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A Modified Approach to Measuring Monetary Policy for Unstable Economies

ABSTRACT

Most of the empirical studies on measuring the effects of monetary policy find positive relationship between interest rate and inflation rate at least in the short run. These studies make use of Vector Autoregressive (VAR) model with small number of variables and then using appropriate identifying restrictions, impulse response functions are estimated. We state, in this paper, that such methodology is inappropriate for unstable economies that are more prone to frequent external and domestic shocks. We hypothesize that positive relationship between interest rate and inflation rate is found due to incomplete capture of endogenous response of monetary policy to changes in inflation rate as variation in the latter is dominated by the effects of shocks. To test this hypothesis, we construct three variables VAR model for Pakistan's economy and data on inflation rate, output and interest rate are taken for the period 2000M01 to 2019M06. We adjust inflation rate for common component of macroeconomic variables, measured as factor score from a group of eight macroeconomic variables; the adjusted inflation rate does not carry information of large shocks that are reflected in almost all of the macroeconomic variables. We find support for our hypothesis as there is negative response of inflation rate to changes in interest rate. This result is robust to different specifications of VAR model and different sets of identifying restrictions to recover structural shocks. Results also reveal that changes in interest rate influence the future path of adjusted inflation rate whereas path of inflation rate – that is correlated with factor score – is pre-dominantly determined by changes in output. Moreover, we find that interest rate Granger causes both components of inflation rate but not the aggregate inflation rate. On the basis of our findings, we support tight stance of monetary policy whenever inflation rate is above acceptable level but cautious response of policy is required in highly and domestically indebted countries and distributional consequences may also be considered before any policy decision.

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Author's contribution in the article: 1- Conceived and designed the analysis, 2- Reviewed and compiled the literature, 3- Collected the data, 4- Contributed data or analysis tools, 5- Performed the analysis, 6- Wrote the paper, 7- Financial support for the conduct of the study, 8-Other

1. INTRODUCTION

For the last three decades, effectiveness of monetary policy has been evaluated using Vector Autoregressive (VAR) Model comprising of policy instrument and the target variables. Short term interest rate is used as an indicator of monetary policy whereas the list of target variables includes unemployment rate, inflation rate, output gap or any other measure of economic activity, bank lending and deposits (see for instance, Bernanke & Blinder, 1992; Sims, 1992). In these models, exogenous policy shocks are separated from endogenous response of policy to state of the economy using appropriate identifying restrictions on structural parameters. Furthermore, this literature has been extended by assuming target variables as latent variables and using underlying factors to measure them. Such Factor Augmented VARs are more informative in that they use more variables without losing degrees of freedom (see for instance, Bernanke et al. 2005; Baumeister et al., 2010; Fernald et al., 2014; Senbet, 2016). Expanded set of variables make researchers able to identify exogenous policy shocks that closely track actual policy changes.

We state in this paper that such VAR or FAVAR models are incapable of tracing the effects of monetary policy shocks on target variables in an economy like Pakistan which is prone to frequent external and domestic shocks and remains unstable most of the times. Whenever economy is hit by a (big) shock, most of the macroeconomic variables change their usual path and their dynamics are then dominated by the effects of that shock. In such a situation most of the energy of policy is consumed to counter the effects of these shocks and the effects of policy cannot be identified. Therefore, researchers are either unable to find significant effect of policy on target variables or they find counter theoretical results. The reason for such finding is that once the momentum of the effects of (big) shocks sets in, then it dominates all other forces that try to lean against the wind, including countercyclical monetary policy.

The objective of this paper is twofold. First objective is to decompose inflation rate into two components; one, that is independent of the effect of big shocks and the other that carries these effects. The second objective is to estimate the effects of monetary policy changes on target variables. We propose a methodology that better suits a country that is more prone to big shocks. To decompose the movement of target variable, inflation rate, into the one dominated by economic shocks and the other that does not carry such effect, we use two steps procedure. In the first step, factor analysis is used to identify common component of macroeconomic variables driven by economic shocks. Factor analysis is a statistical technique used to identify underlying factors or latent variables that explain the correlations among observed variables. There are different methods of factor analysis, such as principal component analysis (PCA) or common factor analysis. In this method, each observed variable is regressed on the extracted factors. The coefficients (loadings) from these regressions represent the relationship between each variable and each factor. Factor score estimates for each individual are then computed by multiplying their observed values on each variable by the corresponding regression coefficients and summing across all variables.

State of the economy is considered latent variable, which is estimated as a factor identified from indicator variables – large scale manufacturing index, inflation rate, interest rate, house price inflation, stock price inflation, exchange rate, money supply, trade deficit, and budget deficit. Whenever a shock hits the economy, most of these variables change their usual path and their movement is dominated by the effect of the shock. This information is captured by factor estimated from above mentioned variables. In the second step, inflation rate is regressed on this factor – common component of macroeconomic variables – and residual is estimated that measures inflation rate, which is independent of the effects of big shocks. This inflation rate is then used in VAR model to evaluate the effectiveness of monetary policy. This newly measured inflation rate is found to decrease after monetary policy tightening; the result is opposite to what is found with aggregate (unadjusted) inflation rate.

Rest of the paper proceeds as follows: section 2 reviews relevant literature; section 3 explains methodology; results are explained in section 4; and section 5 concludes the paper.

2. LITERATURE REVIEW

The literature on identification of monetary policy shocks and measuring the effects of these shocks evolved over time. In 1990s, empirical literature mostly used structural vector autoregressive (SVAR) model to measure monetary policy. Bernanke and Mihov (1998) extended the Bernanke and Blinder (1992) model and they developed semi structural VAR. For identification of monetary policy shocks, they imposed contemporaneous identification restrictions of policy variables to non-policy variables but leave other macroeconomic variables unrestricted. Bernanke et al. (2004) put forward that small number of factors capture valuable information on the basis of large amount of information. Therefore, it is better to use factor-augmented-VAR (FAVAR) model, instead of VAR. They extracted factors by using large amount of information and incorporated in VAR and restriction – monetary policy affects macroeconomic variables with a lag – was used for identification of monetary policy shocks. Furthermore, Uhlig (2005) introduced sign restrictions for identification of monetary policy shocks in VAR methodology. He suggested that monetary policy only respond to prices and non-borrowed reserves. Moreover, the VAR models are also extended by including asset prices in monetary transmission mechanism (Bjornland & Jacobsen, 2013, Yijin & Zeng, 2011; Kserssenfischer & Alessi, 2019). They used two identifying restrictions to identify monetary policy shocks that policy did not affect stock price and output.

The empirical evidence on response of inflation to monetary policy shocks can be categorized into three types. The first type of evidence on response of inflation to monetary policy shocks is consistent with economic theory. In response to monetary tightening inflation tends to decrease, both in short run and long run (see, for instance, Nguyen et al., 2019, Islam et al., 2021, Gern et al., 2023). High interest cost discourages firms' investment demand and consumers' consumption, thereby lowering aggregate demand that results in low inflation rate. In the second category, there are studies that show counter theoretical finding; in response to monetary tightening, inflation starts increasing and this effect does not reverse even in the long run (see, for instance, Vo & Nguyen, 2010; Chowdhury et al., 1995; Barth & Ramey, 2002). When demand for goods is less elastic, then firms do not cut production and investment in response to monetary tightening; rather, they pass on higher borrowing cost to consumers by raising goods prices. In this case, cost channel of monetary policy dominates. The third type includes studies that show positive response of inflation to monetary tightening in the short run while negative response in the long run. Initial positive response of inflation to monetary tightening is known as Price Puzzle that may occur due to forward looking behavior of monetary policy (for evidence on price puzzle, see Bhattacharya, 2013; Salunkhe & Patnaik, 2017; Javid & Munir, 2010; Xiao & Masron, 2017; Al-Mashat & Billmeier, 2007; Estrella, 2015; Olawale & Tarawalie, 2008; Fung, 2002). The hump shaped response of inflation to monetary policy shock reflects dominance of cost channel dominates over the traditional demand channel in the short run but former is dominated by later in the long run.

