2 Do Oil Prices Affect the USD/YTL Exchange Rate: Evidence from Turkey

RESEARCH PAPER

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Abstract

This study aims at investigating the link between international oil prices and the exchange rate in the case of a small open industrial economy without oil resources – Turkey. Johansen cointegration and Granger causality tests are used to analyze the relationship between oil prices and the exchange rate in the period 1982:12-2006:5. We find that international real crude oil prices Granger cause the USD/YTL real exchange rate.

Keywords: oil price, exchange rate, Granger causality, cointegration, Turkey
JEL classification: C2, Q43, F4

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1 Introduction[1]

Oil price shocks adversely affect small open economies that are oil-dependent through various transmission channels. In this paper, we investigate the link between oil prices and the exchange rate in the case of Turkey, which has a rather bitter experience of how surging energy prices can depress economic growth and lead to a balance-of-payments crisis.

In the attempt to explain how oil prices may influence the exchange rate in the long-run in the case of a small economy, Amano and van Norden (1998) consider a model with two sectors, one producing tradable goods, and the other producing non-tradable goods. Each sector uses a tradable input (oil) and a non-tradable input (labor) in the production process. Besides constant returns to scale technology, it is assumed that inputs are mobile between the sectors and that both sectors do not make economic profits. The output price of the tradable sector is set on the world markets, while the real exchange rate is determined by the output price in the non-tradable sector. Consequently, a rise in the oil price leads to a decrease in the labor price in order to meet the competitiveness requirement of the tradable sector. If the non-tradable sector is more energy-intensive than the tradable one, its output price rises and so does the real exchange rate. The opposite applies if the non-tradable sector is less energy-intensive than the tradable one.

Golub (1983) considers both small and large economies and focuses on the balance-of-payments issues and international portfolio choices. A rise in oil prices is viewed as a wealth transfer from oil-importing countries to oil-exporting ones. Consequently, its impact on exchange rates depends on the distribution of oil imports across oil-importing countries and on portfolio preferences of both oil-importing countries, whose wealth declines, and oil-exporting ones, whose wealth increases.

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Following the 1973-74 oil crisis, the relationship between oil prices and the exchange rates has received much attention in the literature (Atukeren, 2003). The impact of oil prices on exchange rate dynamics has been investigated, for example, by Golub (1983), McGuirk (1983), Krugman (1983a, 1983b), Hamilton (1983), Shazly (1989), Yoshikawa (1990), Rogoff (1991), Dotsey and Reid (1992), Throop (1993), Zhou (1995), Dibooglu (1996), De Grauwe (1996), Amano and van Norden (1998), Chaudhuri and Daniel (1998), Akram (2004), and Bénassy-Quérét et al. (2005). However, these studies have offered mixed support for the assumed covariance between oil prices and exchange rates.[2]

This paper aims at investigating the link between international oil prices and the exchange rate in the case of a small open industrial economy without oil resources - Turkey. To the best of our knowledge, there are no studies examining whether oil prices account for permanent movements in the USD/YTL exchange rate. Thus, this paper aims at contributing to the literature by filling this gap.

The rest of the paper is structured as follows. Section 2 describes data and methodology, Section 3 presents the empirical results, and Section 4 concludes.

2 Data and Methodology

The following empirical analysis uses monthly observations and covers the period 1982:12-2006:5. Data on crude oil prices (in USD per barrel) come from the International Energy Agency.[3] Average world crude oil prices are deflated by the U.S. consumer price index in order to be expressed in real terms. Data for the exchange rates come from the Central Bank of the Republic of Turkey.[4] End-of-the-period nominal exchange rates are converted into real exchange rates by consumer price indices. Real exchange rates are

[2] *An in-depth overview of the literature is beyond the scope of this paper. Interested readers may refer to Brown and Yücel (2002).*
[3] *http://www.iea.org*
[4] *http://www.tcmb.gov.tr*

constructed by defining relative prices as the ratio of the U.S. to Turkish consumer price indices. Exchange rate and oil price variables are expressed in logarithms (see Figure 1). Log values are used in unit root and cointegration tests. However, for the purpose of causality test, series are transformed into logarithmic returns in order to make the econometric testing procedures valid.

