Environmental Energy and Economic Research (2018) 2(1): 51-61
DOI 10.22097/eeer.2018.142182.1031

The Impact of Shocks in Oil price and Exchange Rate on Inflation in Iran: The Application of the VAR Approach

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Received: 1 August 2017 /Accepted: 25 December 2017

Abstract
Iran is one of the oil exporting countries, so the oil price plays a remarkable role in the government budget and is a major source of foreign exchange. On the other hand, the reliance of the government budget to oil income as well as its fluctuations is a fact referred to as the most important cause of inflation by many researchers. This paper explores the effect of shocks in the exchange rate, oil price, and production as the three main shocks in the economy on the most important variable in Iran's macroeconomy, i.e. price level. So, the vector auto-regression (VAR) model is used with seasonal data for the period of 1991-2016. After the model is estimated, impulse response functions are calculated and analysis of variance is performed to figure out the contribution of each shock in the variance of the prediction error of these variables. The results show that the strong dependence of exchange rate on foreign exchange earnings of oil price allows the rapid growth of the prices in Iran and the effect of the shock is increasing over time. Also, sanctions in 2012 did not reduce oil price, but they influenced the exchange rate and inflation significantly.

Keywords: Shock, Oil, Inflation.

Introduction

Fluctuations in inflation or prices may be a source of economic variations with some impacts on the overall economic performance. Thus, the inflation rate is usually considered an important economic indicator to assess the economic performance (Kun Sek, 2015).Since the 1970s, inflation has emerged as one of the gravest economic problems in various countries. Economists and economic agencies in Iran have listed a wide range of factors in their attempts to explain the causes of inflation, including the structure and foundations of the economy, how exchange policies are implemented, and shocks. However, a look at inflation as an acute problem shows that all these factors contribute to it and reinforce the impacts of one another and, in some cases, they create one another in a series (Yazdani and Zare, 2016).

Public people are very familiar with oil price as an economic indicator as they see a close relationship between oil price and their daily life. People closely follow the variations in the prices of oil products, such as gasoline or gas. Also, their expectations have been firmly

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shaped by the relationship between oil prices and economic cycles since the oil shocks of the 1970s (Yoshizaki, 2013).Iran possesses 11 percent of the oil reserves of the world so that 80-90 percent of total exports and usually half of the government's annual budgets are supplied from oil exports and oil sale accounts for over 20 percent of Iran's gross domestic product (GDP). In this situation, any shock in the global oil market can entail extensive impacts on Iran's economic structure. Thus, to avoid economic crises and to use the potential opportunities, it is imperative to explore the impacts of global oil price fluctuations on Iran's economy and to develop proper economic policies in order to uphold the stability of the economy (Sameti et al., 2017). Also, due to the over-reliance of Iran's economy to foreign exchange earnings of oil sale over the years, the fluctuations of exchange rate have emerged as a key factor in policymaking. So, when formulating the development plans and annual budgets, the policymakers need to understand and predict how fluctuations of variables would influence economic inflation in order to minimize the negative impacts of shocks in oil price and exchange rate on inflation by adopting appropriate policies. The present paper evaluates the effect of the shocks in oil price and exchange rate on inflation in Iran using seasonal data over the 1991-2016 period.

The paper is organized into five sections. The first section is an introduction to the subject matter. The second section briefly reviews the relevant literature. The model is introduced in the third section followed by the presentation of the results of model estimation for Iran's economy in the fourth section and finally, the concluding section that contains some recommendations.

