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Linking Historical Oil Price Volatility and Growth: Investment and Trade Dynamics

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ABSTRACT

This paper investigates the impact of historical crude oil-price fluctuation on diverse economies. It employs the use of structural vector autoregressive (SVAR) and panel VAR methodologies as innovative paths of investigating oil-shock association. While evidence of linear and non-linear shock specifications hold for developed economies within the SVAR specification, growth patterns for emerging counterpart are only defined by the linear shock. The asymmetric behaviour of growth response along shock specifications and development is predisposed to two main channels: First is the differential systemic and institutional framework in place across economies, making shock vulnerabilities differ. Secondly, identification restrictions imposed within SVAR methodology is perceived to have overruled conditions consistent with the non-linear shock model. Positive oil-price shocks benefits accrue to the global community through investment while negative oil-price shocks are transmitted through interest rate triggered trade cut-backs.

Keywords: Oil-price Volatility, Asymmetric Growth, Structural Vector Autoregressive, Panel VAR Methodology, Trade, Investment
JEL Classifications: C01, O47, Q32, Q40

1. INTRODUCTION

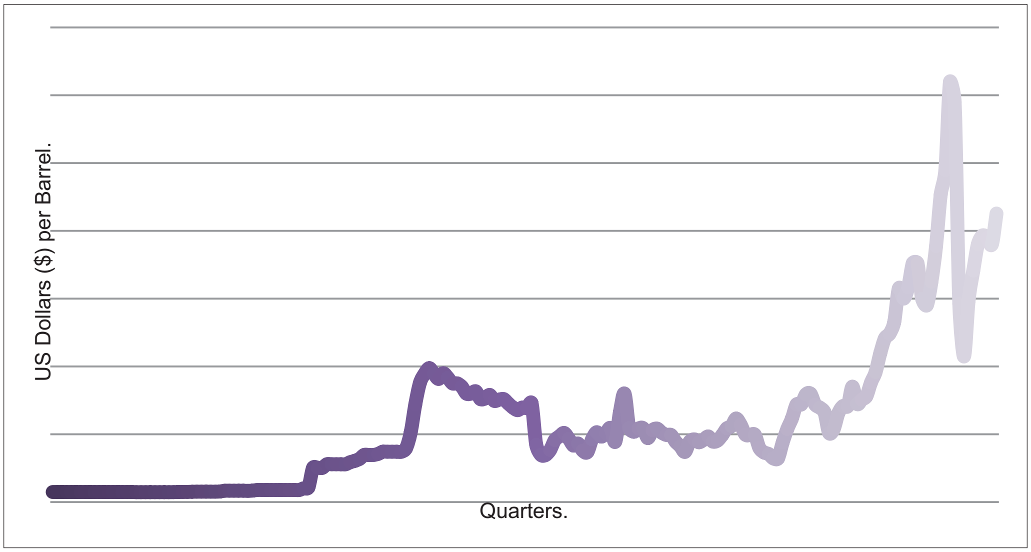
Oil price stabilization plays an important role in macroeconomic stability across developed and developing countries, irrespective of the status of the economy as a net-importer or net-exporter. Oil-shock effect on macroeconomic variables has drawn extensive attention in energy economics over the past decades. Liu et al. (2014) recently highlights a unique dimension of this importance across diverse countries by showing that synergy with monetary policy of the developing country is required for an effective oil-pricing policy for the developing category. This is partly as a result of further economic declines experienced in the developing world aftermath of the early 1970's oil shock. It is also attributable to the difficulty with the discovery of a perfect and suitable alternative for crude oil's industrial use in the current world. However, there is a need to have a broader understanding of the effects of oil price shocks which will accord corresponding importance to oil price shock effects in both developing and developed economies under the same platform. In this regard, the implementation of alternative vector autoregressive (VAR) methodologies, useful for multiple contexts, is applied in our study.

2. BACKGROUND

The basis for oil shocks is oil price volatility which has become considerably sustained within OPEC session in the oil market. Current events in the global crude oil market are important indications of the importance of oil price stability across countries of the world. There is a consensus of three distinct epochs of crude oil price behaviour, in persistence and volatility, in the literature. Evidence shows clearly that the OPEC era displays the most volatile epoch of oil price movements between 1861 and 2011 (Figure 1). A large spectrum of literature has continually examined the effects of oil-shocks on economic activities in various dimensions. Many studies have affirmatively established the existence of an inverse relationship between economic activities and oil price shocks.

Given the various strands in the literature, it may be somewhat difficult to allocate a model for the global crude oil market (Kilian, 2010). However, economic fundamentals (demand and supply dynamics) remain the most fundamental channel of movements in the world oil price in addition to new discoveries

Figure 1: Trend of quarterly series of Nominal West Texas Intermediate (1960q01-2010q04)



Source: International Financial Statistics (International Monetary Fund) 2011

and exploration breakthrough. Therefore, a considerable number of studies have tried to empirically establish a relationship between oil price, oil supply and/or oil demand shocks, while others engage in establishing how these altogether affect some macroeconomic variables (Bjornland, 2000). Also, it must be emphasised that in the relating oil price shocks with economic fundamentals, supply shock is considered more relevant relative to demand shock. This is due to the role historical supply shock play in obstructing crude oil prices in the oil market which has actually led some researchers to examine the effects of oil supply shocks on certain economies. However, in recent times, oil demand shocks are increasingly becoming more relevant in oil price movements in the global oil market (Kilian, 2010)[1]. While growth has been the focus of most empirical oil-shock papers, distinctively understanding the mechanism is the utmost priority of this paper.

In general, the trend in oil price shock studies over the years has revealed expansion in the scope and coverage of oil price shock activities. Hamilton (1983) argued that historic correlation between oil price increase and economic recession is not a statistical coincidence with empirical support from Gisser and Goodwin (1986). However, Loungani (1986) deviated from this strand of literature by confirming the disruptive effects of real oil price on employment through sectorial shifts, in particular labour reallocation process. As a flavour to oil-price shock studies, a new trend of asymmetric effects established by Mork (1989) modified by Lee et al. (1995) and Hamilton (1996, 2003) have since then been the trend in numerous studies including those in recent times (Mendora and Vera, 2010).

Systemic and institutional frameworks put in place across economic categories, by virtue of their differing growth stages, may likely account for different dispositions to international market crude oil price shocks. Essentially, developed countries may be capable of shielding against negative oil-price shocks relative to the developing countries and this call for an empirical investigation. The United States, Norway and South Africa have been chosen as case studies given the global representation these economies have regarding oil trade categories. Basically, SVAR and panel VAR (PVAR) methodologies have been used in addition of unrestricted VAR to establish the effect of imposition of identification restriction and pooled data on oil shock studies.

Our results show that the developed economies (United States and Norway) stick to the non-linear oil-price shock specifications argued in the literature. However, these are not feasible within the context of the emerging net-oil importing economy, South Africa. Furthermore, SVAR model decisively restricts the oil-price shock effects while the effects intended to be captured may have been overruled by the identification restrictions. However, the PVAR methodology accommodates all oil-price shock specifications for the developed countries. Evidence of investment proliferation emerges as a mechanism in support of spill-over distribution during positive oil price shock accruals to the global community using Foreign Direct Investment (FDI). On the other way round, there is suggestive evidence of possible unprecedented and unsatisfactory effects during negative oil-price shock periods through cut-back trades.

3. RELATED LITERATURE

Hamilton (1983) is the pioneer oil price macroeconomic relationship paper in the literature. Consequent studies on the United States in the late 1980s by Gisser and Goodwin (1986) and Hickman et al. (1987) confirmed the earlier documented inverse relationship between oil prices and aggregate economic activities in the theoretical literature. Furthermore, a generalisation of similar relationship is evident in the documentation for countries other than the United States by Darby (1982) and Burbidge and Harrison (1984).

1 This new development basically establishes how oil flow demand shocks fundamentally differs to oil demand and oil supply shocks from theoretical perspective.

