International Journal of Management, Accounting and Economics
Vol. 1, No. 2, September, 2014
ISSN 2383-2126 (Online)

www.ijmae.com

Asymmetric Effects of Oil Price Shocks on Gross Domestic Product in Iran Using the Markov Switching Model

Morteza Salehi Sarbijan[1]
Faculty Member in School of Engineering, Department of Mechanics, Zabol University, Zabol, Iran

Abstract

The role of oil shocks as factors in economic growth of a country is important. With little reflection on the Iran economic structure and other major oil exporter countries that have a strong bond to the proceeds of oil sales ،this is a strong suspicion that the origin of the oil shock is caused by economic shocks. Purpose of this article is determining and solving of Iran cycles and effect of oil price fluctuation on these cycles using Markov switching model. In line with the main objective of research, extracting of oil price shocks by using Markov switching model and estimation long run relation by using the pattern accumulation Johansen Juselius estimated by using of quarterly data 1988(1) - 2008(2). The results suggest that hypothesis of symmetry of positive and negative oil shocks on production have been rejected. So we can infer that the effects of negative and positive shocks on production are different.

Keywords: Oil Price Shocks, Gross Domestic Product in Iran, Markov Switching Model, Johansen Juselius

Cite this article: Sarbijan, M. S. (2014). Asymmetric Effects of Oil Price Shocks on Gross Domestic Product in Iran Using the Markov Switching Model. *International Journal of Management, Accounting and Economics, 1*(2), 112-124.

[1]*Corresponding author's email: m.salehisarbijan@uoz.ac.ir*

International Journal of Management, Accounting and Economics
Vol. 1, No. 2, September, 2014
ISSN 2383-2126 (Online)

www.ijmae.com

Introduction

Oil price shocks due to their significant impact on macroeconomic variables have attracted many economists (Brown & Yucel, 2002). Oil price shocks led to a reversible decrease in investment, reduce the role of technological shocks in business cycle models and changes in the natural rate of unemployment. Theoretically, there are many reasons whereby oil shocks affect macroeconomic variables (Hamilton, 2003).

More generally, the oil price shock can be considered energy price shock. Since 1973, the productivity growth rate was decreased in major oil-consuming economies. This caused oil and energy prices are used as major inputs in total production function. Hence, elasticity of actual product compared to energy and oil prices is an important and interesting issue in energy economics. With a little reflection on the structure of our economy and other major oil exporting countries that are highly dependent on income from oil sales, it is strongly suspected that the origin of many shocks to the economy is caused by the oil shock. In fact, relations and economic characteristics of such countries have been shaped in such a way that any oil shock whether price shock or income shock in addition to its direct effects on GDP growth, as well as it has indirectly undergone a transformation the monetary base, the trade balance and the balance of the state budget by which it will be followed by a series of monetary and real trends and consequences for the economy (Sadorsky, 1999).

There are several studies in which different theoretical discussions are presented for the inverse relationship between oil price changes and the level of economic activities. After 1973 when the first oil shock occurred, experimental studies to achieve the relationship between business cycles and fluctuations in oil prices have been risen dramatically. (Darby & Hamilton, 1983) are the first researchers who have estimated the effects of increase in oil prices on real income of U.S. economy. (Hamilton, 1983) found that the oil price shock has been one of important factors of all U.S. recessions from 1949 to 1972. According to (Wijnbergen, 1984) rising oil prices would increase disposable incomes and demand for both commercial and non-commercial goods. (Mork, 1989) stated that positive changes in oil prices had a strong and significant negative relationship between changes in real GNP and negative changes in oil price had no significant effect. Using system dynamics model, (Mashayekhi, 2001) demonstrated that rising oil price would increase oil-dependent structure in the oil exporting countries. According to (Cunado, et al, 2003), the effect of oil price on inflation and industrial production is a non-linear model and oil price has a permanent effect on inflation and GDP growth (Hamilton, 2003) investigated the nonlinear effects of oil price on GDP growth in U.S and demonstrated that increase in oil price had a negative impact on production and employment. (Diong Zhang, 2008) has claimed that the relationship between oil price shocks and economic growth in Japan's macroeconomic activities is nonlinear and these effects are asymmetric. According to (Farzanegan & Markwardt,2009) positive shocks to oil price increase the real effective exchange rate, reduce the prices of imported goods and increase the exported goods prices. Based on Hamilton’s regime switching model (1989), (Mark & Ping Wang, 2003) have estimated the effect of oil price shocks on GDP growth in the UK. The results have indicated that asymmetries are increased insofar as higher oil price tends to reduce the length of the boom phase of the business cycle. Using two-regime Markov switching model, (Raymond & Rich, 1997) estimated the relationship between oil price shocks and the business cycle. Their results showed that oil prices did not determine the economic regimes. According to Markov-Hamilton autoregressive model, (Clements & Krolzig, 2000) modeled asymmetries and tested based on (Clements & Krolzig, 2002). The results indicated that U.S. post-war economic growth was explained by the development precipice.

