The Impact of Oil Shocks on the South African Economy[$]

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Abstract The recent increases in oil prices have raised the importance of studying the effects of oil supply and demand shocks on an economy. The purpose of this paper is to investigate the impact of the oil supply and demand shocks on the South African economy using a sign restriction-based structural Vector Autoregressive (VAR) model. Our results show that an oil supply shock has a short-lived significant impact only on the inflation rate, while the impact on the other variables is statistically insignificant. Supply disruptions result in a short-term increase in the domestic inflation rate with no reaction from the monetary policy. An aggregate demand shock results in short- to medium-term improvements in domestic output and the real exchange rate. The effect is statistically insignificant for the inflation rate as well as the monetary policy instrument. The inflation rate and the real exchange rate react negatively to an oil-specific demand shock, while output is positively related to unanticipated changes in oil price due to speculations. Our results highlight the importance of understanding the source of the oil price movements, since an oil price increase necessarily does not imply a negative effect on the economy.

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1. Introduction

The purpose of this paper is to investigate the impact of the oil supply and demand shocks on the South African economy, via macroeconomic variables which include inflation, economic output, interest rate and exchange rate using quarterly data from 1975:01 to 2011:02. The contribution of our research to the South African literature is twofold. Firstly, unlike many studies that do not assess the source of the increase in oil prices, we disaggregate the causes of the oil price increases and distinguish between three types of oil shocks – oil supply shock, oil-specific demand shock and the oil demand shock caused by global economic activity. Secondly, the methods used in these studies differ to the methodology that we use. Following Peersman and van Robays (2009) we use a structural VAR model specification with sign restrictions – which enables us to capture the dynamic relationship between macroeconomic variables and oil price shocks within a liner model. This approach will enable us to disentangle different sources of oil price shocks and quantify the dynamic effects on the macroeconomy mainly because a structural VAR model is more explicit about the contemporaneous relationship among the variables.

For South Africa, there have been several studies that assess the impact of oil price shock on the economy using various methods. Fofana, Mabugu and Chitiga (2007; 2008) find that oil price increases have a negative impact on the South African economy given its dependency on imported oil. Nkomo (2006a; 2006b), establishes that oil price shocks tend to increase the total import bill for a country, largely because of the huge increase in the cost of oil and petroleum products. This proves to have adverse effects on the South African economy through falling GDP. A study by Wakeford (2006) concludes that the South African economy is affected by an increase in oil prices, although depending on the period of the shock. During the 1970's oil price shocks were somewhat offset by the increase in the price of other commodities, although short

lived as international demand declined soon after – resulting in a decline in exports, increased inflation and a recession. The effect of the most recent oil price shocks have contributed to higher inflation, increased interest rates and a slowdown in domestic growth (Wakeford (2006)). Other studies include Essama-Nssah, Go, Kearney, Korman, Robinson and Thierfelder (2007), and McDonald and Van Schoor (2005), which uses computable general equilibrium models to simulate the economy-wide and sectoral impacts of an oil price increase in the South African economy. The studies conclude that a 20 per cent increase in global oil prices reduced domestic output by 1 per cent. Swanepoel (2006) employs VAR model to investigate amongst other shocks, an oil price increase on South Africa's macroeconomic variables. The impact is found to be marginal in other variables and statistically insignificant for producer and consumer prices. Bellamy (2006), using a VAR framework, found that the South African economy fairly resisted oil price shock mainly due to the rising price of gold. More recently, Hollander (2012), based on a Dynamic Stochastic General Equilibrium (DSGE) model as well as a VAR model, also finds that an oil price shock has a considerably lesser effect on the South African economy. So overall, the evidence is mixed as far as the effect of oil price on the South African macroeconomic variables is concerned. These papers, however, did not differentiate between the causes of the change in the price of oil, i.e., whether the price change is demand- or supply-driven.

The rest of the paper is set out as follows: the second section outlines the model and the methodology, the third section discusses the results, and the fourth section concludes.