3.1. Mechanisms for Transmission of Oil-Price Shocks to Macro Economic Variables

The channels earlier argued for the inverse relationship between oil price movements and the aggregate economic fundamentals have been modified as soon as oil price movements encountered radical trends during unprecedented global recessions. Oil-price shocks (volatility) have been documented to particularly have the four major potential channels of impacting macroeconomic variables: (1) The Classical Supply-Side Effect; which entails reduced availability of basic production inputs, as a result of rising oil prices. (2) Income Transfer Effect; which represents demand-side cutbacks in periods of oil price shocks. (3) Monetary Policy Response; revealing how induced monetary policy through the central banks influence oil-price macroeconomic relationship[2]. 4. The Real Balance Effect; which implies how the rigidity of the monetary authority to meet up with increased money demand may stifle economic growth.

3.2. Oil Price Shocks and Asymmetric Effects on the Economy

Associated with the oil price shock (volatility) is the asymmetric effect of remarkable and significant recession from oil price increase relative to insignificant boom associated with oil price falls. In particular, the 1980s and 1990s featured increased apparent asymmetric response of the United States' macro-economic variables to oil price shocks. The uncertainty effect and the reallocation effect are basically at play in the asymmetric response of macroeconomic variables to oil price shocks. They magnify the response of macroeconomic aggregates during oil price increases while response to oil price falls are not correspondingly significant. Among the early studies documenting asymmetric effects are Mork (1989), Mory (1993), Lee et al. (1995) and Hamilton (1996, 2003). In addition to solely monetary policy, some literature have proposed monetary policy and asymmetry; adjustment costs and asymmetry; and gasoline market structure and asymmetry as possible channels of asymmetry.

3.3. Oil Price Shocks: Co-examining Developing and Developed Economies

Most oil price studies in the past have separately considered a group of industrialised economies (Lardic and Mignon, 2006; Blanchard and Gali, 2008), studied industrial economy independently (Gausden, 2010; Kormilitsina, 2011) or individually examined non–OECD economies (Mendora and Vera, 2010; Iwayemi and Fowowe, 2011). With this approach, results have largely been dichotomised along the net oil-importing or net oil-exporting economic classifications. Analysis on unilateral economic focus have shown that each of the categories have certain unique characteristics in common in reaction to oil price shocks. For instance studies conducted by Mendora and Vera (2010) and Iwayemi and Fowowe (2011) respectively on Venezuela and Nigeria, which are both developing economies, confirm asymmetric response of growth. Also, developed economies have been justified to dispose more stable macro to oil price shocks probably due to safeguarding structures and signalling indicators they take seriously before oil-shocks or perhaps due to plans. Apart from the asymmetry response, several studies on the United States among other developed countries have reflected that sound monetary policy stance of the Central Bank can help to support the economies against the effect of negative oil price shocks (Blanchard and Gali, 2008).

2 A more recent theoretical evidence is documented in Liu et al. (2014) and supports synergies required between oil-price stabilization policy and the monetary policy in developing countries.

3.4. Empirical Literature

Recent studies have broadened the analysis of macroeconomic impacts of oil shocks. Blanchard and Gali (2008) examined why the macroeconomic effects of oil-price shocks in the previous decade differ from that of the 1970s. They conclude, using the G7 countries, that improvement in monetary policy, more flexible labour market, smaller share of oil in production and good luck were responsible for this difference. A comparative study of aggregate demand, aggregate supply and oil-price shocks was carried out by Bjornland (2000), with the conclusion that oil-price fluctuation was mainly responsible for affecting the economic activities. Lardic and Mignon (2008) and Jimenez-Rodriguez and Sanchez (2005) among others using different countries or group of countries and different methodologies are some of the studies that established asymmetric relationship between oil-price shocks and economic activities (gross domestic product [GDP] growth in some cases).

Also, another strand of research linking oil-price shocks and economic growth in inflation targeting and technologically driven countries was carried out by Doroodian and Boyd (2003). The United States was used as a case study and showed that technological advancement would make an economy less vulnerable to oil-price fluctuations. Eika and Magnussen (2000) investigated Norway between 1979 and 1985. It was established that negative effects from lower foreign demand and higher interest rates crowded out the windfalls from oil shock accruable to Norway as an oil exporter. However, the application of an expansionary fiscal policy with spending cuts within the economy during that period stabilized the macro-economic variables.

Also, a spectrum of country-specific investigation of the effect of oil-price shocks, each using a number of carefully selected macroeconomic variables of interest exists in the literature. This include, Aydin and Acar (2011), Iwayemi and Fowowe (2011), Omojolaibi (2014), Omojolaibi and Egwaikhide (2014). Results from some of the aforementioned support the existence of asymmetric effect of oil-price shocks on certain variables albeit in a direction contrary to a priori expectation in theory. In a similar direction, Gausden (2010) presents oil price shocks previously undermined, as becoming more pervasive and of greater prominence after structural shifts were accommodated within the models used. Du et al. (2010) empirically investigate how China's macro-economy relates with global oil-price shocks. It proposes, through his study, that there is a significant non-linear relationship existing between oil-price shocks and China's macro-economy with the conclusion that China's successive economic era are not capable of affecting the world oil prices simultaneously.

Foremost, the gap to be filled in the literature is in the area of scarcity of developing net-oil importing literature in oil price shock studies. Also, this paper will investigate the authenticity of asymmetry in this category and South Africa has been spotted as an eligible[3] case study of net oil-importing developing economy for that purpose. This will be co-examined with the developed world net oil importing (United States) and exporting (Norway) respectively. Also, attention will be paid to the mechanisms at work during positive and negative oil price shocks.

4. EMPIRICAL STRATEGY

Applicable methodologies for the current study are VAR Models. Multiple VAR will be applied on both linear and the non-linear oil-shock specification to capture the intensity of the impacts of oil-price shocks on quarterly macroeconomic variables which are real GDP (RGDP), Inflation rate (INFCPI), Interest Rate (INT), Real Effective Exchange Rate (REER) and FDI from 1980 to 2010. Figures 2-4 below are the graphical depiction of relationship between linear oil-price and macro-economic variables across countries beginning from q1 1970.

This study follows studies conducted by Jimenez-Rodriguez and Sanchez (2005), Du et al. (2010) and Iwayemi and Fowowe (2011) in the choice of macroeconomic variables as documented above. The linear benchmark specification entails the spot oil-price linearly denoted by OIL, specifying both increase and decrease in oil-price (Figure 5), while the three models of oil-price shocks under the non-linear specifications (Figures 6-11).

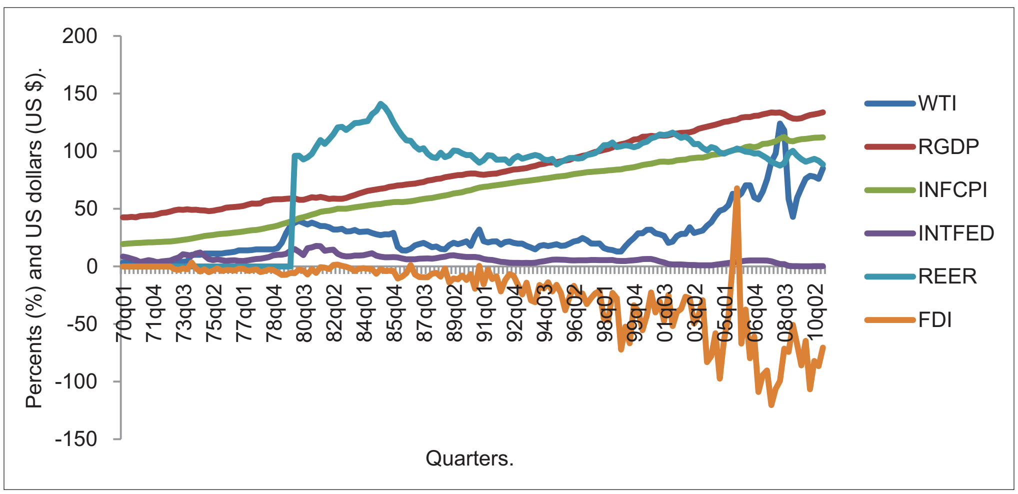
Mork (1989) claimed an asymmetric response to the increase or decrease in oil-shock under certain conditions and so separated positive oil-price shocks from negative oil-price shocks. Mork's positive and negative real oil price shocks are respectively denoted by $ROILP_t^{+}$ and $ROILP_t^{-}$ and these are obtainable in the following ways.

