SBP Research Bulletin
Volume 15, Number 1, 2019

Asymmetric Pass Through of Global Oil Prices to Macroeconomic Variables of Pakistan

Kalim Hyder and Syed Qamar Hussain [1]

Abstract: *This study presents a multivariable threshold analysis of global oil price movements for Pakistan's economy. Instead of imposing exogenous thresholds for global oil prices, we apply threshold vector autoregressive approach to identify the thresholds endogenously. On the basis of statistical significance, we identify two thresholds of global oil prices, which define immensely declining, declining and increasing oil prices regimes. The study confirms the existence of asymmetries and nonlinearity among oil price shocks and real effective exchange rate, real interest rate, inflation and output of manufacturing sector. These variables respond differently in terms of magnitude, direction and adjustment period in various regimes. Real effective exchange rate depreciates in response to increase in global oil prices in all the regimes. Real interest rates witnesses decline in the first and third regimes but increases in the second regime. This may be due to intensity of the reaction of the monetary authorities to anchor the inflation expectations. In the second and third regimes, economic activity plummets in response to the increase in global oil prices but witnesses expansion in the first regime, which may be due to the negative real interest rates. Pass through to inflation of global oil prices is positive in the first and third regimes whereas the inflation declines in the second regimes, which may be due to aggressive monetary stance.*

JEL Classification: C19, E37, E52, Q43

Keywords: Multivariate Threshold Models; TVAR; Local Projections; Oil Shocks; Inflation; Real Exchange Rate; Interest Rates; Pakistan

[1] The authors are Senior Economist (kalim.hyder@sbp.org.pk) and Deputy Director (syed.qamar@sbp.org.pk), at the Monetary Policy Department, State Bank of Pakistan, Karachi.

1. Introduction

The hike in crude oil prices during 1970s resulted in stagflation in the oil importing economies that was characterized by declining growth and higher inflation. This garnered the attention of researchers regarding the quantification of the impact of oil price movements on the key macroeconomic variables. Mork et al., (1994), Barsky and Kilian (2004) and Hamilton (2005) examine the impact of oil price shocks on economic activity, trade balances, inflation, exchange rates and other key macroeconomic variables in the oil importing and exporting countries after the pioneer contribution of Hamilton (1983, 1988, 1996). Bruno and Sachs (1982), Hooker (1996), Hamilton (1996) and Brown and Yucel (2002) identify transmission channels through which oil prices impact economic activity. Mory (1993), Lee et al. (2001), Lee and Ni (2002), Cunado and Gracia (2003), and Lardic and Mignon (2006) estimate these theoretically developed channels and quantify the relationship between international oil prices and aggregate economic activity. Further, Chuku (2012), Mordi (2010), Markwardt et.al. (2008), Huang et al. (2005), Bhattacharya and Bhattacharya (2001), Hooker (1999), Sadorsky (1999), Hamilton (1996), Lee et al. (1995), Mork (1989) add value by concluding that the oil price changes have asymmetric impact on economic activity. In this regard, there are four possibilities. The pass through of oil prices to domestic consumer prices and macroeconomic variables could either be linear or nonlinear and symmetric or asymmetric depending upon the structure of the economy. In the case of Pakistan, Afia (2010), Sidra (2011), Khan and Ahmad (2011), Sidra and Abdul (2014), Sultan and Waqas (2014), and Chughtai and Kazmi (2014) quantify the impact of global oil prices on macroeconomic performance of Pakistan. However, these studies assume linear pass through of oil prices in Pakistan. Linearity assumption may lead to misspecification bias if there exists asymmetries and nonlinearities in the pass through of changes in global oil price to domestic economy. Therefore, there is a need to re-examine the pass through of global oil prices to Pakistan's economy with the consideration of asymmetries and nonlinearities. With this motivation, we quantify the impact of oil price movement on key macroeconomic variables.

In the developing countries like Pakistan, governments administered the energy prices to limit the pass through of global oil prices to domestic prices. In the case of massive increases in oil prices, the fiscal burden limits the capacity of the governments to subsidize the consumers. However, small increases in oil prices may be subsidized by the governments depending on fiscal situation and investment priorities. Therefore, there is possibility that intensity of increase in the international oil prices may determine the pass through to the consumer. On the other side, slight decline in the global oil prices may not be passed on to the consumers due to fiscal revenues concerns of the governments but political pressures may demand cut in domestic energy prices in the case of massive decline in international oil prices. The fiscal behaviour regarding administering the domestic energy prices leads to the asymmetries and nonlinearities in the pass through of international oil prices to consumer prices.

Huang et al. (2005), Sadorsky (1999) and Tsay (1998) present the methodology of incorporating asymmetries and nonlinearities in the estimation of pass through of global oil prices by various threshold levels. We adopt their methodology and compute various

threshold levels of global oil price for Pakistan. In doing so, we identify immensely declining growth, declining growth and increasing growth of global oil prices as three statistically significant threshold levels. Further, we quantify pass through of each threshold level to (i) real effective exchange rate, (ii) interest rate, (iii) industrial production and (iv) inflation in Pakistan. The responses of macroeconomic variables to the shocks in global oil prices within each regime is computed by applying local projection procedure of Jordà (2005). The second threshold of declining global oil prices (between -3.4 to -6.6 percent) have no significant impact on the inflation in consumer prices, however, rest of the two threshold levels of immensely declining (below -6.6 percent) and increasing (above -3.4 percent) global oil prices have significant impact on inflation. All the threshold levels of global oil prices have symmetric impact on real effective exchange rate and industrial production. The monetary authority increases interest rates in the increasing oil prices regime.

After presenting the motivation of the study in the introduction, next section discusses the literature review. Global oil prices and Pakistan's energy scenario are discussed in third section. Fourth and fifth sections present theoretical framework and methodology of the paper. Data sources, variable construction and stationarity of data are discussed in sixth section. The discussion on the results of estimation are presented in seventh section. Final section concludes the paper.

2. Literature Review

Since the largest oil price shocks of the century in 1970s, Hamilton (1983, 1988, 1996) initiates the research on impact of oil prices on economic activity. After his pioneering contribution, Mork *e. al.*, (1994), Barsky and Kilian (2004) and Hamilton (2005) quantify the impact of oil price shocks on economic activity, trade balances, inflation, exchange rates and other key macroeconomic variables in oil importing and exporting countries. Bruno and Sachs (1982), Hooker (1996), Hamilton (1996) and Brown and Yucel (2002) develop transmission channels of pass through of international oil prices to domestic economies. Mory (1993), Lee *e. al.* (2001), Lee and Ni (2002), Cunado and Gracia (2003), and Lardic and Mignon (2006) estimate these theoretical channels. Further, Chuku (2012), Mordi (2010), Markwardt et.al (2008), Huang et al. (2005), Bhattacharya and Bhattacharya (2001), Hooker (1999), Sadorsky (1999), Hamilton (1996), Lee *et. al.* (1995), Mork (1989) explore the asymmetric impact of oil price changes on economic activity by considering exogenous thresholds.

