The Relationship between Real Exchange Rates and Oil Prices in Iran: Evidence from M-TAR Model

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Abstract

The present article investigates the relationship between the real exchange rate and oil price and identification of Dutch disease from 1962 to 2012 in Iran. Dutch disease refers to a situation where the discovery of a natural resource such as oil, and therefore, the increase of exchange revenues reduce the real exchange rate and the competitiveness is weakened in the country. The cointegration testing was used in traditional methods in order to describe the relationship between real exchange rate and oil prices. The main hypothesis in that method is the symmetrical adjustment of exchange rate in response to positive or negative diversities of the oil price from its balanced rate. But since various factors such as government interventions, cause asymmetric reactions in the real exchange rate as compared to the oil price, the obtained results from this method become invalid and unreliable. The momentum threshold autoregressive model (M-TAR) is exclusive method in using nonlinear models or the models with asymmetric data assumption. The study results show that: (a) oil prices have a long-run effect on the exchange rates; and (b) there is no evidence of short-run causality between real exchange rates and real oil prices; and (c) the real exchange rate reacts faster to negative deviations from the equilibrium. Thus, the results of the estimated model imply the existence of the Dutch disease in Iran.

Keywords: Real exchange rate, Momentum threshold autoregressive (M-TAR) model, Dutch disease, Asymmetry.

JEL Classification: C32, C52, F31, F37, F47

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1. Introduction

One of the characteristics of single-product economies exporting natural resources is having Dutch disease. Increased income from sales of natural resources can bring out the national economy from the productive state. This happens due to the reduction of exchange rate or the lack of its increase in proportion to inflation. The activities of unexchangeable sector grow which are not subject to international competitions such as service sector and building sector and the activities of exchangeable sector are stagnated which are extensively exchanged in international markets, such as industrial sector in this situation [9] as quoted by [6]. Result of Dutch Disease in oil exporting countries is the significant increase of the oil sector's contribution in national income than non-oil sectors. Increase in the per capita income is only due to increase in oil incomes in this situation and this phenomenon is observed in the economies including Iranian economy.

This study investigates the relationship between oil price and real exchange rate and occurrence of Dutch disease in Iran by using momentum-threshold autoregressive (M-TAR). This method is applied when asymmetric adjustment of the exchange rate is in response to positive and negative deviation of oil price.

2. Theoretical Foundations

Although diagnosis of Dutch disease is necessary for reduction of its losses in oil exporting countries, its detection is not simply possible. Economists and experts use indicators and signs for understanding of emergence of Dutch disease in the economics which the most important ones are:

1) A decrease in the real exchange rate (RER = real exchange rate is obtained from the formula: RER= $\frac{E.P^*}{P}$ where E is equal to the nominal exchange rate and it is defined as the price per unit of foreign currency in terms of domestic currency, p * is equal to the world price index, P is equal to the domestic price index and RER represents the real exchange rate.

2) Expansion of the service sector

3) an increase in the price of non-tradable goods (such as land, housing and services)

4) Reduction of the proportion of non-oil exports (especially manufactured goods) to GDP

5) Increase in imports (especially commodities)

6) Reduction of the share of the value added industrial and agricultural sectors from GDP

So, when the mentioned signs are appeared in the economy along with boom of natural resources (especially oil boom), we can say that the economy suffers from the Dutch disease (Zenouz, 1387), although part of the events may be resulted from other factors and these factors may also come into existence in the wake of the oil boom.

The basic assumption of conventional cointegration tests is the symmetrical adjustment of exchange rate in response to positive and negative deviations of oil price from equilibrium. However, numerous factors may have asymmetric responses of the real exchange rate than the oil price in the oil exporting countries. The results create the shadow of a doubt about the effect of real exchange rate than oil price shocks. As a result, the usual cointegration tests lose their power. Momentum-threshold autoregressive (M-TAR) is a suitable method for asymmetric reactions which has been developed by Enders and Granger [16], Enders and Siklos [15], and Enders [17].

Since the mentioned approach has not been applied in the investigation of the relationship between oil price and real exchange rate in Iran, this study investigates the short - run and long - run relationship between oil price and real exchange rate and occurrence of Dutch disease in Iran by using momentum-threshold autoregressive (M- TAR).

3. Literature

Many studies have not been carried out about non-linear relationship between exchange rate and oil price and the assumption of most studies which have been done is asymmetric equilibrium of exchange rate in response to

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positive and negative deviations of oil price from the equilibrium. The following are some studies which have been carried out in recent years.

In an article entitled "The impact of oil price shocks on the Iranian economy," Farzanegan and Markwardt [19] investigated the dynamic relationship between oil price shocks and the main variables of the Iranian economy by using VAR method. The results showed the positive effect of shocks of oil price on inflation and a strong positive relationship between shocks of oil price and growth of industrial products. Furthermore, by using the observation of a significant strengthening of the real exchange rate, the result showed that the Iranian economy is suffering from Dutch Disease.

