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Macroeconomic Impacts of External Shocks on Economy: Recursive Vector Autoregressive (RVAR) Analysis

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Abstract
This study examines the short run analysis of external shocks impact on Pakistan's economy. We applied the Recursive Vector Autoregressive (RVAR) methodology using the monthly data over the period 2001M1 to 2016M12. We examine impact of external shocks like oil price shocks and foreign interest rate shocks on the macro variables of Pakistan economy. These macro variables include inflation rate, output, interest rate, money supply and real effective exchange rate. We also analyze the transmission channels of these external shocks on domestic economy. Then we applied impulse response function on both external shocks (oil price and foreign interest rate). These impulse response functions concluded that oil price shocks have inflationary pressure on Pakistan economy while foreign interest rate shocks have minor impact on Pakistani macroeconomic variables except real effective exchange rate. According to impulse response function analysis, when oil price shock arises inflation immediately increases while the foreign interest rate shocks have no serious effects on domestic macroeconomic variables. However, the changes in foreign rate of interest have effect on real effective exchange rate. On the basis of generalized impulse response function, our findings are supported by generalized forecast error variance decompositions analysis. This decomposition analysis clearly supporting the impulse response functions that revealed that oil price shocks have inflationary impact on Pakistan economy while foreign interest rate changes have minor impact on domestic variables. However, real effective exchange rate is majorly affected by foreign interest rate. In sum up, these external shocks are strengthening the stagflation in Pakistan. Policy makers should make viable policy to cope this problem and take into account these shocks during policy making. To minimize the Oil price shocks inflationary pressures on the economy, we should focus on alternative renewable sources of energy sector like solar plant.

Keywords: External shocks, oil price and foreign interest rate shocks, Recursive, GRIFs, GFEVDs
JEL Codes: D66, E3, E43

I. Introduction

The countries are dependent on each other around the world due to the fact of high economic integrations and globalization. There are some global shocks that effects the economies of the world together and the domestic policies become fail due to these external shocks. A large body of research is available which dealings with the effects of these shocks on a domestic economy. After 1970s recession, oil price shocks became the vital variable for any economic policy implication. It have been accused for major economic recessions, higher inflation, productivity slow down and stagflation. They also have been blamed for monetary policy changes and energy sector prices. The macroeconomics of the ***Oil Price Shocks*** is the most conversed issue in the energy economics literature since 1970s. There is unanimous perception that after 1973 oil crises all downturns have been connected with the shocks of oil price but not all these shocks lead to a serious collapse. Following figure showing the Oil prices trends during major economic events.

Figure 1: Crude Oil Prices in major economic events

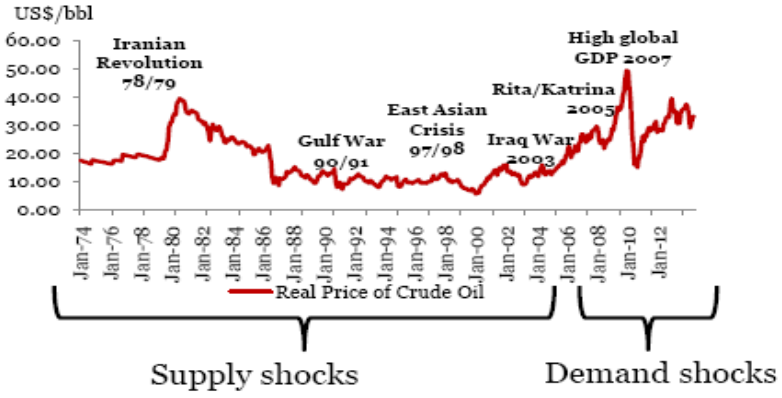


Figure Source: Bloomberg.com

Another shock that we analyses in this study is the ***Foreign Interest Shock*** i.e. US monetary policy changes impact on Pakistan macroeconomic variables. There is international monetary policy coordination among economies. Monetary policy in the US have impact on asset prices not only in American marketplaces but throughout the world. This perception can be confirmed from the recent global financial crisis of 2008-09. These crisis starts from US that not only US economy affected but also the spillover effect on other economies of the world through different channels. These macroeconomic spillover effect includes flows of capital, exchange rates, interest rate, international trade, and economic growth level of an economy.

In this study, our basic objective is to improve the existing plethora of research on the macroeconomic impacts of external shocks on the domestic economy. The issue we wish to address here is the macroeconomic impacts of oil price shocks and disturbances of foreign monetary policy on the Pakistan economy using Recursive Vector Autoregressive (RVAR) Model to examine the short run behavior of macroeconomic variables. We developed a macro-modelling framework that enables us to evaluate the effects of shocks on the domestic economy through various transmission channels. In sum up, this study is carried out to response the subsequent questions:

- What are the impacts of shocks caused by oil prices on the major macroeconomic variables of Pakistan economy?
- Is the US monetary policy variations have effects on the Pakistani macroeconomic variables?

The effects of external and domestic shocks on the growth of developing economies like Pakistan have supreme significance. The consequences of these shocks push millions of people into abject poverty and scarcity. We choose two important external shocks (oil Price shock and foreign monetary policy shocks) in our study. The micro-foundation idea is best way to understand the significance of this external shock study. The oil prices have key importance for the American and global economy because it gives us the important signals about the future of world economy. Whenever we study the history of world's major economic recession, the literature suggested that oil price shocks have vital significance. As we know Pakistan is an importer of oil so when oil price decreases the beneficiaries will be Power sector, paints industry, consumable chemical and packaging, auto sector and cement Sector etc. While the international decrease in oil price have

negative impact on companies like OGDC, PPL, and POL, etc. while PSO, HASCOL, APL, and SHEL etc. suffer inventory loss.