$$ROILP_t^{+} = \max \{0,(ln\text{roilp}_t - ln\text{roilp}_{t-1})\}$$

$$ROILP_t^{-} = \min \{0,(ln\text{roilp}_t - ln\text{roilp}_{t-1})\}$$

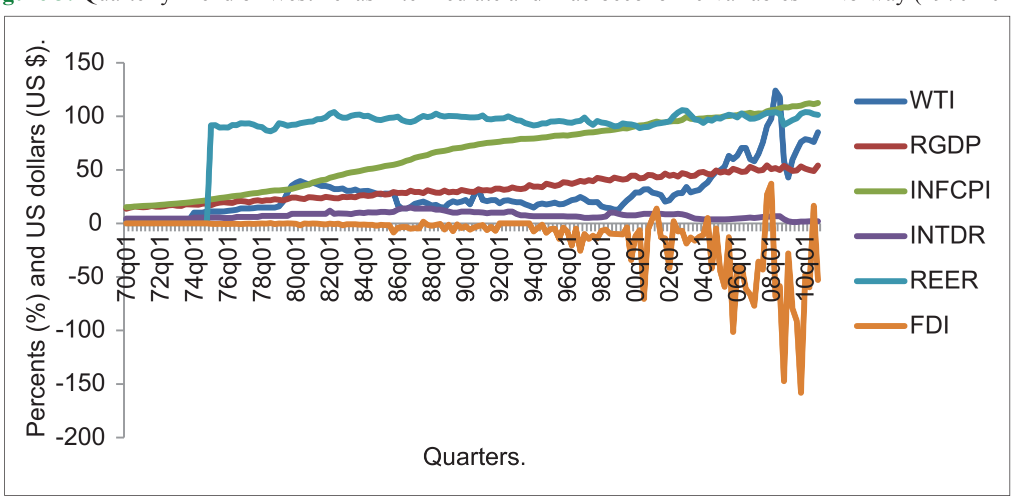
3 South Africa is considered eligible due to the proximity of its economic structure to those of the comparable advanced countries in this paper and data availability for the estimation.

Figure 2: Quarterly Trend of Oil Price and Macroeconomic Variables in United States (1970-2010)



Source: International Financial Statistics, International Monetary Fund (June, 2011)

Figure 3: Quarterly Trend of West Texas Intermediate and Macroeconomic Variables in Norway (1970-2010)

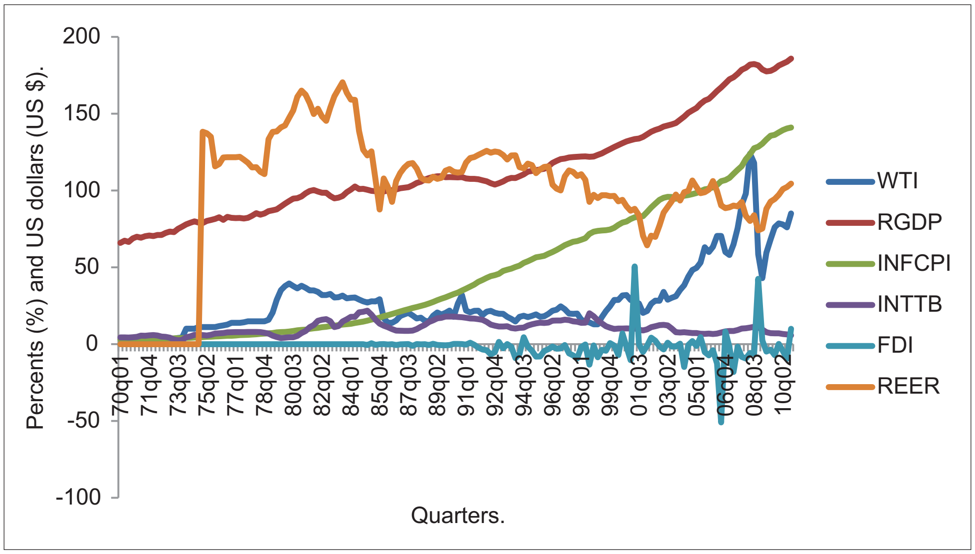


Source: International Financial Statistics, International Monetary Fund (June, 2011)

Where *ln* is natural logarithm; $ROILP_t$ and $ROILP_{t-1}$ are known as the real oil price at times t and t−1 respectively.

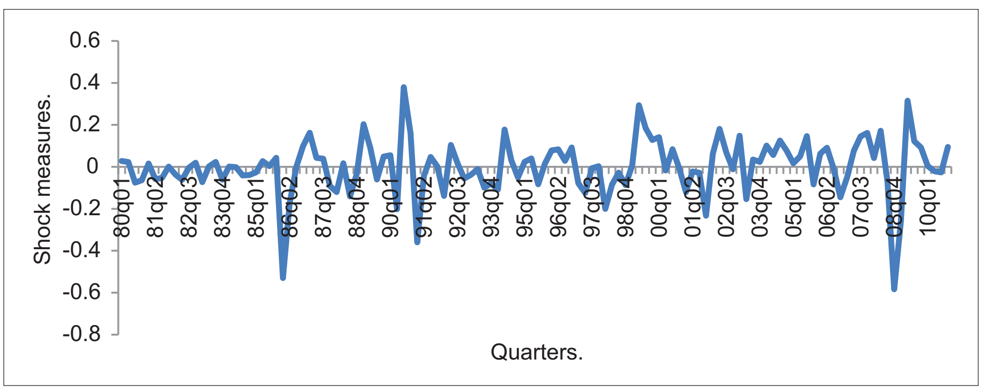
Hamilton's (1996) non-linear specification of oil shocks argues that, in order to know the extent to which oil-price shocks affects consumption and investment decisions, current oil-prices are not expected to be compared with the immediate previous quarter, but with previous four quarters. This leads to net oil price increase (NOPI) being defined as the percentage increase in the current price of oil over the price of the previous four quarters if it is positive and zero otherwise. This is written as:

Figure 4: Quarterly Trend of West Texas Intermediate and Macroeconomic Variables in South-Africa (1970-2010)



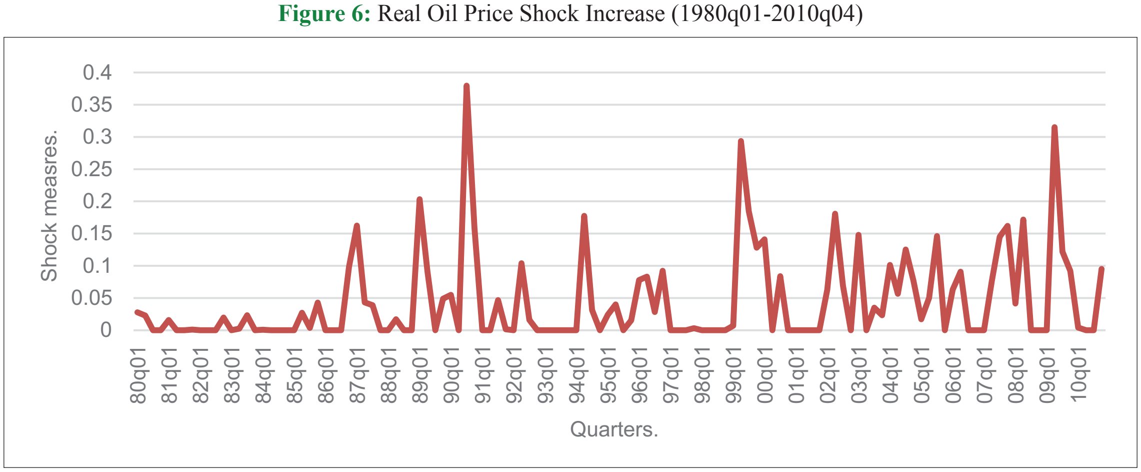
Source: International Financial Statistics, International Monetary Fund (June, 2011)

