

## Exchange rate pass-through to macroeconomic indicators using Vector Auto Regression: Empirical evidence from Pakistan

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**Abstract.** *This study aims to examine the exchange rate pass-through to oil prices, import prices, money supply, consumer prices and interest rate in the context of Pakistani economy. By using, monthly data from July 2005 to December 2015, unrestricted VAR model is employed as suggested by McCarthy (2000). This study looks at the degree and existence of causality or shock between variables/series. The major shock was seen in money supply by one unit point in exchange rate and less impact of impulse response was seen in discount rate, consumer prices and oil prices. It was also found that causality exists between exchange rate and money supply and discount rate. Furthermore variance decomposition results indicate that nominal exchange rate was explained mainly by money supply shocks which were contributing to 15.10% at a lag period of 12. For the Consumer price index variance decomposition was around 7.19%, for discount rate and oil prices it was 3.4% and 3% respectively at the optimal lags selected for 12 periods. This study helps policymakers to take steps according to the extent of shocks caused in different times.*

**Keywords:** exchange rate; interest rate; oil prices; money supply.

**JEL Classification:** F41, E52, E31.

## 1. Introduction

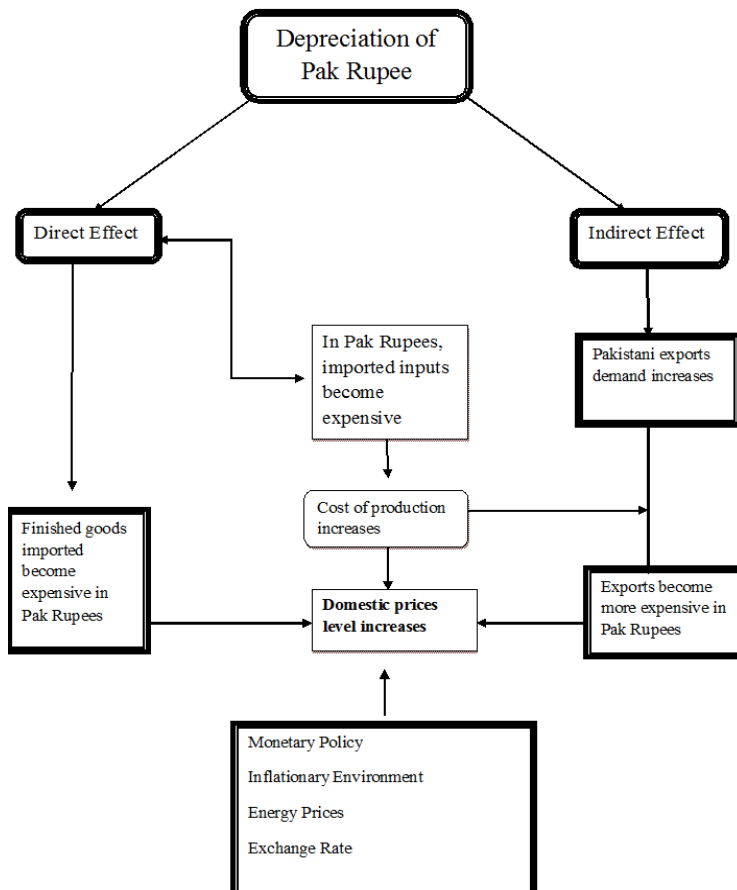
International trade plays an important role for the development of any economy. In this 21<sup>st</sup> century, technologies are rapidly changing, product life cycle is getting smaller, raising new need, demand which lead to increased production and the concept of viewing the world as single market has triggered the international trade. Frequent international trades, integration of world financial market, easy access of information, fast spread of random news have increased the competition as well as uncertainty across the world. A single new innovation can make the whole industry obsolete. Due to reducing trade barrier, companies are synergizing cross border to give maximum quality product with features at low price to cater the need of consumer. One very important factor in such international transaction is the difference of currency which is being evaluated under a concept called exchange rate. When a home country currency exchange rate appreciates, it benefits the importing country and under depreciation, it benefits exporting country. Recently, countries more often depreciate or devalue their currency to be more competitive in the world market. Exchange rate movements are considered as an instrument to determine the competitiveness of a country in the world market. It is of great importance to policy makers to know the channel and monetary policy variables which have impact on the exchange rate movement on inflation. In addition to this, many economists have been interested to examine the impact of exchange rate movements on domestic prices and output whose analysis is done through ERPT (exchange rate pass-through).

ERPT is referred to the degree to which exchange rate changes are reflected in domestic prices. There are number of important reasons to why it is essential to understand ERPT. First to forecast the inflation, setting monetary policy and the speed of pass through of shocks to domestic prices. Secondly, to design the macroeconomic policy to support the stabilization and those stabilization options can be like devaluation will depend on the speed of ERPT. A deviation in exchange rate impacts significantly on import and export prices of goods whether they are in raw form, immediate or finished goods. A country which trades in foreign market faces exchange rate risk and it has a significant impact of consumer price index (CPI) and wholesale price index (WPI). Due to Globalization, internet and technology, the world financial markets are now integrated and interdependent. A single change in one variable creates domino effect across the world. In order to reduce or mitigate such kind of risk, monetary policies are made to stabilize the internal and external value of the currency of a particular country. Pakistan is a net import based country.

