Exchange rate stability in the emerging economies: Does renewable energy play a role. A panel data analysis.

Abraham Deka (20203625@std.neu.edu.tr)
Yakin Dogu Universitesi https://orcid.org/0000-0002-7354-5744

Huseyin Ozdeser
Yakin Dogu Universitesi

Behiye Cavusoglu
Yakin Dogu Universitesi

Mehdi Seraj
Yakin Dogu Universitesi

Turgut Tursoy
Yakin Dogu Universitesi

Research Article

Keywords: Renewable energy, Environmental Kuznets Curve, Emerging economies, Exchange rate

Posted Date: January 28th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1197040/v1

Abstract

The Environmental Kuznets Curve alludes that there is an inverted U-shaped association between the economic growth of a nation and environmental stress. This implies that, as the Gross Domestic Product of a nation rises, environmental stress will initially rise and later decline after a turning point is reached. Rising economic growth together with an increase in environmental degradation necessitates a trade-off situation as nations face a dilemma regarding what to forego as both indicators are equally important. According to the literature, adopting the use of renewable energy helps mitigate this dilemma since it is friendly to the environment and also reduces income inequalities. The current study is aimed at investigating whether renewable energy use helps stabilize the foreign exchange rate of emerging economies. Stability in the foreign exchange rate of a nation is very crucial as this helps to stabilize the inflation rate. This study employs the Fully Modified Ordinary Least and Dynamic Ordinary Least Square methods to analyze panel data of emerging economies. FMOLS and DOLS provide robust results in the presence of cointegration among variables and on panel data that has aa unit root at level and is stationary at first difference. The Pedroni and Kao cointegration tests are employed and the results show that a long-run relationship exists among the variables examined. The study uses the results obtained from the DOLS model for policy recommendations since its results have no autocorrelation and Partial Autocorrelation problems, and the residuals are normally distributed. In this research study, we suggest that renewable energy should be promoted since it helps to stabilize the foreign exchange rate. An increase in Gross Domestic Product is also observed to promote exchange rate stability in the E7 economies, while a high rate of inflation, high population growth and trade are associated with currency depreciation.

Introduction

The Environmental Kuznets Curve (EKC) hypothesis, which was developed as a result of the work of Grossman and Kruger (1995), Seldon and Song (1994), Shafik (1994); and Stern, Common and Babbier (1996), is now considered to be a critical and strong foundation for ascertaining the relationship between environmental impacts and economic activities such as Gross Domestic Product (GDP). It was developed from the work of Kuznets (1955), who alluded that when a country moves from a low to a high-income level, then inequalities in income will initially rise and then decline, forming an inverted U-shaped relationship between economic growth and income inequality. The work of Kuznets (1955) later motivated other scholars such as Grossman and Kruger (1995), Seldon and Song (1994), Shafik (1994), and Stern, Common and Babbier (1996) to examine whether such a relationship exists between economic growth and environmental impacts and it was observed. Many other studies have thus far been conducted on this topic and the EKC hypothesis has been supported (see, for instance; Ma, Ahmad & Oei, 2021; Dietz, Rosa & York, 2012; Filippidis, Tzouvanas & Chatziantoniou, 2021).

The current study is motivated by the work of Filippidis et al. (2021) who postulated that Renewable Energy (RE) use helps in reducing income inequalities and the environmental stress of nations. Other scholars have also suggested that RE use is a major factor that plays a crucial role in reducing carbon dioxide (CO_2) emissions; hence, negative impacts on the environment are suppressed. If RE use has the significant effect of reducing income equality and greenhouse gas emissions, one could ask whether RE use may also help in stabilizing the exchange rates of nations. Currency depreciation is not healthy for nations as this erodes the buying power of the currency, thus causing inflation to rise. Thus, nations seek to keep their currencies as stable as possible. The studies by Deka and Dube (2021) and Deka, Cavusoglu and Dube (2021) attempted to ascertain the impact of RE use on the exchange rates in Mexico and Brazil and the findings indicated that RE use did have a significant effect on stabilizing foreign exchange rate.

Renewable energy includes sources such as hydropower, wind, biomass, solar power, geothermal, tidal and wave energy. Emerging economies have long started investing in renewable energy sources, as indicated by Salim and Rafiq

(2012). Fossil fuels provide more harm than good in the world due to their emission of CO2, which has the effect of causing global warming, and hence, climate change. Shahbaz et al. (2020) alluded that non-renewable resources emit large quantities of CO2 into the air, which causes the greenhouse effect; therefore, to reduce this effect, nations are encouraged to shift to the use of renewable energy sources. Salim and Rafiq (2012) reported that global warming concerns will lead to a reliance on renewable energy use in the future. In fact, one of the United Nations' goals is to promote net zero carbon by resorting to the use of renewable energy that is environmentally friendly.