Hamilton (1983) finds strong correlation between the changes in crude oil prices and some, if not all, of the U.S. economic recessions during 1948-1972. Mork (1989) extends the study of Hamilton (1983) and investigates if Hamilton's results hold in periods of price decline as well. He confirms negative correlation of oil price with economic activity in the case of increase in oil prices and finds no correlation between U.S. economic activity and oil price declines. He validates the asymmetric pass through of oil prices to economic activity. Hooker (1999) estimates the consequences of oil price changes on U.S. inflation by using

Phillips curve framework. He concludes that the oil price changes contribute to core inflation substantially before 1980, however, after that there is negligible pass-through.

Leduc and Sill (2004), Huang *et al*. (2005) and Cologni and Manera (2008) examine the role of macroeconomic policies in coping with the oil price shock. They explore the possibilities regarding the weakening of the association between oil price variation and aggregate economic activity. Given that the deceleration in economic activity and rise in inflation are two unavoidable impacts of oil price shocks, the studies of this strand are looking for a befitting monetary policy that intend to cope with the oil supply shock. Although there are arguments if oil shocks are the major hinder for economic slowdown, it is broadly acknowledged that oil price shocks partially transmits into inflation (Bohi, 1989).

IMF (2000) ascertains that persistent oil prices increase builds inflationary pressures and can shrink the global demand and production because the reduction in aggregate demand of oil importing economies offsets the rise witnessed in oil exporting countries. Moreover, the disruption depends upon the status of the business cycle, response of macroeconomic policies and responsiveness of the economies. In order to handle the oil price shock , IMF (2000) suggest that monetary policy formulation should minimize the second round impact of oil price increases, prevailing fiscal policies should stay unchanged and greater flexibility of labour markets.

The focus towards nonlinearity and asymmetry of oil price shocks in the oil exporting and importing countries become more important after the large fluctuations of oil prices during 1980s. Mork (1989), Lee *et al.* (1995), Hamilton (1996), Sadorsky (1999), Bhattacharya and Bhattacharya (2001), Markwardt *et. al.* (2008), Mordi (2010), Chuku (2012) differentiate the regimes of oil price shocks based on positive and negative changes in oil prices to examine the asymmetry. They conclude that rising oil prices are the primary cause of inflation whereas declining oil prices have no favorable impact on price levels. Furthermore, it is not necessary that every rise in oil prices, whether a little or significant, may have a similar impact on economic variables. Therefore, the pass through of oil prices varies from country to country depending on the market characteristics and policy responses in each country. However, these studies consider the decline and increase of oil prices as two different regimes exogenously whereas threshold levels to which domestic variables react need to be derived endogenously. Huang et al. (2005) address this issue by using Tsay (1998) approach and identify different thresholds of oil price changes for US, Japan and Canada.

In the case of Pakistan, Afia (2010), Sidra (2011) and Sidra and Abdul (2014) and Chughtai and Kazmi (2014) use simple causality analysis and linear specifications to quantify the impact of oil price shocks to macroeconomic variables of Pakistan. Khan and Ahmad (2011) derive the exogenous threshold by considering the increase and decline of global oil prices. Afia (2010) examines the impact of oil price on real effective exchange rate, debt–GDP ratio, real foreign exchange reserves and economic growth of Pakistan. She considers an IS function for an open economy, Phillips curve and monetary policy reaction function. Her results suggest a strong association between oil prices and output. She considers quadratic specification to isolate the impact of slight and large movements in oil prices on the

macroeconomic variables. Sidra (2011) and Sidra and Abdul (2014) perform multivariate analysis and conclude that the oil prices changes significantly impact balance of payment in Pakistan. Sultan and Waqas (2014) conclude that oil prices have a minimum impact on the economic activity in the short run and a significant impact in the long term by applying Granger Causality in error correction model. Chughtai and Kazmi (2014) conclude that oil prices significantly affect the economic growth of Pakistan.

Khan and Ahmad (2011) examine the macroeconomic effects of global food and oil prices shocks to inflation, interest rate, money balances, output and real effective exchange rate of Pakistan. They find that the oil price shocks negatively affect the industrial production, positively affect the inflation and appreciates real effective exchange rate symmetrically but have an asymmetric effect on the short-term interest rates.

In the case of Pakistan, there is a lack of studies that are geared towards pinning down endogenous threshold. Therefore, considering the oil price changes as a threshold variable in this paper, we perform the multivariate threshold analysis of Pakistan. We follow the methodology of Huang et al. (2005) for testing the nonlinearity and identification of thresholds.

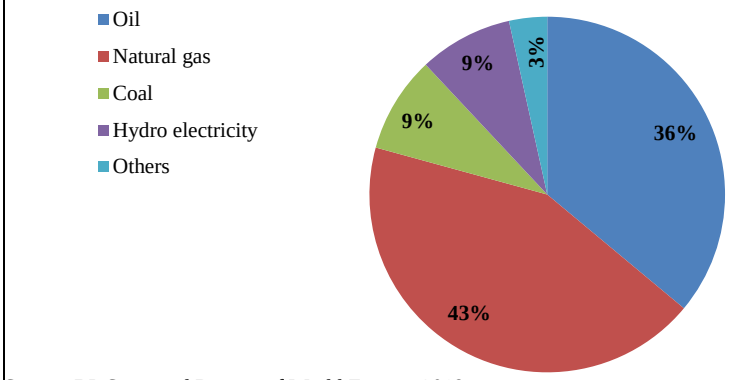
3. Global Oil Prices and Pakistan's Energy scenario

In Pakistan's energy mix, though the major share in total energy consumption is of indigenous natural gas, oil still has a large share of around (36%) in the total primary energy consumption (Figure 1). The domestic production of crude oil remains well short of the demand. As much as around 70 percent (average of FY06-FY15) of the total crude oil processed by refineries is imported from abroad. Due to this fact, Pakistan's economy is vulnerable to global oil price shock like every other oil importing economy.

Figure 2 presents the global oil prices, policy rate and domestic inflation. The unchanged policy rate during 1980-1993 indicate that the monetary policy was not responding to the pass through of global oil prices to the domestic economy. After that, monetary authority started to control inflation through monetary targeting till 2002. In the last two decades, the interest rates are setting under monetary policy help in anchoring of inflation expectations and control the pass through of oil prices to the domestic economy.