Empirical literature coped with the counter theoretical finding – positive response of inflation rate to monetary policy tightening – in number of ways. Sims (1992) proposed the solution of price puzzle by including commodity prices because these contain additional information about future inflation (see also, Vinayagathasan, 2013; Kim & Roubini, 2000). Kamada and Sugo (2006) used sign restriction, proposed by Uhlig (2005), that prices do not decrease in response to monetary policy shock; by applying this restriction price puzzle was avoided. Furthermore, problem of price puzzle has been solved by separating permanent shocks reflecting in inflation target and temporary shocks reflecting in interest rate (Bache and Leitemo, 2008). Price puzzle also disappear by including asset prices in SVAR as these prices signal future inflation (See, Bjornland & Jacobsen, 2013; Yijin and Zeng, 2011; Alessi & Kerssenfischer, 2016). Another way of coping with price puzzle is narrative approach. Champagne and Sekkel (2017) identified monetary policy shock by introducing a new series of interest rate which was extracted from meetings of Federal Open Market Committee (FOMC); this was then used to estimate the effect of interest rate on inflation rate.

However, the empirical literature cited above is criticized based on the fact that VAR models consider only unanticipated changes in monetary policy and ignore systematic response of monetary policy (see, Sims & Zha, 2006; Cochrane, 1998; Bernanke et al., 1997). Moreover, VAR models use only limited information in terms of small number of variables. Price puzzle appears due to this limited amount of information which is less than what is required to forecast inflation. Bernanke et al. (2004) analyze monetary policy effectiveness using FVAR model. They suggest, it is better to augment standard VARs with estimated factors if small number of factors provide useful information on the basis of large amount of information. In this approach, large amount of indicators are used to estimate unobserved latent variables which are responsible for systematic portion of the economy. For instance, series of inflation rate and output are not taken as measured, rather there is large number of variables that are helpful in estimating latent variables – economic activity and inflationary environment (Bernanke & Boivin, 2003). Many studies use FAVAR model and find evidence contrary to price puzzle (see for instance, Beckers, 2020; Hatigan and Morley, 2019; Kaufmann and Lein, 2012; Tulip & Bishop, 2017; Bernanke et al., 2005). For the case of Pakistan, Munir and Qayyum (2013) used FAVAR model consisting of 115 macroeconomic variables; they did not observe price puzzle in their results.

Henzel and Rengel, (2016) highlight that economies evolve overtime and therefore uncertainty does not remain constant. Economies are continuously hit by small economic shocks while they also experience big disasters like great depression, stagflation and global financial crisis. Therefore, paths of economic variables change overtime as they carry information of shocks that hit the economy. As most of the macroeconomic variables are affected by common shocks, therefore, they move together either in the same direction or in opposite direction. Hence, movement in inflation rate – the target variable of monetary policy – is dominated by common component of all variables which carries information of economic shocks. We hypothesize, in this study, that the counter theoretical response of inflation rate to monetary policy shocks is the result of missing information regarding common component, in VAR models that may dominate variation in inflation rate. We therefore, propose to control for common component, measured as factor score, from inflation rate and then to use this adjusted series of inflation rate in VAR model.

3. METHODOLOGY

3.1 Theoretical Framework

In order to estimate the effects of monetary policy on inflation rate and economic activity, we use structural macroeconomic model proposed by Bernanke and Blinder (1992).

$$Y_t = B_0 Y_t + B_1 Y_{t-1} + C_0 P_t + C_1 P_{t-1} + u_t \quad (1)$$
$$P_t = D_0 Y_t + D_1 Y_{t-1} + G_0 P_{t-1} + v_t \quad (2)$$

Y is a vector of (target) macroeconomic variables (output and inflation rate) that depends, in equation 1, on lags of Y and contemporaneous and lagged values of policy variable, P[1]. The second equation represents monetary policy reaction function, in which, policy variable depends on its own lagged values and current and lagged values of target variables. Equation 1 and 2 represent unrestricted dynamic model with ${u_t}^y$ and ${v^p}_t$ as independently and identically distributed.

Theoretically, increase in interest rate reduces aggregate demand, which discourages economic activity and therefore decreases inflation rate. Moreover, increase in interest rate signals tight monetary policy stance

[1] The objective of Monetary policy is to smooth interest rate

and makes economic agents expect lower inflation rate in future; inflation rate decreases due to self-fulfilling expectations. However, due to inelastic aggregate demand in the short run increase in interest rate is unable to contain inflation. Producers take increased interest rate as higher cost of production, so they tend to pass on this higher cost of borrowing to consumers; therefore, inflation rate may respond positively to higher interest rate. If this cost channel of monetary policy dominates the demand channel for a longer period of time, then the positive response of inflation rate to monetary policy tightening remains significant in the long run. This result is contrary to dominant view in Monetary Theory; therefore, it can be termed as counter theoretical.

Such result may also be found when movement in inflation rate is dominated by common component of macroeconomic variables that carries information of shocks that hit the economy. When a shock hits the economy then some of the macroeconomic variables change their path and their near future movement is dominated by the effects of this shock. Which of the variables are affected more by a shock depends on nature of the shock; a domestic shock may result in changing domestic demand, while a shock that originates in the external sector of the economy may result in external account imbalances. Inflation rate has the tendency to absorb the effects of all types of shocks if goods prices are not sticky[2]. This tendency of inflation rate makes it positively respond to high interest rate if policy tightening itself is an endogenous response to shock. So, inflation rate must be adjusted for the common component of macroeconomic variables if prices in an economy are not rigid. We propose such an adjusted inflation rate series to be used in VAR model to avoid counter theoretical finding of positive response of inflation rate to changes in interest rate.

3.2 Econometric Methodology

To estimate the effects of short-term interest rate on inflation rate and output, we have used structural VAR model containing three variables:

$$Bx_t = B_0 + \sum C_i x_{t-i} + \varepsilon_t \tag{3}$$

Here, B is a matrix of contemporaneous coefficients, x_t is a vector of endogenous variables, (inflation rate, output and interest rate), C is a matrix of coefficients attached with lagged endogenous variables, and ε contains zero mean, constant variance and serially and contemporaneously uncorrelated structural shocks. The above system of equations can be converted into reduced form VAR as:

$$x_t = A_0 + \sum A_i x_{t-i} + e_t \tag{4}$$

e_t consists of one step ahead forecast errors with zero mean and constant variance. These errors are serially uncorrelated but may be contemporaneously correlated.

3.2.1 Granger Causality

In the first step of analysis, we have used Granger Causality test to check whether or not lagged variables are helpful in predicting other variables.

$$\begin{aligned} y_t &= A_{10} + A_{11}(L)Ly_t + A_{12}(L)Z_t + e_{yt} \\ Z_t &= A_{20} + A_{21}(L)Ly_t + A_{22}(L)LZ_t + e_{zt} \end{aligned} \tag{5}$$

[2] The focus of this study is Pakistan's economy, where prices are found to be more flexible against any type of shock (See, Malik et al., 2008; and Choudhary et al, 2016).

y_t does not Granger cause z_t, which implies that variable y_t is not helpful in the prediction of variable z_t, if coefficients of $A_{21}(L)$ are zero in the above model. We have used F-stats to test this hypothesis of zero coefficients.

3.2.2 Identifying Restrictions

As VAR models are under-identified so some restrictions are needed to be imposed on structural parameters with the minimum requirement that the number of estimated reduced form parameters is equal to that of remaining unrestricted structural parameters that are yet to be recovered. This minimum requirement necessitates restricting n(n-1)/2 number of structural parameters, where n is the number of variables in the VAR model. These restrictions are mostly imposed on S matrix (equation 2), which contains contemporaneous response coefficients.

Our goal is to quantify the impact of interest rate shocks on inflation and output. To do this, we estimate the model in equation 5, then utilize the estimated parameters of these equations to identify structural parameters and recover structural shocks from the system in equation 4 by applying suitable structural parameter constraints.

The moving average representation of VAR in equation 5 is given as:

$$x_t = B(L)e_t \quad (6)$$

$B(L)$ denotes the matrix of coefficients polynomial in the lag operator L, defined as B (L) =$\sum_{j=0}^{\infty} B_j * L^j$. e_t can be written as linear combination of structural shocks as: $e_t = S\epsilon_t$

So VMA can be written in terms of structural shocks as:

$$x_t = B(L)S\epsilon_t \quad (7)$$
$$x_t = \emptyset(L)\epsilon_t \quad (8)$$

Here, $\emptyset(L)$ represents impulse response functions.
Though the forecast errors, e_t, are estimated, the structural shocks, εt, need to be recovered. For that, n(n-1)/2 restrictions are needed on S to identify the system, where n is number of variables in VAR model. In our case, we need three restrictions on structural parameters. We have used two different identification schemes. In the first, interest rate is allowed to respond to inflation rate only after lags, while in the second the former does respond contemporaneously to the later. For instance, in one of the sets of identifying restrictions, economic activity and short term interest rate are assumed to not affect inflation rate contemporaneously. Output is allowed to respond contemporaneously to inflation rate but not to interest rate. Interest rate is assumed to contemporaneously respond to output and inflation rate.

