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Dynamics between Oil Prices and UAE Effective Exchange Rates: An Empirical Examination

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Abstract: Utilizing monthly data for 1994-2017, we investigate the dynamic relationship between real oil prices and the real broad effective exchange rate of the United Arab Emirates (UAE). Our findings indicate that this relationship experienced a structural change around 2008. That is, for both 1994-2008 and 2008-2017, the series each has a unit root, but they possess a long-run equilibrium relationship only for the latter period with the real effective exchange rate asymmetrically responding to eliminate disequilibrium; i.e., the response is relatively small when disequilibrium is negative and relatively large when disequilibrium is positive. Further evidence indicates that oil prices have directional predictive power for the real exchange rate for the period after but not before the 2008 financial crisis. Accurate directional predictions for 2008-2017 imply symmetric loss, meaning that they are of value to a user who assigns the same loss (cost) to upward and downward moves in the real effective exchange rate. These findings are important to both UAE policymakers in promoting trade and attracting foreign investment and to foreign entities which consider the UAE an attractive environment for investing in various sectors.

Keywords: Foreign exchange; Oil prices; Cointegration; Asymmetric adjustment; Directional accuracy

JEL Classifications: F31, G15, Q43

1. Introduction

Following the seminal work of Hamilton (1983), numerous studies have investigated the impact of oil price fluctuations on macroeconomic and financial indicators (see Oladosu, *et al.* 2018 and the references therein). One strand of research focuses on the relationship between real oil prices and real exchange rates, which is the focus of this study in the case of the United Arab Emirates (UAE). In recent years, the UAE has experienced remarkable economic growth with a high level of financial development which has resulted in a tremendous transformation from an underdeveloped to a modern country with high GDP per capita. The UAE is a major oil exporting country with a free-market economy that promotes both greater private-sector activities and free international trade and capital movements. However, it faces a significant long-term challenge for its dependence on oil revenue. Economic diversification plans to reduce this dependence focus on positioning the country as a global trade and tourism hub.[1] Factors contributing to the recent success of such plans include, among others, the distinct geographical location which has facilitated the re-export process and made the UAE a transit route for many goods. In addition, free trade zones (established throughout the country) offer full foreign ownership with zero taxes and, as such, have attracted foreign direct investment (FDI) as many foreign companies have chosen the UAE as a regional base.

As an important feature, the UAE dirham is pegged to the US dollar at a fixed rate. However, as we shall see, the UAE real broad effective exchange rate displays considerable fluctuation over time. The real exchange rate is an important indicator of a country's trade competitiveness in the world economy, and its movements influence trade, foreign investment, and capital flows which, in turn, are the key drivers of a country's economic growth and employment (Goldberg and Klein, 1997; Al-Abri and Baghestani, 2015; Guzman, *et al.* 2018). Given the importance of trade and foreign investment for UAE economic growth and the dependence of the UAE economy on oil revenue, we set out to explore the dynamic relationship between the UAE real effective exchange rate and oil prices. This is an important topic, which, to the best of our knowledge, has received limited attention. Al-mulali and Che Sab (2011), for instance, focus on the real exchange rate of the UAE dirham to the US dollar using annual data from 1977 to 2007. They find a long-run relationship between the (bilateral) real exchange rate and oil prices, with oil prices Granger causing the real exchange rate both in the short- and long-run. Amin and El-Sakka (2016) focus on GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE). Using panel analysis with annual data from 1980 to 2012, they find a long-run relationship between oil prices, real GDP per capita, and real exchange rates, with short-run causality running from oil prices to real exchange rates.

Utilizing monthly data for 1994-2017, our study reveals that the relationship between the UAE real effective exchange rate and real oil prices experienced a structural change around 2008. That is, for both 1994-2008 and 2008-2017, the two series each has a unit root, but they possess a long-run equilibrium relationship only for the latter period with the real effective exchange rate asymmetrically responding to eliminate disequilibrium (i.e., the response is relatively small when disequilibrium is negative and relatively large when disequilibrium is positive). Additional findings indicate that oil prices have directional predictive power for the UAE real exchange rate for the period after (but not before) the 2008 global financial crisis, pointing again to a structural change around 2008. We proceed by reviewing the related literature in Section 2. Section 3 discusses the data. Section 4 presents the methodology and empirical results, and section 5 concludes.

2. Literature Review

The literature cites various factors influencing a country's real exchange rate. The "Balassa-Samuelson" effect describes the mechanism through which changes in the relative price of tradable and non-tradable goods result in fluctuations in real exchange rates across countries. In particular, technological advances (and thus higher productivity) in producing tradable goods result in lower prices of such goods everywhere through international competition. As opposed to tradable, non-tradable goods face little international price competition. Thus, for a country whose consumption

[1] Grigoli, *et al.* (2018) investigate the effect of the 2014-2016 oil price decline on the major macro-economic indicators of oil-exporting countries, including the UAE. They find those countries with more diversified export bases were able to weather the adverse impact of falling oil prices better.

basket contains a larger (smaller) share of non-tradable goods, the fall in prices of tradable goods relative to prices of non-tradable goods translates into a rise (fall) in the country's consumer price index relative to that of the world economy, and hence the country's real effective exchange rate tends to appreciate (depreciate).

