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The Effect of Key Macroeconomic Shock Variables on GDP in Iran: A Sign-Restricted Bayesian VAR Approach

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Abstract

This paper is to study the effect of key macroeconomic shock variables including exchange rate, broad money, stock price index, and supply shock effect on GDP growth rate in Iran by using a novel econometric method namely sign-restricted vector autoregressive (SRVAR). We use 5 variables in the model including GDP growth rate, broad money, exchange rate, stock price index, and inflation rate as well as quarterly data from 1370Q2 to 1395Q4 (1991Q3–2017Q1). We identify shocks by using Arias et al. (2014) algorithm. The empirical findings from impulse response functions indicate that negative supply shock declines the growth rate for about 5 periods. Positive exchange rate shock reduces the growth rate for about 4 periods and thereafter raises the growth rate. The monetary shock declines the growth rate after a short period. A positive stock market shock has a positive effect on the growth rate for about 3 periods, and thereafter decreases it. The forecast error variance decomposition (FEVD) indicates that the negative supply shock, monetary shock, and exchange rate shocks are the most important explainers of the GDP growth rate shock.

Keywords: GDP, Iran, BVAR, Shock.
JEL Classification: C11, C39, E23, E52.

1. Introduction

The main goal of this paper is to investigate the effect of four different important macroeconomic shocks including expansionary monetary shock, the stock market shock, exchange rate shock, and negative supply shock on the real GDP growth rate in Iran. Expansionary monetary policy can reduce the interest rate and increase investment,

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and output and contractionary monetary policy can increase the interest rate and decrease investment and output level. Due to the institutional stabilization of interest rate in Iran, this variable may not have the same importance of advanced economies; therefore, we examine the monetary policy shock effect on real output via the inflation rate channel. Expansionary monetary policy can increase the inflation rate, deteriorate the competitiveness situation of the economy, and declining the growth rate. Negative supply shock can increase the inflation rate, and decrease real output. Exchange rate shocks or devaluation can deteriorate trade balance in the short-run, but in the long-run can increase export volume and raise the growth rate. A higher exchange rate raises the import price index, and, thereafter raises consumer price index or domestic inflation. This effect is known in the open macroeconomic literature to exchange rate pass-through. About the stock market shock effect on real output in this study, we assume that a positive shock, for example, good news or any other positive shock, has a positive effect on the stock market, and we expect to have a positive effect on real GDP growth rate. Although there are many studies about these shocks effect on real output, the main contribution of this paper to the existing literature is employing an advanced and state-of-the-art econometric methodology, which has not been used in the previous literature for the Iranian economy and therefore can fill this gap and enrich the previous literature significantly. To the best of our knowledge, this is the first attempt to identify these shocks with this approach. This approach has several advantages. First, by construction, impulse responses of a shock should agree with opinions on what these signs should be for a while. Secondly, because of identifying monetary policy shocks by using impulse responses for several periods following the shock, a wide range of monetary policy shocks can be captured. Third, impulse responses are taken out from the posterior distribution of the reduced form of VAR covariance matrices and coefficients, and from the series of structural matrices consistent with the assumed sign restrictions (Mountford, 2005). The approach of using sign restrictions to identify structural VAR models was pioneered by Faust (1998), Canova and De Nicolo (2002), and Uhlig (2005). This approach has become popular as an alternative to the traditional approaches to identification based on exclusion restrictions (Kilian and Lutkepool, 2016). There are different methods for estimation of sign-restricted VAR models such as Uhlig's (2005) penalty function, Uhlig's (2005) pure-sign-restriction method, etc. Although these methods have advantages and disadvantages, recently Arias, Rubio-Ramirez, and Waggoner (2014) indicated that Uhlig's (2009) penalty function (most widely used algorithm) had considerable shortcomings, and the results might be misleading. They proposed a novel algorithm which had not the previous shortcomings, which we use in this paper. After estimating the model, we obtain impulse response functions (IRF), and forecast error variance decompositions (FEVD), historical decompositions (HD), and the variables from 1395Q1 to 1404Q4 (2017Q2–2026Q1). We calculate root mean square error (RMSE), mean absolute error (MAE), and mean percentage absolute error (MAPE) in the studied period (1395Q1 to 1395Q4/2017Q2–2018Q2), which for brevity we report them in the appendix section. The remainder of this paper is organized as follows. Section 2 provides a literature review of the subject matter, and Section 3 presents the data and methodology. Section 4 reports the empirical findings, and Section 5 concludes the paper.

2. Literature Review

Various studies are using the sign-restricted VAR method to identify the specific shocks, e.g. monetary policy shocks (Faust, 1998; Canova and De Nicolo, 2002; Uhlig, 2005; Castelnovo, 2012), technology shocks (Peersman and Straub, 2009; Dedola and Neri, 2006), exchange rate shocks (Lewis, 2007; Farrant and Peersman, 2006), oil supply and demand shocks (Kilian and Murphy, 2013), and stock price shocks (Berg, 2010). This section reviews some of these studies and their results.