Similarly, the ***American Central Bank Policy*** have importance for all countries because US dollar is an international currency. Federal Reserve, the Central Bank of US, deals with different roles in global perspectives. By manipulating rate of interest, the American central bank change the value of dollar for foreign exchange. The hikes of dollar value could affect the emerging markets, and most of them have big aggregates of dollar-denominated arrears like Pakistan. If rate increases occur earlier than projected, or if rates increase more rapidly than expected once that first hike takes place, then the value of the American dollar is likely to rise against other foreign currencies. This could make effects very problematic for Pakistan which have to repay their amount overdue in dollars, and could cause a growth crunch in parts of the world far away. Majority of the previous research related to oil price shocks and foreign monetary policy linkages have been shown in the perspective of advanced nations. But in the context of developing countries, very limited studies yet been conducted. The main cause for the absence of studies on the developing nations is may be their smaller amount of dependency on oil or may be due to less availability of macroeconomic data on these fluctuating variables. To the best of our knowledge, from the point of view of foreign monetary policy shocks, this is the first study for Pakistan that empirically testing the US monetary policy shocks impact on Pakistan monetary policy as well as other major macro variables.

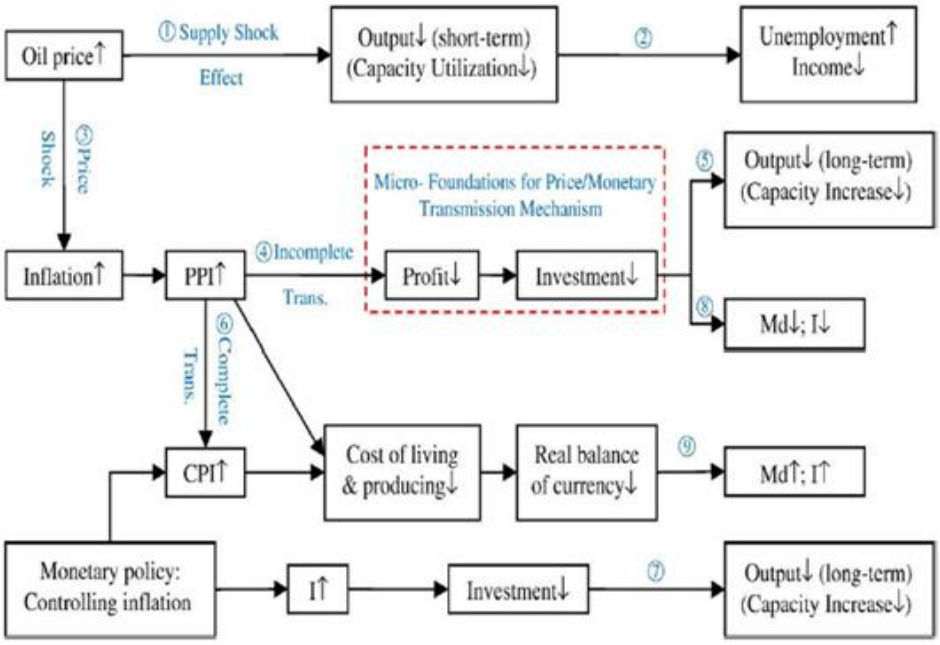
II. Literature Review

A growing body of the literature belongs to external shocks and their impacts on the macroeconomic variables of any economy. Most part of the literature studies have relied on aggregate data that pins out shocks impact on the growth rate of GDP, inflation, interest rate, exchange rate etc. This section covers a wide variety of external shock theories and research findings to review the background literature about our study.

II.I. Oil Price Shocks

A Shock in oil price behaves like a consumption tax and the benefits of these types of taxes go to oil exporter countries rather than importing states like Pakistan. Further, we can observe the macroeconomic impacts of oil price shocks on an economy through various transmission channels via using the modern economics concept "micro-foundation". Micro-foundation refers to the microeconomic analysis of the individual behavior such as firms, consumer, agents, etc. that underpins a macroeconomics theory.

Figure 2: Oil-price Shocks channels



Source: Khan and Ahmed (2011)

Overall, we can say that there are no consensus on practical outcomes about the effects of oil price shocks on the macro economy. In addition, there is also no consensus on the oil price transmission channels (Hamilton, 1983). In experimental studies Oil price shocks have received substantial significance. What oil price shock really is? Archanskaïa et al. (2012) tried to explain the main motivating force behind these oil price shocks in the period 1970-2006. The strategy used by them for identification based on a basic premise: oil price shocks which are supply-driven have negative effects on universal financial activity, whereas oil price shock wave that are demand-driven do not have negative effects. They concluded that between 1970 and 1992 oil price shocks were adverse supply-driven shocks, while between 1992 and 2006 these shocks were favorable global oil demand shocks. These findings can also be confirmed by Hamilton (1983, 1996, and 2009) and Kilian (2008a, 2008b and 2009).

External oil price shocks for any economy is not trivial at all. Hamilton analysis always suggested that these oil price shocks contribute in almost all US recessions. USA always remained the biggest oil consumer and the largest manufacturer of petrol till the 1974 when Soviet Union was exceeded by it. Specifically, during 1974-1975 oil prices tripled that trigger the US and global recession succeeding the war of Yom Kippur and the embargo of oil trade. During 1981-1982 oil price suffered with a spike due to Iranian revolution in 1979 that leads to US and global recession. Similarly, during 1990-1991 US economy also suffering from the recession. This time recession was partly due to the spike in oil prices and partly by the Iraqi attack of Kuwait in summer of 1990.

On the empirical side of oil price shocks Hamilton (1983) study was the pioneered of literature. Other important names are Bruno and Sachs (1982), they analyzed the oil price impacts of 1970s crises on inflation and output in detail. Hamilton (1983) pinned out via VAR model analysis that prior to 1973 recessions would have been diverse in extent if there was no oil prices increase. Hooker (1996) concluded that 1973 shocks of oil prices had superior influence on macro economy comparatively 1979 shock. If the world oil production decrease in reaction to a positive shock of oil price, the shock is known as negative supply shock or a precautionary demand shock. If, however, in reaction to a positive oil price shock, the world oil production increases then this oil price shock is referred to as positive demand shock (Kilian, 2009).