Studies in the literature provide overwhelming evidence that RE reduces the emissions of CO2 released into the environment, thus reducing the global warming effect. The question of how RE consumption affects the economic activities of nations has been answered through the studies of (Chen, Pinar and Stengos, 2020; Chica-Olmo et al., 2020; Dogan, et al., 2020; Eren, Taspinar & Gokmenoglu, 2019; Ivanovski et al., 2021; Rahman & Vehayutham, 2020). Other studies have been conducted to analyze the impact of renewable energy on employment (see Ge and Zhi (2016)). The literature provides mixed results on the impact of RE consumption on economic growth, with some studies postulating a positive impact, some a negative impact and others allude that the relationship is not significant (Chen, et al. 2020).

The current research is an addition to the existing literature on the effects of RE use on currency exchange. Unlike past studies that have examined the impact of RE use on exchange rate, the current study examines this relationship among emerging economies popularly known as the E7 economies. The current study also differs from past studies in that it uses panel data of 7 emerging economies and makes use of cointegration regression methods in the presence of unit root, such as Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS). The FMOLS and DOLS models give robust long-run results on panel data that is cointegrated, not stationary at level and stationary at first difference. Hence, in this study, as there is cointegration among the variables and they are integrated of order one, these models are used. The Johansen and Kao cointegration tests are also applied to ascertain the long-run relationship among the variables, while the Augmented Dickey Fuller and Phillips Peron tests are used to check the unit root of the individual variables. Determinants of foreign exchange rate, including balance of payment (BOP), inflation rate, GDP, money supply, trade and population size, are also specified in the model to avoid endogeneity problems.

Literature Review

Environmental Kuznets Curve proposition

The EKC proposition alludes that an inverted U-shaped relationship exists between environmental impact and economic growth, see for instance, Grossman and Kruger (1995), Seldon and Song (1994), Shafik (1994), and Stern, Common and Babbier (1996). It follows that as the GDP of a nation rises, this is initially accompanied by more stress being imposed on the environment. The increase in environmental stress as economic growth increases continues until a certain point known as the turning point, after which any further increases in the GDP of a nation will reduce environmental stress (Grossman and Kruger, 1995; Seldon and Song, 1994; Shafik, 1994; and Stern, Common and Babbier, 1996). The EKC proposition was conceived from the work of Kuznets (1955), who postulated that a rise in a nation's GDP is first accompanied by rising income inequalities up until a turning point is reached, after which any further increases in the GDP will reduce income inequalities. Thus, there is initially a positive relationship between economic growth and income inequality, which later becomes negative.

Moreover, Dietz, Rosa and York (2012) postulated that the shape of the EKC is due to the shift by countries from sources of energy that degrade the environment, such as fossil fuels, to the use of energy sources that are friendly to

the environment, such as RE. Thus, an increase in GDP is first accompanied by a rise in environmental impact since the sources of energy used to achieve economic growth are non-renewable, and once nations change and adopt RE use, then any increase in GDP will not tend to result in environmental degradation. Nations seek to achieve a high rate of growth of GDP, and at the same time, want to preserve a clean and safe environment. Thus, if a rise in GDP is accompanied by environmental degradation, then the nation faces a trade-off situation (Dietz, et al., 2021). This trade-off situation can be best solved by adopting RE sources of energy that are less harmful to the environment. Fillipidis et al. (2021) concurred with Ma et al. (2021) that the use of RE sources of energy tends to reduce income inequalities and CO2 emissions.

The Nexus between Economic Indicators and Renewable Energy

It is of paramount importance that the impact of RE consumption on economic activities is studied, since nations are shifting to RE use to curb the negative effects of fossil fuels on the environment. Several studies have been undertaken to examine how RE impacts economic growth in various nations and mixed results have been observed (Chen, Pinar and Stengos, 2020; Chica-Olmo et al., 2020; Dogan, et al., 2020; Eren, Taspinar & Gokmenoglu, 2019; Ivanovski et al., 2020; Smolovic et al., 2020; Wang & Wang, 2020; Rahman & Velayutham, 2020). The studies by Wang and Wang (2020) and Chen et al., (2020) on Organization for Economic Cooperation and Development (OECD) countries found that RE consumption has a significant positive impact on economic growth. These findings were supported by the studies of Smolovic et al. (2020) and Chica-Olmo et al. (2020), who observed that in Europe, RE positively impacts economic growth. Therefore, this indicates that an increase in RE consumption will increase the growth of economies. Thus, in addition to reducing the greenhouse effect, RE significantly improves nations' economic growth. Therefore, RE consumption has double-positive effects and nations should be encouraged to use it. Another study by Dogan et al. (2020) that employed Quantile regression analysis showed that for lower and low middle quantiles, RE positively affects economic growth and that the effect becomes negative in middle, high middle and higher quantiles. The study results also indicated that RE has a negative impact on economic growth across all quantiles (Dogan et al., 2020).