More specifically, Equation 8 with zero restrictions on coefficients can be written as:

$$\begin{pmatrix} \pi_t \\ \Delta y_t \\ i_t \end{pmatrix} = B(L) \begin{pmatrix} S_{11} & 0 & 0 \\ S_{21} & S_{22} & 0 \\ S_{31} & S_{32} & S_{33} \end{pmatrix} \begin{pmatrix} \epsilon^{\pi}{}_t \\ \epsilon^{y}{}_t \\ \epsilon^{MP}{}_t \end{pmatrix} \quad (9)$$

We have estimated VAR model with aggregate inflation rate as well as with two components of inflation rate – one that is correlated with common component of macroeconomic variables and the other that is not.

3.3 Data and Construction of Variables

We define the inflation rate as the percentage change in the consumer price index (CPI), excluding house rent, over the year – twelfth lagged difference divided by twelfth lag and multiplied by 100. In order to estimate adjusted measure of inflation rate we have generated a common factor by using factor analysis. It is worthy to note that most of the macroeconomic variables change their usual paths in response to big shocks. In this case, monetary policy seems ineffective if effects of shocks are not controlled. Pakistan's economy experienced different crisis, during our sample time period, including huge capital inflow after 9/11 and oil price hike in 2008. All of these shocks significantly affected macroeconomic variables, especially inflation rate. Therefore, we have used budget deficit, trade deficit, asset prices (house prices, stock prices and exchange rate), output, inflation rate and money growth rate (M2) to make a factor score defined as common component of macroeconomic variables. All of these eight variables are indicators of economic crisis and reflect information regarding shocks. This common component dominates variation in inflation rate and monetary policy is found ineffective to control inflation rate if the effect of this common component is not controlled. To find adjusted measure of inflation rate we regress it on the common component found using eight variables and then estimate residual of this regression. This residual series does not contain variation in inflation rate that is dominated by the effects of big shocks.

Output, in our analysis, is proxied by Large Scale Manufacturing Index; this variable is available at monthly frequency and is the most relevant measure of output that monetary policy is supposed to affect. In the VAR model, annualized growth rate[3] of this variable is used. Karachi Interbank Offered Rate (KIBOR) is used for short term interest rate; KIBOR represents money market rate that SBP targets through interest rate corridor system.

We utilized monthly data on output, inflation, and interest rates from 2000M01 to 2019M06. International Financial Statistics (IFS) provides statistics on exchange rates and stock prices. The monthly Bulletin of Statistics released by the SBP contains statistics on CPI, LSM, KIBOR, and M2. The data on the House Rent Index is derived from the Pakistan Bureau of Statistics' Monthly Price Indices. The data on budget deficit is taken from Pakistan Fiscal Operations available on website of Ministry of Finance. Data on trade deficit, defined as imports minus exports, is taken from monthly Bulletin of Statistics published by SBP. Both trade deficit and budget deficit are taken as ratio of GDP.

4. RESULTS AND DISCUSSION

The objective of this paper is to estimate the effects of monetary policy on output and inflation rate. For that, three variables VAR model has been constructed and then impulse response functions are estimated. Forecast error variance is also decomposed into sources of variation in inflation rate. However, in the first step we use Granger Causality test to determine whether or not inflation rate and output are Granger caused by short term interest rate.

4.1 Granger Causality Test

Granger causality test helps determine predictability of a variable in VAR model for other included variables. In our case, inflation rate and output are supposed to carry information on lagged interest rate. After all, if they do not carry then monetary policy does not alter the path of target variables. However, this does not guarantee that the target variables are weakly exogenous as policy may have contemporaneous effects. We have tested Granger Causality for output, interest rate and three measures of inflation rate – aggregate inflation rate, inflation rate adjusted (Appendix A1) for common component, and inflation rate correlated with common component – in separate VAR models. Results in table 1 show that interest rate and output are Granger caused by all measures of inflation. Moreover, both of these variables Granger cause each other in all three VAR models.

[3] Percentage change over the period of one year.

Table 1: Granger Causality among Variables

	Inflation Rate	Adjusted Inflation Rate	Fitted Inflation Rate	Output	Interest Rate
Inflation Rate				47.72 (0.00)	17.35 (0.015)
Adjusted Inflation Rate				58.15 (0.000)	3.76 (0.709)
Fitted Inflation Rate				50.34 (0.000)	20.99 (0.001)
Output	5.56 (0.592)	15.62 (0.016)	30.29 (0.000)		42.41 (0.000)
Interest Rate	10.33 (0.171)	25.31 (0.000)	19.62 (0.002)	14.28 (0.046)	

* Results of interest rate and output in each other's equations are given only for VAR model with aggregate inflation rate. Similar results are found for VAR models with other measures of inflation.

Interestingly, both components of inflation rate – one that is correlated with common component and the other that is not – are Granger caused by interest rate and output. Correlated inflation rate is predicted by interest rate because both of these variables are driven by same shocks, while adjusted inflation rate is predicted by interest rate due to theoretical relationship that exists between these variables. Similar interpretation can be made for predictability by output. However, interest rate and output do not predict future values of aggregate inflation rate. This unusual finding reflects the fact that sign of coefficients attached to lagged values of interest rate and output, in VAR model with correlated inflation rate, are opposite to that found in VAR model with adjusted inflation rate. When aggregate inflation is taken then the coefficients with opposite signs cancel out and the net effect becomes insignificant.

4.2 Impulse Response Functions

Impulse response functions are used to estimate the effects of monetary policy instrument on inflation rate and output. For that we have estimated three variables – interest rate, output, and inflation rate – VAR model. Inflation rate is measured as annualized change in non-house-rent CPI, while output is proxied by annualized growth in large scale manufacturing index. Furthermore, inflation rate is decomposed into two components; one that is correlated with common component of macroeconomic variables and the other that is uncorrelated. Results are given for all the three measures of inflation rate – aggregate rate and the two sub-components. Each measure of inflation rate is used in a separate VAR model. Interest rate is taken in level form; however, analysis is also done with first differenced interest rate. Moreover, as identifying restriction, interest rate is allowed to respond to inflation rate and output only after lags. For robustness analysis we have also assumed contemporaneous response of interest rate to target variables – inflation rate and output. Finally, lag length is selected after testing joint restrictions on coefficients of lagged variables, one at a time, using Likelihood Ratio statistics.

