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# Oil Prices and Real Exchange Rates in Oil-Exporting Countries: A Bounds Testing Approach

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December 2008

**Abstract:** We test the validity of the Dutch disease hypothesis by examining the relationship between real oil prices and real exchange rates in a sample of fourteen oil exporting countries. Autoregressive distributed lag (ARDL) bounds tests of cointegration support the existence of a stable relationship between real exchange rates and real oil prices in all countries, suggesting a strong support for the Dutch disease hypothesis.

**Key Words:** Oil Prices, Real Exchange Rates, Dutch Disease, Cointegration, Autoregressive Distributed Lags.

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

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## 1. Introduction:

The sharp increase in oil prices over the past decade has renewed interest in the “Dutch disease” hypothesis. According to the hypothesis, the inflow of oil windfalls into an oil exporting country may cause appreciation of the real exchange rate, reduce its competitiveness in the non-oil exporting sector, and limit its ability to build a diversified exports base. The culprit for the disease is the “spending effect”. More specifically, higher oil income may increase the demand for non-traded goods, and increase their prices relative to those of traded goods. This appreciation of the real exchange rate will reallocate resources from the non-oil traded sector into the non-traded sector, contracting the former to the extent that it is exposed to international competition. Early literature on the subject includes Dornbusch (1973), Gregory (1976), Forsyth and Kay (1980), Corden (1984), Corden and Neary (1982), Buiters and Purvis (1982), Bruno and Sachs (1982), Eastwood and Venables (1982), Enders and Herberg (1983), Edwards and Aoki (1983),

Edwards (1986), van Wijnbergen (1984). More recent studies include Gylfason (2001), Torvik (2001), and Stevens (2003).<sup>1</sup>

Despite a great deal of theoretical work on mechanisms of Dutch disease, formal empirical work on the subject has received limited attention. Examples include Edwards (1984, 1985), Taylor, Yarakoglu, and Chaudhry (1986), Warr (1986), Fardmanesh (1991), Brunstad and Dyrstad (1997), Bjorland (1998), Hutchinson (1994), and Jahan-Parvar and Mohammadi (2008). As it appears, available evidence on the Dutch disease hypothesis is mixed.

This paper provides a formal test of the Dutch disease hypothesis by examining the possibility of a long-run relationship between real oil prices and real exchange rates in monthly data for a sample of fourteen oil exporting countries. Our empirical results using the “autoregressive distributed lag” (ARDL) model of Pesaran, et al. (2001) reveal the existence of stable long-run relationship between real oil prices and real exchange rates across all fourteen countries. Furthermore, analysis of the short-run dynamics reveals the existence of unidirectional causality from oil prices to exchange rates in four countries, from exchange rates to oil prices in two countries, bidirectional causality in four other countries, and no causality in the remaining four countries.

The remainder of the paper is organized as follow: Section two outlines the empirical model and tests of hypothesis. Section three explains the data and provides the empirical findings. Section four concludes.

## **2. The Model:**

The Dutch disease hypothesis suggests a positive relationship between real exchange rates and real oil prices. A log-linear form of the relationship can be written as,

$$\log e_t = \alpha_0 + \alpha_1 \log q_t + u_t. \quad (1)$$

Where  $e_t$  is the real exchange rate, representing the relative price of non-traded goods;

$q_t$  is the real price of oil; and  $u_t$  is the error term. We measure the real exchange rate as

$e_t = \frac{E_t P_t}{P_t^*}$ , where  $E_t$  is the U.S. dollar price of a unit of domestic currency in an oil-

exporting country;  $P_t$  and  $P_t^*$  are domestic and U.S. price levels respectively. An increase

in  $e_t$  reflects an appreciation of the real exchange rate in the oil-exporting country, and

implies a loss of export competitiveness. The real price of oil,  $q_t$ , is the nominal dollar

price of oil deflated by the U.S. price level.

Support for the Dutch disease hypothesis requires a positive and stable relationship between real oil prices and real exchange rates. Thus cointegration provides an appropriate framework to examine this issue. Following Engle and Granger (1987),  $\log e_t$  and  $\log q_t$  are cointegrated if (a) both variables are non-stationary in level but their linear combination,  $u_t$  in Equation (1), is stationary; or (b) as the two variables move towards the long-run equilibrium, the equilibrium error is corrected. This idea is captured by the error-correction model (ECM),

$$\Delta \log e_t = \beta_0 + \sum_{i=1}^m \beta_i \Delta \log e_{t-i} + \sum_{i=1}^n \gamma_i \Delta \log q_{t-i} + \lambda u_{t-1} + v_t \quad (2)$$

where  $u_{t-1}$  is the lagged equilibrium error, and  $\lambda$  is the speed of adjustment towards

equilibrium. A negative and significant  $\lambda$  is consistent with cointegration between

$\log e_t$  and  $\log q_t$ .