Uhlig (2005) studied the effects of monetary policy on real GDP for the US economy by employing the sign-restricted VAR approach and 6 variables including federal funds rate, total reserves, GDP price deflator, nonborrowed reserves, and commodity price index. He used penalty function and pure sign-restriction methods for the identification of monetary policy shock for the period from 1965:1 to 1996:12. Results indicated that the contractionary monetary policy shocks had no clear effect on real GDP, even though prices moved only gradually in response to a monetary policy shock. The neutrality of monetary policy shocks is not inconsistent with the data.

Mountford (2005) investigated the effects of UK monetary policy by using a structural vector autoregression (VAR) and quarterly data for the period from 1974Q1 to 2001Q2. He used Uhlig (2005) sign-restriction methodology and identified four shocks including a monetary policy shock, an oil price shock, and aggregate supply shock, and a non-monetary aggregate demand shock. Results revealed that shocks, which could reasonably be described as the monetary policy shocks, played a small role in the total variation of UK monetary and macroeconomic variables. Most of the variation in the UK monetary variables has been due to their systematic reaction to other macroeconomic shocks, namely non-monetary aggregate demand, aggregate supply, and oil price shocks.

Uhlig and Mountford (2009) studied the effects of fiscal policy shocks by employing a sign-restricted VAR approach for the US economy. They examined 10 variables including GDP, private consumption, total government expenditure, total government revenue, real wages, adjusted reserves, producer price index, GDP deflator, interest rate, and private non-residential investment with quarterly data over the period 1955–2000. They identified the two different shocks of government expenditure and government revenue. They found that deficit-financed tax cuts worked best to improve GDP, with a maximal present value multiplier of five dollars of total additional GDP per each Dollar of the total cut in government revenue, 5 years after the shock.

Kucserová (2009) studied the effects of the positive monetary policy shocks in Slovakia by using a sign-restricted SVAR method as well as the monthly data for the period from 1996:12 to 2008:3. He used 4 variables of real output, price index, nominal effective exchange rate, and short-run interest rate. Results indicated that an unanticipated 50 basis points increase of the key interest rate lowered the prices by up to 0.4% against the baseline. As expected, the peak response reached about one year after the shock at the latest. Yet, the effect on output was conflicting, suggesting that variations in the monetary policy account for a little variation in output.

Berument et al. (2012) studied the effects of monetary policy on the components of aggregate demand by using quarterly data on the Turkish economy over the period 1987–2008 and structural vector autoregression (VAR) methodology. They used Uhlig’s (2005) sign restrictions on the impulse responses of main macroeconomic variables to identify the monetary shock. They found that expansionary monetary policy stimulated output through consumption and investment in the short-run, but was ineffective in the long-run.

Berg (2010) studied the transmission of US stock price shocks to real activity and prices in G-7 countries by using a multicounty vector autoregressive (VAR) model. He used 9 variables for each of the G-7 countries in the model including government budget, real government expenditure, real GDP, real private consumption, real private investment, GDP deflator, a nominal short-run interest rate, a monetary aggregate (M1), and nominal stock prices with quarterly data for the period of 1974–2005. He identified three different shocks in the model including monetary policy shocks, business cycles shocks, and government expenditure shocks by using a sign-restriction method on impulse response functions. Results indicated that the stock price movements were important for fluctuations in G-7 real activity and prices, but did not qualify as demand-side business cycle shocks, and the transmission was the same across G-7 countries.

Sariola (2015) studied structural shocks and drove the business cycle in Sweden. He identified four different shocks including external demand shock, labor demand shock, technology shock, and labor supply shock. He used a sign-restricted SVAR model from 1993Q1 to 2013Q3 with 6 variables including real GDP, total hours worked, inflation, real wage, interest rate, and real export. Results indicated that a technology shock was contributing strongly to the GDP growth in several long periods. The domestic demand shock seemed to have contributed neither to the buildup of the boom nor in the bust. Table (1) shows the description of some of the previous studies, which identified various shocks by using the sign-restriction method.

Table1: Some of the Previous Studies

Researcher	Methodology	Variables	Identification Scheme
Peersman (2011)	VAR model	Ind. production HICP Loan volume Lending rate Policy rate Loans - M0	Loan Demand: 0, 0, +, +, ?, ? Monetary Policy: 0, 0, +, -, -,? Loan Supply: 0, 0, +, -, +, +
Gambetti and Musso (2012)	TVP-VAR-SV	Real GDP CPI Inflation Loan volume Lending rate Policy rate	Aggregate Supply: +, -, +, +, ? Aggregate Demand: +, +, +, +,? Loan Supply: +, ?, +, -, ?
Kilian and Murphy (2013)	Sign-Restricted BVAR	Oil production Real activity Real oil price Inventories	Flow supply shock: -, - , + Flow demand shock: + , + , + Speculative demand shock: +,- ,+,+
Mikko Sariola (2015)	Sign-Restricted BVAR	output hours prices wages interest rate exports	External demand: +, +, ? ,? ,+ Labor demand: +, +,?,? ,0 Technology: +,- ,+ ,? ,? Labor supply: + , - , -,?, ?
Bijsterbosch and Falagiarda (2015)	TVP-VAR-SV	Real GDP GDP deflator Policy rate Lending rate Credit volume	Aggregate Supply: +, -, ?, ?, ? Aggregate Demand: +, +, +, +, ? Monetary policy: +, +, -, ?, ? Loan supply: +, +, +, -, +

Source: Research Findings.

