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 ARDL 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 (ARDLM)

JEL Classification: C32; F31; O53; Q43

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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 аналізується 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. За періоди 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. На дану оцінку впливу на фактичний середній обмінний курс у В’єтнаму спостерігався у останній період (2016 рік – другий квартал 2019 року). Це підтверджує наявність тісного взаємозв’язку між валютним ринком і світовою ціною на сиру нафту. Коефіцієнт кointеграції має негативне значення.

Ключові слова: сирна нафта; ціна на сиру нафту; ціна на нафту; світова ціна на сирну 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 рассказывает 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, полученными в результате 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.

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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 m³ 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 m³ 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), Hamilton (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), Ferederer (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), Bjornland & 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 ARDL 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 ARDL 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:

\[ \text{REER} = \frac{\text{NEER} \cdot \text{CPI}}{\text{CPI}_{\text{annual}}} \]

where: REER is the real effective exchange rate of the country under study against a basket of currencies of trading partners; CPI is the consumer price index of the country under study, is the nominal effective exchange rate of the country under study,
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);

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

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:

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

where:

- $D$ is the difference operator; $\alpha_i, \beta_i$ 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

| Variable | Mean | Median | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | Janker-Bera Probability | Sum | Sum Sq. Dev. | Observations |
|----------|------|--------|---------|---------|-----------|----------|----------|------------------------|------|-------------|-------------|
| REER     | 1116.042 | 19.80612 | 323.3248 | 0.218750 | 0.0680000 | 0.0800000 | 0.091250 | 0.098832 | 9.985771 | 1116.647 | 11443245 | 326.2853 |
| WORLD_OIL | 206.2100 | 18.83000 | 558.7300 | 17.49000 | 0.523500 | 0.556000 | 0.576000 | 0.587739 | 7.973703 | 41.04959 | 11.9225 |
| D.REER   | 531.6900 | 53.91000 | 1219.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |
| D.WORLD_OIL | 531.6900 | 53.91000 | 1219.0000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 |

Source: Compiled by the authors in EVIEWS

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

| Variable | Statistical value | Test value according to probability | Conclusion |
|----------|-------------------|-------------------------------------|------------|
| REER     | -0.0973 | 0.0000 | Stationary |
| WORLD_OIL | -1.4688 | 0.0577 | Non-stationary |
| D(REER)  | -2.84127 | 0.0000 | Stationary |
| D(WORLD_OIL) | -9.31178 | 0.0000 | Stationary |

Source: Compiled by the authors

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

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
|----------|-------------|------------|-------------|--------|
| D(REER(-1)) | 0.064036 | 0.011452 | 5.591790 | 0.0000 |
| D(REER(-2)) | 0.001116 | 0.000750 | 0.0000 | 0.9934 |
| D(REER(-3)) | 0.011969 | 0.001440 | -0.146578 | 0.1407 |
| D(REER(-4)) | 0.015826 | 0.000750 | -2.043800 | 0.0450 |
| D(REER(-5)) | 0.012355 | 0.001440 | -0.844000 | 0.3999 |
| D(REER(-6)) | 0.012940 | 0.000750 | -1.658000 | 0.0975 |
| D(REER(-7)) | 0.007711 | 0.000750 | -1.046578 | 0.1407 |
| D(REER(-8)) | 0.002041 | 0.000750 | 0.0000 | 0.4600 |
| D(REER(-9)) | 0.002761 | 0.000750 | -2.043800 | 0.0450 |
| D(REER(-10)) | 0.009521 | 0.000750 | 1.279800 | 0.2000 |
| D(WORLD_OIL) | -3.21460 | 0.772199 | -4.179876 | 0.0000 |

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

Source: Compiled by the authors
Thus, the ARDL (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
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:

\[
D\text{REER}_t = -1.308121 \times D\text{WORLD OIL}_t - 4.40432 + u_t.
\]

4.2. Period of January 1991 - January 1999

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

Thus, the ARDL (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

Source: Compiled by the authors

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

Source: Compiled by the authors

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

Source: Compiled by the authors

Figure 3: Hannan-Quin’s criteria for the 20 best models in the period of Jan 1991 - Jan 1999

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:

$$\text{Table 16:}\hspace{1cm}\text{Long-run relationship between the variables in the period of Jan 1991 - Jan 1999}$$
DREER\(_t\) = – 1.054522 * DWORLD_OIL\(_t\) + 0.161581 + u\(_t\).

4.3. Period of February 1999 - December 2015
The ARDL 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 1\textsuperscript{st} and the 2\textsuperscript{nd} 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.
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:

\[ D_{\text{REER}} + 0.073939 \times D_{\text{WORLD\_OIL}} + 0.236626 + u_t. \]

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:

\[ D_{\text{REER}} + 66.856643 \times D_{\text{WORLD\_OIL}} + 31.307896 + u_t. \]

**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

Source: Compiled by the authors

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

Source: Compiled by the authors

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

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

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

Source: Compiled by the authors

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

Source: Compiled by the authors

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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.

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

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|--------------|------------|-------------|-------|
| D(STERL) | 0.246189     | 0.813860   | 0.302495    | 0.7685 |
| D(SAUD)  | -0.245133    | 0.836393   | -0.294033   | 0.7747 |
| D(IRAN)  | -0.786649    | 0.785783   | 0.1011   | 0.3040 |
| D(PHIL)  | -1.223273    | 0.697356   | 1.754157    | 0.1099 |
| D(INDO)  | -0.934273    | 0.502674   | 1.856607    | 0.0927 |
| D(EGYPT) | -0.361924    | 0.246486   | 0.362401    | 0.7163 |
| D(NIGER) | -0.760528    | 0.536705   | 1.342541    | 0.1845 |
| D(OMAN)  | -0.769973    | 0.504899   | 1.504899    | 0.1297 |
| D(IRAQ)  | -0.121983    | 0.092390   | 1.342541    | 0.1845 |
| D(DER)   | 0.246189     | 0.813860   | 0.302495    | 0.7685 |

**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

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|--------------|------------|-------------|-------|
| D(WORLD_OIL) | 66.856643 | 45.3692861 | 0.37605 | 0.1071 |
| D(STERL) | 0.310796    | 0.592844   | 0.302495    | 0.7685 |

Source: Compiled by the authors
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

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 | DRER = 0.062322 * DREER + 0.023054 * DREER + 0.028454 * DREER + 0.0019382 * DREER + u1 | DRER = 1.308121 * DWORLD_GOLD - 4.40432 |
| Jan 1991 - Jan 1999 | DRER = 0.249725 * DREER + 0.257698 * DREER + 0.268485 * DREER + 0.0369879 * DREER + u1 | WCOF has had an adverse impact on the REER |
| Feb 1999 - Dec 2015 | DRER = 0.311185 * DREER - 0.214461 * DREER + 0.073391 * DREER + 0.047493 * DREER + 0.0197626 * DREER + u1 | WCOF has had an adverse impact on the REER |
| Jan 2016 - June 2019 | DRER = 0.491322 * DREER + 10.769979 * DREER + 15.62928 * DREER + 13.52005 * DREER + 19.26226 * DREER + 0.236626 * DREER + u1 | WCOF had no impact on the mean factual exchange rate |

Source: Compiled by the authors based on [21]
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 considering 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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