Literature Review

Extensive research has focused on describing the relationship between oil price shocks and the national economy of the US. For example, Hamilton (1983) observed that oil price shocks were the main factor responsible for the recession. This encouraged other researchers in both developed and developing countries to work in order to either support or refute this finding. Examples include Rasche and Tatom (1981), Darby (1982), Hamilton (1983, 1996, 2003, 2008), Chang and Wong (2003), Cunado and Gracia (2005), Lorde et al. (2009), Dogrul and Soytas (2010), and Rasmussen and Roitman (2011) who have argued that oil price shocks significantly influence economic activities, mainly economic growth.Ragabooorur and Chicooree (2013) focused on the effect of exchange rate on consumer and producer price index and import prices in Mauritius. They found that the effect of exchange rate pass was strong on consumer price index but weak on import price. Analysis of variance pointed to oil price shock as the main cause of import price fluctuations. Madesha et al. (2013) empirically tested the relationship between exchange rate and inflation in Zimbabwe over 1980-2007. They employed the Granger causality test to estimate the long-term relationship between exchange rate and inflation rate. The results showed that inflation and exchange rate had Granger-causality over the studied period. According to the results, if appropriate policies are adopted, they can orient the attitudes towards determining exchange rate without leading to inflation. Fakieh (2013) addressed the relationship between inflation and exchange rate policies in Saudi Arabia to specify an appropriate policy for this main oil exporting country with respect to inflation rate using econometric techniques and time series data.si milar to Altowijiri (2011), Hassan and Alogell (2008) and Albarwani et al. (2010), he applied the econometric techniques of OLS, Dickey-Fuller test, unit root test, integrating, and error correction models. He reported that the fixed exchange rate system was not appropriate for Saudi Arabia. Accordingly, other variables, e.g. growth, oil price, and export and import prices, should be considered when suitable exchange rate system was to be specified. Then, he argued that the current exchange rate system was the main cause of high inflation in Saudi

Arabia. Aloui and Jammazi (2010) used a two-regime model (MS-EGARCH) to relate the fluctuations of the oil market and stock price in France, the UK, and Japan for the 1989-2007 period. The results showed that the increase in oil price significantly influences both stock return fluctuations and transfer possibility across the regimes. With respect to the impacts of oil shocks on stock market dynamics, the monetary economy is based on the premise that there is not a long-term relationship between inflation and real economic activities. Sameti et al. (2017) addressed the impacts of oil income growth shocks on Iran's economy using the TVP-VAR models for the 1988-2012 period. They included the variables of added-value growth of industry and mining sector, unofficial exchange rate, inflation rate, the government's real consumption expenditure growth, real imports growth, real oil income growth, and oil market shocks in the model. They found variations in the relationships of these variables over time. Also, they reported that how the current conditions affect the economy influences how model variables affect one another. Asna Ashari et al. (2015) employed Qu and Perron (2007)'s suggested model to explore the effect of oil price shocks on inflation, growth, and money in Iran's economy in 1961-2011. They identified five structural shocks happened in September 1973, July 1979, May 1990, July 1994, and May 2006. The highest coefficients of oil price impact on production, inflation, and money growth were related to the first, first, and fifth regimes, respectively. Furthermore, the longest period of oil price impact on production, inflation, and money growth was found in the fourth, second, and fifth regimes, respectively. Yazdani and Zare (2016) investigated the effect of exchange rate shocks in Iran's economy using the seasonal time series statistics for the period of 2000-2012. They employed structural vector auto-regression model (SVAR). They found that in the studied period, exchange rate variations and exchange policies have been the main causes of inflation so that they have created a structural inflation in Iran's economy. Thus, the exchange policies adopted in this period, including the policy of exchange rate stabilization, have fomented the inflation. Ghafari et al. (2013) focused on the effect of exchange rate increase on main macroeconomic variables of Iran in a structural macroeconometric model by assessing the impact of the gradual or sudden increase in exchange rate within some simulation scenarios. They reported that the detrimental effects of exchange rate increase on main macroeconomic variables are less severe in case of gradual growth of exchange rate than in case of its sudden increase.

