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Can Oil Prices and GDP Be Cointegrated? An Asymmetric Cointegration Approach[1]

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Abstract: The goal of this study is to investigate the long-run relationship between oil prices and GDP in Iran, as an oil-exporting country. In order to distinguish the presence or lack of asymmetry between two variables, we designed a model using asymmetric cointegration methodology on quarterly data (1988 q2 -2007 q1). Based on the empirical results, in spite of the rejecting standard cointegration, the presence of asymmetric cointegration has been confirmed.

JEL classification: C22; E32; Q43

Key words: Oil prices · GDP · Asymmetric relationship · Cointegration

INTRODUCTION

The aim of this study is to investigate the effect of variations of the oil prices on GDP in Iran, as one of the major oil-exporting countries. There are some studies, which confirm the negative relation between oil prices and GDP [1, 2]. In the first half of 1980s, the significantly linear relation between oil prices and GDP is questionable. During this time, there is some evidence [3-5]; That GDP reacts to oil prices asymmetrically. In fact, the increase of oil prices has a greater effect on GDP than its decrease.

Lardic and Mignon, [6] investigated the existence of a long-term relationship between oil prices and GDP in 12 European countries. To account for the fact that economic activity responds asymmetrically to oil price shocks, they propose an approach based on asymmetric cointegration. their results show that, while standard cointegration is rejected, there is evidence for asymmetric cointegration between oil prices and GDP in the majority of the considered European countries. Moreover, in the recent study, Lardic and Mignon, [7] reported that asymmetric cointegration is not only present in the U.S., but also exists in the other considered countries, such as the G7, Europe and Euro area countries.

Following Enders and Dibooglu [8], Enders and Siklos [9] and Schorderet [10] among others, a model based on an asymmetric cointegration framework has been modified and applied. We distinguish positive and negative increments of time series allowing us to break down a series into its initial value and its negative and positive cumulative sums. Asymmetric cointegration comes from the analysis of multivariate combinations arising from this decomposition.

The paper is organized as follows. Section 2 recalls the main transmission channels through which oil prices may have an impact on GDP. Section 3 briefly presents the econometric framework of asymmetric cointegration. Section 4 is devoted to data and empirical analysis of the link between oil prices and GDP in the long-run in Iran. Section 5 presents some concluding remarks.

MATERIALS AND METHODS

Transmission Channels Between Oil Prices and GDP: Oil prices may affect GDP through different means. First, based on the concept of classic supply-side effect, an increase in oil prices leads to a decrease in the availability of the basic inputs, which causes a lowering of output

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[11-13]. Second, according to Dohner [14], an increase in oil prices challenges the trade situation of oil-importing countries because the wealth transition from the oil-importing countries to the oil-exporting countries causes a decrease in the purchasing power of people in the oil-importing countries. Third, an increase in oil prices leads to an increase in money supply (see Mork [15]), which causes the failure of monetary strategies as well as increasing the interest rate and finally decreasing economic growth [5]. Fourth, an increase in the oil price may have a negative effect on consumption, investment and stock prices, which are affected by consumption via its positive relation with disposable income and investment, by increasing firms' cost [7]. Fifth, if the increase in the oil price continues for a long time, it leads to change in the production structure for firms, which are dependent on oil. Finally, firms attempt to create production methods using less oil and this can also cause reallocation of the labor force and capital into different sectors and may have a long-term effect on employment [16]. These are all ways in which oil prices can affect GDP.

Previous studies have generally investigated the relation of the two variables in a linear cointegration framework [5], but current evidence of an asymmetric relation between oil prices and GDP indicates that the relation should be investigated outside the standard cointegration framework. Hence, this study begins with a brief presentation of the asymmetric cointegration framework method.

Asymmetric Cointegration Methodology[2]: Following Schorderet [10], the starting point consists in the decomposition of a time series X_t into its positive (X_t^+) and negative (X_t^-) partial sums:

$$X_t^- = \sum_{i=0}^{t-1} 1\{\Delta X_{t-i} < 0\}\Delta X_{t-i} \text{ And } X_t^+ = \sum_{i=0}^{t-1} 1\{\Delta X_{t-i} \geq 0\}\Delta X_{t-i} \quad (1)$$

If we consider two integrated time series X_{1t} and X_{2t} and define X_{jt}^+ and X_{jt}^- for j=1, 2, according to Eq. (1) and suppose that there exists a linear combination z_t between X_{jt}^+ and X_{jt}^- such that:

$$z_t = \beta_0 X_{1t}^+ + \beta_1 X_{1t}^- + \beta_2 X_{2t}^+ + \beta_3 X_{2t}^- \quad (2)$$

