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Asymmetric Impacts of Oil Prices and Revenues Fluctuations on Selected Macroeconomic Variables in Iran

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ABSTRACT

In this paperwe study the asymmetric effects of Iran's oil revenues, mainly caused by exogenous changes in oil prices, on the growth rates of GDP, CPI and Government Capitaland Current Expenditures. Findings from a structural VAR modelon quarterly data during 1990:02 to 2008:03 show that the effects of negative shocks which decrease economic growth have been much stronger than the effects of positive shocks which increase economic growth. It is also indicated that whether we take fluctuations of oil price or that of oil revenues as explanatory variables, inflation and growth rate of Government Current and Capital Expenditures show a quite asymmetric response to both positive and negative shocks.

KEY WORDS: Oil Shock, Asymmetric Effects, GARCH Model, SVAR Model, Economic Growth, Iran's Economy.
JEL Classification: E32; E37; Q32

1. INTRODUCTION

Like many other oil exporting countries, Iran's economy has been gradually structured around oil revenues in recent decades. Although reduction of dependency on oil revenues has been a major target for policy makers in the country, oil revenues still form most of the government resources and foreign exchange earnings so every fluctuation in these revenues, because of global oil price changes or any other reasons, affects many macroeconomic variables like the whole economic growth, and annual government budgets. An abrupt change in oil price, either increase or decrease, is called an oil shock. In oil exporting countries like Iran, because of economic structure and political issues, the government is acting as the biggest economic agent in the manufacturing and service sectors and as the recipient of oil earnings directs oil revenues to different sectors of economy by means of Government Expenditures. Therefore, to avoid economic crises and devising suitable economic policies to maintain economic equilibrium and stability, the evaluation of change effects of the world oil prices on Iran macroeconomic variables seems essential.

The main question in this study is that whether the oil shocks, in the forms of going oil prices and thereby oil revenues down and up, have the same effects on Iranian macroeconomic variables? In other words, are those effects on Iran's macroeconomic variables symmetric or asymmetric?

2. LITERATURE REVIEW

Oil price positive and negative shocks have been measured by authors in different ways. For instance, Hamilton (1983) and Bachmeier (2008) hired a linear framework, which was computed as the percentage change in the nominal price of crude oil. In contrast, Mork (1989), Lee et. al. (1995) and Hamilton (1996) have proposed different nonlinear specifications of oil price shocks. Hamilton (1996), in his nonlinear measure as the net oil price increase (NOPI)asserted that in order to know the size of oil shocks effects onconsumption and investment decisions, current oil prices should be compared with that of several periods and not just one period. Hamilton (1996) defines the net oil price increase as follows:

$$NOPI_t = Max\{0, p_t - Max\{p_t - 1, p_t - 2, p_t - 3, p_t - 4\}\} \quad (1)$$

Mork (1989) allowed for asymmetries in the price of oil and derived positive and negative oil price shocks, so oil price change is defined as follows:

$$ROIL_t^+ = Max\{0, (roilp_t - roilp_{t-1})\} \quad (2)$$

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$$ROIL_t^- = Min\{0,(roilp_t - roilp_{t-1})\}$$

Where, $ROIL_t$ is the real price of oil at time t, $ROIL_t^+$ is the real oil price increase, and $ROIL_t^-$ is the real oil price decrease.

Leeet. al. (1995) used a GARCH model to calculate oil price volatility and constructed an oil shock variable, which reflects both the unanticipated component of real oil price movement and the time-varying conditional variance of oil price change forecasts. They used the following GARCH (1, 1) model:

$$O_t = \alpha_0 + \alpha_1 O_{t-1} + \alpha_2 O_{t-2} + \alpha_3 O_{t-3} + \alpha_4 O_{t-4} + e_t$$

$$e_t | I_{t-1} \approx N(0, h_t) \quad (3)$$

$$h_t = \gamma_0 + \gamma_1 e_{t-1}^2 + \gamma_2 h_{t-1}$$

$$SOPI_t = MAX(0, \hat{e}_t / \sqrt{\hat{h}_t})$$
$$SOPD_t = MIN(0, \hat{e}_t / \sqrt{\hat{h}_t}) \quad (4)$$

Where, O_t is the real price of oil at time t and e_t is the white noise term with zero mean and Variance of h_t.