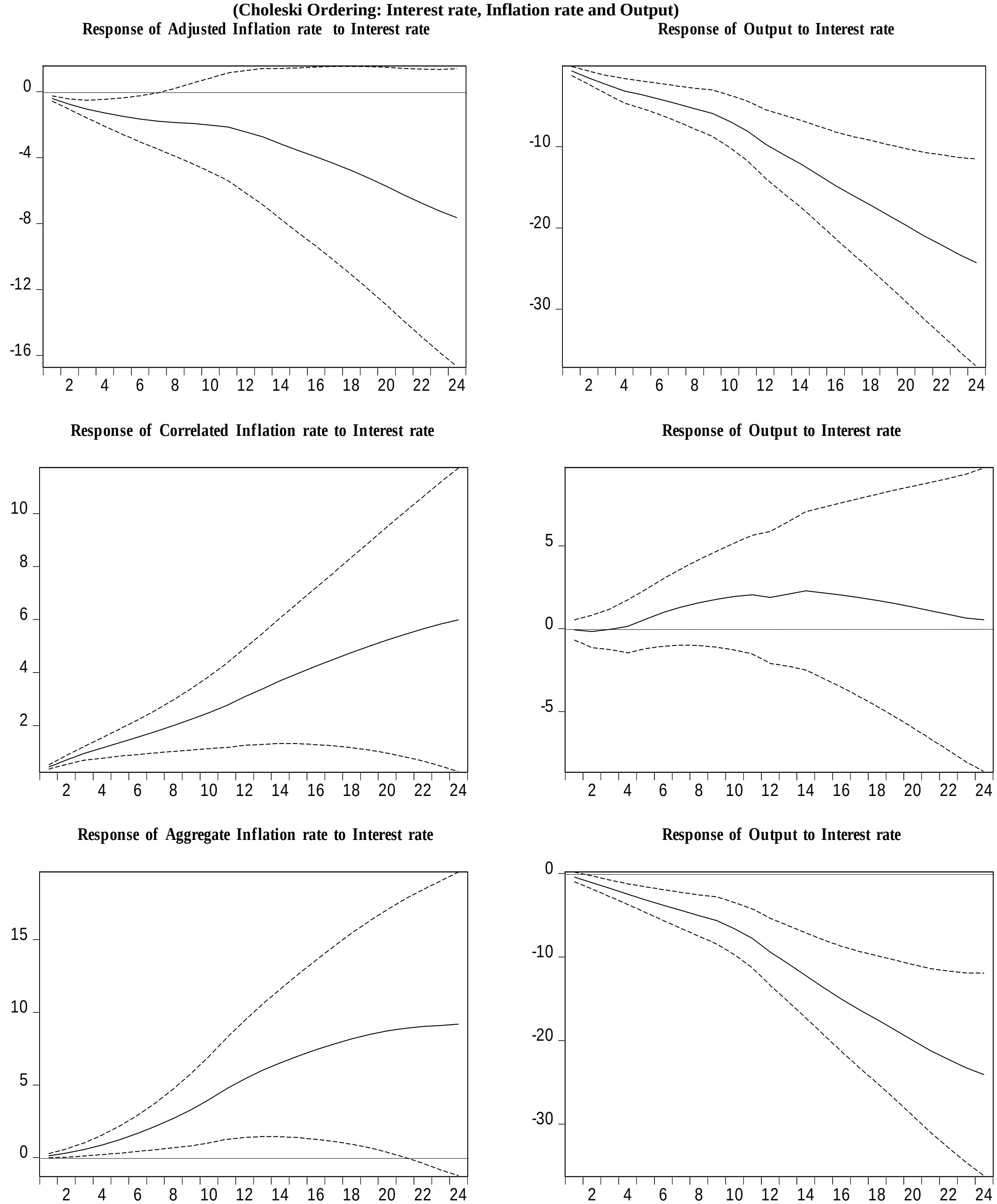
Results in figure 1 show that when interest rate does not contemporaneously respond to inflation rate and output and the former is taken as its sub-component that is uncorrelated with common component of macroeconomic variables, then both inflation rate and output negatively respond to increase in interest rate. This negative effect remains statistically significant for seven months in the case of inflation rate and about two years for output. The negative response is in conformity with the standard economic theory according to which increase in interest rate contracts economic activity, through discouraging investment and consumption, resulting in slowdown of increase in goods prices. The result is also consistent with limited empirical literature that find negative response of inflation rate and output to changes in interest rate. Interestingly, we do not find positive response of inflation rate to monetary policy tightening even in the short run. This is because we have set aside part of inflation rate that is correlated with common component of macroeconomic variables, variation of which is dominated by the effects of big shocks. This pre-dominance of shocks results in finding positive response of inflation rate to increase in interest rate. In this case, discouraging effects of policy tightening, on output and inflation rate, are dominated by the endogenous response of policy to the target variables. When such dominance is controlled and inflation rate is adjusted for the common component, estimated as factor underlying variation in macroeconomic variables, then actual effects of policy changes on target variables can be estimated. Through such adjustment in inflation rate we are able to avoid counter theoretical result that is there in the empirical literature. It is also important to note that, contrary to existing empirical evidence, we have found less inertia in inflation rate and more in economic activity. This is because the adjusted inflation rate does not carry the persistent effect of shocks that dominate variation in aggregate inflation rate, whereas output is not subjected to such adjustment.

To further support our hypothesis that dominating role of shocks, measured through common component of macroeconomic variables, in variation of inflation rate and the endogenous response of monetary policy to such shocks results in seemingly positive response of inflation rate to interest rate changes, we also estimate impulse response function using component of inflation rate that is correlated with common component of macroeconomic variables. Results in middle panel of Figure 1 show that cumulative response of correlated inflation rate is positive to changes in interest rate while such response is statistically insignificant for output4. We also estimated the effect of interest rate on aggregate inflation rate; results in lower panel of Figure 1 show that such effect is also positive – finding that is counter theoretical. This is because positive response of correlated inflation rate to policy tightening is so powerful that it dominates the negative response of adjusted inflation rate. This is not unexpected when monetary policy decisions are predominantly taken as endogenous response to shocks. This result confirms that the seemingly positive response of inflation rate to policy tightening or price puzzle effect can be attributed to endogenous response of policy to changes in inflation rate and the fact that such endogenous response is not fully captured by small number of variables in VAR model. In a country like Pakistan that is more prone to shocks, such endogenous response can be controlled by taking component of inflation rate that is uncorrelated with the effects of these shocks.

[4] Yearly responses are shown in Appendix A2.

Figure 1: Accumulated Impulse Response Functions (± 2 S.E)

(Choleski Ordering: Interest rate, Inflation rate and Output)



Note: Adjusted (correlated) inflation rate refers to component of inflation rate which is (un)correlated with common component of macroeconomic variables. Aggregate inflation rate is sum of these two components.

4.3 Sensitivity Analysis

To check how much sensitive or robust our results are to changing identifying restrictions and model's specification we have redone our analysis number of times. First of all we have re-estimated VAR model with first differenced interest rate but identifying restrictions remain same. Secondly, the variables of VAR model remain same as there in the main analysis but identifying restrictions are changed. When interest rate is taken in first differenced form then all results (Figure 2) are in conformity with that found in the main analysis. Adjusted inflation rate negatively responds to monetary policy tightening; correlated inflation rate responds positively; inflation rate correlated with common component of macroeconomic variables dominates the relationship between inflation and interest rate – response of aggregate inflation rate to interest rate is positive. Economic activity is discouraged by monetary tightening in all the three cases; however, this response is found insignificant when correlated inflation rate is used in VAR model. Similarly, we find same results when different identifying restrictions are used provided interest rate does not contemporaneously respond to inflation rate. More specifically, in one specification, interest rate remains at same position as it was in main analysis but place of output and inflation rate is interchanged in triangular identification. In another specification, we allow interest rate to respond contemporaneously to output while inflation responds to both output and interest rate but output does not respond to other two variables. In both of these sets of identifying restrictions, results remain same as those found in main analysis and in variant of VAR model with first differenced interest rate. These results are shown in Appendix A3 and A4.

We also allow interest rate to contemporaneously respond to inflation rate; in one set of identifying restrictions interest rate contemporaneously responds to both of the target variables while in another it responds to inflation rate within same period and to output only after lags. Results using first of these sets of restrictions are shown in Figure (3) below, while that for second set are given in Appendix A5. In these cases three main differences are noted in results: adjusted inflation rate portrays price puzzle – it first increases in response to policy tightening but then becomes negative in the long run; response of correlated inflation rate to increase in interest rate is found negative; when correlated inflation rate is included in VAR model, response of output to increase in interest rate is found positive. At first glance, these results, especially for that of correlated inflation rate, seem contrary to what has been found in the main analysis. However, both of these results convey the same story. When interest rate is allowed to contemporaneously respond to correlated inflation rate then common component of macroeconomic variables is captured by endogenous response of monetary policy to variation in target variables. Whatever is leftover in interest rate series contains exogenous policy changes, which are negatively correlated with inflation rate. In the main analysis, changes in interest rate were considered as exogenous shocks but inflation rate was adjusted for common component of macroeconomic variables. Hence, when dominating role of shocks, captured through common component, is controlled in any way, relationship between inflation rate and monetary policy instrument is negative. When adjusted inflation rate is considered in VAR model, then price puzzle is found as endogenous response to shocks is not controlled from changes in interest rate.