Other factors responsible for real exchange rate fluctuations include differences in fiscal policies and tariffs across countries in addition to ongoing changes in both the balance of payments and terms of trade. Early studies including Golub (1983) and Krugman (1983a; 1983b) focus on the reallocation of wealth among oil exporters and importers when oil prices change. For instance, due to rising oil prices, oil exporters (oil importers) experience a balance of payment surplus (deficit) and thus real currency appreciation (depreciation). Focusing on the terms of trade channel, Chen and Chen (2007) present a simple theoretical model with two sectors for tradable and non-tradable goods in order to explain why and how oil prices influence the terms of trade and thus real exchange rates.

Empirical evidence suggests that the real oil price is integrated or non-stationary, meaning that it can wander aimlessly following a major shock. The same can be true for the real exchange rate. With the two series integrated, one can conclude that the real oil price is the dominant factor in influencing real exchange rates, if the two series happen to possess a stable long-run equilibrium relationship with the real exchange rate responding to eliminate disequilibrium in the short-run.[2] These are, in fact, the findings of Chen and Chen (2007), supporting their claim that the real oil price is the dominate factor influencing real exchange rates of the G7 countries. They further show that oil prices contain useful predictive information for these real exchange rates.

Amano and van Norden (1998a; 1998b) investigate the relationship between real oil prices and real exchange rates of Germany, Japan, and the US; and Bénassy-Quéré, *et al.* (2007) examine the relationship between real oil prices and real price of the US dollar. The findings of these studies again reveal that real oil prices and real exchange rates are cointegrated and thus possess a long-run relationship. Chen, *et al.* (2013) report similar findings for the Philippines, with the real exchange rate asymmetrically responding to eliminate short-run deviations from the long-run equilibrium relationship. Ahmad and Hernandez (2013) also find cointegration with asymmetric adjustment for three countries (Brazil, Nigeria, and the UK) and for the Eurozone. In a more recent study, McLeod and Haughton (2018) show that real oil prices and the US real effective exchange rate are cointegrated with significant asymmetric adjustments. In particular, their results indicate that the US real exchange rate is weakly exogenous and, thus, it is the real oil price that asymmetrically adjusts to eliminate disequilibrium. However, the adjustment is slower (faster) when a downward (upward) oil price movement is necessary to restore equilibrium.

Numerous other studies investigate the relationship between *nominal* oil prices and *nominal* exchange rates. Reboredo (2012) examines the co-movement between oil prices and exchange rates of the oil-exporting countries for the periods before and after the 2008 global financial crisis. His analysis reveals a much tighter relationship between the two series for the latter period. Tiwari and Albulescu (2016) focus on the relationship between monthly oil prices and the India-US exchange rate for 1980-2016 using a continuous wavelet approach. Their results reveal Granger-causality from the exchange rate to oil prices in the long run and from oil prices to the exchange rate in the short run. Ghosh (2011) investigates the impact of oil price shocks on the India-US exchange rate in

[2] The converse, however, is not necessarily true. That is, even if the two series are not cointegrated, real oil prices can still be a dominant factor influencing real exchange rates through other types of dynamics. See, among others, Basher, *et al*. (2012) and Atems, *et al.* (2015).

a period of extreme oil price volatility (July 2007 – December 2008). He concludes that positive and negative oil price shocks have similar effects (in terms of magnitude) on exchange rate volatility. Huang, *et al.* (2017b) examine the relationship between the effective exchange rate, oil prices, and the stock markets of both China and Russia for the period from January 2000 to October 2015. They show that the combined influence of oil price and exchange rate is larger (smaller) on the Russian (Chinese) stock market. In a similar study, Narayan and Narayan (2010) examine the relationship between the exchange rate, oil prices, and the stock markets of Vietnam for 2000–2008. Using daily data, they show that the three series are cointegrated, with oil prices positively affecting stock prices. Huang, *et al.* (2017a) combine the wavelet and VAR modeling approaches to examine the relationship between oil prices and Chinese stock markets in multiple time horizons, with both the exchange rate and interest rate included in the model. Their results indicate that oil price changes have a greater effect on the stock market than on the exchange rate. In investigating the effects of oil price shocks on China's economy, Ju, *et al.* (2014) further show that oil price shocks negatively (positively) affect China's GDP and exchange rate (consumer price index).

Put together, our literature review separates the studies which focus on the relationship between nominal oil prices, stock markets, and nominal exchange rates, and the studies which explore the relationship between real oil prices and real exchange rates. The former studies employ a variety of econometric modeling approaches. However, the latter studies largely utilize cointegration and error-correction modeling, which we adopt to investigate the dynamic relationship between the real oil price and UAE real effective exchange rate.

