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Shocks to Monetary Policy and Response of Commodity Prices in Pakistan: Structural Vector Autoregressive Approach

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Abstract: Present paper analyzes channels, through which monetary policy influences commodity price in Pakistan, employing Structural Vector Autoregressive Technique (SVAR) methodology covering time period 1991q1-2014q4. Empirical results indicate that tight monetary policy shocks have positive effects on commodity prices, that respond quickly to policy shocks and cost push supply shocks are dominant in Pakistan. Moreover, tight monetary policy has negative effects on real activity of economy, i.e., industrial productivity. Impulse response also demonstrates similar results and commodity prices response positively to positive interest rate shocks.

Key words: Monetary policy, Interest rate, Shocks, Commodity price, SVAR.

INTRODUCTION

Monetary policy is considered as a vital policy instrument to control inflation rate. Monetary policy affects price and output of an economy through multiple channels, e.g., interest rate channel, desire for holding cash, credit channels, exchange rate channel and also through altering prices and value of other assets. However, theoretical debates on monetary policy and empirical literature exhibited that monetary policy influenced real activity only in short run, while in long run, it only influenced nominal variables. According to monetarist school of thought, inflation is always and everywhere a monetary phenomenon and does not have any impact on real variables. Similarly, according to classical and neo-classical schools of thought in long run money supply leads to inflation while output remains constant, at the same time, classical theory advocates that in short run money supply may affect real output due to underemployment. According to Keynes School of Thought, aggregate demand is a key factor for resolving economic issues, e.g., unemployment and extreme business cycle phases. Keynes elaborates that monetary policy affects real output in short run, due to price and wage rigidity, but in long run, money supply affects only inflation, while real output remains constant. Theoretical debate depicts that other causes of inflation are cost push, demand pull inflation and future expectation about price. According to neo classical, correctly anticipated monetary shocks have proportional effects on nominal variable, while it has no effect on real variables (Nagel and Parker, 2003). Similarly, unanticipated monetary shocks have greater effects on real variables. Empirically, Anzuini *et al*., 2010 explored that future expected price also lift-up demand and prices. Rahman and Hasan (2011) investigated that besides monetary policy decision interest rate was also affected by future expectations of speculators. Monetary policy had a greater effect on market rate in case of speculation having good understanding of monetary policy. Moreover, Anzuini *et al*. (2010) and Frankel (2007) revealed that monetary policy and interest rate were main driving forces of commodity price and monetary policy affects commodity price through supply and demand forces. From demand side, low interest rate (expansionary policy) reduces opportunity cost of holding money, increases demand for commodities which in turn raises price level of economy (Anzuini *et al*., 2010). From supply side, low interest rate induces firms to not extract their inventories which in turn diminish supply level and lift up prices of economy (Anzuini *et al*., 2010). Similarly, Frankel (2006), keeping in view Dornbusch overshooting theory, explored that high interest rates lead to diminish prices through reducing demand for carrying commodity inventories thereby encouraging speculators to shift out of commodity contracts into treasury bills.

Previous empirical studies also depicted nominal effects of monetary policy. Komijani *et al*. (2012) studied effect of negative and positive monetary policy shocks on the economy. They explored that positive shocks had larger effects on economy, i.e.,

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lead to increment in price and production but inflation is affected at a greater extent as compared to production (convex supply curve). Moreover, negative monetary policy shocks were adapted to control inflation, which in turn lead to reduction in growth at a greater extent. Joao and Andrea (2007) investigated that a change in unexpected monetary aggregates caused permanently increment in price level with temporary increment in real level of global output. Ahmadia and Harald (2012) explored that tight monetary shocks lead to persistent reduction in CPI but on other side effects of policy on GDP are non-obvious and monetary policy shocks account for less than 10% of the negative variation in industrial production along with the federal funds rate. Ivrendi and Zekeriya (2013) explored that contractionary monetary policy caused increment in interest rate, appreciation of domestic currency and reduction of output growth. Similarly, Christiano *et al.* (1996) revealed that tight monetary policy was associated with increment in bank rate and decline in real activity, additionally tight monetary policy leads to sharp reduction in commodity prices and delayed decline in GDP deflator. Fung and Marcel (1997) investigated that in long term expansionary monetary policy increased price level and reduced short term interest rate but monetary policy had no effect on real variable, i.e., output, real interest rate and employment. Kim (1999) found out that policy had significant effects on real output only in short run and in long run monetary authorities could obtain significant consequences by changing its systematic reactions to the state of economy. Kahn *et al.* (2002) explored that effects of monetary policy shocks on short run interest rate and industrial output were greater as compared to long term interest rate. Kim and Roubini (2000) indicated that theoretically monetary contractions caused reduction in interest rate and increment in price but on other side in case of exogenous monetary shocks no theory implies and monetary policy has no influence on price and output[1].