In an article entitled "The relationship between oil revenues and economic variables", Mehrara reviewed the relationship between oil revenues and oil exporting industrial products to 13 countries in the period (1965 – 2004). Selected countries were Algeria, Colombia, Ecuador, Indonesia, Iran, Kuwait, Libya, Mexico, Nigeria, Qatar, Saudi Arabia, United Arabic Emirates and Venezuela respectively. To assess the impact of oil revenues on economic growth of the mentioned countries, he used pubic moments. The results showed that the negative shocks of oil revenues have undesirable impact on economic growth and in the other hand, the positive shocks of oil revenues also play a role making limited the motivation of economic growth and in fact , it represents the Dutch disease in these economies .

In an article entitled "The investigation of long- run relationship of crude oil price and real exchange rate of dollar" , Bazzazan et al [2] investigated the long-run relationship between oil price and dollar by using Johansen-Juselius cointegration and ARDL. By using seasonal data of the period of 1975 to 2008, they showed a long-run relationship between the price of dollar and oil price, however, this relationship is not very strong. Dollar rate also shows stationary behavior against different shocks on it (which is a deviation from the long-term trend) , although the convergence rate is not high.

In an article titled "The volatility of oil prices on Iran's macroeconomic performance", and by using a vector error correction model (VECM), Hadiyan and Parsa (1385) concluded that one of the sources of fluctuations on macroeconomic variables is the shocks of oil price in Iran as twenty percent of fluctuations of GDP, thirty percent of fluctuations of unemployment rate and sixty percent of fluctuations in public level of prices are resulted from fluctuations of oil price. Inflicted shocks on oil price also add fluctuations of mentioned variables in a time-scale and they lead to divergence of achieved values of these variables from their equilibrium.

4. Research Method

It is used from cointegration tests for the investigation of the relationship between oil price and real exchange rate in the traditional and common methods. The basic assumption of conventional cointegration tests is symmetrical adjustment of exchange rate in response to positive and negative deviations of oil price from the equilibrium. However, several factors may have an asymmetric response in the real exchange rate than oil price in the oil exporting countries. These results create shadow of a doubt about effects on the real exchange rate relative to the shocks of oil price. In the case of asymmetric adjustments, implicit dynamic relationships in the Dutch disease hypothesis tests are incorrectly specified based on the conventional techniques such as Engel and Granger (1987), Johansen [23] and Pesaran et al (2001). Moreover, conventional cointegration tests lose their power(Pippenger and Goering (1993; Anders and Granger, 1998; Anders and Siklos,2001). Momentum threshold autoregressive (M-TAR) is a suitable method for asymmetric reactions which these models have been developed by Anders and Granger (1998), Anders and Siklos (2001) and Anders (2001).

Cointegration tests on the residual of the model (Engel and Granger, 1987) studies the accuracy of the Dutch disease hypothesis through estimation of the following relationships:

$$e_t=\alpha_0+\alpha_1 q_t+\varepsilon_t \quad (1)$$

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$$\Delta\varepsilon_t = \rho\varepsilon_{t-1} + \sum_{i=1}^{k} \beta_i \Delta\varepsilon_{t-i} + v_t \quad (2)$$

Where e_t is logarithm of the real exchange rate, q_t is logarithm of the real oil price, α_1 is strength of real exchange rate relative to oil price and ε_t is random error. Equation (1) shows long-term relationship between oil price and the real exchange rate. If $\alpha_1 > 0$, ε_t follows a stationary process, the Dutch disease hypothesis is confirmed in a country. The second condition is estimated if the null hypothesis of unit root tests ($\rho = 0$) is rejected in favor of ($\rho < 0$) in the augmented Dickey Fuller test.

The implicit assumption in the unit root test in equation (2) is linear and symmetric adjustment of exchange rate relative to positive and negative deviations of oil price from the equilibrium. In contrast, several studies have been conducted on non-linear adjustment of the real exchange rate showing the results of equation (2) are invalid (Taylor et al., 2001). M-TAR method is an alternative approach in the case of asymmetric adjustments and this method requires the estimation of the following model:

$$\Delta\varepsilon_t = \rho^{+} M_t \varepsilon_{t-1} + \rho^{-}(1-M_t)\varepsilon_{t-1} + \sum_{i=1}^{k} \beta_i \Delta\varepsilon_{t-i} + u_t \quad (3)$$