Moreover, other studies have suggested that economic growth causes RE consumption, (Rahman and Velayutham, 2020; Sadorsky ,2009). Rahman and Velayutham (2020) found a unidirectional causality from economic growth to RE consumption in five Asian countries, while Sadorsky (2009) determined that economic growth has a positive impact on RE consumption in emerging economies. Therefore, we observe that increases in the growth of an economy cause RE consumption to increase. Thus, if economies are growing and improving economically, this will improve the consumption of RE. Hence, economic growth should be encouraged in emerging economies and other nations to enhance RE consumption, which will in turn result in a reduction in CO2 emissions and global warming effects. Eren, Taspinar and Gokmenoglu (2019) also found a bidirectional relationship between economic growth and RE in India. This implies that economic growth impacts RE, and RE also impacts economic growth. Financial development is also found to cause RE (Eren et al., 2019), while RE is also found to positively impact employment in developing and developed countries (Ge and Zhi, 2016).

Additionally, several other researchers have been recently conducted to ascertain the association between RE use on the one hand and exchange rate and inflation rate on the other (Deka & Dube, 2021); Deka, Cavusoglu and Dube, 2021). The association between RE use and currency exchange has been found to be negative and significant, indicating that relying on the use of RE has the effect of stabilizing the nation's foreign exchange rate (Deka & Dube, 2021; Deka, Cavusoglu & Dube, 2021). The association between RE use and inflation rate has been observed to be significant and positive, indicating that RE use has the tendency to increase the prices of products in a nation. This is

because RE sources are more expensive than non-renewable sources. Thus, governments should intervene by providing subsidies on the production of RE.

Nexus between foreign exchange rate and other economic indicators

The relationship between exchange rate and economic growth has been examined in the studies by Fraj, Hamdaoui and Maktouf (2018), Ribeiro, McCombie and Lima (2020), Tang (2015), and Papanikos (2015). Exchange rate appreciation (currency overvaluation) negatively affects economic growth (Papanikos, 2015), whereas exchange rate undervaluation, or depreciation, has the effect of increasing the growth of nations since this stimulates technological progress and knowledge spillovers (Ribeiro et al., 2020). They showed that to enhance economic growth, the currency should not be overvalued as this will hinder growth. In China, low real exchange rates have not induced any growth benefits (Tang, 2015).

However, Wesseh and Lin (2018) postulated that in Liberia, the depreciation of the Liberian dollar has caused the Gross Domestic Product (GDP) to fall, indicating that currency depreciation negatively impacts economic growth. The findings of Wesseh and Lin (2018) concurred with Ribeiro et al., (2020) that currency undervaluation has the effect of raising income inequality, which will harm output growth. This shows that currency appreciation should improve an economy's growth, and thus, nations should improve and maintain their currency values.

The studies by Deka and Dube (2021), and Deka, Cavusoglu and Dube (2021) examined the relationship between foreign exchange rate and inflation rate. In the case of Mexico, Deka and Dube (2021) ascertained that there is a significant positive link between the nation's rate of currency exchange and its rate of inflation. This shows that currency depreciation will tend to cause a high rate of inflation and currency appreciation stabilizes inflation rate in the country. Deka, Cavusoglu and Dube (2021) also supported the findings of Deka and Dube (2021) that the two indicators are positively related. This is in line with the postulations of the Relative Purchasing Power Parity theory by Fisher (1930), which states that a high inflation rate causes currency depreciation. Therefore, any factors that stabilize the exchange rate will indirectly stabilize the rate of inflation, and vice versa.

Data And Methodology

Data and sample

In this research study, we specify the variables exchange rate, inflation rate, RE, BOP, GDP, money supply, population size and trade of the emerging economies for the period 1990 to 2019. The data employed in this study is secondary data and is retrieved from the official website of the Organization for Economic Cooperation and Development (OECD), www.oecd.org. In this study, we use a study sample of seven countries known as the emerging seven (E7 economies): China, India, Brazil, Mexico, Russia, Indonesia and Turkey.

The exchange rate is the price of one country's currency expressed as a ratio of that of another country. Thus, the exchange rate shows the value of one country's currency related to that of other countries. The exchange rate values used in this study are expressed as the home currency per one United States dollar. Thus, an increase in the exchange rate causes a depreciation of the home country's currency and vice versa. Inflation is a continuous increase in a country's goods and services and is not suitable for the country's economy since it erodes the currency's buying power. RE is referred to as the contribution of renewables to the total primary energy supply, and it comes in the form of hydro, tidal, geothermal, wind, solar and wave sources. Money supply is the total amount of money available in circulation in the money market and in this study, the number of notes and coins (M1) in circulation is taken to

represent money supply. GDP refers to the total value of all products produced within the boundaries of a country and is measured in million dollars. Population size is the number of people currently residing in a country. Balance of payment is the current account record of one nation's international transactions with those of other countries in the world and trade in goods and services is the transactions in goods and services between residents of a country and non-residents.