Figure 5: Linear Oil Price Shock Series (1980q01-2010q04)



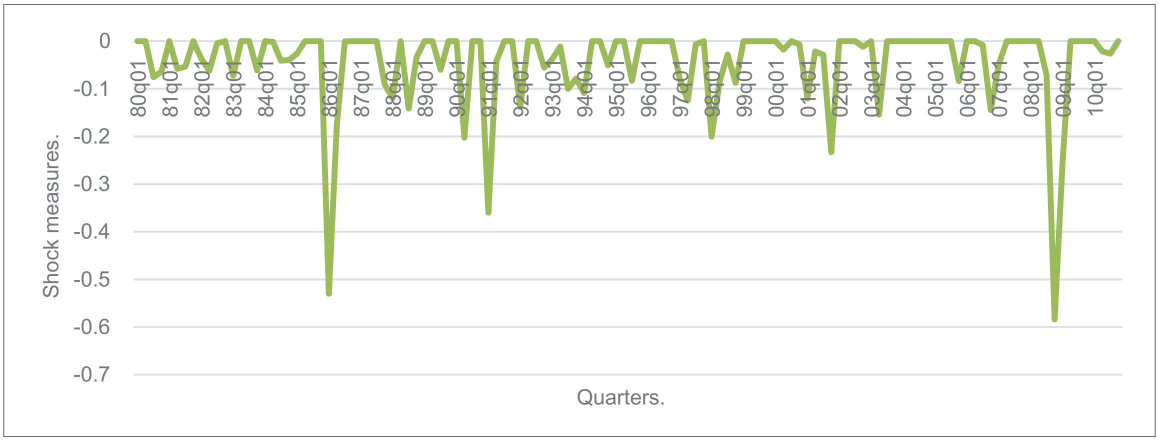
Source: Derived from data from International Financial Statistics, International Monetary Fund (June, 2011)

Figure 6: Real Oil Price Shock Increase (1980q01-2010q04)



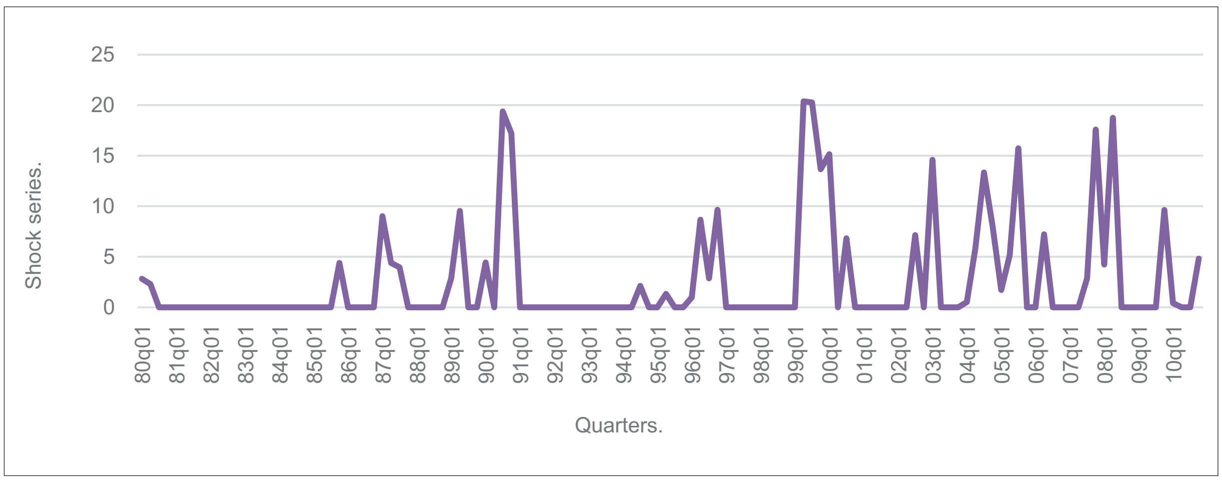
Source: Derived from data from International Financial Statistics, International Monetary Fund (June, 2011)

Figure 7: Real Oil Price Shock Decrease (1980q01-2010q04)



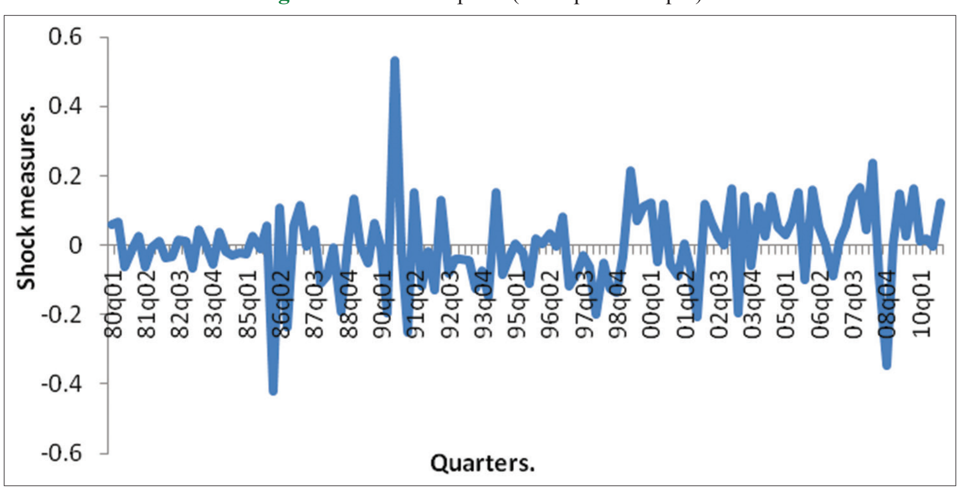
Source: Derived from data from International Financial Statistics, International Monetary Fund (June, 2011)

Figure 8: Net Oil Price Increase (1980q01-2010q04)



Source: Derived from data from International Financial Statistics, International Monetary Fund (June, 2011)

Figure 9: Scaled oil price (1980q01-2010qo4)



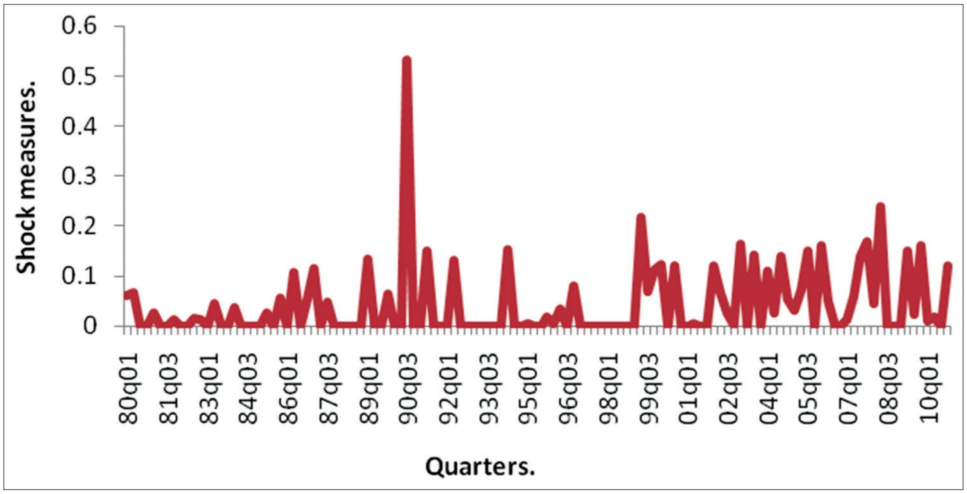
Source: Derived from data from International Financial Statistics, International Monetary Fund (June, 2011)

$NOPI_t = \max\{0,(ln(oil_t) - ln(\max(oil_{t-1}.,oil_{t-4}))\}$

Where *ln* is natural logarithm; oil_t and oil_{t-i} are known as the real oil price at times t and t-i respectively.