3. Data and Methodology

Choosing the model’s variables depends on the research objectives and the shocks type. We assume a small open economy and, henceforth, in this paper, we study 5 variables including GDP (real GDP growth rate), Inf (inflation rate), Stock (stock market index growth rate), EXR (exchange rate growth), and M2 (broad money growth rate). The exchange rate is USD against the Rial. Choosing the variables depends on the number and type of shocks and their identification channels as well as the openness of the economy. Following some of the previous studies, we used the year-on-year growth rate data except for inflation. When using the growth rate, we can obtain stationary variables and, therefore, it is not necessary to deal with cointegration or other similar issues in the model estimation.

The data were obtained from the database of the Central Bank of Iran from 1370Q2 to 1395Q4 (1991Q3–2017Q1). In this stage, we applied the ADF and KPSS tests for the variables. Table 2 shows the results. Based on the results, the variables are stationary at 5% and 10% significance level. Due to the structural break in M2 and the inflation rate, we applied the unit root test with a structural break. Results indicate that the study variables are stationary. As mentioned before, we have different algorithms for estimation of this sign-restricted Bayesian VAR model, e.g. Uhlig's (2005) penalty function method, Uhlig's (2005) pure sign-restriction method, Uhlig's (2009) penalty function approach, etc., but recently Arias, Rubio-Ramirez, and Waggoner (2014) proposed a novel algorithm, which has no drawbacks of PFA (most widely used algorithm). According to their novel algorithm, we can impose three different types of restriction to the model: 1) sign-restriction (positive or negative), 2) zero restriction, and 3) magnitude restriction for a specific shock identification. This algorithm is not sensitive to the order of the variable in the VAR model.

Table2: ADF and KPSS Unit Root Test Results

Variables	ADF-test stat.	C.V 5%	C.V 10%	Result
GDP	-5.322	-2.890	-2.582	I(0)
Stock	-5.485	-2.890	-2.582	I(0)
EXR	-3.061	-2.891	-2.582	I(0)
M2	-5.302	-4.443	-4.193	I(0)
Inf	-5.249	-4.443	-4.193	I(0)

Variables	KPSS- test stat.	C.V 5%	C.V 10%	Result
GDP	0.091	0.463	0.347	I(0)
Stock	0.045	0.463	0.347	I(0)
EXR	0.093	0.463	0.347	I(0)
M2	0.265	0.463	0.347	I(0)
Inf	0.273	0.463	0.347	I(0)

Source: Research Findings.

The study model can be summarized as follows. First, we draw the reduced-form of the VAR coefficients and residual variance-covariance matrix ($A_1, A_2, A_3, \ldots\ldots, A_p, \Sigma$) from their posterior distributions, and recover the reduced form of the VAR model. Equation (3) shows the reduced form of VAR.

$$B_0Y_t = B_1Y_{t-1} + B_2Y_{t-2} + \cdots\cdots\cdots + B_pY_{t-p} + \epsilon_t \quad (1)$$

$$Y_t = B_0^{-1}B_1Y_{t-1} + B_0^{-1}B_2Y_{t-2} + \cdots\cdots\cdots + B_0^{-1}B_pY_{t-p} + B_0^{-1}\epsilon_t \quad (2)$$

$$Y_t = A_1Y_{t-1} + A_2Y_{t-2} + A_3Y_{t-3} + \cdots\cdots + A_pY_{t-p} + u_t \quad (3)$$

$$E(\epsilon_t\epsilon_t') = I \quad , E(u_tu_t') = E\left(B_0^{-1}\epsilon_t\epsilon_t'B_0^{-1'}\right) = E\left(B_0^{-1}IB_0^{-1'}\right) = \Sigma$$

$$Y_t = A_1LY_t + A_2L^2Y_t + A_3L^3Y_t + \cdots\cdots + A_pL^PY_t + u_t \quad (4)$$

$$Y_t = (A_1L + A_2L^2 + A_3L^3 + \cdots\cdots + A_pL^P)Y_t + u_t \quad (5)$$

$$Y_t - (A_1L + A_2L^2 + A_3L^3 + \cdots\cdots + A_pL^P)Y_t = u_t \quad (6)$$

$$(I - A_1L - A_2L^2 - A_3L^3 \ldots\cdots\cdots - A_pL^P)Y_t = u_t \quad (7)$$

$$A(L)Y_t = u_t \quad (8)$$

$$Y_t = A(L)^{-1}u_t \quad (9)$$

$$Y_t = \psi_0u_t + \psi_1u_{t-1} + \psi_2u_{t-2} + \psi_3u_{t-3} + \cdots \quad (10)$$

$$B_0^{-1}B_0 = I \quad (11)$$

$$Y_t = \psi_0B_0^{-1}B_0u_t + \psi_1B_0^{-1}B_0u_{t-1} + \psi_2B_0^{-1}B_0u_{t-2} + \ \ldots \quad (12)$$