Bernanke (1983) suggested that when there is uncertainty in the economy it leads to the postponement of the purchasing of capital and durable goods. According to him, oil price shocks can generate ambiguity in the economy and this ambiguity will influence the economy. Rogff (2006) point out that the impacts of the oil price shocks on the economy are usually deteriorated by increase in energy effectiveness, technological advancements, and financial market expansion. When we talk about the Asian countries, japan is the most widely studied country related to the Oil price shocks effects on economy. Burbidge and Harrison (1984) use the Recursive vector autoregressive model to analyze the five OECD countries containing japan. They used the monthly time series data which cover the period of 1960M to 1983M6. They concluded that the price of oil have minor effect both on the industrial production and inflation than the U.S. economy.

There are many other studies also the part of literature that focus on Asian economies. Abeysinghe (2001) did a wide study by taking top Asian countries along with the United States of America. He concluded that even the net exporter countries of oil cannot escape from the adverse effects of oil shocks such as Malaysia and Indonesia. Another important study is conducted by Cunado and Gracia (2005). They examine the 6 Asian countries (Singapore, Thailand, South Korea, Malaysia, japan and Philippines) by taking data period 1975Q1 to 2002Q2. They concluded by saying that oil price surprises have a substantial influence on the economy and CPI.

II.II. Foreign Monetary Policy Shocks

There is no such a serious research attempt has yet been made on this topic and only a small amount of studies available which are showing the mixed results. Some important findings of these studies via using different econometrics techniques are presenting in this part. The difference in interest rate between among countries have significant influence on foreign exchange rates. According to economic theory, a rise in US rate of interest will rise the degree of return on US dollar overhead the proportion of return on Pakistan rupees, lead the financiers to shift investments from Pakistani assets to British, and result in a rise in the PKS/US$ rate of exchange (i.e., an increase in the value of American currency and decrease of the Pakistani currency value). In contrast, a reduction in US interest rate will reduce the rate of return on US dollar below the rate of return

on Pakistan rupees, lead the investors to shift investments to Pakistani assets from US assets, and result in an decrease in the PKS/US$ exchange rate (i.e., depreciation of US dollar and depreciation of the Pakistani rupees. This appreciation/depreciation channel have impact on Pakistan's major macroeconomic variables like exchange rate, Gross Domestic Product (GDP), inflation rate etc.

There is monetary policy coordination among countries across the world. That can be seen from the global financial crises of 2007-09. Crises starts from US and spread throughout the world in short period. US monetary authority decisions not only effect returns on US assets but also the international assets. Global financial assets strongly respond to the American central bank interest rate and even the expectations about Fed monetary policy have key importance for the foreign economies (Travis, and Guangye, 2016).

The respond to Federal Reserve's policy decisions depends on the economic condition of country. Advanced and emerging countries responds, on average, similarly to the Fed policy decisions. However, assets return links with Fed policy shocks are vary country to country. The countries which have close financial relation with United States are most affected by US monetary policy changes. In this regard, some major European and Latin American countries are the best examples that have close financial links with United States (Travis, and Guangye, 2016).

Globalization leads to economic integration that increase the investor's response to interest rate differentials. The latest analysis proposing that the globalization in financial sectors has left the interest rate less delicate to monetary policy as compared to the past (Mark, 2007).

There are plenty of research have been made to check the spillover impact of interest rate via using time series analysis. Major contributors in this regards are Chinn and Frankel (2004), and Bayoumi and Swiston (2007). They used different econometric techniques like Vector auto-regressive, Cointegration and error correction models to check spillover effects. They all concluded the significant cross-border spillovers in bond yields among the United States and other economies. Kim (2001) analyze the United States economy with the help of Vector auto-regressive approach using major economic variables for instance, output, federal fund rate and inflation. He examine the impact of some external variables and conclude that Federal Reserve policy surprises have minor impact on international (G6) short-term rate of interest. However, there is a substantial impact on international long-run output. Also, Federal Reserve's monetary policies during 1994 to 2005 significantly effects the foreign equity prices. It also have significant impact on long-term and short-term foreign rate of interest (Hausmann, and Wongswan, 2006).

Financial openness have great importance to check the US monetary policy shocks on stock market prices. The stock prices of economies with more financial openness strongly effected from the US monetary policy changes (Ehrmann, and Fratzscher, 2006). If the capital account of an economy is more opened then the domestic rate of interest significantly replies to foreign interest rate (Shambaugh, 2004).

III. Methodology and Data

There are total seven variables in our model, five endogenous and two exogenous. In endogenous variables we take real GDP, REER, nominal rate of interest, money supply and inflation while oil price and foreign interest rate are exogenous variables. Our key emphasis is to analyze the impacts of oil price shocks and US monetary policy change on Pakistani main macro variables. For this purpose RVAR model is an ideal scheme. For the purpose of shock analysis, we select West Texas spot crude oil price in terms of dollar for oil price. To check the US monetary policy influence on Pakistani macro variables we take federal fund rate of US. Monthly Pakistani Real GDP (y_t) is not frequently available, so we proxied it via using industrial production index. We used CPI to find the inflation rate. For this purpose we take log difference of CPI multiply by 100. For the analysis of monetary transmission mechanism of oil price shockwaves, we use M2 definition of money supply. When oil prices fluctuate, monetary authority respond to achieve its given target. That's why we choose M2 variable. Overnight call money rate used for the analysis of nominal interest rate responds to shocks. The definition of real effective exchange rate is used for the FX rate. The general Recursive VAR model with VAR (p) system is specified as:

$$AX_t = A_1 X_{t-1} + A_2 X_{t-2} + \ldots\ldots\ldots\ldots + A_p X_{t-p} + e_t \qquad (1)$$

Where X_t is a (n x 1) endogenous variable vector (Global Oil price, foreign interest rate (US), domestic interest rate, Money supply (M2), the real effective exchange rate, the industrial production index and the inflation rate). A is (n x n) a coefficients of contemporaneous relations on the endogenous variables matrix which captures long term relations between the k variables of our model, and e_t is a (n x 1) Recursive error terms vector and P is showing the lags length. The error terms of the model are expected to be linearly associated to Recursive disturbances, denoted by U_t, so that $U_t = Be_t$, where B is (n x n) matrix of Recursive coefficients signifying the impacts of Recursive shocks. So, above model can be expressed as:

$$AX_t = A_1X_{t-1} + A_2X_{t-2} + \ldots\ldots\ldots\ldots + A_pX_{t-p} + Be_t \qquad (2)$$