Method

Based on the findings of Deka and Dube (2021), and Deka, Cavusoglu and Dube (2021) who found a significant link between currency appreciation and the use of RE, in this study, we seek to further examine whether the association really holds. Cointegration Regression analysis, including Fully Modified Ordinary Least Square (FMOLS) by Phillips and Hansen (1990) and Dynamic Ordinary Least Square (DOLS) by Stock and Watson (1993), is used as the study methodology to ascertain the relationship between exchange rate as the dependent variable and the explanatory variables (RE, GDP, BOP, money supply, population size, trade and inflation rate) of the E7 economies. The FMOLS and DOLS models provide robust long-run results on panel data that is cointegrated, not stationary at level and stationary at first difference. Hence, in this study as there is cointegration among the variables and they are integrated of order one, we employ these models. FMOLS and DOLS are cointegration regressions that require two essential prerequisites to be met: the variables should be non-stationary at level and stationary at first difference (integrated of the same order 1) and they must have at least one cointegration equation.

In this study, we employ the Augmented Dicker Fuller (ADF) test and Phillips Peron (PP) test to check the stationarity of the variables (Box & Jenkins, 1976; Granger, 1986; Engle & Granger, 1987). The ADF test was pioneered by Dickey and Fuller (1979), and it is an extension of the Dickey test developed by Dickey (1976). The Dickey test is only capable of checking the stochastic trend of a variable but not the deterministic trend and the ADF test can identify both stochastic and deterministic trends in a time series (see Gujarati, 2004). The other test of unit root in a variable is the PP test by Phillips and Peron (1988). The PP test is used together with the ADF test for robustness (Gujrat, 2004; Granger, 1986). Granger (1986) and Engle and Granger (1987), suggested that if the variables are non-stationary at level and stationary at first difference, then a relationship such as Z_t exists that is stationary, and this is known as the cointegration relationship. Granger (1986) stated that if variables Yt and X_t, are connected through a relationship that contains a constant term, then the following cointegration relationship that is stationary will be obtained.

$Z_t = Y_t - aX_t \sim I(0)$ (1)

Where Z_t is the cointegration relationship between Y_t and X_t that is stationary at level, and **a** is a unique constant term connecting Y_t and X_t, in a cointegration relationship, see Granger (1986). The relationship expressed in Equation 1 above may contain some seasonal problems (Granger, 1986). However, another relationship such as the one below may exist that has no seasonal issues.

$Y_t = aX_t$ (2)

If variables are cointegrated, this means that a long-run relationship among them exists. They have a long-run association, and this association can be ascertained by employing cointegration regressions such as FMOLS and DOLS models, among others. For this study, the following equation (Equation 3) represents the statistical representation of the cointegration regression (FMOLS and DOLS) used in this study. Equation 3 below shows the statistical relationship between the exchange rate and the explanatory variables employed. In this study, we used the exchange rate as the explained variable.

$ER = \beta_0 + \beta_1 RE + \beta_2 INFL + \beta_3 BOP + \beta_4 MS + \beta_5 GDP + \beta_6 PP + \beta_7 TRD + e_t$ (3)

In Equation 3 above, ER represents the exchange rate, RE is the renewable energy, INFL represents inflation rate, BOP is the balance of payment, MS is the money supply, GDP is the Gross Domestic Product, PP is the population size, TRD is the trade of goods and services and et is the error term, while β0 to β7 are the model's coefficient values.

Data analysis

Descriptive statistics

The results of this study's descriptive statistics are provided in Table 1. The total number of observations per each variable, exchange rate, balance of payment, inflation, RE, money supply, trade, GDP, and population size is 210. In Table 1, we also provide the mean, median, maximum, standard deviation and total value of every indicator under study. It is shown that in the E7 economies for the period under study, the average values of BOP, exchange rate, GDP, inflation, money supply, population size, RE and trade are -0.1191, 1190, 9164.9, 58.77, 39.97, 454.16 21.38 and 20.6. respectively (see Table 1 below). Moreover, their Sum values are -25.02, 249903, 1924649, 12341.7, 8393.4, 95373.75, 4490.34, and 4426.14, respectively. For the median, maximum, minimum and standard deviation values of the indicators under study, please see Table 1 below.