3. Data

As a small but major oil-exporting country, the UAE has followed a fixed exchange rate regime for several decades. In 1978, the UAE dirham was pegged to the International Monetary Fund's special drawing rights and then re-pegged to the US dollar since 1997 at a rate of $1 to AED 3.67. In this study, we utilize the monthly data on the UAE real broad effective exchange rate (index 2010 = 100), which are constructed by the Bank for International Settlements (BIS) and are available only for the period since January 1994. BIS calculates a country's real broad effective exchange rate as a weighted average of bilateral real exchange rates with its trading partners worldwide. As a noteworthy aspect, the weights are time varying (three year average, chain linked) in order to capture the ongoing change in the world trade pattern.[3] As for crude oil, we use the global price of Dubai crude (US dollars per barrel). With the oil price typically in US dollars, in line with Huang and Guo (2007) and Basher, *et al.* (2012), among others, we use the US consumer price index (CPI) as the deflator in calculating the real price of oil.[4]

Figure 1 plots the UAE real broad effective exchange rate together with the real price of oil for the January 1994 - December 2017 (1994.01-2017.12) period. For 1994.01-2008.08 (2008.09-2017.12), the real exchange rate has a mean value of 86.4 (101.9) with a high value of 99.4 (115.1)

[3] For more information on the construction of BIS real effective exchange rates, see Klau and Fung (2006). Also, see Bahmani-Oskooee, *et al.* (2009) who use the BIS data to test purchasing power parity (PPP).

[4] Monthly data on the UAE real exchange rate, global price of Dubai crude, and US consumer price index are all available on the Federal Reserve Bank of St. Louis website. Daily data on the global price of Dubai crude (also known as Dubai Fateh crude oil spot price) come from the Bloomberg website.

and a low value of 69.2 (90.8) index points. In addition, for 1994.01-2008.08 (2008.09-2017.12), the real oil price has a mean value of 17.5 (33.8) with a high value of 59.9 (53.4) and a low value of 6.13 (11.3). Also, unlike for 1994.01-2008.08, Figure 1 reveals a pronounced (inverse) common trend between the two series for 2008.09-2017.12.

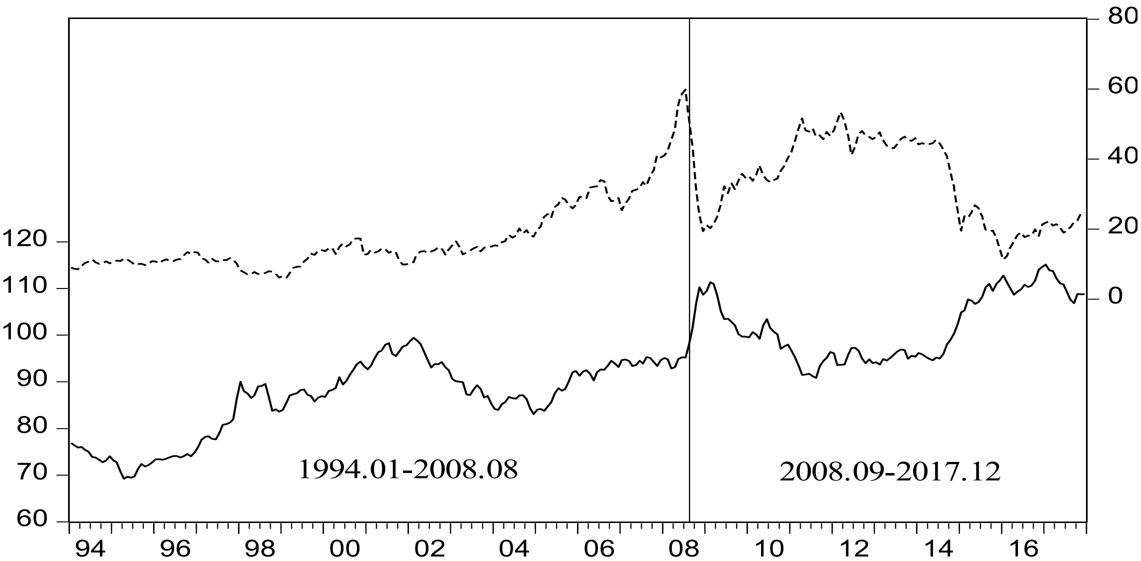

Figure 1. UAE real effective exchange rate (solid line) and real crude oil prices (dotted line)

4. Methodology and Empirical Results

We proceed by answering the following three questions:

1. Do the UAE real exchange rate and oil prices possess a long-run equilibrium relationship?
2. Does the UAE real exchange rate asymmetrically respond to eliminate disequilibrium?
3. Do oil prices have directional predictive power for the UAE real effective exchange rate?

We answer Questions 1 and 3 for the two periods of 1994.01-2008.08 and 2008.09-2017.12 and Question 2 only for the latter period in which, as we shall show, the real exchange rate and real oil prices are cointegrated. Also, in answering Question 3, we make use of nominal oil prices since, at the time of the forecast, the CPI for month *t* is not yet known.

4.1 Do the UAE real exchange rate and oil prices possess a long-run equilibrium relationship?

We start with examining the stochastic properties of the series using the KPSS (Kwiatkowski, *et al.* 1992) test for the two periods of 1994.01-2008.08 and 2008.09-2017.12. This test examines the null hypothesis of stationarity against a unit root alternative, and the literature suggests it is relatively more powerful than the augmented Dickey-Fuller unit root test (Bahmani-Oskooee 1998).

Table 1 reports the calculated KPSS test statistics along with the critical values for the logarithm of real exchange rate (X_t) and the logarithm of real oil prices (RP_t). As reported in rows 1 and 2 for 1994.01-2008.08, we reject the null hypothesis of stationarity in favor of a unit root alternative for both X_t and RP_t. Further results in rows 3 and 4 confirm that X_t and RP_t each has a unit root, since we cannot reject the null hypothesis of stationarity for ΔX_t and ΔRP_t. The same happens for 2008.09-2017.12, according to the results reported in rows 5-8.