For the purpose of analysis of policy process and to infer the economical interpretation, this (2) equation Recursive model must be identified (Leeper et al., 1996). In reduced form equations, single variable is express as a linear function of its own lags and all other variables lags. Then each equation can be estimated by OLS. If the variables in the system are interconnected with each other, then the residuals will also be correlated with each other. Reduced form of the model of equation (2) can be expressed as:

$$X_t = A_1 * X_{t-1} + A_2 * X_{t-2} + \ldots\ldots\ldots\ldots + A_p * X_{t-p} + u_t \qquad (3)$$

The variables appear on LHS of the model are Global Oil price, foreign interest rate (US), domestic interest rate, M2, the industrial production, the real effective exchange rate and the inflation rate, where $A_i* = A^{-1}A_i$ and $U_t = Be_t$

Structure parameter means the parameters that tells us about the structure of the economy. When we try to find the impact of variables on the economy using Vector autoregressive (VAR) models, economic theory tell us something about the structure of the economy. As economist, we must take into account these structure or assumptions from economics on Vector autoregressive (VAR) model. There are two types of restriction that can be imposed. First type imposes restrictions on the short run behavior of the system and second type imposes restriction on the long run behavior of the system. For the purpose of identification of Vector autoregressive (VAR) model, we impose restrictions on the parameters that come from the economic theory. In our model we use the $(n^2+n)/2$ restrictions on the parameters for the purpose of identification. Furthermore, we required an additional restriction $n^2-(n^2+n)/2$ on B matrix. Furthermore, we need 21 additional restrictions in our model to estimate it because our total variables are seven.

There are two main identification methods that can be used to identify the required restriction of the model. First is the Structural VAR and the second is Recursive VAR. Both schemes are different from each other in sense of restriction matrix. In recursive model, Cholesky decomposition assumes the matrix as diagonal (most probably lower diagonal), while in Recursive identification we can assume any structure of the model via applying restrictions. According to Recursive VAR scheme, first of all we estimate our Vector autoregressive (VAR) model then with the use of covariance matrix find the Cholesky factorization of the reduced form. The covariance matrix of the Recursive disturbances should be a diagonal matrix while the second matrix should be lower triangular. In simple words we can say that the Recursive shocks are orthogonal. Recursive VAR Sim and Zha (1998) and Roubani and Kim (2000) suggested this identification scheme. According to this approach, we can impose restrictions on the parameters what we want, does not matter our matrix is diagonal or not. This can be done only if we know each equation theoretical background, for example, money demand is function of income, interest rate and inflation. So money demand will respond to these three variables and we will apply restrictions according to this sequence. Following the methodologies of Ali (2015), Ali and Rehman (2015), Ali (2018), Ali and Audi (2018) and Sajid and Ali (2018), the recursive RVAR model can be described in a linear system of following equations.[1]

1 We cannot achieved converge when we used theory-based RVAR model. Alternatively, we specify RVAR with recursive structure to analyze short run.

$$lrop_t^* = E_{t-1} lrop_t^* + \varepsilon_t^{lrop^*} \quad (4)$$

$$fr_t^* = E_{t-1} fr_t^* + \lambda_1 \varepsilon_t^{lrop^*} + \varepsilon_t^{fr^*} \quad (5)$$

$$lmpe_t = E_{t-1} lmpe_t + \lambda_2 \varepsilon_t^{lrop^*} + \lambda_3 \varepsilon_t^{fr^*} + \varepsilon_t^{lmpe} \quad (6)$$

$$lrm2_t = E_{t-1} lrm2_t + \lambda_4 \varepsilon_t^{lrop^*} + \lambda_5 \varepsilon_t^{fr^*} + \lambda_6 \varepsilon_t^{lmpe} + \varepsilon_t^{lm2} \quad (7)$$

$$lcmr_t = E_{t-1} lcmr_t + \lambda_7 \varepsilon_t^{lrop^*} + \lambda_8 \varepsilon_t^{fr^*} + \lambda_9 \varepsilon_t^{lmpe} + \lambda_{10} \varepsilon_t^{lrm2} + \varepsilon_t^{lcmr} \quad (8)$$

$$lreer_t = E_{t-1} lreer_t + \lambda_{11} \varepsilon_t^{lrop^*} + \lambda_{12} \varepsilon_t^{fr^*} + \lambda_{13} \varepsilon_t^{lmpe} + \lambda_{14} \varepsilon_t^{lrm2} + \lambda_{15} \varepsilon_t^{lcmr} + \varepsilon_t^{lreer} \quad (9)$$

$$\inf_t = E_{t-1} \inf_t + \lambda_{16} \varepsilon_t^{lrop^*} + \lambda_{17} \varepsilon_t^{fr^*} + \lambda_{18} \varepsilon_t^{lmpe} + \lambda_{19} \varepsilon_t^{lrm2} + \lambda_{20} \varepsilon_t^{lcmr} + \lambda_{21} \varepsilon_t^{lreer} + \varepsilon_t^{\inf} \quad (10)$$

Where

$lrop_t^*$ Log of real oil price

fr_t^* Foreign interest rate (US monetary policy rate)

$lmpe_t$ Log of manufacturing production index

$lrm2_t$ Log of real money Supply (M2 definition)

$lcmr_t$ Log of Call money rate (short term domestic rate of interest)

$lreer_t$ Log of real effective exchange rate

$\inf_t$ Inflation Rate obtained from log difference of CPI

All variables of the model are in logarithm form except interest rate. Where E_{t-1} are the conditional expectations operator while λ is impulse response coefficients. From whole discussion, we can say that there are two categories of disturbances. First the reduced form errors and the second is Recursive disturbances. Recursive vector autoregressive (RVAR) recursive identification matrix form can be expressed as:

$$\begin{bmatrix} u_t^{lop} \\ u_t^{fr} \\ u_t^{lmpe} \\ u_t^{lrm2} \\ u_t^{cmr} \\ u_t^{lreer} \\ u_t^{\inf} \end{bmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 & 0 \\ b_{71} & b_{72} & b_{73} & b_{74} & b_{75} & b_{76} & 1 \end{pmatrix} \begin{bmatrix} e_t^{lop} \\ e_t^{fr} \\ e_t^{lmpe} \\ e_t^{lrm2} \\ e_t^{cmr} \\ e_t^{lreer} \\ e_t^{\inf} \end{bmatrix} \quad (12)$$

The recursive form correlations in the system can be explained as: first variable is only respond to its own shock while the second variable respond to its own shock as well as the first variable. Similarly, third variable respond to its own shock as well as the first two variables. This process continue till last variable who respond to all the variables in the system. One important think to note here is that the disturbances to this variable have no impact on each other variables. According to the recursive method, variables ordering in the system has importance for the shocks identification. For this we have to use strong economic theoretical background, for example, oil prices shocks have strong impact on inflation variable.