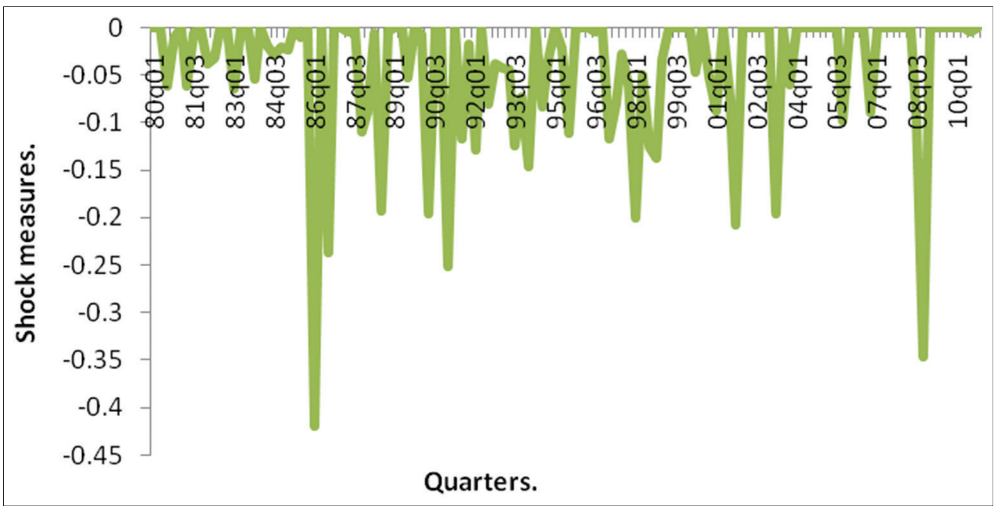
Lee et al. (1995) argued that an oil-price change is likely to have a greater impact on RGDP in an environment where oil prices have been previously stable than in an environment where the oil prices have been erratic. GARCH (1,1) model was employed to capture

Figure 10: Scaled oil price increase (1980q01-2010q04)



Source: Derived from data from International Financial Statistics, International Monetary Fund (June, 2011)

Figure 11: Scaled oil price decrease (1980q01-2010q04)



Source: Derived from data from International Financial Statistics, International Monetary Fund (June, 2011)

oil shock in different environments with different backgrounds in the following way:

$$O_t = \delta + \sum_i^k \beta_i O_{t-i} + \varepsilon_t$$

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

$$h_t = \Upsilon_0 + \Upsilon_1 \varepsilon_{t-1}^2 + \Upsilon_2 h_{t-1}$$

$$SOPI_t = \max\ (0, \mathcal{E}_t/\sqrt{h_t})$$

$$SOPD_t = \min\ (0, \mathcal{E}_t/\sqrt{h_t})$$

Where $SOPI_t$ and $SOPD_t$ are used as measures of non-linear effects of oil-price volatility and are defined respectively as positive and negative scaled oil-price measures.

4.1. Data Source, Unit Root and Stability Tests

The data sets used in this section are gathered from IMF's International Financial Statistics database and BP Statistical Review of World Energy (2011) from 1980 to 2010. Carefully examining the unit root tests' results, it can be extracted that all variables are stationary at their first difference except for some oil price shock measures. In addition, The data shows an insignificance structural break points defined by the Quandt-Andrews unknown structural break point tests for the United States and Norway using all oil shock measures[4] under consideration. However, South Africa displays a specific structural break date of 1993q02 in all the oil price shock series particularly when examined independently of all other variables. The structural break date is exogenously adjusted-for using a dummy variable[5]. Tables 1-4 (below) present the unit root tests (Augmented Dickey-Fuller and Phillips-Perron) on oil shock measures as well as macroeconomic variables across countries.

In summary, the general framework of a pth-order VAR model that is adopted for analysis in this study is:

4 This is investigated considering the series of each oil price shock measure with other variables of estimation and independent of other variables of estimation.

5 This is different from other studies e.g Du *et al* (2010), where the structural break date discovery led to the separation of the estimation period into two different estimations.

Table 1: Unit root tests of oil price shock measures

Variables	ADF (8)			PP		
	None	Intercept	Intercept and trend	None	Intercept	Intercept and trend
$LRWTI_t$	−0.6197	−1.5419	−1.9703	−0.5606	−1.6095	−1.8140
OIL_t	−9.2046***	−9.1661***	−9.4176***	−9.1714***	−9.1176***	−10.2181***
SOP_t	−12.5043***	−12.4566***	−8.2275***	−12.5044***	−12.4568***	−12.8545***
$NOPI_t$	−6.6721***	−7.8103***	−8.1216***	−6.7604***	−7.9041***	−8.0147***
$ROILPI_t$	−6.6808***	−8.5924***	−9.0556***	−7.0345***	−8.5819***	−8.8675***
$ROILPD_t$	−7.8993***	−9.3744***	−9.3348***	−8.0093***	−9.2599***	−9.2098***
$SOPI_t$	−3.4760***	−11.8267***	−12.4775***	−10.4898***	−11.8189***	−12.4789***
$SOPD_t$	−4.9882***	−11.8675***	−11.8593***	−10.0132***	−11.8655***	−11.8576***

*, ** and *** represents 10%, 5% and 1% levels of significance respectively. ADF (n): Augmented Dickey-Fuller with allowance for n autoregressions, PP: Phillips-Perron. Note that maximum lag of eight is allowed in the unit root test

Table 2: Unit root tests of united states' macroeconomic variables

Variables	ADF (8)			PP		
	None	Intercept	Intercept and trend	None	Intercept	Intercept and trend
$LRGDP_t$	4.4925	−1.0224	−1.5371	6.1124	−0.9738	−1.1275
$INFCPI_t$	4.4512	−0.8020	−2.6937	8.7243	−0.9704	−3.2691*
$INTFED_t$	−2.1905**	−2.2061	−4.5486***	−2.2645**	−2.1439	−3.1094
$LREER_t$	−0.271	−1.7669	−2.2874	−0.2402	−1.7147	−2.1701
FDI_t	−1.3325	−2.3963	−7.0227***	−1.9996	−3.5382***	−7.0596***
$\Delta LRGDP_t$	−3.3680***	−5.5407***	−5.7265***	−4.9635***	−7.1063***	−7.0750***
$\Delta INFCPI_t$	−1.6570*	−10.6999***	−10.6965***	−5.9111***	−9.0523***	−9.0208***
$\Delta INTFED_t$	−4.1060***	−6.2385***	−6.1933***	−9.7616***	−9.8098***	−9.7637***
$\Delta LREER_t$	−8.0863***	−8.0570***	−8.1009***	−8.0177***	−7.9878***	−8.0247***
ΔFDI_t	−17.2466***	−17.1979***	−17.1301***	−28.1873***	−29.7974***	−30.0343***

*, ** and *** represents 10%, 5% and 1% levels of significance respectively. ADF (n): Augmented Dickey-Fuller with allowance for n auto regressions, PP: hillips-Perron. Note that maximum lag of eight is allowed in the unit root test

Table 3: Unit root tests of Norwegian macroeconomic variables

Variables	ADF (8)			PP		
	None	Intercept	Intercept and trend	None	Intercept	Intercept and trend
$LRGDP_t$	1.8815	−1.4806	−1.3678	3.7037	−0.4297	−7.7613***
$INFCPI_t$	2.2478	−3.8932***	−2.8800***	5.4436	−4.0956***	−2.9976
$INTDR_t$	−1.0173	−1.1891	−2.8789	−1.0243	−0.9568	−2.3772
$LREER_t$	0.3763	−3.7321***	−3.7165**	0.6826	−3.1545**	−3.1389
FDI_t	3.0662	3.7569	−5.1537***	5.9845	−7.0432***	−8.6561***
$\Delta LRGDP_t$	−1.5899	−3.9340***	−4.1798***	−15.9663***	−23.9102***	−24.4774***
$\Delta INFCPI_t$	−1.9558**	−10.5897***	−11.5253***	−6.8297***	−10.8637***	−11.5185***
$\Delta INTDR_t$	−9.1046***	−9.1067***	−9.1311***	−9.0846***	−9.0602***	−9.0349***
$\Delta LREER_t$	−9.6684***	−9.6358***	−9.5956***	−11.0924***	−11.0835***	−10.9952***
ΔFDI_t	−9.2542***	−7.1328***	−7.3141***	−66.0582***	−88.5955***	−87.6187***