Javid and Kashif (2010) also investigated that monetary policy influenced interest rate, price and output level depending upon demand and supply force of economy. They explored that, from demand side, tight monetary policy raised interest rate and higher interest rate increases opportunity cost of holding money thus consumers prefer to utilize money for speculative purpose and reduce transaction demand for money. Reduction in transition demand leads to backward shift in demand for consumer goods thus general price level also goes downward. They also reported, "sometime output and prices react contrary to the theoretical transmission mechanism of monetary policy, recognized as price puzzle". Hanson (2004) explored that commodity price puzzle arose in case of increment in price level in response of tight monetary policy. Price puzzle occurs in economy from supply side forces of economy, i.e., higher interest rate due to tight monetary policy lift up cost of borrowing for industries and raises input cost of capital which, in turn, induces producers to increase prices of commodities in order to compensate their cost.

In order to analyze price puzzle, commodity price index is used because commodity prices respond more quickly to monetary policy and it is considered as indicator of expected future inflation. Hanson (2004) demonstrated that commodity price was a successful indicator to mitigate the price puzzle. According to Sims (1992), the inclusion of commodity price removed the problem of price puzzle and investigated that 'commodity prices serve as information variable and considered as an indicator of nascent inflation'. Castelnuovo and Paolo (2009) ended up with the results that positive price response was associated with weak repose of interest rate to monetary policy. They demonstrated that positive price response was associated with weak response of interest rate to monetary policy.

Monetary policy framework in Pakistan

Pakistan is facing problem of inflation since last few decades and the central bank is implementing different monetary instruments to control inflation. State Bank of Pakistan (SBP) has the authority of monetary policy formulation and Act 1956 of SBP presents legal set-up of monetary policy framework in Pakistan. Main instrument of central bank is monetary aggregate (M2) used to control inflation based on two assumptions: firstly, demand for M2 function is stable; secondly, it has strong association with the rate of inflation (Qayyum, 2008; Rahman and Hasan, 2011). However, State Bank of Pakistan (SBP) puts into practice multiple monetary policy instruments with objective to control inflation and enhances economic growth. Initially, SBP used monetary aggregate, i.e., broad money as intermediate and reserved moneys operational target to obtain its target. In mid 1990s, SBP decided to use a liberal policy and market oriented instrument, i.e., SBP adopted 3-day discount rate as a main policy instrument. Similarly, after weakness of financial sector and structural changes in the economy, SBP moved toward eclectic approach, i.e., moved from reserve money to overnight money market from January 2009 (Hanif, 2014). Hence, SBP employed multiple instruments to achieve its targets but, according to Hanif (2014), Pakistan's inflation rate was equal to difference between broad money growth rate and real output growth and this elaborates that inflation is purely monetary phenomenon in Pakistan. Khan (2008) demonstrated that, in case of Pakistan, positive monetary shocks enhanced output and inflation only in short run and this positive effect on output and inflation disappears between 23 to 32 and 12 to 18

[1] Higher interest rate increase opportunity cost of holding money and consumer prefer to utilize money for speculative purpose so, demand and price for consumer goods fall.

months horizon, respectively. Moreover, according to Khan (2008), real demand shocks had stronger effect on output while nominal shocks strongly affect inflation rate of economy. Kahn *et al*. (2002) explored that monetary policy shocks caused 0.4% increments in one year interest rate but inflation expectations fall by 0.6% points. Malik (2006) investigated that monetary policy affected inflation with a lag of half year and then got another one year to arrive at the peak. Further, Malik (2006) suggested that policy makers should take into account the identification of variables responsible for inflation and they should keep in view supply side factor and foreign inflation at time of policy formulation. Qayyum and Nadeem (2006) explored that monetary variables were the reason of inflation in Pakistan rather than real variables. Likewise, in case of Pakistan, money supply affects inflation with lag of one year. Qayyum and Nadeem (2006) further explored one to one relation between inflation and growth in money supply plus growth in real income and growth in velocity of money in long run.

Previous literature also elaborates existence of price puzzle in Pakistan, e.g., Rashid and Jehan (2014); Javid and Kashif (2010) investigated existence of price puzzle in Pakistan economy. Javid and Kashif (2010) and Khan and Qayyum (2007) concluded that supply shocks were dominant in Pakistan and tight monetary policy raises discount rates, discourages private sector investment and leads to rise in price level. Choudhri *et al*. (2015) concluded that monetary policy shocks had insignificant effects on real GDP negative and effects on inflation.

The main objective of this study was to analyze the channels, through which monetary policy influences commodity price and economy of Pakistan. Previous studies analyzed the role of monetary policy towards consumer price index but present paper analyzes the effects of monetary tools towards commodity price index of Pakistan.

