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EVALUATION OF BUSINESS CYCLE SYNCHRONIZATION BY THE OIL REVENUES (MARKOV SWITCHING BAYESIAN VAR ANALYSIS)

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Abstract

The synchronization of business cycles is one of the new topics that have been raised in recent decades in the field of international business at the same time of increased economic integration between countries. Accordingly, considering the influenced Iranian economy by the flow of business cycles, and given that synchronization is investigated by the existence of common factors, so in this study, the synchronization of business cycles of a country as OPEC member with the important and influential factors of oil, which have a significant effect on both the economy of the country and the world, has been studied. Due to the formation of business cycles and the process of oil revenue, the method used is Markov Bayesian VAR Switching (MSBVAR) analysis. According to the obtained results, the synchronization of business cycles between Iran and Iraq during 1985-2015 indicates the high synchronization and symmetry between the two countries' business cycles. The role of oil revenues is significant in justifying the degree of synchronization of business cycles. Regimen 1 (Stagnation) has been more stable than Regime 2 (Inflation) and Regime 1is more likely to be dominant.

Key Keywords: Oil Revenues, Business Cycle Synchronization, Markov switching Bayesian VAR method

JEL Classification: *04, K14, C33*

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Introduction

Business cycles in each country explain the fluctuations of national production, so that these fluctuations play an important role in the performance of each country. The study of business cycles, therefore, is important because economic planning does not seem to be very effective without understanding GDP fluctuations and the cause of these fluctuations. Therefore, identification of the causes and the wave of the emergence of these cycles leads to the avoidance of its negative effects, i.e. the emergence of crises by proper macroeconomic planning, and its positive effects can be achieved, i.e. achieving economic prosperity and preserving it, and as a result optimal allocation of resources. One of these factors is the price fluctuations of oil that considering influenced Iran economy by these fluctuations, study oil price in relation to these cycles is of particular importance. The synchronization of business cycles is one of the new topics that have been raised in recent decades in the field of international business at the same time of increased economic integration between industrialized countries. The synchronization of business cycles, interpreted in many studies as the co-movement or a "change" in business cycles, actually means that the time of occurrence of peak and perigee points in cycles is the same. In other words, the cycles have the same timing. The synchronization of business cycles is closely related to the Optimal Currency Area theory. Indeed, the synchronization topic has been discussed for the first time with the advent of Optimal Currency Area theory as one of the important measures for identifying the level of readiness of countries to create an optimal currency area, and in many empirical studies related to the monetary union and economic integration has been considered by researchers and economists. On the other hand, one of the important factors affecting the synchronization of business cycles is expanding trade relations, and increasing the integration of trade between countries (Shin and Wang, 2004). If the expansion of business leads to an increase in the countries' synchronization of business cycles, it can form an optimal currency area and create a monetary union against the existence of a floating exchange rate system. In fact under such conditions, asymmetric shocks occur in the range of the business countries that there is no need to adopt independent monetary policies and changes in interest or exchange rates to deal with them, or at least they will be faded, so the benefits of joining the monetary union will be greater than its possible loss (Frankel and Rose, 1998). In this research, the synchronization of business cycles of a country as OPEC member has been studied with important and influential factors of oil, which have a significant effect on both the economy of the country and world. Due to the formation of business cycles and the process of oil revenue, the method used is a combination of Markov Bayesian VAR Switching analysis. Therefore, this research seeks to answer the following questions by Markov Bayesian VAR Switching method.

1) Is there the synchronization of business cycles of Iran and Iraq?

2) Does the synchronization of business cycles affect oil revenue?

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In the present paper, after the introduction, we introduce the model and model estimation. In the next section, the model's results, and in the final section the conclusions are presented.

Methodology

Markov Switching Bayesian VAR model

The model objectives can be summarized as follows:

1) The possibility of introducing a system consisting of two main and auxiliary variables in order to avoid an explanatory error caused by ignoring indirect effects
2) Specify the regime change feature of the variables studied in the model
3) The possibility to explain more than two regimes in the model
4) Using Bayesian method to consider uncertainties and avoid shortcomings of the classical method from an econometric perspective, transferring from a regime to another is effective on data behavior and should be considered in the design of the model.

