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The effects of world crude oil price on the real effective exchange rate: empirical evidences from Vietnam

Abstract. The paper examines impact the world crude oil price (WCOP) on the real effective exchange rates (REER) based on empirical evidences from Vietnam in the period from 1986 to 2019. It includes five parts. Section 1 introduces research issues. Section 2 presents an overview of the research on the relationship between the WCOP and the REER. Section 3 describes the data and research methods. In Section 4, we use the autoregressive distributed lag model (ARDLM) to study the impact of the WCOP on the REER of Vietnam. Section 5 presents the key findings and explains the results in the light of actual practices. Monthly data are divided into four periods: Dec 1986 - Dec 1990, Jan 1991 - Jan 1999, Feb 1999 - Dec 2015, and 2016 - 2Q 2019, corresponding to the principles of the monetary policy in Vietnam. The obtained results basing on the ARDLM show that there was no impact of the WCOP on the REER in the period between Dec 1986 and Dec 1990. In the remaining two periods, the impact of the WCOP on the REER was observed in the short-term. The last period between 2016 and 2Q 2019 shows that the WCOP has a strong impact on the actual average exchange rate in Vietnam. In some way, this is also a positive expression of the close relationship between the foreign exchange market and the WCOP. In all the periods, there exists a co-integration relationship between the WCOP and the REER.

Keywords: Crude Oil; Crude Oil Price; Oil Price; World Crude Oil Price (WCOP); Exchange Rate; Real Effective Exchange Rate (REER); Autoregressive Distributed Lag Model (MRDLM)
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Вплив світової ціни сирої нафти на реальний ефективний обмінний курс: практика В'єтнаму

Анотація
У статті розглянуто вплив світової ціни на сиру нафту на реальний ефективний обмінний курс на основі даних Соціалістичної Республіки В'єтнам за період з 1986 по 2019 роки. Робота складається з п'яти частин. Перша частина розкриває предмет дослідження. У другій частині досліджується взаємозв'язок між світовою ціною на сиру нафту та реальним ефективним обмінним курсом. Розділ третій подає актуальні дані та методи дослідження. У четвертому розділі було використано авторегресійну модель із розподіленим лагом для визначення впливу світової ціни на сиру нафту на реальний ефективний обмінний курс. У п'ятому розділі запропоновано висновки та пояснення отриманих результатів дослідження. Дані, необхідні для проведення дослідження, були розподілені на чотири періоди: грудень 1986 – грудень 1990; січень 1991 – січень 1999; лютий 1999 – грудень 2015; 2016 – другий квартал 2019 р. Згідно результатів, отриманих внаслідок застосування авторегресійної моделі з розподіленим лагом, було встановлено, що за період від грудня 1986 по грудень 1990 р. впливу світової ціни на сиру нафту на реальний ефективний обмінний курс виявлено не було. У наступних двох періодах такий вплив був. Найбільший вплив на фактичний середній обмінний курс у В'єтнамі спостерігався в останній період (2016 рік – другий квартал 2019 року). Це підтверджує наявність тісного взаємозв'язку між валютним ринком і світовою ціною на сиру нафту. Коефіцієнт коінтеграції має негативне значення.
Ключові слова: сира нафта; ціна на сиру нафту; ціна на нафту; світова ціна на сиру нафту; обмінний курс; реальний ефективний обмінний курс; авторегресійна модель із розподіленим лагом.

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Влияние мировой цены на сырую нефть на реальный эффективный обменный курс: практика Вьетнама

Аннотация
В статье рассмотрено влияние мировой цены на сырую нефть на реальный эффективный обменный курс на основе данных Социалистической Республики Вьетнам за период с 1986 по 2019 г. Данная работа состоит из пяти частей. Первая часть раскрывает предмет исследования. Во второй части исследуется взаимосвязь между мировой ценой на сырую нефть и реальным эффективным обменным курсом. Третий раздел содержит информацию об актуальных данных и методах исследования. В четвертом разделе использована авторегрессионная модель с распределенным лагом для определения влияния мировой цены на сырую нефть на реальный эффективный обменный курс. В пятом разделе содержатся выводы, касающиеся полученных результатов исследования. Данные, необходимые для проведения исследования, были разделены на четыре периода: декабрь 1986 – декабрь 1990; январь 1991 – январь 1999; февраль 1999 – декабрь 2015; 2016 год – второй квартал 2019 г. Согласно результатам, полученным в следствии применения авторегрессионной модели с распределенным лагом, было установлено, что за период с декабря 1986 по декабрь 1990 г. влияния мировой цены на сырую нефть на реальный эффективный обменный курс обнаружено не было. В последующих двух периодах такое влияние было. Наибольшее же влияние на фактический средний обменный курс во Вьетнаме наблюдается в последний период (2016 год – второй квартал 2019 года), что подтверждает наличие тесной взаимосвязи между валютным рынком и мировой ценой на сырую нефть. В ходе проведения исследования было установлено, что коэффициент интеграции имеет отрицательное значение.
Ключевые слова: сырая нефть; цена на сырую нефть; мировая цена на сырую нефть; обменный курс; реальный эффективный обменный курс; авторегрессионная модель с распределенным лагом.

1. Introduction

Since being discovered and put into operation, crude oil has been used as a lighting fuel and a medicine for skin diseases. Gradually with the development of the technical economy along with a more complete understanding of crude oil, it has been used as fuel for electricity supply, fuel for almost types of transport means; it has been used in the chemical industry to produce plastics and over 2,000 other popular products. 1986 was the time of national renewal, also the first year when Vietnam exploited the first ton of oil from Bach Ho oilfield and officially enrolled in the list of oil producing and exporting countries in the world. In terms of energy security, in 1991, with the oil production of 3.96 million tonnes, Vietnam started to balance imports and by 2019 the country's petroleum industry has attracted USD 45 billion of foreign direct investment with 100 contracts. The result of 2018 showed that 13.97 million tonnes of crude oil and 10.01 billion m^3 of gas and 1.63 million tonnes of nitrogenous fertilizer were exploited; production of 170 billion kWh of electricity was achieved on December 2nd, 2018. The plan of 2019 is to exploit 12.37 million tonnes of crude oil and 9.69 billion m^3 of gas, and produce 21.6 billion kWh of electricity, 1.575 million tonnes of nitrogenous fertilizer, 11.350 million tonnes of petroleum, with total revenue of VND 612.2 trillion.

According to the report of the Vietnam National Oil and Gas Group, the current oil reserve is about 4.4 million barrels, ranking 28th among the countries with oil reserves in the world, maintaining the output of 340,000 barrels/day from 2014 to the present.

The statistics about the relationship of exporting-importing crude oil in the period of 2012-2018 are as follows:

- 0.73 million tonnes importing - 9.25 million tonnes exporting in 2012;
- 1.29 million tonnes importing - 8.41 million tonnes exporting in 2013;
- 0.70 million tonnes importing - 9.31 million tonnes exporting in 2014;
- 0.18 million tonnes importing - 9.18 million tonnes exporting in 2015;
- 0.44 million tonnes importing - 6.85 million tonnes exporting in 2016;
- 1.18 million tonnes importing - 6.81 million tonnes exporting in 2017;
- 5.17 million tonnes importing - 3.96 million tonnes exporting in 2018.

At the end of February 2019, Vietnam imported more than 1.462 million tonnes of crude oil, with a total turnover of USD 635.4 million, which increased by 16 times in volume and 14 times in value compared to the same period in 2018. The statistics about the quantity and proportion of Vietnam's crude oil exporting to major markets in 2018 are:

- Thailand - 964 thousand tonnes (24%);
- the United States - 133 thousand tonnes (3%);
- South Korea -189 thousand tonnes (5%);
- Singapore - 227 thousand tonnes (6%);
- Malaysia - 79 thousand tonnes (2%);
- China - 1060 thousand tonnes (27%);
- Japan - 347 thousand tonnes (9%);
- Australia - 823 thousand tonnes (21%);
- other markets - 136 thousand tonnes (3%).

Oil prices are affected by many factors and are always fluctuating, especially in terms of the WCOP. Therefore, oil prices are always concerned and analysed by organisations conducting professional analyses, economic organisations and financial institutions. In January 1999, the price of US crude oil was USD 17/barrel, but due to the influence of the war in Iraq, the amount of crude oil products decreased in 2008. At that time, crude oil price reached USD 100/barrel, especially in July 2008; the world crude oil price reached USD 147/barrel, then fell to USD 33 in December 2008. In 2009, crude oil price fluctuated within USD 35 and USD 48/barrel, but in the period of June 2009 to early 2010, oil price reached USD 71-80 (Weiwen, 2012). The fluctuation of world crude oil prices has also affected the open economy like Vietnam. This source of foreign currency is also important to stabilise the exchange rate, regulate the macroeconomics and improve the foreign currency liquidity for the entire economy of Vietnam. Since being exploited, the export value of crude oil always accounts for a high proportion compared to other key export items such as footwear, textiles and seafood.