Table 1
Descriptive statistics results

	BOP	ER	GDP	IFL	MS	PP	RE	TRD
Mean	-0.1191	1190.0	9164.9	58.77	39.97	454.16	21.38	20.60
Median	0.00	8.49	8624.5	6.95	22.5	182.14	18.14	22.57
Maximum	10.35	14236.9	29189	2947.7	170.6	1433.8	46.71	48.19
Minimum	-8.82	0.00	0.00	-1.40	0.00	55.12	0.00	0.00
Std. Dev.	2.87	3259.3	7489.34	294.15	41.99	498.51	14.80	9.72
Sum	-25.02	249903	1924649	12341.7	8393.4	95373.75	4490.34	4326.14
Obs.	210	210	210	210	210	210	210	210

Correlation analysis

Table 2 below provides the correlation results of exchange rate, balance of payment, inflation, RE, money supply, trade, GDP, and population size for the E7 economies. The results of the correlation analysis show that population size is negatively correlated with inflation rate and GDP and positively correlated with BOP. Furthermore, the results provided in Table 2 indicate that money supply is negatively correlated with BOP and inflation rate, while it is positively correlated with GDP and population size. RE use is negatively correlated with BOP, inflation rate, GDP, and money supply, but positively correlated with exchange rate, and population size. Trade is also negatively correlated with inflation rate, population size and RE use, but positively correlated with BOP, exchange rate, GDP and money supply. A negative significant correlation shows that the variable has an inverse association such that a rise in one variable will cause a decline in the other, whereas a positive significant correlation implies that the variables move in the same direction such that a rise in one causes the other to rise as well.

Table2: Correlation results

Correlation t-Statistic	BOP	ER	IFL	LGDP	LPP	MS	RE	TRD
BOP	1.000							

ER	-0.0536	1.0000						
	-0.6954	----						
IFL	-0.0202	-0.0829	1.0000					
	-0.2623	-1.0792	----					
LGDP	-0.0702	-0.0913	-0.0577	1.0000				
	-0.9119	-1.1886	-0.7495	----				
LPP	0.2596	0.0171	-0.3555	-0.6268	1.0000			
	3.4837***	0.2212	-4.9294***	-10.4269***	----			
MS	-0.1480	0.0735	-0.3796	0.5199	0.1409	1.0000		
	-1.9398*	0.9549	-5.3189***	7.8902***	1.8447*	----		
RE	-0.3086	0.4089	-0.1280	-0.3297	0.203000	-0.0104	1.0000	
	-4.2049***	5.8082***	-1.6729*	-4.5269***	2.6871***	-0.1348	----	
TRD	0.3109	0.2158	-0.0453	0.2010	-0.0520	0.0518	-0.4263	1.000
	4.2402***	2.8646***	-0.5888	2.6597***	-0.6761	0.6724	-6.1082***	----
***significant at 1% level								

Unit root test results

In this section of the study, we provide the findings of the ADF and PP unit root tests. In Table 3 below, the results of the unit root test are given for all the variables that have been employed in this research, including exchange rate, balance of payment, inflation, RE, money supply, trade, GDP, and population size. The findings of both ADF and PP tests show that all variables are stationary at first difference, and hence, they are integrated of order one. They are non-stationary at level and become stationary after first difference. It is only inflation rate that is stationary at level at 1% level of significance according to the results of both tests. However, it is stationary again at first difference. Cointegration regressions such as FMOLS, DOLS, VECM require that variables should be stationary at first difference (Granger, 1986); Engle and Granger, 1987).

Table 3
Unit root test results

	ADF		PP	
	level	*First Difference*	*level*	*First Difference*
ER	11.1195	41.9224***	9.96939	65.6024***
RE	6.02590	27.9352**	2.65510	37.5590***
lnGDP	11.2178	27.0733**	5.24613	99.4086***
lnPP	10.1000	29.2318**	269.945***	43.6814***
IFL	31.5105***	93.5171***	43.6471***	93.5171***
BOP	7.54456	41.9177***	8.14009	88.8733***
MS	26.6199*	33.5923***	12.2573	46.7127***
TRD	16.3276	61.5499***	14.0176	126.053***
***significant at 1% level				

Cointegration analysis

In this study, we employ the Johansen and Kao cointegration tests to analyze the cointegration relationship among the variables specified in the research model of this study. Table 4 below shows that for both the trace test and max-eigen test, the variables of exchange rate, balance of payment, inflation, RE, money supply, trade, GDP, and population size are significantly cointegrated at 1% level of significance. This is because the p-values of both the Trace test and max-eigen test are less than 0.01, indicating that the variables are cointegrated at 1% level. The results of the Kao cointegration test also show that we should reject the null hypothesis of no cointegration and accept that the variables are cointegrated. This shows that exchange rate, balance of payment, inflation, RE, money supply, trade, GDP, and population size have a long-run relationship (Granger, 1986); Engle and Granger, 1987); Granger and Weiss, 1983). Therefore, the variables move together in the long run.