(Cologni & Manera, 2009) studied the dynamic relationships between oil market conditions and business cycles for G7 economies. Using Hamilton's regime switching model, they estimated business cycles in real GDP series. Results showed that positive changes in oil prices, the net increase of oil prices and oil price volatility as oil shock variables provided more accurate identification of changes in the economic phases.

The remainder of this article is as follows: in section 2, the econometric methodology along with Markov switching model and a variety of these models are described. The data used in the study is expressed in Section 3. Section 4 examines the results and estimates Markov model and the long-run relationship between oil shocks and production. Finally, the study ends with conclusions and suggestions.

Econometric methodology

Markov switching approach

In Markov switching model, regime conversion depends on an unobservable variable. (Hamilton, 1989) first used Markov switching models in economics. Using Markov Switching Auto Regressive (MS-AR) model, he studied the business cycles of the U.S. economy and demonstrated that results were consistent with recession and prosperity offered by National Bureau of Economic Research (NBER) for the U.S. economy. In Hamilton's model, recession and prosperity are explained in terms of regime transition process that is caused by the growth rate of GDP. The average production growth rate of prosperity regime is positive and in recession regime is negative .In Hamilton's model, assuming that the growth rate of real production is MSM (2)-AR (4) is as follows Formula (1):

$$\Delta y_t - \mu(S_t) = \alpha_1(\Delta y_{(t-1)} - \mu(S_{(t-1)})) + \ldots + \alpha_4(\Delta y_{(t-4)} - \mu(S_{(t-4)})) + u_t$$
$$u_t \to NID(0,\sigma^2) \tag{1}$$

$$\mu(S_t) = \begin{Bmatrix} \mu_1 > 0 & if \quad S_t = 1 \\ \mu_2 < 0 & if \quad S_t = 2 \end{Bmatrix}$$

The average growth rate of real production is dependent on the regime type and in the first regime (recession) is $\mu_1 < 0$ and in second regime (prosperity) is $\mu_2 > 0$. In this model, the probability of transition from one regime to another regime should be calculated along with other parameters which are obtained according to Formula (2):

$$P_{ij} = P\left(S_{t+1} = j \middle| S_t = i\right); \sum_{j=1}^{2} P_{ij} = 1, \forall i, j \in (1,2) \tag{2}$$

Where P_{12} is the probability of transition from recession to prosperity and P_{21} is the probability of transition from prosperity to recession, P_{11} is the probability of recession regime stability, and P_{22} is the probability of prosperity regime stability.

Markov switching models

Given which part of autoregressive model is depended on the regime and transfers affected by it, Markov switching models can be classified into different types. What is considered by the most economic studies includes four modes of Markov switching models in mean (MSM), intercept (MSI), autoregressive (MSA) parameters, and heteroscedasticity (MSH). Considering the fact that according to economic theories and empirical observations, some economic variables have non-linear behaviors and using these models such non-linear variables can be modeled (Ivanova, et al, 2000).

Markov switching models with mean

- MSM-AR

The mean is changing and is according to Formula (3).

$$\Delta y_t = \mu\left(S_t\right) + \sum_{i=1}^{p} \alpha_i (\Delta y_{t-i} - \mu\left(S_{t-i}\right)) + \varepsilon_t \tag{3}$$

It is assumed that the residual errors are independent and have the same distribution.
$\varepsilon_t \sim IID\left(0, \sigma^2\right)$ ، $\mu\left(S_t\right)$ is defined as process mean in different regimes.