We use the Granger causality test to investigate the relationship between oil prices and the exchange rate. Granger's definition of causality is the most widely used concept of causality. According to Granger (1969), Y is said to "Granger-cause" X if and only if X is better predicted by using the past values of Y than by not doing so with the past values of X being used in either case. In short, if a scalar Y can help to forecast another scalar X, then we say that Y Granger-causes X. If Y causes X and X does not cause Y, it is said that unidirectional causality exists from Y to X. If Y does not cause X and X does not cause Y, then X and Y are statistically independent. If Y causes X and X causes Y, it is said that feedback exists between X and Y. Essentially, Granger's definition of causality is framed in terms of predictability. In other words, this technique helps to determine whether certain time series is useful in forecasting another one. While Granger (1969) originally suggested the test, it was later improved by Sargent (1976).

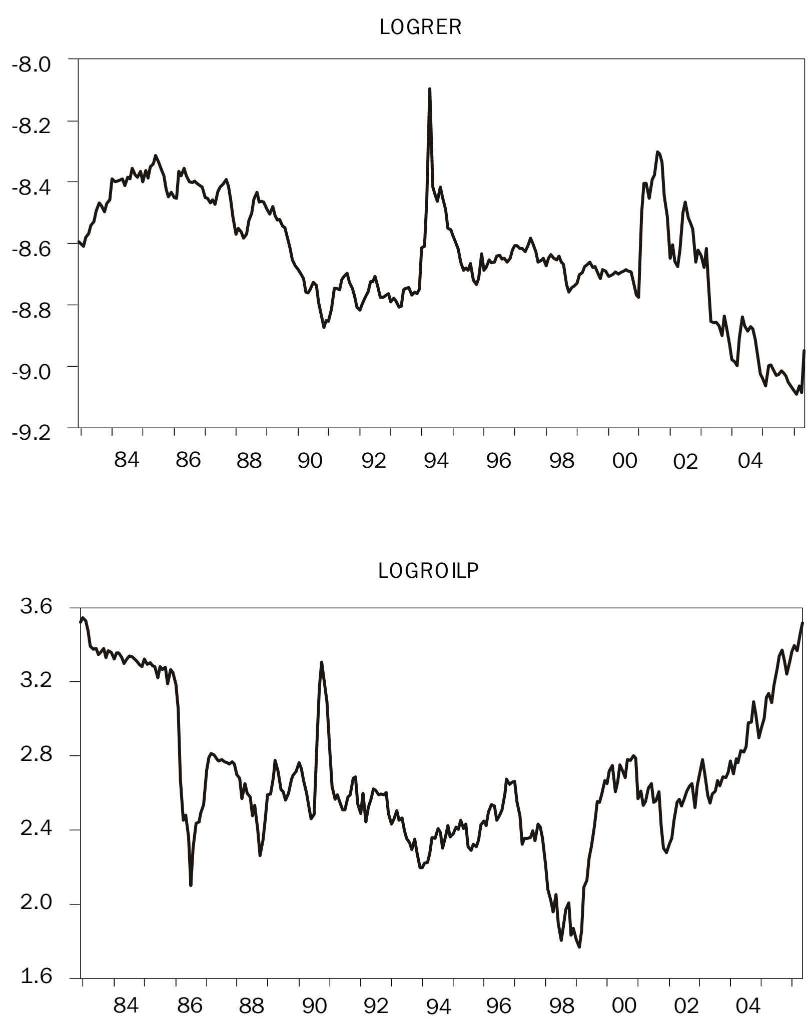
To implement the Granger test, we assume an autoregressive lag length of order *k* and *p*, and estimate Equations (1) and (2) by OLS:

$$X_t = \lambda_1 + \sum_{i=1}^{k} a_{1i} X_{t-i} + \sum_{j=1}^{k} b_{1j} Y_{t-j} + \mu_{1t} \quad (1)$$

$$Y_t = \lambda_2 + \sum_{i=1}^{p} a_{2i} X_{t-i} + \sum_{j=1}^{p} b_{2j} Y_{t-j} + \mu_{2t} \quad (2)$$

To test the null hypothesis that Y does not Granger cause X, i.e. $H_0 : \sum_{j=1}^{k} b_{1j} = 0$, the F-test (sometimes referred as the Wald test) is used.

Figure 1 **Real Exchange Rate and Real Oil Price: 1982:12-2006:5**



Note: The real exchange rate is defined as the nominal exchange rate adjusted for changes in relative prices in the home and foreign country. The oil prices variable is expressed in real terms, i.e. it is deflated by the U.S. consumer price index. All variables are expressed in logs.

If the F-statistic is above critical value for the F-distribution, then we reject the null hypothesis that Y does not Granger cause *X* (Equation 1), meaning that Y Granger causes X.

