Revisiting Exchange Rate Determination In Vietnam: Does Renewable Energy Matter?

Xuan Hoan Pham[1,*], Le Tung Duong Hoang[2,*], Xuan-Hoa Nghiem[3], , Ha My Nguyen[4]

[1] Faculty of Economics and Management, International School, Vietnam National University, Hanoi, Vietnam. Email: pxhoan@vnu.edu.vn

[2] Department of Academic Affairs, International School, Vietnam National University, Hanoi, Vietnam. Email: duonghlt@vnuis.edu.vn

[3] Faculty of Economics and Management, International School, Vietnam National University, Hanoi, Vietnam. Email: hoanx@vnu.edu.vn

[4] Mekong Research Development Institute. Email: myhnguyen265@outlook.com

[*]Corresponding author: pxhoan@vnu.edu.vn (Xuan Hoan Pham), duonghlt@vnuis.edu.vn (Le Tung Duong Hoang)

Abstract

In the last decade, there has been a tremendous growth in the trend toward environmental sustainability with the shift to renewable energy sources. Nevertheless, the fundamental question is whether using renewable energy could spur economic growth in general and Vietnam exchange rate in particular. This study aims to examine a number of determinants of exchange rate in Vietnam, with the emphasis on renewable energy. To investigate the issue, this study looks into six widely accepted determinants of exchange rate: Income, Money supply, Total reserves, Inflation rate, Brent crude oil price and Interest rate, and an addition determinant - Renewable energy consumption percentage. By employing unit root test, I attempt to illuminate the effect of all determinants on the rate of exchange, in either positive or negative direction. The estimated results reveal that in the short term, the use of energy from renewable sources in Vietnam has a significant and positive effect on the rate of currency exchange. In other words, a growth in the use of renewable energy in Vietnam will significantly cause the Vietnam's exchange rate to depreciate, which may result in a surge in Vietnam's exports and GDP growth. Therefore, it is recommended that Vietnam should encourage the transition to exploitation and utilization of renewable energy. This action will also promote a zero-carbon society in the near future.

Research purpose:

This study aims to examine a number of determinants of exchange rate in Vietnam, with the emphasis on renewable energy.

Research motivation:

While there have been several studies examining exchange rate in Vietnam, none of them has mentioned the role of renewable energy – an increasingly important factor in our daily life. This study is aimed at verifying whether renewable energy is important in determining exchange rate in Vietnam.

Research design, approach, and method:

This paper employs a quantitative approach in dealing with the topic. Specifically, this study employs time series method (unit root test, robust least squares regression) to examine important facotrs in determining the exchange rate in Vietnam. The period under investigation ranges from 1990 to 2022.

Main findings

Empirical results confirm that renewable energy plays a significant and increasing impact on the exchange rate. Other significant factors include income, money supply and oil price (which have similar effects) and foreign exchange reserves and lending interest rate (which have negative effects).

Practical/managerial implications

The significant and positive impact of renewable energy on exchange rate implies that higher energy consumption can lead to exchange rate depreciation which in turn, may prove beneficial to exports and ultimately economic growth. Therefore, renewable energy production and consumption should be encouraged to achieve both environmental and economic objectives.

Keywords: exchange rate, renewable energy, foreign exchange reserves, income, oil price, Vietnam.

1. INTRODUCTION

Since 1986, as part of the "Doi Moi" (Renovation) policies, the Vietnamese economy implemented a significant transition, from a centrally planned to a market-oriented economy (Le, 2008). Even though the Doi Moi was started in 1986, Vietnam did not carry out a full-scale transition toward a market economy until the spring of 1989. A proper exchange rate policy as well as stringent monetary and fiscal policies were the program's main pillars. The reforms consist of devaluing and unifying exchange rates, hiking nominal interest rates (which in turn, helped drive the real interest rates

from negative to positive levels), cutting down subsidies to State-owned enterprises, reining in public sector spending, holding back wage increases and spending on the State sector and State budget, and ceasing to print money to cover state budget deficits. A more innovative banking system was designed to substitute the outdated mono banking system, which operated with a two-tier banking system that distinguished between the managerial duties performed by state-owned banks and the commercial banks' business operations. Despite having an annual growth rate of 6.92% on average in the period from 1991 to 2020 (General Statistics Office-GSO, 2020), the economy of Vietnam has exhibited symptoms of diminishing and lagging behind other regional nations. The reason is that Vietnam's growth model is primarily resource-intensive rather than capital-intensive, which in turn, results in low efficiency and poor quality of growth (Nguyen, 2021). Following the outbreak of the COVID-19 pandemic by the beginning of 2020, Vietnam's economic development has suffered a substantially lower growth rate. The COVID-19 pandemic, according to the World Bank, caused a drop in Vietnam's GDP growth rate, from 7.02% in 2019 to 2.91% in 2020, then reached 2.58% in 2021. However, it is crucial to remember that Vietnam is among the few nations in the world enjoying positive economic development throughout this period (GSO, 2021).

In the new global economy, exchange rate has become a central issue for researchers to study. It plays an essential role in various aspects of economic performance. For example, international trade of a nation is directly impacted by exchange rates. A country's exports may become more competitive if its currency appreciated since they will be more affordable for overseas consumers. On the other hand, a more powerful currency may enable domestic customers to purchase imports at a lower cost, thereby increasing imports. A country's trade balance, or the ratio of imports to exports, is a key indicator of its economic health (Broll and Eckwert, 1999). Besides, exchange rates and inflation have been shown to be strongly related. A declining value of the currency may result in increased import costs, which might raise inflation. However, by lowering the price of imported products, an appreciating currency can control inflation rate. Nevertheless, in order to control inflation, central banks frequently keep an eye on currency rates (Ghosh et al., 1996). In addition, it is impossible not to mention the impact on government spending and revenue. The value of foreign transactions, including import and export taxes, can be affected by fluctuations in currency rates. Various studies have found that exchange rate devaluation helps to improves the government budget, however, not been confirmed for problem debtor countries (Reisen, 1990). When preparing their budgets, governments frequently take exchange rate swings into account