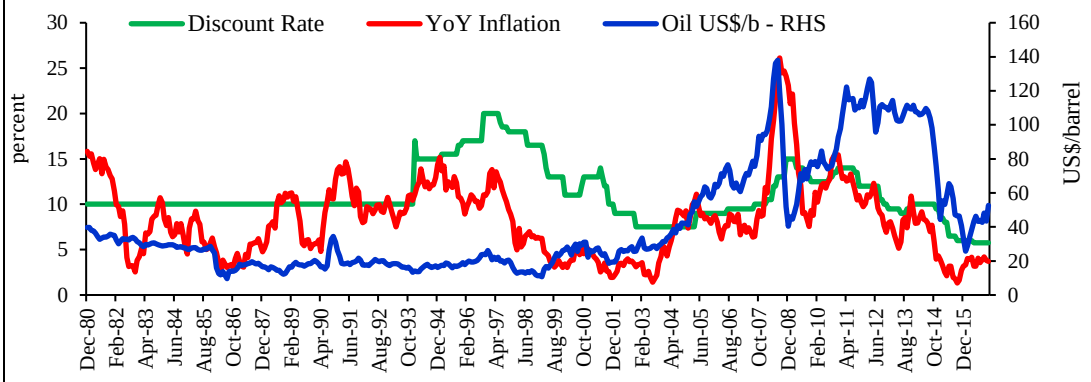
Figure 3 presents dynamic correlations of global oil prices with the lead of domestic inflation in consumer prices in Pakistan. The highest pass through of growth of global oil prices is observed after six months in the inflation. Bernanke (2013) mentions that the immediate impact of global oil prices on the domestic consumer prices is due to the expectation channel whereas the increase in marginal costs and consumer prices require adjustment lag.

Figure 1: Pakistan's Energy Consumption in 2017 (share)



Source: BP Statistical Review of World Energy, 2019

Figure 2: Historical Analysis of Global Oil Prices, Discount rate and Inflation



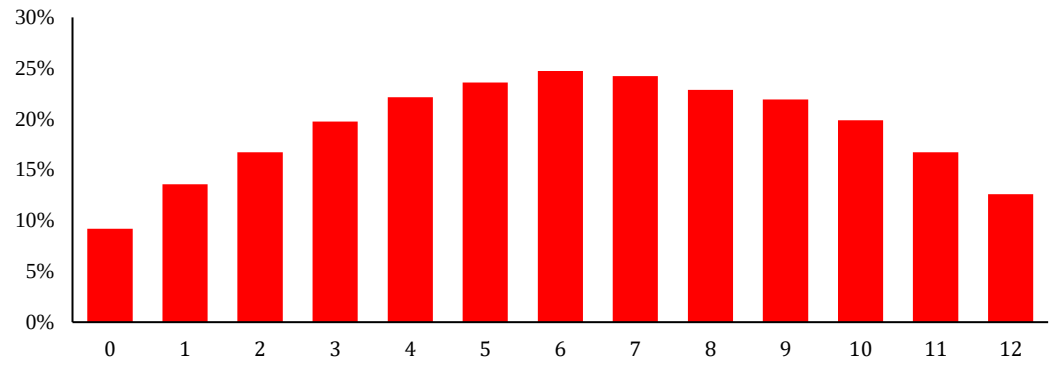
Source: Bloomberg, SBP

Theoretical Framework

There are three main transmission channels (fiscal, prices and trade) of pass through of global oil prices. In developing economies, governments usually intervene through administered prices to limit the pass through of global oil price increases to domestic energy prices. Some prefer to intervene through complete subsidizing the oil price increase, which results in minimum pass through. Whereas some governments do not afford higher subsidies due to predetermined budgets. Hence these governments adopt market based pricing mechanism, which results in complete pass through of global oil prices. Another category of government subsidize a proportion of the changes in oil price, which results in incomplete pass through to domestic prices. Therefore, the fiscal priority of subsidizing the domestic consumers determines the level of pass through to the economy.

However, the government decision to partially subsidize the rampant increase in global oil prices have two implications on the fiscal account of the economy. Firstly, the indirect taxes would be increased for improving the government revenues and secondly the provision of subsidies increases the government expenditures, which increase public debt and squeezes other government spending. Generally, this unforeseen additional expenditure enhances the government fiscal deficit. Bacon and Kojima (2006) present that the countries, which administered the fuel prices and adopt subsidizing strategy, witness strong retaliation from public when the prices adjust upwards. Indonesia, Nigeria, and Venezuela has faced violent protests against the hike in fuel prices. Several governments have tried to reduce subsidies since 2003 but only a few manage it smoothly. Such subsidies are, helpful for the poor, but cost a lot to the society as a whole and to the governments as well. These apprehensions lead to the intervention of governments and delayed incomplete pass through of global oil prices.

Figure 3: Dynamic Correlation of Global Oil and Domestic Consumer Prices



Source: Authors' calculations

On the other hand, once the international oil prices elevate the domestic oil demand may go down and hence the total volume of oil imports decline with a higher quantum impact. However, in the case of inelastic oil demand, the price impact becomes higher and the total volume of oil imports is increased. Consequently, an economy is more likely to face trade deficit having a colossal burden on import payments due to which balance of payment get out of order and deterioration in the level of reserves is clearly reflected in the sharp depreciation in exchange rate. Such considerable depreciation in currency leads to higher inflation.

Bernanke (2013) mentions that oil price impacts the inflation from two perspectives. Firstly, oil price changes immediately pass through to the domestic prices due to expectation formation of the agents. Secondly, considerable lag is involved in the pass through of oil prices, which is dependent on the structure of the economy and fiscal behaviour. In terms of emerging economies, Alom (2011) concludes that oil price increase is detrimental for the industrial output, and a decline in industrial output may result in a rise in inflation. Reserve Bank of India (2011) estimates that a 10 percent increase in global crude prices, may directly increase the overall inflation by 1 percentage point, if fully passed through to domestic

prices. While the total impact may be higher as input cost increases overtime and could translate to higher output prices. Jamali et. al. (2011) show that a rise in oil prices translates in to higher cost of production and reduces the industrial production, which indirectly increases inflation. In addition, the prices of imported goods and petroleum products also increase directly. The likely rise in headline and core inflation due to the oil price increases may trigger the tightening of monetary policy (Hunt, Isard and Laxton 2001). In a developing country like India, if the oil price increase transmits without any hindrance, it may increase the general price level directly through the rise in domestic fuel prices and also indirectly because of increase in costs of production of goods (Bhanumurthy et. al. (2012).