First, it is necessary to introduce the model hypotheses as well as the symbols to explain the model.

$$y_t = (y_1. \dots . y_t) \in (R^n)^t \qquad \textbf{1}$$
$$\Theta = (\Theta i)_{i \in H} \in (R^r)^h \qquad \textbf{2}$$
$$Q = (q\ .j)_{i.j \in H \times H} \in (R^h)^2 \qquad \textbf{3}$$
$$s_t = (s_0. \dots . s_t) \in H^{t+1} \qquad \textbf{4}$$
$$s_{t+1}^T = (s_{t+1}. \dots . s_T) \in H^{T-1} \qquad \textbf{5}$$

Where Y_t is the endogenous variables, H is a finite set with h components, Q is Markov transformation matrix and q_{ij} is the probability that the state variable is equal to I, provided that s_{t-1} is equal to j, matrix Q is attached as follows:

$$\sum_{i \in H} q_{i.j} = 1 \qquad \textbf{6}$$

If the density function of two random vectors is considered with the symbol, the boundary and conditional density functions are defined as follows:

$$P(\mathrm{v}) = \int P(u.\mathrm{v})\mathrm{du} \qquad \textbf{7}$$

$$p(u|\,\mathrm{v}) = P(u.\mathrm{v}) / \int P(u.\mathrm{v})\mathrm{du} \qquad \textbf{8}$$

Θ is the parameters set, y_t is data set, and s_t is a sequence of non-visible variables. It is assumed that the following conditions apply for the conjugate density function p $(Y_t.\Theta.\mathrm{Q}.S_t)$ with Lebesgue measure $(R^n)^t \times (R^r)^h$ and the counting measure H^{t+1}:

$$p(s_t|y_{t-1}.\Theta\,, Q.S_{t-1}) = q_{s_t.s_{t-1}} \qquad \textbf{9}$$
$$p(y_t|y_{t-1}, \Theta, S_t) \qquad \textbf{10}$$

According to condition (1), S_t sequence is exogenous based on Markov process and dynamic according to Q change in transitions (transition) matrix. According to condition (2), also there is need to obtain standard Posterior density function Q conditional on S_t. By applying these conditions, the following propositions are obtained as proven by Hamilton (1989), Chib (1996) and Kim and Nelson (1999):

$$p(s_t|y_{t-1}.\Theta, Q.S_{t-1}) = \sum S_{t-1} \in H q_{s_t.s_{t-1}} p(s_{t-1}|y_{t-1}.\Theta, Q) \quad \textbf{11}$$

$$p(s_t|y_t.\Theta, Q) = p(y_t|y_{t-1}.\Theta.s_t)p(s_{t-1}|y_{t-1}.\Theta, Q) \quad \textbf{12}$$
$$/\sum S_{t-1} \in H \ (y_t|y_{t-1}.\Theta \text{و} s_t)p(s_t|y_{t-1}.\Theta, Q)$$

And for t<T≤0

$$p(s_t|y_t, \Theta, Q, S_{t+1}) = p(s_t|y_t, \Theta, Q, S_{t+1}^T) \qquad , S_{t+1}^T = \{s_t, \ldots, s_{t+1}\} \quad \textbf{13}$$

$$p(y_t|y_{t-1}, \Theta, Q, s^T) = p(Y_t|y_{t-1}, \Theta, Q, S_t) \quad \textbf{14}$$

The change in transitions matrix Q with Dirichlet density is considered as follows:

$$p(Q) = \prod_{i \in H} [(\mathrm{T}(\sum_{i \in H} \alpha_{i,j}) / \prod_{i \in H} (\mathrm{T}\alpha_{i,j})) \times \prod_{i \in H} q_{i,j}{}^{\alpha_{i,j}} - 1] \quad \textbf{15}$$

Where the function T(0) is the standard gamma. The former density ΘQ. s^T is as follows:

$$\mathrm{P}((\Theta.Q.S_t)) = P(\Theta.Q)P(S_0|(\Theta.Q)\prod_{t=1} T\, P(S_T|(\Theta.Q.S_{T-1}) \quad \textbf{16}$$

By definition $P(S_0|(\Theta.Q) = 1/h$ and s0 ∈ H, also assuming that the former density Θ is independent of the former density Q, and according to the condition (1), the following result is obtained:

$$P(\Theta.Q.S_t)) = P(Q)P(Q)/h \prod_{t=1}^{T} q_{s_t.s_{t-1}} \quad \textbf{17}$$

