.012** **
	S.Oil+	13.377	2	**0.001*** **
	S.Oil-	0.49359	2	0.781
IMP is not Granger-caused by	ΔOil	14.753	2	**0.001*** **
	S.Oil+	8.4351	2	**0.015** **
	S.Oil-	7.1433	2	**0.028** **

***, ** and *** denote significance for 10%, 5% and 1% respectively**

Impulse Response Function:

The results of impulse Response Functions are reported below. Clearly, it confirmed the findings of the previous Granger causality test, but it also revealed the magnitude of an oil price shock.

As it can be seen in Figure 1.1, a 100% standard deviation of oil prices increases total industrial production by 7% the following month and the impact decreases steadily until it almost dies away after a year. A similar response is experienced by inflation as well as exports and imports.

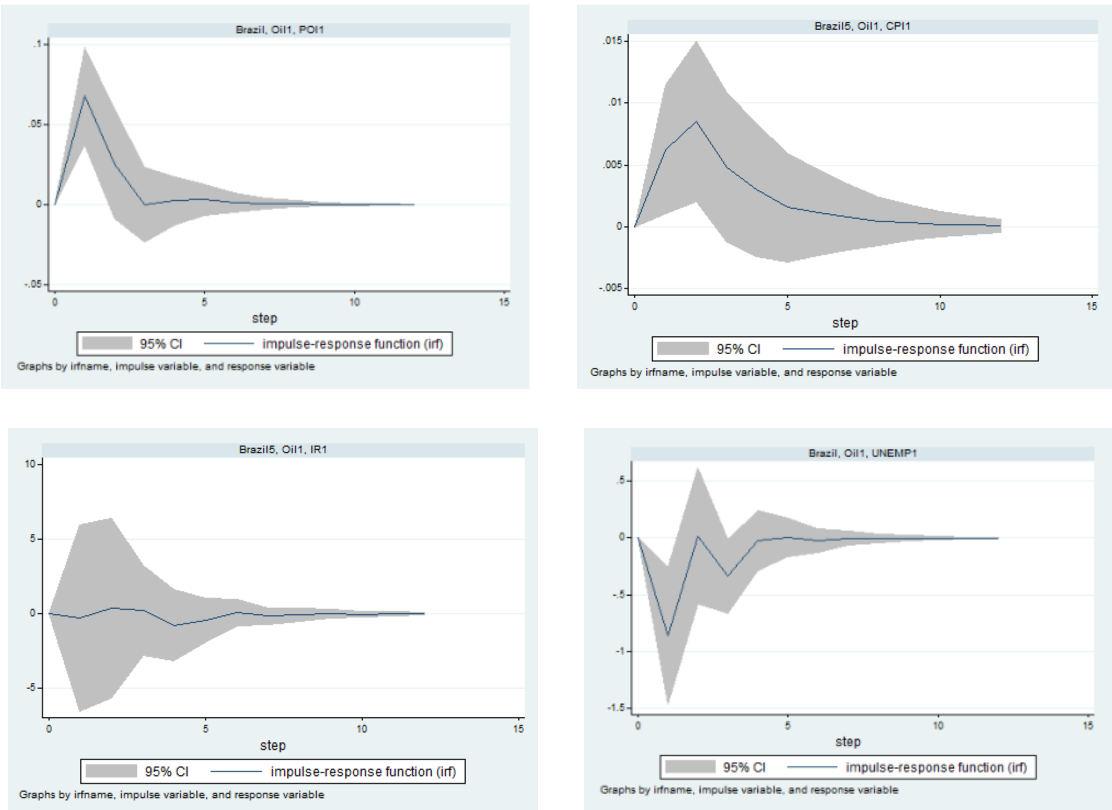
However, imports saw more fluctuations, with a 29% increase the 2nd month, a drop of 6% followed by a 4.8% increase until the shock impact disappears.

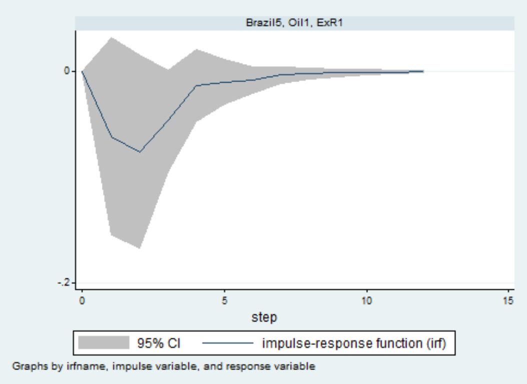
Following the Granger causality test which was insignificant with regards to interest rates and exchange rates, both confidence intervals looked insignificant as well. However, it seems that an oil price shock has a negative impact on those latter. Exchange rates response shows oscillations for four months before the shock dies out.

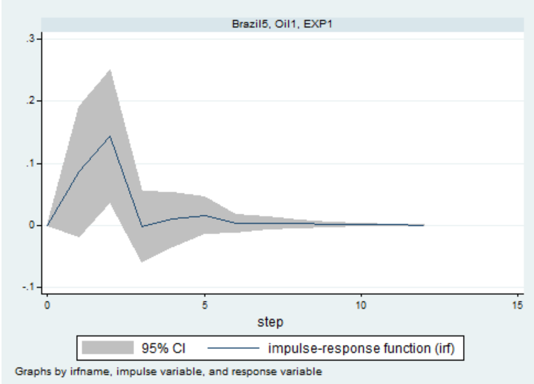
Generally, inflation, total industrial production, interest rates, exports and imports witnessed a positive response to an oil price shock. By contrast, unemployment rates and exchange rates show negative responses.

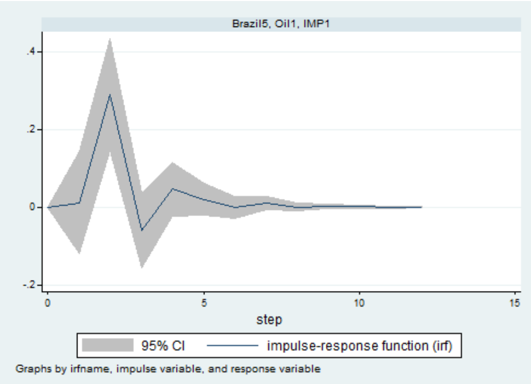
Figure1*: Impulse response functions – Brazil*

1.1: Oil price variation





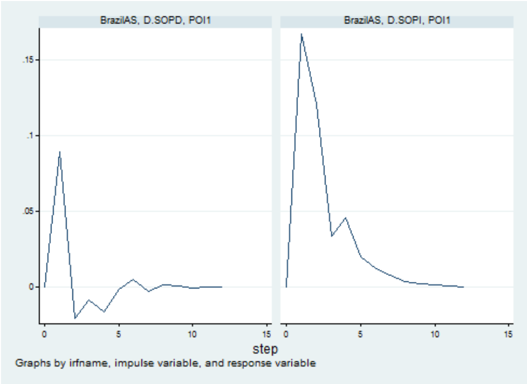


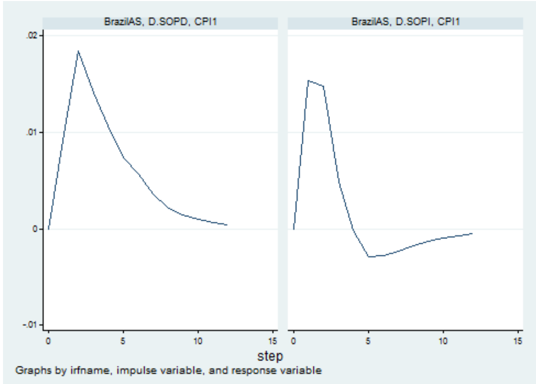


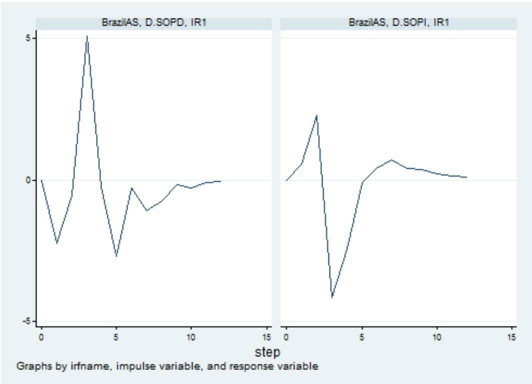
The second block of IRF graphs illustrate the responses of the variables subject to scaled oil price increases (SOPI) and decreases (SOPD). Although scaled oil price increases did not have a direct impact on inflation, a negative shock led to a 2% increase. An increase of a smaller magnitude was noticed when the shock was positive. Interest rates followed most likely due to the inflationary pressure as it will be explained below. Unemployment rates responded negatively when scaled oil prices shock was negative, and positively with positive shocks. As aforementioned, total industrial production responds positively to both positive and negative shocks, even though the positive shock yields a higher response.

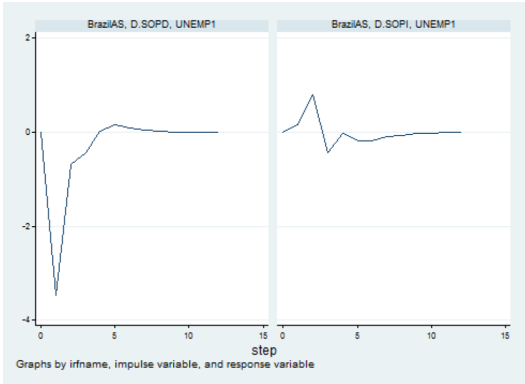
The response of both imports and exports was close to one another with regards to positive shocks. The negative shock, however, led to opposite responses: imports increased the second month and then decreased while the exports decreased then increased. Those responses may have been associated to exchange rates variations, where a negative shock led to a positive response and vice versa.

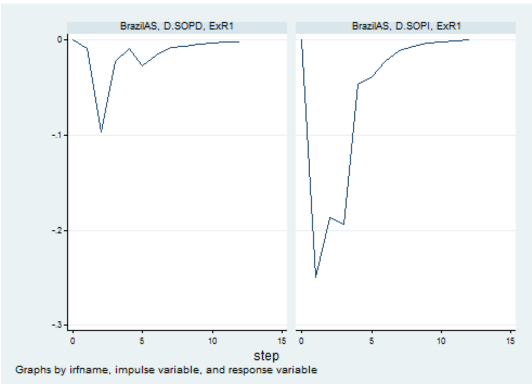
1.2 Scaled Oil prices decreases and increases.

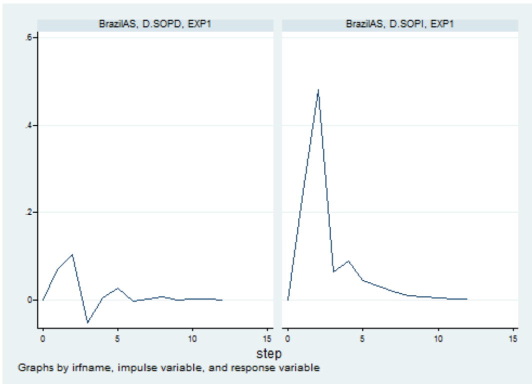


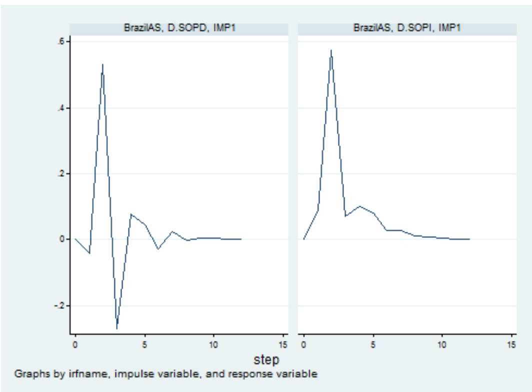












Variance Decomposition

Table 4 reports that up to 6.44% of total industrial production volatility is explained by oil price shocks in the year. Moreover, oil price volatility contributes by up to 1.4% in the forecasted error variance of inflation, by 3.8% with regards to unemployment rates, 4% for exports and almost 5% for imports.

Table 4: Forecast Error Variance Decomposition (FEVD)-Brazil: ΔOilP

ΔOilP	TIP	CPI	IR	UR	ExR	EXP	IMP
1	0	0.023832	0.006222	0.000176	0.009136	0.010768	0.001696
4	0.064432	0.014451	0.006866	0.037519	0.027419	0.039628	0.050782
8	0.06443	0.013537	0.00688	0.037802	0.027539	0.03981	0.051754
12	0.064433	0.013506	0.00688	0.037804	0.027537	0.03981	0.051753

Only total industrial production was explained by its own innovations in the first month.