According to Akbari and Rankaduwa (2006) Pakistan is small open economy operating below full employment and dependent on imports to meet the domestic demand of intermediate, consumer and capital goods. In Pakistan, there is more than 20,812 Million USD reserves as of December 2015 (<http://www.sbp.org.pk/ecodata/forex.pdf>). Net Foreign direct investment in Pakistan was 922.9 USD million in 2015 (<http://www.sbp.org.pk/ecodata/FIS-FDI-Arch.xls>). Comparatively Oil has major chunk in our import bills. Declining trend of oil prices from the past year 2015 has significantly

reduced the dollar value of import bills which resulted in improved balance of payment and reduction of transportation cost in the country which is good for overall economy and end consumers. State Bank of Pakistan has also reduced policy rate to 6% in Sept 2015 ([http://www.sbp.org.pk/m\\_policy/2015/MPS-Sept-2015-Eng.pdf](http://www.sbp.org.pk/m_policy/2015/MPS-Sept-2015-Eng.pdf)) which encourages households and corporation to go for more investments and spending. Through direct and indirect channels exchange rate movements can influence the domestic prices. Exchange rate movements can influence the domestic prices through changes in the price of not only imported finished goods but also imported inputs. If the cost of imported goods whether raw material or in the form of intermediate, are higher which is associated with depreciation in the exchange rate increase the marginal costs and result in higher domestic priced goods. Exchange rate depreciation in case of indirect channel influence the net exports which further influences the domestic prices through the change in aggregate demand causing upward pressure on domestic prices. As Choudhri and Hakura (2001) studied and identified that since 1982 under flexible exchange rate regimes, many developing countries like Pakistan experienced that domestic currencies depreciate sharply.

Figure 1. Exchange rate pass through to domestic prices



Source: Akinbobola and Fatai (2015), Aliyu et al. (2008), Hyder and Shah (2004), Laflièche (1997).

Through direct and indirect channels such depreciation can lead to increase in inflation. The speed of exchange rate pass through and its extent depends on various factors such as pricing policies, inflationary environment, market structure, relative share of imports in CPI basket, etc. For instance, in the export market a complete pass through can be seen when firms pass the changes in the exchange rate fully or completely to selling prices. Zero pass through comes when exchange rate changes are borne to keep the selling prices unchanged or combination will be known as partial pass through. In reality, substantial literature work is done which shows that exchange rate pass through is far distant from full or complete ERPT.

This research paper is organized as follows: Section 1: Introduction chapter consisting problem statement, research question and objectives of the study. Section 2 presents a review of literature on ERPT to consumer prices, producer prices and inflation. Section 3 describes the methodology carry out for the analysis purpose. Section 4 includes empirical analysis and major findings of the study. Section 5 is consisted of conclusion, policy recommendations and areas of further study

Pakistan is a net import country in which the oil has major chunk of import Bills. Deviation in oil prices affects significantly Pakistan's balance of payments and foreign reserves. In this way, the effect is passing through to home currency and domestic prices. The cost of transportation and other operating cost vary significantly which will be transferred to product price which benefit or burden to final consumer. In the past decade from 2005 to 2015, Oil has reacted in very uncertain way. In just 10 years, oil prices reached to \$109.45/per Barrel in 2012 and drop to \$49.49/per barrel in 2015 ([http://www.opec.org/opec\\_web/en/data\\_graphs/40.htm](http://www.opec.org/opec_web/en/data_graphs/40.htm)). Such deviation of oil had significant impact on exchange rate, domestic prices and inflation level. In order to tackle and keep the situation under control, government makes different monetary policies. This study will help policy makers to understand the responsiveness of variable due to the changes in exchange rate.

**Following are the questions which has been addressed in this study:**

- What is the extent of Exchange rate pass through (ERPT) in Pakistan?
- What are the key variables which has strong, moderate and slightly impact from the changes in exchange rate?
- What is the speed of pass through to different domestic prices?
- What will be the impact of exchange rate shock on domestic prices?

The objective of the study is to examine and understand the pass through of exchange rate on macroeconomic indicators in Pakistan by using recursive VAR Model (Vector Autoregression proposed by McCarthy 2000). This study aims to determine the extent of exchange rate pass through (ERPT) and impact on selected macroeconomic indicators.

## 2. Literature review

In this study, exchange rate of pass through effect is seen to money supply, import prices, consumer prices, and discount rate and oil prices in the context of Pakistan market. The objective of conducting this research is to assist in designing monetary policies and examining the impact ERPT (Exchange rate pass through) to these variables. There is substantial theoretical and empirical literature work has been done on the exchange rate pass-through to consumer and domestic prices. Much of the work has done with advanced economies like USA and Japan. The last two decades have witnessed a huge economic literature on exchange rate pass-through. Therefore, this section focuses on reviewing related empirical and theoretical literature. Recent literature focuses more on the importance of exchange rate pass through in carrying out the effective exchange rate and monetary policies.