Materials and Methods

We selected vector auto-regression (VAR) model for data analysis as it is the best model to analyze the empirical model of the present study because it uses a very easy procedure and does not require the researcher to determine whether the variable is indigenous or exogenous (Sarzaeem, 2007). VAR models yield better predictions than simultaneous equations, and their potential to represent the dynamic structure of the model and the rational expectations in short run enables tackling the constraints and limitations usually associated with economic theories(Kani, 1989). For these reasons, it is said that the VAR method does not need an explicit economic model to estimate the model. The model of the present study that is derived from Samadi et al. (2010)'s empirical model employs the VAR method to examine and calculate how much inflation is accounted for by the shocks. The variables included gross domestic product (GDP), oil price (POIL), exchange rate calculated as USD to IRR (Ex), and inflation at general level of prices (CPI). Time series data of Iran's economy for the time period of 1991-2016 were employed and they were analyzed with Eviews software package. The research estimated the following equations to relate the variables using the VAR model:

$$y_t = c + \sum_{i=1}^{p} A_i Y_{t-1} + \varepsilon_t \qquad (1)$$

$$CPI_t = \alpha_{10} + \alpha_{11}CPI_{t-1} + \alpha_{12}GDP_{t-1} + \alpha_{13}POIL_{t-1} + \alpha_{14}EX_{t-1} \qquad (2)$$

$$GDP_t = \alpha_{20} + \alpha_{21}CPI_{t-1} + \alpha_{22}GDP_{t-1} + \alpha_{23}POIL_{t-1} + \alpha_{24}EX_{t-1} \qquad (3)$$

$$POIL_t = \alpha_{30} + \alpha_{31}CPI_{t-1} + \alpha_{32}GDP_{t-1} + \alpha_{33}POIL_{t-1} + \alpha_{34}EX_{t-1} \qquad (4)$$

$$EX_t = \alpha_{40} + \alpha_{41}CPI_{t-1} + \alpha_{42}GDP_{t-1} + \alpha_{43}POIL_{t-1} + \alpha_{44}EX_{t-1} \qquad (5)$$

Model Estimation

To estimate the model, we should first determine whether the variables are stationary. Unit root test is a popular method to identify the stationarity of a time series process. This test can be conducted in two forms: Dickey-Fuller test and augmented Dickey-Fuller (ADF) test. The present paper uses the latter test.

Table 1. Results of augmented Dickey-Fuller unit root test for the variables included in the model

Variable	Level				First-order differentiation			
	With *y*-intercept		With *y*-intercept and trend		With *y*-intercept		With *y*-intercept and trend	
	Calculated Statistic	Critical statistic	Calculated Statistic	Critical statistic	Calculated Statistic	Critical statistic	Calculated statistic	Critical statistic
Inflation	1.39	-2.58	-0.94	-3.02	-2.09	-1.94	-3.40	-3.02
Exchange rate	2.39	-1.94	-0.63	-3.02	-9.09	-1.94	-9.62	-3.02
Oil price	-1.30	-1.94	-2.78	-3.02	-8.04	-1.94	-7.98	-3.02
Production	1.35	-1.96	-1.98	-3.02	-2.39	-1.94	-4.24	-3.02

Note: Critical values at $p < 0.05$ level.
Source: Computer appendix (the output of Eviews software package)

The results show that the log of the time series variables that were included in the model was non-stationary at data level and the t-values calculated by ADF was smaller than the MacKinnon critical values at the 1%, 5%, and 10% levels. So, the null hypothesis of unit root was not refuted and it was confirmed that the variables were not stationary. Thus, it was necessary to perform first-order differentiating on them. All variables became stationary after performing one-time differentiating.

The first step in Johansson long-run cointegration method is to determine the optimal lag length in the VAR model. This was estimated by the Schwarz–Bayesian criterion (SBC) statistic. The optimal lag was selected to be 3.

In the study, before examining the presence of a long-term relationship, the correlation of the residuals was estimated by the LM test. The results showed the lack of correlation between residual terms up to eight lags. Also, this shows that the order by which the variables were included in the model had no effect on the estimations.

In the next step, to determine whether there was a long-run relationship between the variables of the model, Johansson test was first performed to estimate the number of long-run cointegration vectors. This was determined with two likelihood ratio tests (Max-Eigen statistic $\lambda_{\max}$ and trace statistic λ_{trace}) whose results are presented in Tables 3 and 4. Accordingly, there was a single long-run cointegration vector.