Threshold models have become popular due to the consideration of nonlinear and asymmetric behaviour among variables. Nonlinear specifications may also be adhere for data generation processes due to the predictability in economic and financial data. Stock returns for instance have a high correlation during the low volatility periods as compared to the times of high volatility. Franses and Dijk (2000) suggest a similar behavior for exchange rate, which is kept within predetermined limits. Therefore, we adopt threshold model for computing the nonlinear and asymmetric pass through of oil prices to domestic economy.

4. Methodology

Sadorsky (1999) investigates the nonlinearity between oil price changes and economic activities through a two-regime model. However, his study is based on exogenous threshold that defines arbitrary regimes of increase and decrease in oil prices, without testing for the need of non-linearity. Huang *et. al.* (2005) argue that it is not necessary that slight movements in oil prices possibly will have an impact on economic variables and it may require a bigger change to respond. Therefore, they follow Tsay (1998) approach in which the nonlinearity among the variables is tested on the basis of statistical significance.

We adopt the methodology of Huang *et. al.* (2005) to test the nonlinearity in the impact of oil price changes to domestic variables. We use statistical approach to identify the threshold levels and regimes of significant oil price movements. After the identification process, multivariate threshold model is used to examine the responses real effective exchange rate, real interest rate, industrial production and inflation to the impulses in the various identified thresholds of international oil price changes.

Tsay (1998) provides the methodology for the threshold models. He gives the representation as follows;

Consider a $l-$ dimensional time series, $y_t = (y_{1,t}, \dots\dots\dots, y_{l,t})`$ and $m-$ dimensional exogenous variables, $x_t = (x_{1,t}, \dots\dots\dots, x_{m,t})`$. Let $-\infty = r_0 < r_1 < \dots < r_{s-1} < r = \infty$, subsequently, y_t follows a multivariate threshold model with a threshold variable z_t and a delay d if it satisfies $-\infty = r_0 < r_1 < \dots < r_{s-1} < r = \infty$.

$$y_t = c_a + \sum_{i=1}^{e} \emptyset_i^{(j)} y_{t-1} + \sum_{i=1}^{qf} \beta_i^{(j)} x_{t-1} + \varepsilon_t^{(j)} \quad \text{if} \quad r_{a-1} < z_{t-d} \leq r_a \quad (1)$$

Where, a $= 1, \ldots, s$, c_a are constant vectors, e and f are non-negative integers. The threshold variable z_t is assumed stationary and having a continuous distribution. Within the threshold space z_{t-d}, the above model is a piecewise linear model and has s regimes, but it is nonlinear in time when $s > 1$.

The monthly changes in the log of oil price is consider as threshold variable to confirm the existence of nonlinearity in the multivariate VAR model. With the confirmation of nonlinear relationship among variables, it is important to distinguish the regimes based on the threshold levels of oil price. This identification of the regime will help in recording the responses of domestic variables to the shocks in thresholds of oil price changes. The linearity is tested by extending the linearity test of Hansen (1999) to multivariate specifications as proposed by Lo and Zivot (2001). Hansen (1999) introduces F-test that compares the residual sum of square (SSR) in the case of linear models and Lo and Zivot (2001) apply the Likelihood Ratio (LR) test to compare the covariance matrix computed in the case of multivariate models.

$$LR_{ij} = T(\ln(det \sum i) - \ln(\det \sum j)) \qquad (2)$$

$\sum i$ is the estimated covariance matrix of the model with i regimes and $i-1$ thresholds, Threshold Vector autoregressive likelihood ratio (TVAR.LR) test is used to confirm the presence of nonlinearity in VAR model and to identify three significant regimes.

The VAR of global oil prices, real effective exchange rate, policy rate, industrial production and inflation can be specified as follows;

$$\begin{bmatrix} OIL_t \\ E_t \\ R_t \\ Ym_t \\ Infm_t \end{bmatrix} = \begin{bmatrix} C_{OIL} \\ C_E \\ C_R \\ C_{YM} \\ C_{Infm} \end{bmatrix} + \begin{bmatrix} B_{OIL,OIL}(L) & B_{OIL,E}(L) & B_{OIL,R}(L) & B_{OIL,YM}(L) & B_{OIL,Infm}(L) \\ B_{E,OIL}(L) & B_{E,E}(L) & B_{E,R}(L) & B_{E,YM}(L) & B_{E,Infm}(L) \\ B_{R,OIL}(L) & B_{R,E}(L) & B_{R,R}(L) & B_{R,YM}(L) & B_{R,Infm}(L) \\ B_{YM,OIL}(L) & B_{YM,E}(L) & B_{YM,R}(L) & B_{YM,YM}(L) & B_{YM,Infm}(L) \\ B_{Infm,OIL}(L) & B_{Infm,E}(L) & B_{Infm,R}(L) & B_{Infm,YM}(L) & B_{Infm,Infm}(L) \end{bmatrix} \begin{bmatrix} OIL_{t-1} \\ E_{t-1} \\ R_{t-1} \\ YM_{t-1} \\ Infm_{t-1} \end{bmatrix} + \begin{bmatrix} e_{OILt} \\ e_{Et} \\ e_{Rt} \\ e_{YMt} \\ e_{Infmt} \end{bmatrix}$$

5. Data sources, Variables and stationarity tests

Pass through of global oil prices to inflation starts immediately by inflation expectation formation, therefore, it becomes prime concern for policy makers at central banks and require policy actions by changing policy rate to respond to such changes of inflation expectations. Krugman (1983) and Golub (1983) argue that an oil prices may also lead to changes in exchange rates. Any rise in oil prices worsens the current account deficit of an oil importing country with an inelastic demand. Therefore, changes in international oil prices impact the inflation, exchange rate and interest rates in the economy. In this study, we estimate the impact of global crude oil prices on real effective exchange rate (REER), consumer price index (CPI), policy rate and large scale manufacturing index (LSM, an indicator of economic activity). Data on monthly frequency from January 1980 to January 2017 of these variables is collected. For global crude oil price, Arab Gulf and Dubai Fateh average monthly crude price (US$/barrel) is taken from the Bloomberg. Haver Analytics is the source of real effective exchange rate (REER) and consumer price index (CPI). The data on discount rate and spliced series of LSM (2005-06=100) is taken from statistical appendix

of various issues of Annual report of State Bank of Pakistan. All the variables except policy rate are logarithmic transformed. Policy rate is converted in to real by adjusting it with lead of CPI inflation.

In order to test the time series properties of the data, we perform unit root tests (Table 2). The results of Augmented Dickey–Fuller (ADF) and Phillip-Perron (PP) tests indicate that all the variables are stationary at level with constant. To be further sure, we also checked stationarity by using Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test that confirms the stationarity of the variables.