### 2.1. Literature related to Pakistan

Very few studies have been conducted in Pakistan on exchange rate pass through to consumer prices and many other macroeconomic variables like GDP (Gross Domestic Product), FDI (Foreign Direct Investment) etc. Most of the studies conducted shows that exchange rate pass through to consumer price is low. One of the study conducted in the context of Pakistani economy which studied the impact of exchange rate changes on consumer prices for the period 1995M1 to 2009M3. In this study long run and short run ERPT in Pakistan is estimated and also takes into account the (RERM) existing real exchange rate misalignment. It was found that in Pakistan ERPT to consumer price inflation is very low which is almost close to zero (Jaffri, 2010). Zaman et al. (2012) also studied the extent to which exchange rate movements affect the consumer prices in Pakistan for the period consists of quarterly data from 1982Q1 to 2010Q4. This study used the SVAR model to estimate the exchange rate pass through to inflation in Pakistan. It was found that ERPT to consumer prices in Pakistan is very low. Another study has also shows the similar results by taking monthly data from June 2005 to June 2011 using the variables wholesale price index, consumer price index, large scale manufacturing, fuel and lightening and the growth of money supply by employing VAR model. The result of impulse responses under their study showed that exchange rate pass through is high on wholesale price index and exchange rate pass through is lower on consumer price index. Variance decomposition results were 5.48% on consumer price index and 10.15% on Wholesale price index (Shaikh and Hussain, 2015). Causality is also analyzed in most of the study between exchange rate and macroeconomic variables as seen one of the research paper where the objective of the study is to analyze the causality between exchange rate and macroeconomic variables (inflation, trade, foreign direct investment and gross domestic product) by using series of models for the period of 1980-2009.

For long-run equilibrium relationship and to check the causality between variables co-integration test and unit root test for stationarity is applied. It is found in the study that there is long run equilibrium relationship between trade and exchange rate. Between exchange rate and inflation there is no long run equilibrium relationship. Causality runs in

both direction in case of exchange rate and foreign direct investment and also reflecting a long run equilibrium relationship between exchange rate and foreign direct investment. In case of gross domestic product causality does not run in either direction but there is long run equilibrium relationship is found between exchange rate and gross domestic product (Khan et al., 2012).

The nature of asymmetric pass-through of global food inflation to domestic inflation is also examined for the period of 1993M2 to 2012M2 in Pakistan. Augmented Dickey Fuller (ADF) test is used to check the stationarity of data. By using the ordinary least square (OLS) found that pass through of global food inflation in consumer prices is asymmetric in Pakistan that is global prices responded differently in the period when there is global surge in prices of food as compared to the period when there is fall in prices (Jaffri et al., 2014). Aliyu et al. (2010) studied the impact of ERPT to consumer and import prices in Pakistan during the period of 1986 and 2007 by using VECM (Vector Error Correction Model). Choudhri and Hakura (2012) by using VAR and regression-based estimates, this study found that ERPT is incomplete for a large number of countries and larger pass through to export prices. Ahmad et al. (2014) investigates the impact of exchange rate on balance of payments by taking Pakistan economy in consideration. Monthly data was taken from January 2007 to October 2013 from the website of (SBP) State Bank of Pakistan. Various tests such as ARDL, unit root and causality test are applied to ascertain the volatility impact of exchange rate on (BOP) balance of payment. It was found that there is significant positive relation between balance of payment and exchange rate.

## 2.2. Literature related to other countries

The trend of short run impact on consumer prices of exchange rate pass through remains low in other countries as well as reflected in the study conducted in Maldives over the period from 1994 to 2010. Using a nonparametric approach to estimate ERPT (exchange rate pass through) to consumer prices and then model both consumer and producer price changes by using a recursive vector autoregression. It was found that ERPT (exchange rate pass through) to producer and consumer is significant (Masha and Park, 2012). Another study also investigates the effect of exchange rate changes on consumer prices in Ghana during the period of 1990M01–2009M02 by applying VAR (Vector autoregressive) model. The study found that exchange rate pass through is low but significant in the short run. Another findings in this study reflect the impact of increased openness and tighter monetary policy which is pursued by the central bank over the period of 1990M01–2009M02 (Frimpong and Adam, 2010). Other studies not only investigates the impact of exchange rate pass through to consumer prices but also examine this impact to producer price index (PPI). One of the study is conducted in the context of Algeria economy in which investigation of ERPT (exchange rate pass through) on producer price index and consumer price index is carried out by using VAR (vector autoregressive) model during the period from 2002Q to 2011Q. The study found that when there is an appreciation in the foreign exchange rates against the Algerian Dinar, in

response to this consumer price increases. Another finding from this study is that supply shock (oil price) contribute around 30% to CPI (Consumer Price Index) fluctuation whereas 5% to PPI (Bendob et al., 2015).