Table 2. The results of the LM test

Lag	LM statistic	Probability
1	151.62	0.000
2	52.85	0.000
3	82.70	0.000

Source: Research findings.

Table 3. Results of the Johanssen cointegration test according to trace statistic

Number of cointegration vectors in null hypothesis	Number of cointegration vectors in opposite hypothesis	Test statistic	Critical value at level	Probability level
*r ≤ 0	r = 1	55.57673	47.85613	0.0080
r ≤ 1	r = 2	18.86053	29.79707	0.5030
r ≤ 2	r = 3	6.723835	15.49471	0.6100
r ≤ 3	r = 4	0.488328	3.841466	0.4847

* Rejection of null hypothesis about the lack of cointegration vectors at significance level
Source: Research findings.

Table 4. Results of the Johanssen cointegration test according to Max-Eigen statistic

Number of cointegration vectors in null hypothesis	Number of cointegration vectors in opposite hypothesis	Test statistic	Critical value at level	Probability level
*r ≤ 0	r = 1	36.71619	27.58434	0.0026
r ≤ 1	r = 2	12.13670	21.13162	0.5342
r ≤ 2	r = 3	6.235507	14.26460	0.5832
r ≤ 3	r = 4	0.488328	3.841466	0.4847

* Rejection of null hypothesis about the lack of cointegration vectors at significance level
Source: Research findings.

After it was ensured that there was a cointegration vector between the variables in long run, the response of the variables to the shocks induced by other variables was examined in order to study the dynamic behavior of the variables in the context of the studied model. This was performed by response functions. Figures 1-3 illustrate the results for a shock at the magnitude of one standard deviation (SD) and the response of other variables to this shock.

Figure 1 displays that when a positive shock with the magnitude of 1 SD is applied to the price index, its impact gradually increases over time so that GDP is increased and oil price and exchange rate are decreased. This shock had significant positive effects over the studied periods ($p < 0.05$).

According to Figure 2, a positive shock to GDP with the magnitude of 1 SD entails a gradually decreasing impact resulting in the increase in price index, oil price, and exchange rate. This shock had positive effects over the studied period and its effects were significant ($p < 0.05$).

Figure 3 depicts that a 1SD positive shock to oil price results in a gradually decreasing impact. The shock to oil price has a negative effect on GDP, but its effect is positive on price index and exchange rate. The shock had positive effects on the studied period, but they were not significant at $p < 0.05$ level.

Figure 4 shows the effect of a positive 1SD shock to the exchange rate. This shock entails a gradually descending effect. The effect of shock to exchange rate is negative on GDP and oil price, but positive on price index. This shock had significant positive effects over the studied period ($p < 0.05$).