$$u_t = B_0^{-1}\varepsilon_t \text{ And we can write } B_0u_t = \varepsilon_t \quad (13)$$

$$Y_t = (\psi_0B_0^{-1})\varepsilon_t + (\psi_1B_0^{-1})\varepsilon_{t-1} + (\psi_2B_0^{-1})\varepsilon_{t-2} + \cdots. \quad (14)$$

$$Y_t = (\widetilde{\psi}_0)\varepsilon_t + (\widetilde{\psi}_1)\varepsilon_{t-1} + (\widetilde{\psi}_2)\varepsilon_{t-2} + (\widetilde{\psi}_3)\varepsilon_{t-3} + \cdots \quad (15)$$

From this reduced-form VAR model, we obtain the impulse response functions ($\psi_0, \psi_1, \psi_2, \ldots.., \psi_p$), and decompose residual variance-covariance matrix $\sum$ with cholesky decomposition function, so that $\Sigma = LL'$ (L is a lower triangular matrix). Then, we generate the initial impulse response functions ($\bar{\psi}_0, \bar{\psi}_1, \bar{\psi}_2, \ldots.., \bar{\psi}_p$).

$$\bar{\psi}_0 = \psi_0L \quad , \bar{\psi}_1 = \psi_1L \quad , \bar{\psi}_2 = \psi_2L, \ldots.$$

However, these initial impulse response functions are not taken out from the correct distribution. To draw from the correct posterior distribution, an additional orthogonalization step is required. To do so, one has to take out a random matrix Q from a uniform distribution and defines $B_0^{-1} = L.Q$. The strategy is then to take out such a Q matrix, which would be orthogonal, to preserve the SVAR property. To obtain an orthogonal matrix Q from the uniform distribution, the procedure is as the following. First, we draw an $n \times n$ random matrix X (n is the number of the variables in the VAR model), for which each entry is taken out from an independent standard normal distribution. Then, we use a QR decomposition of X, so that $X = QR$, with Q as an orthogonal matrix and R as an upper triangular matrix. It is then possible to generate the definitive structural impulse response functions ($\widetilde{\psi}_0$, $\widetilde{\psi}_1$, $\widetilde{\psi}_2$, $\widetilde{\psi}_3$ …).

$$\widetilde{\psi}_0 = \bar{\psi}_0 Q \quad , \quad \tilde{\psi}_1 = \bar{\psi}_1 Q \quad , \quad \tilde{\psi}_2 = \bar{\psi}_2 Q \quad , \ldots$$
$$B_0^{-1} = L.Q \, , E\left(B_0^{-1} I B_0^{-1'}\right) = E(LQQ'L') = E(LL') = \Sigma \qquad (16)$$
$$\tilde{\psi}_i = \psi_i B_0^{-1} = \psi_i LQ = \bar{\psi}_i Q \, , i = 1,2,3, \ldots.$$

In the second stage, we examine the significant restrictions on the structural impulse response functions. If the restrictions are satisfied as described in the model, we hold them; otherwise, we discard them and repeat until the desired number of iterations satisfying the restrictions is obtained. $\widetilde{\psi}_i$ are the structural impulse response functions. Therefore, we have a series of impulse response functions with the desired sign, whose we report the median. Table 3 shows the sign restrictions of the impulse response functions. We impose these sign restrictions to the model based on the economic theories such as the previous studies. Due to the 5 variables in the model, we have 5 shocks there. Yet, it is not necessary to identify all shocks in one model. Identification of the number of shocks depends on the researcher and the study objectives. Therefore, we only identify four shocks in the model. Negative supply shock reduces the growth rate, and raises inflation rate. Therefore, we impose a positive sign to the inflation rate. A positive monetary shock raises the inflation rate, and may reduce the GDP growth rate. Because it deteriorates the economic competitiveness situation. Therefore, we impose a positive sign to the inflation rate. A positive exchange rate shock can increase the inflation rate due to the exchange rate pass-through from import price index to domestic inflation. Therefore, we impose a positive sign to the inflation rate variable. We assume that a positive stock market shock have a positive effect on the stock market growth rate. Therefore we impose a positive sign to this variable. According to this identification procedure, we are agnostic about the response of real GDP growth to these shocks. We identify the shocks only with sign restriction, and don't impose zero or other restrictions to the model. If we impose too many restrictions to the model, the computation will be very complex and, therefore, time consuming. Therefore, we do not impose many restrictions to the model. We imposed the sign restrictions to first four quarters (1 to 4) due to the quarterly nature of the data. We set Minnesota prior for the model (the most popular prior in the Bayesian VAR literature) and 4 lags in the model, which is consistent with quarterly data (Koop, 2009), and estimate the model based on the Arias, Rubio-Ramirez, and Waggoner's (2014) methodology with powerful MATLAB software.