Conforming to the results of previous subsections, insignificant findings were found regarding interest rates (only 0.68%). However, 2.7% of exchange rate volatility was explained by oil price volatility.

Tables 5 and 6 of variance decomposition show that scaled oil price increases account for more than scaled oil price decreases for all the variables: SOPI explain 8.6 % of TIP volatility compared to 0.7% explained by SOPD. With regards to inflation, 0.9 % of CPI volatility is due to SOPI where 2.5% is due to SOPD. Regarding exports and imports, 5% and 3% of the variations were related to SOPI, and 0.5% and 2.8% to SOPD respectively.

Table 5: FEVD-Brazil: S.Oil+

S.Oil+	TIP	CPI	IR	UR	ExR	EXP	IMP
1	0	0.000014	0.00039	0.007171	0.033668	0.008622	0.000665
4	0.082496	0.00785	0.000755	0.009327	0.060308	0.048954	0.028192
8	0.086603	0.009349	0.000894	0.009835	0.061029	0.05418	0.029466
12	0.086642	0.00972	0.000923	0.009865	0.061027	0.050439	0.029483

Table 6: FEVD-Brazil: S.Oil-

S.Oil-	TIP	CPI	IR	UR	ExR	EXP	IMP
1	0	0.045887	0.007513	0.004321	0.002917	0.001924	0.00105
4	0.00633	0.025653	0.010314	0.074653	0.00413	0.005055	0.02791
8	0.00688	0.024873	0.010354	0.074432	0.004201	0.005147	0.028352
12	0.006884	0.024813	0.010362	0.07443	0.004203	0.005152	0.028352

<u>Discussion</u>

Remarkably, interest rates are not likely to be affected either by oil price changes or by positive shocks. This might be due to the excessive Brazilian interest rates. According to the IMF (2012), Brazil has considerably elevated interest rates since 1980 due to hyperinflation and low saving rates. Notwithstanding its substantial decrease from 1994, the rates are still higher than the other developing countries reaching 40% in 1995 (IMF, 2012). This may explain the reason why the Granger-causality is not significant in terms of interest rates. Exchange rates seem to be linked to interest rates. In fact, the central bank opted for an inflation targeting policy; but has deviated from the "floating exchange rate" regime adopted in 1999 through regular interventions of dollar purchases (Tobal and Yslas, 2016).

Manifestly, oil price shocks do not seem to have an expected decisive macroeconomic impact on Brazil. Those results may be explained by the considerable decline in oil dependence (Cavalcanti and Jalles, 2013). In parallel, Brazil set a long-term target of maximising its oil production. This led to a 36% increase in oil exports in 2015 (EIA, 2015) and allowed to less vulnerability to oil prices fluctuation.

In line with previous findings, Cavalcanti and Jalles (2013) found that oil price volatility could explain only a limited proportion of inflation or total industrial production volatilities. They also confirmed the impact of negative oil variations, in increasing unemployment and reducing consumption and demand, matching with what this paper found in terms of direct impact on unemployment rates, inflation and interest rates

However, as inflation has experienced the same response following both scaled oil prices increases and decreases, one might look at the rationale behind this outcome. In fact, according to Farzanegan and Marwardt (2009), the inflation response may rely heavily on oil revenues. Thus, following an oil price increase, the government enjoys higher foreign reserves.

Meanwhile, import volume expands as Brazil still imports significant volumes of petroleum products (EIA, 2015), and domestic production would increase. Those movements would lead to higher inflation (Farzanegan and Marwardt, 2009). Analogously, international oil price decreases would reduce foreign reserves and cause currency depreciation as oil exports represent almost 10% of total Brazilian exports (UN Comtrade, 2014). This generates higher import prices and more expensive foreign products. As a result, total industrial production would witness a decrease while potentially explaining the increase in prices (Farzanegan and Marwardt, 2009). The impact of scaled oil prices movements seems thus indirect, which corroborates the outcomes of the Granger causality test.

4.2 Russia

According to the VAR results, oil prices impact positively on total industrial production, exports and imports, but negatively on inflation rates, interest rates, unemployment rates and exchange rates. The Wald test revealed that all the endogenous variables at lag 1 are jointly significant for each equation and for all the equations.

Granger Causality Test:

The Granger causality test results are reported in Table 7 below. The conclusion drawn from this test is that oil prices changes are Granger-causing total industrial production, interest rates, as well as imports and exports. Insignificant results are reported regarding inflation, unemployment rates and exchange rates.

The Granger causality test showed similar results. Both negative and positive changes are significant in terms of total production, interest rates, exports and imports whereas only positive oil price shocks had a direct impact on unemployment rates. On the other hand, no Granger Causality was noticed for inflation and exchange rates. This result is surprising apropos of inflation. As Russia is considered the world’s largest crude oil producer (EIA, 2015), it was expected to see a Granger-causality of oil prices.

Table 7: Granger causality Test-Russia

H_0		$\varkappa^2$		**I P > $\varkappa^2$**
TIP is not Granger-caused by	ΔOil	16.701	2	**0.000*** **
	S.Oil+	14.079	2	**0.001*** **
	S.Oil-	5.9689	2	**0.051***
CPI is not Granger-caused by	ΔOil	1.6672	2	0.434
	S.Oil+	0.65777	2	0.720
	S.Oil-	1.3386	2	0.512
IR is not Granger-caused by	ΔOil	14.337	2	**0.001*** **
	S.Oil+	4.5956	2	**0.1***
	S.Oil-	13.328	2	**0.001*** **
UR is not Granger-caused by	ΔOil	0.87893	2	0.644
	S.Oil+	5.6914	2	**0.058** **
	S.Oil-	1.0696	2	0.586
ExR is not Granger-caused by	ΔOil	3.2208	2	0.200
	S.Oil+	2.105	2	0.349
	S.Oil-	1.5588	2	0.459
EXP is not Granger-caused by	ΔOil	57.255	2	**0.000 *** **
	S.Oil+	51.083	2	**0.000*** **
	S.Oil-	17.945	2	**0.000*** **
IMP is not Granger-caused by	ΔOil	15.98	2	**0.000*** **
	S.Oil+	11.958	2	**0.003*** **
	S.Oil-	7.3619	2	**0.025** **

***, ** and *** denote significance for 10%, 5% and 1% respectively**

Impulse Response Function:

The variables' responses corroborate the VAR outcomes. An increase of 8% in total industrial production was witnessed followed by an oscillation until the shock dies away after 6 months. Exports showed a dramatic jump of 48.8% and the impact decreases steadily until the 10th month. Similarly, imports' response showed a rise of 26% which dropped gradually until the 6th month. On the other hand, inflation rate's response remains negative, and the effect seems to disappear only a year after.

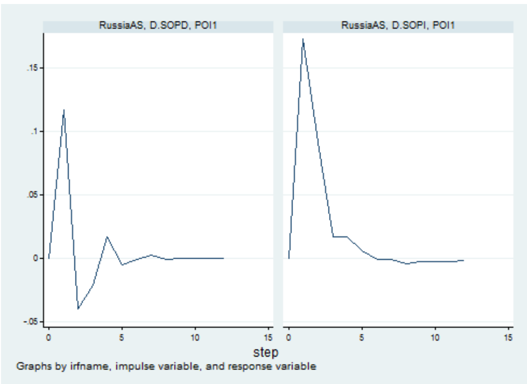
Figure 2: IRFs- Russia

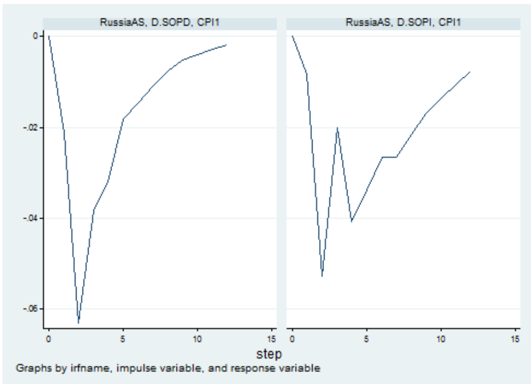
2.1: O Oil prices variation

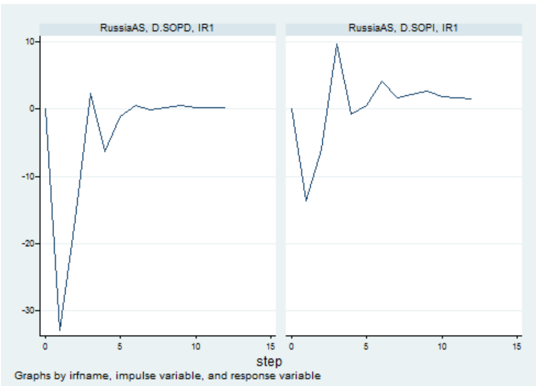
A sharper drop characterised unemployment rates, reaching 11.5% three months later after which a recovery started. Interest rates and exchange rates responses had a similar response: a decrease of 11% and 6.2% respectively in the 1st month.

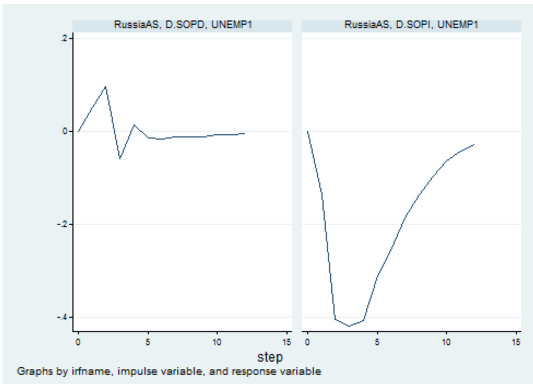
With regards to scaled oil prices increases, only total industrial production, imports and exports responded positively. A negative response was associated with inflation rates, interest rates, unemployment rates and exchange rates. The responses of the variables were similar following a scaled oil price decrease except for unemployment rates, which saw a decrease in the 1st month. When comparing the magnitude of the shocks, negative shocks were followed by a higher response in terms of inflation and interest rates, whereas positive scaled oil price shocks characterised the responses of total industrial production, exchange rates, exports and imports.

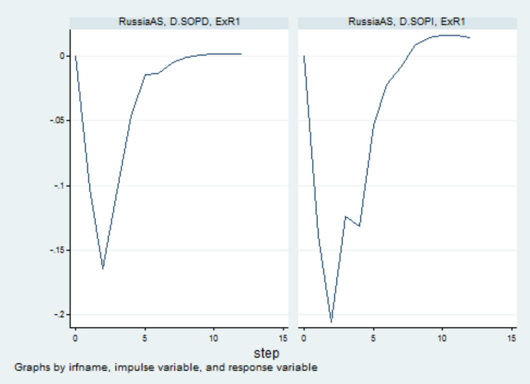
2.2: Scaled Oil prices decreases and increases

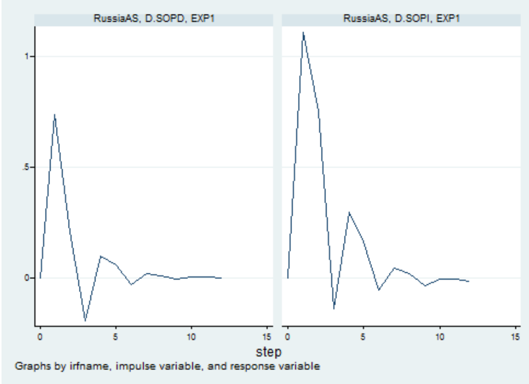


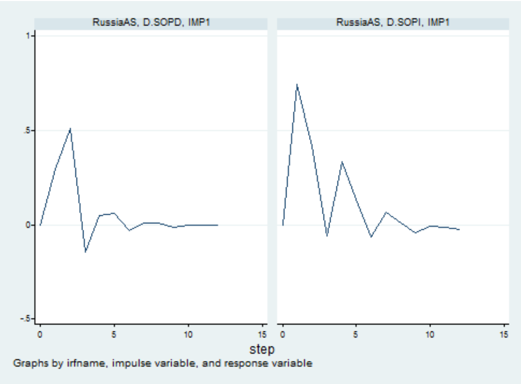












Variance Decomposition:

According to Table 8 presented below, an oil price shock accounts for 8% of total industrial production variance, which confirms the findings above. It also accounts for 9.3% of export variance.

Regarding unemployment rates, exchange rates and imports, oil shocks explained between 3.5% and 5.5% of their variation. This impact was less pronounced in terms of inflation and interest rates, with 1.5% and 1.2% respectively of variance explained by oil price volatility.