2. Methodology

2.1. Data

We estimate a 7 variable structural VAR model using quarterly data for the period 1975:01 to 2011:02. For the global oil market variables, we include the price of crude oil based on the US refiners' acquisition cost for imported crude oil obtained from the US Department of Energy starting from 1975:01. Following Barsky and Kilian (2002) the data for the price of crude oil (POIL) has been extrapolated back to 1975:01 and was deflated using the US CPI inflation. We also obtained the data for the global oil production (QOIL) measured in millions of barrels of oil - expressed in per cent changes from the US Department of Energy. To measure the global real economic activity (WPI) we rely on Kilian (2009) methodology. The global activity index is constructed by cumulating average rates of increase in dry cargo ocean shipping freight rates[1]. The series is deflated using the US consumer price index. The inclusion of these three variables captures supply and demand conditions in the global oil market. Note that, the raw data for the WPI series is available in growth rate form already.

We also include four domestic macroeconomic variables; the real effective exchange rate (XZAR) calculated using a weighted average of currencies adjusted for inflation effects, real GDP measured by total volume of industrial production (RGDP), the consumer price index (CPI) and the interest rate (*i*). The inclusion of these variables captures the transmission mechanism through which oil price shocks affect the economy. The data for the domestic macroeconomic variables was sourced from South African Reserve Bank (SARB), International Monetary Fund's (IMF's) International Financial Statistics (IFS) and Statistics South Africa (STATSSA). Except for the interest rate and the exchange rate, all data have been seasonally adjusted. Since no

[1] For further details on the construction of this index, the reader is referred to Kilian (2009).

significant cointegration relation was found in the model, and to ensure stationarity, all variables are transformed to growth rates by taking the first difference of the natural logarithms, except for the interest rate which remains in levels, and the global real economic activity index which is already in its growth rate form. In general, based on standard unit root tests, we found that all variables are I(1), except for the global real economic activity and the interest rate.[2]

The impulse response functions of the variables estimated in first differences are accumulated and shown in levels. Based the Akaike Information Criterion (AIC) and the Final Prediction Error (FPE) Criterion, we include two lags of the endogenous variables, which appears to be sufficient to capture the dynamics of oil shocks on the macro variables.

2.2. Benchmark structural VAR model

As not all oil shocks are alike, although each oil shock is associated with an increase in the price of oil. This differentiation is crucial for economic consequence. We follow Kilian and Park (2009), Peersman and van Robays (2009) and distinguish between three types of shock – oil supply shocks, oil-specific demand shocks and oil demand shocks. To do this, we rely on a sign restriction VAR model specification which allows us to capture the dynamic relationship between macroeconomic variables within a linear model. In a reduced form VAR model specification, all variables are treated systematically by including for each variable an equation explaining its evolution based on its own past values of all variables in the model and an error term. These error terms are serially uncorrelated but likely correlated with each other. In order to ensure identification, structural VAR models are therefore explicit about the contemporaneous relationships between the variables. With such an approach, it is possible to disentangle oil price

[2] The details of the unit root and cointegration tests are available upon request from the authors.

movements depending on the underlying driving force and the dynamic effects on the macroeconomy.[3]

The structural VAR representation is similar to Kilian (2009), Peersman and van Robays (2009) and given by:

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = c + A(L)\begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + B\begin{bmatrix} \varepsilon_t^X \\ \varepsilon_t^Y \end{bmatrix}$$

The endogenous variables of the benchmark VAR can be divided into two groups. The first group of variables, X_t, contains world oil production (QOIL), price of crude oil (POIL) based on the US refiners acquisition cost for imported crude oil, global real economic activity index (WPI) which are designed to capture supply and demand conditions in the global oil market. The other group of variables, Y_t, are specific for the South African economy, i.e. the rate of inflation (CPI), real GDP (RGDP), the real interest rate (TBR) and the real effective exchange rate (XZAR). A matrix of constants and linear trends is represented by c, $A(L)$, is matrix polynomial in the lag operator L and B the contemporaneous impact matrix of the vectors of mutually uncorrelated disturbances ε_t^X and ε_t^Y where ε_t^X is a vector which contains the three types of oil shocks and ε_t^Y are four shocks specific to the South African economy.