A potential weakness of the Engle and Granger (1987) technique is the requirement that the underlying time series have a unit root. However, as is well known, standard unit root tests have low power. Also as Perron (1997) has shown, tests are sensitive to the existence of structural breaks in the process. As an alternative, Pesaran et al. (2001) have proposed an auto regressive distributed lag (ARDL) bounds testing procedure which allows for  $I(0)$ ,  $I(1)$ , or mutually cointegrated variables.<sup>2</sup> Application of this procedure follows two steps. The first step involves a re-specification of the error-correction model, Equation (2), by substituting  $u_{t-1}$  with a linear combination of  $\log e_{t-1}$  and  $\log q_{t-1}$ , as in Equation (3),

$$\Delta \log e_t = \beta_0 + \sum_{i=1}^m \beta_i \Delta \log e_{t-i} + \sum_{i=1}^n \gamma_i \Delta \log q_{t-i} + \lambda_1 \log e_{t-1} + \lambda_2 \log q_{t-1} + v_t \quad (3)$$

The null hypothesis of no cointegration is examined by testing for the joint significance of  $\lambda_1$  and  $\lambda_2$  using a non-standard  $F$  test. Pesaran et. al. (2001) have computed the upper- and lower-bound critical values for the test when all variables are purely  $I(1)$  or  $I(0)$ . For cointegration, the calculated  $F$  statistic should be greater than its corresponding upper bound critical value.

Equation (3) captures both the short-run and the long-run relations between the real exchange rate and real oil prices. Short-run effects are captured by the size

of  $\hat{\gamma}_i (i = 1, \dots, m)$ . The long-run effect is estimated by the  $-\frac{\hat{\lambda}_2}{\hat{\lambda}_1}$  ratio, which is obtained by

setting  $\hat{\lambda}_1 \log e_{t-1} + \hat{\lambda}_2 \log q_{t-1}$  to zero and solving for  $\log e_{t-1}$  as,

$$\log e_{t-1} = -\frac{\hat{\lambda}_2}{\hat{\lambda}_1} \log q_{t-1} \quad (4)$$

Support for the Dutch disease hypothesis requires  $-\frac{\hat{\lambda}_2}{\hat{\lambda}_1}$  to be positive and significant.

The second step is the estimation of the long-run parameters and the short-run dynamics in Equation (3) using the ARDL methodology. That involves a parsimonious specification of the conditional error-correction model through the construction of the error-correction term,  $EC_{t-1}$ ,

$$EC_{t-1} = \log e_{t-1} + \frac{\hat{\lambda}_2}{\hat{\lambda}_1} \log q_{t-1}, \quad (5)$$

and its substitution in Equation (3),

$$\Delta \log e_t = \beta_0 + \sum_{i=1}^m \beta_i \Delta \log e_{t-i} + \sum_{i=1}^n \gamma_i \Delta \log q_{t-i} + \delta EC_{t-1} + v_t. \quad (6)$$

The parameter  $\delta$  provides three types of information on the relationship between  $\log e_t$  and  $\log q_t$ . First, as in Engle and Granger (1987), a negative and significant value for  $\delta$  implies a long-run relationship between  $\log e_t$  and  $\log q_t$ , and provides an alternative test of cointegration between the two variables. Second, a significant value for  $\delta$  implies the existence of long-run causal relation from  $\log q_t$  to  $\log e_t$ . Finally, the size of  $\delta$  provides information on the speed of adjustment to equilibrium errors as the system moves towards its equilibrium.

### 3. Results

Monthly data on nominal exchange rates and CPI indices for fourteen oil exporting countries and the U.S., as well as nominal spot oil prices are collected from the International Financial Statistics of the IMF. We measure world prices by the CPI in the U.S., and nominal oil prices by West Texas Intermediate (henceforth WTI).<sup>3</sup> Real

exchange rates and real oil prices are constructed from this data. As reported in column two of Table (1), sample periods differ across the fourteen countries due to data availability, ranging from the high of 1970 - 2007 for eight countries, and low of 1995 - 2007 for Angola.