There is a growing body of literature that recognizes the importance of studying exchange rate's effect on the global economy in general, and Vietnamese economy in particular. Devaluation results in decline in the price of exports denominated in foreign currency, thus increasing demand for exports (Broll and Eckwert, 1999). At the same time, prices of imported goods denominated in local currency become higher, reducing demand for imported goods. Vietnam is in the process of integrating deeply into the international economy with tariff and quota barriers for trade protection being gradually removed, thus signaling the crucial importance of the exchange rate on Vietnam's trade balance (Vo et al., 2016). On the one hand, employment and economic growth can possibly be affected by exchange rates. Domestic industries and exports can benefit from a competitive exchange rate, which may accelerate economic growth and the creation of jobs. Notwithstanding, export-oriented sectors may face difficulties due to a strong currency (Yokoyama et al., 2015). For instance, due to the significant decline in the Taiwanese dollar and Japanese yen's value recently, Vietnamese laborers in both countries are receiving lower pay than they expected, which will probably cause domestic labor to rise dramatically, while export labor might decrease. It is not overstated that the exchange rate can exert significant effects on various aspects of the economy especially a developing one as Vietnam, necessitating an in-depth understanding of its determination.

With regard to the internal and external balances of the economy - including economic development, price stability and trade balance stabilization, the Vietnam Dong/USD exchange rate serves as an important tool of monetary policy[1]. In line with the comprehensive economic rehabilitation and renovation policies "Doi Moi" initiated in 1986, Vietnam's economic integration into the global economy has become increasingly advocated. (Tran, 2018). Several crucial bilateral and multilateral free trade agreements were inked and come into effect (such as the bilateral Vietnam-US FTA or the EVFTA), not to mention those that are still being negotiated. The liberalization of trade, investment, and capital flows is a common trend that reflects the goals of the trade agreements in which Vietnam is a signatory.

The exchange rate regime in Vietnam is managed float (de jure-which is self-declared by the SBV) or stabilized arrangement (de facto-which is classified by the International Monetary Fund - IMF). The foreign exchange rate fluctuates in accordance with the market's relationship between demand and supply, while the central bank intercedes to influence the exchange rate, but does not commit to keep the exchange rate at a constant level or any range of fluctuation around the central rate. The managed floating exchange rate regime is a compromise between the fixed exchange rate regime and the freely floating exchange rate regime. Therefore, it combines the advantages of both modes but at the same time has certain limitations. It has the advantage of a relatively stable exchange rate, thereby supporting global economic relations, fostering economic stability, ensuring the relative independence of exchange-rate policy and reducing the impact of external shocks on the financial system. However, in exchange for maintaining this regime, the central bank has to reserve an appropriate amount of foreign currency to intervene in the market when needed and to manage the extent of

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[1] According to the Law on State Bank of Vietnam (2010), the central bank in Vietnam (State Bank of Vietnam-SBV) has several tools to implement its monetary policy, including the exchange rate, re-financing, interest rates, reserve requirements and open market operations.

intervention; or else, it may become a fixed exchange rate regime. Since the early 1970s, research in determinants of exchange rate has passed through various stages in its development. Several researchers take the position that three categories of explanatory variables, including national price levels, interest rates, and the balance of payments have traditionally been the focus of exchange rate determination models (Taušer, 2007). In addition, a recent study by Tran and Dao (2020) was more detailed and explicit in defining exchange rate determination in the case of Vietnam, which focused on economic growth, inflation, oil price, balance of payment between Vietnam and other countries.

Based on the above-mentioned discussions, it can be noticed that most traditional theories focus on monetary factors while ignoring the roles played by non-monetary factors. Among non-monetary factors, the effects of renewable energy deserve greater attention because of the following reasons. First, the application of renewable energy to replace non-rechargeable sources of energy has become an indispensable trend. Coal, oil, and natural gas and other fossil fuels are only available in limited amount. This is due to the fact that, despite being generated by natural processes, they do not repopulate as fast as human activities consume. Fossil fuels will eventually run out, but the worse thing is that the process of extracting and producing them releases particles that are harmful to human health and contributes to greenhouse gas emissions. In addition to its ability to reduce carbon emissions, renewable energy may also bring about other benefits, ranging from economic growth to job creations. It is expected that the energy transition may lead to an increase in global employment, since more jobs being generated by increasing renewable capacity than being lost by gradually phased out fossil fuels. The fact that approximately 70 percent of employment in the oil and gas sector match the skills required for the energy transition offers even more expectation, which in turn can ultimately affect the exchange rate. Secondly, resilience of energy infrastructure and energy security are now top priorities in numerous energy programs due to significant changes in the energy markets and geopolitical unpredictability. Energy security is threatened by geopolitical unrest and upheavals, which are frequently accompanied by rising energy costs and restricted access to supplies. Renewable energy is less impacted since it is generated locally and minimizes the demand for energy imports. Thirdly, renewable energy technologies — solar and wind energy in particular — remain more affordable than fossil fuels around the world (REN21, 2022). As seen by the accompanying data, the levelized cost for renewable technologies is also continuing to drop quickly. With respect to the Vietnamese economy, as a developing nation, it may have to import certain renewable energy technologies as well as increase its investments in research and development (RandD) in renewable energy, which can affect the exchange rate. However, to the best of the author's knowledge, there exists few studies examining the effects of renewable energy on exchange rates and a study regarding Vietnam is missing. This study aims to close this gap in literature.