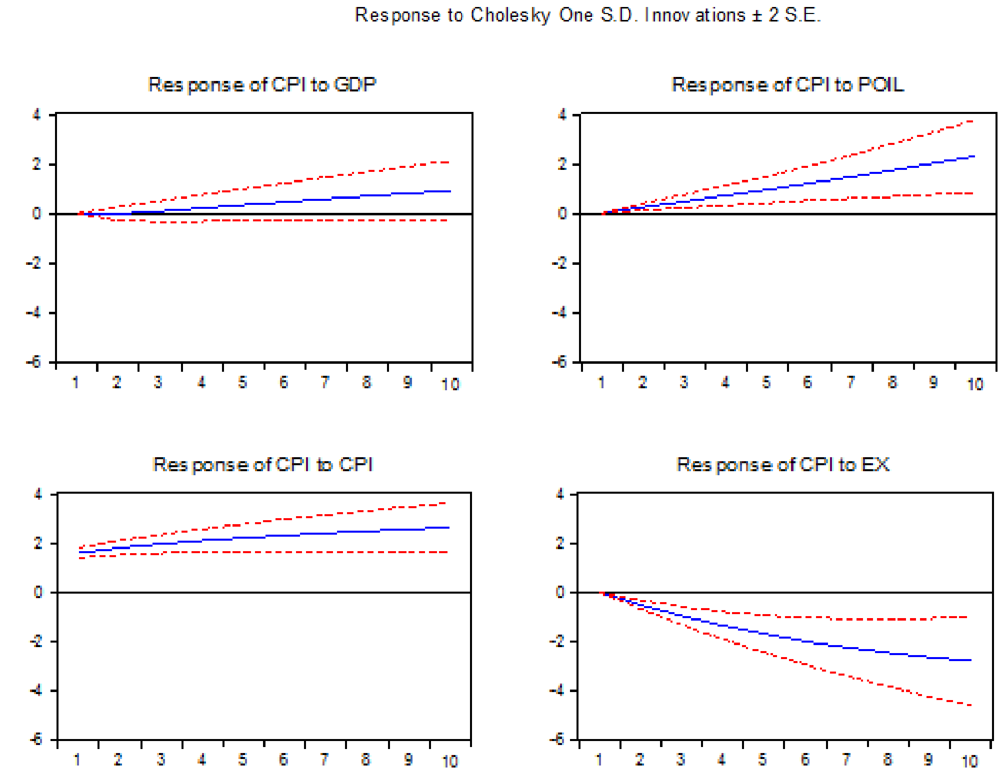

Figure 1. Impulse response functions when shock is applied to inflation

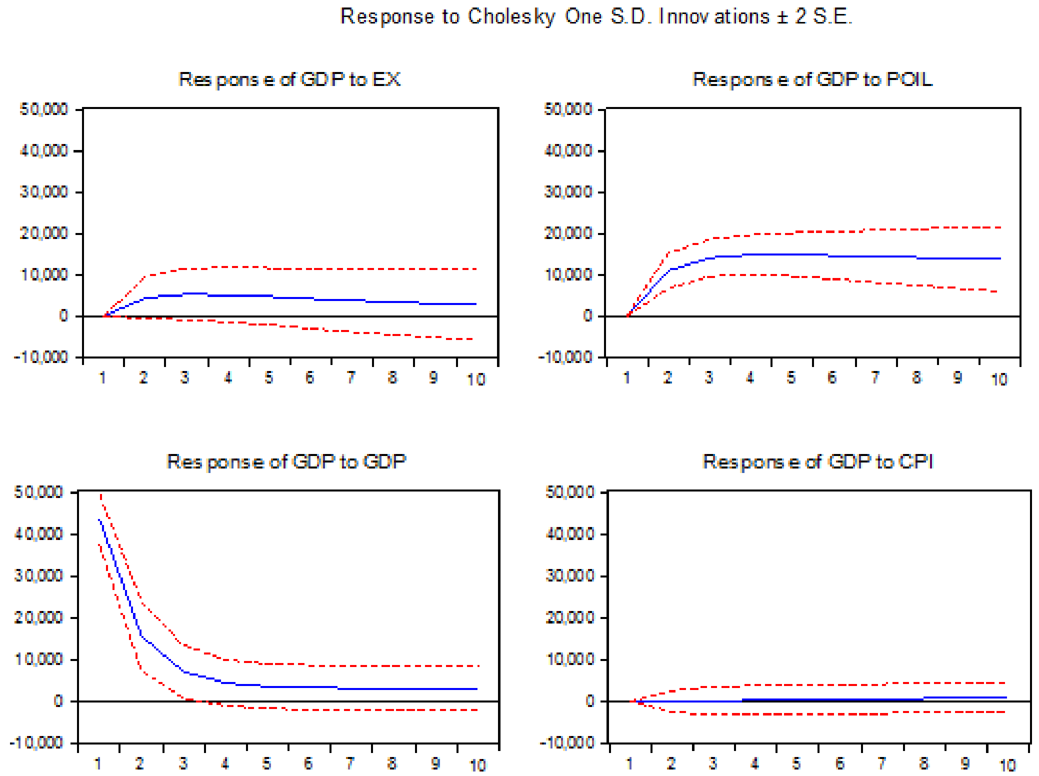

Figure 2. Impulse response functions when shock is applied to GDP

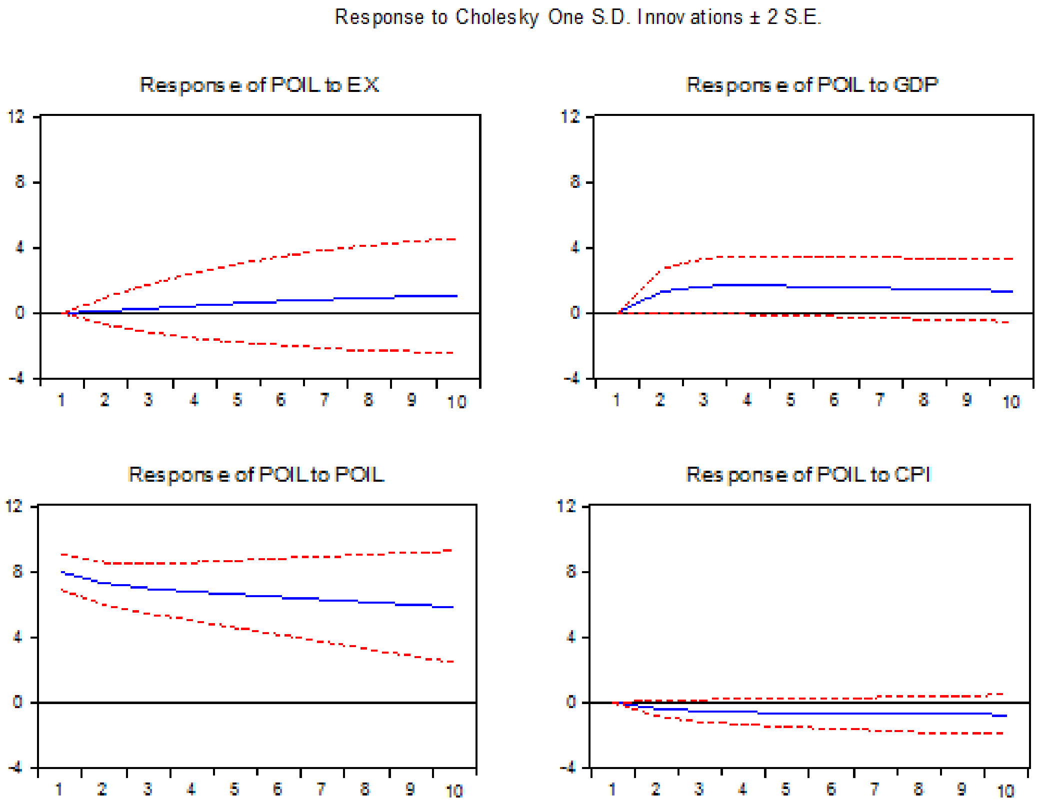

Figure 3. Impulse response functions when shock is applied to oil price

Whilst the response functions draw the effect of a shock to an indigenous variable on other variables of the VAR model, analysis of variance (ANOVA) distinguishes the variations in an indigenous variable with the changes in other indigenous variables. Therefore, ANOVA informs on the relative importance of each random shock in influencing the model variables.

Table 5. Analysis of variance for price index

Lag	Analysis of variance of CPI			
	CPI	EX	GDP	POIL
1	100.0000	0.000000	0.000000	0.000000
2	94.16286	4.577014	0.083079	1.177042
3	85.58128	11.12161	0.195075	3.102039
4	77.26831	17.25052	0.289753	5.191414
5	70.13250	22.29486	0.355248	7.217395
6	64.23898	26.24849	0.392971	9.119565
7	59.40780	29.28553	0.407923	10.89875
8	55.42622	31.59492	0.405378	12.57348
9	52.10954	33.33595	0.389970	14.16454
10	49.31133	34.63294	0.365581	15.69014

Source: Research findings.