2.3. SVAR Restrictions

It is not possible to estimate the contemporaneous impact matrix *B* and therefore identify the structural innovations ε_t^X and ε_t^Y without further assumptions. In particular, since the structural shocks are mutually orthogonal, the variance-covariance matrix of a reduced form estimation of the VAR is $\Omega = B\,B'$. Given Ω, there is an infinite number of possible *B*. in line with recent

[3] For a detailed discussion of the methodology, the reader is referred to Peersman and van Robays (2009).

literature, we impose certain restrictions to obtain, ensuring that only a set of possible *B* are considered conditional on fulfilling a number of sign condition. The assumption that contemporaneous fluctuations in oil production, oil prices and global economic activity are only driven by the three different types of shocks, which corresponds to restricting *B* to be block lower triangular is made.

Since we are only interested in the impact of ε_t^X , there is no need to further identify the components of the lower block ε_t^Y . To uniquely disentangle the three types of shocks in the upper block ε_t^X , we follow Kilian and Park (2009), together with Peersman and Van Robays (2009) and implement sign restrictions. These restrictions are derived from the supply and demand model of the world oil market. We impose the sign restrictions to hold for the first four quarters after the shock. An unfavourable oil supply shock will result in a fall in global oil production, an increase in the price of oil and a weaker global demand. The distinction between an oil demand shock and an oil specific demand shock lies in their effect on level of world economic activity. Oil specific demand shocks originate from fears of uncertainty about future supply of oil and hence are thought to have a negative effect on world economic activity and lead to higher oil production and oil prices. On the other hand, oil demand shocks which are simply demand shocks caused by increased world economic activity have positive impacts on global oil production, causing a rise in the price of oil and increased world economic activity. The sign restrictions are imposed for a period of 4 quarters (one year). It is important to note that the restrictions are only imposed on the impulse responses of the global oil market variables X_t, the responses of all other variables are fully determined by the data.

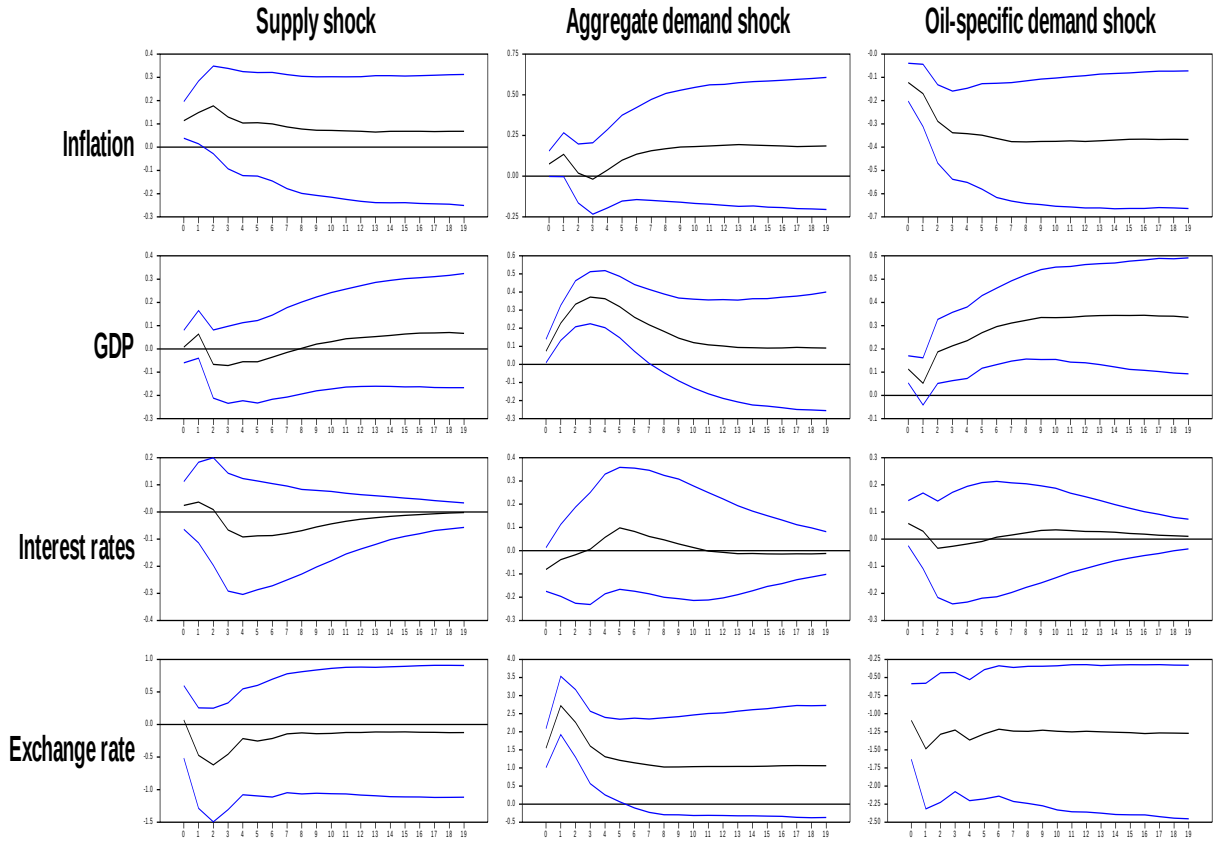
In line with Peersman (2005) and Peersman and Van Robays (2009), we use a Bayesian approach for estimation and inference. The prior and posterior distributions of the reduced form VAR that we use depend on the Normal-Wishart. To draw the candidate truths from the posterior, we take a joint draw from the unrestricted Normal-Wishart posterior for the VAR parameters and a random possible block lower triangular decomposition *B* of the variance-covariance matrix. This will allows us to construct impulse response functions. If the impulse response functions from a particular draw satisfy the imposed sign conditions, the draw is kept, otherwise the draw is rejected. Each draw needs to satisfy the restrictions of all three shocks simultaneously. A total of 1000 successful draws from the posterior are used to show the median, 84th and 16th percentiles in Figure 1. For ease of comparison, the identified shocks are normalised to increase the price of oil contemporaneously by 10 per cent.