The remaining parts of this research proceeds as follows: Chapter 2 presents a comprehensive review of the literature on currency exchange rate determination theories and relevant empirical literature. Chapter 3 deals with model specification, data preliminary analysis and method used. Chapter 4 focuses on results discussion while Chapter 5 concludes the study, offers policy implications and discusses some limitations of this paper, as well as areas for future research.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. An overview of the Vietnamese economy

Prior to the 1980s, the Vietnamese economy suffered greatly from severe consequences due to several decades of war. Furthermore, in the 1980s, living circumstances had become deteriorating due to the economic system's inefficiencies. It was imposed upon the Vietnamese government to change its economic policies. This section reviews the major change in Vietnam's economic policy regarding monetary system and policy, especially those related to exchange rate.

Following the reunification in 1975, Vietnam's economy suffered greatly due to several factors such as high manufacturing costs, demand and supply mismatches, inefficient distribution and circulation, high rates of inflation, and mounting debt issues. In the postwar reconstruction phase, Vietnam is among the remarkable nations in in modern history to witness a significant decline in economy (The World Bank, 2023). Its economy, which was among the worst in the world throughout peacetime, was shown to be a negative to extremely sluggish growth in both total national income and industrial and agricultural production (Krueger, 2006).

In 1986, Vietnam initiated a renovation campaign (Doi Moi) which focused on both political and economic aspects, introducing changes to encourage the country's shift from a command economy to a market economy with a socialist orientation. The goal of this policy was to encourage foreign investment and the establishment of private corporations, especially foreign-owned corporations, by combining state planning with incentives from the free market. The Resolution No. 10 (issued on April 1988) on renovating agricultural management formally permitted household farmers to use the output contract system rather than just signing contracts based on various production stages, as had been the case since 1981. State-owned businesses (SOEs) were granted autonomy in doing business by the decision 217/HDBT, which also signaled the end of government support for SOEs.

In an effort to entice international investment into the nation, the government issued the International Investment Law in December 1987. By the end of 1988, the SOEs had to take bank loans and pay interest as they were no longer receiving capital from the government budget. The state building businesses were among the other operations that followed the same procedure. In addition to encouraging the private sector to engage in commercial activity, SOEs were

now subject to the same taxes as the private sector (before, SOEs paid a proportion of their earnings to the national treasury to recover the capital granted by the national budget). In order to handle the changing circumstances, the financial system was reorganized and reconstructed as well (Tran and Chau, 1998). By the end of 1990s, the achievements of Doi Moi's agricultural and commercial reforms became apparent. The number of private companies operating had surpassed 30 thousand, and the economy was expanding at a pace of over 7% annually, while the percentage of poverty had almost reached 50%. Throughout the 1990s, Vietnam's exports rose 20% to 30%. Amidst the economic crisis that stricken other Asian nations in 1999, Vietnam's total export value still grew by an impressive 23.4 percent, account for 40 percent of GDP—an outstanding achievement (World Bank, 2000).

By the beginning of 2020s, despite trade between with Vietnam and its main trading partners, along with a pandemic and the rising tendency in deglobalization, Vietnam's economy continues to be the best-performing in Asia. Since 2000, thanks to its increased concentration of highly qualified labor, Vietnam has been able to produce higher-value products with better-paying employment. In ten years from 2002 to 2022, the GDP per capita raised by 3.6 times, reaching about US$3,700. In addition, the rate of poverty dropped significantly, from 14% in 2010 to only 3.8% in 2020 (World Bank, 2023).

2.2. Vietnam's exchange rate system

Suffered from severe consequences from two vicious wars, in the mid-1980s, Vietnam was regarded among the world's poorest nations, before making strong developmental strides and achieve lower middle-class rank in 2010 (IMF, 2020). This section analyzes the pivotal point of monetary policy reforms, particularly those that affect the currency exchange rate and interest rates. Additionally, it highlights the existing issues the State Bank of Vietnam is now experiencing. Vietnam's economy has gone through crucial changes, from a highly centrally planned to a mixed economy since the mid-1980s during the Doi Moi period. Prior to the collapse of the Soviet Union, the Northern Vietnam and the reunified Vietnam were dependent on Communist assistance, whereas the Southern was dependent on US's aid (Prybyla and Jan, 1996). In order to remedy the circumstance, a political and economic regeneration effort (Doi Moi) was launched in 1986, including measures meant to make it easier to shift from a command (centrally planned) economy to a type of market socialism known as a "Socialist-oriented market economy." By mixing incentives from free-market with economic planning, Doi Moi promoted the establishment of private corporations involved in the production of consumer goods as well as foreign investment, particularly from foreign-owned enterprises.

Despite initial success, Vietnam confronted an economic crisis in 1986, marked by ongoing food shortages, escalating inflation, and significant shortfalls in the state budget and foreign trade (Vuong, 2014). The demand for change and reform that had been accumulating for several years reached a boiling point. Therefore, the government implemented a number of basic and significant initiatives to change the economy from a centrally planned, bureaucratic model to a more decentralized, market-oriented one. Vietnam's exchange rate (ER) system has undergone significant modifications in conjunction with the country's larger economic reform effort. Prior to 1989, a complex system of multiple fixed ERs was applied, including an official rate for international trade transactions, a rate for non-commercial transactions, a rate known as the "internal settlement rate" to make up for export enterprises' losses, and a different rate for money sent back home from abroad. In 1989, the State Bank of Vietnam announced a single official rate, replacing the several exchange rates (IMF, 1996). Commercial banks were permitted to establish their selling and buying rates within a span of +/- 5% of the officially stated rate, with a maximum bid-ask spread of 0.5%. By the end of 1990s, it was obvious that Doi Moi's corporate and agricultural reforms was a huge success. The economy was growing at a rate exceeding 7% per year (Pham and Hoang, 2009), Over 30,000 private corporations had been founded, and the poverty rate had been decreased by 50% (LoC, 2005). Vietnam achieved notable successes regarding GDP growth, increasing exports, inflation control and attracting foreign direct investment (FDI), particularly between 1989 and 1996 (Table II.1). After suffering from severe food shortages and importing roughly 500,000 tons of food per year between 1986 and 1988, Vietnam rose to become the third-largest rice exporter in 1989 and subsequently the second-largest exporter behind Thailand in the 1990s (Vo et al., 2000).