The conclusion from the variance decomposition of both SOPI and SOPD is that the positive oil shocks account for more than the negative shock for all variables. The exception comes with regards to interest rates, where the proportion is minimal (1.4% for SCOD compared to 1.1% for SOPI).

Table 8: FEVD-Russia: ΔOil

ΔOil	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	.010182	.000176	.001324	.000016	.03095	.009958
4	0.079819	.011376	.012073	.03411	.033106	.093343	.037292
8	0.079809	.014941	.012639	.053098	.036363	.093463	.03812
12	0.079818	.015642	.01278	.054964	.036377	.093462	.038151

Table 9: FEVD-Russia: S.Oil+

S.Oil+	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	0.008298	0.005633	0.001257	0.00222	0.0026	0.006513
4	0.064964	0.008793	0.010671	0.075082	0.035604	0.087492	0.036226
8	0.065368	0.013086	0.011007	0.130444	0.040695	0.090089	0.038542
12	0.065415	0.01437	0.011365	0.13525	0.040787	0.09011	0.03858

Table 10: FEVD-Russia: S.Oil-

S.Oil-	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	0.002108	0.001899	0.000156	0.00162	0.032604	0.004735
4	0.02267	0.003436	0.013772	0.003967	0.007528	0.027354	0.01038
8	0.022989	0.003617	0.014011	0.003746	0.007641	0.026851	0.010487
12	0.022985	0.003631	0.013991	0.003725	0.007636	0.026838	0.010487

Discussion

Those results, especially the ones regarding total industrial production and exports are related to the large dependence of the Russian economy on crude oil (EIA, 2017). The accentuated significance regarding the latter two variables are mainly due to the elevated production of oil. In fact, the Russian economy is dominated by oil and natural gas exports (EIA, 2015), and the energy exports account for 70% of the total Russian exports (UN Comtrade, 2014).

This outcome corroborates the findings of Izatov (2015), who highlighted the considerable impact of oil prices on the Russian GDP. Besides, the heavy impact on imports is most likely due to the goods imported by Russia, where 35% of total imports are industrial and electrical machineries and plastics products (UN Comtrade, 2014), usually depending on and related to oil, which should affect their prices.

Interestingly, neither inflation nor exchange rates were significant with the Granger causality test. This might be explained by the focus on exchange rate stability (Central Bank of Russia, 2016) involving extensive money supply changes to counter Ruble appreciation, which led to high inflation rates up to 2008. Since then, Russia has adopted an inflation targeting regime to monitor price stability. A floating exchange rate regime was gradually implemented until November 2014 (Central Bank of Russia, 2016), so that both inflation and exchange rates have been under full government control. Moreover, and as argued by Leduc and Sill (2003), total industrial production and inflation tend to be less vulnerable to oil price variation when the policy framework aims at price stability. The findings of this paper are in alignment with Izatov's (2015) outcomes. The results of this latter confirm the "anti-inflation policy". This policy exerts an important control over currency depreciation to prevent a loss of value of the Ruble.

With regards to interest rates, subject to a direct impact of both scaled oil prices increases and decreases, the impact could be explained through the liquidity expansion needed when international oil prices go up. This leads to a drop in nominal interest rates (Hamilton, 2001); and the inflationary pressures which heighten when oil prices decline.
A point worth mentioning is that Russia has been subject to several financial and trade sanctions by the United States and the European Union, resulting in confidence loss in the Russian economy (World Bank, 2015; EIA, 2015). Apart from the currency depreciation which pressured inflation, this may have affected unemployment rates; firms were in difficulties especially with regards to new project financing; trade, consumption and investment were affected (WB, 2015).

4.3 India

The conclusion drawn from the VAR is that oil price changes have a significant positive effect on Indian total industrial production, inflation, exports and imports. Insignificant positive impact was noticed on both interest and exchange rates. Lagrange-multiplier test revealed no autocorrelation at the lag order, and conducting the Wald test confirmed the significance of all the endogenous variables for each equation and for all the equations at the lag order selected.

Granger Causality test:

The Granger causality test showed that oil price variation has a causal impact only on inflation, exports and imports. No Granger-causality relationship was revealed concerning total industrial production, interest rates or exchange rates. With regard to the asymmetric model, only oil prices increases Granger-cause exports. Both movements have a direct impact on inflation and imports.

Table 11: Granger Causality- India

H_0		$\varkappa^2$	**DF**	**P > $\varkappa^2$**
TIP is not Granger-caused by	ΔOil	2.8929	2	0.235
	S.Oil+	1.9293	2	0.381
	S.Oil-	1.5728	2	0.455
CPI is not Granger-caused by	ΔOil	9.9572	2	**0.007*** **
	S.Oil+	5.2374	2	**0.073***
	S.Oil-	6.2386	2	**0.044** **
IR is not Granger-caused by	ΔOil	1.2368	2	0.539
	S.Oil+	0.71484	2	0.699
	S.Oil-	1.5561	2	0.459
ExR is not Granger-caused by	ΔOil	1.2629	2	0.532
	S.Oil+	0.46951	2	0.791
	S.Oil-	1.9476	2	0.378
EXP is not Granger-caused by	ΔOil	18.863	2	**0.000*** **
	S.Oil+	23.951	2	**0.000*** **
	S.Oil-	2.3684	2	0.306
IMP is not Granger-caused by	ΔOil	45.428	2	**0.000*** **
	S.Oil+	44.13	2	**0.000*** **
	S.Oil-	12.624	2	**0.002** **

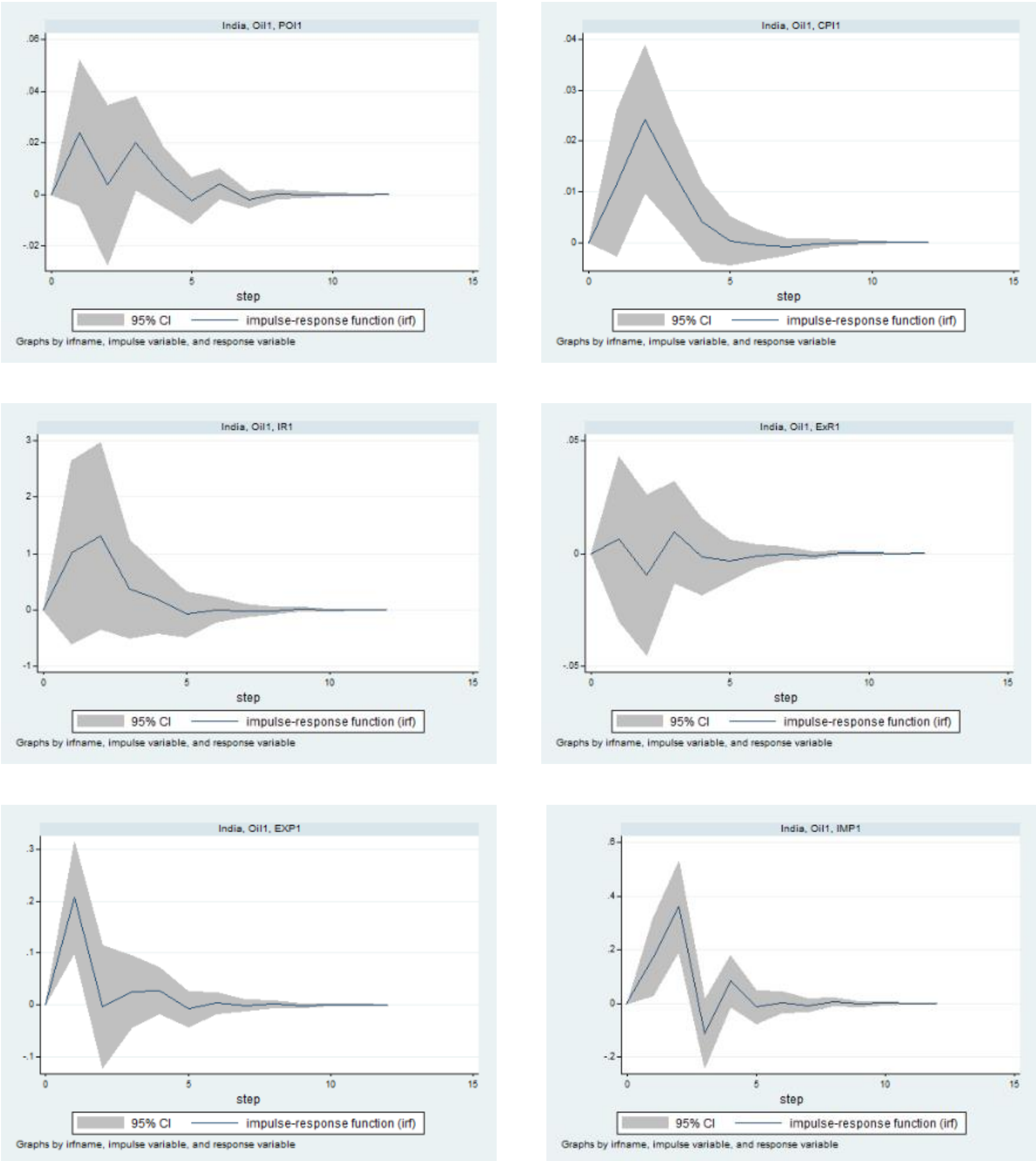
***, ** and *** denote significance for 10%, 5% and 1% respectively**

Impulse response function:

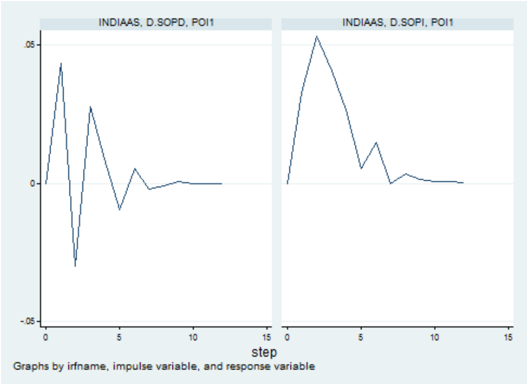
Conforming to the results obtained from the previous section, a first look at the impulse responses shows the insignificance of the confidence intervals of total industrial production, interest rates and exchange rates.

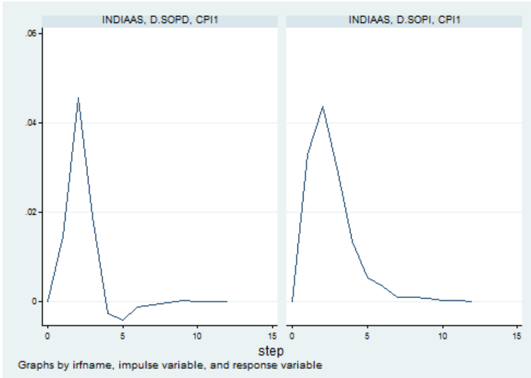
Figure 3: IRFs – India

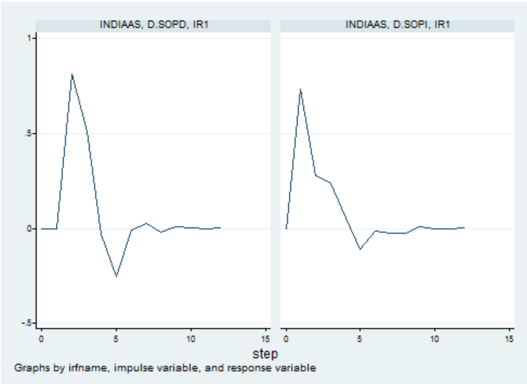
3.1: Oil prices variations

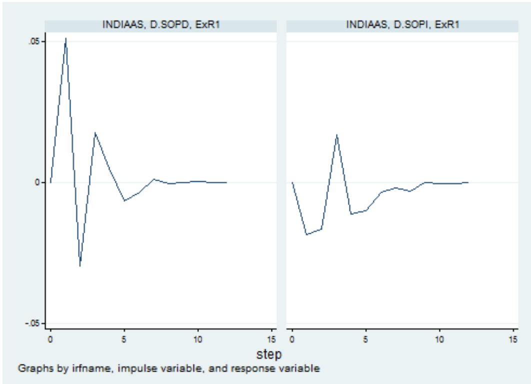


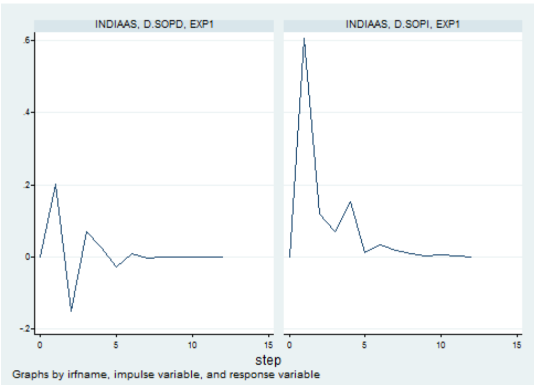
3.2: Scaled oil prices decreases and increases

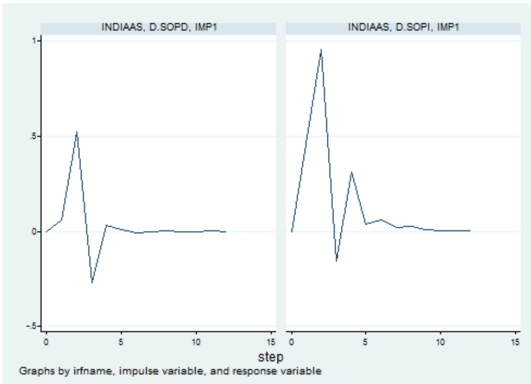












More closely, an oil price shock leads to an initial increase of 2.4% in total industrial production, which dies away 8 months later after three oscillations. Interest rate responses seem of a higher magnitude as 100% oil prices standard deviation led to 101% jump, most likely affected by the rise in economic activity. On the other hand, only a 0.64% rise was seen in terms of exchange rates in the first month and the impact disappeared from the 5th month.