Raguindin and Reyes (2005) examined the effects of oil price shocks on the Philippine economy over the period of 1981 to 2003. Their impulse response functions in a symmetric model showed that an oil price shock leads to a prolonged reduction in the real GDP of the Philippines. Conversely, in their asymmetric VAR model, oil price decreases had a greater effect on each variable than oil price increases.

Farzanegan and Markwardt (2007) analyzed the dynamic relationship between oil price shocks and major macroeconomic variables in Iran by applying a VAR approach. The study points out the asymmetric effects of oil price shocks; for instance, positive as well as negative oil price shocks significantly increase inflation. Also, they found a strong positive relationship between positive oil price changes and industrial output growth.

3. DATA AND METHODOLOGY

In this paper, four macroeconomic variables are included in the analysis: Real GDP Growth Rate (GR), Inflation (INF) and Growth Rates of Government Capital and Current Expenditures (as RCONEXPand RCUREXP). We use quarterly data for Iran over the period 1990:1 to 2008:2. The variables and the period of analysis were selected based on the availability of data and all these data and also Iran's oil revenues (OILREV) sources are Central Bank of Iran. Oil price series was derived from Federal Reserve's internet website.

To decompose positive and negative shocks, we follow Lee et. al (1995) approach. Then, to model the asymmetric effects of oil shocks on macroeconomic variables we hire a SVAR model. Schwarz's Bayesian Information Criterion (SIC) is used to select the number of lags to be included in the VAR model.

4. Empirical Results

4.1. Decomposition of Oil Shocks

To decompose oil shocks to positive and negative shocks, we use a GARCH specification method. Table 1 shows the optimumARMA (p, q) pattern ofdifference of Iran's logarithmic oil revenues (DLNOILREV) anddifference of logarithmic oil prices WTI (DLNOILP) series. Also this table shows ARCH-LM Test to see if there are GARCH effects in the serieswithannual and seasonal frequencies.

Table 1. ARCH-LM Test

Series	Data Type	Period	Optimum ARMA Structure	F Statistic	**Prob**
DLNOILREV	Quarterly	1990:02-2008:03	**ARMA(1,0)**	**6.652**	0.0119
	Annual	1965-2008	ARMA(5,1)	0.424	**0.5191**
DLNOILP	Quarterly	1990:02-2008:03	**ARMA(5,3)**	**9.148**	0.0035
	Annual	1965-2008	ARMA(2,2)	0.973	**0.3306**

Source: Authors' Calculates
Note: Optimum degree of p and q are extracted based on AIC & SBC Criterion.

Based on table 1 results, GARCH effects are only observable in the seasonal series. Then we specify a GARCH model for both price and revenue series with seasonal frequencies. Optimum model for oil price series are as follows:

$$DLnOILP_t = \alpha_0 + \sum_{1}^{5} \alpha_i DLnOILP_{t-i} + \sum_{0}^{3} \varepsilon_{t-i}$$ Mean equation

$$\varepsilon_t | I_{t-1} \approx N(0, h_t)$$

$$h_t = \gamma_0 + \gamma_2 h_{t-1}$$ Variance equation

Estimation results are shown in table 2.

Table 2. The Result of GARCH(0,1) Estimation in Oil Price Model

Variable	Coefficient	Standard Error	Z Statistic	**Prob**
C	0.00017	0.000135	1.300950	**0.1933**
GARCH(-1)	1.02575	0.016839	60.94924	**0.0000**
R2	0.2475			
Durbin-Watson	1.57464			

Source: Authors' Calculates

Optimum model for Oil revenue series are as follows:

$$DLnOILREV_t = \alpha_0 + \alpha_1 DLnOILREV_{t-1} + \varepsilon_t$$ **Mean equation**

$$\varepsilon_t | I_{t-1} \approx N(0, h_t)$$

$$h_t = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 h_{t-1}$$ **Variance equation**

Estimation results are shown in table 3.