During the period 2008-2009, the Vietnamese government responded to these conditions by implementing several exchange rate policíe to lessen the Vietnam dong's downward pressure. Generally, the implementation of monetary policy was considered successful thanks to clear goals, flexible cooperation between regulators and coordinated implementation of monetary policy (Truong et al., 2020). However, the Vietnamese government's crisis response initiatives also have some limitations. For example, despite increasing liquidity in the credit market, lowering interest rates may not help domestic credit develop further, since businesses are impacted by sluggish domestic demand and declining exports (Pham, 2009). Besides, inflation and credit problems both carried significant potential risk. The overall means of payment and credit rose at an elevated level as a consequence of the monetary policy relaxation and support in interest rates, however, re-inflation pressure will be considerable in medium and long term (Xuan, 2011). With the application of VAR model, Tran (2018) highlighted the following significant aspects : first, the devaluation of Vietnamese dong has no discernible effect on economic growth, as well as no contribution to any considerable improvement in the trade balance, but causes the import price index to rise, which causes Vietnam's inflation; second, although the level of ERPT [2] to the

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[2] Exchange-rate pass-through (ERPT) is a measure of how responsive international prices are to changes in exchange rates.

import price index is quite large, it significantly decreases when transferred to the consumer price index, showing that the influence of currency rate volatility on inflation may be decreased if ERPT to the import price index is constrained.

2.3. Exchange rate determination

2.3.1. Empirical literature review of exchange rate determination in other countries

Generally, an exchange rate (also known as currency rate) is the rate at which, a national currency can be exchanged for another (Frieden et al., 2019). In the same view as Frieden, Vogler et al. (2019) defined exchange rates as the cost of one nation's currency relative to another. They can be indicated as either the rate at the conclusion of the period or as the average rate over a certain period of time.

A a considerable number of existing researches in the broader literature have examined the determinants of exchange rates (Isard, 1987; Kikumoto et al., 1996; Lee and Boon, 2007). According to Isard (1987), there were four well-known and traditional theories of exchange rate determination: balance-of payments, purchasing-power-parity theory, forward exchange theory, and the speculative run view. However, on the basis of both theoretical and empirical evidence, it is demonstrated that none of the first three hypotheses can adequately account for exchange rate behavior in short term (Isard, 1987; Castillo, 2002); on the other hand, at that time there was no appropriate model for forecasting exchange rates based on past data from the speculative-run perspective. A previous study concerning specifically the fluctuation of exchange rates by Kikumoto et al. (1996) had given priority to the range of real exchange rates, as well as its determinants. The results suggested that the profitability condition of firms had a significant impact on the range. At the same time, variables which have a considerable effect on the range of exchange rates include the demand for commodities and technical conditions. Therefore, these elements should be taken into account when determining a range of exchange rates.

Another point of view has been advanced by Bouraoui and Phisuthtiwatcharavong (2015), who attempted to investigate the connection between the fluctuations in the Thai Baht currency rate and the fluctuations in the basic principles. By examining six factors, the result suggested that both international reserves and terms of trade show a major positive and negative influence on THB/USD, respectively. On the other hand, the exchange rate seems not to be significantly affected by monetary base, manufacturing production index, interest rates differential and government debt. Despite the fact that this result appears consistent with prior research, this study cannot be considered as conclusive because it only considers the case of Thai's bath, while others other currency exchange rate was not addressed. These determinants may have varying impacts on currency rates depending on the situation of the markets in each country.

In an investigation into the effect of oil price on exchange rate, outstanding research by Beckmann et al. (2016) had utilised static and copula models to examine fluctuations over a 10-year period from 2003 to 2013, analysing concurrent relationship between the oil price in US and the exchange rates of 12 countries from two groups: oil-importer and oil-exporter. The finding provided further evidence that different effects may occur on the currency rate of the both two groups compared to the US dollar. For example, a greater level of short-term oil price may cause a country's currency to depreciate while pushing the equilibrium currency of oil exporters higher. Another study by Basher et al. (2012) investigated the influence of oil prices focusing on two distinct patterns of oil importers and exporters. The structural VARs testing approach was utilized to test the exchange rate's responsiveness to an oil supply and demand shock, based on monthly data in developing countries between 1988 and 2008. The findings suggested that there is a substantial possibility of short-term exchange rate fluctuations in developing countries due to abrupt changes in oil prices. Furthermore, a rising oil price can result in a devaluation of a country's currency, making the demand shock for oil a significant factor in the currency exchange between oil exporters and importers.

Among prior studies on exchange rate determinants, there exists a relatively little literature published on energy consumption as a determinant of exchange rate. For instance, the following study by Deka and Dube (2021) and Deka et al. (2021) strongly suggests that there is a reciprocal connection between the exchange rate and the use of renewable energy. The conclusion suggested that the exchange rate considerably increases as the usage of sustainable energy increases. According to the findings, in long-term, the application of sustainable energy has a negative impact on exchange rates (appreciation), while the rates of inflation and currency exchange have a positive impact on the consumption of sustainable energy. However, the effect of RE on currency rates varies from country to country, depending on whether a country imports or exports commodities necessary to exploit renewable energy (Deka et al.,2023). Despite decades of research, it can be assumed that no ideal model can reliably and exactly determine exchange rates (Nandrajog, 2019). Depending on the model's reliability and accuracy, different countries utilize different forecasting methods for exchange rates. However, much of the recent literature has not taken into account the direct and indirect impacts of renewable energy on the exchange rate in different countries. This study attempts to close this gap in the body of knowledge.