*, ** and *** represents 10%, 5% and 1% levels of significance respectively. ADF (n): Augmented Dickey-Fuller with allowance for n auto regressions, PP: Phillips-Perron. Note that maximum lag of eight is allowed in the unit root test

Table 4: Unit root tests of South African macroeconomic variables

Variables	ADF (8)			PP		
	None	Intercept	Intercept and trend	None	Intercept	Intercept and trend
$LRGDP_t$	3.1247	0.9008	−1.4425	4.6534	0.9153	−0.9806
$INFCPI_t$	4.2941	2.4990	−1.4642	9.3144	3.7768	−1.1391
$INTTB_t$	−0.8854	−3.0830**	−4.0245**	−0.7470	−2.6562*	−3.3531*
$LREER_t$	−0.5507	−1.8696	−3.2115**	−0.5224	−1.9989	−2.6924
FDI_t	−1.0653	−11.0130***	−11.0955***	−1.0754	−11.0185***	−11.0975***
$\Delta LRGDP_t$	−4.7540***	−5.8133***	−5.9899***	−4.7540***	−5.8496***	−5.9551***
$\Delta INFCPI_t$	−2.9118***	−5.2335***	−6.0602***	−2.4656**	−5.2201***	−6.0929***
$\Delta INTTB_t$	−6.8223***	−6.7938***	−6.8843***	−6.7771***	−6.7483***	−6.7980***
$\Delta LREER_t$	−5.2223***	−5.2357***	−5.2973***	−9.9675***	−9.9432***	−9.9354***
ΔFDI_t	−9.5773***	−9.5350***	−9.4930***	−88.2856***	−86.6234***	−92.3413***

*, ** and *** represents 10%, 5% and 1% levels of significance respectively. ADF (n): Augmented Dickey-Fuller with allowance for n auto regressions, PP: Phillips-Perron. Note that maximum lag of eight is allowed in the unit root test

$$y_t = c + \sum_{i=1}^{p} \Phi_i y_{t-1} + \varepsilon_t \qquad (1)$$

$$\mathcal{E}_t \sim N(0,1)$$

The order-*p* of the VAR model is established following Gausden (2010) in which maximum lags are determined by lag length criteria from E-views.

4.2. Models for Estimation

4.2.1. Unrestricted VAR model

The general VAR model of p[th] order can be literally written as:

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \ldots + \phi_p y_{t-p} + \mathcal{E}_t \qquad (2)$$

$\mathcal{E}_t \sim$ iid $N(0,\Sigma)$

where y_t is a *nx1* vector of variables at time t and c is an intercept

Whereas, considering the multivariate models in our current study, we have the following as p[th]-order oil price shock multivariate model for estimation in each country.

$$\Delta LRGDP_t = c1 + \sum_{i=1}^{p} \alpha_i OIL_{t-i} + \sum_{i=1}^{p} \beta_i \Delta INFCPI_{t-i} + \sum_{i=1}^{p} \Phi_i \Delta INT_{t-i}$$

$$+ \sum_{i=1}^{p} \mu_i \Delta LREER_{t-i} + \sum_{i=1}^{p} \lambda_i \Delta FDI_{t-i} + \varepsilon_{1t}$$

Model 1.

The granger causality[6] is examined with a focus on the extent to which oil-price shocks cause the macroeconomic variables with different oil-price shock sessions experienced under the period of investigation.

4.2.2. SVAR Model

SVAR model is a restricted version of the VAR model in which identification restriction is imposed on the VAR model to be estimated. Majorly, the kind of identifying restriction on dynamics SVAR favours imposition of identification restrictions on the matrix of contemporaneous coefficients, variance-covariance matrix (Σ) or long run coefficients (Lack and Lenz, 2000). In the present study with an assumption of *n* variables, n^2 independent restrictions on parameters of the structural form are required for an exact identification of the system.

Furthermore, the reason for imposing the identification restriction is to limit the interaction/direction of causality among variables of concern. In SVAR literature, these restrictions are usually taken from economic theory and are intended to represent meaningful short-run or long-run relationship between the variables and the structural shocks. Short-run restrictions are allowed directly on reduced VAR to show forth the contemporaneous reaction of variables to structural innovations. For a six variable case of our SVAR model, the minimum identification restriction that can be imposed is 21, which would lead to an exactly identified model. Using the Cholesky-decomposition of errors imposes an ordering where structural shocks contemporaneously affects only succeeding variables in a pre-specified order. The format of a six variable SVAR model exactly identified through the identification scheme is as follows:

$$\mu_{OIL} = \epsilon_{OIL}$$

$$\mu_{RGDP} = c_{21}\mu_{OIL} + \epsilon_{RGDP}$$

$$\mu_{INFCPI} = c_{31}\mu_{OIL} + c_{32}\mu_{RGDP} + \epsilon_{INFCPI}$$

$$\mu_{INT} = c_{41}\mu_{OIL} + c_{42}\mu_{RGDP} + c_{43}\mu_{INFCPI} + \epsilon_{INT}$$

$$\mu_{REER} = c_{51}\mu_{OIL} + c_{52}\mu_{RGDP} + c_{53}\mu_{INFCPI} + c_{54}\mu_{INT} + \epsilon_{REER}$$

$$\mu_{FDI} = c_{61}\mu_{OIL} + c_{62}\mu_{RGDP} + c_{63}\mu_{INFCPI} + c_{64}\mu_{INT} + c_{65}\mu_{REER} + \epsilon_{FDI}$$

where, μ: Observed residual, Є: Structural innovations/shocks or fundamental shocks.

4.2.3. PVAR methodology

This methodology helps in pooling of the macroeconomic variable series of the different economies together. The dynamic fixed-effect

6 The impulse response function and variance decomposition analysis of the VAR outcome are equally important are co-examined in this section with granger causality. These are reported in the annex section.

Table 5: Granger causality of oil price shock measures on variables in United States

Variables	OIL_t	SOP_t	$NOPI_t$	$ROILPI_t$	$ROILPD_t$	$SOPI_t$	$SOPD_t$
$\Delta LRGDP_t$	0.9561	0.8419	0.0893*	0.0298**	0.1538	0.0281**	0.7484
$\Delta INFCPI_t$	0.1808	0.0134**	0.0351**	0.0013***	0.3642	0.1626	0.0343**
$\Delta INTFED_t$	0.7146	0.7981	0.0449**	0.0432**	0.5286	0.4651	0.6567
$\Delta LREER_t$	0.2783	0.0886**	0.8553	0.8467	0.9126	0.1304	0.4692
ΔFDI_t	0.9615	0.4686	0.638	0.8297	0.579	0.6333	0.8262

*, **, ***represents 10%, 5% and 1% levels of significance respectively

Table 6: Granger causality of oil price shock measures on variables in Norway

Variables	OIL_t	SOP_t	$NOPI_t$	$ROILPI_t$	$ROILPD_t$	$SOPI_t$	$SOPD_t$
$\Delta LRGDP_t$	0.7674	0.5564	0.0566*	0.282	0.8098	0.6408	0.3112
$\Delta INFCPI_t$	0.1839	0.2374	0.9434	0.0875*	0.4777	0.1742	0.5118
$\Delta INTDR_t$	0.3765	0.4612	0.9049	0.8951	0.2843	0.5147	0.125
$\Delta LREER_t$	0.0083***	0.0049***	0.0040***	0.0226**	0.0532*	0.0142**	0.0035***
ΔFDI_t	0.23	0.7915	0.0013***	0.0200**	0.0456**	0.0217**	0.9205

*, ** and *** represents 10%, 5% and 1% levels of significance respectively

panel estimation which is recommended for a situation where it is uncertain if errors and variables of interest are uncorrelated is used.