According to Tang et al. (2010), the survey and analysis of energy prices in general and crude oil prices in particular indicated a link with economic activities in three main groups. Specifically, the first group, according to Bruno and Sachs (1982), Hooker (1996), Hamliton (1996),

Brown & Yücel (2002), is the study of the theory of increasing energy prices and reducing economic activities. The second group, according to Lee & Ni (2002), Lardic & Mignon (2006, 2008), focuses on the relationship between changes in energy prices or its flexibility and economic activities. The symmetry or asymmetry affects linear models or non-linear models, which has been clearly shown in the developed economy. The last group, according to Huang, Hwang, & Peng (2005) and Cologni & Manera (2008), points out the role of macroeconomic policy in addressing the impact on world energy price volatility. Research results relating to this group show that possibly there is a relationship between world oil price volatility and macroeconomic activities.

In this article, the authors follow the direction of the last group, conducting research on the relationship between fluctuations in world energy prices in general and crude oil prices in particular in relation to the volatility of the economy. Studies with relevant to this group include Lee, Ni & Ratti (1995), Ferderer (1996), Amano & van Norden (1998), Guo & Kliesen (2005), Chen & Chen (2007), Elder & Serletis (2010), and Weiwen (2012). The type of energy selected to study is crude oil. Among the macroeconomic variables, we choose the real effective exchange rate variable. With this specialised content, there have been many empirical studies conducted on oil prices and real exchange rates in developed countries, including the ones by Clarida & Gali (1994), Chaudhuri & Daniel (1998), Spatafora & Stavrev (2003), Bjørnland & Hungnes (2008), Akram (2004), and Habib & Kalamova (2007). However, only few studies have been carried out on crude oil price and the real exchange rates, for example, Ozsoz and Akinkunmi (2011), Hassan and Zahid (2011), Oriavwote & Eriemo (2012), and Jahangard, Daneshmand & Tekieh (2017) in developing countries, including Vietnam. In particular, in Vietnam, there is no research on the impact of the world crude oil price on real effective exchange rates. It should be noted that the research issues, as well as the research methods in this article, are inherited from previous studies, yet they are validated in new data with a completely new approach in Vietnam. The differences are that the selected macroeconomic variable is the real effective exchange rate variable, according to different periods of implementation of the monetary policy of Vietnam. Hence, it is evident that there is no empirical coincidence with the previous studies.

2. Brief Literature Review

Krugman (1983a, 1983b), Golub (1983), Blomberg & Harris (1995), Zhou (1995), Chen & Chen (2007), Hem et al (2014), and Baghestani and Toledo (2019), explain the reason for the change in the price of crude oil in relation to the exchange rate in terms of theory. Exporting or importing crude oil is related to the exchange rate when crude oil prices rise or fall. Specifically, an increase in WCOP reduces the balance of trade for the country's crude oil imports, requiring real reduction of foreign currencies in order to improve the national level of competition. Based on the theory of the law of one price, the studies also explain that the change in the exchange rate affects the price of crude oil. The United States has implemented a consistent and objective international trade in USD. As the USD has a relationship with other currencies, this raises the demand for crude oil, which leads to price increases.

Further, the related study by Zhang et al. (2008) and Akram (2009) points out that the weak relationship of the USD has led to an increase in crude oil prices in developing countries, unlike previous studies that focused on developed countries. At the same time, the study by Hem et al. (2014) has shown that there exists a relationship between the WCOP and the REER in exporting countries such as Canada and Norway in both the short term and the long term. Integration and related relationships are often used to determine long-term or short-term trends. The test results indicate that the WCOP and the REER have two trends in terms of the Canadian Dollar and the Norwegian Krone. The first trend is that the diverging cycle indicates a close relationship of the general positive direction in the trend and the period that constitutes circulation. The second group shows that the national monetary economy relationship will also affect the price of crude oil. There was no difference in quality in the trend and cycle trajectories when implementing control over the WCOP. Research results on price fluctuation of crude oil play a special role in explaining the changes in the exchange rate of crude oil exporting countries.

The study by Baghtani & Toledo (2019) points out a basic prediction of the effects of the WCOP and the REER in NAFTA countries such as Canada, Mexico and the US in many periods. Another study by Al-mulali & Che Sab (2012) on crude oil exporting countries has shown the impact

of crude oil prices on the exchange rate in the period between 2000 and 2010 in 12 oil exporting countries: Algeria, Bahrain, Egypt, Indonesia, Kuwait, Nigeria, Oman, Qatar, Saudi Arabia, Sudan, United Arab Emirates and Venezuela. These studies establish a framework model applied in 6 variables, in that the exchange rate is an independent variable and the dependent variables are the oil price, the government spending, the current account, the inflation rate and gross domestic product. The obtained result suggests that increases in oil prices are caused by real exchange rate assessments in these countries.

The research team on the relationship between the WCOP and the REER implemented in Asian countries, represented by Nusair & Kisswani (2014), Hem & Kamal (2015), Bilgin, Gozgor & Karabulut (2015) have studied the relationship between the real exchange rate of Asian countries and oil prices in the long term and pointed out the structural breakdown. The relationship is clearly reflected by the level of world integration. Using the conventional test, Johansen et al. conducted it in two stages, which does not consider international integration relationship. However, this process has a clear result on the importance of the relationship in order to affirm its long-term stability as it is in Japan and the Philippines. At the same time, the results provide direct causes in Malaysia, Thailand and Korea. In the Philippines and Singapore, the direct impact of oil prices on the exchange rate changes is observed in Indonesia, and there is no evidence of changes in oil price in Japan. The research sample has been applied in Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand, not in Vietnam.

Hem & Kamal (2015) analysed the factors affecting oil price by the output requirements.

The inflation at the exchange rate in Thailand, Malaysia, Singapore, Philippines and Indonesia (ASEAN-5) were analysed using the structure of the Var model by Kisswani, Harraf & Kisswani (2018). The test of the e-integration factor has shown that the macroeconomic variables of these countries are integration variables and have a general trend in the long term. The promotion of functions has indicated that oil price fluctuations are not affected by the ASEAN-5 economy in the long term and the degree of variation in the six quarters. The analytical results confirm that the exclusion of sudden oil price changes does not explain specific variables. We also determine that there is only one response pattern to the change in oil prices between Malaysia and Singapore, the Philippines and Thailand. Another study of Vietnam was conducted by Bilgin, Gozgor & Karabulut (2015), regarding the topic of analysing influencing factors of the WCOP by the REER, but the influencing factor of the WCOP is represented by macroeconomic variables. They are Asian developed countries like Bangladesh, China, India, Indonesia, Malaysia, Pakistan, Philippines, Thailand, Turkey and Vietnam, with the data used in the period between 1960 and 2010. Therefore, in this article, we will focus on the research on the WCOP in relation to the REER, which is why there is no duplication of data as well as research methods. At the same time, according to Jahangard, Daneshmand & Tekieh (2017), the ARDLM model used is a reasonable choice, since the results provide information on the influence degree of dependent variables on independent variable, and the model is also tested with Iranian data. In terms of developed countries, the REER variable will affect WCOP, however for developing countries like Vietnam, the international economy variable will have a national REER factor like the WCOP, and there is no reverse. Therefore, the reasonable approach in the method is the one in which WCOP and ARDLM are independent variables, and national REER is a dependent variable.

3. Data and Research methodology

3.1. Research data

The REER data are inherited from the study by Darvas (2012a). He calculated the REER based on CPI for 178 countries with annual data and for 153 countries with monthly data, including Vietnam. The formula is calculated as follows:

$$REER_t = \frac{NEER_t \cdot CPI_t}{CPI_t^{(foreign)}},$$

where:

$REER_t$ is the real effective exchange rate of the country under study against a basket of currencies of trading partners; CPI_t is the consumer price index of the country under study, is the nominal effective exchange rate of the country under study,

$$NEER_t = \prod_{i=1}^{N} S(i)_t^{w^{(i)}}$$

which is in turn the geometrically weighted average of $S(i)t$, the nominal bilateral exchange rate between the country under study and its trading partner i (measured as the foreign currency price of one unit of domestic currency);

$$CPI_t^{(foreign)} = \prod_{i=1}^{N} CPI(i)_t^{w^{(i)}}$$

is the geometrically weighted average of CPI indices of trading partners; $CPI(i)t$ is the consumer price index of trading partner i; $w(i)$ is the weight of trading partner i, and N is the number of trading partners considered. The weights sum to one, i.e.,

$$\sum_{i=1}^{N} w^{(i)} = 1.$$

We use geometrically weighted averages because this is the most frequently used method by Darvas (2012a, 2012b, 2012c). Although the study was published in 2012, the authors continue to update the data of January 2017, yet no new figures are available. In order to carry out the study of the impact of the world crude oil price on the exchange rate between the US dollar and Vietnam dong, the authors accepted to use the actual average exchange rate in the country, based on the website of Vietnam's Customs. The site provides actual average exchange rates of VND/USD by date. In order to receive monthly data, the authors of this article have calculated the average exchange rate by date in a month to get a monthly rate. Due to the limited data collection, the actual average exchange rate is used in place of the real effective exchange rate. The results are likely to be partially different, however this does not significantly affect the latest research outcome. Meanwhile, the world crude oil price in this period is still exploited from https://www.investing.com.