Then, as stated by Schorderet [10], X_{1t} and X_{2t} are asymmetrically (or directionally) cointegrated if there exists a vector $\beta' = (\beta_0, \beta_1, \beta_2, \beta_3)$ with $\beta_0 \neq \beta_1$ or $\beta_2 \neq \beta_3$ (and β_0 or $\beta_1 \neq 0$ and β_2 or $\beta_3 \neq 0$) such that z_t in Eq. (2) is a stationary process. The idea is that the relationship between the variables might not be the same when they increase as when they decrease. To simplify and without loss of generality, suppose that only one component of each series appears in the co-integrating relationship (2), that is:

$$z_{1t} = X_{1t}^+ - \beta^+ X_{2t}^+ \text{ Or } z_{2t} = X_{1t}^- - \beta^- X_{2t}^- \quad (3)$$

Due to the nonlinear properties of z_{jt}, j=1, 2, OLS on Eq. (3) are likely to be biased in a finite sample. For this reason, Schorderet [10], suggests estimating the auxiliary models by OLS:

$$\varepsilon_{1t} = X_{1t}^- + \Delta X_{1t}^+ - \beta^- X_{2t}^- \text{ Or } \varepsilon_{2t} = X_{1t}^+ + \Delta X_{1t}^- - \beta^+ X_{2t}^+ \quad (4)$$

As proved by West [17], since the regressor has a linear time trend in mean, the OLS estimate of Eq. (4) is asymptotically normal and the usual statistical inference can be made. In order to test the null hypothesis of no cointegration against the alternative of asymmetric cointegration, the traditional Engle and Granger procedure can be applied to Eq. (4).

RESULTS AND DISCUSSION

Data and Empirical Results: As mentioned above, the aim of this study is to investigate the relation between oil prices and GDP in Iran, as an oil-exporting country. The quarterly time series data (1988 Q2 -2007 Q1) of oil prices and GDP in real term have been used. The oil price series is the U.S. dollar per barrel market price of crude oil taken from the *OPEC Annual Statistical Bulletin* and real GDP data taken from the *Statistical Center of IRAN.*

Unit Root and Standard Cointegration Tests: The standard unit root tests applied for variables (in logarithm) and based on results in Table 1, both variables are I(1) at the 1% significance level. To distinguish a cointegration relation between the two variables, we applied a regression analysis of GDP on oil price and intercept. Next, unit root tests were also applied for the residuals. For this, we consider three tests of the null hypothesis of no cointegration: Augmented Dickey–Fuller (ADF) [18], Phillips– Perron (PP) [19], the Kwiatkowski *et al.* (KPSS) [20] and the trace statistic developed by Johansen [21] and Johansen and Juselius [22]. Results are shown in Table 2.

[2]The description here is based on Lardic and Mignon (2008)

Table 1: Unit root tests on individual series

	Series in logarithm		Series in first difference	
	ADF	PP	ADF	PP
LGDP	-3.919994 *	-3.662485 *	7.506064 **	-15.28034 **
LOP	-2.076072	-2.108946	-8.342516 **	-8.341767 **

Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests applied to individual series. Both ADF and PP contain the constant and trend term.
* (resp. **): Rejection of the null hypothesis at the 5% (resp. 1%) significance level

Table 2: Unit root tests on residual series

ADF	PP	KPSS	Johansen
-2.735915	-2.609838	0.668933	6.465255

Augmented Dickey–Fuller (ADF), Phillips–Perron (PP), Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and Johansen (trace statistic) tests. ADF, PP, KPSS and Johansen tests are based on the null hypothesis of no cointegration between oil prices and GDP. ADF and PP tests are containing constant and time trend term, while the KPSS has only constant term
* (resp. **): Rejection of the null hypothesis at the 5% (resp. 1%) significance level.

Table 3: Unit root tests on residual series: tests for asymmetric cointegration

Test on ε_{1t}		
ADF	PP	Johansen
-8.996424 **	-9.013698 **	52.95655*

Results of asymmetric cointegration tests applied to the residuals of Eq. (5). Three tests are applied: Augmented Dickey–Fuller (ADF), Phillips–Perron (PP) and Johansen (trace statistic) tests. ADF, PP and Johansen tests are based on the null hypothesis of no asymmetric cointegration between oil prices and GDP.
* (resp. **): Rejection of the null hypothesis at the 5% (resp. 1%) significance level.

According to ADF and PP tests residual series are nonstationary, meaning that oil prices and GDP series are not cointegrated. In addition, Results of the Johansen test indicate that the two considered series are not cointegrated.

Indeed, as previously mentioned, strong evidence exists in favor of an asymmetric relationship between oil prices and GDP series. To investigate this possibility, it is necessary to go further than the usual concept of cointegration in order to allow for asymmetric cointegration.