Figure 2: Accumulated Impulse Response Functions (± 2 S.E)

(Choleski Ordering: Interest rate, Inflation rate and Output)

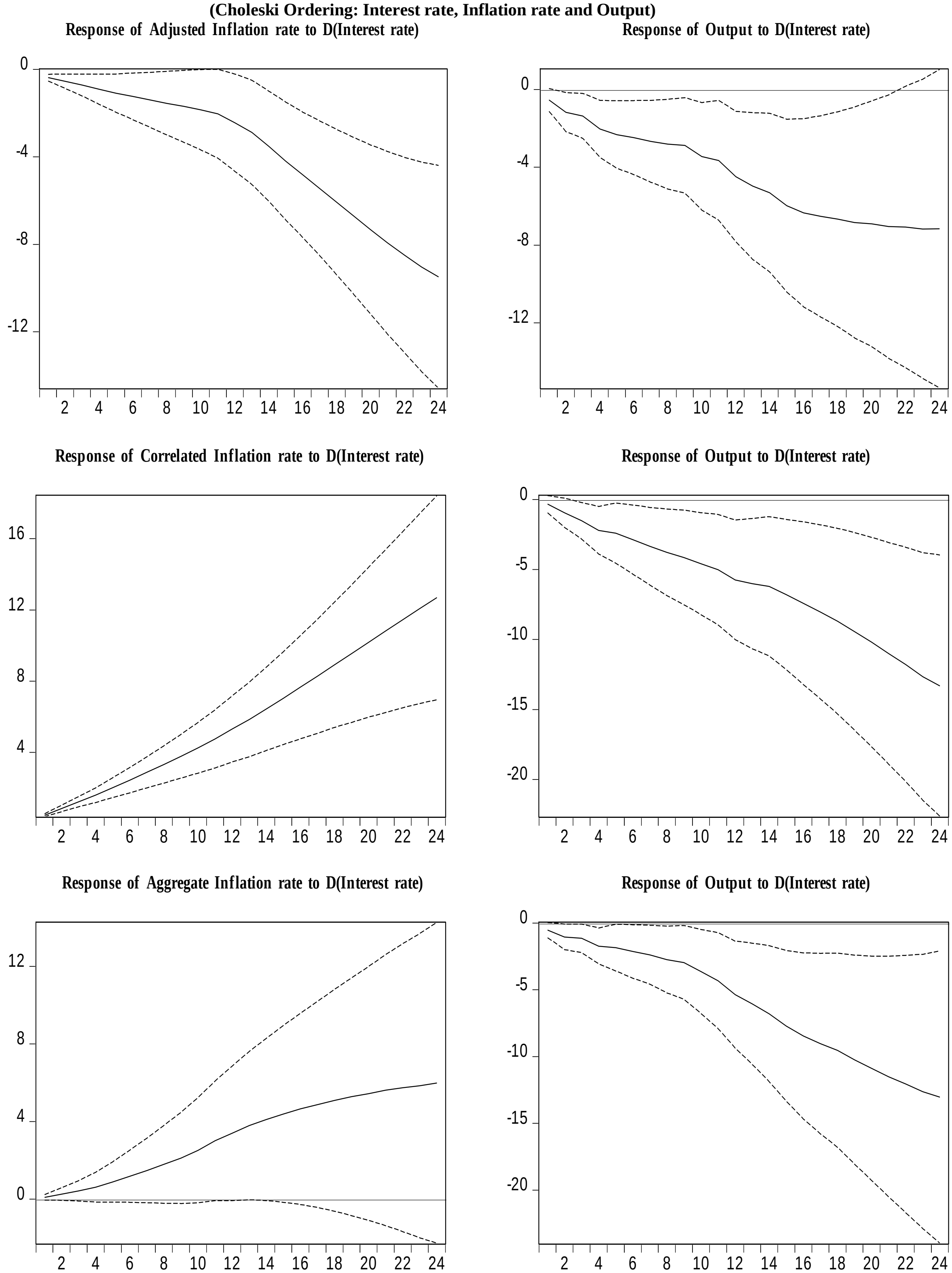
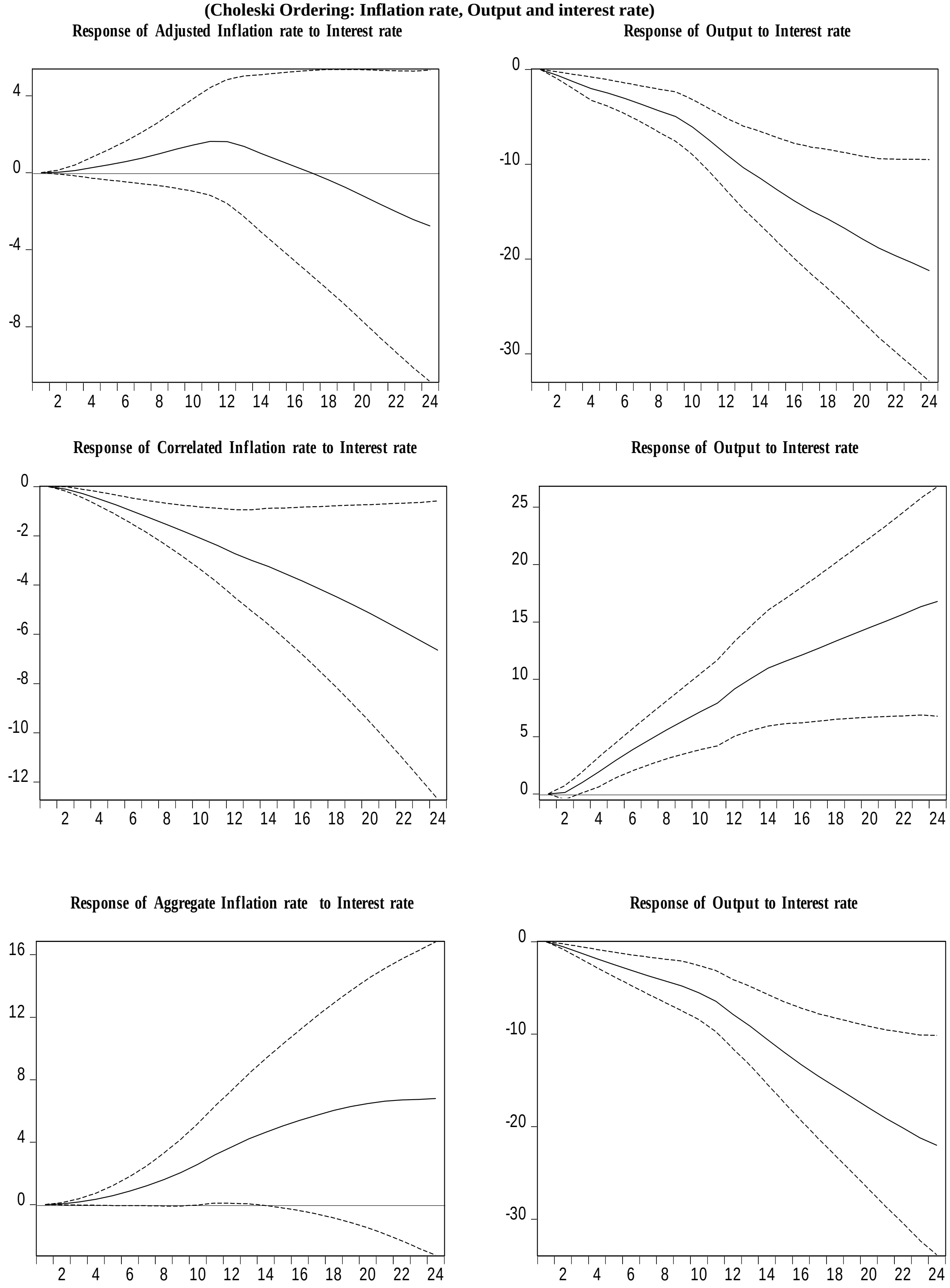


Figure 3: Accumulated Impulse Response Functions (± 2 S.E)
(Choleski Ordering: Inflation rate, Output and interest rate)



4.4 Variance Decomposition

At the end, we have estimated variance decomposition to know how much variation in different measures of inflation is explained by other variables in the model. The result which is consistent with other studies – variation in inflation rate is pre-dominantly explained by its own lags – is found in case of adjusted inflation and not in case of correlated inflation rate (Table 2). Moreover, correlated inflation rate is much affected by other variables in the model, especially output, which shows that variation in inflation rate is dominated by the effects of shocks. This effect, if not controlled, results in positive response of inflation rate to policy tightening. Finally, monetary policy instrument is more effective for adjusted inflation rate than for correlated inflation over longer period of time. This is because changes in interest rate are unable to affect inflation rate if variation in the later is dominated by shocks in other variables. If that dominant effect is controlled then monetary policy is found effective in determining the variation in inflation rate at longer time horizon.