Table 2: Unit Root Tests

		Monthly growth of global oil prices (OIL)	Monthly growth of REER (E)	Monthly changes in real policy rate (R)	Monthly growth of production LSM (YM)	Monthly growth in Consumer prices (P)
a)Augmented Dickey-Fuller (ADF) - Null Hypothesis: the variable has a unit root						
With Constant	t-Statistic	-10.00	-10.39	-2.40	-4.14	-3.19
	Prob.	0.00	0.00	0.14	0.00	0.02
b) Phillip-Perron (PP) - Null Hypothesis: the variable has a unit root						
With Constant	t-Statistic	-392.89	-15.07	-3.29	-28.34	-17.72
	Prob.	0.00	0.00	0.01	0.00	0.00
c) Kwiatkowski-Phillips-Schmidt-Shin (KPSS) - Null Hypothesis: the variable is stationary						
With Constant	t-Statistic	0.10	0.63	0.23	0.07	0.12

Notes: Lag Length based on AIC, Probability based on MacKinnon (1996) one-sided p-values for ADF and PP tests. : Probability based on Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

6. Results

This section starts with the discussion on the identification of threshold levels of global oil price movements. We identify tow thresholds that lead to three regimes of immensely declining, declining and increasing oil prices. Finally, within each regime, the impact of movements in global oil prices on the domestic variables is discussed.

7.1 Threshold identification process

First step is the search for the statistical significant threshold values of global oil price changes that will determine the regimes of oil price movements. There will be i regimes in the case of i-1 thresholds, which are statistically significant. We apply threshold Vector Autoregressive Likelihood Ratio (TVAR-LR) test to find statistical significant levels of thresholds. Hansen (1999) introduces the grid search process of minimizing the sum of squared of residuals (SSR) for the identification of the threshold in linear models. The F-test is applied to the SSR of different models for confirming the statistical significance of

identified threshold in the linear threshold models. Lo and Zivot (2001) extend this process to the nonlinear models and suggest the comparison of the covariance matrix of different model with Likelihood Ratio (LR) test.

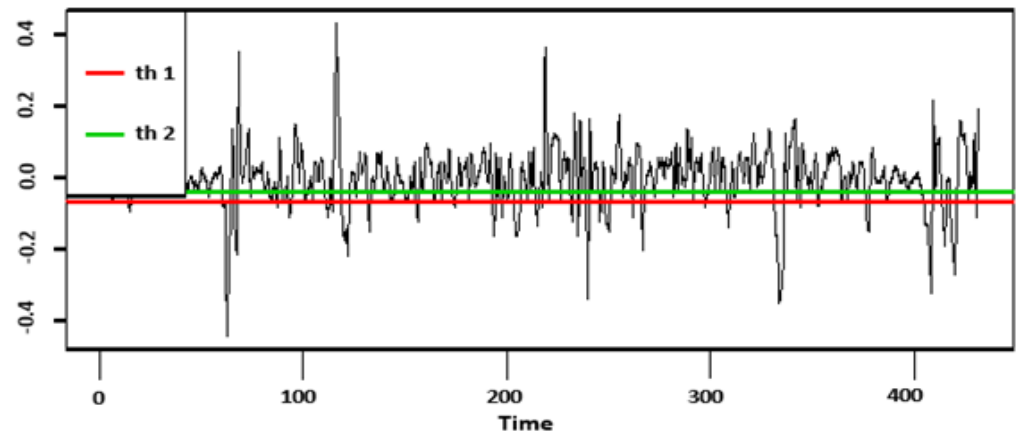
Table 3: Threshold identification and Regime determination

	1vs2	1vs3	2vs3
Threshold VAR likelihood ratio Test	916.49	1496.92	897.30
	(0.00)	(0.00)	(0.00)

Test 1vs2: Linear VAR versus 1 threshold VAR,
Test 1vs3: Linear VAR versus 2 threshold VAR
Test 2vs3: 1 threshold TAR versus 2 threshold VAR
Probabilities are given in the parenthesis.

The LR test is applied on the covariance matrix of simple VAR and TVAR models, which yield the statistically significant regimes and first threshold. The conditional search with one iteration is performed to identify the statistical significance of other regime and identification of second threshold. We identify two statistical significant threshold levels that define three regimes of the global oil price movements. Growth in global oil prices of -6.6 and -3.4 percent are the statistically significant threshold levels. Therefore, immensely declining growth of oil prices of lower than -6.6 percent is the first regime, declining growth of global oil prices lower than -3.4 percent and higher than -6.6 percent is the second regime and increasing growth of oil prices above -3.4 percent is the third regime. The growth in global oil prices is plotted against time in Figure 4. Two parallel lines are the statistically significant threshold levels (-6.6 and -3.4 percent) that distribute the data into three regimes.

Figure 4: Regimes and Threshold of Global oil price movements



After the identification of regimes and thresholds of movements in global oil prices from the TVAR-LR test, we estimate the relationships of global oil prices with domestic macroeconomic variables. For this purpose, we estimate the local projections VAR and derive the responses of the macroeconomic variable to shocks in each threshold of global oil prices.

7.2 Local Projections based Impulses

The Impulse Response Functions (IRF) measure responses of domestic variables to the shocks in various threshold levels of growth in global oil prices. These IRF may yield biased and inconsistent results if VAR procedure is unable to capture the underlying data generating process (DGP). Therefore, we apply local projection method of Jordà (2005), which is not sensitive to misspecification in the estimation of an unknown true multivariate system. The impulse responses in the simple VAR extrapolate the higher distance horizons whereas the local projections VAR estimate at each period of interest. Simplicity of estimation, more robust to misspecification, analytic inference and accommodative to highly nonlinear and flexible specifications are the main advantages of local projections