METHODOLOGY

Monetarist are of view that money supply has affective outcomes only in short run while in long run money supply affects only price level of economy. Milton Friedman proponent of monetarist school of thought states that inflation is always monetary phenomenon. According to him, an increase in money supply affects output only in short run but in long run producers and consumers anticipate money supply and adjust prices and wages accordingly, which leads to an increase in inflation in economy keeping output level constant. Similarly, classical dichotomy also depicts that money supply affects only nominal variables, i.e., nominal wages, nominal GNP and money balance, while real output remains constant. By keeping in view monetarist vision, the role of monetary policy on commodity price in case of Pakistan will be estimated.

Following Anzuini *et al.* (2010), our model can be written in the following form;

$$\mathrm{WPI} = \alpha_0 + \alpha_1(\mathrm{M}_2) + \alpha_3(\mathrm{ir}) + \alpha_4(\mathrm{CPI}) + \alpha_5(\mathrm{IPI}) + \varepsilon \ldots 1$$

where, WPI refers to commodity price index, Wholesale Price Index (WPI) is employed here to evaluate commodity prices of economy. In simple words, WPI represents the wholesale price of a basket of goods over time or prices charged by manufacturers and wholesalers and it is considered as the best indicator of inflation or average change in prices of traded goods in the whole sale market. For the sake of estimation, data series of Wholesale Price Index is used and the data is taken from International Financial Statistics (IFS) 2014. M2 and IR are money supply and call money rate, respectively. In order to estimate IR, data series of money market rate is used while data is taken from IFS. Similarly, for estimation of money supply, data series of broad money (M2) is used, while data is taken from Annual Report of State Bank of Pakistan.

CPI and IPI refer to consumer price index and industrial productivity index, respectively. For the sake of estimation, data series of Consumer Price Index is used and the data is taken from IFS statistics 2014. For industrial productivity index, data series of manufacturing production is used and data is taken from IFS.

Interest rate and its effects on commodity prices

Interest rate or money market rate means short term interest rate provided by banks to brokers. Money market is considered as important tool to affect different sectors of economy, e.g., inflation, commodity prices, investment decision, inventories decision of economy.

According to previous literature, interest rate affects commodity price from supply and demand forces of economy. Anzuini *et al.* (2010) explored that from demand side lower interest rate reduced cost of holding money, raised demand for commodities (reduction in speculative demand for money and increment in transitive demand for money), which in turn, increases prices level in economy. From supply side, lower interest rate induces firms to reduce supply of commodities by increasing the desire for holding inventories as cost of holding inventories fall and consequently spot and expected price rise in economy (Anzuini *et al.*, 2010; Frankel, 2013). In short, high interest rate induces consumers to use money for speculative purpose, producers to reduce inventories and extract minerals, livestock and other oil today rather than tomorrow and all these factors lead to reduce price level.

Money supply and its effects on commodity prices

M2, i.e., money supply, shows total monetary assets available in economy. M2 is considered as broad money and modern economists prefer to use M2 to estimate money supply because it includes highly liquid assets.

Money supply affects inflation and commodity prices of economy, e.g., increment in money supply influences commodity prices through Fischer effect, while output level of economy remains constant. Moreover, changes in money supply affect inflation and interest rate and then changes consumption pattern, investment, employment and trade balance of economy.

Frankel (2006) argues that in short period contraction in money supply influences nominal interest rate and reduces demand for commodities as individuals prefer to hold treasury bills for speculation purpose and hence price level of commodities falls down, but in long run, individuals foresee expected inflation and prices of commodities and wages are adjusted to money supply of economy. Moreover, an increment in money supply induces producers to increase inventories, due to low cost of holding inventories, which creates supply shortage and in turn the price level rises in economy.

Consumer prices and its effects on commodity prices

Consumer price index (CPI) is considered as headline inflation and affects money supply, supply of goods, government price adjustment strategies also cause global food and oil prices. Commodity prices are also affected by consumer prices index because both are types of inflation and increase in one due to any external factor and the other also increases, e.g., future uncertainty about inflation (expected future inflation), fear of supply shocks or unavailability of goods in future or negative supply shocks. Uncertainty about increment in future oil prices influences current demand and induces consumer and producer to increase demand for commodities and hence affects price level of commodities in current time period. Alquist and Kilian (2010) revealed the importance of precautionary demand shocks, which enhance current demand for oil and other commodities due to an increase in uncertainty about future oil supply. Similarly, sometimes consumers think that in future supply will fall short of demand so they increase demand for commodities in current time which leads to increase in the commodity prices of economy.

Industrial productivity index and commodity prices index

Industrial productivity index (IPI) also affects prices level of commodities through negative supply shocks. Reduction in industrial productivity trims down supply of commodities (negative supply shocks) and hence supply becomes lesser than demand from commodities and creates problem of excess demand. Excess demand in turn induces current inflation and general commodity price level goes up in economy. Similarly, shortage of credit and problems involved in availability of credit discourage industrial sector and reduces industrial productivity, i.e., supply falls short of demand which in turn raises commodity prices in economy. Khan (2008) demonstrates that industrial sector is the largest recipient of bank credit and reduction in money supply influences commodity supply and price through credit lessening and higher borrowing cost.