A time series with a stable mean value and standard deviation is called a stationary series. If a series has to be *d* times differenced to become stationary, then it can be defined as integrated of order *d*.[5] If several variables are I(d) series, their linear combination may be cointegrated, that is, their linear combination may be stationary. Although the variables may drift away from equilibrium for a while, economic forces are expected to restore equilibrium, thus, they tend to move together in the long-run irrespective of the short-run dynamics.

Granger causality definition is based on the hypothesis that X and Y are stationary, I(0). However, it has been widely recognized that many macroeconomic series appear to be I(1). Since the Granger causality technique cannot be applied to I(1) variables, in the next section we use the Augmented Dickey-Fuller (ADF) test to determine the order of integration of each series. Afterwards, we apply Johansen's method to test if a cointegrating relationship exists between the respective series.

3 Results

3.1 ADF Unit Root Tests

As mentioned above, the first step in performing the Granger causality test is to study the stationarity of the time series used in the analysis and to establish the order of their integration. The Augmented Dickey-Fuller (ADF) (1981) unit root test consists of running a regression of the following form (Enders, 1995):

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \qquad (3)$$

[5] *Granger (1981) introduced the concept of cointegration, while Engle and Granger (1987) have made further improvements.*

where $\gamma = -\left(1 - \sum_{i=1}^{p} a_i\right)$, $\beta_i = \sum_{j=i}^{p} a_j$, p indicates the lag length and t represents the time trend.

If the estimated coefficient γ is equal to zero, the equation is in first differences and contains a unit root. In the ADF test, the rejection of the null hypothesis implies stationarity. If the calculated ADF statistic is higher than McKinnon's critical value (1996), then the null hypothesis cannot be rejected and it may be concluded that the considered variable is non-stationary, i.e. it has at least one unit root. Consequently, the procedure needs to be repeated after transforming the series into first differences.

Table 1 **Augmented Dickey-Fuller Unit Root Test Results**

	Test with an intercept		Test with an intercept and trend		Test with no intercept or trend	
	ADF (Levels)	**ADF (1st differences)**	**ADF (Levels)**	**ADF (1st differences)**	**ADF (Levels)**	**ADF (1st differences)**
Exchange Rate	-0.1833	-16.3485	-1.9147	-16.3583	-0.2931	-16.2264
Oil Price	-1.7171	-12.5353	-2.2071	-12.6622	0.1743	-12.5489
CV* (1%)	-3.4535	-3.4535	-3.9911	-3.9911	-2.5732	-2.5732
CV* (5%)	-2.8716	-2.8716	-3.4259	-3.4259	-1.9419	-1.9419

*Notes: * MacKinnon (1996) one-sided p-values.*
The lag length was determined by Schwartz Information Criteria (SIC).

Table 1 summarizes the results of the ADF unit root tests for the exchange rate and oil prices in levels and first differences. The results suggest that all the respective series are I(1).

3.2 Cointegration Tests

Next, we use cointegration analysis to identify long-run relationships between two or more variables avoiding the risk of spurious regression. If two non-stationary variables are cointegrated, the VAR model in first differences is misspecified since it does not control for the short-run effects of a common trend. On the other hand, if cointegrating relationship is identified, the model should include residuals from the vectors (lagged one period) in the dynamic Vector Error Correcting Mechanism (VECM).

Here, we use the Johansen cointegration test to identify cointegrating relationship among the variables. Within the Johansen multivariate cointegrating framework, the following system is estimated:

$$\Delta X_t = \sum_{i=1}^{p-1} \pi_i \Delta X_{t-1} + \pi X_{t-p} + \varepsilon_t \tag{4}$$

where $\pi = -\left(1 - \sum_{i=1}^{p} A_i\right)$, $\pi_i = \left(1 - \sum_{j=1}^{i} A_j\right)$, X denotes a vector of variables and ε_t ~ niid $(0,\Sigma)$. Π is a $(p*p)$ matrix of the form $\Pi = \alpha\beta'$, where α and β are both $(p*r)$ matrices of full rank, with β containing the r cointegrating relationships and α carrying the corresponding adjustment coefficients in each of the r vectors. The Johansen approach can also be used to carry out Granger causality tests. In the Johansen framework, the first step is to estimate an unrestricted, closed p^{th} order VAR in k variables. Johansen (1995) suggests two test statistics to determine the cointegrating rank - trace statistics and maximum eigenvalue statistics. The trace statistics is defined as:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \ , \tag{5}$$