Tests for Asymmetric Cointegration Between Oil Prices and GDP Series: To present the relation of asymmetric cointegration between oil price and GDP two auxiliary models based an Eq. (4) are presented:

Table 4: Unit root tests on residual series: tests for asymmetric cointegration

Test on ε_{2t}		
ADF	PP	Johansen
-8.42784**	-8.430995**	35.06139*

Results of asymmetric cointegration tests applied to the residuals of Eq. (6). Three tests are applied: Augmented Dickey–Fuller (ADF), Phillips–Perron (PP) and Johansen (trace statistic) tests. ADF, PP and Johansen tests are based on the null hypothesis of no asymmetric cointegration between oil prices and GDP.
* (resp. **): Rejection of the null hypothesis at the 5% (resp. 1%) significance level.

Table 5: Long-run relationship

Relation (5)			
α^-	β^-	Adj. R^2	Std. error
0.041483	0.233035	0.921756	0.066448
(1.010974)	(13.26037)		

Adj. R^2 is the adjusted R-squared. Std. error is the S.E. of regression resulting from OLS estimation of the two equations. t-statistics have been corrected as in West (1988) and are displayed in parentheses

Table 6: Long-run relationship

Relation (6)			
α^+	β^+	Adj. R^2	Std. error
0.403219	0.264212	0.981480	0.044560
(6.607468)	(17.39469)		

Adj. R^2 is the adjusted R-squared. Std. error is the S.E. of regression resulting from OLS estimation of the two equations. t-statistics have been corrected as in West (1988) and are displayed in parentheses.

$$LGDP_t^- + \Delta LGDP_t^+ = \alpha^- + \beta^- LOP_t^- + \varepsilon_{1t} \tag{5}$$

$$LGDP_t^+ + \Delta LGDP_t^- = \alpha^+ + \beta^+ LOP_t^+ + \varepsilon_{2t} \tag{6}$$

As mentioned by Schorderet [10], standard unit root and cointegration tests can be applied to the residuals of these auxiliary models. Thus we test if the residuals ε_{1t} and ε_{2t} are stationary or not. To remove dependence in the residuals, we choose the suitable lags of dependent variables and residuals and truncation parameters (because the quarterly data the applied number of lags for ADF is 5 and the applied bandwidth parameter for PP is 3). Thus, the residuals of Eqs. (5) and (6) are not auto-correlated. Before interpreting the results, it should be noted that, since we work on residuals (i.e. on series that are estimated and not observed) we have to use other critical values than those tabulated when tests are applied on "true" series. Performing a Monte Carlo experiment, Schorderet [10] showed that critical values for the ADF test are essentially the same as those given by Fuller [23] when serial correlation has been correctly removed. Thus, for the PP test, we use the same critical values as for the ADF test.

The results are in Tables 3 and 4. The rejection of null hypothesis of no cointegration based on the all three tests in table 3 show that the price of oil and GDP to be asymmetrically cointegrated. In addition, the results of ADF, PP and Johansen tests for ε_{2t} confirm the presence of the long-term asymmetric relation between the oil prices and GDP as well.

The estimations of long-term relations along with amounts of *Adjusted R-squared* (Adj. R^2) and *Standard error of regression* (Std. error) have been indexed in Tables 5 and 6.

Based on the results obtained in model (5) the amount of α^- was not significant but the level of β^- is significant in the model while in model (6) the amount of both α^+ and β^+ are significant.

It must be noted that, the relations and results have been taken based on partial sums of variables, not the variables themselves and this problem causes a difficulty in correctly interpreting the levels of β^+ and β^- regarding the amount of *Adj.* R^2, model (6) has a better distributing effect because it has greater Adj. R^2.

It is important to note that the amounts of β^+ and β^- are significantly different from each other. This means that asymmetry exists between the variables and indeed, the fact that the amount of β^+ is greater than β^- means that the effects of an increase in oil price on GDP is more than the effect of a decrease in oil price. Thus, our results suggest that GDP reacts asymmetrically to changes in oil price. Despite the confirmation of the asymmetrical relation between GDP and oil price shocks, an important question remains as to the explanation for this.

Base on Brown and Yücel [5], classical supply-side effects are not able to explain the asymmetry. The probably explanations are: monetary policy, adjustment costs and/or the adverse effects of uncertainty on the investment environment [4]. According to monetary policy, if one supposes that the nominal prices are downward, then an increase in oil price would cause a decrease in GDP. At the same time, after the decrease in oil price, the real wage would be raised in order to clear the market. So based on the monetary policy explanation (e.g. Bernanke *et al.*, [24]), changes in oil price can have an asymmetric effect. According to the cost adjustment explanation [25], the costs induced by a change in oil price can retard economic activity. Such costs could arise from sectoral imbalances, coordination failures between firms [26], or because the energy-to-output ratio is embedded in the capital stock [27]. Thus, there exist various reasons for explaining the asymmetric cointegration relationship, which has been shown between oil prices and GDP.