Structural vector autoregressive technique (SVAR)

SVAR model is used in this study to analyze monetary policy shocks. SVAR model was introduced in eighties for analyses of impulse response. Later on, Sims (1980) presented recursive SVAR model for estimation of contemporaneously correlated variable. Present study estimates model of study through SVAR system employing five variables, i.e., CPI (consumer price index) and the WPI (commodity price index), M2 (broad money), IR (call money rate) and IPI (industrial productivity index). SVAR model is used here because in our model on one side, policy shocks affect commodity prices while on other side commodity prices also affect monetary policy decision of economy. Policy makers formulate policies by keeping in view inflation and commodity price level of economy and similarly consumer and commodity prices index are also affected by policy variables. Simple VAR or simultaneous equation of our model is given below;

$$Y_t = \alpha_{10} - \alpha_{11}X_t + \gamma_{11}Y_{t-1} + \gamma_{12}X_{t-1} + \varepsilon_{1ti} \quad \ldots 2(a)$$

$$X_t = \alpha_{20} - \alpha_{21}Y_t + \gamma_{21}X_{t-1} + \gamma_{22}Y_{t-1} + \varepsilon_{2ti} \quad \ldots 2(b)$$

In equation 2(a) and 2(b) Y_t refers to vector of outcome variables (that is commodity price index WPI), X_t is vector of policy variables (M2 and IR) and other variable (IPI and CPI index) used in our study. Coefficients α_{ii} illustrates matrix of contemporaneous variable and γ_{ii} refers to matrix of instantaneous variable while ε_{1ti} and ε_{2ti} are error terms. Adding contemporaneous coefficients on right side of equation 2(a) and 2(b);

$$Y_t + \alpha_{11}X_t = \alpha_0 + \gamma_{11}Y_{t-1} + \gamma_{12}X_{t-1} + \varepsilon_{1ti} \quad \ldots 3(a)$$

$$\alpha_{21}Y + X_t = \alpha_{20} + \gamma_{21}Y_{t-1} + \gamma_{22}X_{t-1} + \varepsilon_{2ti} \quad \ldots 3(b)$$

Converting model 3(a) and 3(b) in matrix form;

$$\begin{bmatrix} 1 & \alpha_{11} \\ a_{21} & 1 \end{bmatrix}\begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} \alpha_{20} \\ \alpha_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}\begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1ti} \\ \varepsilon_{2ti} \end{bmatrix} \ldots A$$

Writing above matrix in equation format;

$$\alpha_1 Y_t = \alpha_0 + \lambda_{t-1}Y_{t-1} + \varepsilon_t \quad \ldots 4$$

Multiplying a on both side of equation with α_1^{-1},

$$Y_t = \alpha_0\alpha_1^{-1} + \lambda_{t-1}Y_{t-1}\alpha_1^{-1} + \varepsilon_t\alpha_1^{-1} \quad \ldots 5$$

where,

$$\alpha_0\alpha_1^{-1} = A_0 \quad \ldots i$$

$$\lambda_{t-1} Y_{t-1} \alpha_1^{-1} = A(L) Y_{t-1} \quad \ldots \text{ ii}$$

$$\varepsilon_t \alpha_1^{-1} = \mu_t \quad \ldots \text{ iii}$$

By putting the value of equation i, ii and iii in equation 5, the SVAR form or reduced VAR model is written as;

$$Y_t = A_0 + A(L) Y_{t-1} + \mu_t \quad \ldots 6$$

In equation Y_t is vector of endogenous variables, these are $m_2, ir, cpi, wpi, ipi,$ while μ_t is vector of reduced form or endogenous shocks, i.e., $\mu_t^{m2}, \mu_t^{ir}, \mu_t^{cpi}, \mu_t^{wpi}, \mu_t^{ipi}$ with no or zero auto co-relation.

As depicted in equation iii;

$$\mu_t = \varepsilon_t \alpha_1^{-1} \quad \ldots \text{ iii}$$

In above equation, ε_s denotes the structural disturbances while μ_s are the residuals in the reduced form equations and help to estimate relationship between reduced form and structural shocks. Multiplying equation iii with α_1;

$$\mu_t \alpha_1 = \alpha_1 \varepsilon_t \alpha_1^{-1} \quad \ldots 7$$

Whereas, $\alpha_1 \alpha_1^{-1}$ is identity matrix;

$$\mu_t \alpha_1 = I \varepsilon_t \quad \ldots 8$$

By keeping in view equation 8, relationship between reduced form shocks and structural shocks can be represented by the following model.