where T is the number of observations, $\hat{\lambda}_i$ are the estimated eigenvalues $\hat{\lambda}_1 > \hat{\lambda}_2 > \hat{\lambda}_3 > \ldots > \hat{\lambda}_n$ and r ranges from 0 to $n-1$ depending upon the stage in the sequence. This is the relevant test statistic for the null hypothesis that a number of cointegrating vectors is less than or equal to r against a general alternative. The maximum eigenvalue test, λ_{max} (r, r+1), is based on the null hypothesis that the number of cointegrating vectors is r against the alternative of r+1 vectors (Enders, 1995). The idea of λ_{max} test is to try to improve the power of the λ_{trace} test by limiting the number of cointegrating vectors in the alternative hypothesis.

The λ_{max} test statistics is:

$$\lambda_{\max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1}) \tag{6}$$

Johansen and Juselius (1990) indicated that the λ_{trace} test might lack the power relative to the maximum eigenvalue test. Based on the power of the test, the λ_{max} test statistic is often preferred. Table 2 presents the results of the Johansen cointegration test among the data sets. Neither λ_{max} nor λ_{trace} tests rejects the null hypothesis of no cointegration at the 5 percent level as the calculated λ_{trace} and λ_{max} statistics are smaller than the critical values.

Table 2 **Johansen Cointegration Test Results**

Trace test					**Maximum eigenvalue test**				
Null	**Alternative**	**Eigenvalue**	**Statistic**	**95 % C.V.**	**Null**	**Alternative**	**Eigenvalue**	**Statistic**	**95 % C.V.**
r = 0	r ≥ 1	0.0301	8.5251	15.4947	r = 0	r = 1	0.0301	8.4603	14.2646
r ≤ 1	r ≥ 2	0.0002	0.0648	3.8415	r ≤ 1	r = 2	0.0002	0.0648	3.8414

Notes: r is the number of cointegrating vectors under the null hypothesis.
A linear deterministic trend is assumed. It was included in the VAR but was not restricted.
Appropriate lag lengths are determined using standard likelihood ratio tests with a finite-sample correction.

3.3 Granger-Causality Tests

The classical approach to deal with the integrated variables is to difference them to make them stationary. Therefore, first differences of the log level of exchange rate and oil price series are taken and transformed into logarithmic returns in order to achieve mean-reverting property, and to make econometric testing procedures valid. Hassapis et al. (1999) show that in the absence of cointegration, the direction of causality can be decided via standard F-tests calculated on the basis of the VAR in first differences. The VAR in first differences can be written as:

$$\Delta X_t = \lambda_1 + \sum_{i=1}^{k} a_{1i} \Delta X_{t-i} + \sum_{j=1}^{k} b_{1j} \Delta Y_{t-j} + \mu_{1t} \tag{7}$$

$$\Delta Y_t = \lambda_2 + \sum_{i=1}^{p} a_{2i} \Delta X_{t-i} + \sum_{j=1}^{p} b_{2j} \Delta Y_{t-j} + \mu_{2t} \tag{8}$$

Since, λ_{max} nor λ_{trace} tests do not reject the null hypothesis of no cointegration at the 5 percent level, the aforementioned VAR method can be used. Table 3 provides Chi-square statistics and probability values of pairwise Granger causality/block exogeneity Wald test results between the endogenous variables.

Table 3 **VAR Granger Causality/Block Exogeneity Wald Tests**

Null Hypothesis	**Observations**	χ^2 **– statistic**	**Probability**	**df**
Exchange rate does not Granger cause oil price	279	0.853	0.652	2
Oil price does not Granger cause exchange rate	279	8.324	0.015	2

The results of Granger causality/block exogeneity Wald test show that the null hypothesis implying that logarithmic returns of the exchange rate do not Granger cause logarithmic returns of oil price is not rejected at the 5 percent and 1 percent significance level. As Table 3 indicates, the null hypothesis that the logarithmic returns of oil price does not Granger cause logarithmic returns of the exchange rate is rejected at the 5 percent level of significance, implying that there is a one-way causality going from oil prices to the exchange rate.

4 Conclusion

This study has investigated the relationship between oil prices and the exchange rate by using the Johansen cointegration and Granger causality tests in case of a small open industrial economy without oil resources. For the case of Turkey, we find that crude oil prices have Granger caused the USD/YTL exchange rate over the period 1982:12-2006:5.

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