$$\begin{bmatrix} u_1^{gdp} \\ u_2^{stock} \\ u_3^{exr} \\ u_4^{m2} \\ u_5^{inf} \end{bmatrix} = \begin{bmatrix} ? & ? & ? & ? & ? \\ ? & + & ? & ? & ? \\ ? & ? & ? & ? & ? \\ ? & ? & ? & ? & ? \\ + & ? & + & + & ? \end{bmatrix} \times \begin{bmatrix} \epsilon_1^{supply\ shock} \\ \epsilon_2^{stock\ shock} \\ \epsilon_3^{exchange\ shock} \\ \epsilon_3^{monetary\ shock} \\ \epsilon_5 \end{bmatrix}$$

$$u_t = B_0^{-1} \times \epsilon_t$$

Table3: Identification of Impulse Response Functions

	shocks			
variables	**Supply shock**	**Stock market shock**	**Exchange rate shock**	**Monetary Shock**
GDP				
Stock		+		
EXR				
M2				
Inf	+		+	+

Source: Research Findings.

4. Empirical Results

Figure 1 illustrates the impulse response functions. The negative supply shock reduces the growth rate for about 5 periods and raises the inflation rate for about 3 periods. The result of this shock on the growth rate is consistent with our expectations. The positive exchange rate shock reduces the growth rate for about 4 periods and, thereafter, raises the growth rate. This is similar to the so-called J-Curve phenomenon in the open macroeconomics literature. The result of this shock on the growth rate is consistent with our expectations. The positive exchange rate shock decreases the growth rate for about 4 periods and, thereafter, raises the growth rate. The J-Curve effect is seen in economics when a country’s trade balance initially worsens following a deterioration of its currency. The higher exchange rate first corresponds to more costly imports and less valuable exports, leading to a bigger initial deficit or a small surplus, in cases when a country’s currency appreciates as a reverse J-Curve. Positive monetary shock raises the inflation rate for about 2 periods and reduces the growth rate for about 4 periods. This is in line with theory, because the expansionary monetary shocks raise the inflation rate, and decreases the economic competitiveness and, therefore, raises import and decline domestic output. The response of positive stock market shock is positive on itself for a short time and has a positive effect on the growth rate for about 3 periods. The results are in line with the theory. There are also other links between stock prices and real economic activity, which have been put in the theoretical literature. The stock market performance affects the real economic activity through lowering the cost of mobilizing savings, and thereby facilitating investment in most productive technologies (Greenwood and Smith, 1997), providing liquid capital through, which stock markets contribute to growth (Levine, 1991), increasing incentives to get information about firms to investors (Holmstrom and Tirole, 1993), improving resource allocation through international risk sharing (Obstfeld, 1994), increasing the wealth of investors, and hence increasing consumption and in turn the economic growth (Mauro, 2003). Figure (2) illustrates the forecast error variance decomposition (FEVD) results for the variables, and Table 2 indicates the FEVD for GDP growth rate. The forecast error variance decomposition is the size of the error variance made in forecasting a variable due to the model's structural shock. We only analyze the FEVD of GDP growth rate based on the main objective of this study. Based on Table (4), the negative supply shock, monetary shock, and exchange rate shocks are the most important explainers of the GDP growth rate after 20 periods. A matter of interest with VAR models is to establish the contribution of each structural shock to the historical dynamics of the data series. Precisely, for every period of the sample, one may want to decompose the value of each variable into its different components, each due to one structural shock of the model. This identifies the historical contribution of each shock to the observed data sample. Figures (3) and (4) show the historical decomposition of the variables in the model. We only analyze the historical decomposition of GDP growth rate and the historical contribution of structural shocks to this variable. According to the results from 1371Q2 to 1375Q4 (1992Q3–1997Q1), on average, supply shock had an important effect on the growth rate, and after that, the exchange rate and the monetary shocks were the most important contributors to the growth rate. In the early 1370s, the Iranian economy experienced exchange rate misalignments and one of the highest inflation rates (1374 by 49.5%). From 1380Q1 to 1385Q4 (2001Q2–2007Q1), the exchange rate shock was the most important contributor to the growth rate on average, and after that, supply shock and monetary shocks were important contributors. The Iranian economy experienced the exchange rate equalization policy between the free-market exchange rate and public exchange rate in the 1380s. From 1390Q1 to 1395Q4 (2011Q2–2017Q1), the supply shock was the most important contributor to the growth rate, and after that, the monetary and the exchange rate shocks were the important contributors. In the early 1390s, the Iranian economy experienced a negative growth rate. It seems that this issue is because of the severe economic sanctions by the western countries against the Iranian economy in the early 1390s. These severe economic sanctions increased the exchange rate significantly and reduced the growth rate. In the last stage, we forecasted the variables from 1390Q1 to 1404Q4 (2011Q2–2026Q1) and calculated the root mean square error (RMSE), the mean absolute error (MAE), and the mean percentage absolute error (MAPE) of forecasting in the studied period, which for brevity, we report in the appendix section. Figure (5) shows the forecasting results.