ISSN 2383-2126 (Online)

- MSMH-AR

The mean and variances are changing and is according to Formula (4).

$$\Delta y_t = \mu(S_t) + \sum_{i=1}^{p} \alpha_i (\Delta y_{t-i} - \mu(S_{t-i})) + \varepsilon_t \qquad (4)$$

$$\varepsilon_t \sim \mathrm{IID}\left(0, \sigma^2(S_t)\right)$$

- MSMA-AR

The estimated coefficients of the variables are changing and is as follows Formula (5):

$$\Delta y_t = \mu(S_t) + \sum_{i=1}^{p} \alpha_i (S_t) \Delta y_{t-i} + \varepsilon_t \qquad (5)$$

$$\varepsilon_t \sim \mathrm{IID}\left(0, \sigma^2\right)$$

- MSMAH

Parameters and variance coefficients are also changing during regimes and is as follows Formula (6):

$$y_t = \mu(S_t) + \sum_{i=1}^{p} \alpha_i (S_t) \Delta y_{t-i} + \varepsilon_t \qquad (6)$$

$$\varepsilon_t \sim \mathrm{IID}\left(0, \sigma^2(S_t)\right)$$

Markov switching models with intercept

If the base is placed on changes in the intercept, then other models can be also estimated which are called MSI models and each of different modes can be considered for it.

International Journal of Management, Accounting and Economics
Vol. 1, No. 2, September, 2014
ISSN 2383-2126 (Online)

www.ijmae.com

- MSI-AR

The most common type of model is according to Formula (7).

$$\Delta y_t = C(S_t) + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \varepsilon_t \tag{7}$$

$$\varepsilon_t \sim \mathrm{IID}\left(0, \sigma^2\right)$$

- MSIH-AR-2

$$\Delta y_t = C(S_t) + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \varepsilon_t \tag{8}$$

$$\varepsilon_t \sim \mathrm{IID}\left(0, \sigma^2(S_t)\right)$$

- MSIA-AR-3

$$\Delta y_t = C(S_t) + \sum_{i=1}^{p} \alpha_i(S_t) \Delta y_{t-i} + \varepsilon_t \tag{9}$$

$$\varepsilon_t \sim \mathrm{IID}\left(0, \sigma^2\right)$$

- MSIA-AR-4

$$\Delta y_t = C(S_t) + \sum_{i=1}^{p} \alpha_i(S_t) \Delta y_{t-i} + \varepsilon_t \tag{10}$$

$$\varepsilon_t \sim \mathrm{IID}\left(0, \sigma^2(S_t)\right)$$

Research data

The study data indicates GDP based on 1997 as a base year which has been extracted seasonally from the Central Bank of the Islamic Republic of Iran. WOP is real average global oil price in terms of Rials which is seasonally adjusted with Iranian PPI and it is used as a representative for Iranian oil price.

In this study, consistent with investigating the effects of positive and negative oil price shocks on GDP, oil price shocks should be extracted using the Markov switching method and then the effect of oil price shocks on GDP is studied using Johansen Juselius cointegration.

Results

Evaluation of stationary state of variables

In cases that variables used in a regression aren't from a same stationary order, the result is known as spurious regression. In order to prevent from such a regression, the series need to be evaluated in terms of stationary state. Therefore, Dickey-Fuller and Phillips tests are used. As shown in table 1, all statistics indicate that the existing series are stationary from order one (I (1)).

Table 1 The stationary results of variables

Series	Series in logarithms		Series in first differences	
	ADF	PP	ADF	PP
LWOP	-2.63	-2.67	-8.55	-8.56
LGDP	-2.24	-2.56	-4.86	-18.26

Extraction of oil price shocks using a Markov switching model

Given that data used in this study are seasonally, Formula (11) is used to calculate the growth rate which calculates it annually (Kirchgässner & Wolters, 2007).

$$GWOP = \left(\log\left(WOP\right) - \log\left(WOP\left(-4\right)\right)\right) * 100 \tag{11}$$

The oil price growth rate is calculated using this method and then positive and negative oil price shocks are estimated and the optimal degree is selected. By the selected degree, a variety of models with intercept and mean are estimated for two-regime and three-regime states and then the nonlinear relationship tests, the normality of errors obtained from estimation which is used for modeling, and the optimal model are determined (Krolzig, 1997).