The shock to a vector autoregressive (VAR) model in known as impulse response function. The idea behind the impulse response function is that when a shock is put to the any error term of the system it responds to the endogenous variables of the system. As our core aim of this research is to capture the oil shocks and

foreign monetary policy change impact on Pakistan macro variables, so impulse response function is best to analyze it. But for calculating impulse response function, the variable ordering is very important. There are many methods are given for ordering but we have chosen Cholesky with degrees of freedom adjusted. For the relative analysis of each dependent variable in explaining variation in explanatory variables, we use variance decomposition analysis (Chuku et al. 2010). It is the prominent tool that researcher used to interpreting model. We use it to check the spillover effects of an external shock like oil price shocks.

IV . Estimations and Results

How many variables we should use in Recursive vector autoregressive (RVAR) model to obtain authentic inference of the economy is great debate for researchers. Some researchers especially Dungey and Pagan (2000) belives that we should use 11 variables while some other researchers including Brichetto and Voss (1999) and Kim and Roubini (2000) recommended that 7 variables are enough. Pakistan is a small developing economy that cannot influence the world oil prices, that's why we assumed oil price as exogenous variable. Similarly, Pakistan cannot influence the US interest rate so it is also exogenous variable. We use total seven variables for Pakistan Recursive vector autoregressive (RVAR) model. Optimal Lag length Selection is the most important part of the RVAR model analysis. There are so many criterion that can be applied to choose optimal lag length of the model like Schwarz Information Criterion (SC), Akiake Information Criterion (AIC) and Hannan-Quinn information Criterion (HQ). Literature suggested that Schwarz information criterion (SC) is best for the purpose of lag length selection. Either we choose AIC or SC, we select the lowest value of the criterion as optimal lag.

Table 1: Optimal Lag Length Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	391.8700	NA	4.99e-12	-6.157920	-5.999535	-6.093577
1	1283.996	1670.060	6.92e-18	-19.64794	-18.38085*	-19.13319*
2	1353.167	121.7414	5.05e-18*	-19.97068	-17.59489	-19.00552
3	1397.469	73.00921	5.54e-18	-19.89550	-16.41102	-18.47994
4	1448.034	77.66806	5.59e-18	-19.92055	-15.32737	-18.05458
5	1486.829	55.24314	6.97e-18	-19.75726	-14.05538	-17.44088
6	1554.984	89.42005*	5.60e-18	-20.06374*	-13.25317	-17.29697
7	1601.560	55.89157	6.60e-18	-20.02497	-12.10569	-16.80778
8	1642.056	44.05895	9.02e-18	-19.88889	-10.86091	-16.22130

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Based on the lag length of order 6, we estimate recursive RVAR model to examine the external shocks on selected macro variables for the case of Pakistan. Table 2 depicts the contemporaneous estimates of the recursive RVAR model.

We applied the AR root table to test the stability of our estimated Recursive Vector autoregressive (RVAR) model and to test weather stationary/non-stationarity effecting the model or not. In AR root table we see that all the roots in modulus are less than one that suggesting us that no root lies outside the unit circle, so our estimated Recursive Vector autoregressive (RVAR) model satisfies the stability condition. In other words, our system is stationary. So no problem of stationarity issue in our estimated RVAR model. Table of AR roots given in appendix.

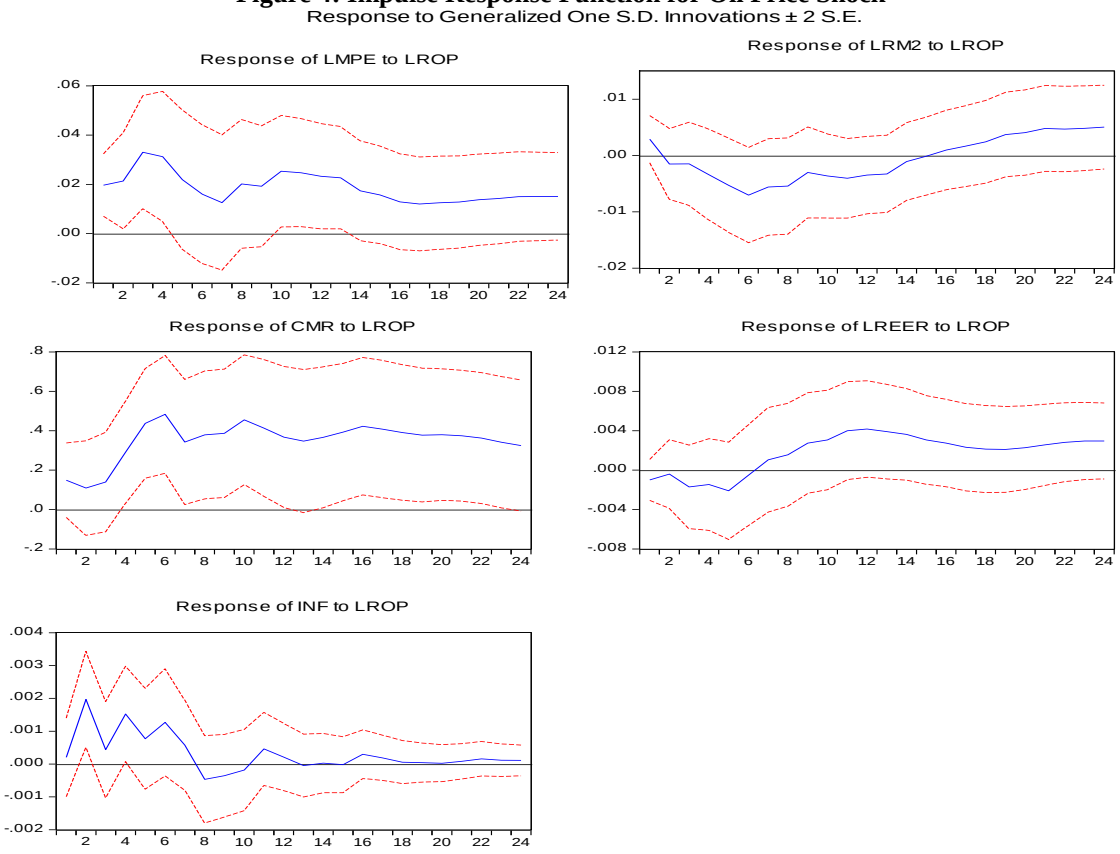
For the purpose of applying impulse response function, first we estimate RVAR. Then apply impulse response function via choosing Cholesky with dof ordering scheme.