Where M is equal to the index from Heaviside[1] step function and the parameters of $\rho+$ and $\rho-$ are positive and negative deviations along with asymmetric adjustment. Furthermore, the Heaviside index value is determined based on the difference between the periods before the error relative to the optimal threshold τ. namely:

$$M_t = 1 \quad \text{if} \quad \Delta\varepsilon_{t-1} \geq \tau \quad (4)$$

$$M_t = 0 \quad \text{if} \quad \Delta\varepsilon_{t-1} < \tau \quad (5)$$

The optimal threshold τ is specified by Chan [11] in the above equations. The threshold value is generally unknown and it needs to be estimated with ρ^{-} and ρ^{+}. To find the estimated adjustment of threshold values, and according to the network method of Chan, obtained wastes from cointegration equation (2),we regulate from the lowest to the highest values and 15% largest and smallest values are set aside and 70% residual can be considered as the threshold. The equations (3) are estimated OLS for each threshold. Optimum threshold gives the smallest sum of squares.

The test procedure consists of three steps: First, cointegration tests and the estimation of the M-TAR model, where the null hypothesis of non-cointegration is H0: $\rho+ = \rho- = 0$. If the null hypothesis of no cointegration is rejected, then the second stage of investigation of zero hypothesis is the existence of symmetry (H0: $\rho+ = \rho-$). If The null hypothesis is rejected and$|\rho^{+}|>|\rho^{-}|$, the exchange rate has faster reactions relative to positive shocks and deviations of oil price from the equilibrium and if $|\rho^{-}|>|\rho^{+}|$, the exchange rate shows faster reactions relative to negative shocks and deviations of oil price from the equilibrium. Finally, the third stage involves the estimation of asymmetric error correction model and short-term and long-term causality test between real oil price (q_t) and real exchange rate (e_t). Asymmetric error correction model consists of the following two equations:

$$\Delta e_t = \sigma^{+} M_t \varepsilon_{t-1} + \sigma^{-}(1-M_t)\varepsilon_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta e_{t-i} + \sum_{i=1}^{k} \varphi_i \Delta q_{i-1} + u_t \quad (6)$$

$$\Delta q_t = \sigma_2^{+} M_t \varepsilon_{t-1} + \sigma_2^{-}(1-M_t)\varepsilon_{t-1} + \sum_{i=1}^{k} \gamma^{*}_i \Delta e_{t-i} + \sum_{i=1}^{k} \varphi^{*}_i \Delta q_{i-1} + u_t^{*} \quad (7)$$

Equation (6) indicates error correction model of the real exchange rate. The real exchange rate changes are determined positively in the

[1] Heaviside step function or unit step function is discontinuous and multi-criterion function whose values is zero for negative numbers and one for positive numbers. It is named after the English scientist Oliver Heaviside.

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model(Mt ε_{t-1})and they are negatively determined by($(1-M_t)$ ε_{t-1})from equilibrium. The mentioned equation shows the short-term and long-term causality relationship from real oil price to the real exchange rate. The real oil price is the cause of changes in the real exchange rate in the long run, if the coefficients of equilibrium errors of σ_1^+ and σ_1^- are significant and if they are significant, the real oil price will be the cause of changes in the short term. Similarly, equation (7) shows the short-term and long- term causality relationship from the real exchange rate to the real oil price so that the real exchange rate is the cause of changes of real oil price in the long run if the coefficients of equilibrium errors of σ_2^+ and σ_2^- are significant and if they are significant , the real exchange rate is the cause of changes of real oil price in the short term.

In order to do the test, it is required to have data which are related to real exchange rate and real oil price. Statistics and yearly information on the indexes of nominal exchange rate, the index of consumer price in the country and outside the country and nominal oil price is also needed to compute these indexes. The mentioned statistics were extracted from databases of the IMF and website of OPEC for the period of 1962 to 2012. The real exchange rate has been calculated by using RER= $\frac{E.P^*}{P}$ where E is equal to nominal exchange rate and it is defined the price of each foreign currency in terms of domestic currency, p^* is equal to the consumer price index outside the country, P is equal to the domestic price index and RER represents the real exchange rate . The real price of crude oil was also calculated by dividing the nominal oil price on the consumer price index in America. Both variables are used in the form of logarithm in the model and the estimations were obtained by using Eviews and Gauss softwares.

5. Research Findings

First of all, durability of variables are tested by using Augmented Dickey – Fuller (ADF) and Phillips-Perron (PP) tests, however, since Augmented Dickey – Fuller (ADF) and Phillips-Perron (PP) tests do not consider the possibility of failure in the reviewed time series and the occurrence of exchange crisis may make structural failure in the reviewed sample simultaneously, the obtained results of ADF and PP will not be without any problem. So Lee – Strazicich (LS) is used for testing the unit root test in the presence of a structural break**.** The null hypothesis indicates the existence of the unit root in this test, just as two other tests (This test has been explained in the appendix).

The results of Lee – Strazicich(LS)test, Augmented Dickey – Fuller (ADF)test and Phillips-Perron (PP)test can be seen in Table (1).