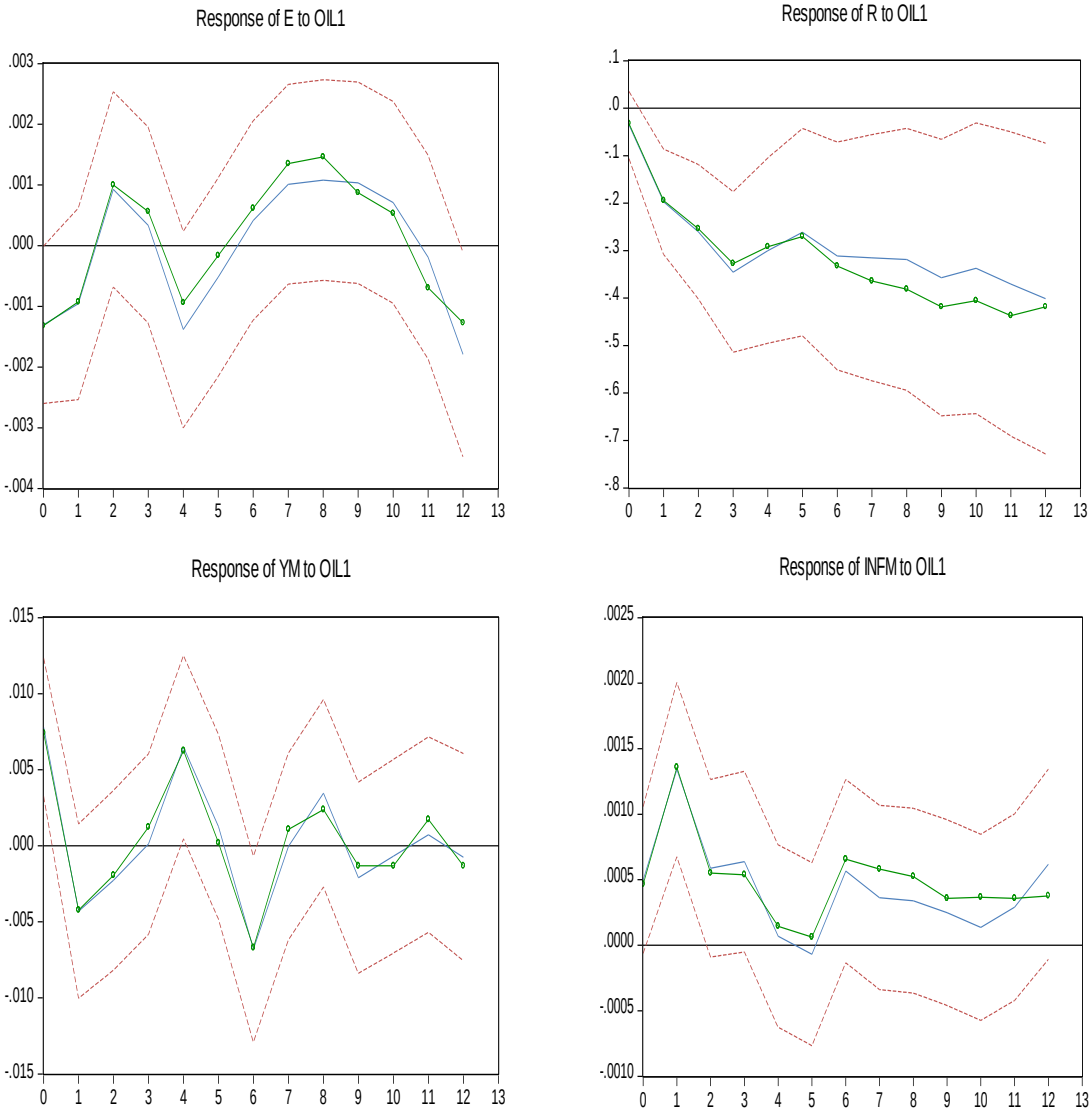
One standard deviation shock is introduced in innovations of threshold levels of global oil price changes and the responses of domestic variables are presented in the Figures 5-7. In all the regimes of global oil prices, real effective exchange rate witnesses depreciation in response to a shock in global oil prices. However, the depreciations of the real effective exchange rate are more pronounced and significant in the third regime of increasing growth in global oil prices. In the first regime of immensely declining global oil prices, real interest rate declines significantly in response to the a shock in global oil prices. Real interest rate increases in the second regime of slight movements in the global oil prices and decline slightly in the third regime of increasing global oil prices. The production of large scale manufacturing sector – an indicator of economic activity, record favorable growth in response to a shock in global oil prices in the immensely declining regime. However, economic activity plummets in the rest of the regimes of global oil price changes. Finally, the core macroeconomic variable of inflation in consumer prices witness positive growth in the case of exogenous shock in global oil prices and immensely declining oil prices regimes. Whereas the inflation declined in second regime of slight movements in the global oil prices.

The responses of the domestic macroeconomic variables to the shocks in the global oil prices vary across regimes confirming the existence of asymmetries. In the first regimes of immensely declining global oil prices (less than -6.6 percent), exogenous increase in the oil prices result in higher inflation in consumer prices which is an indication that government passes on the burden to the consumers. However, central bank may not response to the increase in global oil prices in this regime, which reduces the real interest rates in the economy. This may cause favorable impact on the economic activity. Therefore, active response of fiscal authorities and sluggish response of the monetary authorities can be inferred from the impulse response analysis in the first regime.

Central bank respond aggressively to the oil price increases in the second regime (monthly growth of oil prices are between -6.6 and -3.4 percent) that results in higher real interest rates, contracting economic activity and declining inflation. Therefore, the inflation in consumer prices observed decline that may be due to sluggish response of the fiscal authorities and well anchored inflation expectations. In the third regime of monthly growth of above -3.4 percent in global oil prices, real interest rates decline slightly indicating

Regime 1: Immensely declining growth of oil prices

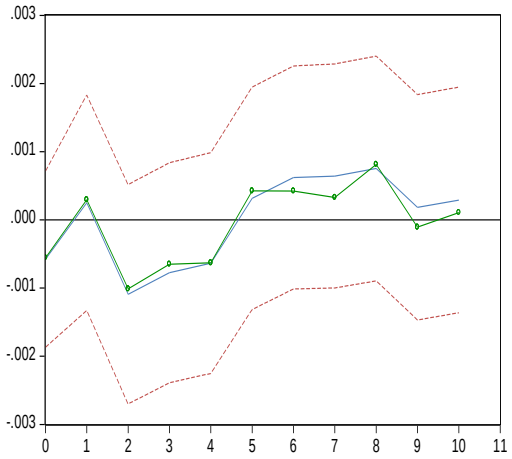
Global oil price witnesses monthly growth below -6.6 percent



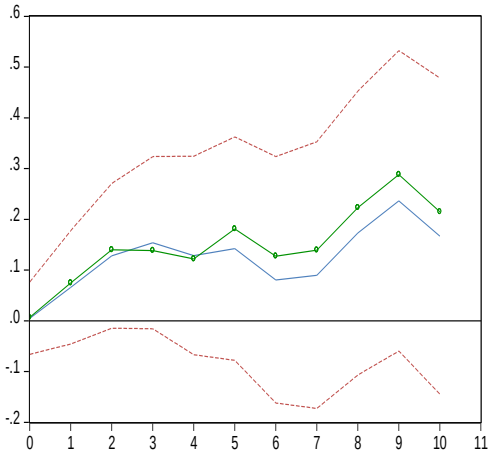
Regime 2: Declining growth of oil prices