3. Results

Figure 1 shows the impulse response functions (IRFs) for the first twenty quarters after each shock for the period 1975:01 to 2011:02. The IRFs are based on a VAR with 2 lags as indicated in the methodology section.[4]

[4] We also estimated IRFs based on a VAR with 1 lag (suggested by the Schwarz Information Criterion and the Hannan-Quinn Information Criterion) and 4 lags (selected by the sequential modified likelihood ratio test statistic) as well, and found the results to be relatively similar to the ones with 2 lags reported in the paper. The results based on 1 lag and 4 lags are available upon request from the authors.

Figure 1: Impact of different types of oil shocks in South Africa for the sample 1975:1-2011:2



Notes:

Graphs are median impulse responses to a 10% contemporaneous rise in oil prices for South Africa's macroeconomic variables, together with the 16th and 84th percentile error bands, horizontal axis is quarterly horizon-ahead following a shock.

3.1. Oil Supply Shock

An unfavourable oil supply shock raises consumer prices and is significant for the first two quarters. This is in line with expectations as we expect a significant reaction from the energy component of the consumer price index in the economy. An increase in liquid fuels for transport and other uses will lead to an indirect cost effect via higher production costs which firms will pass on to consumers by raising food / retail prices (Baumeister, Peersman and Van Robays,

2009; Peersman and Van Robays (2009); Kilian (2009); and Wakeford (2006). The impact however becomes insignificant thereafter, suggesting that the impact is only on impact and there is no positive persistence on inflation. Although we expected to see a contraction of the monetary policy in the form of increased interest rates to offset the inflationary consequences, the impact on the three-month Treasury bill rate is statistically insignificant. Monetary policy authorities do not necessarily react on instantaneously to changes in inflation rate. This is not surprising because although the monetary policy authorities target inflation rate, they also consider the consequences of output and other real variables. The reaction of South African output to an oil supply shock is statistically insignificant, so is the behavior of the real exchange rate to an oil supply shock. The only variable that is statistically significant and that the impact makes economic sense is the inflation rate, indicating that the domestic economy is only affected by an oil supply shock through the inflation rate – an increase in the cost of fuel.

3.2. Oil demand shock driven by global economic activity shock

The effects of an oil demand shock driven by rising global economic activity result in the economy facing a transitory increase in real GDP which is in line with the literature (Baumeister *et al.*, 2009; and Peersman and Van Robays, 2009). Even for an oil-importing country such as South Africa, output is expected to rise because the country itself is in a boom, or because it indirectly gains from trade with the rest of the world. An unexpected 10 per cent increase in aggregate global demand will result in a sharp increase – with a peak on 0.36 during the third quarter, before moderating. The effect becomes insignificant after seven quarters indicating a short-term increase in domestic GDP.