2.3.2. Exchange rate determinants in Vietnam

In Vietnam, the determinants of exchange rate have been discussed by a small number of authors in literature. In a same view with Isard (1987), Le (2015) highlighted the impact of economic components on VND/USD exchange rate, by application of balance of payment (BOP) approach, monetary and portfolio approach and purchasing power parity (PPP) approach on VND/USD exchange rate. The result suggested that inflation rate contributes significantly to the exchange rate determination, while price ratio, interest rate difference and BOP are insignificant. While Le (2015) focused on traditional determinants, Huy (2016) is more concerned with stock prices as a variable affecting exchange rate. By

applying several statistical tests, he has been able to show an unidirectional causal correlation between stock prices and USD/VND rates. A qualitative study by Tran and Dao (2020) reports that there is an obvious connection between macro variables and exchange rates, in both long term and short term. With the application of ARDL and ECM tests, she concluded that over both short and long time horizons, the change in total money supply has a significant impact on all three of the exchange rates. More specifically, money supply has an adverse effect on the Vietnamese currency against the other 3 currencies. Furthermore, trade balance and export activity have a significant impact on VND value relative to JPY and EUR, while have no correlation with the USD. Another study carried out by Nguyen et al. (2021) substantiates that GDP possesses a long-term impact on exchange rates, and interest rates also show a favorable impact on exchange rates. While a surplus current account of the balance of payment would restrain fluctuations in currency rates in long run, Reverses only negatively affected exchange rate volatility in the short run, but insignificant in long run.

2.4. Research objectives and research question

2.4.1 Research objectives

Following a thorough analysis of existing literature, this study observed that there have been a few discussions on the connection between currency exchange rate and the use of renewable energy. In addition, the literature is observed spanning only some restricted time periods, along with the conventional econometric methods to investigate the relationship between the aforementioned variables. Although a large amount of earlier research has examined sustainable energy in the relation to economic development and exchange rate globally, this study observed no empirical study that took place in Vietnam, which leaves a large gap in the scientific research. Furthermore, the results of previous studies in different economies are inconsistent, which results in difficulties in predicting the link between the two above-mentioned variables in the Vietnamese context. Therefore, this research attempted to close this gap by applying advanced and appropriate econometric approaches in order to obtain evidences more comprehensively.

In short, the purpose of this research is to contribute to the area of environmental finance and environmental sustainability in Vietnam by focusing on the roles/effects of renewable energy as a factor affecting the exchange rate. Specific research objectives include:

- From a theoretical perspective, this study attempts to explain the effect of renewable energy on exchange rates in Vietnam.

- From a practical perspective, this study offers suggestions for policy makers and corporations in Vietnam to promote economic growth, profits and sustainable development.

2.4.2. Research Question

For the purpose of achieving the aforementioned research objectives, this study attempts to look into the following two research questions:

1. Does non-monetary factor matter for exchange rate determination in Vietnam?

2. Do monetary factors matter for exchange rate determination in Vietnam?

In order to answer this question, this study first examines Vietnam's economic history since the adoption of the Doi Moi. After a thorough review of prior exchange rate theories and the empirical data, the author use several data frequencies to undertake an empirical analysis of the factors influencing exchange rates in Vietnam. Robust least squares (RLS) is applied to conduct regression analysis of some exchange rate's determinants in the context of Vietnam, with 8 variables taken into consideration: Nominal exchange rate, income, money supply, interest rate, inflation, total reserves, Brent oil price and Renewable energy. By adopting this model, the author would like to investigate the significance of variables, from which give an objective assessment of the impact of sustainable energy on Vietnam's exchange rate.

3. METHODOLOGY

3.1. Model specification for nominal exchange rate determination

By combining Dornbusch's (1976) model, Frenkel's (1976) flexible price model, Frankel's (1979) interest rate differential model and Nghiem (2020)'s exchange rate model, this study applies exchange rate formula as follow:

$$e^t = \alpha_0 + \alpha_1 e_{t-1} + \alpha_2 y_t + \alpha_3 m_t + \alpha_4 fx_t + \alpha_5 \pi_t^e + \alpha_6 oil_t + \alpha_7 l_t + \alpha_8 \Re_t \text{ (1)}$$

Where e^t denotes the nominal exchange rate at time t; y_t, m_t, fx_t, π_t^e, oil_t, l_t, $\Re_t$ stand for income, money supply, foreign exchange reserves, expected inflation, oil price, Lending interest rate and the proportion of renewable energy in the final total amount of energy used at time t respectively; εt is the error term.

The one-period lag of the exchange rate is introduced to correct for endogeneity or variable omission bias. The number of Vietnamese Dong (VND) per US dollar (USD) is used to indicate exchange rates, sourced from International Financial Statistics of IMF (IFS IMF).

There are a large number of variables that can be used as a proxy for income. However, when comparing the sizes of national economies, annual GDP totals are commonly utilized. Policymakers, business owners and market participants are more intrigued by fluctuations in the GDP over time, which are shown as the growth or contraction rate annually. Vietnam's GDP is sourced from World Bank Open Data (WB).

There is a variety of interest rates in an economy, and are good indicators of several factors, including the competitive environment, the terms governing loans and deposits, and the relative positions and statuses of creditors and debtors. In some economies, interest rates are determined by government decree or legislation. In economies with imperfect markets, it may be difficult to obtain statistics on interest rates that reflect real market transactions accurately, as well as when reported nominal rates do not accurately reflect effective rates. The lending interest rate is the bank rate that typically meet the private sector's demands for short- and medium-term funding. This rate is often varied based on the financing goals and the creditworthiness of the borrowers. However, the terms and conditions associated with these rates differ across countries, making them less comparable. Vietnam's lending rate is sourced from World Bank Open Data (WB).

3.2. Data and variable description

This section covers the definitions, sources, and measurements of the variables utilized in the model in Table 1 (subsection 3.2.1). In the subsection 3.2.2, basic descriptive statistics for these variables are shown in Tables 2. Next, the results from the PP and ADF unit root tests are presented in Tables 4. Subsequently, in subsection 3.2.3, the figures present the dependent variable (the VND/USD exchange rate) against independent factors are presented. Lastly, the calculation of expected inflation is discussed in subsection 3.2.4

3.2.1. Definitions and Sources of variables

The variables used in Equation (1) are described in Table 1 below.