Table 2: Contemporaneous Recursive Coefficients

	Coefficient	**SE**	**z-Stat**	**Probability**
b_{21}	0.234259	0.143800	1.629060	0.1033
b_{31}	0.293787	0.090413	3.249381	0.0012
b_{32}	-0.039533	0.054797	-0.721443	0.4706
b_{41}	0.040974	0.031213	1.312725	0.1893
b_{42}	-0.029248	0.018224	-1.604899	0.1085
b_{43}	0.027522	0.029223	0.941803	0.3463
b_{51}	3.399865	1.389777	2.446339	0.0144
b_{52}	-1.190492	0.814089	-1.462362	0.1436
b_{53}	-3.569934	1.297002	-2.752450	0.0059
b_{54}	1.015805	3.894371	0.260839	0.7942
b_{61}	-0.006711	0.015480	-0.433555	0.6646
b_{62}	-0.000789	0.008938	-0.088291	0.9296
b_{63}	-0.042414	0.014532	-2.918770	0.0035
b_{64}	0.042237	0.042416	0.995780	0.3194
b_{65}	0.001341	0.000959	1.398980	0.1618
b_{71}	0.012126	0.007958	1.523830	0.1276
b_{72}	0.002735	0.004591	0.595664	0.5514
b_{73}	-0.010605	0.007707	-1.376009	0.1688
b_{74}	-0.134086	0.021872	-6.130495	0.0000
b_{75}	0.000103	0.000496	0.208277	0.8350
b_{76}	0.097815	0.045227	2.162749	0.0306

LR (Likelihood Ratio) test for restriction identifications: □2 (2) = 4.25[0.114]

Figure 4: Impulse Response Function for Oil Price Shock



It is observed from Figure 4 that in reaction to one unit standard deviation shock wave to oil price, inflation immediately rises up to the third month, thereafter the response turns to be negative and crossed zero line in 8th month. However, after 13th-14th months it almost die out. This suggest that oil price shocks have inflationary stress on the economy of Pakistan economy in the short-run. Khan and Ahmed (2011) and Javid and Munir (2011) also found similar findings for the case of Pakistan. Domestic output is not so much effected by oil price shocks, immediately minor fluctuation then after 2 or 3 months decreases up to 7 months. After it again fluctuate and then became stagnant for the rest of months. This impulse response tells us that output decline after oil price shocks but after short fluctuation it recovers. Oil price shocks have negative impact on money balances initially. After six months money balances start increasing and after sixteenth month cross the negative regime and became positive. This oil impulse point out the fact that monetary authority decreases the money supply when oil price shock came. This analysis can be verified with the inflation targeting theory of monetary policy, according to it central bank give inflation target and then try to meet these targets via using monetary policy. As we have seen that when oil price came it put inflationary pressure on the Pakistan economy, that is why monetary authority cut money supply to control these inflationary pressures to meet their given inflation targets of the monetary policy.

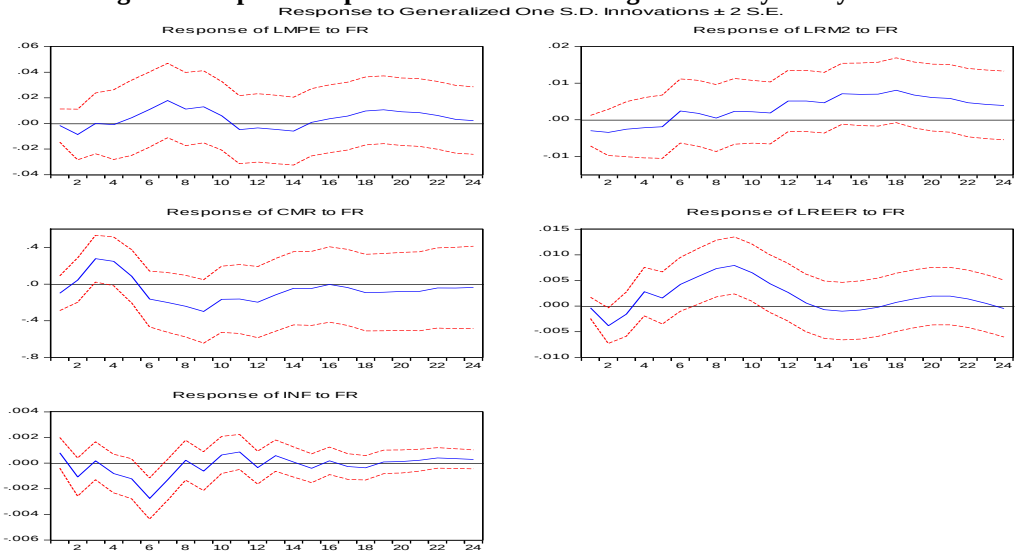
When money supply decreases, according to the theory of liquidity preference, interest rate increases. This statement clearly linked with our impulse response function model. As we observe inflationary pressure due to oil price shocks, monetary authority cut the money supply. This money supply cut increases the interest rate. This is confirmed by impulse response (IRF) figure in which short term interest rate instantaneously increases by our oil price shocks and this pattern continue till six months. After 7 to 8 month it became stagnant and sustained with pattern. After the oil price shocks, IRF showing the appreciation in REER immediately. Following table presenting the Generalized Forecast Error Variance Decompositions (GFEVDs) of Oil Price over the 24 months horizon. For GFEVDs analysis our Cholesky ordering is oil price, foreign interest rate, output, M2, domestic interest rate, REER and inflation.