In South Africa, effect of exchange rate pass through (ERPT) to producer, consumer and import prices is examined. Using the unrestricted VAR and accounting tools (variance decomposition and impulse response) to examine the effect of pass through and to look at the importance of variables in explaining changes in domestic prices. The study is conducted using monthly data from 2000M1 to 2009M5. It is found in the study that there is a link between CPI (consumer price inflation) and external factors. Consumer price inflation increases by 0.125 percent after one percent shock to exchange rate. After 24 months, 20 percent is the pass through elasticity of producer price suggesting favorable shocks to producer price inflation which can have moderate effect on consumer price inflation (Ocran, 2010). For nine OECD countries impact of exchange rate pass through into producer, import and consumer price index is carried out using the used the VAR (Vector Autoregression). It was found that ERPT is greatest for import price index and smallest for CPI (consumer price index). Other findings seen in this study is that greater exchange rate pass through is existed in an economy which has higher import share, smaller size, persistent exchange rate, higher inflation rate, volatile monetary policy and less volatile aggregate demand (Wang and An, 2011). It was found that there is presence of complete and incomplete pass through regimes depending on the appreciations of a currency and inflation rates both in the short and long run. Findings from this study also has important macroeconomic policy implications (Kılıç, 2010).

Money supply reflects the central bank reaction function and it has major implications in designing and implementing monetary policy. Most of the studies have taken growth in money supply as variable while looking at the impact of exchange rate pass through. In Nigeria, impact of exchange rate pass through is investigated to inflation, import prices and monetary policy in Nigeria during the period of 1986 to 2012. The study used VAR model and Variance Decomposition (VD) to estimate the Impulse Response Function. It was found that ERPT is moderate during the period under consideration, in case of inflation it is slow and short lived. In case of import prices ERPT (exchange rate of pass through) is significant and persistent (Fatai and Akinbobola, 2015). Mohammed et al. (2015) examines the exchange rate pass through (ERPT) on producer and consumer price indexes by using VAR model (Vector Autoregressive Model) in Algerian economy. Cozmanca and Manea (2010) investigates the exchange rate pass through (ERPT) into producer prices, import prices and consumer price of Romanian economy. Using econometric methods related to VAR to determine the size and find out the dynamics of exchange rate pass through. It is found in the study that there is an almost complete pass through in case of import prices and complete pass through both in consumer prices and producer prices. Jin (2012) estimate the exchange rate pass through (ERPT) and examine the relationship with monetary policy in China. To analyse the robustness, VAR and linear models are employed in the study. Shioji (2012) examines the influence of exchange rate pass through on exports, domestic and import prices by employing the VAR model. The study has employed the time period of January 1980 through January

2010. It was found that pass through rates trend downward both on import and domestic prices throughout the period. Exchange rate pass through impact to import prices on several sectors including chemicals, transport, machinery, metal manufactures, equipment and food processing sector (which is the 70 percent of India's total) is also carried out. For estimation, an economic framework was used. It was on simultaneous equation imperfect model. Panel data regression technique applied on data from different sources as econometric method. Due to up and down ERPT (exchange rate pass through) movement in India, it results is incomplete ERPT to the prices of import also. The data during research was on currency and prices for US import with conditional change on the price over the period of time (Pyne et al., (2011).

### 2.3. Vector auto regression model

This model is proposed by McCarthy (2000). It is an econometric model which measure and capture the linear interdependencies among multiple time series. In this model, each variable becomes the linear function of past lags of other variables and also of itself. Such model is used for forecasting purpose. To disentangle the relations between variables impulse responses and variance decompositions are typically used in VAR model<sup>(1)</sup>. Here variance decomposition refers to volume of information of every variable contributes to other variable during autoregression. It assess forecasting error of variance described by exogenous shocks to the other variables. Whereas impulse response traces shock of one standard deviation to endogenous variables' current and future values. This study employs six variable VAR model to examine the influence of exchange rate pass through. The first variable taken in consumer price index. The second variable is growth in money supply so to incorporate monetary policy in this model<sup>(2)</sup>. The other variables taken are oil prices, import prices and interest rate. All these variables are taken from literature review.

$$\Pi_{toil} = E_{t-1} [\Pi_{toil}] + \varepsilon_{toil} \quad (1)$$

$$\Delta M2_t = E_{t-1} [\Delta M2_t] + \beta_1 \varepsilon_{toil} + \varepsilon_{\Delta M2} \quad (2)$$

$$\Delta \varepsilon_t = E_{t-1} [\Delta \varepsilon_t] + \lambda_1 \varepsilon_{toil} + \lambda_2 \varepsilon_{\Delta M2} + \varepsilon_{\Delta \varepsilon} \quad (3)$$

$$\Pi_{tcpi} = E_{t-1} [\Pi_{tcpi}] + \gamma_1 \varepsilon_{toil} + \gamma_2 \varepsilon_{\Delta M2} + \gamma_3 \varepsilon_{\Delta \varepsilon} + \varepsilon_{\Pi_{tcpi}} \quad (4)$$

$$\Psi_{tDR} = E_{t-1} [\Psi_{tDR}] + \partial_1 \varepsilon_{toil} + \partial_2 \varepsilon_{\Delta M2} + \partial_3 \varepsilon_{\Delta \varepsilon} + \partial_4 \varepsilon_{\Pi_{tcpi}} + \varepsilon_{\Psi_{tDR}} \quad (5)$$

$$\begin{aligned} \varphi_{timp} = E_{t-1} [\varphi_{timp}] + \Omega_1 \varepsilon_{toil} + \Omega_2 \varepsilon_{\Delta M2} + \Omega_3 \varepsilon_{\Delta \varepsilon} + \Omega_4 \varepsilon_{\Pi_{tcpi}} + \\ + \Omega_5 \varepsilon_{\Psi_{tDR}} + \varepsilon_{\varphi_{timp}} \end{aligned} \quad (6)$$

Here,

$Y_t$  – Vector of endogenous variables (Nominal Effective Exchange Rate Index ( $\Delta \varepsilon$ ), Oil Price Index; ( $\Pi_t^{oil}$ ), Interest Rate ( $\Psi_t^{DR}$ ), Inflation ( $\Pi_t^{cpi}$ ), Money Supply ( $\Delta M2_t$ ) and Import Prices ( $\varphi_t^{imp}$ ));

$A$  – vector of constants;

$\beta_i$  – Matrices of autoregressive parameters;

$\varepsilon_t$  – Vector of white noise processes.