To gain a better understanding of the time-series properties of the variables, we begin with augmented Dickey and Fuller (1979) and Perron (1997) unit root tests.<sup>4</sup> The ADF tests broadly fail to reject the null hypothesis of a unit root in levels but reject the hypothesis with first-differenced data. The only possible exceptions are Saudi Arabia and Indonesia. However, allowing for an endogenous break delivers a different outlook. Now the null hypothesis of a unit root in levels is rejected in five countries (Angola, Bahrain, Bolivia, Kuwait and Russia), and fails to be rejected with first-differenced data in two countries (Bahrain and Colombia). These results provide additional justifications for our choice of the ARDL methodology, which can be applied irrespective of whether the variables are  $I(0)$  or  $I(1)$ .

As Pesaran et. al. (2001) has pointed out, estimation of the error-correction models (3) and (6) and tests of cointegration are sensitive to the choice of lag lengths  $m$  and  $n$ . We circumvent this problem by setting the maximum lag lengths at 12 and choosing the optimum lag using the Akaike Information Criterion (AIC).  $F$  tests on the existence of cointegration as well as tests of long-run and short-run causality are obtained under the selected optimum lag lengths.

The results of these tests along with long-run parameter estimates are reported in Table (1). Four interesting patterns emerge. First, as reported in column three, there are substantial variations in the order of the *ARDL* model across countries, reflecting a rather

complicated dynamics between the real exchange rate and real oil prices in each country. Second, the calculated  $F$  statistics reported in column four exceed their 5% upper bound critical value of 4.85 for Angola, Mexico, Russia, and Saudi Arabia, suggesting a stable long-run relationship between exchange rates and oil prices in these four countries. Third, the estimates of  $\delta$ , the coefficient of the lagged equilibrium error,  $EC_{t-1}$ , are negative and significant at the 5% level across all countries. This finding has three important implications: (1) It provides a broader support for the existence of a long-run relationship between oil prices and exchange rates, and the Dutch disease hypothesis. (2) It suggests the existence of long-run causality from oil prices to exchange rates. And (3) it predicts moderate- to- low speeds of adjustment towards equilibrium, ranging from the high of 0.296 for Bolivia and low of 0.012 for Colombia. Finally, estimates of  $\alpha_1$ , the normalized long-run coefficient on real oil prices, are positive in eleven of the fourteen countries, and significant in five countries of Angola, Bahrain, Indonesia, Nigeria and Russia.

We also examined the possibility of short-run causality between oil prices and exchange rates by estimating alternative conditional error-correction models (equation 6) with  $\Delta \log e_t$  and  $\Delta \log q_t$  as dependent variables, respectively. The resulting  $\chi^2$  test statistics are reported in Table (2). There is evidence of unidirectional causality from oil prices to exchange rates in four countries of Angola, Colombia, Norway, and Venezuela, from exchange rates to oil prices in two countries of Bolivia and Russia, and bidirectional causality in four countries of Gabon, Indonesia, Nigeria and Saudi Arabia. There is no evidence of short-run causality in the remaining four countries of Algeria, Bahrain, Kuwait and Mexico.

#### 4. Conclusions

Application of the ARDL testing methodology to monthly data from fourteen oil exporting countries reveals the existence of stable long-run relations between real oil prices and real exchange rates in all countries, supporting the Dutch Disease hypothesis. However, real exchange rates appear to adjust to equilibrium errors at moderate to slow rates. One implication of our findings is that the probability of Dutch disease problem has not diminished over time and especially monetary authorities in developing oil exporting countries should be vigilant to counter the negative impact of oil windfalls.

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**Table 1. Tests of Cointegration, and Long-Run Parameter Estimates (Model includes a trend.)**