Table 2: Variance Decomposition of Inflation Rate

	Adjusted Inflation Rate			Correlated Inflation Rate		
Period	Inflation Rate	Output	Interest rate	Inflation rate	Output	Interest rate
1	86.73	0.00	13.27	56.36	0.00	43.64
6	87.38	5.39	7.23	54.58	21.42	24.01
12	86.68	8.03	5.30	47.05	34.42	18.53
18	80.27	7.87	11.86	38.47	44.66	16.88
24	72.75	7.30	19.96	36.28	49.42	14.30

5. CONCLUSION AND POLICY IMPLICATIONS

Most of the empirical studies on measuring the effects of monetary policy find positive relationship between interest rate and inflation rate at least in short run. This literature makes use of VAR model with short term interest rate as policy instrument and inflation rate along with a measure of economic activity as target variables. Interest rate is either assumed to respond contemporaneously to changes in target variables or it is allowed to respond only after lags. We state, in this paper, that such methodology is inappropriate in an unstable economy that is more prone to external and domestic shocks. The hypothesis we set in this paper is that the positive relationship between inflation rate and short term interest rate is because of the shocks that, when hit the economy, influence the path of inflation and if the dominant role of shocks measured through common component of macroeconomic variables is controlled then response of inflation rate to interest rate is not positive. Monetary policy responds to changes in inflation rate but in a VAR model, with small number of variables, that endogenous response is not completely captured and monetary policy shocks are not properly identified; therefore, counter theoretical relationship between monetary policy decisions and inflation rate is found.

To test this hypothesis, we construct three variables VAR model for Pakistan's economy and data on inflation rate, output and interest rate are taken for the period 2000M01 to 2019M06. We adjust inflation rate for common component of macroeconomic variables, measured as *factor score* from a group of eight macroeconomic variables. We find support for our hypothesis as there is negative response of inflation rate to changes in interest rate. However, the usual counter theoretical positive response is found when a component of inflation rate is taken which is correlated with common component of other macroeconomic variables. In previous studies, with positive relationship between interest rate and inflation rate, such effect dominates the theoretical negative relationship. Our results are robust to different specifications of VAR model and different sets of identifying restrictions to recover structural shocks. Results also reveal that changes in interest rate influence the future path of adjusted inflation rate whereas path of correlated inflation rate is pre-dominantly determined by changes in output. Moreover, we find that the absence of

Granger causality from interest rate to inflation rate is due to opposite signs of coefficients of lagged interest rate in the equations of two components of inflation rate; these opposite signed coefficients cancel out and net predicting power of interest rate for inflation rate is found insignificant. This is confirmed by our finding that interest rate Granger causes both components of inflation rate but not the aggregate inflation rate.

On the basis of our findings, we support tight stance of monetary policy whenever inflation rate is above acceptable level. However, this is not an absolute recommendation as our model has certain limitations. Increasing interest rate in a country with high proportion of domestic debt has unintended consequences for debt servicing and fiscal space may shrink to unacceptable levels. Moreover, we suggest to extend this VAR model by including asset prices as controlling inflation rate through higher interest rate, when former is driven by speculation activities in asset markets, may cause income distribution skewed towards asset market and becomes unfavorable for goods market. Moreover, the ultimate goal of monetary policy is to provide enabling environment, through price stability, for sustained economic growth. But as Stiglitz (2012) put it, world as a whole is paying a high price of income inequality in terms of low growth and greater instability. Hence, the ultimate objective of monetary policy is compromised if income/wealth inequality is ignored. Finally, monetary policy cannot ignore inequality in a democratic world; otherwise central banks' autonomy will lose public support. Future work may be extended to differentiate between variation of inflation and output triggered by monetary policy and that caused by other factors. In this case, the true role of asset prices will be estimated by shutting off the response of asset prices to interest rate and variation of output and inflation caused by changes in interest rate.

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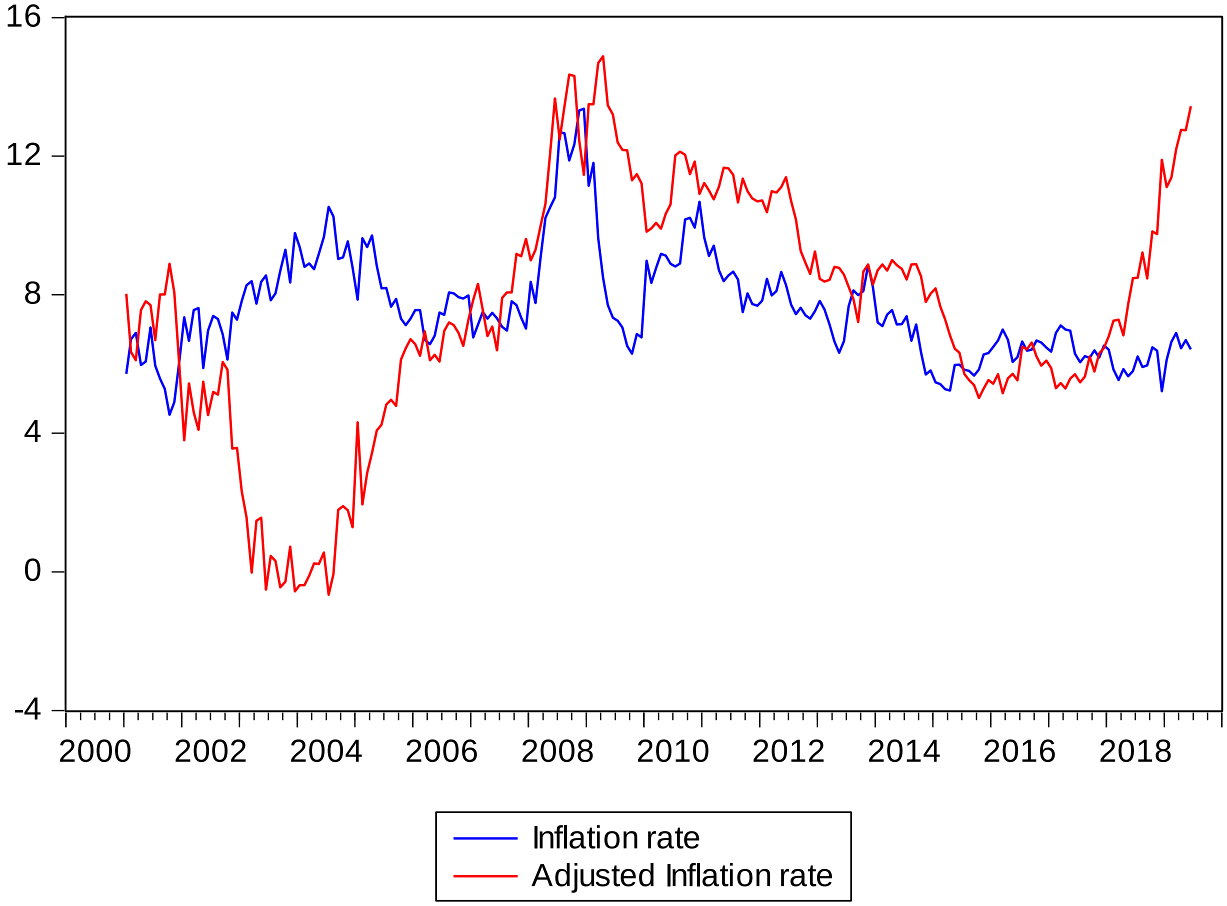
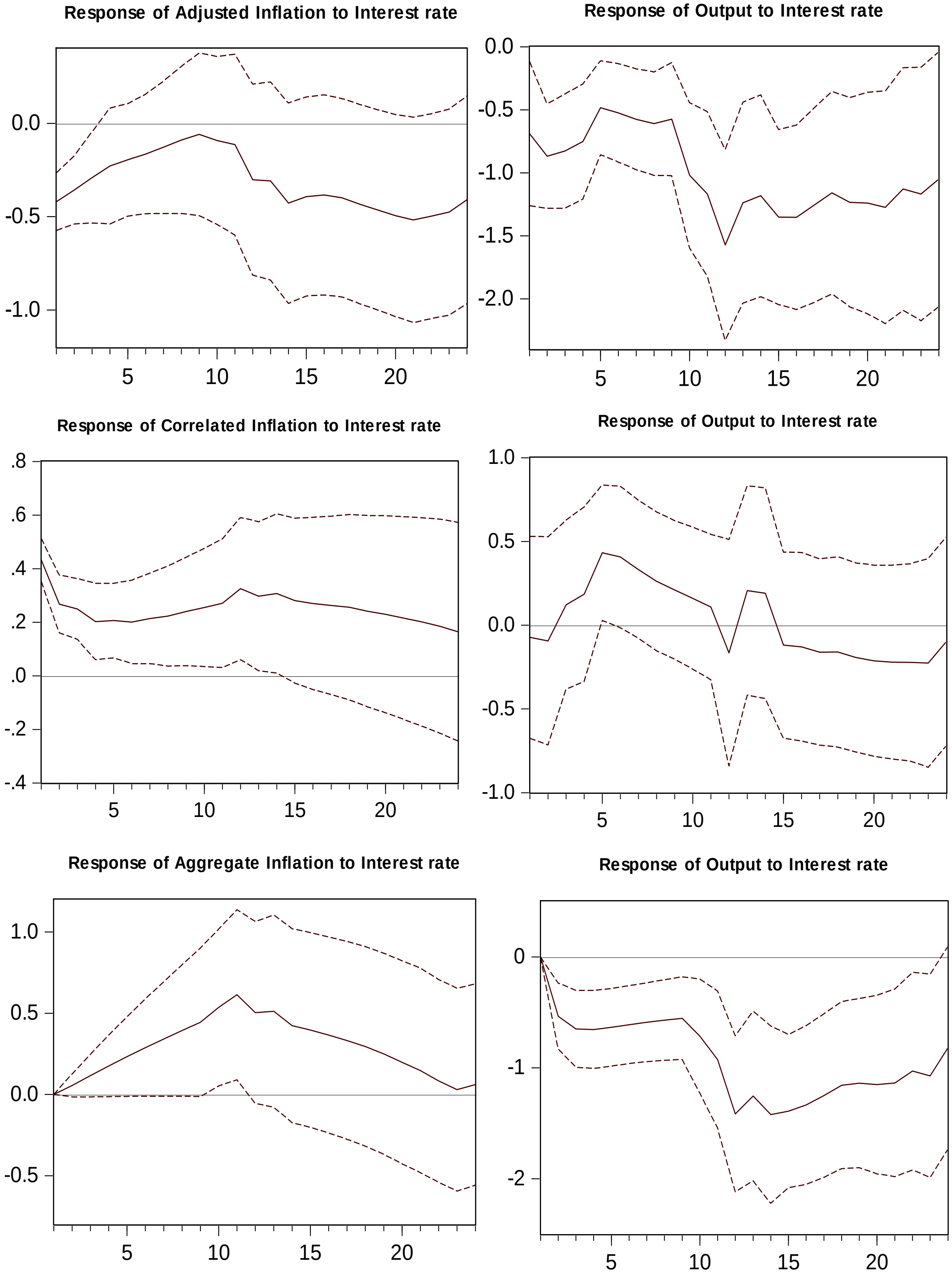
Appendix A1: Inflation Rate and Adjusted inflation rate of Pakistan