Table 1. KPSS stationarity test results

Row no.	Variable	Calculated KPSS statistics	Critical values 10%	5%	1%
		Sample period: 1994.01-2008.08			
1	X_t	0.268[a]	0.119	0.146	0.216
2	RP_t	0.288[a]			
3	ΔX_t	0.136	0.347	0.463	0.739
4	ΔRP_t	0.180			
		Sample period: 2008.09-2017.12			
5	X_t	0.262[a]	0.119	0.146	0.216
6	RP_t	0.241[a]			
7	ΔX_t	0.145	0.347	0.463	0.739
8	ΔRP_t	0.127			

Notes: X_t is the logarithm of real exchange rate, and RP_t is the logarithm of real oil prices. The KPSS test examines the null hypothesis of stationarity against a unit root alternative. The KPSS test equations for the variables in levels include a constant and a time trend. The KPSS test equations for the variables in first differences include only a constant. The calculated test statistics (obtained using the Bartlett window approach) are compared with the critical values in Kwiatkowski, *et al.* (1992). Superscript **a** indicates significance at the 10% (or lower) level of significance.

With X_t and RP_t each having a unit root, the pre-condition for cointegration is satisfied. We take two steps in investigating whether the two series possess a long-run equilibrium relationship. First, we utilize the dynamic ordinary least squares (DOLS) method and estimate

$$X_t = b_0 + b_1 RP_t + \sum_{i=-3}^{3} c_i \Delta RP_{t-i} + \varepsilon_t$$

where the inclusion of both the leads and lags of ΔRP_t is intended to alleviate problems arising from serial correlation in the error term. Stock and Watson (1993) show that the DOLS estimators of b_0 and b_1 are superior to those proposed by Engle and Granger (1987), Johansen (1991), and Phillips and Hansen (1990).

In the second step, we follow Shin (1994) and utilize the residual-based test that extends the KPSS methodology to examine the null hypothesis of cointegration. This test is designed to overcome the low power of the standard tests that examine the null hypothesis of no cointegration. Row 1 (row 2) of Table 2 reports the DOLS parameter estimates of b_0 and b_1 along with the calculated Shin test statistic for 1994.01-2008.08 (2008.09-2017.12). Comparing these calculated test statistics with the critical values from Shin (1994, Table 1), we conclude that the null hypothesis of cointegration is rejected for 1994.01-2008.08, but not for 2008.09-2017.12.

Put together, our findings reveal that the relationship between the two series experienced a structural change around 2008. For 1994-2008, the UAE real exchange rate and real oil prices are not cointegrated and, thus, they are not related in the long-run. For 2008-2017, however, the UAE real exchange rate and real oil prices are cointegrated and, thus, possess a stable long-run equilibrium relationship in the form of $X_t = 4.422 - 0.173RP_t$. This relationship further indicates that the two series are inversely related in the long-run, as also displayed clearly in Figure 1 for 2008.09-2017.12. It follows that, for this period, a positive (negative) oil price shock leads to depreciation (appreciation) of the UAE real effective exchange rate.

Table 2. Residual-based Shin cointegration test results

Row no.	Sample period	DOLS estimates	Calculated Shin test statistic
1	1994.01-2008.08	$X_t = 4.650 + 0.102\ RP_t$	0.489[a]
2	2008.09-2017.12	$X_t = 4.422 - 0.173\ RP_t$ (0.015) (0.014)	0.087

Notes: Newey-West standard errors are in parentheses. The calculated Shin (cointegration) test statistics (obtained using the Bartlett window approach) are compared with the critical values in Shin (1994). Superscript **a** indicates significance at the 10% (or lower) level for the Shin cointegration test. The estimation period for the DOLS estimates in row 1 (row 2), after adjusting for lags and leads, is 1994.05-2008.05 (2009.01-2017.09).

More specifically, as shown in Figure 1, the relationship between the UAE real effective exchange rate and real oil prices turns negative after 2008. Theoretically, however, both the wealth transfer and terms of trade transmission channels suggest that rising oil prices result in currency appreciation (depreciation) of oil exporting (importing) countries. For the UAE (the US) as a major oil exporter (importer), this means a positive (negative) relationship between the real exchange rates and oil prices. Figure 2 plots the UAE real effective exchange rate along with the US real effective exchange rate. As can be seen, the UAE real effective exchange rate has begun to closely track the US real effective exchange rate after 2008 and, as such, a positive (negative) oil price shock has resulted in a depreciation (appreciation) of the UAE real effective exchange rate. Contributing factors for the change in the behavior of the UAE real exchange rate in relation to oil prices may include, among others, the observed intensity in oil price fluctuations for the period after 2008 in addition to the fact that the UAE dirham is pegged to the US dollar.