The inflation response was an 11.6% increase after which it decreases until the 5th month. In like manner, both imports and exports expressed a sharp rise of 20% and 38% respectively.

Although exports response remains positive until it reduced to zero, imports response became negative in the 4th month, and their responses were statistically significant for the first month.

Turning to the SOPI shocks, an increase was experienced in the first period for all the variables except exchange rates. The SOPD led to a similar response, but of a smaller magnitude.

Variance Decomposition:

The results of Cholesky variance decomposition are presented in table 12, 13 and 14 below. According to FEVD tables, oil prices changes could explain roughly 0.5 to 2.5 % of total industrial production, interest rates and exchange rates volatilities.

Moreover, oil prices variations contributed a moderate proportion of 5.4% in explaining inflation variations. 5 % of exports and 11% of imports variances were due to oil prices fluctuations.

Table 12: FEVD-India: ΔOil

ΔOil	TIP	CPI	IR	EXR	EXP	IMP
1	0	0.000982	0.000609	0.017885	0.020405	0.034773
4	0.023035	0.053477	0.00486	0.017423	0.048466	0.106425
8	0.02515	0.054415	0.00531	0.017507	0.049127	0.107951
12	0.02515	0.054415	0.005318	0.017509	0.04913	0.107954

Table 13: FEVD-India: S.Oil+

S.Oil+	TIP	CPI	IR	EXR	EXP	IMP
1	0	0.0007	0.002482	0.042588	0.018574	0.034558
4	0.018632	0.029309	0.008237	0.038491	0.056892	0.082171
8	0.021716	0.031896	0.008428	0.038652	0.059192	0.087711
12	0.021746	0.031915	0.008431	0.03866	0.059215	0.087744

On the other hand, SOPD could explain about 3% and 0.8% of the latter variables and SOPI accounted for approximately 6% and 8.8% of their variations.

SOPI variations were responsible for 2 to 4 % of inflation, total industrial production, and exchange rates variance, while SOPD has a smaller portion of 3%, 0.9% and 0.6% respectively.

Table 14: FEVD-India: S.Oil-

S.Oil-	TIP	CPI	IR	EXR	EXP	IMP
1	0	0.005263	0.000179	0.000365	0.001052	0.002566
4	0.008389	0.031489	0.006739	0.005923	0.008085	0.030794
8	0.009003	0.031507	0.007129	0.006029	0.008248	0.030543
12	0.009006	0.031507	0.007132	0.00603	0.008247	0.030541

Discussion:

Regarding inflation, it seems that the results found herein corroborate the theory, such as Rafiq and Salim (2014)'s paper. According to the EIA (2016), the drop in international oil prices has been advantageous for the Indian economy especially with regards to government spending. Analogously, Jain and Pail (2015) asserted that numerous oil related products as "liquefied petroleum gas" and "fertilisers" represent a heavy charge, thus weakening investment and economic growth. Sharma et al. (2012) assert that the government was taking serious reforms to switch into other sustainable options such as biomass and hydroelectric or nuclear energies. This may explain the insignificant impact of oil on total industrial production especially that India has substantial coal reserves. Notably, the coal sector has been experiencing a large development since the late nineties (EIA, 2016). Another noteworthy reflection is the equity purchase the Indian National Oil Companies have made overseas, principally in South American and African oil companies (EIA, 2016; Inter-American Development Bank, 2015). This investment allowed an access to the natural resources as well as production effectiveness.

A further reason for oil prices changes being partially prevalent on the Indian economy is its expanded services sector from which the largest economic development comes (IMF, 2005). This not only accredited for less vulnerability and exposure to oil prices shocks but also shaped the exports structure relying mainly on the sophisticated Indian products. More clearly, it is believed that both pharmaceutical and IT sectors are the main contributors to the economic development (Nassif, 2007); in comparison with agriculture or manufacturing, a sector which requires high energy sufficiency.

Eventually, and with regards to the monetary regime adopted, India opted for a floating regime where the Reserve Bank of India has an active intervention to limit exchange rate volatility. This was more noticeable from 2000, where the rupee was almost the only unaffected currency remaining stable despite the high volatility for the other currencies (Joshi and Sanyal, 2004). Moreover, India is following a “multi-indicator monetary policy” with price stability a priority (Reserve Bank of India, 2016), which implies that theoretically, the oil shock would not show an impact on inflation, but would affect trade balance and GDP.

Note that few researchers have focused on the macroeconomic impact of oil prices changes in India. They tended to commonly focus on the stock market such as Fang and You (2014), Ghosh and Kinjilal (2016), most likely due to the limited availability of macroeconomic data for high frequencies.

4.4 China

The VAR outcomes showed a significant positive relationship between oil prices and Chinese industrial production, inflation, interest rates, exports and imports, whereas it showed a negative relationship with unemployment and exchange rates. At 5% significance level, no autocorrelation was observed at the lag order 1, and the Wald test confirmed that all the endogenous variables at lag 1 are jointly significant for each equation and for all the equations (at 1% for all except of exchange rates, significant only at 10%).

Granger Causality test:

As shown in Table 15, Granger-causality was significant in terms of total industrial production, unemployment rates, exports and imports. This impact was foreseen as China is the largest energy consumer worldwide (EIA, 2015). No causal relationship was significant in terms of interest rates or exchange rates. Moreover, while oil prices changes, in general, did not Granger-cause inflation, it seems that both scaled oil prices increases and decreases do have a direct impact. Unemployment rates experience the same direct impact from both scaled price movements. Exports and imports turned out to be Granger-caused by oil price increases.

Table 1: Granger Causality Test- China

H_0		$\varkappa^2$	DF	P > $\varkappa^2$
TIP is not Granger-caused by	ΔOil	5.073	2	**0.079***
	S.Oil+	4.3787	2	0.112
	S.Oil-	0.5855	2	0.746
CPI is not Granger-caused by	ΔOil	3.3991	2	0.183
	S.Oil+	5.0059	2	**0.082***
	S.Oil-	9.7865	2	**0.007*****
IR is not Granger-caused by	ΔOil	0.3734	2	0.830
	S.Oil+	0.30635	2	0.858
	S.Oil-	1.2206	2	0.543
UR is not Granger-caused by	ΔOil	7.2994	2	**0.026****
	S.Oil+	7.0245	2	**0.030****
	S.Oil-	5.4463	2	**0.066***
ExR is not Granger-caused by	ΔOil	1.0169	2	0.601
	S.Oil+	1.9886	2	0.370
	S.Oil-	0.88555	2	0.642
EXP is not Granger-caused by	ΔOil	32.219	2	**0.000 *****
	S.Oil+	41.615	2	**0.000*****
	S.Oil-	1.7366	2	0.420
IMP is not Granger-caused by	ΔOil	56.046	2	**0.000 *****
	S.Oil+	70.308	2	**0.000*****
	S.Oil-	0.95994	2	0.619

***, ** and *** denote significance for 10%, 5% and 1% respectively**

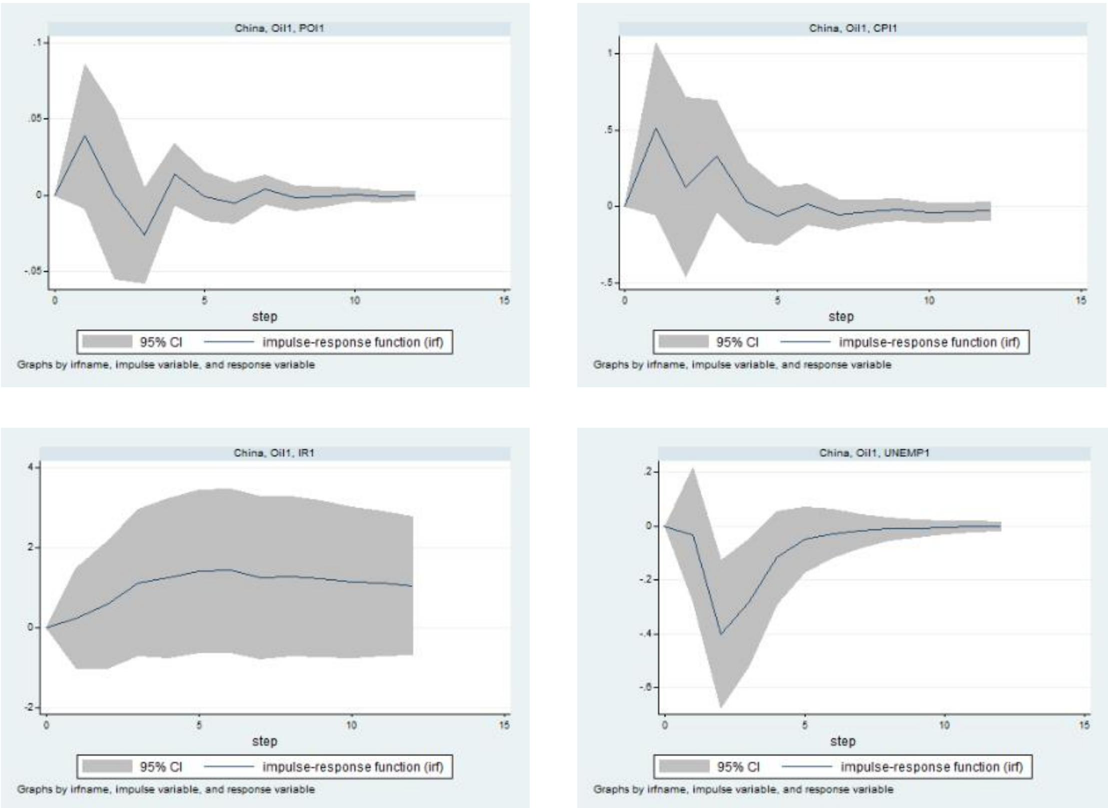
Impulse response function:

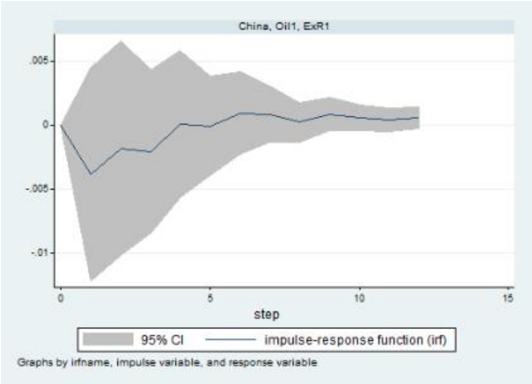
The IRFs were in accordance with the previous section outcomes through confidence interval examination. As it can be seen from Figure 4.1, one oil price shock increased total industrial production by 4%. The impact on exports and imports was of a higher weight, reaching 36 % and 47 % for the first month, respectively. All those variables fluctuated for approximately 10 months until the shock gradually disappears. Unemployment rates witnessed an opposite response with a considerable drop of 40% in the second month. Although not statistically significant, the IRFs showed that oil price volatility caused an increase in interest rates as well as a 51% increase in inflation rates, and depreciation of exchange rates.