$$A\mu_t = B\varepsilon_t \quad \ldots 9$$

Writing equation 9 in matrix form;

$$\begin{bmatrix} 1 & \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} \\ \alpha_{21} & 1 & \alpha_{22} & \alpha_{23} & \alpha_{24} \\ \alpha_{31} & \alpha_{32} & 1 & \alpha_{33} & \alpha_{34} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 & \alpha_{44} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{m2} \\ \mu_t^{ir} \\ \mu_t^{cpi} \\ \mu_t^{jpi} \\ \mu_t^{spi} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{m2} \\ \varepsilon_t^{ir} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{jpi} \\ \varepsilon_t^{wpi} \end{bmatrix}$$

In above matrix, μ_t^{m2}, μ_t^{ir} are policy variables (monetary aggregate and interest rate respectively), while μ_t^{wpi} is target variable (commodity price shocks). In above matrix, μ_t^{cpi}, μ_t^{ipi} are vector of other variables those affecting our target variable, i.e., consumer price index and industrial productivity index respectively.

Identification of restrictions in SVAR: Next step in SVAR model is identification of restriction in order to estimate contemporaneous response of variables that is short run restriction and long run restrictions.

Short run restrictions: Following recursive ordering and using Cholesky decomposition (for identity matrix), the model takes the following matrix form:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \alpha_{21} & 1 & 0 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & 1 & 0 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 & 0 \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{m2} \\ \mu_t^{ir} \\ \mu_t^{cpi} \\ \mu_t^{ipi} \\ \mu_t^{wpi} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{m2} \\ \varepsilon_t^{ir} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{ipi} \\ \varepsilon_t^{wpi} \end{bmatrix}$$

Long run restrictions: Blanchard and Quah (1989) methodology is used to estimate long run theory-based restrictions. This methodology assumes two types of shocks, aggregate demand shocks and aggregate supply shocks and evaluate role of exogenous shocks on endogenous variables. In order to identify the SVAR model, where 10 restrictions are needed, i.e.,

$$\frac{n(n-1)}{2} = \frac{5(5-1)}{2} = 10.$$

$$\begin{bmatrix} \varepsilon_t^{m2} \\ \varepsilon_t^{ir} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{ipi} \\ \varepsilon_t^{spi} \end{bmatrix} = \begin{bmatrix} 1 & \alpha_{11} & 0 & 0 & \alpha_{14} \\ \alpha_{21} & 1 & \alpha_{22} & \alpha_{23} & 0 \\ 0 & 0 & 1 & \alpha_{33} & 0 \\ 0 & 0 & 0 & 1 & 0 \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{m2} \\ \mu_t^{ir} \\ \mu_t^{cpi} \\ \mu_t^{ipi} \\ \mu_t^{wpi} \end{bmatrix}$$

The above matrix indicates a long run identification of model, where ε_s denote the structural disturbance, while μ_s are the residuals in the reduced form equations. The detail description of matrix C is depicted below;

The first row of matrix measures the behavior of money supply in response of other variable included in the study. According to first row of matrix, coefficient of μ_t^{cpi} and μ_t^{ipi} are zero, i.e., CPI and IPI do not affect money supply contemporaneously and Anzuini *et al.* (2010) indicated that such type of information was not available contemporaneously to monetary authority in long run. Interest rate and commodity inflation affects money supply, e.g., rise in interest rate induces policy makers to supply money through purchase of bond and securities.

The second row of matrix measures the behavior of interest rate in response of other variables included in study. The second row indicates that speculative demand for money, i.e., μ_t^{ir} is affected contemporaneously by money supply, industrial productivity (reduction or increment in production) and consumer price index. For the reason that, reduction in money supply and increment in CPI raises interest rate contemporaneously.

The third row of matrix measures the behavior of Consumer Price Index in response of other variables included in the study. According to third row μ_t^{cpi} is affected by μ_t^{ipi} contemporaneously because reduction in industrial production creates problem of shortage of good and leads to increase in consumer

prices. Moreover, policy variables affect μ_t^{cpi} only with lag value because time lag is involved between action of monetary authorities and its effects on economy.

Fourth row of matrix indicates the behavior of IPI in response of other variable included in study. As, real activity of economy μ_t^{ipi} responds to consumer price index and commodity price index only with a lag, so in fourth row their coefficients are assumed to be zero. CPI and WPI affect IPI with a lag because current inflation affects output with a lag of one year. For the reason that time lag is involved in production process and supply of final products in market. So, increment in prices of inputs in current time raises cost of production which in turn affects total output and supply of final products in future**.** There are different schools of thoughts about policy variables (i.e., money supply and interest) and its effects on real activity. According to Keynes money is neutral and affects nominal variables while money has no effects on real activity of economy, i.e., output and employment. On other side, according to monetarist and neo-classical monetary is not neutral in short run and state bank can stabilize growth through altering money supply but in long run money is neutral. By keeping in view above theory, the coefficients of interest rate and money supply are kept zero in above matrix.