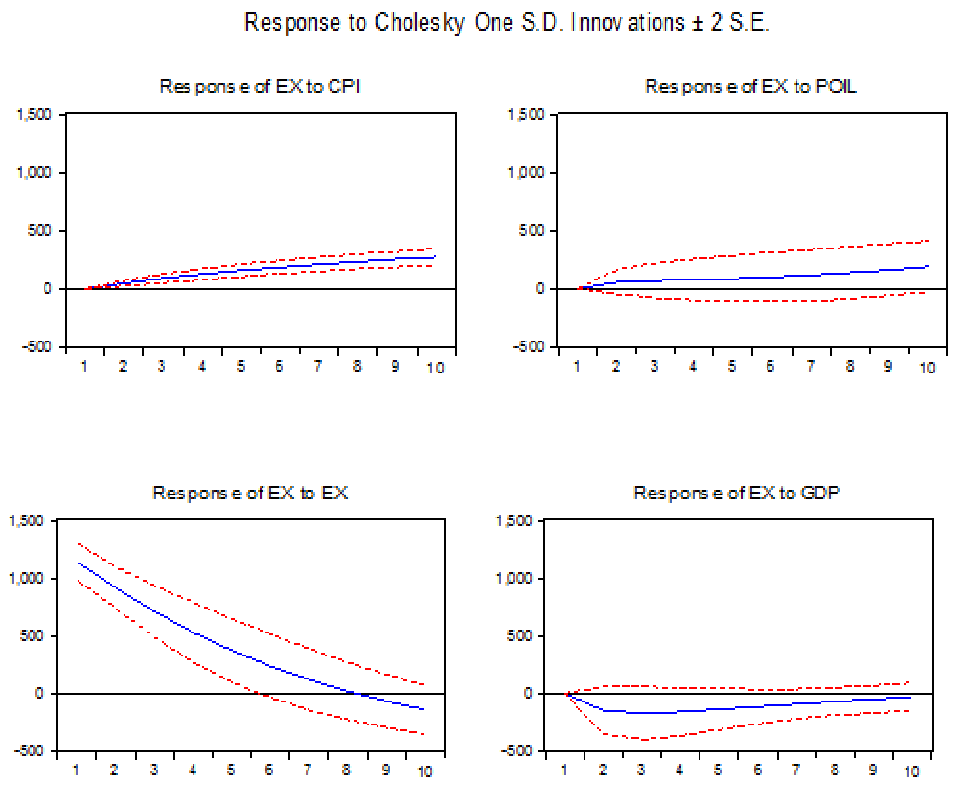

Figure 4. Impulse response functions when there is a shock with the magnitude of one standard deviation

As is evident in Table 5, the greatest part of the prediction error of the variable price index is accounted for by the variable itself in the short run. But, over time the other variables gain increasing importance. In this respect, the variable exchange rate is more influential than the other variables. After 10 periods, 34.63% of the prediction variance error of price index is captured by exchange rate and 15.69% is accounted for by oil price. The variable GDP had the lowest share in explaining the prediction error of price index so that it amounts to 0.36% after 10 lags.

Table 6. Analysis of variance for GDP

Lag	Analysis of variance of GDP			
	GDP	CPI	EX	POIL
1	100.0000	0.000000	0.000000	0.000000
2	93.82804	0.000127	0.851331	5.320505
3	85.60529	0.000249	1.842613	12.55184
4	78.22476	0.001737	2.589816	19.18369
5	72.14178	0.005597	3.084451	24.76817
6	67.16409	0.012203	3.392871	29.43084
7	63.03913	0.021544	3.573842	33.36549
8	59.56519	0.033424	3.668900	36.73248
9	56.59454	0.047572	3.706082	39.65181
10	54.01991	0.063701	3.704257	42.21213

Source: Research findings.

Table 6 shows that in the short run, the prediction error of the variable GDP is mostly explained by the variable itself. But, as time elapses, the contribution of the other variables grows. In this respect, the variable oil price has a higher share than the other variables so that after 10 periods, it accounts for 42.21% of the prediction variance error of GDP while 3.70% is explained by GDP. The variable price index has the lowest share in explaining the prediction error of GDP so that it accounts for only 0.063% after 10 lags.