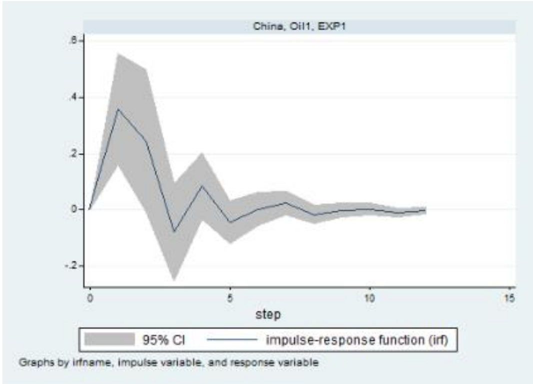
On the other hand, SOPI led to positive responses for TIP, CPI, interest rates, exports and imports. Comparably, SOPD were followed by positive responses for total industrial production, inflation and exchange rates. Interest rates, exports and imports showed negative responses the first month.

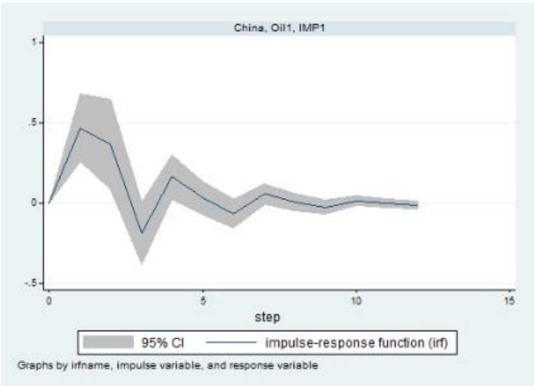
Figure 4: IRFS-China

4.1: Oil prices variations

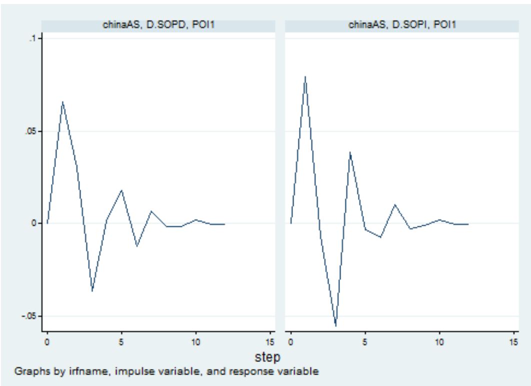


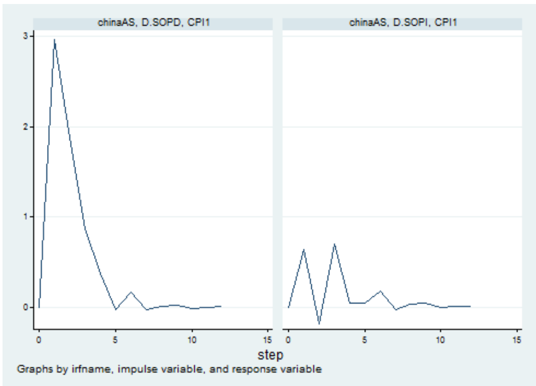


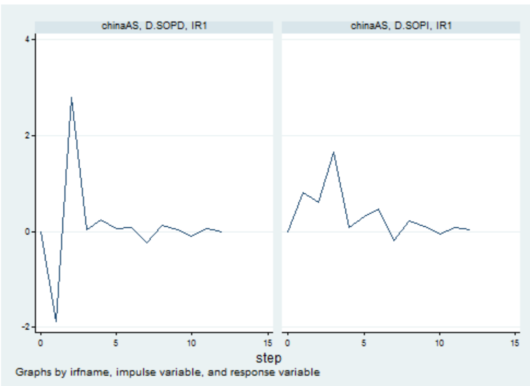


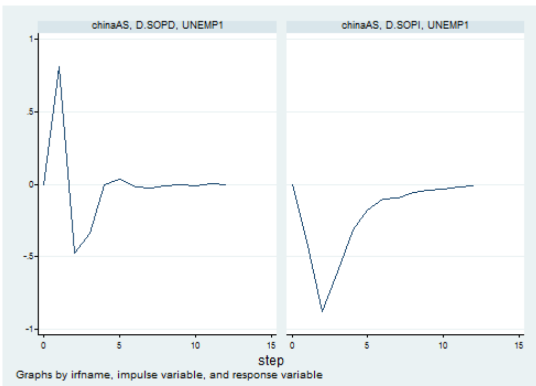


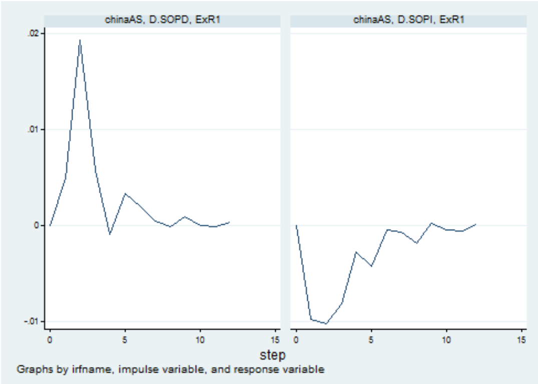
4.2: Scaled oil prices decreases and increases

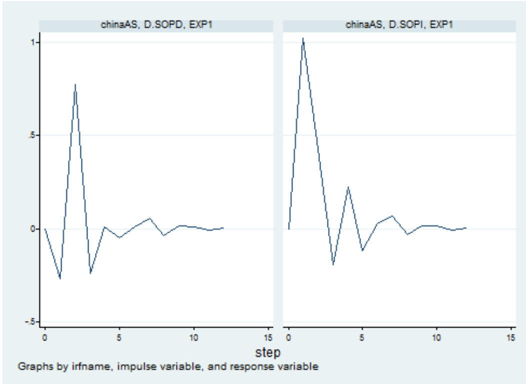


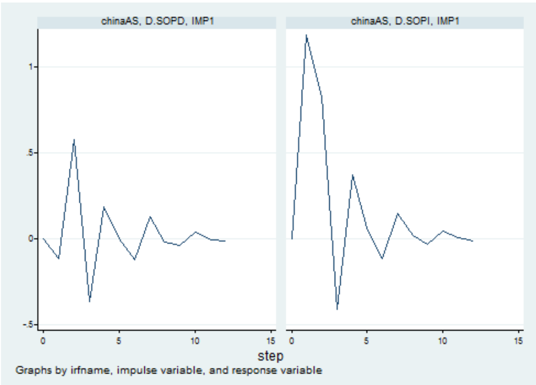












Variance Decomposition:

The volatilities that showed the highest sensitivity with regards to oil prices volatility were, as in the previous sections, exports, imports and unemployment rates. In fact, oil prices were a sizeable source of volatility with a contribution of almost 15 % in imports variations, and around 8% for the two first variables.

Table 2: FEVD- China: ΔOil

ΔOil	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	0.032172	0.003701	0.004889	0.0029	0.003243	0.001948
4	0.019244	0.064132	0.020795	0.071994	0.016425	0.07284	0.140235
8	0.021324	0.064931	0.021894	0.079931	0.018068	0.07583	0.147917
12	0.021338	0.064972	0.022133	0.080183	0.018216	0.075849	0.147958

The unpredictable outcome was in terms of total industrial production, as only 2% of its volatility was due to oil price changes. The remaining results did not differ from the earlier findings, and oil prices deviation explained 6.5% of both CPI, and 1.8 % of the exchange rates variability.

The variance decomposition of both SOPI (Table 17) and SOPD (Table 18) revealed that positive oil shocks account for more than negative shocks do for all the variables. The portion of scaled oil price decreases is low for total industrial production, interest rates, exchange rates, exports and imports; while scaled oil prices increases range between 1.5% and 4.3 % for total industrial production, inflation, interest rates and exchange rates. The highest contribution of SOPI was in terms of unemployment rates, exports and imports (9.3%, 12.8% and 16.9% respectively).

Table 3: FEVD- China: S.Oil+

S.Oil+	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	0.038618	0.000315	0.002547	0.002589	0.005162	0.007551
4	0.025194	0.043113	0.01387	0.08466	0.024034	0.124519	0.165826
8	0.028635	0.043273	0.014968	0.093149	0.025644	0.128284	0.169623
12	0.02866	0.043314	0.015172	0.093443	0.025859	0.128341	0.169467

Table 4: FEVD- China: S.Oil-

S.Oil-	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	0.009048	0.003549	0.000484	1.9E-07	0.019672	0.001317
4	0.001896	0.070586	0.021668	0.019235	0.003678	0.024891	0.010056
8	0.002311	0.070639	0.021481	0.018983	0.004149	0.024598	0.011781
12	0.00232	0.070628	0.021508	0.018968	0.004169	0.024651	0.011889

Discussion

Firstly, those results were in accordance with what Du, He and Wei (2010) found regarding the economic growth and the non-linear impact. It is also in agreement with Rafiq and Salim (2014) where oil prices volatility did not have any direct impact on Chinese inflation but was significant in terms of GDP. Similarly, Faria et al. (2009) confirmed the positive relationship between oil prices and exports.

To better analyse the findings of this paper, one might look at the macroeconomic regime adopted by China. The policy framework aimed to protect the national currency from fluctuations against the US dollar by adopting the fixed exchange rate regime until 2005 (Sadeghian, White and D'Arcy, 2013). Although China switched to a floating exchange regime, a control was exerted on the currency for two years to counter the substantial exports decrease due to the financial crisis. This not only might have protected exchange rates from any oil prices influence but also led to a better control of inflation as argued by Gosh et al. (1997) and Suranovic (2005). The two papers suggested that pegged exchange rate regimes were strongly linked with improved inflation performance. Regarding fiscal policy, the Chinese government imposed taxes on the consumption of oil in order to "rationalise consumption" (Fattouh et al., 2015) and lower the oil dependency. Huang and Guo (2007) found that both lower dependence on imported oil and rigid regulation were the reason for the negligible impact of oil prices.

As one might expect, total industrial production is negatively correlated with oil prices, Faria et al. (2009) argued that the rationale behind this relationship is the high competitiveness of China. Conceivably, it is likely that China is able to convert oil needs to a labour need in the production function (with labour and oil as inputs), which augments both productivity and boost exports (Faria et al., 2009). Specifically, they argue that the boost in exports is explained by an increase in the "relative labour productivity" and the important labour surplus, and this plays a role in increasing oil prices. The latter claim leads to an elementary justification of Du, He and Wei (2010), who claimed that the high volume of Chinese exports might have impacted the international oil prices. Although China's oil production satisfies almost all national needs in the domestic market (EIA, 2015), this claim may hold as China is the largest worldwide exporter of goods (EIA, 2015); a key position China has in the international trade market which may allow it to act upon international oil prices.

4.4 South Africa

A first look at the VAR outcomes revealed a statistically significant positive relationship between oil price fluctuations and total industrial production, as well as inflation, imports and exports. A negative relationship characterised interest rates, unemployment rates, and exchange rates. The Wald test turned out to be significant for all the variables at 5% except exchange rates which was significant only at 10%. Further, no autocorrelation at lag order was noticed.

Granger Causality test:

As predicted, the Granger-causality test exhibits significant outcomes for all the variables apart from interest rates and unemployment rates.