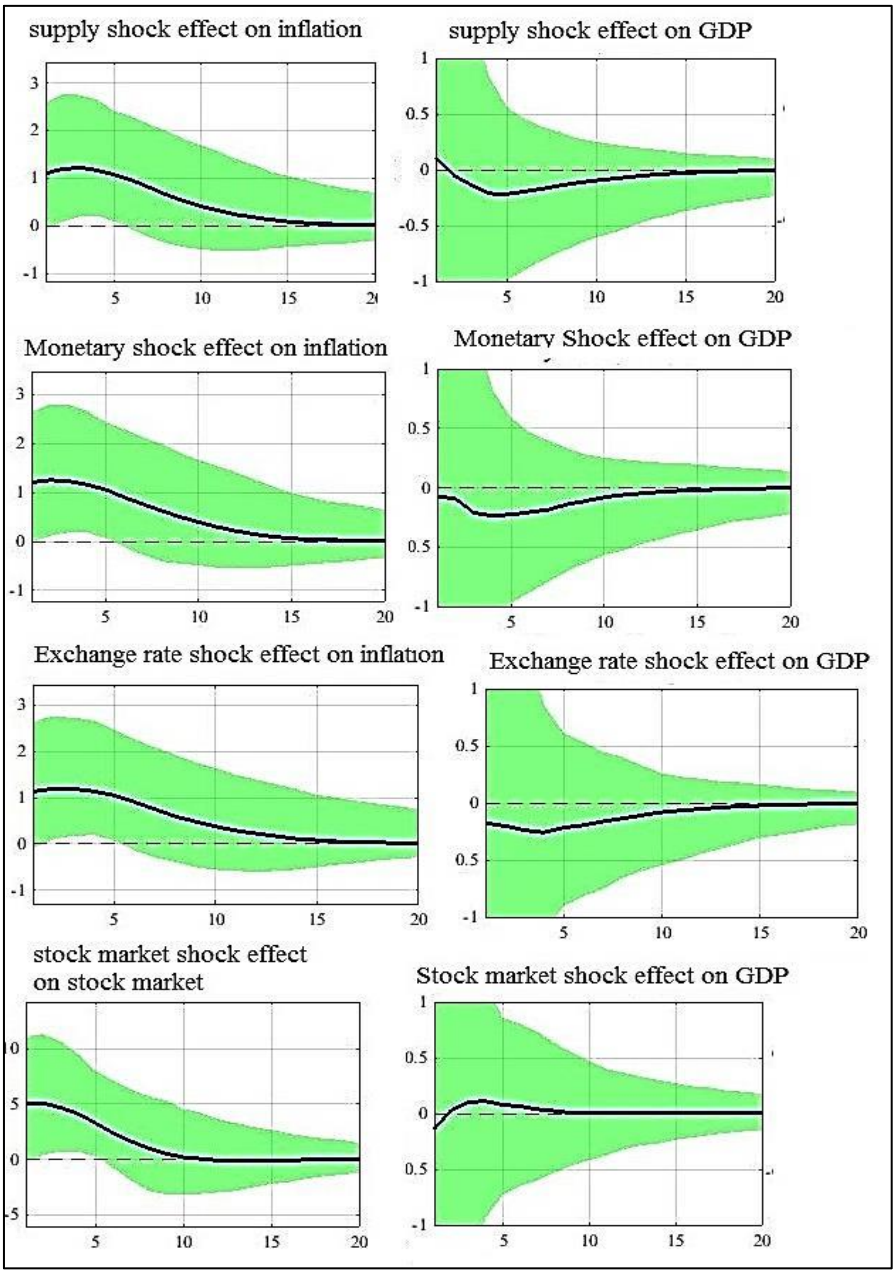

Figure1: Impulse Response Functions
Source: Research Findings.

Table4: Forecast Error Variance Decomposition of GDP Growth Rate

Period	GDP	EXR	M2	Stock	Inf
1	0.1291	0.1313	0.1311	0.1200	0.1079
2	0.1267	0.1296	0.1332	0.1173	0.1067
3	0.1308	0.1301	0.1330	0.1215	0.1087
4	0.1327	0.1302	0.1364	0.1225	0.1137
5	0.1378	0.1335	0.1423	0.1240	0.1170
6	0.1390	0.1357	0.1422	0.1256	0.1202
7	0.1436	0.1380	0.1430	0.1257	0.1222
8	0.1457	0.1399	0.1438	0.1252	0.1240
9	0.1471	0.1419	0.1432	0.1248	0.1255
10	0.1474	0.1424	0.1435	0.1251	0.1260
11	0.1470	0.1432	0.1442	0.1262	0.1265
12	0.1495	0.1439	0.1446	0.1262	0.1267
13	0.1492	0.1440	0.1448	0.1266	0.1268
14	0.1500	0.1443	0.1453	0.1275	0.1268
15	0.1506	0.1448	0.1461	0.1276	0.1269
16	0.1514	0.1452	0.1468	0.1287	0.1275
17	0.1513	0.1454	0.1471	0.1289	0.1281
18	0.1518	0.1462	0.1476	0.1289	0.1282
19	0.1518	0.1459	0.1477	0.1290	0.1282
20	0.1519	0.1455	0.1477	0.1290	0.1283

Source: Research Findings.