Table 7. Analysis of variance for oil price

Lag	Analysis of variance of GDP			
	POIL	GDP	EX	CPI
1	100.0000	0.000000	0.000000	0.000000
2	98.47763	1.518547	0.001623	0.002198
3	97.18286	2.785353	0.024713	0.007070
4	96.28408	3.620215	0.081558	0.014145
5	95.64404	4.162295	0.170684	0.022983
6	95.15613	4.524633	0.286009	0.033227
7	94.75873	4.775595	0.421070	0.044600
8	94.41771	4.955092	0.570308	0.056892
9	94.11382	5.086945	0.729292	0.069945
10	93.83585	5.185909	0.894602	0.083641

Source: Research findings.

According to Table 7, the variable oil price has the highest share in accounting for the prediction error of this variable in the short run, but over time the other variables become more important. Among these variables, GDP has a higher share than the other variables so that it captures 5.18% of the prediction variance error of oil price after 10 periods, while 0.89% is accounted for by GDP. The least important variable in explaining the prediction error of GDP is price index that accounts for 0.083% of this error after 10 lags.

Table 8. Analysis of variance for exchange rate

Lag	Analysis of variance of GDP			
	EX	CPI	GDP	POIL
1	100.0000	0.000000	0.000000	0.000000
2	96.54783	2.954625	0.496792	0.000749
3	91.90744	7.516742	0.574853	0.000962
4	86.82443	12.66594	0.507339	0.002292
5	81.59322	17.93071	0.473585	0.002484
6	76.48551	22.99042	0.495868	0.028203
7	71.69840	27.57402	0.590197	0.137382
8	67.33008	31.49321	0.802713	0.373993
9	63.40163	34.66348	1.178858	0.756033
10	59.88970	37.08686	1.731322	1.292116

Source: Research findings.

Table 8 reveals that in the short run, the most important variable in explaining the prediction error of the exchange rate is the variable itself. However, over time other variables gain importance among which price index is more important than the other variables and accounts for 37.07% of the prediction variance error of price index after 10 periods. The share of GDP in explaining the prediction variance error of exchange rate is 1.73%. The variable oil price is the least important in explaining the prediction error of exchange rate and accounts for 1.29% of this error after 10 lags.

Conclusion and Recommendations

The facts about Iran's economy show that any fluctuation in oil price and the exchange rate is influential on inflation whereas foreign exchange earnings from oil exports have dominated the total foreign exchange earnings of this country despite the emergence of diverse socioeconomic shocks, nuclear issues, and sanctions. Our results show that Iran has faced a drastic decline of oil incomes in 2012 and 2013 due to the severe sanctions on the banking system and oil expert by the European Union, the US and the UN given the fact that oil accounts for about 80% of foreign exchange incomes. In this period, oil price did not change considerably, but the production and exportation rates were decreased and since sanctions were applied on foreign exchange transfer via the banking system, Iran started to suffer from the shortage of exchange supply. Subsequently, the exchange rate was multiplied and mismanagement aggravated the turmoil of the exchange market. The increase in the exchange rate and the loss of national exchange value resulted in the reduction of imports, and since capital and intermediate commodities mostly constitute the importing items, the loss of imports impaired manufacturing section substantially so that some industrial units were closed and some kept operating with their minimum capacity. Also, the construction activities of the government were stopped in these years and most projects were abandoned unfinished. Consequently, the country sank into a deep recession so that the inflation rate exceeded 10 percent and economic growth rate became negative. The main cause of this stagflation was the severe loss of oil incomes due to the sanctions. According to our results, the government should manage oil incomes soundly and prevent the swift change of exchange incomes which aggravates inflation. It should also direct oil incomes towards manufacturing projects to hinder the inflation pressure induced by the increase in general level of the prices. It is, also, imperative to reform economic policies of taxes in the national economy to shift the reliance of the government expenditures to oil incomes. Furthermore, actions should be taken to manage and substitute other commodities to avoid the impacts of the shocks in the oil market.

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