### 3. Methods

The monthly data is taken for the period from 2005M to 2015M, consisting of total 126 observations. The research philosophy of the study is positivist as based on quantitative analysis; from approach point of view it is deductive from general to specific in the sense of taking only six key variables which includes interest rate, money supply, oil price index, nominal exchange rate, and inflation and import prices. It is mono-method quantitative choice based on time series (monthly data from 2005 to 2015). In this study, VAR (Vector Auto regression) model is applied to examine the Impulse response function and variance decomposition to find out the impact of ERPT to consumer prices in Pakistan. In this study money supply, oil prices, interest rates, import prices, inflation are selected to assess the pass-through from exchange rate fluctuation. First, descriptive statistics has been computed. After, Unit root test applied to bring stationary in the data. Then lag structure tools Akaike information criterion (AIC) to find the optimal lags. Thereafter, VAR (Vector Autoregressive) is applied to assess the pass through from exchange rate fluctuations to macroeconomic variables which are taken in this study, two sets of statistics are used. First, impulse responses of money supply, oil prices, interest rates, import prices, CPI inflation to a one standard deviation shock of exchange rate are calculated. Secondly, variance decomposition of money supply, oil prices, import prices, interest rates are used to see how much of forecast variance is attributable to exchange rate fluctuations. This study employs secondary data covering the period from 2005 to 2015.

Monthly data on Import prices (IMP), Nominal exchange rate index, Money supply, interest rates and are obtained from the publication of SBP (State Bank of Pakistan). Monthly data on oil prices and inflation are obtained from Bloomberg. Many studies employing VAR model produce sensible results of impulse response and variance decomposition for obtaining shocks effect from ERPT (Exchange rate pass through) in individual countries (McCarthy). Ivanov and Kilian (2005) based on simulation design the study concludes the most accurate impulse response in terms of structure and semi structure for realistic sample sizes tends to be produced by the Akaike Information Criterion (AIC) for monthly VAR models. The optimal lags taken using AIC in this study is 12 periods so to come with accurate impulse responses results.

## 4. Results and discussion

### 4.1. Descriptive statistics

**Table 1.** Descriptive statistics

Variable	Mean	Median	STDIV	Skewness	Kurtosis
CPI	0.09	0.087854	0.042194	0.537121	3.311664
DR	0.1	0.1	0.02149	0.158335	2.209472
ER	67.21	61.582	13.12528	0.608011	1.991135
IMP	2935.40	3076.273	576.3493	-0.281468	1.944894
M2	6444.97	5851.017	2521.196	0.434988	1.980273
OP	82.82	77.84673	24.99339	0.006544	1.683392

Descriptive statistics is computed on 126 observations and results are summarized in Table 1 above.

#### 4.2. Unit root test

Phillips and Perron (1988), and Dickey-Fuller (1981) assisted to avoid false results through time series stationarity tests. Results shown in Table 2 below which are drawn from stationary test reflects rejection of null hypothesis in the first difference which signifies that there is no stationarity in all our variable series but at a level that enables us an acceptance that signifies integration of variables at first order.

**Table 2.** *Unit root test*

Factor	Remarks	ADF Test	PP Test
CPI	Series is stationary at first Difference	I(1)	I(1)
DR	Series is stationary at first Difference	I(1)	I(1)
ER	Series is stationary at first Difference	I(1)	I(1)
IMP	Series is stationary at first Difference in ADF and at Level in PP	I(1)	I(0)
M2	Series is stationary at Second Difference in ADF and at 1st Difference in PP	I(2)	I(1)
OP	Series is stationary at first Difference	I(1)	I(1)