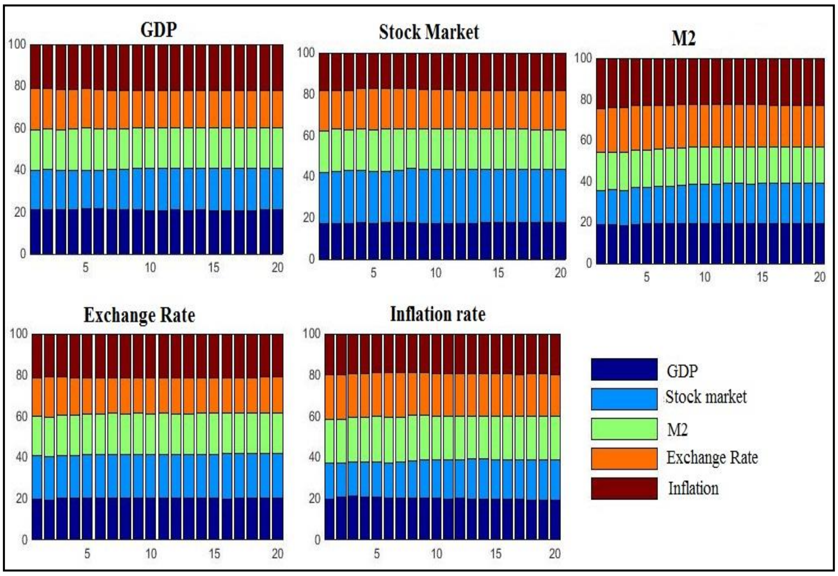

Figure2: Forecast Error Variance Decomposition of the Variables

Source: Research Findings.

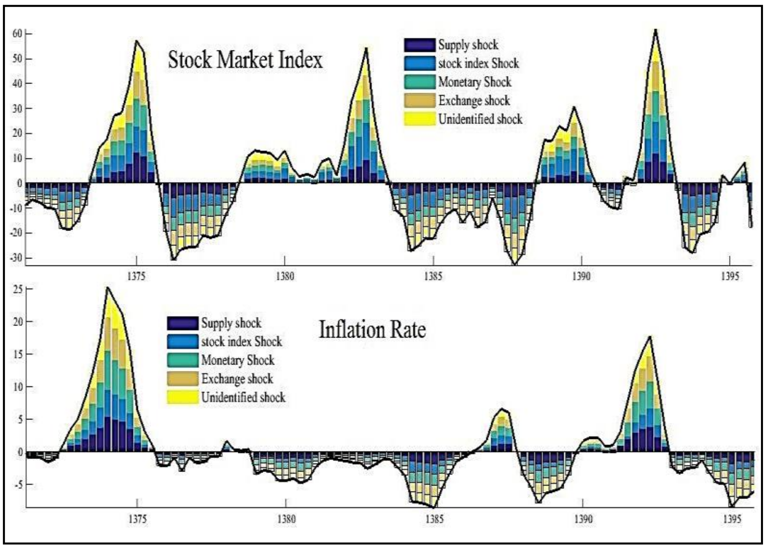

Figure 3: Historical Decomposition of Stock Market and Inflation
Source: Research Findings.

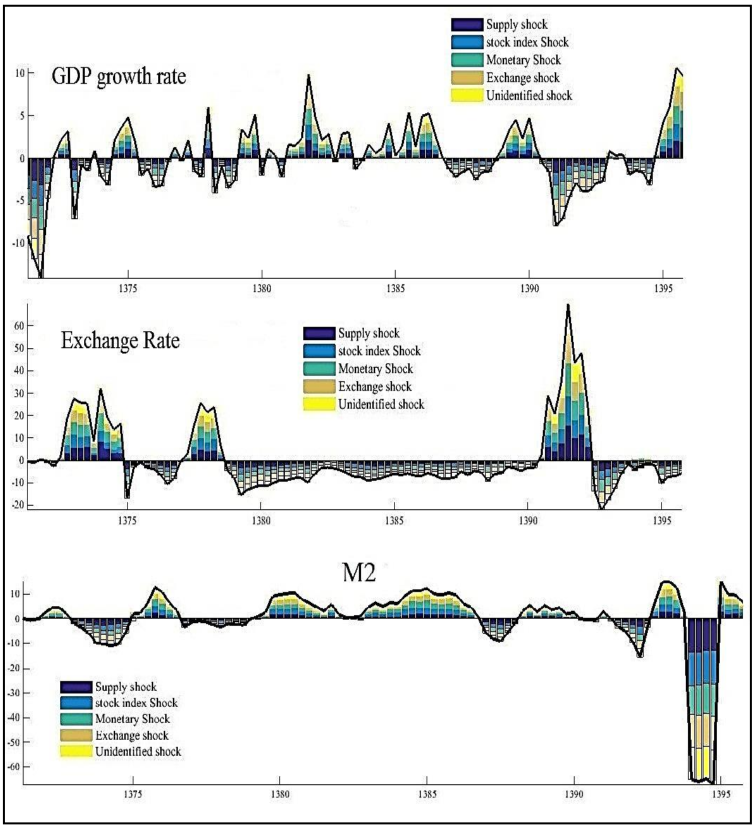

Figure 4: Historical Decomposition of GDP, Exchange rate and M2
Source: Research Findings.