Table 4
Cointegration test results

Johansen Fisher Panel Cointegration Test			Kao Cointegration Test
Hypothesized No. of CE(s)	*Trace test)*	*Max-eigen test*	*t-Statistic*
None	325.9***	73.52***	-2.901470***
At most 1	189.9***	106.7***	
At most 2	228.6***	107.2***	
At most 3	141.5***	68.58***	
At most 4	86.98***	40.74***	
At most 5	55.29***	32.74***	
At most 6	33.34***	24.63***	
At most 7	27.14***	27.14***	
***significant at 1% level			
*significant at 10% level			

FMOLS and DOLS results

At this juncture, we have ascertained that the variables under study are integrated of the same order I(1), and they are cointegrated, indicating that they have a long-run relationship (Granger, 1986); Engle and Granger, 1987). In Table 5 below, we provide the FMOLS and DOLS results. In this model, for both FMOLS and DOLS, exchange rate is the explained variable, while balance of payment, inflation, RE, money supply, trade, GDP, and population size are the explanatory variables. The results of the FMOLS model in Table 5 below show that BOP, inflation rate, population size and money supply have a significant positive impact on the foreign exchange rate of the E7 nations. Therefore, when BOP, inflation rate, money supply and population size increase in these nations, then this will have the effect of causing a depreciation in the nation's currencies. When the inflation rate of a nation rises, its currency will tend to depreciate; thus, our results concur with the Relative Purchasing Power Parity theory of Fisher (1930). The results also support the findings of Deka and Dube (2021) and Deka, Cavusoglu and Dube (2021), who alluded that a high inflation rate has the effect of depreciating the nation's currency and vice versa. Additionally, an increase in money supply is seen to cause currency depreciation in the E7 nations; thus, it should be kept a minimum level as printing too much money is not healthy for the economy since it triggers demand pull inflation. Population size should also be kept at normal levels to ensure stability in the currency exchange, since overpopulation will result in a struggle for limited and scarce resources, leading to a crisis.

The results in Table 5 below also show that GDP, RE use and trade have a significant negative association. It follows that an increase in the Gross Domestic Product of the E7 economies will result in a decrease in their foreign exchange rate, indicating that economic growth in the E7 nations tends to encourage appreciation of the currency value. This is a good sign for the E7 nations as there is no dilemma faced in trying to achieve a high growth rate and stabilize the currency at the same time. RE use is also observed to have a significant negative effect on foreign exchange rate in the emerging economies, showing that increased use of RE has the effect of encouraging currency appreciation. These findings support the results of Deka and Dube (2021), and Deka, Cavusoglu and Dube (2021), who alluded that RE use enhances currency appreciation. Therefore, the use of RE should be encouraged in the emerging economies

since it contributes towards the stabilization of the currency value. Trade is also seen to encourage appreciation of the currency exchange value in the E7 nations.

Table 5
FMOLS and DOLS results

	FMOLS		DOLS	
	Coefficient	*t-Statistic*	*Coefficient*	*t-Statistic*
BOP	91.0124	6.9028***	-0.0458	-0.9033
IFL	18.9255	10.2581***	0.0705	6.0982***
LGDP	-1499.777	-12.7779***	-4.0602	-7.0136***
LPP	8242.744	13.5037***	27.8472	2.5143*
MS	7.3445	5.6770***	-1.4605	-0.0007
RE	-158.6387	-14.5778***	-0.0475	-2.3985*
TRD	-51.2979	-8.9636***	0.1056	3.8863**
R-squared	0.9089		0.998953	
Adjusted R-squared	0.9010		0.994068	
Long-run variance	85739.60		0.000193	
Dependent variable: Exchange rate				
***significant at 1% level				
**significant at 5% level				

To verify the results of FMOLS in this study, we also employ the DOLS model. The results of the DOLS model are given in Table 5 above. The results of DOLS concur with the FMOLS results that inflation rate and population size in the emerging economies positively raises the exchange rate value. Therefore, low levels of inflation rate in these nations tend to encourage stability in the currency exchange value and low population size also brings stable foreign exchange values as opposed to overpopulated nations where people scramble for resources. The findings of the DOLS model in Table 5 above also concur with those of FMOLS that GDP and RE use has a strong negative association with currency exchange value. An increase in the use of RE will help to lower the currency exchange value in the E7 nations, hence causing the currency to appreciate (Deka and Dube, 2021; Deka, Cavusoglu and Dube, 2021). However, the findings of the DOLS model indicate that exchange rate does not have any significant association with BOP and money supply in the E7 economies and that trade rather has a significant positive association with foreign exchange rate.

Residual Diagnostic testing

To test for the validity, robustness and reliability of the findings provided above by the FMOLS and DOLS models, residual diagnostic testing is performed. We employ the Correlogram of residual test and Correlogram of residual squared test to check if the model's residuals are free from Autocorrelation and Partial Autocorrelation problems. We also employ the Jarque-Bera Normality Test to check if the model's residuals are normally distributed. In Table 6 below, the results shows that the FMOLS model suffers from Autocorrelation and Partial Autocorrelation problems. The statistics values are greater than the critical values and the p-values are less than 1% significant level showing that the

model has Autocorrelation and Partial Autocorrelation problems (Gujarati, 2004; Deka & Resatoglu, 2019). Moreover, the residuals of the FMOLS model are not normally distributed. Thus, the results of the FMOLS model are not reliable and valid.