3.2. Research methodology

To analyse the impact of the world crude oil price on the real effective exchange rate of Vietnam, the authors used the ARDLM. This model was proposed by Pesaran, Shin & Smith (1996).

The mathematical form of the ARDLM used in the article is as follows:

$$D(REER)_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i D(REER)_{t-i} + \sum_{i=1}^{n} \beta_i D(WORLD\_OIL)_{t-i} + u_t,$$

where:

D is the difference operator; α_i, β_i are the regression coefficients, and u_t is the residual which has a simultaneous correlation but no correlation with its lags and all independent variables. Therefore, the right side of the regression equation consists of the lags of independent and dependent variables.

The ARDLM estimation process can be summarised through the following steps:

Step 1, we verify the stationarity of the time series. We transform time series which are non-stationary to the station ones. It means that, after being transformed, times series have expectation, variance and covariance which is constant over time. The time series in ARDLM must be stationary. Stationarity is an important concept when studying time series. However, in fact, most financial data series are non-stationary. To test the stationarity, we use unit root tests, due to a common test Augmented Dicky-Fuller test (ADF test). We use the unit root test with the order of lag is automatically selected according to the Schwarz criterion, with intercept is included in the test equation. ADF tests for the initial time series, and their first difference will be performed. Usually, after taking the first difference, we get the stationary time series. The use of the first difference of time series is not only to obtain stationary time series, but also the first difference series provide information about increasing or decreasing trend (depending on the sign of the difference) rather than focusing on providing information about the real value of the time series.

Step 2, we select the optimal lag for the ARDLM. This is an important step before estimating the ARDLM. The traditional way to select the optimal lag is to estimate the ARDLM multiple times with descending lags to 0. Among the estimated ARDLM, we choose the one with the smallest Hannan-Quin information criterion value. In this article, the authors try out up to the top 10 lags and select the recommended model according to the Hannan-Quin criterion. The image depicting Hannan-Quin's criterion value for the best 20 models, including the best model.

Step 3, we estimate the best ARDLM selected in the above step.

Step 4, we test the results of the ARDL model estimation:

- We test if the model is well-specified or not using Ramsey RESET test.
- Also, we test the stability of ARDLM thanks to the cumulative sum of residuals (CUSUM: Cumulative Sum of Recursive Residuals). If the cumulative sum of the residuals is within the standard range at the 5% significance level, then it can be concluded that the residual of the model is stable, and thus the model is stable.
- We test the residual of ARDLM without auto correlation thanks to Lagrange Multiplier test (LM test).

If the estimated ARDLM is appropriate, then the ARDLM can be used to describe the impact of the world crude oil price on Vietnam's real effective exchange rate in the short term.

Step 5, in order to check if there exists a cointegration between the world crude oil price and Vietnam's real effective exchange rate, we implement the Bound Test.

Details of the ARDLM can be found in Chapter 17 of Gujarati (2004).

4. Empirical results

4.1. Period of December 1986 - December 1990

The ARDLM estimation process and resulting findings for the first period analysed are presented in Tables 1-7 and Figures 1-2.

Table 1:
Descriptive statistics of variables in the period of Dec 1986 - Dec 1990

	REER	WORLD_OIL	DREER	DWORLD_OIL
Mean	1118.042	19.80612	-123.3248	0.218750
Median	206.2100	18.83000	0.525000	0.080000
Maximum	5981.730	39.51000	71.92000	12.19000
Minimum	51.76000	13.37000	-3376.200	-6.380000
Std. Dev.	1905.463	4.823223	493.4301	2.642876
Skewness	1.539994	2.261192	-6.153644	1.844486
Kurtosis	3.551276	8.973703	41.04959	11.09225
Jarque-Bera	19.98839	114.6132	3198.482	158.1862
Probability	0.000046	0.000000	0.000000	0.000000
Sum	54784.04	970.5000	-5919.590	10.50000
Sum Sq. Dev.	1.74E+08	1116.647	11443245	328.2853
Observations	49	49	48	48

Source: Compiled by the authors in EVIEWS

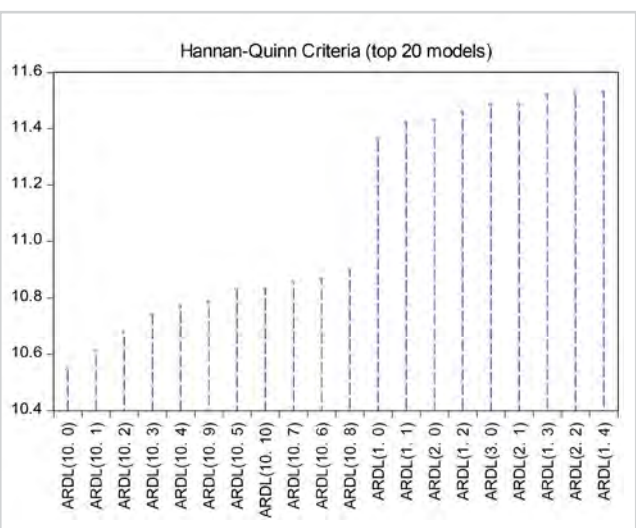

Figure 1:
Hann-Quin's criteria for the 20 best models in the period of Dec 1986 - Dec 1990
Source: Compiled by the authors

Table 2:
Stationarity test results of the time series in the period of Dec 1986 - Dec 1990

Variable	Statistical value *t*	Test value according to probability	Conclusion
REER	-40.0973	0.0001	Stationary
WORLD_OIL	-1.46888	0.5377	Non-stationary
D(REER)	-20.84127	0.0001	Stationary
D(WORLD_OIL)	-5.931718	0.0000	Stationary

Source: Compiled by the authors

Table 3:
Results of ARDLM estimation (10.0) in the period of Dec 1986 - Dec 1990

Dependent Variable: D(REER)
Method: ARDL
Sample (adjusted): 1987M11 1990M12
Included observations: 38 after adjustments
Maximum dependent lags: 10 (Automatic selection)
Model selection method: Hannan-Quinn criterion (HQ)
Dynamic regressors (10 lags, automatic): D(WORLD_OIL)
Fixed regressors: C
Number of models evaluated: 110
Selected Model: ARDL(10.0)

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.*
D(REER(-1))	0.064036	0.011452	5.591709	0.0000
D(REER(-2))	-0.001116	0.011493	-0.097065	0.9234
D(REER(-3))	-0.011969	0.011436	-1.046578	0.3049
D(REER(-4))	-0.015183	0.011471	-1.323586	0.1972
D(REER(-5))	-0.013255	0.011445	-1.158117	0.2573
D(REER(-6))	-0.011290	0.011446	-0.986385	0.3330
D(REER(-7))	-0.007711	0.011445	-0.673728	0.5064
D(REER(-8))	-0.020491	0.011589	-1.768102	0.0888
D(REER(-9))	-0.027684	0.011454	-2.417058	0.0230
D(REER(-10))	0.095621	0.011450	8.351540	0.0000
D(WORLD_OIL)	-1.241460	2.222122	-0.558682	0.5812
C	-4.179876	7.427199	-0.562780	0.5784

R-squared	0.820697	Mean dependent var.	-11.83079
Adjusted *R*-squared	0.744837	S.D. dependent var.	74.98077
S.E. of regression	37.87551	Akaike info criterion	10.35858
Sum squared resid.	37298.41	Schwarz criterion	10.87571
Log likelihood	-184.8129	Hannan-Quinn criter.	10.54257
F-statistic	10.81869	Durbin-Watson stat	1.937930
Prob(*F*-statistic)	0.000000		

Note: * *p*-values and any subsequent tests do not account for the model selection.