The last row of matrix measures the behavior of commodity prices (μ_t^{wpi} , i.e. target variable of the model) in response of other variable included in the study. According to Anzuini *et al.* (2010), the last row is known as arbitrage equation[2], which elaborates equilibrium in the commodity market in response of financial and macroeconomic variables of economy, i.e., money supply, interest rate, industrial productivity and CPI.

RESULTS AND DISCUSSION

For the sake of lag length selection, Schwarz and Akaike information criteria is used. In our model, lag length is one according to Schwarz criteria, as shown in Table 1.

Table 1: Lag length criteria.

Lag	SC	HQ
0	3.875491	3.793190
1	–3.630916*	– 4.124724
2	–2.875865	–3.781180

Short run estimated coefficients

Present section contains the results of short run, as tabulated in Table 2.

[2] **Arbitrage pricing theory (APT)** refers to method of estimating assets prices with assumptions that asset's return depends on various macroeconomic variables.

Table 2: Estimated short run coefficients of matrix A.

Coefficients of matrix	Coefficient	z-Statistic	Prob.
α_{21}	0.127714	0.207897	0.8353
α_{31}	0.001591	0.167007	0.8674
α_{32}	-0.002258	-1.412506	0.1578
α_{41}	-0.069993	-1.841955	0.0655**
α_{42}	-0.013580	-2.107091	0.0351*
α_{43}	-0.575077	-1.397590	0.1622
α_{51}	-0.005076	-0.707654	0.4792
α_{52}	0.000369	0.301781	0.7628
α_{53}	-0.824065	-10.68942	0.0000*
α_{54}	-0.008913	-0.465986	0.6412

*, ** Indicate significant at $p < 0.05$ and $p < 0.10$ respectively.

Results are also symbolized in matrix form as given below.

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.127714 & 1 & 0 & 0 & 0 \\ 0.001591 & -0.002258 & 1 & 0 & 0 \\ -0.069993 & -0.013580 & -0.575077 & 1 & 0 \\ -0.005076 & 0.000369 & -0.824065 & -0.008913 & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{m2} \\ \mu_t^{ir} \\ \mu_t^{cpi} \\ \mu_t^{ipi} \\ \mu_t^{wpi} \end{bmatrix} = \begin{bmatrix} 0.34309 \\ 2.04349 \\ 0.03167 \\ 0.12635 \\ 0.02343 \end{bmatrix} .....A$$

The above matrix illustrates a matrix of short run coefficients.

According to second row of matrix A, monetary aggregate (μ_t^{m2}) has insignificant impact on interest rate (μ_t^{ir}) in short run because interest rate is not affected by money supply contemporaneously. Similar results are shown in Table 2, by coefficient α_{21}, i.e. interest rate, have insignificant effects on monetary aggregate. Third row of matrix indicates policy variables (μ_t^{m2} , μ_t^{ir}) have insignificant impact on *CPI* (μ_t^{cpi}) because *CPI* is affected by lag value of policy variable. Likewise, Table 2 elaborates insignificant effects of policy variables on *CPI* as depicted through coefficients α_{31} and α_{32} . Fourth row of matrix (A) depicts that *IPI* (μ_t^{ipi}) is affected negatively by interest rate shocks (μ_t^{ir}) because an increment in interest rate increases cost of borrowing and reduces output of industries. In the same way, money supply (μ_t^{m2}) is negatively related to *IPI* because higher money supply creates inflationary pressure, enhances cost of inputs and reduces output level. Table 2 also elaborates negative effects of policy variables on industrial productivity because coefficients α_{41} and α_{42} are significant at $p < 0.05$ level. According to fifth row of matrix A, tightening of monetary policy has negative effect on *WPI* (μ_t^{wpi}) and interest rate is positively related to WPI and the results are persistence with Anwar (2012), Jaehan and Abdul (2014), Javid and Kashif (2010). Detail results

are depicted in Table 2, coefficient on interest rate (α_{51}) and coefficient of money supply (α_{52}) are negative and insignificant in short run. The reason is that the supply shocks are dominant in Pakistan and tight monetary policy raises interest rate, which in turn increases cost of borrowing and boosts commodity prices of economy. Likewise, *CPI* has negative and significant (at p < 0.01) impact on *WPI* because in short run consumer cannot foresee inflationary pressure (the same results are shown by coefficient α_{53} in Table 2). Similarly, in short run increment in prices induces consumer to postpone their demand for some commodities and consequently overall commodity prices level go down because of a decrease in demand. According to matrix increment in *IPI* (μ_t^{ipi}) has negative but insignificant impact on commodity price in short run as shown in Table 2 by coefficient α_{54}.

Long run estimated coefficients

The results of long run restricted estimated coefficients are depicted in this section (Table 3).

Table 3: Estimated long run coefficients.