5. PRESENTATION AND INTERPRETATION OF RESULTS

5.1. Granger Causalities: Unrestricted VAR Models

The United States' outcomes show an asymmetric response to positive and negative oil shocks across significance and magnitude lines respectively. Given the non-restrictive nature of Tables 5-7, our results need to be interpreted with caution. This is important for all the three non-linear specifications as probabilities in positive oil price shocks are relatively more significant while magnitudes are more pronounced in negative oil price shocks. The implication of this is that while oil price increase in the US aids growth to some extent, it may be more devastating in negative oil shock periods. Although, asymmetric relationship exists through other non-linear specifications, the claim of Lee et al. (1995) does not seem to be hold sway for Norway. However, Mendora and Vera (2010) have emphasized relevance of NOPI as the appropriate oil price shock measure for exporting economies. This is supported by the result in Table 6 with Norway's business cycle demonstrating an asymmetric response along NOPI. Hence, results in United States and Norway comply with a priori expectation of asymmetry as in the literature.

Furthermore, the above results (Tables 5-7) show some level of persistence in the effect of shocks on REER of both net-oil producing and net-oil importing economies (Norway and US). It is puzzling that same feat is recorded in negative oil price shock periods for Norway especially. In the US (a net oil importing country for the focus period), having a strengthened exchange rate can be related to the need for oil-exporting economies to sell more crude for international transactions during dwindling oil-price periods. Also, the claim that accruable funds from crude oil transactions is beneficial not only to the oil producing economies, but to the whole world through foreign investment or transfers is seen with Norway's FDI's. Importantly, this is insignificant by magnitude and can be perceived as insufficient to effect a sustainable change.

Table 7: South Africa's oil granger causality

Variables	OIL_t
$\Delta LRGDP_t$	0.0426**
$\Delta INFCPI_t$	0.1873
$\Delta INTTB_t$	0.962
$\Delta LREER_t$	0.7288
ΔFDI_t	0.1468

*, ** and *** represents 10%, 5% and 1% levels of significance respectively

5.2. Structural VAR Model Results

While estimates become considerably weak for Norway (as seen on Table 8 for the economic growth variable), Table 9 shows that the United States still exhibits some level of asymmetry regarding the impact of real oil price increase and decrease proposed by Mork (1989) in addition to the linear specification. However, of interest is the inverse relationship of interest rate with oil price shocks (Norway and South-Africa) in addition to positive inflationary trends (South-Africa) with linear oil-price specification. Obviously, increase in interest rate will dampen trade potentials, especially in developing countries. Another, devastating outcome is that of South-Africa, where the SVAR model is non-beneficial with the linear oil-price measure (Table 10).

This approach proclaims a strict exogenous nature of the oil price shock measures against which Kilian (2010) has emphatically argued. This implies that Kilian (2010) was probably right as oil price shock measures are not meant to be completely determined outside the model but should be considered within the model, which was satisfied to a large extent with the use of unrestrictive oil price shock models. However, a model which would amplify a considerably robust endogeneity of oil price shock measures is much awaited in the oil-price shock literature.

5.3. PVAR

Table 11 shows a strong and persistent asymmetric response when the economies are pooled for PVAR. Generally, the results derived from specified models for the combined scenario is quite insightful. Despite strong evidence in support of non-linear specifications by the OECD economies, linear specification by the non-OECD still holds. Specifically, different economic category is accountable

Table 8: Structural VAR results of oil price shock measures on variables in Norway

Variables	OIL_t	SOP_t	$NOPI_t$	$ROILPI_t$	$ROILPD_t$	$SOPI_t$	$SOPD_t$
$\Delta LRGDP_t$	−0.0026	−0.0061	0.0002	−0.0324	0.0191	−0.0181	0.0158
$\Delta INFCPI_t$	0.3957	0.5654	0.0325	1.2716	0.1947	0.8746	0.8777
$\Delta INTDR_t$	−1.3175**	−0.9448	−0.0278*	−1.6193	−1.1704	−1.0096	−1.2276
$\Delta LREER_t$	0.0359**	0.0446***	0.0009**	0.0362	0.0525***	0.0008	0.0779***
ΔFDI_t	−2652.004	−1990.473	−54.121	−6269.728*	404.378	−4593.277	3054.106

*, ** and *** represents 10%, 5% and 1% levels of significance respectively. VAR: Vector autoregressive

Table 9: Structural VAR results of oil price shock measures on variables in United States

Variables	OIL_t	SOP_t	$NOPI_t$	$ROILPI_t$	$ROILPD_t$	$SOPI_t$	$SOPD_t$
$\Delta LRGDP_t$	0.0082*	0.0036	−0.00003	0.0027	0.0196***	−0.0012	0.0126
$\Delta INFCPI_t$	2.2080***	2.0268***	0.0348***	1.3009**	3.4509***	2.0395***	3.4407***
$\Delta INTFED_t$	0.3766	0.2546	0.01208	0.6413	0.4183	−0.8385	1.1384
$\Delta LREER_t$	−0.0714***	−0.0569**	−0.0005	−0.0680**	−0.0732**	−0.1019***	−0.0484
ΔFDI_t	6.5475	4.4106	0.01814	1.8751	3.9263	4.605	1.0546

*, ** and *** represents 10%, 5% and 1% levels of significance respectively. VAR: Vector autoregressive

for the establishment of linear and/or non-linear specification for business cycle growths in their respective cases. While the impulse response functions are not reported due to space limitation, the ensuing variance decompositions that follows the granger causality are reported in the Appendix.

5.4. Diagnostic Tests[7]

Results for normality, serial correlation and residual autocorrelation tests are respectively reported in Tables 12-14 below respectively for United States, Norway and South Africa. It is evident that the models have similar behaviour across countries. The behaviour that the models elicit with respect to normal test is quite unique as the models are basically multivariate normal with five variables, while there is an indication that an additional sixth variable is responsible for the deviation of some models from multivariate normality. The FDI which is purely determined outside each economy is likely to be responsible for this deviation. However, with the serial correlation test, the models behave quite satisfactorily. Also, all the residual autocorrelation tests are fit and support the chosen lags for our models.

In addition, the Wald F-statistic is used to test for the joint significance of lagged oil shock measures on economic growth (Table 15). The outcomes are consistent with the granger causality results. In summary, most preferred specifications using the diagnostic and Wald tests, for United States, Norway and South Africa are respectively ROILPI/ROILPD, NOPI and OIL.

7 The diagnostic tests are discussed but values unreported due to space limitation. The results are available from the author upon request.

Table 10: Structural VAR results for South Africa

Variables	OIL_t
$\Delta LRGDP_t$	0.0001
$\Delta INFCPI_t$	1.5795***
$\Delta INTTB_t$	−1.3470*
$\Delta LREER_t$	0.0298
ΔFDI_t	−271.3459

*, ** and *** represents 10%, 5% and 1% levels of significance respectively

Table 14: Diagnostic tests on South Africa

Diagnostic tests	OIL
Normality test	
Variables	5
Skewness	−0.1544
Variables	6
Skewness	0.96***
Serial correlation test	
Lags	3
P	0.8517
Residual autocorrelation test	
Maximum lags	12
P	0.6949

*, ** and *** represents 10%, 5% and 1% levels of significance respectively

Table 11: Wald joint significance test of oil price shock measures on pooled series

Variables	OIL	SOP	NOPI	ROILPI	ROILPD	SOPI	SOPD
$\Delta LRGDP_t$	2.4130**	1.5547	2.2939*	1.4691	3.2413***	1.8766*	1.3947