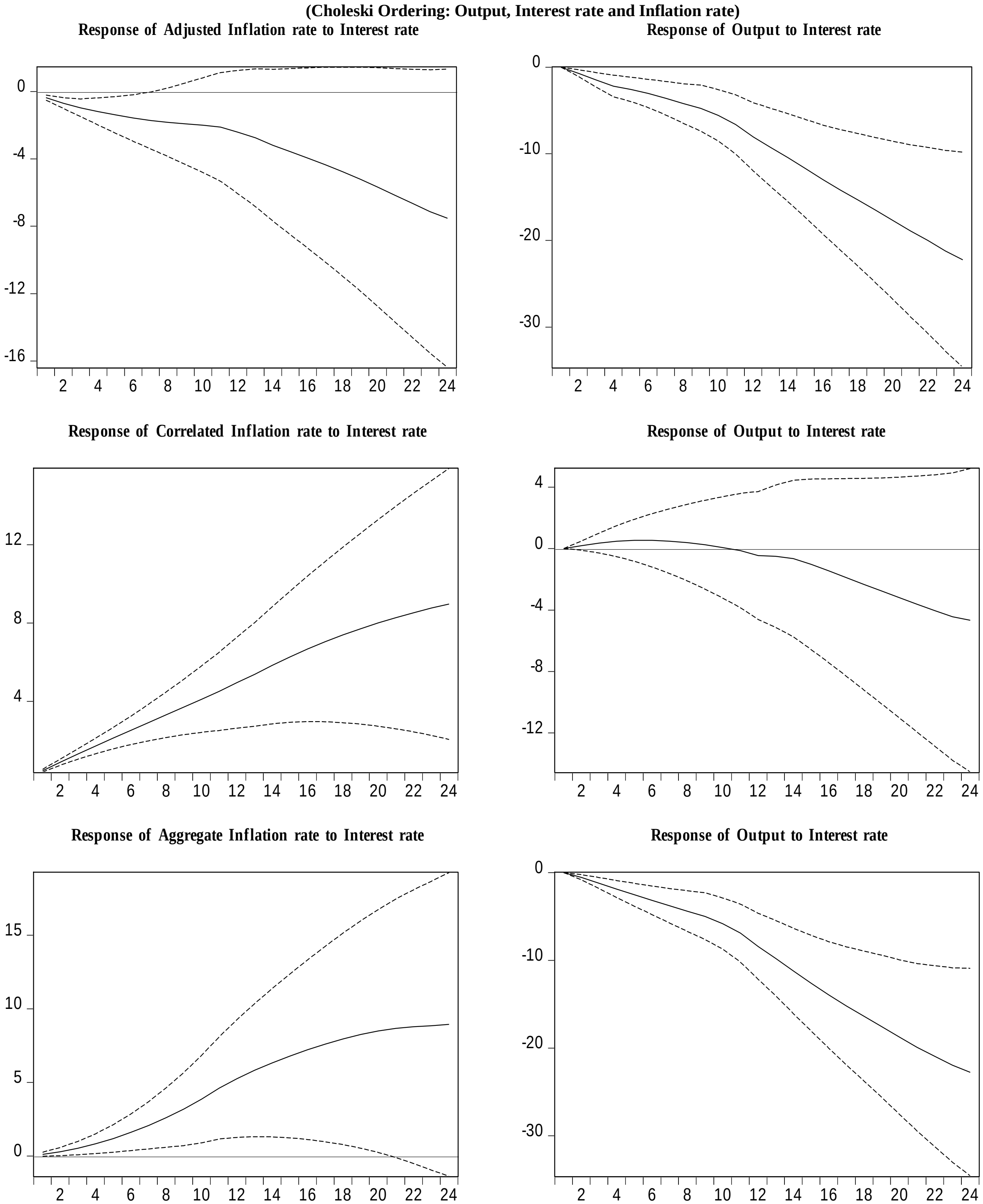


Appendix A2: Impulse Response Functions (± 2 S.E)

(Choleski Ordering: Inflation rate, Output and interest rate)



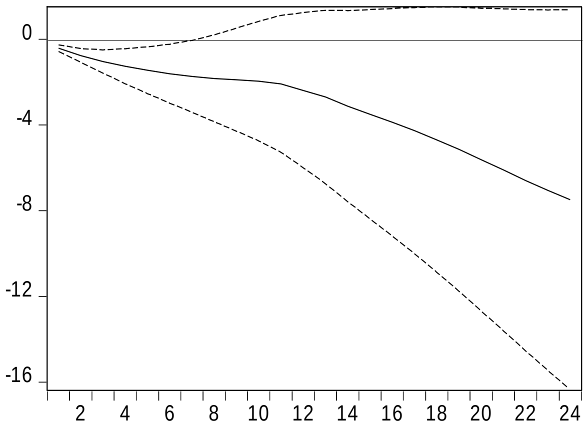
Appendix A3: Accumulated Impulse Response Functions (± 2 S.E)



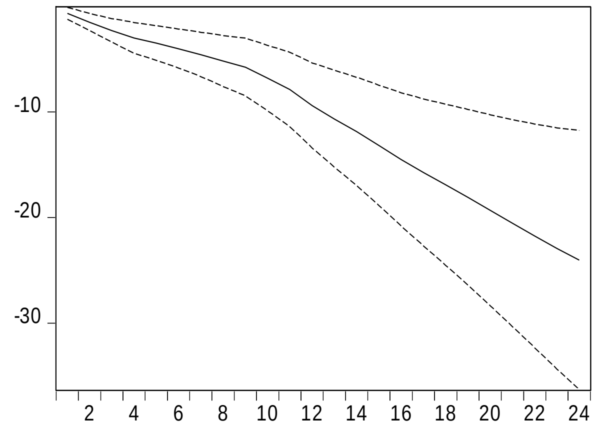
Appendix A4: Accumulated Impulse Response Functions (± 2 S.E)