In contrast to the oil supply shock, we observe a sharp appreciation of the exchange rate in the first two quarters due to the expansion of global economic activity. Robust global growth will

result in rising demand for industrial commodities and South Africa is an exporting country of mining commodities. The improvement in global demand will likely increase demand for our commodities and as a result, higher exports and an appreciated real exchange rate. The inflation rate and the interest rate remain statistically insignificant.

3.3. Oil-specific demand shock

The impact of oil-specific demand shocks is different from the other two shocks, as shown in Figure 2. This shock is followed by a permanent statistically significant fall in the inflation rate (with an insignificant reaction from the monetary policy instrument). These results are contradicting literature that suggests that an oil-specific demand shock result in inflationary pressures for oil importing countries (Baumeister *et al.*, 2009). Domestic growth remains positive and statistically significant over the horizon. This may suggest that oil-exporting countries are transferring wealth obtained from oil-importing economies like South Africa from speculative transactions, thereby containing the negative impact on output caused by the demand specific shocks. This may also be a result of lower inflation and depreciation in the exchange rate following such a shock and also given the theoretical trade-off between inflation, real exchange rate and output. As expected, the exchange rate depreciates and remains statistically significant for the entire horizon, explained by wealth and resources moving from oil importing economies to oil exporting countries.

4. Conclusion

This paper analyses the impact of different oil shocks in South Africa using a sign restriction-based VAR estimation. We disentangle the three types of shocks and show that oil price shocks differ depending on the source of the oil price increase. Output is positively affected by both the

oil demand and oil-specific demand shocks, while an oil supply shock has no significant effect. There is an immediate but transient rise in inflation caused by both the oil supply and oil demand shocks, but a negligible impact by the oil-specific demand shock. The effect on the real exchange rate is significant for the oil demand and oil-specific demand shocks. An interesting result to note is the lack of reaction from the monetary authorities. All three oil shocks have no impact on interest rates, as they remain insignificant throughout.[5]

Currently, the monetary policy in South Africa is primarily inflation-targeting to achieve and maintain price stability in the interest of sustainable and balanced economic development and growth. Based on the results we obtained, there is no apparent immediate reaction from the monetary authority to these oil shocks, an indication that it is not an explicit oil inflation-targeter, but rather considers the reaction of the real variables, following oil shocks, when coming up with policies.

Our results highlight the importance of recognizing the origin of an oil price increase. As can be seen from the impulse response functions reported in Figure 1, there exists a a positive and significant relationship observed between economic growth and oil price increases, when the increase in the oil price originates from oil demand shock. For an economy like South Africa trying to grow consistently above the five percent mark in an attempt to eradicate its persistent unemployment problems, this relationship should be taken advantage of. South Africa has been gradually removing barriers to trade, mainly by reducing trade protection and structural constraints. Continued trade liberalization and the removal of trade barriers (especially for

[5] We carried out two sub-sample analyses starting 1990:Q1 and 1994:Q1 to capture, respectively, the beginning of informal inflation targeting by the SARB and South Africa's integration in the world economy, which in turn, led to a sharp increase in oil consumption, to check for the robustness of our results in terms of the interest rate behavior. Our results, however, continued to indicate lack of significant response of the SARB following the different shocks that led to an increase in oil price. The details of these results are available upon request from the authors.

commodities) will benefit from high global prices. Our findings suggest that policy initiatives should be aim at containing the sharp appreciation of the rand following an aggregated demand shock and removing any domestic structural constrains in the export market, especially primary commodities exports, to take advantage of higher global oil prices. These domestic constraints include low levels of competition and relatively restrictive product market regulations which tend to hamper trade. Policies that should be considered to boost export growth and minimize the volatility of the real exchange rate should include:

- Making fiscal policy more rule-based and more countercyclical;
- Using foreign exchange intervention more actively to resist overvaluation;
- Removing existing capital controls and replacing them by prudential rules

As part of future research it would be interesting to conduct this study in a time-varying framework to see how the interest rate decisions, as well as, the effect on the other macro variables have evolved over time following oil price shocks.

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