Country	Period	ARDL( $m, n$ )	$F$ Statistic	$\delta$	$\log e_t = \alpha_0 + \alpha_1 \log q_t + u_t$	
					$\alpha_0$	$\alpha_1$
Algeria	1974:01 - 2007:09	ARDL(2, 0)	2.599	-0.022 (0.009)*	-2.579 (0.260)*	0.324 (0.237)
Angola	1995:11 - 2007:09	ARDL(11, 8)	5.401*	-0.101 (0.044)*	0.993 (1.904)	1.813 (0.958)*
Bahrain	1975:07 - 2001:09	ARDL(11, 1)	1.866	-0.040 (-0.010)*	0.267 (0.049)*	0.211 (0.335)*
Bolivia	1983:11 - 2007:09	ARDL(1, 0)	1.801	-0.296 (0.065)*	-1.119 (0.374)*	0.314 (0.335)
Colombia	1970:01 - 2007:09	ARDL(12, 5)	2.049	-0.012 (0.006)*	-7.008 (0.257)*	0.178 (0.173)
Gabon	1970:01 - 2007:03	ARDL(1, 2)	0.801	-0.029 (0.010)*	-5.187 (0.245)*	0.178 (0.168)
Indonesia	1970:01 - 2007:08	ARDL(10, 0)	0.661	-0.063 (0.017)*	7.175 (0.153)*	0.355 (0.103)*
Kuwait	1973:01 - 2007:06	ARDL(1, 0)	3.244	-0.016 (0.008)*	-1.200 (0.216)*	-0.120 (0.151)
Mexico	1970:01 - 2007:09	ARDL(11, 0)	6.453*	-0.048 (0.016)*	-2.399 (0.168)*	-0.004 (0.115)
Nigeria	1970:01 - 2007:09	ARDL(4, 8)	2.146	-0.027 (0.009)*	-2.019 (0.536)*	0.884 (0.369)*
Norway	1970:01 - 2007:09	ARDL(1, 4)	3.862	-0.207 (0.010)*	-2.016 (0.172)*	-0.099 (0.127)
Russia	1992:09 - 2007:09	ARDL(10, 0)	7.702*	-0.055 (0.012)*	-0.826 (0.728)	1.115 (0.335)*
Saudi Arabia	1980:02 - 2007:09	ARDL(2, 5)	5.039*	-0.017 (0.007)*	-0.975 (0.149)*	0.052 (0.947)
Venezuela	1970:01 - 2007:09	ARDL(4, 11)	1.894	-0.036 (0.016)*	-6.418 (0.326)*	0.145 (0.218)

**Notes:**  $ARDL(m,n)$  is the autoregressive distributed lag model with orders  $m$  and  $n$ .  $F$ -statistic tests the null hypothesis of no cointegration. The 5% (10%) upper and lower bounds critical values for this test are 4.85 (4.14) and 3.79 (3.17) respectively (Pesaran et. al. 2001). Parameter  $\delta$  reports the estimated coefficient of the error-correction term along with its standard error (in parentheses) from equation (6) under the optimum lag length. The last two columns report the estimated long-run parameters. Significance at 5% and 10% levels are represented by \* and \*\* respectively.

**Table 2. Tests of Short-Run Causality**

Country	$\chi_n^2$ Test Statistics	
	$\Delta \log q \Rightarrow \Delta \log e$	$\Delta \log q \Leftarrow \Delta \log e$
Algeria	2.17 (0.14)[1]	0.01 (0.92) [1]
Angola	33.06 (0.00)[9]*	2.49 (0.12) [1]
Bahrain	1.59 (0.21)[1]	2.30 (0.33) [1]
Bolivia	0.08 (0.78)[1]	42.53 (0.00)[11]*
Colombia	12.49 (0.03)[6]*	5.73 (0.13)[3]
Gabon	4.89 (0.09)[2]**	12.89 (0.05)[5]*
Indonesia	5.98(0.01)[1]*	6.01 (0.01)[1]*
Kuwait	0.64 (0.42)[1]	6.53 (0.84)[11]
Mexico	0.01 (0.97)[1]	1.89 (0.17)[1]
Nigeria	18.83 (0.02)[8]*	9.55 (0.05)[4]*
Norway	14.88 (0.01)[4]*	2.44 (0.79)[5]
Russia	0.04 (0.84)[1]	10.82 (0.06)[6]**
Saudi Arabia	16.49 (0.00)[2]**	19.68 (0.00)[4]*
Venezuela	24.46 (0.01)[11]*	4.32 (0.12) [2]

**Notes:**  $\chi_n^2$  test statistics test the null hypothesis that past changes in real oil prices do not Granger cause real exchange rates.  $\chi_m^2$  test statistics test the null hypothesis that past changes in real exchange rates do not Granger cause real oil prices. Parameters  $m$  and  $n$  represent degrees of freedom. Conventional 5 and 10 percent significance levels are represented by \* and \*\*, respectively.

## Notes

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<sup>1</sup> A related literature exists on “curse of natural resources” (see Sachs and Warner, 2001). This literature is based on the observation that resource-rich developing countries have underperformed their resource-poor counterparts at least since 1970s. One empirical observation is that resource-rich developing countries tend to be relatively high-price economies. This observation is suggestive of presence of Dutch disease type effects.

<sup>2</sup> A recent application of ARDL methodology is Bahmani-Oskooee and Tankui (2008).

<sup>3</sup> As a check on robustness, we also experimented with two alternative oil prices, the North Sea Brent and the Dubai Fateh spot prices. The results are robust to this choice.

<sup>4</sup> The results are available from the authors upon request.