The likelihood is determined regressively:

$$p(y_t|y_{t-1}.\Theta \text{و} Q) = \sum_{s_t \in H} P(p(y_t|y_{t-1}.\Theta.Q)p(S_t|y_{t-1}.\Theta.Q) \quad \textbf{18}$$

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Using Bayesian rule, the Posterior distribution Θ and Q is as follows:

$P(\Theta.Q|\,Y_T) \square P(\Theta.Q)P(Y_T|\Theta.Q)$ **19**

Since the Posterior density is uncertain, and thus Monte Carlo simulation is inefficient, to obtain the Posterior experimental density $(\Theta.Q.S_T|\,Y_T)$:

$P(S_T|\,Y_T.\Theta.Q)$ **20**

$P(Q|\Theta.S_T\,Y_T)$ **21**

$P(\Theta|Q.S_T\,Y_T)$ **22**

The Posterior conditional distributions are sampled alternately. The Posterior conditional distribution of S_T is:

$$P(S_T|\,Y_T.\Theta.Q) = P\left(P(S_T|\,Y_T.\Theta.Q)\prod_{t=0}^{T-1}P(\,S_T\middle|\,Y_T,\Theta.Q.S_{t+1}^T\right) \quad \textbf{23}$$

According to the above propositions, the following statement can be written:

$p(S_T|Y_T,\Theta.Q,S_{t+1}^T) = p(S_T|Y_T,\Theta.Q,s_{t+1})$ **24**

$=p(s_{t,s_{t+1}}|\,Y_T,\Theta.Q)/p(s_{t,s_{t+1}}|\,Y_T,\Theta.Q) =$ **25**

$$\frac{p(,s_{t+1}|\,Y_T,\Theta.Q,s_t)p(s_t|Y_T,\Theta.Q)}{p(s_{t,s_{t+1}}|\,Y_T,\Theta.Q)} = q_{s_t,s_{t+1}}p(s_{t,s_{t+1}}|\,Y_T,\Theta.Q)/p(p(s_{t,s_{t+1}}|\,Y_T,\Theta.Q)$$

This density is determined regressively with the starting point of s_t. The Posterior conditional distribution of chane in transitions matrix Q is given according to the constraints imposed on it. Markov processes are independent from the product of tensor multiplication of the change in transitions matrices.

If k is the independent Markov process, the following statement can be defined:

$$S_t^K \square H^K.H^K = \{1.\dots.h^k\}.H = \prod_{K=1}^{K}H^K.h = \prod_{k=1}^{k}h^k \quad \textbf{26}$$

$s_t = (s_t^1.\dots.s_t^k)$ **27**

Accordingly, the change in transitions matrix Q is as follows:

$Q=Q^1 \square \dots\dots \square\ Q^K$ **28**

Where $q_{i.j}^k=Q^K$ is a matrix $h^k \times h^k$ with the following condition:

$$q_{i.j}^k \geq 0\,, \sum_{i \square H^K} q_{i.j}^k \quad \textbf{29}$$

The representation of Q in the form of the product of tensor multiplication determines that if $i = (i^1.\dots.i^k) \square H$ and $j = (i^1.\dots.j^k) \square H$,

$$q_{i.j} = \prod_{k=1}^{k} q_{i^k.j^k}^k \quad \textbf{30}$$

By applying such a hypothesis, the composite Markov process s_t will include k independent Markov processes of s_t^k. The conditional likelihood function of the model is considered as follows:

$$y = \mu(s_t) + \sum_{i=1}^{p} y_{t-i} A_i(s_t) + \varepsilon_t \qquad \textbf{31}$$

Where ε_t is random invisible moment, by defining the following symbols:

$$y_{t-i} = \begin{pmatrix} y_{t-1} \\ \vdots \\ y_{t-p} \end{pmatrix} . A(S_t) = \begin{pmatrix} A(S_t) \\ \vdots \\ A_P(S_t) \end{pmatrix} . y_t = \begin{pmatrix} y_1 \\ \vdots \\ y_p \end{pmatrix} . s_t = \begin{pmatrix} s_0 \\ \vdots \\ s_t \end{pmatrix} \qquad \textbf{32}$$

it is assumed that y_y conditional density follows a normal multivariate distribution with the mean μ and variance Σ:

$$p(y_t|y_{t-1}.\Theta , Q.s_t) = n \quad (y_t|\mu(s_t). \sum s_t)) \qquad \textbf{33}$$