Source: Compiled by the authors

Table 4:
Model estimation after removing some variables in the period of Dec 1986 - Dec 1990

Dependent Variable: D(REER)
Method: Least Squares
Sample (adjusted): 1987M11 1990M12
Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
D(REER(-1))	0.062322	0.011081	5.624242	0.0000
D(REER(-8))	-0.023054	0.011016	-2.092791	0.0439
D(REER(-9))	-0.028454	0.011084	-2.567057	0.0148
D(REER(-10))	0.093482	0.010958	8.531013	0.0000

R-squared	0.770520	Mean dependent var	-11.83079
Adjusted *R*-squared	0.750272	S.D. dependent var	74.98077
S.E. of regression	37.46998	Akaike info criterion	10.18426
Sum squared resid	47735.98	Schwarz criterion	10.35664
Log likelihood	-189.5009	Hannan-Quinn criter.	10.24559
Durbin-Watson stat	1.579687		

Source: Compiled by the authors

Table 6:
Test of model specification of ARDLM (10.0) in the period of Dec 1986 - Dec 1990

	Value	Degrees of freedom	Probability	Conclusion
t-statistical	0.958661	25	0.3469	Model is well specified
F-statistical	0.919031	(1.25)	0.3469	

Source: Compiled by the authors in EVIEWS

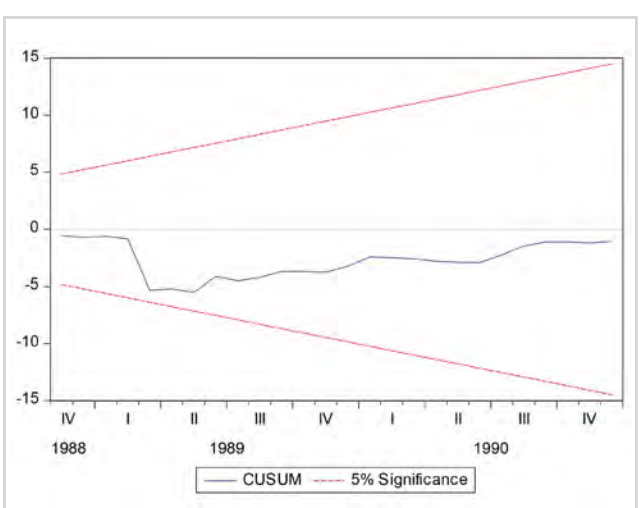

Figure 2:
The cumulative sum of recursive residuals of the model in Table 4 at a 5% significance level
Source: Compiled by the authors

Thus, the ARDLM (10.0) for the period between Dec 1986 and Dec 1990 has a residual without autocorrelation in the 1st, 8th, 9th and 10th orders.

The result confirms that there is a long-run relationship between the WCOP and the REER in Vietnam in the period between December 1986 and December 1990. The long-run model is shown in Table 8.

In the cointegration test, the cointegration regression coefficient is negative (-0.94904) and is statistically significant at 5% (with a

Table 5:
LM test for the residual of the ARDLM in the period of Dec 1986 - Dec 1990

Hypothesis H_0: The residual has no first-order autocorrelation phenomenon			
F-statistic	0.023598	Prob. F(1.25)	0.8791
Obs* *R*-squared	0.035835	Prob. Chi-Square(1)	0.8499
Conclusion: Accept the hypothesis H_0.			
Hypothesis H_0: The residual has no eighth-order autocorrelation phenomenon			
F-statistic	0.353942	Prob. F(8.18)	0.9315
Obs* *R*-squared	5.165168	Prob. Chi-Square(8)	0.7398
Conclusion: Accept the hypothesis H_0.			
Hypothesis H_0: The residual has no ninth-order autocorrelation phenomenon			
F-statistic	0.297137	Prob. F(9.17)	0.9656
Obs* *R*-squared	5.165174	Prob. Chi-Square(9)	0.8197
Conclusion: Accept the hypothesis H_0.			
Hypothesis H_0: The residual has no tenth-order autocorrelation phenomenon			
F-statistic	0.338268	Prob. F(10.16)	0.9565
Obs* *R*-squared	6.63179	Prob. Chi-Square(10)	0.7597
Conclusion: Accept the hypothesis H_0.			

Source: Compiled by the authors

Table 7:
Test of long-run relationship between the variables in the period of Dec 1986 - Dec 1990

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	439.2926	1
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

Source: Compiled by the authors

Table 8:
Long-run relationship between the variables in the period of Dec 1986 - Dec 1990

Cointegrating Form

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
D(REER(-1), 2)	0.013077	0.031017	0.421591	0.6768
D(REER(-2), 2)	0.011961	0.029339	0.407687	0.6868
D(REER(-3), 2)	-0.000008	0.027704	-0.000275	0.9998
D(REER(-4), 2)	-0.015191	0.025809	-0.588586	0.5612
D(REER(-5), 2)	-0.028446	0.023712	-1.199666	0.2411
D(REER(-6), 2)	-0.039736	0.021318	-1.863993	0.0737
D(REER(-7), 2)	-0.047447	0.018566	-2.555542	0.0168
D(REER(-8), 2)	-0.067937	0.015364	-4.421933	0.0002
D(REER(-9), 2)	-0.095621	0.011450	-8.351540	0.0000
D(WORLD_OIL, 2)	-1.241460	2.222122	-0.558682	0.5812
CointEq(-1)	-0.949040	0.032371	-29.317325	0.0000

Cointeq = D(REER) - (-1.3081*D(WORLD_OIL) -4.4043)

Long Run Coefficients

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
D(WORLD_OIL)	-1.308121	2.348873	-0.556914	0.5823
C	-4.404320	7.744059	-0.568735	0.5744

Source: Compiled by the authors

very small probability value) indicating that cointegration relationship exists between the variables. That is, in the long term, when the system is in equilibrium when a shock occurs, the variables in the model tend to move, pulling the whole system back to the equilibrium, which means a reverse movement tendency (the negative sign of the cointegration regression coefficients) compared to those fluctuations.

The cointegration equation, or equation that represents the long-run equilibrium relationship among the variables, is as follows:

$$DREER_t = - 1.308121 * DWORLD\_OIL_t - 4.40432 + u_t .$$

4.2. Period of January 1991 - January 1999

The ARDLM estimation process and resulting findings for the second period analysed are presented in Tables 9-15 and Figures 3-4.

Thus, the ARDLM (6.2) the period of January 1991 - January 1999 has a residual without autocorrelation from the 1st to the 6th order.

The result confirms that there is a long-run relationship between the WCOP and the REER in Vietnam in the period between January 1991 and January 1999.

Table 9:
Descriptive statistics of variables in the period of Jan 1991 - Jan 1999

	REER	WORLD_OIL	DREER	DWORLD_OIL
Mean	94.89175	19.01732	0.217396	-0.091562
Median	94.86000	19.44000	0.265000	-1.78E-15
Maximum	117.9000	25.92000	9.450000	2.800000
Minimum	64.62000	11.22000	-10.11000	-3.850000
Std. Dev.	11.22208	2.801656	2.708427	1.249072
Skewness	-0.460196	-0.453262	-0.334669	-0.362128
Kurtosis	2.998365	3.186502	5.775109	3.156034
Jarque-Bera	3.423799	3.461971	32.59698	2.195574
Probability	0.180523	0.177110	0.000000	0.333609
Sum	9204.500	1844.680	20.87000	-8.790000
Sum Sq. Dev.	12089.76	753.5303	696.8796	148.2171
Observations	97	97	96	96

Source: Compiled by the authors

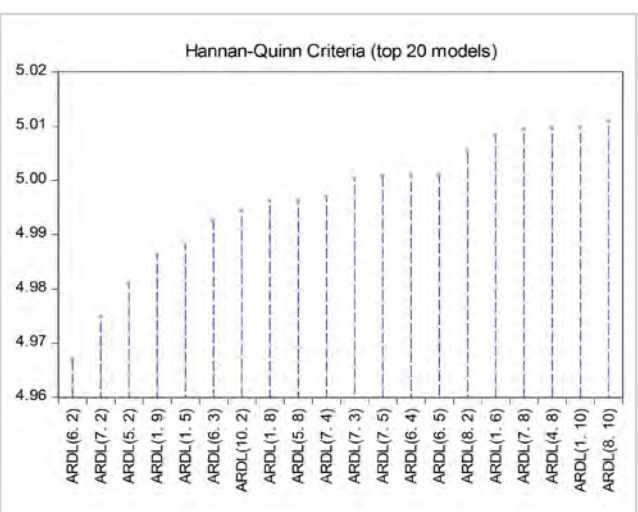

Figure 3:
Hann-Quin's criteria for the 20 best models in the period of Jan 1991 - Jan 1999
Source: Compiled by the authors

Table 10:
Stationarity test results of the time series in the period of Jan 1991 - Jan 1999