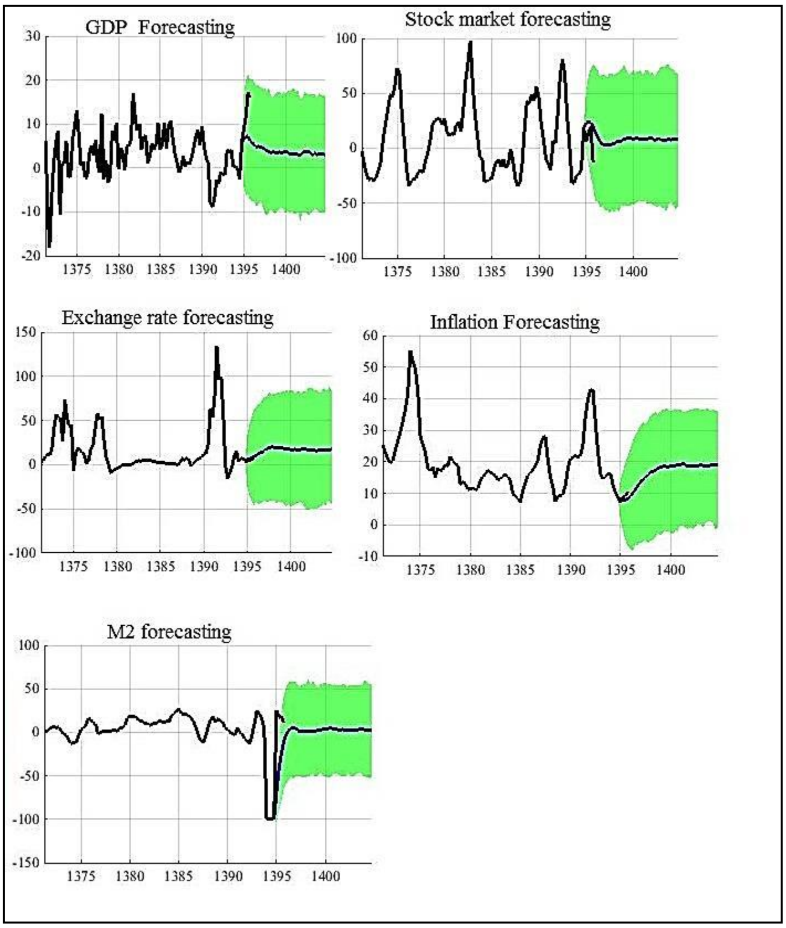

Figure 5: Forecasting of the Variables from 1390Q1-1404Q4

Source: Research Findings.

5. Conclusions

This paper studied the effect of key macroeconomic variables shocks on the real GDP growth rate of Iran by employing a sign-restricted Bayesian VAR approach. Although there are different methods in the sign-restricted Bayesian VAR literature for the model estimation, we used Arias, Rubio-Ramirez, and Waggoner's (2014) methodology, which is one of the most recent and advanced econometric methodologies in the literature. Empirical findings indicate that the negative supply shock reduces the growth rate for about 5 periods, the expansionary monetary policy shock raises the inflation rate and decreases the GDP growth rate for a short time, and then increases the growth rate. The exchange rate shock has a negative effect on the growth rate for about 4 periods, and then raises the growth rate. A positive stock market shock has a positive effect on the growth rate for about 3 periods. The historical decomposition of GDP growth rate showed that in early 1370s, the supply shock was the most important contributor to the growth rate in average. In early 1380s, the exchange rate shock was the most important contributor to the growth rate. In this period, the exchange rate had more stationarity than the early 1370s and 1390s. In early 1390s, the supply shock was the most important contributor to the growth rate in average, and after that, the monetary and exchange rate shocks were the important contributors.

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Appendix:

GDP forecast

	1395q1	1395q2	1395q3	1395q4
RMSE:	2.288	3.598	6.464	7.402
MAE:	2.288	3.417	5.602	6.623
MAPE:	25.457	32.244	40.766	45.776

Stock market forecast

	1395q1	1395q2	1395q3	1395q4
RMSE:	16.849	14.164	11.785	19.380
MAE:	16.849	13.841	10.536	16.139
MAPE:	264.803	172.275	121.490	153.338

M2 forecast

	1395q1	1395q2	1395q3	1395q4
RMSE:	95.402	79.878	69.853	61.451
MAE:	95.402	77.948	66.408	55.206
MAPE:	373.198	361.365	319.366	288.828

Exchange rate forecast

	1395q1	1395q2	1395q3	1395q4
RMSE:	1.470	1.494	2.322	2.106
MAE:	1.470	1.494	2.137	1.914
MAPE:	34.722	31.533	46.633	38.878

Inf forecast

	1395q1	1395q2	1395q3	1395q4
RMSE:	0.944	1.098	1.155	1.550
MAE:	0.944	1.089	1.146	1.451
MAPE:	13.129	13.439	13.546	15.683