Table 19: Granger Causality Test- South Africa

H_0		$\varkappa^2$	**DF**	**P > $\varkappa^2$**
TIP is not Granger-caused by	ΔOil	3.5233	2	**0.061***
	S.Oil+	12.673	2	**0.002*****
	S.Oil-	0.646	2	0.724
CPI is not Granger-caused by	ΔOil	15.763	2	**0.000*****
	S.Oil+	33.532	2	**0.000*****
	S.Oil-	2.8106	2	0.245
IR is not Granger-caused by	ΔOil	0.4188	2	0.518
	S.Oil+	0.90792	2	0.635
	S.Oil-	1.4709	2	0.479
UR is not Granger-caused by	ΔOil	0.06384	2	0.801
	S.Oil+	1.6934	2	0.429
	S.Oil-	1.4439	2	0.486
ExR is not Granger-caused by	ΔOil	3.9027	2	**0.048****
	S.Oil+	4.5158	2	0.105
	S.Oil-	1.6456	2	0.439
EXP is not Granger-caused by	ΔOil	8.7576	2	**0.003 *****
	S.Oil+	14.477	2	**0.001*****
	S.Oil-	13.346	2	0.001***
IMP is not Granger-caused by	ΔOil	3.3998	2	**0.065***
	S.Oil+	20.339	2	**0.000*****
	S.Oil-	5.7276	2	**0.057***

***, ** and *** denote significance for 10%, 5% and 1% respectively**

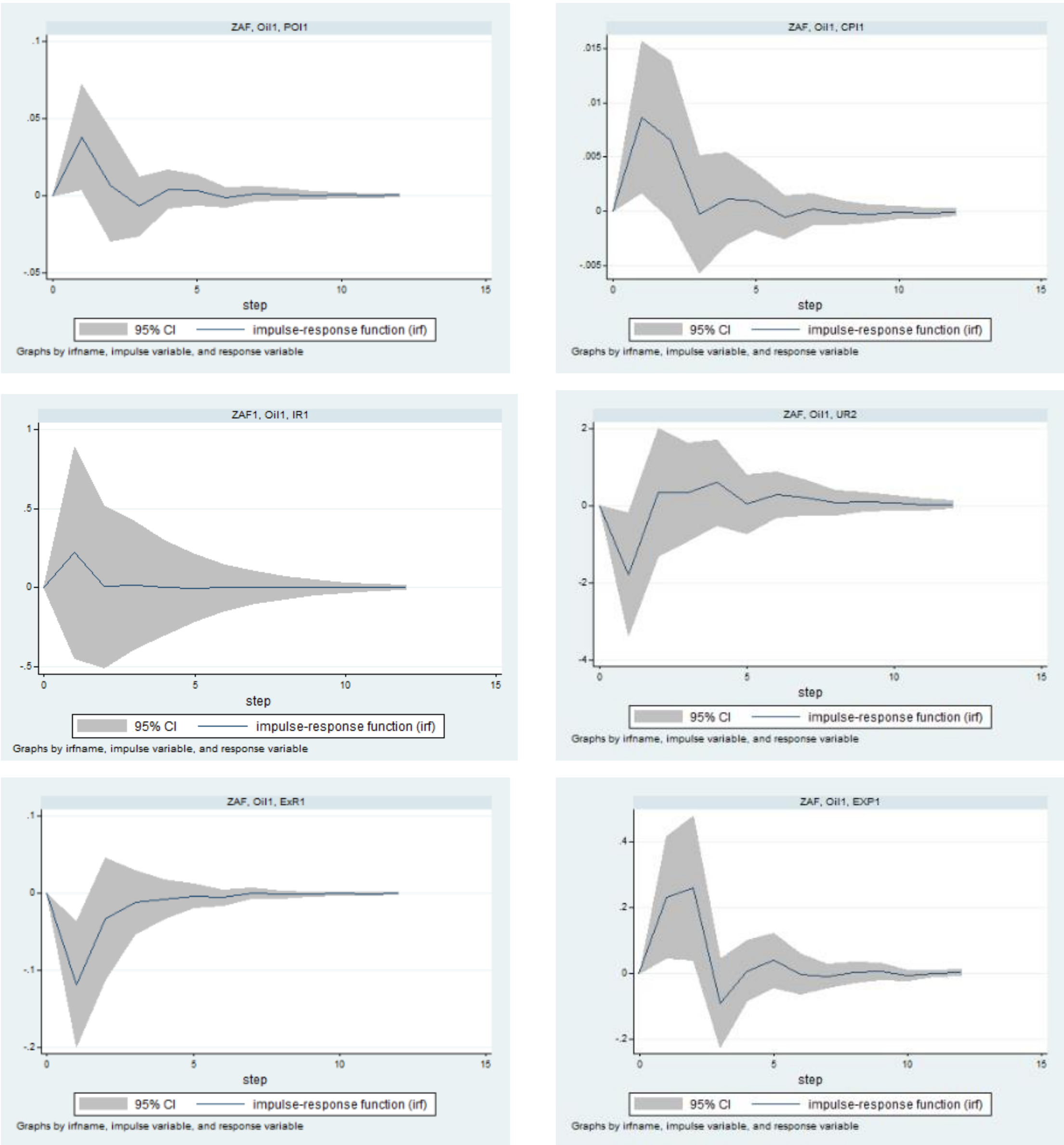
At the 99% confidence level, oil Granger-causes inflation and exports. This causality holds at 95% level for exchange rates and total industrial production, and at 10% in terms of imports.

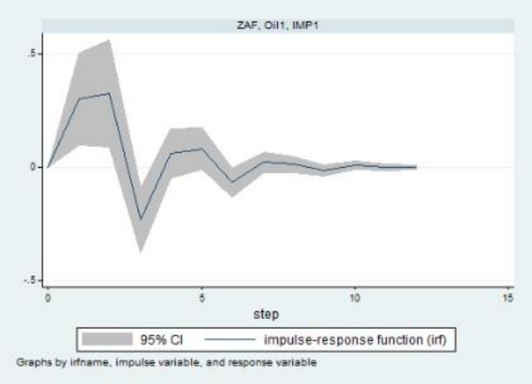
Similar results were obtained with regards to SOPI. However, SOPD did not exhibit any direct impact on any of the variables except of imports.

Impulse response function:

Figure 5: IRFs- South Africa

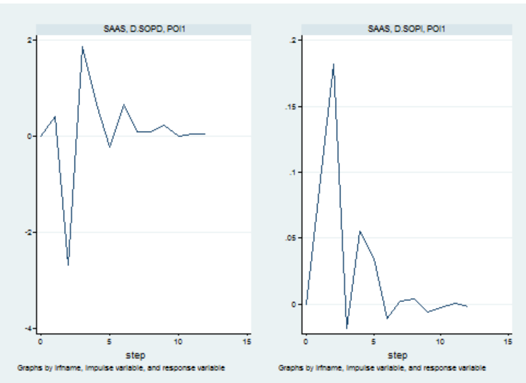
5.1 Oil prices variations:

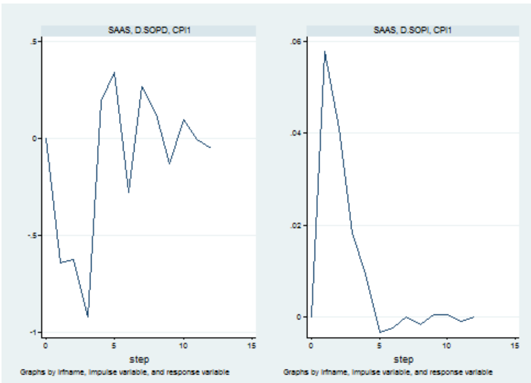


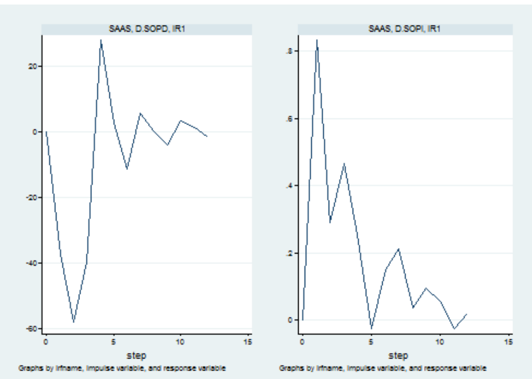


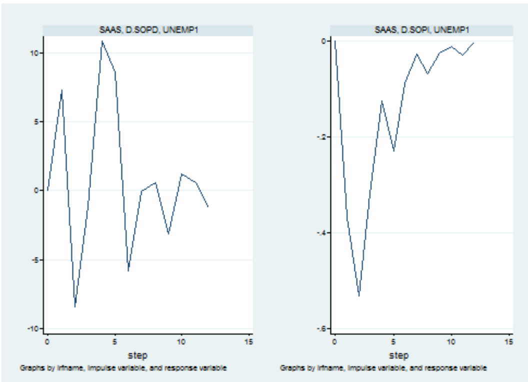
The IRFs verified the VAR's results. A 100% standard deviation of oil prices increased total industrial production by 4% and needed 6 months to die away. It has a similar impact on exports and imports, but with a higher magnitude, with approximately 23% and 30% increase respectively. Imports displayed a longer sensitivity as the shock did not fade away until the 8th month. Only 0.9% increase was associated with inflation response the first month, after which it gradually lessens. On the other hand, an oil price shock led to a 12% decline in terms of exchange rates, with a quick offset afterwards. Lastly, and although statistically insignificant, interest rates response exhibited a 16% increase the first month, disappearing after the 3rd month.

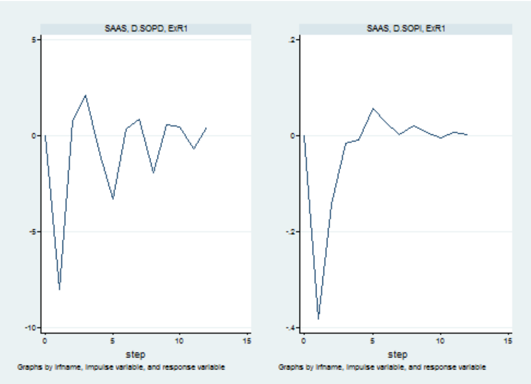
5.2: Scaled oil prices decreases and increases:

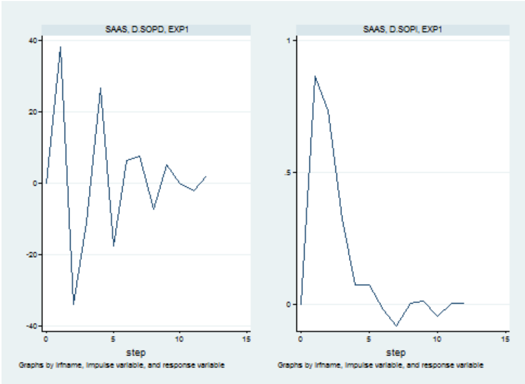


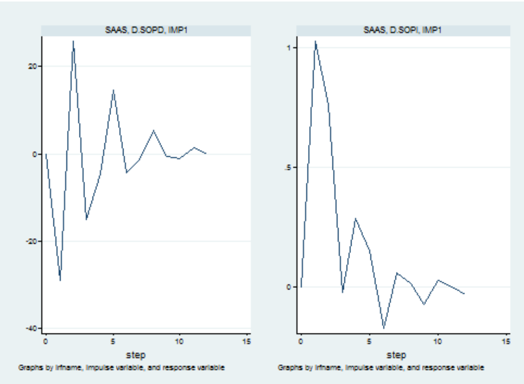












Variance Decomposition:

According to Table 20, 3.6% of the volatility of total industrial production is explained by the oil price volatility. A smaller proportion of 2% explains the variation of inflation. Exports and exchange rates had a higher proportion of volatility accounting for by oil prices (8.5% and 8% respectively). In terms of import volatility, around 7% were due to the oil prices variance, whilst the latter accounted for more than 5% of unemployment rates. Comparatively, only a contribution of 0.2 % was associated with oil prices for interest rates.

Table 20: FEVD South Africa: ΔOil

ΔOil	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	0.06179	0.002982	0.051521	0.065835	0.011067	0.031565
4	0.035066	0.196622	0.002781	0.053297	0.078934	0.08251	0.066027
8	0.035671	0.205922	0.002777	0.053982	0.080532	0.085086	0.068632
12	0.035695	0.206141	0.002777	0.054014	0.080585	0.085168	0.068711

Except for interest rates and unemployment rates, scaled oil prices increases explained the variance of the variables more than scaled oil prices decreases. The latter accounts for a small portion in the explanation of the variation of the variables under analysis.

Table 21: FEVD South Africa: S.Oil+

S.Oil+	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	0.006206	0.002569	0.022126	0.084597	0.01141	0.002704
4	0.062863	0.224868	0.003264	0.038784	0.102409	0.144223	0.089971
8	0.06715	0.212177	0.005055	0.039815	0.100986	0.129902	0.090234
12	0.067111	0.211277	0.005221	0.040078	0.100856	0.129076	0.089943

Table 22: FEVD South Africa: S.Oil-

S.Oil-	TIP	CPI	IR	UR	EXR	EXP	IMP
1	0	0.034322	0.000955	0.024298	0.106272	0.00059	0.000227
4	0.011724	0.045734	0.026259	0.0223	0.116496	0.094577	0.099645
8	0.011983	0.051352	0.039044	0.029931	0.115356	0.131351	0.110966
12	0.012011	0.052845	0.039279	0.030171	.0116115	0.134329	0.112725

Discussion

Firstly, the outcomes are likely to be foreseen since South Africa is not only the largest African energy consumer but also the second highest oil consumer in the African continent (EIA, 2015). This paper’s findings are consistent with previous studies. Clearly, Kin and Courage (2014) asserted the significant effect of oil prices on South African exchange rates in terms of value and fluctuations. Niyimbanira (2013) confirmed the positive unidirectional causal relationship found between oil prices and inflation rates. Wakeford’s (2012) research corroborates the findings of this study with reference to exchange rates depreciation, exports expansion, especially coal and inflation rise. A more recent paper of Sibanda, Hove and Murirapchena (2015) argued that the reason is the heavy dependence on oil. This claim becomes more consistent if one considers the importance of oil in the production function, the transportation and other energy prerequisites in one hand, and the absence of "commercial oil deposits" in South Africa (Nkomo, 2006).