CONCLUSIONS

This research investigates the long-run relation between oil price and GDP in the Iranian economy. Our empirical results, based on the linear cointegration framework, denied the existence of any direct relation between the two variables, however there was some evidence of the presence of asymmetry in the relation between the variables. Therefore, with taking the tests according to the asymmetric cointegration methodology, the asymmetric relation between the oil prices and GDP has been confirmed.

We found that an increase in oil price has a greater effect on GDP than its decrease. It is suggested that, developing oil-exporting countries follow the oil price fluctuations trend exactly, in order to decrease the negative effects of oil price fluctuations on their economies.

REFERENCES

1. Burbidge, J. And A. Harrison, 1984. Testing for the effects of oil price rises using vector autoregression. Intl. Econ. Rev., 25: 459-484.
2. Gisser, M. And T.H. Goodwin, 1986. Crude oil and the macroeconomy: tests of some popular notions. Journal of Money, Credit and Banking, 18: 95-103.
3. Olsen, O. And H. Mysen, 1994. Macroeconomic responses to oil price increases and decreases in seven OECD countries. Energy J., 15: 19-35.
4. Ferderer, J.P., 1996. Oil price volatility and the macroeconomy: a solution to the asymmetry puzzle. J. Macroecon., 18: 1-16.
5. Brown, S.P.A. and M.K. Yücel, 2002. Energy prices and aggregate economic activity: an interpretative survey. Quarterly Rev. Econ. Finance, 42: 193-208.
6. Lardic, S. And V. Mignon, 2006. The impact of oil prices on GDP in European countries: An empirical investigation based on asymmetric cointegration. Energy Policy, 34: 3910-3915.

7. Lardic, S. And V. Mignon, 2008. Oil prices and economic activity: An asymmetric cointegration approach. Energy Econ., 30: 847-855.
8. Enders, W. And D. Dibooglu, 2001. Long-run purchasing power parity with asymmetric adjustment. Southern Econ. J., 68(2): 433-445.
9. Enders, W. And P.L. Siklos, 2001. Cointegration and threshold adjustment. J. Business and Econ. Statistics, 19: 166-176.
10. Schorderet, Y., 2004. Asymmetric cointegration. Working Paper. Deptment of Econometrics, University of Geneva.
11. Brown, S.P.A. and M.K. Yücel, 1999. Oil prices and U.S. aggregate economic activity. Federal Reserve Bank of Dallas Econ. Rev., pp: 16-53.
12. Abel, A.B. and B.S. Bernanke, 2001. Macroeconomics. Addison Wesley Longman Inc.
13. Karimi Hosnije, H. And R. Jafari, 2008. Sustainable Development and Energy Demand of Iran Analysis Genetic Algorithm Approach. World Appl. Sci. J., 5(4): 472-478.
14. Dohner, R.S., 1981. Energy prices, economic activity and inflation: survey of issues and results. In: Mork, K.A. (Ed.), Energy Prices, Inflation and Economic Activity. Cambridge Mass., Ballinger.
15. Mork, K.A., 1994. Business cycles and the oil market. The Energy J., 15: 15-38.
16. Loungani, P., 1986. Oil price shocks and the dispersion hypothesis. Rev. Econ. Statistics, 58: 536-539.
17. West, K.D., 1988. Asymptotic normality when regressors have a unit root. Econometrica, 56: 1397-1417.
18. Dickey, D.A. and W.A. Fuller, 1979. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," Journal of the American Statistical Association, 74: 427-431.
19. Phillips, P.C.B. and P. Perron, 1988. "Testing for a Unit Root in Time Series Regression," Biometrika, 75: 335-346.
20. Kwiatkowski, D., P.C.B. Phillips, P. Schmidt and Y. Shin_i, 1992. "Testing the Null Hypothesis of Stationary against the Alternative of a Unit Root", J. Econ., 54: 59-178.
21. Johansen, S., 1988. "Statistical analysis of cointegration vectors", J. Econ. Dynamics and Control, 12: 231-254.
22. Johansen, S. and K. Juselius, 1990. "Maximum Likelihood Estimation and Inference on Cointegration--With Applications to the Demand for Money", Oxford Bulletin of Economics and Statistics, 52: 169-210.
23. Fuller, W.A., 1976. Introduction to Statistical Time Series. Wiley, New York.
24. Bernanke, B.S., M. Gertler and M. Watson, 1997. Systematic monetary policy and the effects of oil price shocks. Brookings Papers on Economic Activity, pp: 91-157.
25. Hamilton, J.D., 1988. A neoclassical model of unemployment and the business cycle. J. Political Econ., 96: 593-617.
26. Huntington, H.G., 2000. Oil Security as a Macroeconomic Externality. Stanford University.
27. Atkeson, A. And P.J. Kehoe, 1999. Models of energy use: putty–putty vs. putty–clay. American Econ. Rev., 89: 1028-1043.