(Choleski Ordering: Interest rate, Output and Inflation rate)

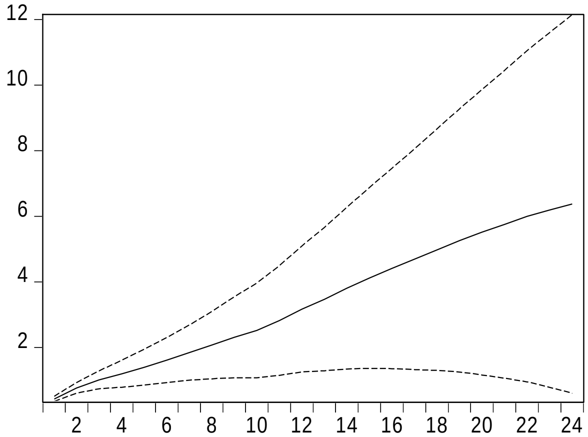
Response of Adjusted Inflation rate to Interest rate



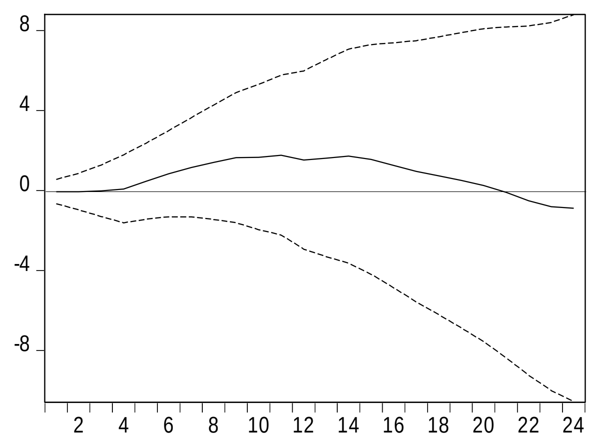
Response of Output to Interest rate



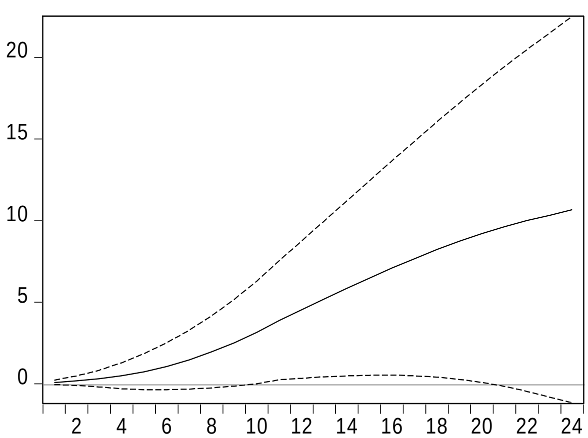
Response of Correlated Inflation rate to Interest rate



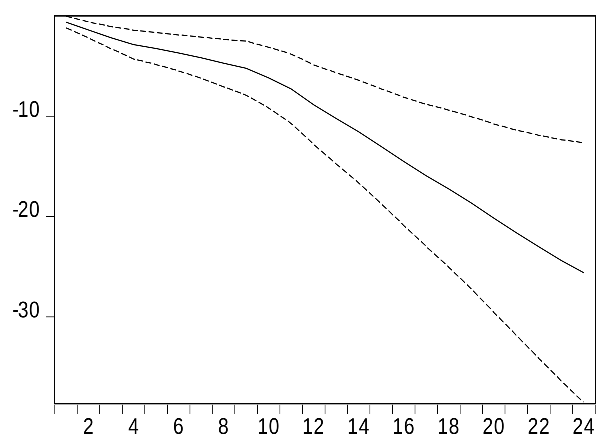
Response of Output to Interest rate



Response of Aggregate Inflation rate to Interest rate



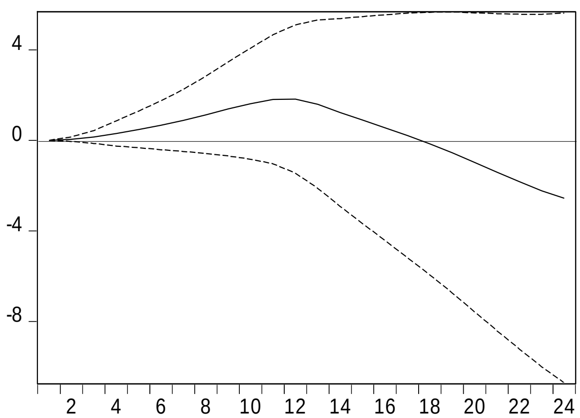
Response of Output to Interest rate



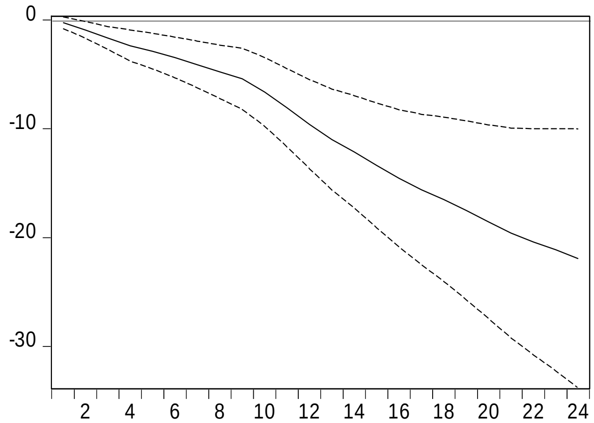
Appendix A5: Accumulated Impulse Response Functions (± 2 S.E)

(Choleski Ordering: Inflation rate, Interest rate and Output)

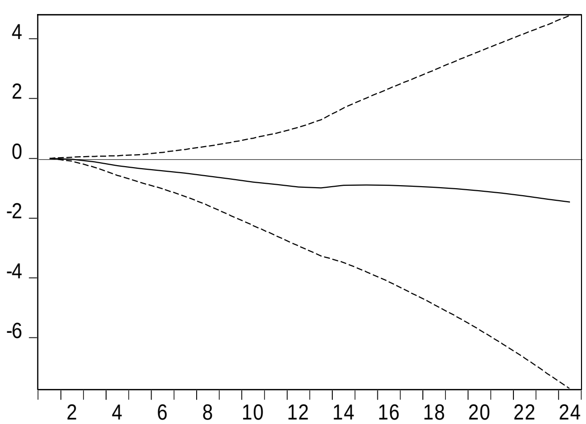
Response of Adjusted Inflation rate to Interest rate



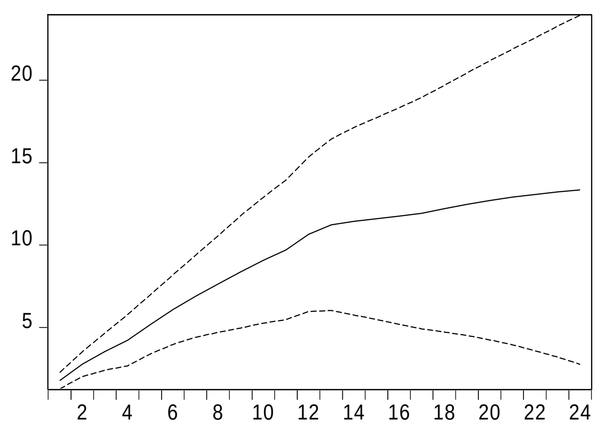
Response of Output to Interest rate



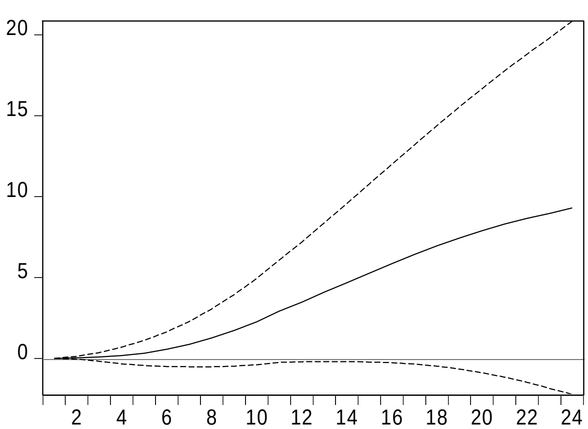
Response of Correlated Inflation rate to Interest rate



Response of Output to Interest rate



Response of Aggregate Inflation rate to Interest rate



Response of Output to Interest rate