Global oil price witnesses monthly growth above -6.6 and below -3.4 percent

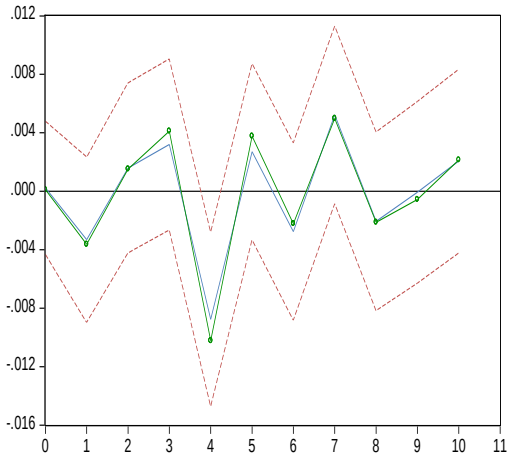
Response of E to OIL2



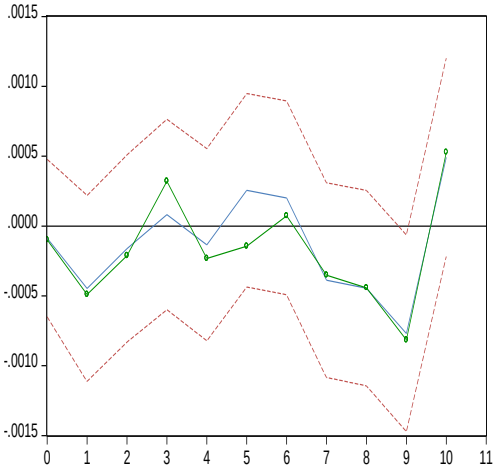
Response of R to OIL2



Response of YM to OIL2

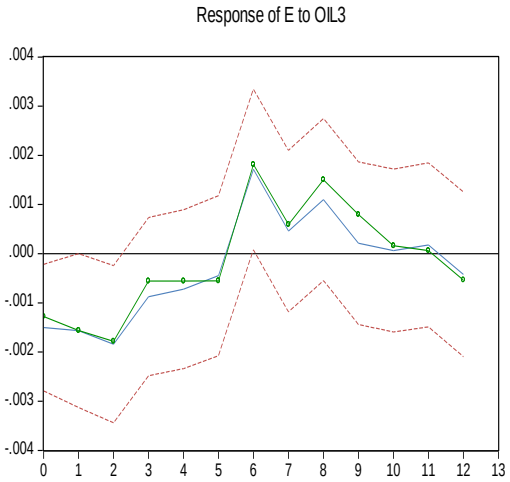


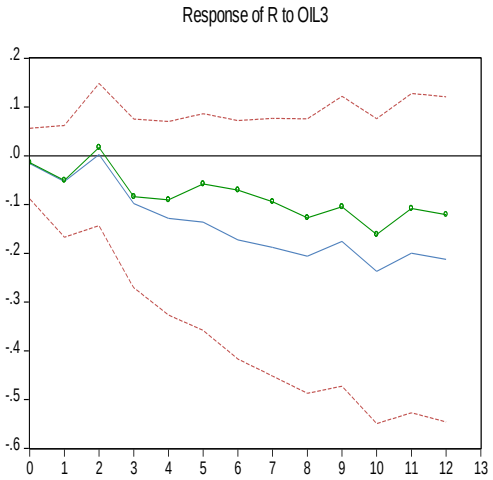
Response of INFM to OIL2

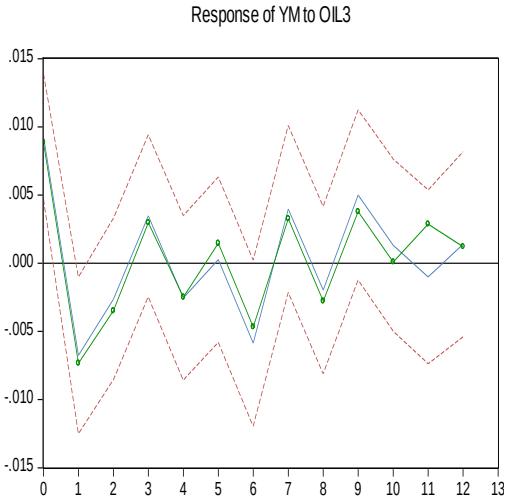


Regime 3: Increasing growth of oil prices

Global oil price witnesses monthly growth above -3.4 percent







sluggish response of the monetary authorities. This results in positive growth in the consumer prices and contraction in economic activity.

Despite asymmetries in the magnitude and directions of the responses of macroeconomic variables to the shocks in various threshold of oil prices, there are also differences in the period of pass through of oil prices to the macroeconomic variables across thresholds. Sadorsky (1999) finds that the economy responds to a favourable oil price change with a lag. In the case of Pakistan, inflation responds to the increase in global oil prices immediately in first and second regime whereas inflation takes three months to responds to the oil price shock in the third regime. The response of the real effective exchange rate is similar in the first and second regime. Most asymmetric responses are observed in the case of real interest rate and economic activity.

7. Conclusion

This study confirms the existence of nonlinearity and asymmetries in the pass through of global oil price shocks on macroeconomic variables of Pakistan. There are two type of differences in the responses of macroeconomic variables to the shocks in various thresholds of global oil prices. Firstly, there is asymmetries in terms of direction and magnitude of the responses of the macroeconomic variables. Secondly, there are differences in the adjustment period of pass through of oil prices to the macroeconomic variables. The adjustment period is lesser in the regimes of declining global oil prices relative to the third regime of higher than -3.4 growth in the global oil prices. Real effective exchange rate depreciates in response to increase in the growth of global oil prices in all the regimes. Real interest rates witnesses decline in the first and third regimes but increases in the second regime. This may be due to intensity of the reaction of the monetary authorities to the anchor inflation expectations. In the second and third regimes, economic activity plummet in response of increase in global oil prices but witnesses expansion in the first regime, which may be due to the negative real interest rates. Pass through to inflation of global oil prices is positive in the first and third regimes whereas the inflation declines in the second regimes, which may be due to aggressive monetary stance.

References

Adeniyi, O. A., Oyinlola, M. A., & Omisakin, O. A. (2011). Oil price shocks and economic growth in Nigeria: Are thresholds important? *OPEC Energy Review,* 35(4), 308-333.

Al-Mulali, U., & Sab, C. N. B. C. (2013). The impact of oil shocks on China's GDP: A time series analysis. *OPEC Energy Review,* 3, 20-29.