Variable	Statistical value *t*	Test value according to probability	Conclusion
REER	-2.180792	0.2146	Non-stationary
WORLD_OIL	-1.740664	0.4077	Non-stationary
D(REER)	-6.890024	0.0000	Stationary
D(WORLD_OIL)	-9.32149	0.0000	Stationary

Source: Compiled by the authors

Table 11:
Results of ARDLM estimation (6.2) in the period of Jan 1991 - Jan 1999

Dependent Variable: D(REER)
Method: ARDL
Sample: 1991M01 1999M01
Included observations: 97
Maximum dependent lags: 10 (Automatic selection)
Model selection method: Hannan-Quinn criterion (HQ)
Dynamic regressors (10 lags, automatic): D(WORLD_OIL)
Fixed regressors: C
Number of models evaluated: 110
Selected Model: ARDL(6.2)

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.*
D(REER(-1))	0.336145	0.097084	3.462419	0.0008
D(REER(-2))	-0.127476	0.097181	-1.311734	0.1931
D(REER(-3))	0.018602	0.085474	0.217631	0.8282
D(REER(-4))	-0.268470	0.083204	-3.226633	0.0018
D(REER(-5))	0.289215	0.087090	3.320889	0.0013
D(REER(-6))	-0.177369	0.088187	-2.011275	0.0474
D(WORLD_OIL)	-0.580774	0.196560	-2.954683	0.0040
D(WORLD_OIL(-1))	0.281803	0.206183	1.366762	0.1752
D(WORLD_OIL(-2))	-0.681051	0.193254	-3.524118	0.0007
C	0.150165	0.288575	0.520368	0.6041

R-squared	0.419246	Mean dependent var.	0.405464
Adjusted *R*-squared	0.359168	S.D. dependent var.	3.269559
S.E. of regression	2.617347	Akaike info criterion	4.859582
Sum squared resid.	595.9939	Schwarz criterion	5.125016
Log likelihood	-225.6897	Hannan-Quinn criter.	4.966911
F-statistic	6.978359	Durbin-Watson stat	1.973482
Prob(*F*-statistic)	0.000000		

Note: * p-values and any subsequent tests do not account for the model selection.

Source: Compiled by the authors

Table 12:
Model estimation after removing some variables in the period of Jan 1991 - Jan 1999

Dependent Variable: D(REER)
Method: Least Squares
Sample: 1991M01 1999M01
Included observations: 97

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
D(REER(-1))	0.249725	0.087947	2.839487	0.0056
D(REER(-4))	-0.257698	0.081067	-3.178838	0.0020
D(REER(-5))	0.268485	0.084718	3.169161	0.0021
D(WORLD_OIL)	-0.582070	0.191479	-3.039857	0.0031
D(WORLD_OIL(-2))	-0.671065	0.179105	-3.746768	0.0003
R-squared	0.377574	Mean dependent var.		0.405464
Adjusted *R*-squared	0.350512	S.D. dependent var.		3.269559
S.E. of regression	2.634964	Akaike info criterion		4.825786
Sum squared resid.	638.7592	Schwarz criterion		4.958503
Log likelihood	-229.0506	Hannan-Quinn crit.		4.879451
Durbin-Watson stat	1.706072			

Source: Compiled by the authors

Table 14:
Test of model specification of ARDLM (6.2) in the period of Jan 1991 - Jan 1999

	Value	Number of degrees of freedom	Probability value	Conclusion
Statistical value *t*	3.003361	86	0.0035	Function is formatted incorrectly
Statistical value *F*	9.020175	(1.86)	0.0035	

Source: Compiled by the authors

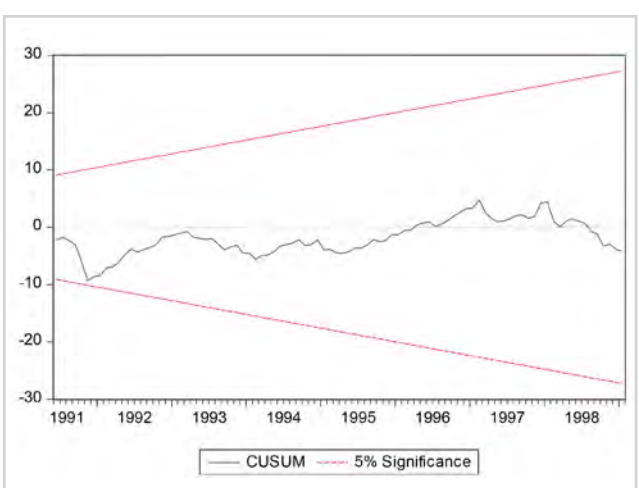

Figure 4:
The cumulative sum of recursive residuals of the model in Table 12 at a 5% significance level
Source: Compiled by the authors

The long-run model is shown in Table 16.

In the cointegration test undertaken, the cointegration regression coefficient is negative (-0.929352) and is statistically significant at 5% (with very small probability value) indicating that cointegration relationship exists between variables. The cointegration equation, or equation that represents the long-run equilibrium relationship among the variables, is as follows:

Table 13:
LM test for the residual of the ARDL in the period of Jan 1991 - Jan 1999

Hypothesis H_0: The residual has no first-order autocorrelation phenomenon			
F-statistic	0.087048	Prob. F(1.86)	0.7687
Obs**R*-squared	0.098083	Prob. Chi-Square(1)	0.7541
Conclusion: Accept the hypothesis H_0.			
Hypothesis H_0: The residual has no second-order autocorrelation phenomenon			
F-statistic	0.75129	Prob. F(2.85)	0.4749
Obs**R*-squared	1.684925	Prob. Chi-Square(2)	0.4306
Conclusion: Accept the hypothesis H_0.			
Hypothesis H_0: The residual has no third-order autocorrelation phenomenon			
F-statistic	0.917401	Prob. F(3.84)	0.4362
Obs**R*-squared	3.077312	Prob. Chi-Square(3)	0.3799
Conclusion: Accept the hypothesis H_0.			
Hypothesis H_0: The residual has no fourth-order autocorrelation phenomenon			
F-statistic	0.68662	Prob. F(4.83)	0.6032
Obs**R*-squared	3.106935	Prob. Chi-Square(4)	0.5401
Conclusion: Accept the hypothesis H_0.			
Hypothesis H_0: The residual has no fifth-order autocorrelation phenomenon			
F-statistic	0.790103	Prob. F(5.82)	0.5598
Obs**R*-squared	4.458379	Prob. Chi-Square(5)	0.4855
Conclusion: Accept rejecting the hypothesis H_0.			
Hypothesis H_0: The residual has no sixth-order autocorrelation phenomenon			
F-statistic	0.688533	Prob. F(6.81)	0.6594
Obs**R*-squared	4.707163	Prob. Chi-Square(6)	0.5819
Conclusion: Accept the hypothesis H_0.			

Source: Compiled by the authors

Table 15:
Test of long-run relationship between the variables in the period of Jan 1991 - Jan 1999

ARDL Bounds Test
Sample: 1991M01 1999M01
Included observations: 97
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	17.63983	1
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

Source: Compiled by the authors

Table 16:
Long-run relationship between the variables in the period of Jan 1991 - Jan 1999

Cointegrating Form

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
D(REER(-1), 2)	0.265497	0.188514	1.408368	0.1626
D(REER(-2), 2)	0.138022	0.156164	0.883828	0.3792
D(REER(-3), 2)	0.156624	0.137263	1.141049	0.2570
D(REER(-4), 2)	-0.111847	0.113773	-0.983071	0.3283
D(REER(-5), 2)	0.177369	0.088187	2.011275	0.0474
D(WORLD_OIL, 2)	-0.580774	0.196560	-2.954683	0.0040
D(WORLD_OIL(-1), 2)	0.681051	0.193254	3.524118	0.0007
CointEq(-1)	-0.929352	0.203922	-4.557395	0.0000

Cointeq = D(REER) - (-1.0545*D(WORLD_OIL) + 0.1616)

Long Run Coefficients

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
D(WORLD_OIL)	-1.054522	0.447832	-2.354726	0.0208
C	0.161581	0.300831	0.537115	0.5926

Source: Compiled by the authors

$DREER_t = -1.054522 * DWORLD\_OIL_t + 0.161581 + u_t$.

4.3. Period of February 1999 - December 2015

The ARDLM estimation process and resulting findings for the third period analysed are presented in Tables 17-22 and Figures 5-6.

Thus, the ARDL (2.2) model for the period between February 1999 and December 2015 has a residual without autocorrelation in the 1st and the 2nd orders.

The result confirms that there is a long-run relationship between the WCOP and the REER in Vietnam in the period of 1999 Feb - 2015 Dec.