Variable	Name	Explanation	Source
e	Exchange rate	Log of exchange rate measured as the number of VND per 1 USD (end of period)	WDI
y	Real income	Log of real GDP of Vietnam; Currency: USD	WB
m	Money supply	Log of money supply of Vietnam. Currency: USD (end of period)	IMF IFS
fx	Total reserves of Vietnam	Log of total reserves comprise holdings of monetary gold, special drawing rights, reserves of IMF members held by the IMF, and holdings of foreign exchange under the control of monetary authorities. Currency: USD	WB
π	Inflation rate	Prices, Consumer Price Index, All items, Percentage change, Corresponding period previous year of Vietnam; Percent	IMF IFS,
oil	Brent crude oil price	Log of Cushing, OK WTI Spot Price FOB (Dollars per Barrel)	EIA
l	Lending interest rate (%)	Lending interest rate of Vietnam (%)	WB
RE	RE consumption	Renewable energy consumption is the share of renewable energy in total final energy consumption (%)	WB

Table 1: Variable description and data sources

3.2.2. Descriptive statistics and Unit Root Tests Results

Table 2 Descriptive Statistics for Nominal Exchange Rate Model (Annually Frequency)

The table below presents descriptive statistics of the variables utilized in the model (described in Table 1) at the annually frequency, where e stands for nominal exchange rate, y, m, fx, π, oil, l, RE stand for income, money supply, foreign exchange reserves, expected inflation, oil price, Lending interest rate and share of renewable energy in total final energy consumption, respectively. N is the number of observations.

	e	y	m	fx	π	oil	l	RE
Mean	16939.31	161,180,163,623.49	13,575,515,6295.82	27,541,068,681.99	5.7722	51.27839	12.48624	47.3971
Median	16054	139,658,815,528.09	77,820,369,120.02	14,993,111,562.32	4.0846	48.66	10.46208	44.25
Maximum	23612	358,918,378,057.65	493,733,481,379.99	109,371,353,442.83	23.1154	99.67	32.1825	75.91
Minimum	8084.375	45,057,980,663.66	2,354,758,258.40	1,323,681,930.29	-1.7103	14.42	6.96	19.11
Std. Dev.	4654.845	9,410,831,2795.58	153,136,904,419.88	30,791,003,799.16	5.2412	28.79873	6.180894	16.89662
N	32	32	30	27	30	29	26	30
Source: Author's calculations					*Table 2: Descriptive Statistics*			

Table 3. Unit Root Test Results for Nominal Exchange Rate Model (Annually Frequency)

The table below presents the ADF and PP unit root test results for the variables used in equation (3.1) at annually frequency (based on a model with constant and trend). The optimal number of lags in ADF test is based on SIC; the bandwidth for PP test is selected based on Newey-West bandwidth. The variables are defined as follows: e stands for nominal exchange rate, y, m, fx, π, oil, l, RE stand for income, money supply, foreign exchange reserves, expected inflation, oil price, Lending interest rate and proportion of renewable energy in total final energy consumption, respectively. The N is the quantity of observations.

A. Level Form – Annual Frequency

	e	y	m	Fx	π	oil	l	RE
ADF	-1.0239	-2.2835	0.1458	-2.9238	-1.9042	-3.4554	-3.0319	-2.8242
(p-value)	0.9258	0.4276	0.9963	0.1717	0.6274	0.0636	0.143	0.2001
PP	-4.845	-1.668	0.2664	-2.4507	-1.9042	-3.5202	-2.9832	-2.6945
(p-value)	0.0025	0.742	0.9974	0.3477	0.6274	0.0558	0.1554	0.2457

B. First Difference form – Annual Frequency

	e	y	m	Fx	π	oil	l	RE
ADF	-12.3057	-5.033	-5.741	-4.3392	-4.8952	-5.2532	-6.212	-5.3667
(p-value)	0	0.0022	0.0003	0.0113	0.0026	0.0011	0.0002	0.0008
PP	-10.8077	-4.3016	-5.7815	-4.2362	-4.9371	-5.2547	-16.5196	-7.963
(p-value)	0	0.0096	0.0003	0.013	0.0023	0.0011	0	0

Source: Author's calculations   *Table 3: Unit root tests results*

Tables 2 presents the descriptive statistics for the nominal exchange rate models. The summary statistics are provided: mean, median, min, max, and standard deviation. Next, Tables 3 displays the ADF and PP test results for the stationarity of the variables, with p-values included in parentheses.

Table 4. RLS estimation results

This table presents empirical analysis of variables used in equation (3.1) at annually frequency; it presents the correlation coefficient values between the exchange rate (e) and dependent variable. $Rn2$ is the test of joint-significance of all variables in the model.

Method: Robust Least Squares

	e(-1)	y	m	fx	π	oil	l	RE
coefficient	0.0003	0.3704	0.0418	-0.0592	-0.0019	0.0053	-0.0025	0.0014
(p-value)	0.9265	0.0000	0.0000	0.0000	0.5527	0.0000	0.0000	0.0000

$Rn2$	0.625893		Adjusted $Rn2$		0.462222	

Source: Author's calculations   Table 4: RLS estimation results

4. RESULTS AND DISCUSSION

Results of the determinants of nominal exchange rate model are presented in Table 3. As can be seen from the table, renewable energy is highly significant at the 1% level, confirming the hypothesis that exchange rate in Vietnam is strongly influenced by renewable energy consumption. Its coefficient is 0.00145, suggesting that the use of renewable energy has a positive impact on Vietnam's exchange rate. More specifically, one percentage increase in the renewable energy consumption will result in a depreciation of 0.145% in the exchange rate, ceteris paribus. This result partly concurs with the data obtain by Deka et al. (2022) and Deka et al. (2023), who suggest that RE causes currency depreciation. Contrary to this result, previous studies by Deka and Dube (2021), Deka and Cavusoglu (2022), Deka, Cavusoglu and Dube (2022) demonstrated a positive effect of renewable energy. However, it should be noted that the relationships between exchange rate and RE may vary throughout countries (Deka et al., 2023).