Table 3. The Results of GARCH(1,1) Estimation in Oil Revenue Model

Variable	Coefficient	Standard Error	Z Statistic	**Prob**
C	0.018673	0.019714	0.947186	**0.3435**
RESID(-1)^2	0.546612	0.262753	2.080328	**0.0375**
GARCH(-1)	0.51457	0.206740	2.486976	**0.0129**
R^2	0.188701			
Durbin-Watson	2.452430			

Source: Authors' Calculates

Now based on the above GARCH models we can extract series of positive and negative shocks as:

oil price model:

$$PGRq = MAX\,(0, \hat{\varepsilon}_t / \sqrt{\hat{h}_t})$$
$$NGRq = MIN\,(0, \hat{\varepsilon}_t / \sqrt{\hat{h}_t}) \quad (5)$$

oil revenue model:

$$PGRq2 = MAX\,(0, \hat{\varepsilon}_t / \sqrt{\hat{h}_t})$$
$$NGRq2 = MIN(0, \hat{\varepsilon}_t / \sqrt{\hat{h}_t}) \quad (6)$$

4.2. Unit Root Tests

Table 4 shows the results of unit root tests for all variables. Based on Augmented Dicky-Fuller (ADF) test, all the research variables except inflation are stationary. Based on Philips-Pron test inflation series is stationary too.

Table 4. Unit Root Tests

Variables	ADF	PP	Decision
PGRq	-8.3128***	-8.4934***	I(0)
NGRq	-6.1797***	-6.1925***	I(0)
PGRq2	-3.6232***	-9.7173***	I(0)
NGRq2	-8.2787***	-9.0837***	I(0)
GR	-35.5925***	-19.9450***	I(0)
INF	-2.2426	-6.7659***	I(0)
RCONEXP	-3.2536**	-15.2449***	I(0)
RCUREXP	-4.5730***	-25.4794***	I(0)

Note: *** and ** indicates 1 and 5 percent Significance levels.
Source: Authors' Calculates

4.3. SVAR Approach

Enders (1995) states that VAR model is a suitable econometric technique for studying the dynamic relationships between variables have the possibility of interactions. Lutkepohl (2004) introduces the VAR model as:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + B_0 x_t + \ldots + B_q x_{t-q} + CD_t + u_t \qquad (7)$$

Where $y_t = (y_{1t},\ldots,y_{kt})'$ is a $k \times 1$ vector of endogenous variables and $x_t = (x_{1t},\ldots,x_{Mt})'$ is a $M \times 1$ vector of exogenous variables and out of model. D_t Includes all pre-determined variables like Constant Term, linear trend and seasonal dummy variables, and u_t are residuals that have distributed normally with mean0 (white noise) and the covariance matrix of $E(u_t u_t') = \sum_u$. A_i, B_j and C are the coefficients matrices with suitable dimensions.

A common problem in using VAR model isitsreduced form. Cooley and Leroy (1985) say that estimated shocks in the VAR model are not structural and without referring to "the specific economic structures of each country" we cannot comprehend the economic consequences of VAR model. Lutkepohl (2004) introduces this model with equation (7) with the establishment of appropriate limits on matrices A and B as follows:

$$Ay_t = A_1^* y_{t-1} + \ldots + A_p^* y_{t-p} + B_0^* x_t + \ldots + B_q^* x_{t-q} + C^* D_t + B\varepsilon_t \qquad (8)$$

By establishment of some appropriate limits on matrices A and B we can analyze the SVAR model. The relationship between VAR and SVAR can be shown by their residuals, $Au_t = B\varepsilon_t$ in which $\sum_u = A^{-1}BB'A^{-1'}$. The model is estimated using Maximum Likelihood Method which has been also used by Amisano and Giannini (1997) and Breitung et al (2004). After the estimation of SVAR model and considering the constraints imposed on the system, we analyze the impulse response functions and the decomposition of prediction error variance of the model.

Oil price fluctuations can be supposed to be exogenous for Iranian economy. Also, since oil production and exports are done based on OPEC arrangements, we can suppose that Iranian oil revenues are pretty exogenous. Then, two series of positive and negative shocks among other series in the model have the highest degree of exogeneity.

In contrast, it can be claimed that economic growth is affected by almost all other variables in the model. Impacts of inflation and growth rate of Government Capital and Current Expenditures on real GDP growth have been indicated in Many Researches in Iran. Also, regarding to the mechanism of spending oil sales revenues, it can be said that oil shocks and changes in government expenditures are among determinants of inflation.

About the growth rates of current and capital government expenditures, it should be said that these two variables are reliant on oil revenues. Furthermore, the relationship between government expenditures and economic growth rate in Iran seems to be bilateral.