Table (1). Results of unit root tests of real exchange rate and the real oil price in Iran

Variable	LS	ADF (level)	ADF (First Difference)	PP (level)	PP (First Difference)
e	-7.28	-0.451	-8.0205	-0.412	-15.491
q	-5.27	-0.745	-4.942	-0.678	-6.848

Source: search results

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e: log of real exchange rate, q: log of real price of oil
PP and ADF statistic critical value at 5% is equal to: -2.92
LS statistic critical value at 5% level is equal to:-3.56

According to the LS test, the unit root in the real exchange rate and the real oil price is rejected. So it can be trusted to the results of ADF and PP tests. According to the ADF and PP tests, the difference between the first two variables is fixed, i.e., the real exchange rate and the real oil price have integration from first order. So we can say that here is a long-term relationship between two variables. Given the unit root tests, it can be estimated M-TAR (model 3). M-TAR model and the optimal threshold estimation results are summarized in Table(2) .

Table (2) - Model M-TAR cointegration tests

F_2	F_1	P^-	P^+	(Optimal threshold) τ
4.311	12.497	-1.1581	-0.06357	0.0069

Source: search results
F_1:F test statistic for the hypothesis $P^+=P^-=0$
F_2 : F test statistic for the hypothesis $P^+=P^-$
Anders – Siklos critical values at 5% and 10% is equal to 6.32 and 5.21 respectively

Based on the results of Table (2) and calculated F_1 value, the null hypothesis of non-cointegration is rejected. We have $|P^-| > |P^+|$, so the real exchange rate shows more rapid response relative to negative deviations of oil price from equilibrium and the Iranian M-TAR model would be as follows:

$$\Delta\varepsilon_t = -0.0635M_t\varepsilon_t -1.1581\ (1-M_t)\varepsilon_{t-1}\ 0.0398+ \Delta\varepsilon_{t-1}\ 0.0828 + \Delta\varepsilon_{t-2}$$

So the next stage is begun which includes the estimated asymmetric error correction model and short-term and long-term causality test between real oil price (q_t)and real exchange rate(e_t). Based on the equations No (6) and (7), causality test results between short-term and long-term real exchange rate and real oil price are summarized in Table 3.

According to statistic values obtained from Table (3) and $F_1(\sigma^+ = \sigma^- = 0)$, H_0 hypothesis is rejected and there is a long-term relationship between oil price and real exchange rate. According to the statistic $F_1(\varphi_i = 0)$, short-term causality from oil price to real exchange rate is rejected at 5% level. In addition, based on the statistic

$F_2(\sigma^+ = \sigma^- = 0)$ and $F_2(\varphi_i = 0)$, long-term causality from real exchange rate to oil price and short-term causality from real exchange rate to oil price at 5% level is rejected.

Table (3) Short-term and long-term causality test

$H_0 : q \neq> e$ Equation (6)				$H_0 : e \neq> q$ Equation (7)			
σ^+	σ^-	$F_1(\sigma^+ = \sigma^- = 0)$	$F_1(\varphi_i = 0)$	$^+\sigma$	σ^-	$F_2(\sigma^+ = \sigma^- = 0)$	$F_2(\varphi_i = 0)$

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0.0641	-1.077	15.692	0.3006	0.1383	0.0075	0.7566	0. 514

Source: search results

H_0 : q ≠> e :The causality relationship from real oil price to real exchange rate does not exist

H_0 : e ≠> q :The causality relationship from real exchange rate to real oil price does not exist

$F_1(\sigma^+ = \sigma^- = 0)$:F- statistic indicates a long- term causality test from real oil price to real exchange rate(F-statistic critical value at 5% level is equal to 2.249)

$F_1(\varphi_i = 0)$: F- statistic indicates a short- term causality test from real oil price to real exchange rate

$F_2(\sigma^+ = \sigma^- = 0)$: F- statistic indicates a long- term causality test from real exchange rate to real oil price

$F_2(\varphi_i = 0)$: F- statistic indicates a short- term causality test from real exchange rate to real oil price

6. Summary and conclusions

In this study, the relationship between real exchange rate and oil price was investigated by estimation of the M-TAR model. The estimated results show that there is a one-way relationship from oil price to real exchange rate in the long run.So the occurrence of Dutch disease is confirmed. It also shows that the exchange rate has faster reactions relative to negative shocks and deviations of oil price from equilibrium. In other words, this relationship is asymmetric which means that exchange rate has greater reactions relative to reduced shocks of oil revenues in the different times.

According to the estimated results which have been presented in this article, it was argued that Iran's economy has been grappling with the Dutch disease.Therefore,the negative effects of this phenomenon should be reduced by appropriate measures and policies(which is outside the presented subject and discussion in this article) and the people should be enjoyed welfare effects of oil.

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