The impact of Vietnam's income is still unclear, as this variable is insignificant at 1% level. Although the positive sign may imply a negative effect of Income on Vietnam exchange rate, it stays partly consistent with previous study by

Nguyen (2021), who found out that the effect of GDP is insignificant in short-run, and only significant in long-run.

The third variable is the money supply. Positive sign for this variable indicates that the hypotheses are supported. In fact, it is widely known that a shift in the domestic money supply leads to a rise in exchange rate from its current position (Dornbusch, 1976). The coefficient is 0.0418, indicating that one percent rise in money supply will lead to a 4.18% depreciation of Vietnam Dong. This finding is in agreement with Levin (1997) and Tran and Dao (2020), who point out that the domestic currency depreciates in response to money supply growth.

Next, the variable of total reserves is negative and significant at the 1% level, implying that growth of total reserves lead to domestic currency appreciation. It has coefficient of -0.0592, implying that when the total reserves of Vietnam increase by one percent, the Vietnamese currency is expected to appreciate by 5.92%, with other variables constant. These results reflect those of Nghiem (2020) who also found that rise in foreign exchange reserves causes Vietnamese dong to appreciate. However, this outcome is contrary to that Fukada and Kon (2007), who previously found that when the government increases its foreign exchange reserves, the real exchange rate depreciated.

According to the results of this study, inflation rate is highly significant at the 1% level, which implies that it has a great influence on Vietnam's exchange rate. The coefficient for this variable is -0.0019, suggests that with one percentage increase in the inflation rate, the exchange rate also appreciates by 0.19%. This result is in line with Nghiem (2020) that, an increase in inflation rate will lead to an appreciation in the domestic currency. Contrary to this result, Le (2015) demonstrated the efficacy a negative relationship, as the depreciation of the Vietnamese dong to the US Dollar may be driven by Vietnam's high inflation rate and the US's low inflation rate.

The next variable is Brent crude oil price. It should be noted that the result might differ between oil exporters and oil importers. The results show that it has a significant impact on exchange rate. The coefficient is 0.0053, suggests that when the oil price increases by one percentage, the exchange rate will depreciate by 0.53% as a result. In accordance with the present results, previous study by Beckmann et al. (2016) has demonstrated that the depreciations against the dollar are associated with a rise in the oil price for oil importers. A country's currency may lose value in response to increased oil prices; which implies that the demand shock for oil plays an essential role in the exchange of currencies between oil producers and importers.

Finally, the empirical finding suggests that lending interest rate has a significant relationship with Vietnam exchange rate at 1% level. The (-) sign implies that it has a negative impact on Vietnam's currency, while the coefficient of - 0.0025 suggests that, with every 1% increase in lending interest rate may lead to a 0.25% appreciation in Vietnamese dong. It is encouraging to compare this result with that found by Hüseyin et al (2019), who suggested that due to an increase in the value of the local currency, high interest rate differentials make it more appealing to international capital inflows, resulting from an appreciation of the local currency. This outcome is contrary to that of Schadler (1984), who found a positive and empirically significant correlation between movements in short-term interest rate differential between Japan and the United States and the dollar/yen exchange rate. This also accords with our earlier observations by Nguyen (2020), which showed that interest rate influence exchange rate and have a positive effect. However, this outcome is contrary to that of Le (2015) and Nghiem (2020) who found that interest rate does not show significant relationship with Vietnam exchange rate. These differences can be explained that other researches examine the interest rate difference between the two countries, instead of the domestic one.

5. CONCLUSION

5.1. Summary of the study

This study examines the potential determinants of Vietnam's nominal exchange rates using data at annual frequencies, with the emphasis on renewable energy. These determinants include income, money supply, total reserves, inflation rate, Brent crude oil price and interest rate, and renewable energy consumption. Based on the findings analyzed in the preceding section, there are some findings to summarize and discuss.

As can be seen from previous chapter, total reserve, inflation rate and lending interest rate are significant and negatively affect Vietnam exchange rate, which means that an increase in these variables will result in an appreciation in Vietnam's currency. On the other hand, the result revealed that money supply, oil price and renewable energy consumption possess a positive impact. Therefore, it can be concluded that that a rise in these variables will cause the value of Vietnamese dong to decline. However, unlike other research carried out in this area, income does not show significant relationship with exchange rate.

The major finding of this study is the confirmation about relationship between the consumption of renewable energy and Vietnam's exchange rate. It is interesting to find that an increase in renewable energy consumption leads to the depreciation of Vietnamese dong. This result is partly consistent with previous studies carried out in different countries (Deka et al., 2022; Deka et al., 2023). In fact, the use of renewable energy slightly increases throughout the period, however the demand for energy increases rapidly, which cause the percentage of renewable energy consumption over total energy consumption to decrease each year. As renewable energy can lead to exchange rate depreciation, which in turn, may encourage exports and GDP growth, the facilitation of renewable energy production and consumption may offer substantial benefits in terms of not only environmental protection but also export facilitation and economic growth.

It is not surprised that money supply has a positive impact on exchange rate, which means, growth in money supply may result in depreciation in Vietnamese dong. This can be attributed to the fact that when the SVB releases more Vietnamese dong into the market, more Vietnamese dong will be available for trading. This increase in money supply can result in a decline in the value of the Vietnamese dong against other currencies, assuming demand remains unchanged.