However, the t-Statistic residual diagnostic results in Table 6 below for Autocorrelation and Partial Autocorrelation are less than the critical value and the p-value is greater than 5% significant level showing that we can accept the null hypothesis that there are no Autocorrelation and Partial Autocorrelation problems in the DOLS model. Furthermore, the Jarque-Bera Normality Test results shows that we should accept the null hypothesis that the residuals are normally distributed. Thus, the DOLS model provides valid, reliable and robust results since it has no Autocorrelation problems and the residuals are normally distributed. Hence, when drawing conclusions and giving policy recommendations in this research, we use the results given by the DOLS model.

Table 6
Residual Diagnostics results

	FMOLS		**DOLS**	
Lag	*Autocorrelation*	*Partial Correlation*	*Autocorrelation*	*Partial Correlation*
Correlogram of Residuals				
1	0.645***	0.645***	-0.356	-0.356
2	0.386***	-0.050***	-0.075	-0.231
3	0.151***	-0.134***	-0.142	-0.311
4	-0.115***	-0.254***	-0.244	-0.608
5	-0.125***	0.169***	0.531**	0.028**
6	-0.129***	-0.024***	-0.219**	-0.250**
Correlogram of Residuals Squared				
1	0.816***	0.816***	-0.209	-0.209
2	0.539***	-0.383***	0.168	0.131
3	0.296***	0.001***	0.249	0.326
4	0.154***	0.089***	-0.292	-0.238
5	0.107***	0.063***	0.262	0.083
6	0.108***	0.010***	-0.321	-0.297
Normality Test				
Jarque Bera	813.21***		0.1389	
Dependent variable: Exchange rate				
***significant at 1% level				
*significant at 10% level				

Conclusion

The Environmental Kuznets Curve alludes that there is an inverted U-shaped association between the economic growth of a nation and environmental stress (Grossman and Kruger, 1995; Seldon and Song, 1994; Shafik, 1994; and Stern, Common and Babbier, 1996). This implies that as the Gross Domestic Product of a nation rises, environmental stress will first rise and later decline after a turning point is reached. Rising economic growth together with an increase in environmental degradation leads to a trade-off situation as nations face a dilemma on what to forego as both indicators are equally important (Dietz et al., 2021). According to the literature, adopting the use of renewable energy helps to resolve this dilemma since it is friendly to the environment and also reduces income inequality (Fillipidis et al., 2021; Ma et al., 2021).

The Johansen Fisher Panel and Kao cointegration tests were employed and the results show that a long-run relationship exists among the variables examined. The study employed the Fully Modified Ordinary Least and Dynamic Ordinary Least Square methods to analyze panel data of the emerging economies. The study also used the results obtained from the DOLS model since its results have no autocorrelation and Partial Autocorrelation problems, and the residuals are normally distributed. We show that in the emerging economies, there is no significant association between foreign exchange rate on the one hand and BOP and money supply on the other. A high rate of inflation is also observed to promote currency depreciation and this supports the Relative Purchasing Power Parity theory postulated by Fisher (1930). High population size and trade cause a significant depreciation in foreign exchange rate. This is because when the population rises, overcrowding may occur and a scramble for scarce resources occurs. High economic growth and increased use of RE are also observed to stabilize foreign exchange rate as the currency tends to appreciate due to an increase in GDP and RE in the emerging economies. It follows that an increase in the use of RE sources will encourage stability in exchange rate (Deka & Dube, 2021; Deka, Cavusoglu & Dube, 2021). These findings can be generalized to nations with the same economic conditions as the emerging economies under study. In the future, more studies should be done to examine how renewable energy consumption affects the exchange rates of various countries with different economic conditions to those of the emerging economies. This study can also be extended by employing different models such as panel Autoregressive Distributive Lag (ARDL) model, panel VECM among many more.

Declarations

Funding

No funding was received from any organization.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The data used in this paper is secondary data and were retrieved from the Organization for Economic Co-operation and Development (OECD) website www.oecd.org

Ethical Approval

Not Applicable

Consent to Participate

Not Applicable

Consent to Publish

The authors guarantee that this manuscript has not been previously published in other journals and is not under consideration by other journals. The authors also guarantee that this manuscript is original and is their own work.

Authors Contributions

AD: Conceptualization, Methodology. **HO:** Editing, Supervision. **BC:** Writing - original draft, Software. **MS**: Data curation, Writing – review. **TT:** Visualization, Investigation.