Coefficients of matrix	Coefficient	z-Statistic	Prob.
α_{11}	-1.549735	-0.269065	0.7879
α_{14}	-11.08417	-14.87204	0.0000*
α_{21}	4.957776	13.17539	0.0000*
α_{22}	14.74368	28.31430	0.0000*
α_{23}	0.998901	0.621448	0.5343
α_{33}	1.445587	14.01548	0.0000*
α_{51}	-0.029514	-2.228238	0.0259**
α_{52}	0.019941	0.038399	0.9694
α_{53}	1.388819	101.5733	0.0000*
α_{54}	1.808245	12.56626	0.0000*

*,** Indicate significant at p < 0.05 and p < 0.10 respectively.

Estimated results are also represented in the following matrix form.

$$\begin{bmatrix} \varepsilon_t^{m2} \\ \varepsilon_t^{ir} \\ \varepsilon_t^{cpi} \\ \varepsilon_t^{ipi} \\ \varepsilon_t^{spi} \end{bmatrix} = \begin{bmatrix} 1 & -1.549735 & 0 & 0 & -11.0841 \\ 4.957776 & 1 & 14.74368 & 0.998901 & 0 \\ 0 & 0 & 1 & 1.445587 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ -0.029514 & 0.019941 & 1.388819 & 1.808245 & 1 \end{bmatrix} \begin{bmatrix} \mu_t^{m2} \\ \mu_t^{ir} \\ \mu_t^{cpi} \\ \mu_t^{ipi} \\ \mu_t^{wpi} \end{bmatrix} ..B$$

The above matrix illustrates a matrix of long run coefficients. According to first row, in long run estimated coefficient of interest rate (μ_t^{ir}) is negative and insignificant impact on money supply which implies that when interest rate increases, central bank increases money supply to reduce interest rate. Similarly, α_{11} also depicts insignificant results of interest rate on money supply in Table 3. Moreover, *WPI* (μ_t^{wpi}) has negative and significant effects on money supply (μ_t^{m2}) because *WPI* is considered as good indicator of inflation and monetary authority reduces money supply to control inflation through keeping in view *WPI* (see coefficient α_{14} in Table 3 for detail). Sims (1992) explored that inclusion of commodity price removed problem of price puzzle and investigated that 'commodity prices are considered as an indicator of nascent inflation'.

According to 2nd row of matrix B, M2 have positive and significant effects on interest rate (μ_t^{ir}) for the reason that interest rate in Pakistan follows inflation and there exists strong positive correlation between them (Javid and Kashif, 2010). This positive correlation also indicates the presence of liquidity puzzle in Pakistan. Similar results are depicted in Table 2 through coefficient of interest rate α_{22}, i.e., significant at 1% level, i.e., $p < 0.01$. Furthermore, *CPI* (μ_t^{cpi}) has also positive and significant influence on coefficient of interest rate (μ_t^{ir}) because both moved in same direction in case of Pakistan. Similarly, Table 3 also reveals through coefficient α_{22} that *CPI* has positive influence on interest rate and results are significant at 1% level. Additionally, *IPI* (μ_t^{ipi}) has positive effects on interest rate because increment in borrowing of industrial sector raises money demand and hence interest rate of economy and similar detail is depicted in Table 3 through coefficient α_{23}.

According to 3rd row of matrix B, *IPI* has positive and significant effects on *CPI* because increment in industrial output widens demand for inputs and also price level of economy. Likewise, Table 3 elaborates that α_{33} coefficient is significant at 1% and *CPI* is positively affected by *IPI* index in long run.

Fourth row of matrix B and coefficient α_{51} of Table 3 indicates that in long run M2 has negative and significant effects on *WPI* (μ_t^{wpi}) because an increment in money supply reduces the interest rate and raises investment level in economy which in turn leads to reduce commodity prices in economy. Moreover, interest rate has positive and insignificant effects on *WPI* as shown in matrix B and through coefficient α_{52} in Table 3, means reduction in interest rate reduces commodity prices and vice versa. This elaborates that *WPI* responds more quickly to money supply in Pakistan. In the long run, *IPI* have positive and significant influence on *WPI* as depicted by coefficient α_{53} in Table 3 and fourth row of matrix B. The reason is that the increment in industrial productivity causes the widen demand for industrial input which leads to increase in *WPI* of economy. Likewise, in long run *CPI* have positive and significant influence on *WPI* because both are a

kind of inflation and increment in CPI due to any external factor leading to boost level of WPI. Similar results are provided in Table 3, as coefficient α_{54} indicated *WPI* is affected positively by *CPI* and results are significant at 1% level.

IMPULSE RESPONSE FUNCTION

This section analyzes impulse response to policy variable, i.e. *M2* and *IR* (Money supply and call money rate, respectively).

Figure1 demonstrates the response of *CPI* (consumer price index), *WPI* (commodity price index), *IPI* (industrial productivity index) and *IR* (interest rate) to *M2* (monetary aggregate).