The long-run model is shown in Table 23.

Table 17:
Statistics describing each variable in the period of Feb 1999 - Dec 2015

	REER	WORLD_OIL	DREER	DWORLD_OIL
Mean	109.3087	61.68084	0.225644	0.122624
Median	104.3300	61.04000	0.275000	0.830000
Maximum	153.5500	140.0000	7.010000	15.19000
Minimum	84.86000	12.27000	-5.820000	-32.83000
Std. Dev.	16.98350	29.63243	1.817627	6.128010
Skewness	0.937243	0.200500	0.031401	-0.981620
Kurtosis	3.034017	1.870337	3.917799	6.936086
Jarque-Bera	29.72981	12.15411	7.123016	162.8380
Probability	0.000000	0.002295	0.028396	0.000000
Sum	22189.67	12521.21	45.58000	24.77000
Sum Sq. Dev.	58264.72	177372.3	664.0572	7548.054
Observations	203	203	202	202

Source: Compiled by the authors

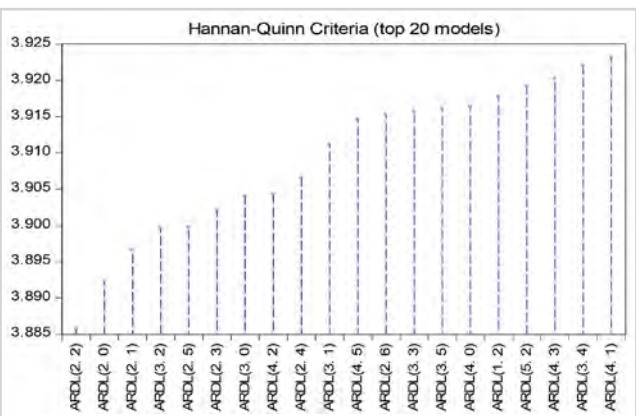

Figure 5:
Hann-Quin's criteria for the 20 best models in the period Feb 1999 - Dec 2015
Source: Compiled by the authors

Table 20:
LM test for the residual of the ARDLM in the period of Feb 1999 - Dec 2015

Hypothesis H0: The residual has no first-order autocorrelation phenomenon			
F-statistic	0.105356	Prob. F(1,196)	0.7458
Obs*R-squared	0.10906	Prob. Chi-Square(1)	0.7412
Conclusion: Accept the hypothesis H0.			
Hypothesis H0: The residual has no second-order autocorrelation phenomenon			
F-statistic	1.805677	Prob. F(2,195)	0.1671
Obs*R-squared	3.691153	Prob. Chi-Square(2)	0.1579
Conclusion: Accept the hypothesis H0.			

Source: Compiled by the authors

Table 18:
Test results of the stationarity of time series in the period of Feb 1999 - Dec 2015

Variable	Statistical value *t*	Test value according to probability	Conclusion
REER	0.767941	0.9933	Non-stationary
WORLD_OIL	-2.09194	0.2482	Non-stationary
D(REER)	-10.2432	0.0000	Stationary
D(WORLD_OIL)	-10.97758	0.0000	Stationary

Source: Compiled by the authors

Table 19:
Results of ARDLM estimation (2.2) in the period of Feb 1999 - Dec 2015

Dependent Variable: D(REER)
Method: ARDL
Sample: 1999M02 2015M12
Included observations: 203
Maximum dependent lags: 10 (Automatic selection)
Model selection method: Hannan-Quinn criterion (HQ)
Dynamic regressors (10 lags, automatic): D(WORLD_OIL)
Fixed regressors: C
Number of models evaluated: 110
Selected Model: ARDL(2, 2)

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.*
D(REER(-1))	0.313185	0.068272	4.587298	0.0000
D(REER(-2))	-0.214441	0.068558	-3.127853	0.0020
D(WORLD_OIL)	-0.073571	0.019671	-3.739974	0.0002
D(WORLD_OIL(-1))	-0.040106	0.020317	-1.974008	0.0498
D(WORLD_OIL(-2))	0.047039	0.020104	2.339725	0.0203
C	0.213261	0.116524	1.830183	0.0687

R-squared	0.214133	Mean dependent var.	0.234581
Adjusted R-squared	0.194187	S.D. dependent var.	1.817588
S.E. of regression	1.631596	Akaike info criterion	3.846106
Sum squared resid.	524.4349	Schwarz criterion	3.944033
Log likelihood	-384.3797	Hannan-Quinn criter.	3.885723
F-statistic	10.73570	Durbin-Watson stat	1.971452
Prob(*F*-statistic)	0.000000		

Note: * p-values and any subsequent tests do not account for the model selection.

Source: Compiled by the authors

Table 21:
Test of model specification of ARDLM (2.2) in the period of Feb 1999 - Dec 2015

	Value	Number of degrees of freedom	Probability value	Conclusion
Statistical value *t*	0.726003	196	0.4687	Function is formatted correctly
Statistical value *F*	0.527081	(1,196)	0.4687	

Source: Compiled by the authors

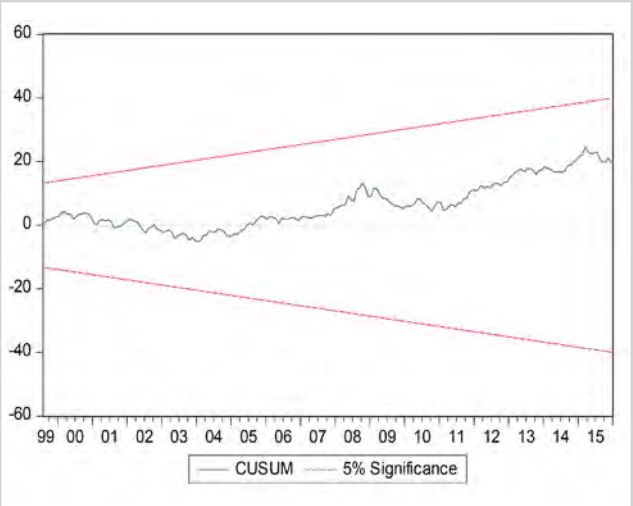

Figure 6:
The cumulative sum of recursive residuals of the model in Table 19 at a 5% significance level
Source: Compiled by the authors

Table 22:
Results of verification of long-run equilibrium relationships among the variables of the period of Feb 1999 - Dec 2015

ARDL Bounds Test
Sample: 1999M02 2015M12
Included observations: 203
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	57.95091	1
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

Source: Compiled by the authors

Table 23:
Long-run relationship between the variables in the period of Feb 1999 - Dec 2015

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(REER(-1), 2)	0.214441	0.068558	3.127853	0.0020
D(WORLD_OIL, 2)	-0.073571	0.019671	-3.739974	0.0002
D(WORLD_OIL(-1), 2)	-0.047039	0.020104	-2.339725	0.0203
CointEq(-1)	-0.901256	0.084580	-10.655644	0.0000

Cointeq = D(REER) - (-0.0739*D(WORLD_OIL) + 0.2366)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(WORLD_OIL)	-0.073939	0.030830	-2.398304	0.0174
C	0.236626	0.127155	1.860921	0.0642

Source: Compiled by the authors

In the cointegration test, the cointegration regression coefficient is negative (-0.901256) and statistically significant at 5% (with very small probability value) indicating that cointegration relationship exists between variables.

The cointegration equation, or equation that represents the long-run equilibrium relationship among the variables, is as follows:

$$DREER_t = - 0.073939 * DWORLD\_OIL_t + + 0.236626 + u_t .$$

In fact, we have investigated the impact of the WCOP on the REER of Vietnam during the whole period from December 1986 to December 2015, using ARDLM approach, without period division, but no results found. This reinforces the fact that the authors divided the research period according to Vietnam's exchange rates policy is relevant theoretically and practically.

4.4. Period of 2016 Jan 2019 June

The ARDLM estimation process and resulting findings for the fourth period analysed are presented in Tables 24-29 and Figures 7-8.

Thus, the ARDL model (7.11) in the period of January 2016 - June 2019 has a residual with autocorrelation defects in the 1st and the 2nd order.

The results confirm that there is not a long-run equilibrium relationship between the WCOP and the REER in Vietnam in the period between January 2016 and June 2019. To investigate more about long-run equilibrium model, Table 30 has been created.

In the cointegration test, the cointegration regression coefficient is negative (-1.548736) but not statistically significant at 5% (the probability value is 0.1044) indicating that the cointegration relationship does not exist between the variables:

$$DREER_t = 66.856643 * DWORLD\_OIL_t + 31.307896 + u_t .$$

5. Discussion and policy implications

The summary of the analysis of the impact of the world crude oil price on the real effective exchange rate in Vietnam is presented in Table 31.