Also, the conditional density ε_t is normal.

$$p(\varepsilon_t|y_{t-1}.\Theta , Q.s_t) = n \quad (\varepsilon_t|0.I_n) \qquad \textbf{34}$$

Where 0 is zero matrix and I_n is the matrix of 1. The conditional likelihood function is defined as follows:

$$p(y_t|y_{t-1}.\Theta . Q.s_t) = |\sum(s_t)|^{-1/2} \exp(-1/2(y_t - s_t)) \sum(s_t)^{-1}(y_t - \mu(s_t))) \qquad \textbf{35}$$

In order to avoid a long sequence of Posterior fractions in the area with a low probability, it is necessary to estimate Θ at the peak of the Posterior distribution (Billio, Casarin, Dijk, Mazzi and Ravazzolo, 2011).

Empirical Results

In order to examine the effect of the synchronization of business cycles of Iran and Iraq on oil revenue, it is necessary first to examine the existence of the synchronization of gross domestic product of these two business partners. For this purpose, according to empirical studies such as Frankel and Rose (1997 and 1998), Calderon (2002), Shin and Wang (2004) integrated GDP correlation coefficient for countries i and j is used by the following method. In this case we will have:

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$$c \quad (y_i^c \cdot y_j^c) \frac{c \quad (y_i^c \cdot y_j^c)}{\sqrt{v \quad (y_i^c) v \quad (y_j^c)}} \tag{36}$$

y_c is the logarithm of integrated GDP based on GDP value at constant prices and in dollars (derived from World Bank Development Indicators). The positive correlation coefficient indicates the synchronization of business cycles of Iran and Iraq, and the negative correlation coefficient indicates the lack of synchronization of business cycles of Iran and Iraq. Before calculating the correlation coefficient between countries, the gross domestic product (GDP) of the studied countries is integrated. Different methods are used to integrate time series. In this study, Hodrick-Prescott filter is used. Many empirical studies have used this technique, including Calderon et al., and Eckin. An estimate of the synchronization of business cycles of the countries Iran and Iraq during 1985-2015 indicates a high synchronization and symmetry of business cycles of these two countries. The correlation coefficient of Iran and Iraq's GDP is estimated 0.826 that indicates a direct and high synchronization of the two countries. Then, to investigate the effect of oil revenue synchronization, R-Studio software has been used for this.
In order to estimate the model, first it is necessary to determine the model lag. Based on Bayesian information criterion and taking into account a maximum of 12 lags, the lag was selected 1. After determining the lag, it is necessary to determine the number of regimes. According to Bayesian criteria presented in the Table below, 2 regimes were determined

The results of determining the optimal model for the selected countries

Table 1: Determine the optimal regime

	2 regimes Compared with 1 regimes	**2 regimes Compared with 3 regimes**
Bayesian Information Criteria	1.529	**1.500**