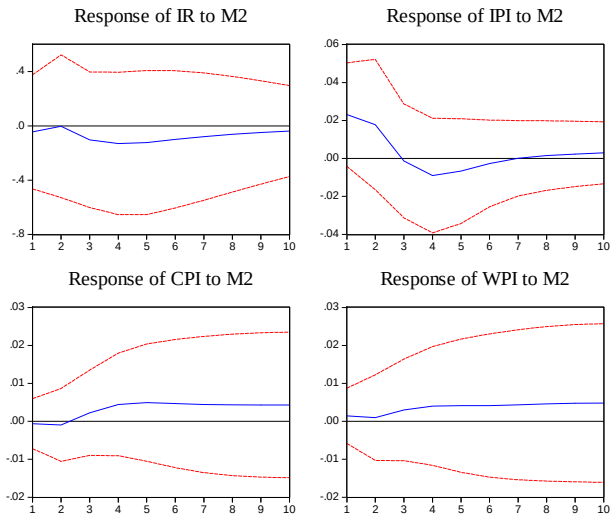

Fig. 1: Response to Cholesky One S.D. Innovations 2 ± S.E.

Response of M2 to IR: Figure 1 reveals that initially interest rate responds negatively to positive monetary policy shocks (first four quarter) but afterwards responds positively and moves towards convergence after 10th half quarter. This indicates that initially interest rate decreases with rise in money supply (theoretical negative relationship) but afterwards interest rates goes upward due to inflationary effects.

Response of CPI to IR: Figure 1 demonstrates initially CPI responds negatively to monetary aggregate but after 2th half quarter CPI responds positively becomes persistent and steady after 6th quarter because time lag is involved in response of inflation to policy.

Response of IPI to IR: Figure 1 indicates IPI fluctuates and responds negatively initially (first three quarters) but afterwards IPT responds positively to expansionary monetary policy. According to Fig. 1, IPI becomes stable and converges to zero after 10th quarter. This illustrates that initially expansionary monetary policy reduces industrial productivity due to increment in input prices but afterward productivity increases due to increment in money supply and smooth availability of credit.

Response of WPI to IR: The repose of WPI is similar to *CPI*, initially *WPI* responds negatively then responds positively during 2nd to 4th quarter but afterwards *WPI* becomes persistent and statically significant (Fig. 1).

Figure 2 demonstrates response of *CPI* (consumer price index), *WPI* (commodity price index), *M2* (broad *money*) and *IPI* (industrial productivity index) to *IR* (interest rate).

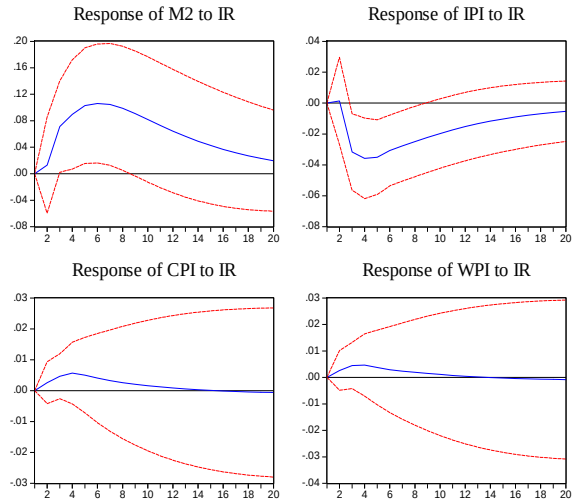

Fig. 2: Response to Cholesky One S.D. Innovations 2 ± S.E.

Response of M2 to IR: Figure 2 indicates persistent rise in monetary aggregate in the response of interest rate till 20th quarter and then monetary aggregate becomes stable after 20th quarter. It means a rise in interest rate induces speculators to reduce their demand for commodities and they spend money for speculation purposes for example purchase bonds and treasury bills.

Response of IPI to IR: Figure 2 indicates IPI responds negatively to interest rate shocks in Pakistan because the rise in interest rate increases cost of borrowing and discourages output level. Figure 2 further indicates that after 6th quarter IPI responds positively to interest rate shocks and it becomes stable.

Response of CPI and WPI to IR: Figure 2 also demonstrates that both WPI and CPI respond positively till 5th quarter but afterwards start declining and become stable after 10th quarter. This illustrates that initially cost push supply shocks are dominant in Pakistan and create inflationary pressure in Pakistan and afterwards these shocks become stable and converge after 10th quarter.

CONCLUSION

In this paper we analyzed impact of policy variable on commodity price in Pakistan. Results indicate that commodity prices counter positively to tight monetary policy shocks. Commodity prices respond quickly to policy shocks and cost push supply shocks are dominant in Pakistan. Moreover, money is

neutral and policy variables have no effect on real variable, i.e., output in Pakistan. Impulse response also demonstrates similar results and commodity prices response positively to positive interest rate shocks because of weak interest response to monetary policy shocks. So policy maker should keep in view commodity prices and response of interest rate at time of policy making.

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