Table 3: GFEVDs of Oil Price

Period	Oil Price	Foreign i	Output	M2	Domestic i	REER	inflation
1	100.0000	2.015768	7.238575	1.481222	1.894583	0.696173	0.089814
4	77.50608	1.268494	14.89838	1.396492	7.313428	1.072870	10.40833
8	56.69900	0.846048	17.28903	6.578831	22.64841	1.576854	10.30740
12	48.98696	0.514561	22.64475	7.635649	27.70147	5.668345	10.01178
16	47.01622	1.195335	23.60230	6.670847	30.62926	8.129559	9.862921
20	46.09125	1.733452	24.01195	6.718939	33.48063	8.786333	9.817807
24	44.51336	1.719756	25.41152	8.087873	34.82782	10.41285	9.797145

Table is explaining the 24 month pattern of impulse/innovation or shock to oil price. The first column of the table showing own shock analysis of oil price shocks, that is, initially 100 percent then showing declining trend. The second column showing the US monetary policy interest rate analysis. Similarly, we will consider all the columns of the table one by one. The impact of oil price shocks to output is 25.41 percent over 24 months. This means that oil price shocks have prominent impact on output that continue for long period of time. As far as money supply is concern, oil price shocks have impact on money supply but not as strong as on output, 8.08 percent over 24 months. Likewise, the effect of short term interest rate is 34.82 percent over 24 month. This means that monetary authority responding to oil price shock quickly. The REER column showing the no quick responds to oil price shocks. Initially 0.69 percent that became 5.66 percent in 12 months and 10.41 percent after 24 month. Finally, the last column showing the respond of inflation to oil price shocks. Initially, first month inflation is 0.89 percent that became above 10 percent after fourth month and consistent up to 12th month then minor drop and ends with 9.80 percent. In other words, these results showing inflationary pressure on Pakistan economy and slow adjustment of domestic prices. Similar analysis can be run for the Foreign Monetary policy shocks.

Figure 5: Impulse Response Function for Foreign Monetary Policy Shock



All given figures presenting the 24 period fluctuations in macroeconomic variables of Pakistan that causes due to one unit standard deviation positive shock to foreign interest rate i.e. US monetary policy changes. We are starting interpretations from the output graph. When US monetary authority increases its monetary policy interest rate, US assets becomes for attractive for rest of the world. All investors moves toward US assets, so US dollar value increase. First graph showing that when US foreign interest rate increases initially Pakistan output decreases because investors moving towards American assets. This process continue only short run because when all investor trying to get advantage from increased interest, profit margin reduces and after 2 3 months Pakistan output move back toward its initial level. After it minor fluctuations continue in Pakistan output over 24 months. Foreign monetary policy shocks have negligible influence on Pakistani money supply. Second figure strengthening the argument that when foreign interest rate increases the foreign currency value increases and Pakistani currency value decreases. So Pakistan monetary authority decreases the money supply only for 2 or 3 months because foreign interest rate have minor and short term impact on Pakistani money balances. After 3 or 4 months Pakistani money supply reached to its initial level and then almost stable.

When Pakistani monetary authority reduces money supply for short term in response to high US interest rate, according to liquidity preference theory, Pakistan interest rate increases as show in the graph of interest rate. But this increase only for 2 or 3 months. After it start decreasing and then stagnant after 15 or 16 months. This implies that US interest rate has negligible impact on Pakistan's short term interest rate. When we see the prominent US interest rate shock, a massive fluctuation can be detected in REER from the graph. As stated earlier, REER measures the worth of a currency against the basket of major other currencies. So, when US interest rate increases the dollar value increases as compared to Pakistani currency. It leads to the increase in REER that becomes highest after 10^{th} period then start decreasing and almost dampened after 14^{th} period. Last graph showing the response of domestic inflation to US interest rate. This response is also negligible because have only 4 or 6 month fluctuation and then becomes stagnant. Following table presenting the Generalized Forecast Error Variance Decompositions (GFEVDs) of foreign interest rate shocks over the 24 months horizon. For GFEVDs analysis our Cholesky ordering is foreign interest rate, oil price, output, M2, domestic interest rate, REER and inflation.

Table 4: GFEVDs of Foreign Interest

Period	Foreign i	Oil Price	Output	Money	Domestic i	REER	inflation
1	100.0000	2.015768	0.049450	1.562461	0.853225	0.085332	1.397716
4	94.20685	5.100579	0.398195	1.837508	8.002305	4.330559	4.080925
8	83.34092	4.497521	2.718190	1.814075	7.812619	14.53372	14.98641
12	76.63871	5.298253	3.205942	3.033867	8.690372	23.13590	15.67124
16	72.74177	9.525439	3.025185	6.831025	7.151222	19.70040	15.84048
20	67.82802	9.071085	3.775768	10.83315	6.352893	18.51194	15.93722
24	64.64616	9.441955	3.960131	11.61965	5.701909	17.99515	16.22468

Table is explaining the 24 month pattern of impulse/innovation or shock to foreign interest rate. The first column of the table showing own shock analysis of foreign interest rate shock, that is, initially 100 percent then showing declining trend. The second column showing the US monetary policy interest rate impact on oil prices. Similarly we will consider all the columns of the table one by one. From the table we can conclude that foreign interest rate (i.e. US interest rate) have negligible impacts on Pakistani macro-economic variables like money supply, output, domestic interest rate. However, foreign interest rate have fluctuated effect on Pakistan real effective exchange rate. This implies that change in foreign interest rate leads to attract the

investors that causes the reduction of Pakistani currency. From the second last column we can see that the first period impact is 0.085 percent and becomes 18 percent over 24 months. Finally, the last column showing the respond of inflation to foreign shocks. Initially, first month inflation is 1.39 percent that became above 14 percent after 8 months and consistent up to 20th month and ends with 16.22 percent. In sum up, foreign monetary policy interest rate have minor impact on all given macroeconomic variables of Pakistan but along with fluctuation in real effective exchange rate.