Concerning the positive relationship between oil prices increases and exports, it could be argued that an oil prices escalation would increase the demand for coal, where South Africa holds 95% of the whole continent's reserves (EIA, 2015). Besides, and because of the Inflation Targeting regime adopted, the South African Reserve Bank relied on interest rates to extenuate any shocks impact (South African Reserve Bank, *n.d.)* The efforts made to stabilise inflation or currency depreciation likely involved greater increasing of interest rates, which may represent an explanation for the insignificance found in this study. Additionally, and as has been explained by Nkomo (2006), the consequential dependence on imported oil generated those anticipated results. With a weak national currency, interest rates would experience a sharp jump; the national income would be declining as well as the South Africans purchasing power, accentuated by a stagnation of the economic growth.

Lastly, and regarding the asymmetric model, it could be said that the impact of scaled oil prices increases is significant when compared to scaled oil prices decreases.

5. How accurate is the model for predicting?

Christ (1951) asserted that "the ultimate test of an econometric model comes with checking its prediction". Therefore, it seems interesting after this analysis and discussion to see how robust the VAR is for predicting. The idea was to make a comparison with one of the first papers analysing the forecasting ability, namely Meese and Rogoff (1983, 1986). Their results revealed that the post-sample forecasting of exchange rates could be improved if a "naïve" random walk were used. It turned out to give a substantially better performance since the eighties (Evans and Lyons, 2005). The outcomes were surprising as they were comparing two models:

$$x_{1,t} = \varepsilon_t \quad (7)$$

$$x_{1,t} = \beta_t x_{2t-1+\varepsilon_t} \quad (8)$$

Where H_0: $\beta_t = \beta^* = 0$ (Rossi, 2006)

The null hypothesis could not be rejected; the random walk is, therefore, a fairly accurate model to forecast the data. In addition, they concluded that the poor performance of the structural models is most likely related to international oil price volatility or to the different macroeconomic policies adopted by central banks. Those factors might have highly accounted for "structural instability".

Those outcomes have led to a contentious debate, where the literature saw a division between papers confirming those findings and others rejecting them. For instance, Cheung, Chinn and Pascal (2005) concluded that through the RMSE comparison, the random walk cannot be defeated by structural models. Likewise, Kilian and Taylor (2003) revealed that from a 1 to 12-steps ahead forecast, it is hard to find a model outperforming the random walk. However, numerous papers found that fundamental models such as Menzie and Alquist (2006) and Brooks et al. (2001), (cited in Anaraki, 2007) perform better. Some papers such as Thomakos and Guerard (2004) found that the elementary models are not necessarily the most robust and that ARIMA models, for instance, proved more reliable in terms of forecasting. Similarly, Den Butter and Jansen (2013) found that although the random walk seems to be the best fit for the data forecast, the ARIMA models showed satisfactory performance.

Thus, it appears valuable to compare the VAR model used by this paper to an AR (1) model forecasting the inflation. The criterion order was determined through the SBIC and the HQIC.

Table 23: Lag Order - CPI:

CPI:	Brazil	Russia	India	China	South Africa
SBIC	**1**	**3**	**1**	**1**	**1**
HQIC	1	3	4	1	3

The last year of data was removed from the dataset, and forecasted by the VAR model, and then the AR (1). The Root Mean Square Error was calculated with the real values.

AR (1): $x_{t+1} = \alpha\, x_t + v_{t+1}$; $\quad v_{t+1} \sim \mathrm{N}\,(0, \sigma^2)$ (9)

$RMSE = \sqrt{\sum_{i=1}^{N=12} \frac{(F_t - R_t)^2}{N}}$; (10)

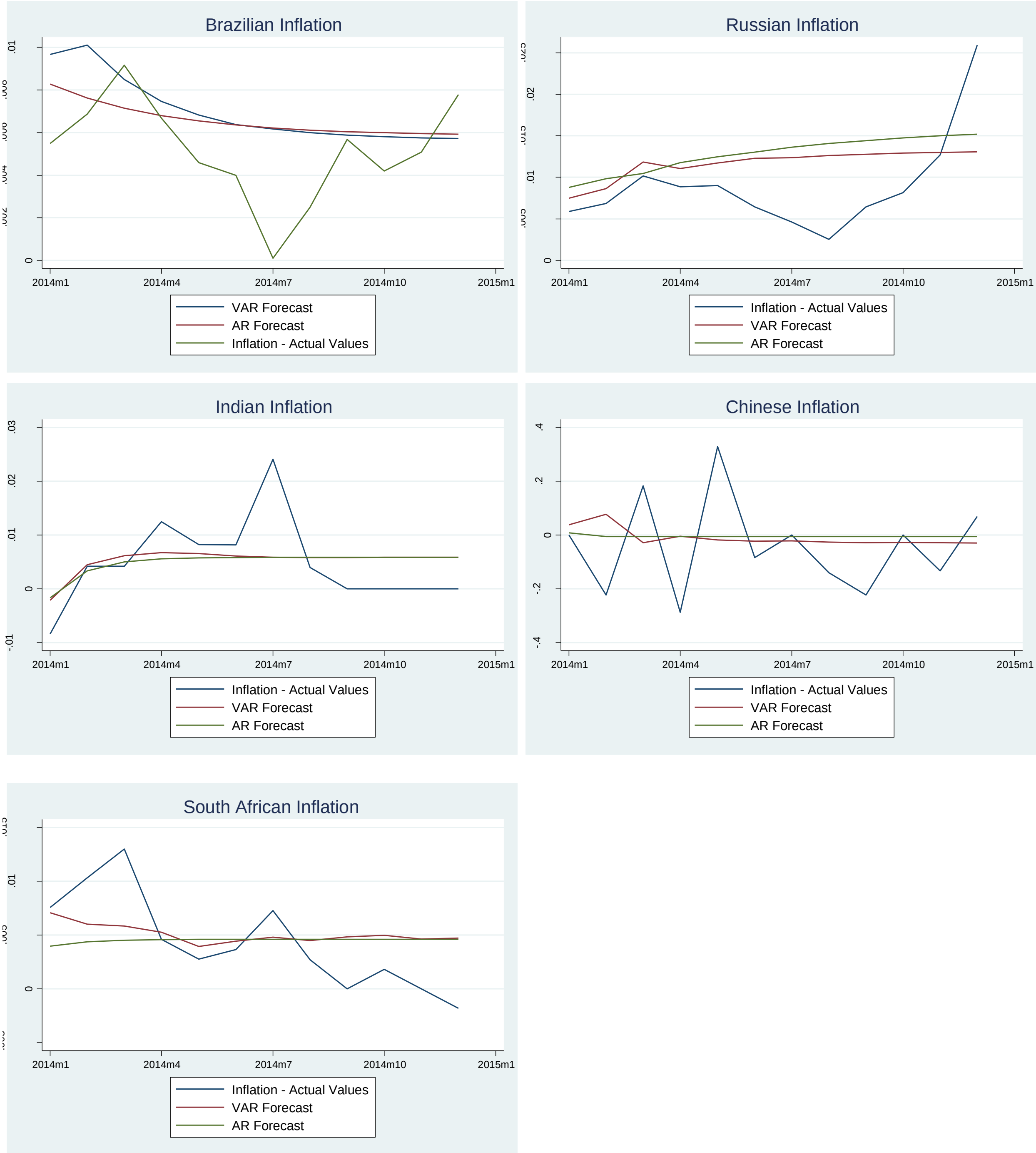
Where F_t is the forecasted value and R_t is the real value

Table 24 below shows the RMSE of both models for every country. The forecast shows no significant difference between the VAR forecast and the AR forecasts, although the VAR turned to be slightly better with smaller RMSE. Hence, it could be argued that neither the VAR nor the AR is significantly accurate at predicting inflation. Nevertheless, as claimed by Rossi (2006), it is likely that the majority of models lead to unsatisfactory forecasts even though it suits adequately the in-sample.

Table 5: VAR and AR's Forecast evaluation – RMSE

	Model	*RMSE*
Brazil	VAR	0.0028
	AR(1)	0.0027
Russia	VAR	0.0064
	AR(3)	0.0069
India	VAR	0.0071
	AR(1)	0.0073
China	VAR	0.1938
	AR (1)	0.1827
South Africa	VAR	0.0040
	AR(1)	0.0045

Figure 6: Forecasts



Ultimately, the findings of this paper varied depending on whether the country is oil-importing or oil-exporting. For India, China and South Africa, and even though every country has its own specificities, the impact tended to be similar and negative on the economy. With regards to Russia and Brazil, they witnessed similar general patterns especially in terms of total industrial production, unemployment rates, exchange rates, exports and imports. The difference was noticed concerning inflation and interest rates, which is likely due to high Brazilian imports of petroleum products, whilst Russia is a net exporter.

Broadly speaking, it seems clear that oil prices changes have a considerable impact on total industrial production and both imports and exports. This direct impact was not as significant when it comes to inflation and interest rates due to monetary policies, although it may be suggested that both variables are subject to indirect impact.

A point worth mentioning is the reliability of both Indian and Chinese data. With respect to India, the Reserve Bank of India's governor raised concerns about the accuracy of the data collected. In fact, he qualified the issue as a "challenge", and highlighted the need for opportune and rigorous "statistical system" (Reserve Bank of India, 2011). He also shed the light on the lack of employment data as mentioned above in the variables choice subsection of this paper. Regarding China, Koch-Weser (2013) argued that notwithstanding the reforms adopted by the authorities, the Chinese data are not credible compared to the European or American data. He pointed out three main issues, namely the data collection process, the measurements used and the way the data is presented. Falsification problems and transparency also represented an obstacle with regards to the reliability of the statistics (China, Koch-Weser, 2013).

Conclusion:

This paper considered the importance of the impact of oil prices fluctuations on different macroeconomic variables in the BRICS, namely inflation rates using consumer price indexes, interest rates, unemployment rates, exchange rates, imports, exports, and total industrial production. The research was built upon on the Granger causality test, the impulse response function and the Cholesky variance decomposition by fitting both linear and non-linear VAR models. The findings suggest that oil price fluctuations have an important impact on the

BRICS economies, mainly on total industrial production and both imports and exports. Moreover, the outcomes of this paper corroborate the literature in evidence of asymmetry found, as the impact of scaled oil prices increases differed from scaled oil prices decreases.

Lastly, a limitation of this research consists in not including the money supply in the model as done by Du et al. (2010), a variable that may give a clearer image with regards to its role in capturing the indirect effect of oil prices shocks. However, as aforementioned, the limited data availability represented an obstacle. Another limitation may be related to the lack of analysis of the transmission channels of oil prices variations through alternative prices such as other energy prices (coal, electricity as an example).