Source: Research calculations

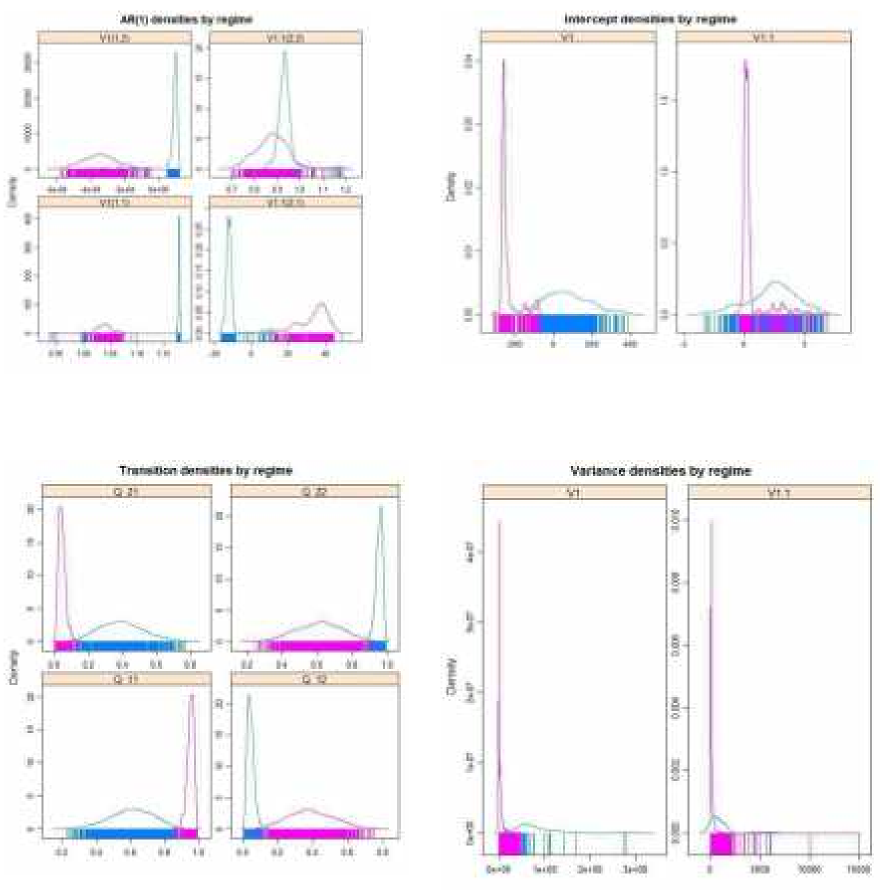
Table 2: Optimal lag value

Lags	**BIC**
1	**-3.236**
2	**-2.627**
3, …	**-2.547**

Source: Research calculations

According to the above, Autoregressive Markov Bayesian Switching with the lag of 1 and 2 of the regime seems appropriate to explain the behavior of the financial variable. The corresponding Figs. (Autoregressive coefficient and intercept density parameters, and parameters of the change in transitions matrix) are presented below.

Figure 1- Density



Estimate Transition densities by regims

Table 3: Transition densities by regims

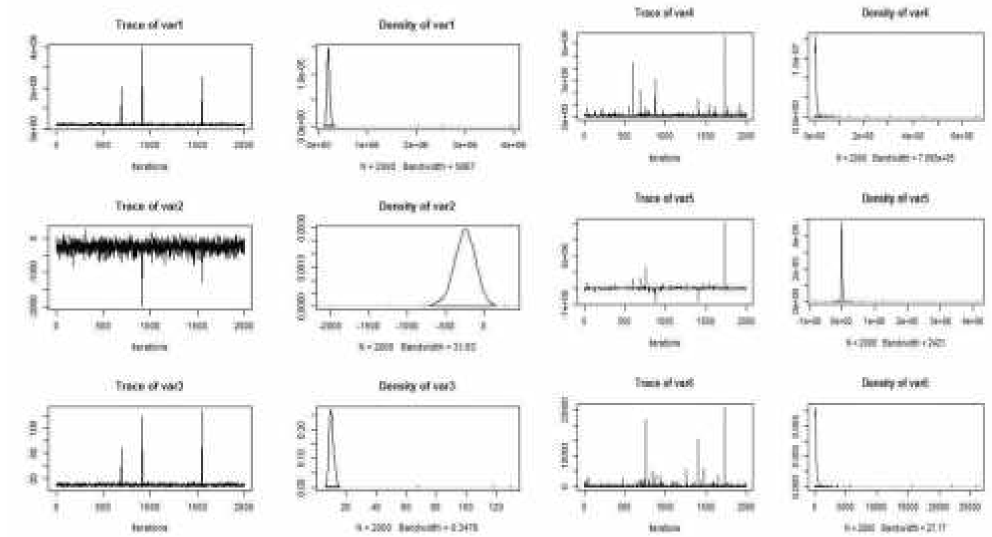
P_{11}	P_{12}
0.999	**0.0001**
P_{21}	P_{22}
0.110	**0.889**

Table 3 shows that the Regime 1 is more stable than other regimes and is more likely to be dominant.

The Posterior distribution of the coefficients of the regression model based on Gibbs sampling algorithm

One of the most common Bayesian methods is Gibbs sampling (Rashedi et al., 2013). Gibbs sampling is a numerical integral method, and a method of Markov chain Monte Carlo methods (MCMC) is provided. Gibbs algorithm is a powerful tool for simulating the Posterior distribution. The Posterior distribution of all coefficients is normal.

Figure 2: Trace and Posterior distribution



With the help of the distribution information of the former density functions, we can extract information about the Posterior distribution.