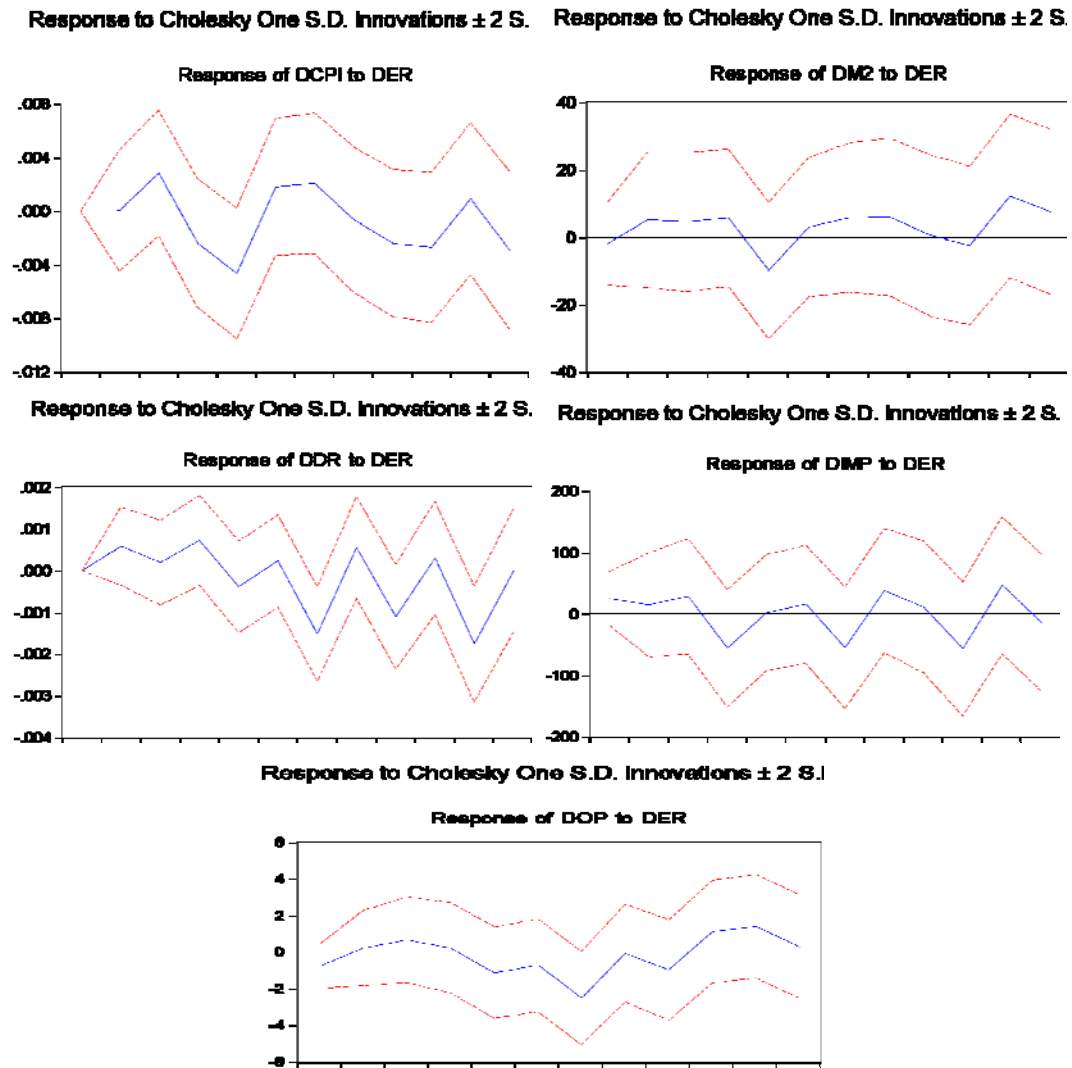
#### 4.3. Granger-causality test

Granger causality test is used to examine the existence of causality from exchange rates to interest rates, money supply, consumer price index, import prices, oil prices and vice versa and also from each of these variables to exchange rates and vice versa in order to investigate the bidirectional causality in the variable series. The results showed that only oil price helps predict CPI with P value of 0.0040 while none of rest variable helping predict CPI which also found by in the study conducted by Zaman et al. (2012) that there is no long run causality exist between CPI inflation and exchange rate. Exchange Rate helps predict discount rate with P value of 0.0056 while none of remaining variable helping predict discount rate while Money Supply (M2) helps predict Exchange Rate with P value of 0.0114 while none of other variable under this study helps predicting Exchange Rate. For import prices, only oil price helps predict import prices with P Value of 0.0025 while none of other variable is helping predict import price. Money supply and oil prices are found the most independent variable as none of variable is helping predict money supply and oil prices under this study.

#### 4.4. Impulse response

The results of impulse response are shown in Figure 2, it is seen that exchange rate pass through (ERPT) to consumer price index is low and is greatest for import prices which is also found in other studies (An and Wang, 2011).

Figure 2. Impulse Responses of Macroeconomic Variables to One Standard Deviation Innovation in Exchange Rate  $\pm 2$  S.E. <sup>(3)</sup>



Impulse responses in above graphs reflects inflation, discount rates, import prices and oil prices to a one standard deviation shock in exchange rate. The shock in exchange rate has no impact on CPI in short term as well as in long term, the shock is minimal. There is a rise in three months period afterward it started to decline to the level back. In impulse response of discount rate to a unit standard deviation shock is that till seven month period there is consistency of increase or decrease in the shocks. Along with the increase in the period of time there is an increase in the intensity of shocks as it started to move to 0.003 units. As it can be seen in the period of five, seven and eleven there is 0.001, 0.003 and

0.0035 unit shocks respectively. During period two and three, there is 100 units shocks and by the period four around 50 unit shocks and then in the period of 8, it has surged to 150 unit and plunge back to around 75 units which shows the major impact of one unit standard deviation change in exchange rate. By the period two, the shock went to around 30 units and sustained till the period of four and fall back around 15 units within one period and then rising trend is seen in the next three period till the month of 8. Surprisingly, there is a substantial surge afterwards crossing 30 units shocks which is seen in the previous periods. By the period three, the shock is around four units and by the period five it fell back below two unit shock and revert back in the seven period. In the very next period (8 month), the shock went to around 3 units adjusted to 2 units in the month 9 and then started rising again till the period eleven.