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Appendix 1: KPSS test for stationarity

H_0: The variable is trend stationary

Critical Values: 10%: 0.119; 5%: 0.146; 2.5%: 0.176; 1%: 0.216

- ***Brazil:***

LAG ORDER	LN OIL	D.LNOIL	LN TPI	D.LN TPI	LN CPI	D.LN CPI	IR	D.IR
0	1.12	0.104	1.540	0.061	3.320	0.414	0.892	0.012
1	0.58	0.083	0.819	0.065	1.690	0.242	0.486	0.014
2	0.4	0.074	0.572	0.068	1.150	0.184	0.343	0.015
3	0.31	0.069	0.448	0.069	0.873	0.153	0.272	0.015
4	0.257	0.066	0.374	0.070	0.709	0.135	0.230	0.015
5	0.222	0.065	0.324	0.073	0.601	0.124	0.204	0.017
6	0.197	0.066	0.289	0.075	0.523	0.115	0.186	0.018
7	0.179	0.068	0.263	0.077	0.465	0.109	0.173	0.020
8	0.165	0.070	0.243	0.078	0.420	0.105	0.163	0.021
9	0.153	0.073	0.227	0.081	0.384	0.100	0.156	0.023
10	0.144	0.075	0.214	0.083	0.354	0.097	0.150	0.025
11	0.137	0.075	0.203	0.086	0.329	0.093	0.146	0.026
12	0.131	0.076	0.194	0.089	0.308	0.090	0.142	0.027
13	0.126	0.077	0.187	0.090	0.291	0.087	0.139	0.028
14	0.121	0.079	0.180	0.093	0.275	0.085	0.137	0.028

LAG ORDER	UR	D.UR	LN EXR	D.LN EXR	LN EXP	D.LN EXP	LN IMP	D.LN IMP
0	3.790	0.087	4.410	0.118	2.060	0.062	3.910	0.034
1	1.930	0.096	2.230	0.117	1.080	0.085	2.020	0.063
2	1.310	0.095	1.500	0.116	0.735	0.098	1.370	0.067
3	0.993	0.093	1.130	0.117	0.563	0.105	1.040	0.078
4	0.807	0.092	0.915	0.117	0.459	0.111	0.839	0.075
5	0.682	0.091	0.769	0.117	0.389	0.111	0.707	0.077
6	0.594	0.089	0.664	0.117	0.339	0.116	0.613	0.079
7	0.528	0.089	0.586	0.120	0.302	0.118	0.542	0.079
8	0.476	0.088	0.525	0.123	0.273	0.115	0.487	0.079
9	0.435	0.087	0.476	0.126	0.249	0.114	0.443	0.079
10	0.402	0.088	0.436	0.129	0.231	0.115	0.408	0.082
11	0.374	0.088	0.402	0.134	0.215	0.113	0.378	0.081
12	0.351	0.089	0.374	0.138	0.202	0.119	0.353	0.086
13	0.330	0.091	0.350	0.142	0.191	0.117	0.331	0.086
14	0.313	0.093	0.329	0.145	0.181	0.119	0.313	0.090

- ***Russia***

LAG ORDER	LN OIL	D.LNOIL	LN TPI	D.LN TPI	LN CPI	D.LN CPI	IR	D.IR
0	1.120	0.104	1.890	0.080	4.990	0.279	2.900	0.228
1	0.580	0.083	0.974	0.095	2.530	0.208	1.480	0.295
2	0.400	0.074	*0.663*	0.109	1.710	0.174	1.010	0.299
3	0.310	0.069	0.505	0.118	1.300	0.148	0.766	0.265
4	0.257	0.066	0.410	0.113	*1.050*	0.131	0.623	0.268
5	0.222	0.065	0.346	0.112	0.882	0.120	0.528	0.257
6	0.197	0.066	0.301	0.113	0.764	0.113	0.460	0.231
7	0.179	0.068	0.268	0.115	0.675	0.108	0.410	0.223
8	0.165	0.070	0.241	0.114	0.606	0.105	0.371	0.205
9	0.153	0.073	0.221	0.111	0.551	0.102	0.340	0.194
10	0.144	0.075	0.204	0.112	0.506	0.100	0.315	0.183
11	0.137	0.075	0.190	0.111	0.468	0.099	0.295	0.176
12	0.131	0.076	0.178	0.112	0.437	0.098	0.277	0.168
13	0.126	0.077	0.168	0.111	0.409	0.098	0.263	0.162
14	0.121	0.079	0.160	0.110	0.386	0.098	0.251	0.157

LAG ORDER	UR	D.UR	LN EXR	D.LN EXR	LN EXP	D.LN EXP	LN IMP	D.LN IMP
0	1.870	0.285	4.050	0.257	1.660	0.025	2.370	0.021
1	0.942	0.193	2.040	0.196	0.888	0.035	1.270	0.032
2	0.632	0.146	1.370	0.171	0.616	0.047	0.872	0.044
3	0.477	0.120	1.030	0.153	0.475	0.051	0.668	0.056
4	0.385	0.105	0.833	0.142	0.389	0.052	0.543	0.057
5	0.324	0.095	0.699	0.135	0.332	0.051	0.459	0.059
6	0.280	0.088	0.604	0.130	0.291	0.056	0.399	0.063
7	0.248	0.082	0.532	0.127	0.261	0.059	0.354	0.070
8	0.223	0.078	0.477	0.125	0.237	0.060	0.318	0.068
9	0.203	0.075	0.432	0.124	0.219	0.060	0.290	0.069
10	0.187	0.072	0.396	0.123	0.203	0.064	0.268	0.074
11	0.174	0.069	0.366	0.121	0.191	0.077	0.248	0.099
12	0.163	0.067	0.341	0.120	0.180	0.069	0.232	0.076
13	0.153	0.066	0.320	0.120	0.170	0.069	0.218	0.074
14	0.145	0.065	0.301	0.119	0.162	0.073	0.206	0.076

- ***India***

LAG ORDER	LN OIL	D.LNOIL	LN TPI	D.LN TPI	LN CPI	D.LN CPI	IR	D.IR
0	1.12	0.104	2.29	0.0713	4.85	0.211	2.46	0.0143
1	0.58	0.083	1.19	0.108	2.46	0.163	1.38	0.0195
2	0.4	0.074	0.806	0.123	1.65	0.152	0.974	0.0218
3	0.31	0.069	0.613	0.128	1.25	0.145	0.759	0.025
4	0.257	0.066	0.497	0.136	1	0.144	0.626	0.0259
5	0.222	0.065	0.419	0.134	0.843	0.151	0.536	0.0278
6	0.197	0.066	0.364	0.13	0.727	0.156	0.47	0.0305
7	0.179	0.068	0.322	0.131	0.641	0.169	0.42	0.032
8	0.165	0.070	0.29	0.129	0.573	0.184	0.381	0.0315
9	0.153	0.073	0.264	0.128	0.519	0.195	0.35	0.0328
10	0.144	0.075	0.243	0.133	0.474	0.201	0.325	0.0343
11	0.137	0.075	0.225	0.125	0.437	0.202	0.304	0.0357
12	0.131	0.076	0.211	0.127	0.405	0.193	0.286	0.0364
13	0.126	0.077	0.198	0.13	0.378	0.185	0.271	0.0369
14	0.121	0.079	0.187	0.128	0.355	0.178	0.258	0.0392

LAG ORDER	UR	D.UR	LN EXR	D.LN EXR	LN EXP	D.LN EXP	LN IMP	D.LN IMP
0			2.19	0.129	1.93	0.0549	1.92	0.0373
1			1.15	0.115	1.1	0.0901	1.08	0.0711
2			0.788	0.114	0.775	0.101	0.752	0.0703
3			0.603	0.112	0.6	0.101	0.582	0.0752
4			0.491	0.116	0.493	0.102	0.477	0.0775
5			0.415	0.114	0.42	0.106	0.407	0.079
6			0.361	0.108	0.368	0.103	0.357	0.0809
7		-	0.321	0.105	0.328	0.104	0.319	0.0868
8			0.289	0.104	0.298	0.106	0.29	0.0899
9			0.264	0.103	0.273	0.105	0.266	0.0955
10			0.244	0.103	0.254	0.109	0.246	0.102
11			0.227	0.104	0.237	0.109	0.23	0.111
12			0.213	0.106	0.223	0.114	0.216	0.111
13			0.201	0.109	0.211	0.117	0.204	0.121
14			0.191	0.112	0.201	-	0.193	0.119

- ***China***

LAG ORDER	LN OIL	D.LNOIL	LN TPI	D.LN TPI	LN CPI	D.LN CPI	IR	D.IR
0	1.12	0.104					4.44	4.44
1	0.58	0.083					2.25	2.25
2	0.4	0.074					1.51	1.51
3	0.31	0.069					1.14	1.14
4	0.257	0.066					0.922	0.922
5	0.222	0.065					0.774	0.774
6	0.197	0.066					0.668	0.668
7	0.179	0.068		Sample contains gaps			0.589	0.589
8	0.165	0.070					0.528	0.528
9	0.153	0.073					0.479	0.479
10	0.144	0.075					0.439	0.439
11	0.137	0.075					0.405	0.405
12	0.131	0.076					0.378	0.378
13	0.126	0.077					0.354	0.354
14	0.121	0.079					0.333	0.333

LAG ORDER	UR	D.UR	LN EXR	D.LN EXR	LN EXP	D.LN EXP	LN IMP	D.LN IMP
0	2.81	2.81	5.41	0.467	0.798	0.00718	0.698	0.00826
1	1.42	1.42	2.72	0.35	0.483	0.0134	0.412	0.015
2	0.958	0.958	1.82	0.28	0.349	0.0163	0.295	0.021
3	0.727	0.727	1.37	0.233	0.277	0.0188	0.232	0.0197
4	0.589	0.589	1.1	0.201	0.233	0.0229	0.194	0.0227
5	0.497	0.497	0.918	0.18	0.202	0.0239	0.169	0.0245
6	0.432	0.432	0.79	0.163	0.18	0.0253	0.151	0.0249
7	0.383	0.383	0.694	0.15	0.164	0.0265	0.138	0.0266
8	0.346	0.346	0.62	0.14	0.151	0.0272	0.128	0.0286
9	0.316	0.316	0.56	0.133	0.141	0.0291	0.12	0.029
10	0.291	0.291	0.512	0.127	0.133	0.0329	0.114	0.0324
11	0.271	0.271	0.472	0.123	0.127	0.0399	0.109	0.0362
12	0.254	0.254	0.438	0.119	0.121	0.0342	0.104	0.0345
13	0.24	0.24	0.409	0.117	0.116	0.0357	0.101	0.0357
14	0.227	0.227	0.384	0.114	0.112	0.0352	0.0979	0.0373

- ***South Africa***

LAG ORDER	LN OIL	D.LNOIL	LN TPI	D.LN TPI	LN CPI	D.LN CPI	IR	D.IR
0	1.12	0.104	1.75	0.0213	1.48	0.259	1.24	0.0692
1	0.58	0.083	0.922	0.0302	0.771	0.19	0.638	0.0478
2	0.4	0.074	0.63	0.0346	0.524	0.156	0.436	0.0397
3	0.31	0.069	0.481	0.0347	0.398	0.134	0.335	0.0359
4	0.257	0.066	0.391	0.0353	0.323	0.121	0.276	0.0349
5	0.222	0.065	0.332	0.0349	0.273	0.112	0.236	0.0346
6	0.197	0.066	0.29	0.0336	0.237	0.103	0.209	0.0346
7	0.179	0.068	0.258	0.0336	0.21	0.0979	0.188	0.0347
8	0.165	0.070	0.234	0.0331	0.189	0.0944	0.172	0.035
9	0.153	0.073	0.215	0.034	0.173	0.0913	0.16	0.0355
10	0.144	0.075	0.2	0.0342	0.16	0.089	0.15	0.0361
11	0.137	0.075	0.187	0.0339	0.149	0.0876	0.142	0.0367
12	0.131	0.076	0.177	0.0345	0.139	0.0857	0.135	0.0375
13	0.126	0.077	0.168	0.0353	0.132	0.0845	0.129	0.0386
14	0.121	0.079	0.16	0.0364	0.125	0.0839	0.125	0.0399

LAG ORDER	UR	D.UR	LN EXR	D.LN EXR	LN EXP	D.LN EXP	LN IMP	D.LN IMP
0	Sample contains gaps		1.65	0.117	1.43	0.0138	1.64	0.0202
1			0.883	0.114	0.845	0.022	0.948	0.0307
2			0.607	0.112	0.605	0.0284	0.675	0.0409
3			0.465	0.11	0.474	0.0286	0.523	0.04
4			0.379	0.109	0.394	0.0318	0.431	0.0456
5			0.321	0.111	0.339	0.0328	0.367	0.0508
6			0.28	0.114	0.299	0.0345	0.321	0.0481
7			0.248	0.116	0.27	0.0368	0.287	0.0536
8			0.224	0.114	0.246	0.0397	0.26	0.0564
9			0.204	0.112	0.227	0.0389	0.238	0.0549
10			0.189	0.11	0.211	0.0423	0.22	0.0606
11			0.175	0.107	0.198	0.0465	0.204	0.0682
12			0.164	0.106	0.186	0.0424	0.191	0.0608
13			0.155	0.105	0.176	0.0434	0.18	0.0615
14			0.147	0.105	0.168	0.0444	0.17	0.0612

Appendix 2: Lag Order - CPI:

Country		HQIC	SBIC
Brazil	0	-7.98167	-7.97256
	1	**-8.66382***	**-8.6456***
	2	-8.64963	-8.62229
	3	-8.64623	-8.60979
	4	-8.63308	-8.58752
Russia	0	-4.58863	-4.57984
	1	-4.71856	-4.70099
	2	-4.73089	-4.70453
	3	**-4.7817***	**-4.74656***
	4	-4.77494	-4.73101
India	0	-6.65027	-6.64148
	1	-6.75911	**-6.74154***
	2	-6.75398	-6.72762
	3	-6.74716	-6.71202
	4	**-6.76034***	-6.71641
China	0	.085165	.096677
	1	**.073283***	**.096307***
	2	.09379	.128325
	3	.110194	.156241
	4	.096543	.154101
South Africa	0	-7.89447	-7.88568
	1	-8.02917	**-8.0116***
	2	-8.03551	-8.00916
	3	**-8.04005***	-8.0049
	4	-8.02561	-7.98168