Monte Carlo (MCMCs) quantile is obtained based on 1000 fractions. The results are presented in Table 4.

Table 4: The Posterior Estimation of Each Regime in terms of the Posterior Quantile

	25%	**50%**	**75%**	**97.5%**
Regime 1	0.500	0.594	0.679	**0.864**
Regime 2	0.035	0.049	0.065	**0.118**

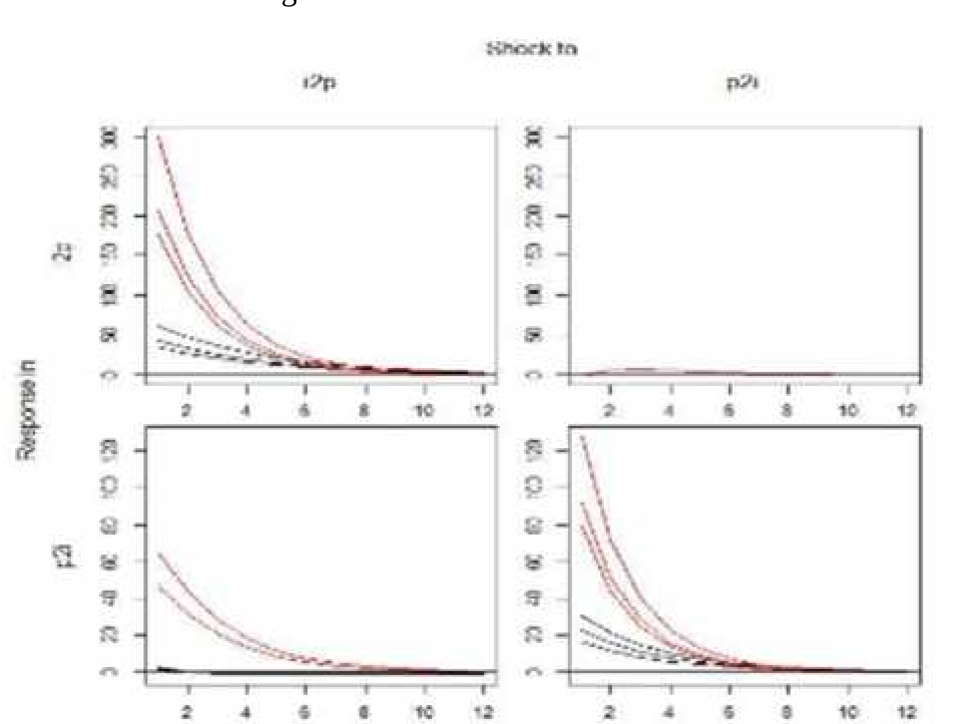
The above Table shows that the Regime 1 period is higher than the other one, and this regime is more durable. The Posterior mean and standard deviation of the variables in each regime are presented in the following Table. This Table shows that in the Regime 2, the growth is positive and in the Regime 1, the growth is negative. The Regime 1 shows the least variance and the Regime 2 shows the most variance. Accordingly, the Regime 2 shows prosperity with more fluctuations, and the Regime 1 shows stagnation with less fluctuations.

Table 5: The Posterior estimate and standard deviations of each regime

		Regime 1	**Regime 2**
σ		0.131	**0.060**
Mean		-0.593	**0.058**

Source: Research calculations

Figure 4: The impulse response functions of the logarithm of GDP to the logarithm of the oil revenue variable



The oil revenue shock affects the synchronization of business cycles, so that the synchronization of cycles is reduced with oil revenue shock and finally returns to its long-term balance process.

Conclusion

In this study, the effect of the synchronization of business cycles on oil revenue was studied. It is natural that according to the formation of business cycles and the process of formation of oil revenue, the method used would be Markov Bayesian VAR Switching analysis. The data used in this paper is for countries including Iran and Iraq during 1986-2015. According to the results, the synchronization of business cycles of Iran and Iraq during the years 1986-2015 indicates the high synchronization and symmetry between the two countries' business cycles. The role of oil revenue is significant in justifying the degree of business cycle synchronization. So that synchronization of cycles is reduced with oil revenue shock and finally returns to its long-term balance process. Regime 1 (stagnation) is more stable than Regime 2 (inflation) and Regime 1 is more likely to be dominant.

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