In addition, this study confirms that total reserves can negatively affect the exchange rate in Vietnam, implying that higher foreign exchange reserves will lead to Vietnamese Dong appreciation. It has been widely known that foreign exchange reserves are essential in order to sustain a country's monetary system and exchange rate. A country that has implemented a managed-float exchange rate system like Vietnam might leverage its foreign exchange reserves to secure a favorable exchange rate vis-à-vis the US dollar and stimulate export by offering goods at a premium over those manufactured in the US. To maintain the value of the home currency, reserves might be utilized to interfere in the foreign exchange market. Japan serves as a prime example of this, as its central bank has continued to purchase US Treasury bonds, therefore maintaining a very competitive exchange rate with the US dollar. As a result, the export sector of Japan's GDP has remained steady and grown at an increasing rate. When the domestic currency is facing a rapid depreciation, the central bank can buy back domestic currency by selling foreign currency. This helps avoid excessive volatility and severe drops in the value of the currency.

On the other hand, the lending interest rate was shown to have negative impact on exchange rate. In other word, an increase in Vietnam's lending interest rate results in an appreciation in Vietnamese dong. To put it simply, when interest rates rise, investors may become more interested in a currency and increase their investment in it. As a result, the currency's value rises due to the increased demand. In fact, since the policymakers have long recognized the relationship between interest rates and exchange rates, they have been sought ways to raise interest rates in an attempt to strengthen the domestic currency (Castillo, 2002). Governments should take measures, for example interest rate support policy, to hold the value of domestic currency.

The oil price, in the context of Vietnam, have a positive effect (imply that its increase causes exchange rate to depreciate) – which appears consistent with previous studies, since oil importer countries may suffer from depreciation. Traditionally, previous studies have in common the finding that high import dependence on oil increases an economy's susceptibility to oil price shocks. A rise in oil prices can result in an appreciation of the exchange rate in oil exporting countries, since the national's income increases; at the same time, it leads to a depreciation in oil importing countries (due to the inelasticity of oil demand and high oil-related expenditures).

5.2. Contributions of the research
5.2.1. Theoretical contribution

Regarding theoretical contributions, although there are a number of studies looking into the determinants of exchange rate, research on effect of renewable energy remains limited. Besides, Vietnam's exchange rate is often assumed associated with factors such as: Gross domestic product (GDP), inflation, Balance of payment and interest rate. In fact, some studies have taken the oil price as a factor of energy consumption (Le and Nguyen, 2011; Ngo et al., 2022), no prior studies have examined renewable energy as a variable that has an impact on exchange rate. According to the findings of this research, renewable energy consumption may have a positive impact on exchange rate, implying that the Vietnamese Dong will depreciate. To the author's best knowledge, this is the first study of exchange rate determination in Vietnam that takes the role of renewable energy explicitly into account. This result also holds practical significance as it may offer helpful recommendations for policymakers, businesses and researchers alike (to be discussed below).

This study also revisits the effects of traditional variables (such as money supply, interest rate, oil price, etc.) on Vietnam exchange rate. This result mostly corroborates the findings of prior research in this area that increase in money supply causes one nation's currency depreciate. Besides, the finding further support the idea of oil price's effect on exchange rate. In this case, the Vietnamese dong may suffer from devaluation as the oil price increases, which is in line with the fact that Vietnam is an oil-importing country. Total reserves, interest rate are reported to have significant and negative impact on exchange rate, which corroborate the findings of a great deal of the previous work (Hüseyin et al, 2019; Nguyen, 2020); Nghiem, 2020), but contrary to that of other researches (Schadler, 1984; Fukada and Kon, 2007; Le, 2015), who found. Nevertheless, contrary to expectations, this study did not find a significant relationship between the Income and exchange rate. Therefore, additional researches with a greater emphasis on income are recommended.

5.2.2. Practical contribution

The significant impact of renewable energy on exchange rate implies that higher renewable energy consumption can cause the Vietnam Dong to depreciate, which in turn, may boost exports and therefore GDP growth. Therefore, the production and consumption of renewable energy should be further encouraged by governments. Governments should take some measures, such as tax breaks and subsidies for solar energy installation, performance-based incentives and make public investments to encourage the use of renewable energy. As renewable energy can bring about substantial benefits in other aspects of the economy (increase job creation, reduce CO_2), the facilitation of renewable energy production and consumption is likely to lead to other side beneficial effects and should be strongly encouraged. Governments and policymakers are recommended to create favorable conditions for the research and development (R&D), implementation of renewable energy technologies. As the initial costs of installing renewable energy, the

government should provide subsidies for eco-friendly products, promulgate laws on the use and exploitation of energy as well as waste management and apply environmental taxes. At the firm-level, companies are strongly advised to increase their energy consumption from renewable sources such as solar energy, wind energy (harness from kinetic energy converters, farms, and turbines), and other alternative heating solutions, such as biomass boilers, air-source heat pumps, etc. Last but not least, households can also play an important role in driving sustainable economies, starting with the installation of renewable electricity supply (such as solar panel, air source heat pump, etc.), use eco-cleaning products and electric vehicles.

5.3. Limitations and future research direction

Despite the fact that this study certainly adds to our understanding of the renewable energy, it is inherited with certain limitations. First, as most of the variables are non-stationary at levels and stationary at their first-difference, these variables enter the model in their first-difference forms. This implies that the model is short-run only in nature. In the future, researchers may want to take into account the long-run interactions among these variables. Therefore, they can employ other models/methods such as autoregressive distributed lags model (ARDL), vector error correction model (VECM) to examine the long-run relationship among variables of interests.

Second, this paper only uses annual data. In future studies, researchers may employ higher frequency data such as quarterly or monthly to investigate the impact of renewable energy on exchange rate in greater details (when these data especially renewable energy are available at greater frequency). Third, this study only cares about the impact of renewable energy (and other variables) on exchange rate while ignoring the other way. Although the lag of the dependent variable is included in the model to account for possible endogeneity, future studies can apply different estimation techniques/models to check for the robustness of this study.

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