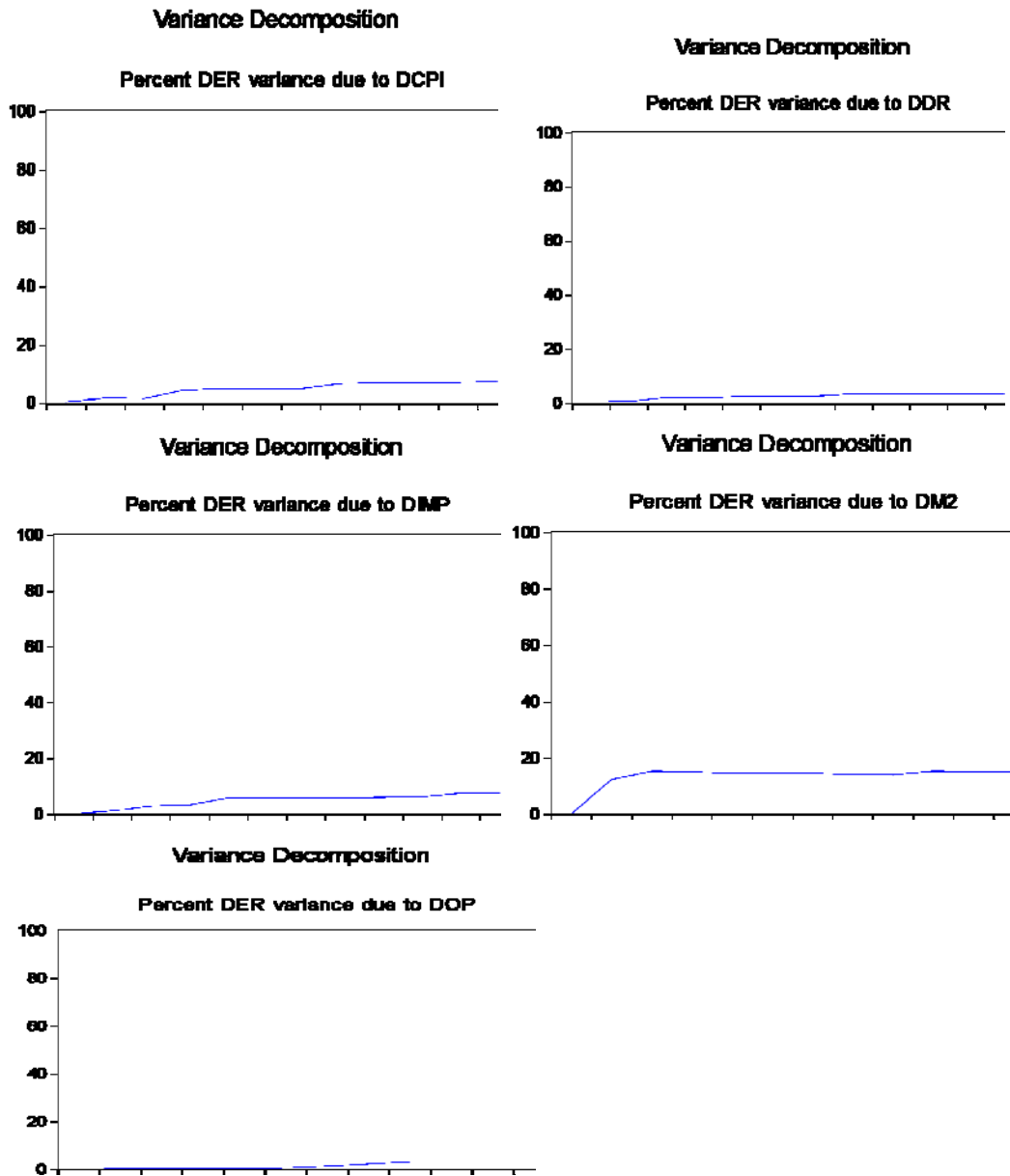
#### 4.5. Variance decomposition

Variance decomposition method is slightly different from other methods being used in VAR model (Vector Autoregressive) where by taking all variables, proportion of shock of dependent variables is measured. In this way, shock will be transmitted to all other variables in the VAR system (Brooks, 2008). Results shown in (Table 3 and Figure 3) reflects the contribution of innovation in the exchange rate to the variability of money supply, oil prices, import prices, consumer price index and discount rate. As shown in Table 3, the exchange rate shock explains only about as much as 3.03 percent, 3.38 percent, 7.19 percent, and 7.61 percent of forecast variance of oil prices, discount rate, CPI inflation and import prices respectively. Among the variables taken the major exchange rate shock explains 15.13 percent of forecast variance of money supply. It is seen in the Table 3 that 99 percent of the variance is explained by its own innovation. Across 12 period lag these values slightly differ amounting to import prices of 7.6 percent, CPI 7.19 percent, discount rate 3.25%, oil prices 2.88 percent and money supply 14.74 percent explaining the exchange rate shock. These results provide support to the claim mentioned in literature that money supply has been considered major cause as reflected in the study by