The results of the analysis of the impact of the WCOP on the REER in Vietnam in each period by using ARDLM are completely consistent with the reality. In each period, in the short term, the

Table 24:
Statistics describing each variable in the period of Jan 2016 - June 2019

	ER	WORLD_OIL	DER	DWORLD_OIL
Mean	22740.05	54.22762	21.49390	0.484878
Median	22690.13	53.15500	1.250000	2.580000
Maximum	23305.00	74.15000	255.0000	8.380000
Minimum	22260.00	33.62000	-143.7500	-14.38000
Std. Dev.	350.4351	9.977691	80.82664	4.671963
Skewness	0.229437	0.109255	1.145246	-0.878022
Kurtosis	1.929702	2.513094	4.932284	3.876441
Jarque-Bera	2.373178	0.498441	15.34096	6.580232
Probability	0.305261	0.779408	0.000466	0.037250
Sum	955082.0	2277.560	881.2500	19.88000
Sum Sq. Dev.	5034994.	4081.727	261317.8	873.0894
Observations	42	42	41	41

Source: Compiled by the authors

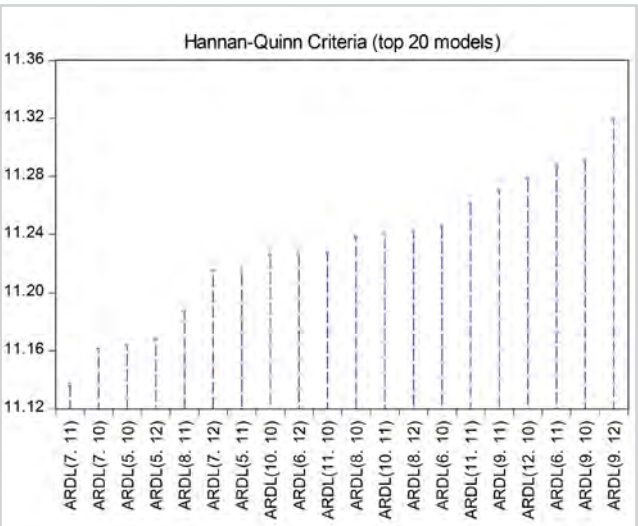

Figure 7:
Illustrating Hann-Quin's standard for the 20 best models for the model of the period of Jan 2016 - June 2019
Source: Compiled by the authors

Table 27:
LM verification of the autocorrelation phenomenon of the residual of the ARDLM in the period of Jan 2016 - June 2019

Hypothesis H0: The residual has no first-order autocorrelation phenomenon			
F-statistic	3.727716	Prob. F(1,9)	0.0856
Obs*R-squared	8.786453	Prob. Chi-Square(1)	0.0030
Conclusion: Reject the hypothesis H0.			
Hypothesis H0: The residual has no second-order autocorrelation phenomenon			
F-statistic	1.975427	Prob. F(2,8)	0.2008
Obs*R-squared	9.917753	Prob. Chi-Square(2)	0.0070
Conclusion: Reject the hypothesis H0.			

Source: Compiled by the authors

Table 25:
Test results of the stationarity of time series in the period of Jan 2016 - June 2019

Variable	Statistical value t	Test value according to probability	Conclusion
ER	-0.103745	0.9422	Non-stationary
WORLD_OIL	-2.305665	0.1751	Non-stationary
D(ER)	-5.12312	0.0001	Stationary
D(WORLD_OIL)	-5.011643	0.0002	Stationary

Source: Compiled by the authors

Table 26:
Results of the ARDLM estimation (7.11) in the period of Jan 2016 - June 2019

Dependent Variable: DER
Method: ARDL
Sample (adjusted): 2017M01 2019M06
Included observations: 30 after adjustments
Maximum dependent lags: 12 (Automatic selection)
Model selection method: Hannan-Quinn criterion (HQ)
Dynamic regressors (12 lags, automatic): DWORLD_OIL
Fixed regressors: C
Number of models evaluated: 156
Selected Model: ARDL(7, 11)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
DER(-1)	-0.302547	0.241580	-1.252366	0.2389
DER(-2)	-0.491322	0.235890	-2.082844	0.0639
DER(-3)	-0.541516	0.376292	-1.439085	0.1807
DER(-4)	-0.436623	0.345017	-1.265512	0.2344
DER(-5)	0.289000	0.335658	0.860996	0.4094
DER(-6)	0.572348	0.352082	1.625613	0.1351
DER(-7)	0.361924	0.264486	1.368404	0.2011
DWORLD_OIL	-7.650282	5.367056	-1.425415	0.1845
DWORLD_OIL(-1)	0.935351	4.855382	0.192642	0.8511
DWORLD_OIL(-2)	10.76979	5.650488	1.905993	0.0858
DWORLD_OIL(-3)	15.62028	6.220204	2.511217	0.0308
DWORLD_OIL(-4)	13.52005	5.019540	2.693484	0.0226
DWORLD_OIL(-5)	8.631672	4.955856	1.741712	0.1122
DWORLD_OIL(-6)	7.121918	4.093290	1.739900	0.1125
DWORLD_OIL(-7)	1.614010	4.387985	0.367825	0.7207
DWORLD_OIL(-8)	1.004663	5.457294	0.184095	0.8576
DWORLD_OIL(-9)	11.79391	6.569902	1.795142	0.1029
DWORLD_OIL(-10)	20.91963	7.417871	2.820167	0.0182
DWORLD_OIL(-11)	19.26226	7.735252	2.490192	0.0320
C	-48.48765	39.80842	-1.218025	0.2512

R-squared	0.667128	Mean dependent var.	21.29167
Adjusted R-squared	0.034671	S.D. dependent var.	73.79457
S.E. of regression	72.50402	Akaike info criterion	11.63988
Sum squared resid.	52568.32	Schwarz criterion	12.57401
Log likelihood	-154.5982	Hannan-Quinn criter.	11.93872
F-statistic	1.054820	Durbin-Watson stat	1.072385
Prob(F-statistic)	0.485288		

Note: * p-values and any subsequent tests do not account for the model selection.

Source: Compiled by the authors

Table 28:
Results of ARDLM function (7.11) test for the period of Jan 2016 June 2019

	Value	Number of degrees of freedom	Probability value	Conclusion
Statistical value t	2.126055	9	0.0624	Function is formatted correctly at 10% significant level
Statistical value F	4.520108	(1,9)	0.0624	

Source: Compiled by the authors

Table 29:
Results of verification of long-run equilibrium relationships among the variables in the period of Jan 2016 - June 2019

ARDL Bounds Test
Sample: 2017M01 2019M06
Included observations: 30
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	7.643181	1

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

Source: Compiled by the authors

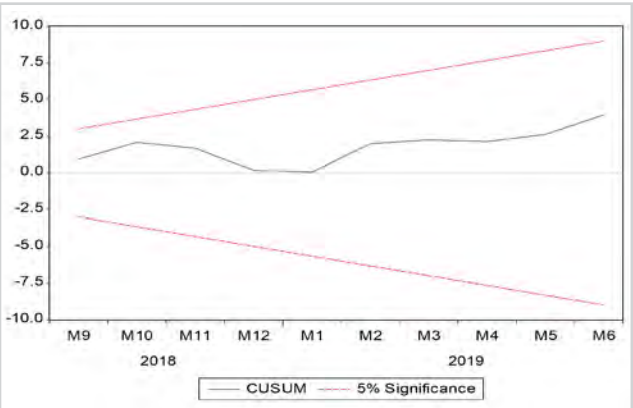

Figure 8:
Illustrating the cumulative sum of the residual of the model in Table 26 with a 5% significance level
Source: Compiled by the authors

Table 30:
Long-run equilibrium relationship among the variables in the period of Jan 2016 - June 2019

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(DER(-1))	0.246189	0.813860	0.302495	0.7685
D(DER(-2))	-0.245133	0.833693	-0.294033	0.7747
D(DER(-3))	-0.786649	0.785783	-1.001102	0.3404
D(DER(-4))	-1.223273	0.697356	-1.754157	0.1099
D(DER(-5))	-0.934273	0.502674	-1.858606	0.0927
D(DER(-6))	-0.361924	0.264486	-1.368404	0.2011
D(DWORLD_OIL)	-7.650282	5.367056	-1.425415	0.1845
D(DWORLD_OIL(-1))	-10.769793	5.650488	-1.905993	0.0858
D(DWORLD_OIL(-2))	-15.620284	6.220204	-2.511217	0.0308
D(DWORLD_OIL(-3))	-13.520052	5.019540	-2.693484	0.0226
D(DWORLD_OIL(-4))	-8.631672	4.955856	-1.741712	0.1122
D(DWORLD_OIL(-5))	-7.121918	4.093290	-1.739900	0.1125
D(DWORLD_OIL(-6))	-1.614010	4.387985	-0.367825	0.7207
D(DWORLD_OIL(-7))	-1.004663	5.457294	-0.184095	0.8576
D(DWORLD_OIL(-8))	-11.793906	6.569902	-1.795142	0.1029
D(DWORLD_OIL(-9))	-20.919633	7.417871	-2.820167	0.0182
D(DWORLD_OIL(-10))	-19.262263	7.735252	-2.490192	0.0320
CointEq(-1)	-1.548736	0.867112	-1.786086	0.1044

Cointeq = DER - (66.8566*DWORLD_OIL -31.3079)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DWORLD_OIL	66.856643	45.369286	1.473610	0.1714
C	-31.307896	39.582844	-0.790946	0.4473

Source: Compiled by the authors

WCOP may have either a positive or a negative impact on the REER. In the long term, in each period, the WCOP has a negative effect on the REER. This result is similar to the results by Jahangard, Daneshmand & Tekieh (2017), when using the same method to study the impact of the WCOP on the REER in Iran, a member of the Organisation of the Petroleum Exporting Countries. These results honestly reflect the practical situation of Vietnam as follows below.