- Model's optimal lag

To determine optimal lag, using OLS method, Formula (12) is estimated for a maximum of 12 lags and then the optimal lag is selected using the selection criteria of Akaike-Schwartz optimal model.

$$Gwop = \alpha_0 + \sum_{i=1}^{12} \beta_i Gwop(-i) \tag{12}$$

According to table 2, Akaike, Henan Quinn and Schwartz statistics suggest the fifth lag as an optimal lag.

- Markov switching model selection for extracting oil price shocks

Since Markov-switching models are produced by switching autoregressive model in mean, intercept, and autoregressive coefficients, for selecting optimal model, Akaike value should be minimum and the null hypothesis (H_0) of no regime switching in the model can be rejected. Given the test statistic values as well as of error normality hypotheses, comparing three-regime models are yielded better results than the two-regime models. The results of H_0 testing and Akaike criterion at three-regime state are summarized in table 3. Results indicated that MSIAH (3)-AR (5) model is selected as an optimal model which the normality hypothesis is confirmed and has a larger maximum likelihood.

Using this model, the growth rate of oil price is divided into three regimes with high low and medium growth rates. The results of MSIAH (3)-AR (5) model to extract the oil price shocks suggest that the study period of the growth rate of oil price can be separated into three regimes, however, since this study merely has examined the positive and negative shocks, two regimes with high and medium growths are considered as positive shocks and negative growth regime is considered as a negative shock which the results are summarized in table 4.

Effects of oil price shocks on production

After extracting positive and negative shocks using a Markov switching method, equation (13) is used for examining the effects of positive and negative shocks of oil price as well the asymmetric assumption of the effects of these shocks on production level.

$$LGDP_t = \alpha_0 + \alpha_1 D^R LGwop_t + \alpha_2 D^E LGwop_t + \varepsilon_{1t} \tag{13}$$

$LGDP_t$ represents GDP logarithm based on the 1997 base year. $LWOp_t$ is Iranian real average price of oil logarithm. D^R is a dummy variable which is 1 in seasons that positive oil shock (positive regime) has been occurred and for the other seasons is 0.

D^E is a dummy variable which is 1 in seasons that negative oil shock (negative regime) has been occurred and for the other seasons is 0. Extracting long-run relationship between variables using Johansen and Juselius method and investigating the asymmetry of positive and negative shocks are presented in the remainder of this study.

- optimal order selection of VAR

Akaike and Schwartz criteria are used to determine the optimal order of VAR model. The results of optimal order of VAR are provided in table 6. Schwartz and Akaike statistics select the minimum and maximum optimal lag, respectively. In this study, considering the sample size as well as examining the results and comparing both criteria, VAR optimal order is selected according to Akaike statistic i.e. 8.

- extracting long-term relationship using Johansen-Juselius method

There are five different models in Johansen Juselius method, these models are estimated from the most bound mode (mode 1) to the most unbound mode (mode 5) and a model is selected which shows the lowest vector. Some researchers believed that the model type selection should be performed congruent with economic theories. It is noteworthy that if λ_{max} and λ_{trace} show different vectors in a model, the lowest vector will be selected and in practice, since the first and fifth modes are less likely, these two models can be disregarded and other three models can be examined. Based on λ_{max} and λ_{trace} statistics, in the number of cointegration vectors five models are presented in table 6.

The results of this table indicate that the optimal model is model 2 which λ_{trace} statistics for model 2 are provided in table 7. λ_{max} test confirms the existence of a cointegration vector and this cointegration vector that is extracted from this method is normalized compared to LGDP variable and it is presented in table 8. Given the cointegration vector of the Johansen Juselius method, production elasticity towards negative shocks of oil price is 1.08, which is statistically significant in 99% confidence level. Unlike negative effects of oil shocks, production elasticity towards positive oil shocks is 0.3, which is not statistically significant. Comparing the coefficients of positive and negative shocks shows that the difference between the effects of these shocks on production is about 0.78 which implies that the symmetry of positive and negative oil shocks on production hypothesis is rejected and therefore, it can be inferred that the effects of positive and negative shocks on production are different or asymmetric.