In brief, the relationship between oil shocks and other variables in the model can be summarized based on a $Au_t = B\varepsilon_t$ model as follows:

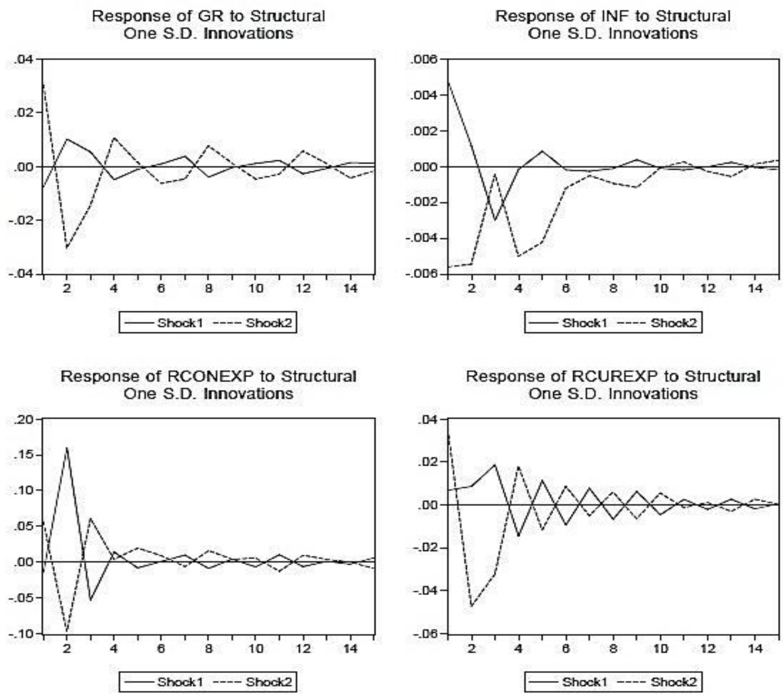
$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & 0 & 1 & a_{45} & a_{46} \\ a_{51} & a_{52} & 0 & 0 & 1 & 0 \\ a_{61} & a_{62} & a_{63} & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_{pgrq} \\ u_{ngrq} \\ u_{gr} \\ u_{\inf} \\ u_{rconexp} \\ u_{rcurexp} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} \end{bmatrix} \begin{bmatrix} \varepsilon^{pgrq} \\ \varepsilon^{ngrq} \\ \varepsilon^{gr} \\ \varepsilon^{\inf} \\ \varepsilon^{rconexp} \\ \varepsilon^{rcurexp} \end{bmatrix} \qquad \textbf{(3)}$$

Impulse Response Functionsand Variance Decomposition

The impulse response functions facilitate the objective variables behavior analysis versus shocks imposed to other variables. Here, using impulse response functions we can obtain the reactions of macroeconomic variables of economic growth rate, inflation rate, capital and current government expenditures growth rates to the oil price shocks. Moreover, variance decomposition of the prediction

error indicates that how many percent of changes in indicated variable is explained by each variable imposed shock.
Figure 1 shows the impulse response functions of oil price model and figure 2 shows that of oil revenue model. Furthermore, tables 5 and 6 are related to the variance decomposition of macroeconomic variables in the mentioned models which have been estimated using 16 periods.

Figure 1. Impulse Response Functions (Oil Price Model)



Note: Shock 1 and shock 2 represent positive and negative shocks respectively.