Period of December 1986 - December 1990:

This is the pre-renovation period of the entire economy of Vietnam, not only of the monetary policy of the Vietnamese government. And this is also the harsh period for the State Bank. These five years are considered to be the climax stage of the comprehensive economic, political and social crisis lasting before the Sixth National Party Congress in 1986. In Vietnam's economy, the old relation of production system has hardly changed. This means that in the early years of reformation, Vietnam's nominal economy was still a unified socialist economy, the opening of the economy is almost nonexistent, so even in 1987, Vietnam started to export crude oil, however the exchange rate management policy was a fixed exchange rate regime, the experimental results reflected that there was no short-term impact of the world crude oil price on Vietnam's real effective exchange rate. However, in the whole period, there was still a long-run relationship between the world crude oil price and the real effective exchange rate.

Period of January 1991 - January 1999:

This is a period of successful development of Vietnam. The transition to a market economy changed the whole economy comprehensively. The 1993-1997 period was a period when Vietnam successfully controlled the inflation and the growth rate was rapid. However, the Asian financial-monetary crisis also slowed down Vietnam's economic growth. Although it reduced the price of the Vietnam dong, in essence, the objectives of these adjustments were completely different. Lowering the price of the Vietnam's dong during the Asian financial-monetary crisis was aimed at strengthening the competitiveness of Vietnam's exports against regional competitors. Due to the innovation, food production achieved miraculous results. Exploiting and exporting crude oil, Vietnam got out of the economic and social crisis, entered a stage of stability and development. The economy

Table 31:
Summary of the impact of the WCOP on the REER in Vietnam during the four periods

Period of time	In short term	During the entire period of time
Dec 1986 - Dec 1990	$DREER_t = 0.062322 * DREER_{t-1} - 0.023054 * DREER_{t-8} - 0.028454 * DREER_{t-9} + 0.093482 * DREER_{t-10} + u_t$. *The WCOP did not affect the REER, only the effective exchange rate of some months in the past affected the REER in the present.*	$DREER = -1.308121 * DWORLD\_GOLD - 4.40432$. *WCOP had an adverse impact on the REER.*
Jan 1991 - Jan 1999	$DREER_t = 0.249725 * DREER_{t-1} - 0.257698 * DREER_{t-4} + 0.268485 * DREER_{t-5} - 0.58207 * DWORLD\_OIL_t - 0.671065 * DWORLD\_OIL_{t-2} + u_t$. *In addition to the impact of REER in the past few months, WCOP of the month and two previous months had adverse effects on the REER.*	$DREER_t = -1.054522 * DWORLD\_OIL_t + 0.161581 + u_t$. *WCOP had an adverse impact on the REER.*
Feb 1999 - Dec 2015	$DREER_t = 0.313185 * DREER_{t-1} - 0.214441 * DREER_{t-2} - 0.073591 * DWORLD\_OIL_t - 0.040106 * DWORLD\_OIL_{t-1} + 0.047039 * DWORLD\_OIL_{t-2} + u_t$. *In addition to the impact of the REER in the last 2 months, the WCOP in the month and 2 latest months also had an impact on the REER.*	$DREER_t = -0.073939 * DWORLD\_OIL_t + 0.236626 + u_t$. *WCOP had an adverse impact on the REER.*
Jan 2016 - June 2019	$DER_t = -0.491322 * DER_{t-2} + 10.76979 * DWORLD\_OIL_{t-2} + 15.62028 * DWORLD\_OIL_{t-3} + 13.52005 * DWORLD\_OIL_{t-4} + 20.91963 * DWORLD\_OIL_{t-10} + 19.26226 * DWORLD\_OIL_{t-11} + u_t$. *In addition to the impact of the mean factual exchange rate in the last 2 months, the WCOP in some previous months also had an impact on the mean factual exchange rate.*	*WCOP had no impact on the mean factual exchange rate.*

Source: Compiled by the authors based on [21]

integrated with the world through a number of activities: in 1995, Vietnam joined the Association of Southeast Asian Nations (ASEAN) and implemented commitments on the ASEAN Free Trade Area (AFTA); in 1996, Vietnam joined the Asia-Europe Meeting; in 1998, Vietnam joined the Asia-Pacific Economic Cooperation (APEC). Experimental results in this period reflected a short-term impact of the world crude oil price on the real effective exchange rate of Vietnam. At the same time, there was a long-run relationship between the world crude oil price and the real effective exchange rate. This is an expression of Vietnam's level of integration into the world economy.

Period of Feb 1999 - Dec 2015:

This is a period when Vietnam actively integrated into the economy, culminating with the signing of the Vietnam-US Trade Agreement in 2001 and joining the World Trade Organisation in 2007. This is a period of real change in awareness of economic thinking, application of market economy and international integration. However, in 2008, Vietnam's economy slowed down, which was considered to have been caused by many reasons, including the 2007-2010 global financial crisis. The impacts of the world economy on the economy of Vietnam clearly expressed a deeper level of the integration of the Vietnamese economy, in which the world crude oil price was also an important world economic variable impacting domestic macroeconomic variables. Experimental results also show that in this period, both in the short and long terms, the world crude oil price had an impact on the real effective exchange rate in Vietnam. It can be seen that the exchange rate policy in the period February 1999 - December 2015 was more flexible than that in the period January 1991 - January 1999, which reduced the impact of the world crude oil price on the real effective exchange rate in Vietnam. It is reflected in the regression coefficients describing the lower impact of the world crude oil price on the real effective exchange rate in Vietnam in the period February 1999 - December 2015, more than that in the period January 1991 - January 1999.

Period of January 2016 - June 2019:

These three years is the turning point of Vietnam's foreign exchange market. On 31 December 2015, the State Bank of Vietnam issued Decision No. 2730 on the announcement of the central exchange rate of the Vietnam dong and the US dollar, and the cross-exchange rate of the Vietnam dong with regard to some other foreign currencies. The decision took effect on 4 January 2016. The central exchange rate is determined on the basis of referring to the evolution of the weighted average exchange rate on the interbank foreign exchange market, the evolution of the international market exchange rate of some currencies of countries with trade relations, borrowing, debt repayment, large investment in Vietnam, macroeconomic balances, and in accordance with monetary policy objectives. The central exchange rate is considered to be the official exchange rate at the closing time of the previous day with a certain margin decided by the State Bank, based on factors affecting market performance, and is taken as the transaction rate of the following day. There are 8 world currencies referenced to calculate the central exchange rate: the US dollar, the Chinese yuan, the European common currency, the Japanese yen, the Korean won, the Singapore dollar, the Taiwan dollar, and the Thai bath. The SBV has changed its strategy by adjusting up and down daily, instead

of securing as before. The result of this period shows that the world oil price has a strong impact on the actual average exchange rate in Vietnam. In some way, this is also a positive expression of the close relationship between the foreign exchange market and the world crude oil market. However, during the whole period (possibly due to the short period of research), no balanced relationship between the WCOP and the actual average exchange rate has been found in the entire period.

According to experiments, the WCOP is also an important indicator in forecasting and consideration the exchange rate policy. A further research direction for this study can be carried out, including an analysis of the impact of the WCOP on other Vietnamese macroeconomic variables, such as real GDP per capita, inflation rate, foreign direct investment, government Consumption, national savings and many others by applying the quantile regression method, panel data analysis or continuing to assess the impact of the WCOP on the REER in Vietnam in the period of 2016 onwards, when the new exchange rate policy has been applied.

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