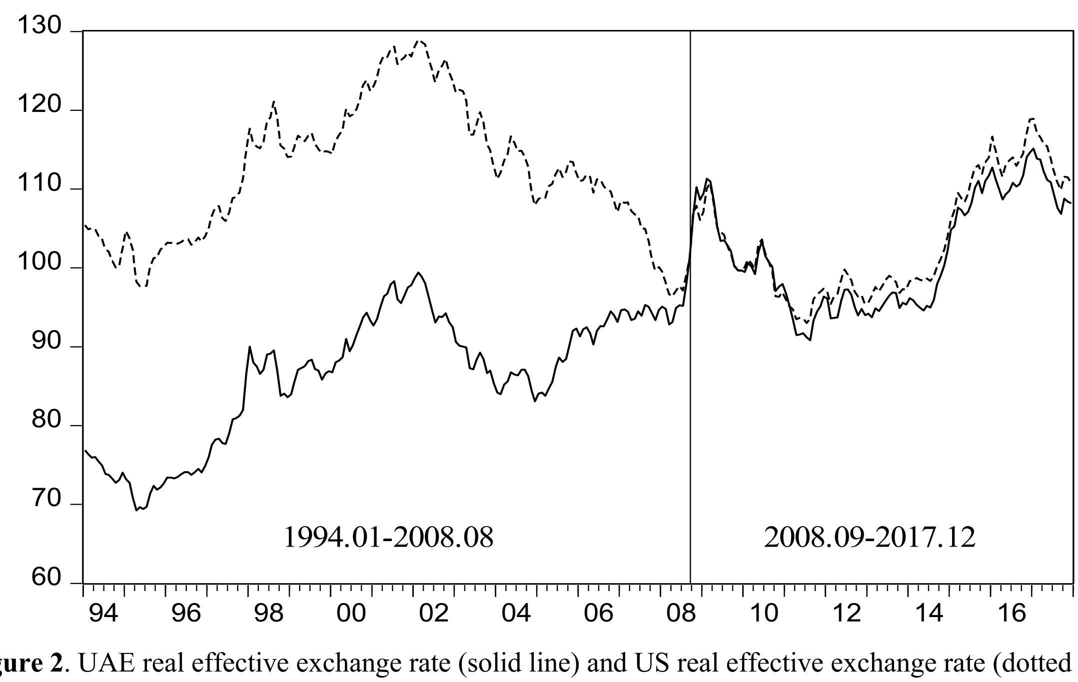

Figure 2. UAE real effective exchange rate (solid line) and US real effective exchange rate (dotted line)

4.2 Does the UAE real exchange rate asymmetrically respond to eliminate disequilibrium?

To answer, we specify the following error-correction model (ECM) for the period 2008.09-2017.12:

$$\Delta X_t = \alpha + \sum_{i=1}^{10} \beta i \; \Delta X_{t-i} + \sum_{i=1}^{10} \gamma_i \; \Delta RP_{t-i} + \sum_{i=1}^{10} \delta_i \; \Delta Y_{t-i} - \lambda \; RX_{t-1} + u_t \qquad (1)$$

where the error-correction term RX_t (= X_t – 4.422 + 0.173 RP_t) measures disequilibrium or short-run deviations of X_t from its long-run relationship with RP_t, and Y_t is the logarithm of the US real broad effective exchange rate (index 2010 = 100), calculated by BIS. Given that the UAE dirham is pegged to the US dollar at a fixed rate, the inclusion of ΔY_{t-i} is intended to control for changes in the value of the US dollar.[5]

We take a general-to-specific approach, by first estimating Equation (1) using OLS. Excluding the highly insignificant lag differences, we then re-estimate the model with the results reported in column 1 of Table 3. As can be seen, the estimate of λ (= 0.227) is significantly between zero and one, indicating that the model is dynamically stable. This specification, however, assumes that the UAE real exchange rate responds symmetrically to negative and positive deviations from the long-run equilibrium relationship. In order to test the validity of this assumption we re-specify the above ECM as follows:

$$\Delta X_t = \alpha + \sum_{i=1}^{10} \beta_i \; \Delta X_{t-i} + \sum_{i=1}^{10} \gamma_i \; \Delta RP_{t-i} + \sum_{i=1}^{10} \delta_i \; \Delta Y_{t-i}$$
$$+ \lambda_1 \, d \, |RX_{t-1}| - \lambda_2 \, (1 - d) \, RX_{t-1} + u_t \qquad (2)$$

where the dummy variable $d = 1$ when the error correction term $RX_{t-1} < 0$ and $d = 0$ otherwise. As such, the parameter λ_1 (λ_2) measures the speed of adjustment or how fast negative (positive) disequilibrium is eliminated through changes in X_t.

Again, we take a general-to-specific approach, by first estimating Equation (2) using OLS. Excluding the highly insignificant lag differences, we then re-estimate the model with the results reported in column 2 of Table 3. These estimates pass a series of diagnostic tests. For instance, with the reported *p*-values above 0.10, the results from the Ljung-Box *Q*-statistic test, the White test, and the Ramsey (1969) RESET point to the absence of autocorrelation, heteroscedasticity, and specification error.[6] The cusum of squares test results in Figure 3 also confirm that the model is stable in terms of parameters. In addition, the estimates of λ_1 (= 0.147) and λ_2 (= 0.345) are both significantly between zero and one, indicating that the model is dynamically stable.

[5] Note that Y_t is I(1); the calculated KPSS test statistic for Y_t and ΔY_t are, respectively, 0.258 and 0.144. A linear combination of X_t and Y_t is also I(1), meaning X_t and Y_t are not cointegrated; the DOLS estimate of the linear combination is (X_t – 0.214 – 0.950 Y_t) with the significant calculated Shin test statistic of 0.688. Also, a linear combination of X_t, RP_t, and Y_t is I(1), meaning that the three series together are not cointegrated; the DOLS estimate of the linear combination is (X_t – 1.464 + 0.053 RP_t + 0.668 Y_t) with the significant calculated Shin test statistic of 0.676.