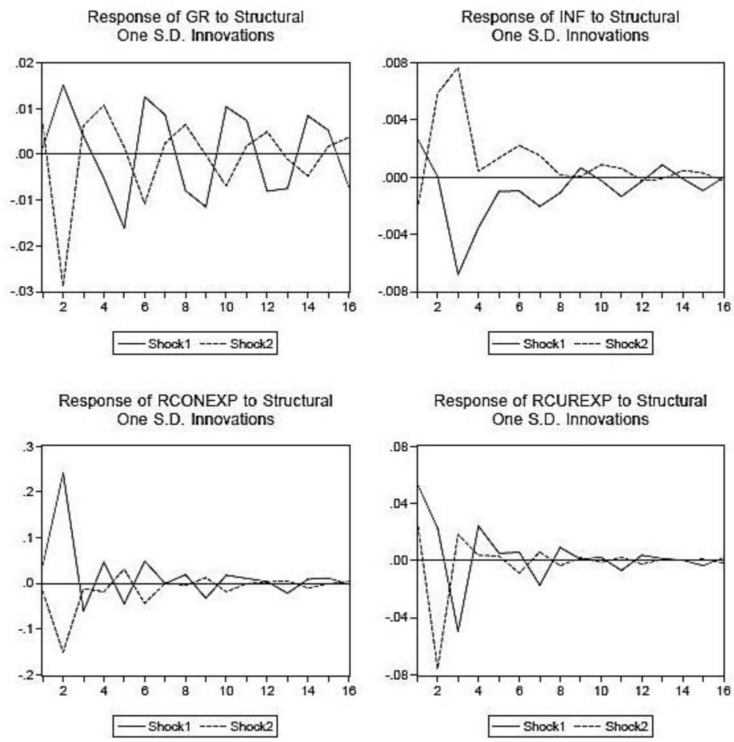
Economic Growth Rate

As it is seen in both figures 1 and 2, in all of 16 reviewed periods the direction of GDP growth rate responses to the positive and negative shocks are opposite. The difference is that in all periods this variable's responses to negative shocks are much tougher than positive shocksand this is more evident in the oil price model[1]. This is an evidence for the asymmetric effects of positive and negative oil shocks on Iran's economic growth.

According to the results of variance decomposition, (table 5) it can be stated that the oil price positive shocks on average explain 1.01 percent of changes in economic growth, while the negative shocks on average explain 10.16 percent of these changes. Therefore, negative changes in oil price have a more powerful effect on GDP growth. Of course the variance decomposition results in the oil revenue model (table 6) are slightly weaker (oil revenue positive shock on average 2.94 percent and the negative shock on average 4.56 percent), but in each case it is verified that the power of oil revenue negative shocksis more than that of positive shocks explaining economic growth rate.

1 - look at the closed area between the equilibrium line and the curves in figure 1.

Figure 2. Impulse Response Functions (Oil Revenue Model)



Note: Shock 1 and shock 2 represent positive and negative shocks respectively.

Inflation Rate

The asymmetric effects of oil price shocks are also observable on the inflation rate series. On this basis, with a positive shock occurrence in the oil price the inflation would be immediately faced with a 0.0047 percent increase. On the other hand the inflation rate variable response to the oil price negative shock would experience a 0.0056 percent decrease and in the next periods would also have a negative value.

Results of figure 2 show that in the oil revenue model, the inflation responses to the oil shocks are asymmetric too. It is observed that a positive shock in the oil revenue, would increase the inflation immediately by 0.0027 percent and a negative shock immediately decrease it about -0.0023 percent. But, after a short time, inflation starts growing. These results indicate that negative oil revenue shocks,after a lag, have profound inflationary effects in Iran's economy. The reported increased inflation in both models when a positive shock occurs can be attributed to the imported inflation caused by more expensive imports. But the inflation increase when a negative shock occursin the oil revenue model is mainly caused by the government's borrowings from the central bank which increases money stock.

Government Capital ExpendituresGrowth Rate

Based on the results of the impulse response functions in both models, the government Capital expenditure as the main factor of investment in Iran, experiences a significant growth following a positive oil shock. This movement is seen in both price and revenue model. An explanation for this is the government's behavior in starting new projects when sees increased revenues.

In the periods of negative oil shocks it is observed that the government Capital expenses would be contracted after a lag. This behavior is mainly attributed to substitution of current expenditures instead of capital ones to pass the budget deficit.

Government Current Expenditures Growth Rate

The growth rate of government current expenditures respondspositively to the positive shocks in the initial periods. It is a sign of increasedgovernment desires in the oil boom intervals.The impulse response function of this variable in the oil price model toward the negative shock shows when this shock happens, the government faces a challenge and despite transferring resources from Capital budget to current budget, the later experiences a dramatic reduction.