Conclusion

In the oil industry history, oil price shocks have provided an incentive for analysts and economists to proceed to investigate and examine theoretically and practically. Iran is the world's fourth largest exporter of the oil and Iran's economy is heavily influenced by fluctuations in oil prices. Hence, in this study, using Markov switching model positive and negative shocks were extracted and then effect of these shocks on production was examined based on Johansen-Juselius cointegration model. Results indicated that the difference between the effects of these shocks on production was about 0.78 which implied that the symmetry of positive and negative oil shocks on production hypothesis was rejected and therefore, it could be concluded that the effects of positive and negative shocks on production were different or asymmetric. The oil price is a factor affecting economic growth and both sides of VAR models should be endogenous variables. Therefore, by combining the Markov switching model with VAR models and creating MS-VAR model, the effect of oil price fluctuations on production could be examined. The effect of oil price fluctuations according to different economic sectors including agriculture, industries and mines, service as well as applying monetary and price variables such as exchange rates, inflation rates, interest rates and consumer price index in the model to better illustrate the volatility of the oil price on the economy could be offered as future suggestions.

Table 2. The results of Akaike, Henan Quinn and Schwarz statistics to determine the optimal lag (12)

LAG	1	2	3	4	5	6	7	8	9	10	11	12
AIC	8.3	8.05	8.07	7.99	7.94	7.97	7.96	7.98	7.92	7.95	7.987	8.00
SC	8.37	8.15	8.21	8.156	8.148	8.21	8.23	8.28	8.26	8.32	8.38	8.43
HAC	8.33	8.09	8.12	8.05	8.028	8.07	8.072	8.1	8.06	8.1	8.14	8.17

Table 3. The summarized results of the model selection

	MSM	MSMH	MSMA	MSMAH	MSI	MSIH	MSIA	MSIAH
H_0	$\mu_0 = \mu_1 = \mu_2$	$\mu_0 = \mu_1 = \mu_2$ $\sigma_0^2 = \sigma_1^2 = \sigma_2^2$	$\mu_0 = \mu_1 = \mu_2$ $A_{0i} = A_{1i} = A_{2i}$	$\mu_0 = \mu_1 = \mu_2$ $A_{0i} = A_{1i} = A_{2i}$ $\sigma_0^2 = \sigma_1^2 = \sigma_2^2$	$I_0 = I_1 = I_2$	$I_0 = I_1 = I_2$ $\sigma_0^2 = \sigma_1^2 = \sigma_2^2$	$\mu_0 = \mu_1 = \mu_2$ $A_{0i} = A_{1i} = A_{2i}$	$\mu_0 = \mu_1 = \mu_2$ $A_{0i} = A_{1i} = A_{2i}$ $\sigma_0^2 = \sigma_1^2$
Chi^2 [pvalue]	3.229[0.357]	17.118[0.071]	46.688[0.00]	20.584[0.422]	9.83[0.277]	46.761[0.00]	49.659[0.00]	66.308[0.00]
AIC	8.594	8.414	8.228	8.64	8.459	8.008	8.187	8.014
log-likelihood	-298.686	-290.127	-275.342	-288.394	-293.771	-275.306	-273.657	-265.532

Table 4. Two positive and negative regimes of oil shocks according to seasons

Positive regime	Negative Regime
1990(2) - 1990(4)	1991(1) - 1991(3)
1992(1) - 1992(1)	1992(2) - 1992(3)
1992(4) - 1992(4)	1993(1) - 1993(4)
1994(1) - 1994(4)	1995(1) - 1995(2)
1995(3) - 1996(3)	1996(4) - 1998(3)
1998(4) - 1999(4)	2000(1) - 2001(3)
2001(4) - 2002(4)	2003(1) - 2003(1)
2003(2) - 2006(1)	2006(2) - 2006(4)
2007(1) – 2008(1)	2008(2) - 2008(2)