V. Conclusions

For the short run analysis of external shocks impact on Pakistan's economy we applied the Recursive Vector Autoregressive (RVAR) methodology using the monthly data over the period 2001M1 to 2016M12. Then we applied impulse response function on both external shocks (oil price and foreign interest rate). These impulse response function concluded that oil price shocks have inflationary pressure on Pakistan economy while foreign interest rate shocks have minor impact on Pakistani macroeconomic variables except real effective exchange rate. Similarly, we applied the generalized impulse response function on foreign interest rate analysis. We concluded that foreign interest rate shocks have no serious impact on domestic macroeconomic variables. However, the changes in foreign interest rate have impact on real effective exchange rate. Impulse response function showing these fluctuations over 24 months. When we see the prominent US interest rate shock, a massive fluctuation can be detected in REER from the graph. So, when US interest rate increases the dollar value increases as compared to Pakistani currency. It leads to the increase in REER that becomes highest after 10^{th} period then start decreasing and almost dampened after 14^{th} period. On the basis of generalized impulse response function (IRF), our findings are supported by generalized forecast error variance decompositions analysis. This decomposition analysis clearly supporting the IRFs that revealed that oil price shocks have inflationary impact on Pakistan economy while foreign interest rate changes have minor impact on domestic variables. However, real effective exchange rate is majorly affected by foreign interest rate. In sum up, these external shocks are strengthening the stagflation in Pakistan. Policy makers should make viable policy to cope this problem and take into account these shocks during policy making. After the analysis of external shocks impact on macroeconomic variables of Pakistan economy, we found that Pakistan's economy is relatively less affected by oil price shocks while foreign monetary policy changes i.e. US monetary policy changes effects on Pakistan economy is negligible.

According to our analysis and empirical findings most adversely affected variable from the set of selected macro variables is industrial production. The reason of it can be confirmed from the fact that industrial sector in Pakistan is heavily dependent on energy like electricity which majorly produce by the imported oil. Furthermore, found that these oil price shocks have spill over impact on Pakistani economy through various different transmission channels like interest rate and REER channels. However, remaining variables from the set of selected variables are not much alert to oil price shocks. Other prominent finding is that when oil price increases our import bills increases because Pakistan is oil importer country. This becomes severe through the REER transmission channel because REER is under pressures because of excess import bills. Our findings suggest that Oil price shocks put inflationary pressure on the economy of Pakistan through REER and interest rate channel. Our outcomes suggested that oil price shocks have prominent importance in policy making process because oil price shocks leads to inflationary pressures on the economy that disturb the policy makers given inflation targets. Prudent macroeconomic policies like exchange rate policy, fiscal and monetary policy should be formed. We should give importance to oil prices as a key factor in explaining the consumer price index. Furthermore, new schemes to deal with these oil price shocks in policy making process is indispensable. Transmutation of our energy sector to other renewable sources also an option i.e. solar energy to reduce the oil shocks impact on economy due to the electricity power generation with oil. As far as foreign monetary policy is concerned, we find that US monetary policy changes have no serious direct effects on the selected set of Pakistan macroeconomic variables except REER. When prominent fluctuations in US monetary policy changes arises it effects the currency value of US dollar. According to real effective exchange rate theory, Pakistani currency value respond to US value. So we found the fluctuations in REER due to these shocks. These fluctuations in REER have adverse impact on the growth of the economy. One policy option here is to transformation of economy reserves denominations from US dollar to some other real commodities like Gold reserves etc.

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Appendix

Roots of Characteristic Polynomial
Endogenous variables: LROP FR LMPE LRM2 CMR LREER INF
Exogenous variables: C
Lag specification: 1 6
Date: 09/14/17 Time: 02:58

Root	Modulus
0.987528	0.987528
0.956331	0.956331
0.949311 - 0.078181i	0.952525
0.949311 + 0.078181i	0.952525
0.832886 - 0.432653i	0.938556
0.832886 + 0.432653i	0.938556
0.737898 - 0.491142i	0.886405
0.737898 + 0.491142i	0.886405
0.885619	0.885619
0.418904 - 0.779501i	0.884931
0.418904 + 0.779501i	0.884931
-0.430079 - 0.738408i	0.854526
-0.430079 + 0.738408i	0.854526
-0.853518	0.853518
0.802117 - 0.285632i	0.851456
0.802117 + 0.285632i	0.851456
-0.768004 - 0.359758i	0.848089
-0.768004 + 0.359758i	0.848089
0.272770 - 0.783273i	0.829410
0.272770 + 0.783273i	0.829410

-0.673158 + 0.484216i	0.829221
-0.673158 - 0.484216i	0.829221
-0.560025 - 0.596170i	0.817953
-0.560025 + 0.596170i	0.817953
0.065173 - 0.804343i	0.806979
0.065173 + 0.804343i	0.806979
-0.022589 - 0.801356i	0.801674
-0.022589 + 0.801356i	0.801674
0.417943 + 0.669403i	0.789162
0.417943 - 0.669403i	0.789162
0.610890 - 0.498093i	0.788215
0.610890 + 0.498093i	0.788215
-0.787007	0.787007
-0.340835 - 0.708652i	0.786356
-0.340835 + 0.708652i	0.786356
-0.560522 + 0.438463i	0.711642
-0.560522 - 0.438463i	0.711642
0.701592 + 0.097016i	0.708268
0.701592 - 0.097016i	0.708268
-0.280620 + 0.132848i	0.310477
-0.280620 - 0.132848i	0.310477
-0.015713	0.015713

No root lies outside the unit circle.
VAR satisfies the stability condition.