*, ** and *** represents 10%, 5% and 1% levels of significance respectively

Table 12: Appropriate diagnostic tests on the United States

Diagnostic tests	OIL	SOP	NOPI	ROILPI	ROILPD	SOPI	SOPD
Normality test							
Variables	5	5	5	5	5	5	5
Skewness	−0.1935	−0.1547	0.1393	−0.2035	−0.0663	−0.2268	−0.0248
Variables	6	6	6	6	6	6	6
Skewness	−0.79***	−0.83***	0.2424	0.026	−0.80***	−0.57**	−0.76***
Serial correlation test							
Lags	1	1	7	5	1	2	1
P	0.2222	0.1	0.5116	0.1684	0.1862	0.005***	0.01***
Residual autocorrelation test							
Maximum lags	4	10	12	10	10	12	10
P	0.1013	0.1598	0.00***	0.1224	0.1155	0.2627	0.2048

*, ** and *** represents 10%, 5% and 1% levels of significance respectively

Table 13: Appropriate diagnostic tests on Norway

Diagnostic tests	OIL	SOP	NOPI	ROILPI	ROILPD	SOPI	SOPD
Normality tests							
Variables	5	5	5	5	5	5	5
Skewness	0.0034	−0.081	0.0699	−0.2534	0.0312	−0.1229	−0.1608
Variables	6	6	6	6	6	6	6
Skewness	−0.38*	−0.37*	−0.2328	−0.3215	−0.61***	−0.3056	−0.64***
Serial correlation test							
Lags	5	5	4	4	5	4	4
P	0.5036	0.669	0.05*	0.3179	0.1711	0.2029	0.1267
Residual autocorrelation test							
Maximum lags	12	12	9	12	12	12	12
P	0.3167	0.2564	0.1508	0.7317	0.3084	0.5138	0.3622

*, ** and *** represents 10%, 5% and 1% levels of significance respectively

Table 15: Wald test for joint significance of oil shock specifications across countries

Variables	OIL	SOP	NOPI	ROILPI	ROILPD	SOPI	SOPD
United States	0.0030	0.0398	1.7660*	2.4788**	2.0344	3.5704**	0.1029
Norway	0.5120	0.7903	2.2970*	1.263	0.4552	0.6303	1.1937

*, ** and *** represents 10%, 5% and 1% levels of significance respectively

6. CONCLUSION

This paper aims at investigating the effects of oil price shocks on selected economies. The inclusion of developing economies in cross country oil-price shock studies has previously been overlooked in the literature and this research seeks to contribute some understanding to this gap in knowledge. In addition, the application of SVAR and PVAR models are major extension to the literature on cross-border oil-price shock studies which has limited its use to unrestricted VAR model among other methodologies. In another dimension, mechanisms of transmission of positive and negative oil price shocks are of interest in our study.

Results show that asymmetric response of major macroeconomic variables continues to hold in selected OECD countries in our model. This is consistent with the literature (Jimenez-Rodriguez and Sanchez, 2005). On the other hand, evidence from South Africa is inconsistent with the literature of oil price shocks in emerging countries. Also, the application of Structural VAR has proven largely inefficient in oil shock studies. This is evident by the findings that proceed from SVAR models which fall short of the expectation of a priori granger-causalities of oil shocks. However, PVAR methodology supports the efficacy of both symmetric and asymmetric nature of oil price shocks. In conclusion, the imposition of identification restrictions may be a barrier for oil-price shock effect measures.

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APPENDIX

Variance decomposition analysis

Table A1: Variance decomposition analysis for the United States

Variables	OIL_t	SOP_t	$NOPI_t$	$ROILPI_t$	$ROILPD_t$	$SOPI_t$	$SOPD_t$
$RGDP_t$							
Q1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Q2	0.502872	0.159929	3.997556	4.534835	2.181663	0.047411	0.640363
Q3	0.760440	0.350110	4.536924	7.403843	2.524649	2.890320	0.724901
Q4	0.827038	0.379392	4.903408	7.987468	2.542273	3.345616	0.718344
$INFCPI_t$							
Q1	29.76396	22.19881	16.59311	4.524980	32.79663	9.511461	23.06031
Q2	31.63968	27.83391	21.98501	12.20967	33.50709	13.19417	27.42549
Q3	31.56920	27.71117	20.82269	9.601880	33.37928	13.41176	27.31045
Q4	31.56140	27.70511	20.24465	10.78815	33.36507	13.39608	27.30809
$INTFED_t$							
Q1	1.295097	0.851977	0.847152	0.573228	1.154674	0.000293	1.826552
Q2	1.567923	0.991900	2.758082	1.377940	1.433813	0.096889	1.887826
Q3	1.597098	0.997421	4.245424	2.918779	1.422200	0.285263	1.875552
Q4	1.599137	0.996493	4.004925	2.829908	1.420805	0.286388	1.875071
$REER_t$							
Q1	8.701138	5.592108	2.072774	3.958370	5.094957	7.443092	2.031715
Q2	9.292855	7.595167	1.901360	4.960649	4.740060	11.34488	2.193630
Q3	9.263283	7.578975	3.732972	5.280349	4.711347	11.48884	2.214486
Q4	9.260214	7.575959	4.521119	6.618138	4.712475	11.78314	2.218375
FDI_t							
Q1	0.056195	0.118760	0.132159	0.001985	0.138681	0.070458	0.157270
Q2	0.431632	1.312215	0.727379	0.358131	0.269079	0.912387	0.888507
Q3	0.429003	1.434255	0.850983	0.352668	0.266333	1.041178	0.874185
Q4	0.431608	1.455978	1.374041	0.818461	0.266122	1.178474	0.872436

Table A2: Variance decomposition analysis for Norway

Variables	OIL_t	SOP_t	$NOPI_t$	$ROILPI_t$	$ROILPD_t$	$SOPI_t$	$SOPD_t$
$RGDP_t$							
Q1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Q2	0.488708	0.515938	2.401702	2.431747	0.003420	0.838141	1.408630
Q3	1.215926	1.221020	6.742566	3.174912	1.129602	0.855015	4.938765
Q4	1.180082	1.219564	8.094784	3.195839	1.440066	1.250688	5.430271
$INFCPI_t$							
Q1	0.647261	1.250892	7.058288	2.081579	0.089862	1.235969	1.322094
Q2	3.289123	5.581102	7.219674	3.783231	0.801680	4.788783	2.858277
Q3	3.207463	5.328003	6.833089	3.809322	1.478650	4.463582	2.852196
Q4	4.303837	6.396262	6.601718	5.774957	1.831419	5.289747	3.846032
$INTDR_t$							
Q1	3.542687	1.629442	1.540249	1.187185	1.739836	0.643832	1.058866
Q2	3.505903	2.307355	1.464515	1.133303	2.589545	1.671992	1.785439
Q3	3.829806	2.276868	1.732859	1.712854	2.817664	1.760200	1.880666
Q4	3.755530	2.227309	1.689582	1.732861	2.705126	2.371652	1.837653
$REER_t$							
Q1	3.717724	6.291079	5.391920	1.357872	4.844920	0.011941	8.069503
Q2	12.40907	15.40411	6.312502	6.899758	11.23782	4.598716	16.39577
Q3	13.65327	17.45140	13.57313	8.484008	11.58729	7.526035	17.02526
Q4	13.94566	17.95024	13.24356	8.413899	12.27659	8.175286	17.46191
FDI_t							
Q1	1.026542	0.313912	0.362114	1.980424	0.210757	1.835125	2.498170
Q2	0.869106	0.457814	1.660613	3.782138	0.493882	5.548609	2.399554
Q3	0.856925	0.738444	12.45558	11.05308	1.624784	12.97786	2.287341
Q4	1.977935	1.098213	15.87010	15.19586	1.457139	14.31916	2.060000

Table A3: Variance decomposition analysis for the South African economy

Variables	OIL_t
$RGDP_t$	
Q1	0.000000
Q2	4.380835
Q3	4.374628
Q4	4.396930
$INFCPI_t$	
Q1	9.384814
Q2	12.94932
Q3	11.72465
Q4	11.45156
$INTTB_t$	
Q1	0.089847
Q2	0.077502
Q3	0.072878
Q4	0.070074
$REER_t$	
Q1	0.324472
Q2	1.623391
Q3	1.588413
Q4	1.534965
FDI_t	
Q1	2.194639
Q2	1.975855
Q3	2.754415
Q4	2.767477