Table 5. Variance decomposition of macroeconomic variables in Oil Price Model

Quarter	RCUREXP	RCONEXP	INF	GR	NGRq	PGRq
Variance decomposition of GR						
1	32.0376	27.96705	12.1993	14.38016	12.6389	0.776986
4	45.40071	25.75141	6.887897	8.044623	12.65252	1.262835
8	56.58699	20.42643	5.326455	7.20882	9.429847	1.021463
12	61.7878	17.65929	4.624893	6.844238	8.174785	0.908991
16	64.45212	16.28128	4.270948	6.614774	7.536877	0.844008
Variance decomposition of INF						
1	10.97767	0.531952	73.30191	9.809157	3.114268	2.265049
4	16.17851	2.515659	61.86823	9.817064	6.943244	2.677288
8	19.43645	2.726242	57.9364	9.44536	7.921894	2.533652
12	21.43336	2.714643	56.2764	9.30309	7.799445	2.473056
16	22.60542	2.701049	55.3566	9.195556	7.702789	2.438583
Variance decomposition of RCONEXP						
1	0	99.22959	0	0	0.72314	0.047266
4	5.413369	86.72781	0.611458	1.485856	2.085009	3.676499
8	7.059182	84.80759	0.803293	1.942862	1.99598	3.391091
12	8.050831	83.68866	0.882011	2.032655	1.99356	3.352279
16	8.692329	83.06457	0.89406	2.030923	1.987723	3.330396
Variance decomposition of RCUREXP						
1	22.05027	38.31939	16.71501	19.70315	3.09685	0.115334
4	14.19041	48.79366	11.15023	19.14041	5.901624	0.823664
8	14.75517	48.10127	11.35983	18.9699	5.702045	1.111791
12	15.25577	47.64996	11.34344	18.8728	5.703526	1.174495
16	15.58619	47.43073	11.3	18.80992	5.693045	1.18011
Source: Authors' Calculates						

Table 6. Variance decomposition of macroeconomic variables in Oil Revenue Model

Quarter	RCUREXP	RCONEXP	INF	GR	NGRq2	PGRq2
Variance decomposition of GR						
1	46.80124	21.19966	9.725963	21.65746	0.586879	0.028794
4	55.63315	17.75499	6.381491	12.87104	5.803889	1.555438
8	60.83801	14.51335	5.620052	11.23866	4.59254	3.197385
12	63.34672	12.93584	5.258687	10.4291	4.143168	3.886487
16	64.50646	12.22713	5.112728	10.12503	3.940196	4.088456
Variance decomposition of INF						
1	8.739666	0.331062	79.16248	10.30695	0.618724	0.841115
4	11.94531	1.050292	60.39107	12.74374	8.318646	5.55094
8	15.67662	1.452361	56.21334	12.73472	8.293878	5.629072
12	17.59983	1.523271	54.62737	12.49726	8.121738	5.630533
16	18.63864	1.542555	53.81136	12.33087	8.015947	5.660633
Variance decomposition of RCONEXP						
1	0	99.451	0	0	0.084156	0.464844
4	8.197071	70.38768	0.978757	8.009747	3.268401	9.158344
8	9.785556	67.29735	1.593657	9.289662	3.274501	8.759276
12	10.65624	66.27886	1.698894	9.381672	3.255709	8.728625
16	11.18687	65.78426	1.72377	9.333028	3.242559	8.729517
Variance decomposition of RCUREXP						
1	23.05931	26.61971	12.21256	27.19454	2.392858	8.521013
4	14.57609	27.69705	12.65123	26.91317	9.379256	8.7832
8	15.19957	28.75249	12.02486	26.86826	8.660303	8.494518
12	15.5308	28.77141	11.90842	26.79682	8.547117	8.445432
16	15.71905	28.70658	11.8747	26.75158	8.516558	8.431535
Source: Authors' Calculates						

5. Conclusion

This paper tried to study an important issue in a developing economy that is very dependent on oil exporting revenues. The main question in this study was that whether the oil shocks, in the forms of going oil prices and thereby oil revenues down and up, have the same effects on Iranian macroeconomic variables? In other words, are those effects on Iran's macroeconomic variables symmetric or asymmetric? We first used a GARCH model to decompose oil shocks to positive and negative shocks. Then, we hired a SVAR approach to show the asymmetric effects of oil price and revenues on macroeconomic variables. Findings from the SVAR model on quarterly data during 1990:02 to 2008:03 showed that the effects of negative shocks which decrease economic growth have been much stronger than the effects of positive shocks which increase economic growth. It is also indicated that whether we take fluctuations of oil price or that of oil revenues as explanatory variables, inflation and growth rate of Government Current and Capital Expenditures show a quite asymmetric response to both positive and negative shocks. Based on these results we can say Oil revenues fall sharply reduces economic growth, but its increase, so does not a powerful effect on the economic growth. Therefore, to achieve a certain growth rate, high and persistent, it is necessary to minimize the negative effects of declining oil revenues on the economy. Since the increase in state budget during theoil pricesare high, is not equal to the its decreases in the conditions that oil prices are not too high, selection of policies such as establish oil stabilization fund and adherence to compliance of its requirements by politicians, it can reduce the adverse effects of oil shocks on the Iranian economy.

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