Alom, F.,Ward, B. D., & Hu, B., (2013). Macroeconomic effects of world oil and food price shocks in Asia and Pacific economies: Application of SVAR models. *OPEC Energy Review*, 9, 327-372.

Barsky, R., Kilian, L. (2004). Oil and the macro economy since the 1970s. *National Bureau of Economic Research, Working Paper* 10855, various pages.

Basnet, H. C., & Upadhyaya, K. P. (2015). Impact of oil price shocks on output, inflation and the real exchange rate: Evidence from selected ASEAN countries. *Applied Economics,* 47(29), 3078–3091.

Bernanke, B. S. (2013). Communication and Monetary Policy: *a speech at the National Economists Club Annual Dinner,* Herbert Stein Memorial Lecture, Washington, DC, November 19, 2013 (No. 611).

Bhattacharya, K., & Bhattacharyya, I. (2001). Impact of increase in oil prices on inflation and output in India. *Economic and Political Weekly,* 36(51), 4735-4741.

Colongni, A., & Manera, M. (2008). Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries. *Energy Economics,* 30 (30), 856-888.

Cunado, J., & Garcia, F. (2003). Do oil price shocks matter? Evidence for some European countries. *Energy Economics,* 25(2), 137-154.

Cunado, J., Jo, S., & de Gracia, F. P. (2015). Macroeconomic impacts of oil price shocks in Asian economies. *Energy Policy,* 86, 867–879.

Eryiğit, M., (2012). The dynamical relationship between oil price shocks and selected macroeconomic variables in Turkey. *Economic Research,* 25 (2), 263-276.

Farzanegan, R. M., & Markwardt, G. (2009). The effects of oil price shocks on the Iranian economy. *Energy Economics,* 31 (1), 134-151.

Ghalayini. L. (2011). The interaction between oil price and economic growth. *Review of Middle East Economics and Finance,* 127-141.

Hamilton, J. D. (1983). Oil and the macro economy since World War II. *Journal of Political Economy,* 91(2), 228-248.

Hamilton, J. D. (1988). A Neoclassical model of unemployment and the business cycle. *Journal of Political Economy,* 96(3), 593-617.

Hamilton, J. D. (2005). Oil and the Macro economy. *Palgrave Dictionary of Economics*, University of California, San Diego, various pages.

Hansen (1999) Testing for linearity, *Journal of Economic Surveys,* 13(5), 551-576.

Herrera, A. M., & Lagalo, L. G. (2015). Asymmetries in the response of economic activity to oil price increases and decreases? *Journal of International Money and Finance,* 50, 108-133.

Hooker, M. A. (1999). Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime. *Federal Reserve Board,* Washington, various pages.

Hooker, M. A. (2002). Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime. *Journal of Money, Credit and Banking,* 34(2), 540-561.

Huang, B., Hwang, M. J., & Peng, H. (2005). The asymmetry of the impact of oil price shocks on economic activities: An application of the multivariate threshold model. *Energy Economics,* 27(3), 455-476.

Idrisov. G., Kazakova, M., & Polbin, A. (2015). A theoretical interpretation of the oil prices impact on economic growth in contemporary Russia. *Russian Journal of Economics,* 1, 257-272.

Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review*, 95(1), 161-182.

Khan, M.A., & Ayaz, A. (2010). Macroeconomic effects of global food and oil price shocks to the Pakistan economy: A structural Vector Autoregressive (SVAR) Analysis. *The Pakistan Development Review,* 50(4), 491-511.

Khan, M. A., & Ayaz, A. (2014). Revisiting macroeconomic effects of oil and food price shocks to Pakistan economy: A structural Vector Autoregressive (SVAR) Analysis. *OPEC Energy Review,* 6, 184-215.

Kose, N., & Baimaganbetov, S. (2015). The asymmetric impact of oil price shocks on Kazakhstan macroeconomic dynamics: A structural vector autoregression approach. *International Journal of Energy Economics and Policy,* 5(4), 1058-1064.

Lee, J., & Song, J. (2012). Oil and small open macro economy: A case of Korea. *Global Economic Review,* Vol. 41(1), 77-95.

Lippi, F., & Nobili, A. (2012). Oil and the macro economy: A quantitative structural analysis. *Journal of the European Economic Association,* 10(5):1059–1083.

Lo, M. C., & Zivot, E. (2001). Threshold cointegration and nonlinear adjustment to the law of one price. *Macroeconomic Dynamics*, 5(4), 533-576.

Malik, A. (2007). How Pakistan is coping with the challenge of high oil prices. *The Pakistan Development Review*, 46(4), 551–575.

Montoro, C.(2010). Oil shocks and optimal monetary policy. *BIS working paper no. 307*, various pages.

Mordi, X. N. O., & Adebiyi, M. A. (2010). The asymmetric effects of oil price shocks on output and prices in Nigeria using a structural VAR model. *Central bank of Nigeria, Economic and Financial Review*, 48(1), 1-32.

Mork, K. A. (1989). Oil and the macro economy when prices go up and down: An extension of Hamilton's results. *Journal of Political Economy*, 97(3), 740-744.

Mork, K. A., Olsen, O., & Mysen, H. T. (1994). Macroeconomic responses to oil price increases and decreases in seven OECD countries. *The Energy Journal*, 15(4), 19-36.

Mory, J. F. (1993). Oil prices and economic activity: Is the relationship symmetric? *The Energy Journal*, 14(4), 151-161.

Natal, J. M. (2012). Monetary policy response to oil price shocks. *Journal of Money, Credit and Banking*, 44(1), 53-101.

Nazir, S., & Qayyum, A. (2014). Impact of oil price and shocks on economic growth of Pakistan: Multivariate analysis. *MPRA*, various pages.

Rafiq, S., Sgro, P., & Apergis, N. (2016). Asymmetric oil shocks and external balances of major oil exporting and importing countries. *Energy Economics*, 56, 42-50.

Rahman, S., & Serletis, A. (2010). The asymmetric effects of oil price and monetary policy shocks: A nonlinear VAR approach. *Energy Economics*, 32 (6), 1460-1466.

Salah A., & Nusair, S. A. (2016). The effects of oil price shocks on the economies of the Gulf Co-operation Council countries: Nonlinear analysis. *Energy Economics*, 91, 256-267.

Shafique, M. J. (2016). Plunging crude oil prices and its effect on inflation in Pakistan. *Journal of Energy Technologies and Policy*, 6(10), 36-41.

Tang, W., Wu, L., & Zhang, Z. (2010). Oil price shocks and their short-and long-term effects on the Chinese economy. *Energy Economics*, *32*, S3-S14.

Tsay, R. S. (1998). Testing and modeling multivariate threshold models. *Journal of the American StatisticalAssociation*,93(443),1188-1202.