**Table 3.** Variance decomposition

Period	S.E.	DCPI	DDR	DER	DIMP	DM2	DOP
1	0.015546	0.310552	0.490878	99.19857	0.000000	0.000000	0.000000
2	0.015895	1.609379	0.664854	84.43618	1.151205	12.11649	0.021894
3	0.017601	1.451339	2.049232	78.43763	2.888398	15.13254	0.040861
4	0.017964	4.186717	2.181837	75.28053	3.319656	14.80823	0.223029
5	0.019075	4.741251	2.436786	72.39554	5.798834	14.36041	0.267186
6	0.019676	4.706344	2.541832	72.24514	5.769879	14.20585	0.530950
7	0.020399	4.802194	2.686202	71.36894	5.714490	14.21533	1.212846
8	0.020834	6.509027	3.382785	68.27827	5.774313	13.98018	2.075421
9	0.021318	6.749643	3.304445	67.19958	5.949312	13.76717	3.029847
10	0.021690	6.859454	3.296273	65.52970	6.260577	15.10195	2.952049
11	0.022074	6.934344	3.246181	64.52803	7.535852	14.84973	2.905870
12	0.023833	7.193563	3.257307	64.30823	7.605788	14.74838	2.886733

Figure 3. Variance decomposition



#### 4.6. Key findings

By employing VAR (Vector Auto Regressive) model following key findings have been explored: To check the random walk behavior and level of stationary Augmented Dickey Fuller test and Philip Pheron test have been used. At first difference all variable have become the unit cycle free while for money supply which is unit cycle free at first

difference in Phillip Pheron test. By using Granger causality test it is seen that money supply granger cause the exchange rate. The results of impulse response reflects that due to exchange rate shocks CPI has minimal impact in short run and long run which is also consistent in the study (see Fatai and Akinbobola, 2015; Wang and An, 2011; Zaman et al., 2012; Shaikh and Hussain, 2015), while discount rate has been impacted in long run and the impact intensify as period passes on. The reason can be to attract foreign investment and give boost to exports to improve balance of payment as Ahmad et al. (2014) also found the significant relationship between exchange rate and balance of payment in Pakistan scenario. Import prices are being impacted immediately along with exchange rate shock because of trade on exchange rate in this variable which is resulting volatility and correction in exchange rate as Fatai and Akinbobola (2015) also investigated the significant relationship between import prices and exchange rates in Nigerian economy. There is a rising trend in money supply along with exchange rate shock while money supply is being controlled upon the interval of every 2 to 3 lags mostly due to the fact that State Bank of Pakistan revises its monetary policy during this interval. State Bank of Pakistan comes up with monetary policy every two months. There is declining trend found in oil price by the mid period due to exchange rate shocks while there is raising trend in oil prices in long run as Kumar (2014) studied on Indian economy and found that domestic prices are significantly affected by energy prices.

The study investigates the extent and degree of exchange rate pass through to macroeconomic variables like money supply, consumer prices, oil prices, and interest rate and import prices. This study examines the effect of exchange rate shocks to these macroeconomic variables. To determine which shock better indicate the variance in import prices, money supply, oil prices, interest rate and consumer prices. In this study, for each price index forecast error variance decomposition have been studied. Another examination in this study is carried out on the degree and existence of causality from exchange rate to all other variables taken. The results from granger causality indicate that causality exists between money supply and exchange rate, oil prices and import and none in other variables. It is found that money supply granger cause nominal exchange rate. Among other variables maximum explanation of exchange rate shock is 15.13 percent of forecast variance of money supply. One of the major channels of monetary transmission mechanism which monetary authorities tend to see is exchange rate which affects the price levels for open economies like Pakistan. It is essential for policy maker to assess to what extent inflation is influenced by exchange rate. The results found in this study has useful implications related to the designing and implementation of monetary policy as there is significant relationship between money supply and exchange rate. State bank can intervene to control money supply through monetary policy which create impact on exchange rate which will be passed on import price, inflation and net trade in the economy.

More macroeconomic variables can be used or added like balance of payment, gross domestic product etc., as these variables have direct impact on the implications of monetary policy. Other econometric methodology can be employed to examine the long

term exchange rate pass through on other variables and the variables used in this study. To capture the monetary policy framework being used in Pakistan, foreign exchange inflows can be taken as a variable in the model as monetary policy plays a vital role in affecting the price levels. Different tests can also be applied like heteroscedasticity test and multicollinearity test. This study is conducted on macroeconomic variables like money supply, oil prices, import prices, interest rate and consumer prices. The extent and degree of exchange rate pass through can also be examined at cross country level.

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## Notes

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- (1) McCarthy has analyzed the impact of exchange rate change & import price fluctuations on producer and consumer prices in six industrialized OECD countries from 1976:1 to 1998:4. The impulse response function and variance decomposition show that the exchange rate has a modest effect on domestic price over the post-Bretton Woods era.
- (2) SBP (State Bank of Pakistan) use monetary aggregate M2 as intermediate target so to incorporate the SBP reaction in the model.
- (3) The dashed lines are two standard error bands and impulse response estimated using Eviews 8.

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