Table 5. The results of the estimation of different VAR model orders

LAG	1	2	3	4	5	6	7	8	9	10
AIC	-0.77	0.78	-1.37	-3.36	-3.49	-3.58	-3.49	-3.68	-3.66	-3.63
SC	-0.64	-0.56	-1.04	-2.94	-2.96	-2.95	-2.75	-2.83	-2.71	-2.57

Table 6. The number of cointegration vectors using Johansen – Juselius method

	No intercept or trend in CE or test	Intercept(no trend) in CE – no intercept in	Intercept(no trend) in CE and test VAR	Intercept and trend in CE - no trend in	Intercept and trend) in CE – linear trend
λ_{trace}	1	1	1	2	2
λ_{max}	1	0	0	1	0

Table 7. The values of λ_{trace} statistic for the second model

λ_{trace}		Statistic	P-Value (5%)	Prob.
H_0	H_1			
r=0	$r \geq 1$	39.51	35.15	0.02
$r \leq 1$	$r \geq 2$	8.21	9.16	0.07

Table 8. The results of the estimation of long-term relationships between variables

Variable	Coefficient	Standard error	Statistic(t)
LGDP	1	-	-
DNEGLWROIL	1.08	0.53	2.03
DPOSLWROIL	0.3	0.39	0.75
C	-15.6	2.83	-5.64

International Journal of Management, Accounting and Economics
Vol. 1, No. 2, September, 2014
ISSN 2383-2126 (Online)

www.ijmae.com

References

Brown, S.P.A., Yucel, M.K. (2002). Energy prices and aggregate economic activity: an interpretative survey. *Quarterly Review of Economics and Finance*, 193–208.

Cunado, J., de Gracia, F.P. (2003). Do oil price shocks matter? Evidence for some European countries. *Energy Economics*, 137–154.

Clements, M.P., & Krolzig, H.M.,(2002). Can oil shocks explain asymmetries in the U.S. business cycle? *Empirical Economics*, 185-204.

Cologni, A., & Manera, M. (2009). The asymmetric effects of oil shocks on output growth: A Markov–Switching analysis for the G-7 countries. *Economic Modelling*, 1-29.

Farzanegan, M.R., & Markwardt, G. (2009). The effects of oil price shocks on the Iranian economy, *Energy Economics*, 134-151

Hamilton, J. D. (2003). What is an oil shock?, *Journal of Econometrics*, 363-398.

Hamilton, J. D. (1983). Oil and the macro economy since World War II. *Journal of Political Economy*, 228–24.

Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica*, 357–384.

Holmes, M. J., & Wang, P. (2003). Oil and the asymmetric adjustment of U.K. Output: a Markov–Switching approach. *International Review of Applied Economics*, 181-192.

Ivanova, D., Lahiri, K., & Seitz, F. (2000). Interest rate spreads as predictors of German inflation and business cycles. *Int. J. Forecasting*,. 39-58.

Krolzig, H.-M., & Hendry, D. F. (2000). Computer automation of general-to-specific model selection procedures. *Journal of Economic Dynamics and Control*, 120-132.

Kirchgässner, G & Wolters, J. (2007). Introduction to Modern Time Series Analysis, Berlin :Springer.

Krolzig. M, (1997). Markov- Switching Vector Auto regressions. Modelling, Statistical Inference and Application to Business Cycle Analysis., Berlin: Springer

Mashayekhi, A. (2001). Dynamics of oil Price in the world Market, *International System Dynamics Conference , system Dynamic Society*, 1012-1020

Mork, K.A. (1989). Oil shocks and the macro economy when prices go up and down: an extension of Hamilton's results. *Journal of Political Economy*, 740–744.

Raymond, J. E., & Rich, R.W. (1997). Oil and the macro economy: a Markov State–Switching Approach. *Journal of Money, Credit and Banking*, 193-213.

Sadorsky, P. (1999). Oil price shocks and stock market activity. *Journal of Energy Econo*mics, 449-469.

Wijnbergen, S. V. (1984). Inflation, Employment and Dutch Disease in Oil Exporting Countries,a Short-Run Equilibrium. *Quarterly Journal of Economics*, 110-119.

Zhang, D. (2008). Oil shock and economic growth in Japan: A nonlinear approach. *Energy Economics*, 2374–2390.