[6] The Ramsey RESET equation includes the first fitted term; we reach the same conclusion when using the RESET equation that includes a quadratic time trend, as proposed by Baghestani (1991).

Table 3. ECM estimates of UAE real effective exchange rate (2008.09-2017.12)

Equation 1: $\Delta X_t = \alpha + \sum_{i=1}^{10} \beta_i \, \Delta X_{t-i} + \sum_{i=1}^{10} \gamma_i \, \Delta RP_{t-i} + \sum_{i=1}^{10} \delta_i \, \Delta Y_{t-i} - \lambda \, RX_{t-1} + u_t$

Equation 2: $\Delta X_t = \alpha + \sum_{i=1}^{10} \beta_i \, \Delta X_{t-i} + \sum_{i=1}^{10} \gamma_i \, \Delta RP_{t-i} + \sum_{i=1}^{10} \delta_i \, \Delta Y_{t-i} + \lambda_1 d \, |RX_{t-1}| - \lambda_2(1 - d) \, RX_{t-1} + u_t$

	Equation 1	Equation 2
Constant	-0.082 (0.79)	0.069 (0.47)
ΔX_{t-2}	0.194 (1.71)	0.202 (1.79)
ΔX_{t-3}	0.207 (1.86)	0.224 (2.01)
ΔX_{t-6}	0.487 (4.49)	0.498 (4.61)
ΔX_{t-9}	-0.372 (1.85)	-0.345 (1.72)
ΔX_{t-10}	0.192 (2.28)	0.187 (2.23)
ΔRP_{t-1}	0.029 (1.87)	0.030 (1.91)
ΔRP_{t-2}	0.031 (1.80)	0.029 (1.71)
ΔRP_{t-3}	0.039 (2.28)	0.039 (2.33)
ΔRP_{t-6}	0.065 (3.84)	0.063 (3.74)
ΔRP_{t-9}	0.021 (1.43)	0.022 (1.52)
ΔY_{t-1}	0.577 (5.23)	0.572 (5.23)
ΔY_{t-9}	0.359 (1.75)	0.328 (1.60)
RX_{t-1}	-0.227 (3.78)	--
$d \, \lvert RX_{t-1} \rvert$	--	0.147 (1.81)
$(1 - d) \, RX_{t-1}$	--	-0.345 (3.43)
Adjusted *R*-squared	0.308	0.317
Ljung-Box *Q*-statistic test *p*-value	0.766	0.681
White test *p*-value	0.751	0.875
Ramsey RESET *p*-value	0.264	0.470
Wald test *p*-value	--	0.073

Notes: Y_t is the logarithm of the US real broad effective exchange rate. Numbers in parentheses are absolute *t*-values. The Ljung-Box *Q*-statistic test examines the null hypothesis of no autocorrelation up to the 24th order. The estimation period, after adjusting for lags, is 2009.08-2017.09 with 98 monthly observations.

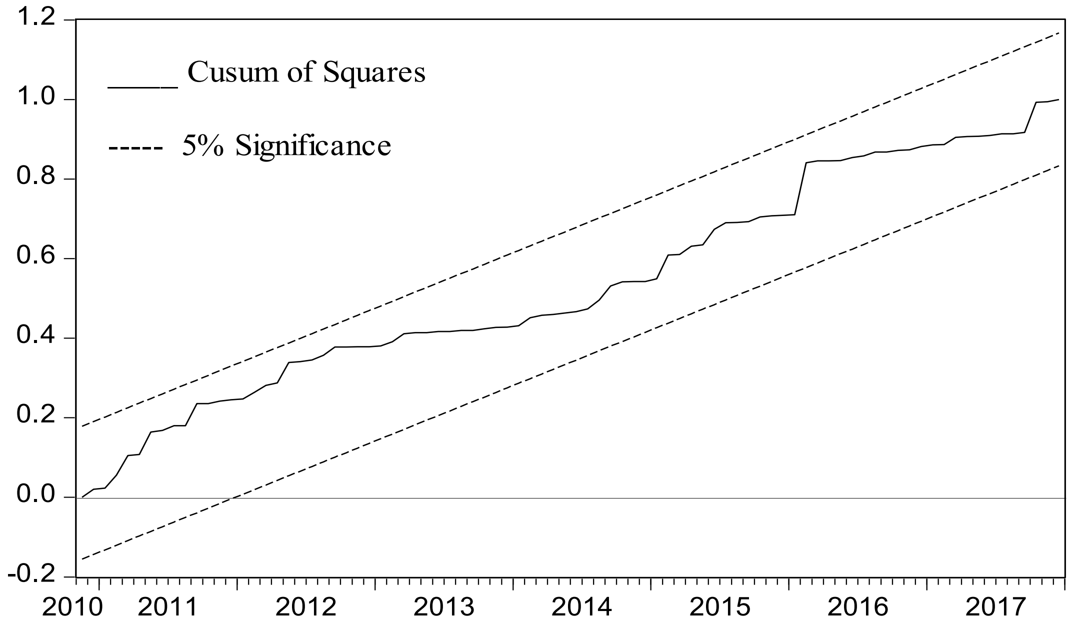

Figure 3. Parameter stability test results for Equation (2)

Column 2 also reports the *p*-value of the Wald test for the null hypothesis that H_0: $\lambda_1 = \lambda_2$. With the reported *p*-value (0.073 < 0.10), we reject this null hypothesis in favor of the alternative that $\lambda_1 \neq \lambda_2$ and conclude that the UAE real exchange rate asymmetrically responds to eliminate disequilibrium. Inspection of the data on the error-correction term RX_t (= X_t – 4.422 + 0.173RP_t) indicates that negative (positive) deviations are due to either a fall (rise) in real exchange rate or a rise (fall) in oil prices or a combination of the two. With the estimates of λ_1 and λ_2 equal to 0.147 and 0.345, respectively, the real exchange rate responds to eliminate negative deviations from the long-run equilibrium relationship with a slower speed of adjustment, and it responds to eliminate positive deviations with a much faster speed of adjustment. This conclusion remains unchanged when we utilize the procedures outlined in Granger and Lee (1989) and Enders and Siklos (2001) in detecting asymmetric adjustment.

4.3 Do oil prices have directional predictive power for the UAE real effective exchange rate?

In answering, we employ the procedure typically used to investigate whether a forecast can accurately predict directional change, by comparing the sign of the actual change with the sign of the predicted change; see among others, Schnader and Stekler (1990), Baghestani (2010, 2011), and Tsuchiya (2014). Here, however, we compare the sign of the future change in the actual real exchange rate ($A_{t+f} - A_{t-1}$) with the sign of the actual oil price change ($P_{t-1} - Pd_t$) known at the time of the forecast. More specifically, Figure 4 presents the timeline of directional predictions made on the 21st day of month *t*. This is when the UAE real effective exchange rate for month *t*-1 is available.

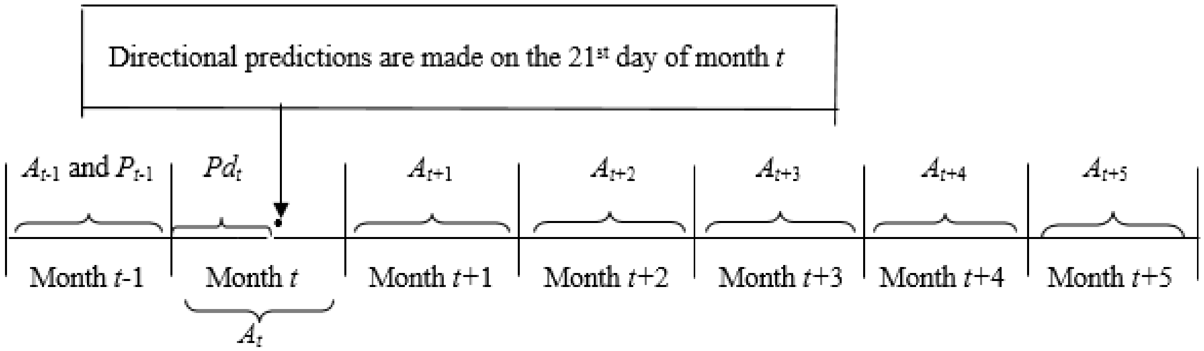

Figure 4. Timeline of directional predictions

Note that, A_{t-1}, A_t, A_{t+1}, A_{t+2}, A_{t+3}, A_{t+4}, and A_{t+5} represent the actual real exchange rate for the respective months. P_{t-1} is the average of the daily oil prices for month *t-1*, and Pd_t is the average of daily oil prices for the first 20 business days of month *t*. With the forecast horizon $f = 0, 1, 2, 3, 4$, and 5, $(A_{t+f} - A_{t-1})$ is the actual change in the real exchange rate, and $(Pd_t - P_{t-1})$ is the change in oil prices. Due to the inverse relationship between the UAE real exchange rate and oil prices, however, we specify the change in oil prices as $(P_{t-1} - Pd_t)$.

Rows 1-6 (rows 7-12) of Table 4 report the related statistics for the current-month and one-through five-month-ahead directional predictions for 1994.07-2008.08 (2008.09-2017.12). More specifically, n_1 (n_2) is the number of correctly predicted upward (downward) moves in the real exchange rate, and n_3 (n_4) is the number of incorrectly predicted upward (downward) moves in the real exchange rate. With the sample size n, $\pi_{All} = (n_1 + n_2)/n$ is the overall directional accuracy rate, $\pi_{Up} = n_1/(n_1 + n_3)$ is the proportion of correctly predicted upward moves, and $\pi_{down} = n_2/(n_2 + n_4)$ is the proportion of correctly predicted downward moves in the real exchange rate.

Table 4. Directional accuracy test results of oil prices for UAE real effective exchange rate

Row		Correct		Incorrect					
no.	f	n_1	n_2	n_3	n_4	π_{All}	π_{Up}	π_{Down}	p-value
				Forecast period: 1994.07-2008.08					
1	0	35	47	63	26	0.48	0.36	0.64	--
2	1	36	46	65	24	0.48	0.36	0.66	--
3	2	39	44	68	20	0.49	0.36	0.69	--
4	3	40	50	62	19	0.53	0.39	0.72	--
5	4	41	50	61	19	0.53	0.40	0.72	--
6	5	42	48	62	19	0.53	0.40	0.72	--
				Forecast period: 2008.09-2017.12					
7	0	36	40	20	15	0.68[b]	0.64	0.73	0.339
8	1	35	38	21	17	0.66[b]	0.63	0.69	0.464
9	2	35	35	23	18	0.63[b]	0.60	0.66	0.535
10	3	34	36	22	19	0.63[b]	0.61	0.65	0.605
11	4	34	36	22	19	0.63[b]	0.61	0.65	0.605
12	5	36	34	24	17	0.63[b]	0.60	0.67	0.468

Note: Superscript b indicates that the *p*-values of Fisher's exact test and the chi-square tests with and without Yate's continuity correction are all below 0.10.

In testing the null hypothesis of no association between the actual change in real exchange rates and the change in oil prices, we use the chi-square tests with and without Yate's continuity correction and Fisher's exact test (Sinclair, *et al.* 2010). For the 1994.07-2008.08 directional predictions in rows 1-6, the overall accuracy (π_{All}) ranges from 0.48 to 0.53, and we cannot reject the null hypothesis of no association. For the 2008.09-2017.12 directional predictions in rows 7-12, the overall accuracy rate (π_{All}), ranging from 0.63 to 0.68, is reasonably high and, as shown by superscript **b**, we reject the null hypothesis of no association. Put together, we conclude that oil prices have directional predictive power for the UAE real exchange rate for 2008.09-2017.12 but not for 1994.07-2008.08. Such evidence reinforces our prior conclusion that the relationship between the UAE real exchange rate and oil prices experienced a structural change around 2008.

Further inspection of the results for 2008.09-2017.12 indicate that π_{Up} ranges from 0.60 to 0.64, and π_{Down} ranges from 0.65 to 0.73. We use the chi-square test described in Berenson, *et al.* (1988, sec. 11.4.1) to test the null hypothesis of no asymmetric loss, meaning that the proportion of incorrectly predicted upward moves ($1-\pi_{Up}$) equals the proportion of incorrectly predicted downward moves ($1-\pi_{Down}$). The *p*-value of this test (reported in the last column of Table 4) for every prediction in rows 7-12 is all above 0.10, indicating that we cannot reject the null hypothesis of no asymmetric loss for the current-month, and for one- through five-month-ahead directional predictions. Accordingly, such predictions are useful to a user who assigns the same loss (cost) to upward and downward moves in the UAE real effective exchange rate.[7] This is important, because accurate predictions of upward (appreciation) and downward (depreciation) moves in the real effective exchange rate are equally crucial for policymaking.

5. Conclusions

The literature points to the real exchange rate as an important factor influencing trade and FDI in both developed and developing countries (Goldberg and Klein, 1997; Guzman, *et al.* 2018). Given the importance of trade and FDI for UAE economic growth and the dependence of the UAE economy on oil revenue, this study sets out to explore the dynamic relationship between the UAE real effective exchange rate and oil prices. We believe that the findings of this study are important to both UAE policymakers in promoting trade and attracting foreign investment and to foreign entities which consider the UAE an attractive environment for investing in various sectors.

In particular, we find that the relationship between the UAE real exchange rate and real oil prices experienced a structural change around 2008. That is, for both 1994-2008 and 2008-2017, the two series each has a unit root, but they possess a long-run equilibrium relationship for the latter period when oil price fluctuations intensified, and the UAE real exchange rate began to be inversely related to real oil prices. Theoretical transmission channels, including the wealth transfer and terms of trade, suggest that rising oil prices result in currency appreciation (depreciation) of oil exporting (importing) countries. This means a positive relationship between the real effective exchange rate and oil prices for the UAE as a major oil-exporter and a negative one for the US as a major net oil-importer. However, this relationship for the UAE turns negative beginning with the 2008 global financial crisis, as the UAE real effective exchange rate closely tracks the US real effective exchange rate. That is, for the period after 2008, a positive (negative) oil price shock leads to a depreciation (appreciation) of both the UAE and US real effective exchange rates. Contributing factors for the change in the behavior of the UAE real exchange rate in relation to oil prices may

[7] Baghestani and Toledo (2019) report similar findings for Canada, Mexico, and the US for 2008-2016.

include, among others, the observed intensity in oil price fluctuations for the period after 2008 in addition to the fact that the UAE dirham is pegged to the US dollar.

Further results for 2008-2017 indicate that the real exchange rate asymmetrically responds to eliminate disequilibrium. That is, the response is relatively small when disequilibrium is negative and relatively large when disequilibrium is positive. Such findings are consistent with Ahmad and Hernandez (2013) and Chen, *et al.* (2013) who have also found asymmetric adjustment for other countries. We also find that oil prices have directional predictive power for the UAE real exchange rate for only the 2008-2017 period. These directional predictions imply symmetric loss, meaning that they are of value to a user who assigns the same loss (cost) to upward and downward moves in the UAE real effective exchange rate. This is important, because accurate predictions of upward (appreciation) and downward (depreciation) moves in the real effective exchange rate are equally crucial for policymaking. Put together, our results point to real oil prices as the dominate factor in influencing the UAE real exchange rate for the period since the 2008 global financial crisis. As to whether this conclusion holds for the period before the crisis, it awaits subsequent research.

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