References

1. Box GE, Jenkins GM (1976) Time series analysis: Forecasting and control San Francisco. *Calif: Holden-Day*
2. Chica-Olmo J, Sari-Hassoun S, Moya-Fernández P (2020) Spatial relationship between economic growth and renewable energy consumption in 26 European countries. Energy Econ 92:104962
3. Chen C, Pinar M, Stengos T (2020) Renewable energy consumption and economic growth nexus: Evidence from a threshold model. Energy Policy 139:111295
4. Deka A, Cavusoglu B, Dube S (2021) Does renewable energy use enhance exchange rate appreciation and stable rate of inflation?.*Environmental Science and Pollution Research*,1–10
5. Deka A, Dube S (2021) Analyzing the causal relationship between exchange rate, renewable energy and inflation of Mexico (1990-2019) with ARDL bounds test approach. Renewable Energy Focus 37:78–83. https://doi.org/10.1016/j.ref.2021.04.001
6. Deka A, Resatoglu NG (2019) forecasting foreign exchange rate and consumer price index with ARIMA model: The case of Turkey. International Journal of Scientific Research and Management 7(8):1254–1275
7. Dickey DA (1976) Estimation and hypothesis testing in non-stationary time series
8. Dickey DA, Fuller WA (1979) Distribution of the estimators for autoregressive time series with a unit root. J Am Stat Assoc 74(366a):427–431
9. Dietz T, Rosa EA, York R (2012) Environmentally efficient well-being: Is there a Kuznets curve? Appl Geogr 32(1):21–28
10. Dogan E, Altinoz B, Madaleno M, Taskin D (2020) The impact of renewable energy consumption to economic growth: a replication and extension of Inglesi-Lotz (2016). *Energy Economics*, *90*, 104866
11. Engle RF, Granger CW (1987) Co-integration and error correction: representation, estimation, and testing.*Econometrica: journal of the Econometric Society*,251–276
12. Eren BM, Taspinar N, Gokmenoglu KK (2019) The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. Sci Total Environ 663:189–197
13. Filippidis M, Tzouvanas P, Chatziantoniou I (2021) Energy poverty through the lens of the energy-environmental Kuznets curve hypothesis.*Energy Economics*,105328
14. Fraj SH, Hamdaoui M, Maktouf S (2018) Governance and economic growth: The role of the exchange rate regime. International economics 156:326–364
15. Ge Y, Zhi Q (2016) Literature review: The green economy, clean energy policy and employment. Energy Procedia 88:257–264

16. Granger CW (1986) Developments in the study of cointegrated economic variables. In *Oxford Bulletin of economics and statistics.*
17. Granger CW, Weiss AA (1983) Time series analysis of error-correction models. Studies in econometrics, time series, and multivariate statistics. Academic Press, pp 255–278
18. Grossman G, Krueger A (1995) Economic growth and the environment. Quart J Econ 110:353–377
19. Gujarati DN (2004) Basic econometrics
20. Ivanovski K, Hailemariam A, Smyth R (2020) The effect of renewable and non-renewable energy consumption on economic growth: Non-parametric evidence.*Journal of Cleaner Production*,124956
21. Kuznets S (1955) Economic growth and income inequality. Am Econ Rev 45(1):1–28
22. Ma X, Ahmad N, Oei PY (2021) Environmental Kuznets curve in France and Germany: Role of renewable and nonrenewable energy. Renewable Energy 172:88–99
23. Papanikos GT (2015) The real exchange rate of euro and Greek economic growth. The Journal of Economic Asymmetries 12(2):100–109
24. Phillips PC, Hansen BE (1990) Statistical inference in instrumental variables regression with I (1) processes. Rev Econ Stud 57(1):99–125
25. Phillips PC, Perron P (1988) Testing for a unit root in time series regression. Biometrika 75(2):335–346
26. Rahman MM, Velayutham E (2020) Renewable and non-renewable energy consumption-economic growth nexus: new evidence from South Asia. Renewable Energy 147:399–408
27. Ribeiro RS, McCombie JS, Lima GT (2020) Does real exchange rate undervaluation really promote economic growth? Struct Change Econ Dyn 52:408–417
28. Sadorsky P (2009) Renewable energy consumption and income in emerging economies. Energy policy 37(10):4021–4028
29. Salim RA, Rafiq S (2012) Why do some emerging economies proactively accelerate the adoption of renewable energy? Energy Econ 34(4):1051–1057
30. Selden TM, Song D (1994) Environmental quality and development: is there a Kuznets curve for air pollution emissions? J Environ Econ Manag 27:147–162
31. Shafik N (1994) Economic development and environmental quality: an econometric analysis.*Oxford economic papers*,757–773
32. Shahbaz M, Raghutla C, Chittedi KR, Jiao Z, Vo XV (2020) The effect of renewable energy consumption on economic growth: Evidence from the renewable energy country attractive index. Energy 207:118162
33. Smolović JC, Muhadinović M, Radonjić M, Đurašković J (2020) How does renewable energy consumption affect economic growth in the traditional and new member states of the European Union? Energy Reports 6:505–513
34. Stern DI, Common MS, Babbier EB (1996) Economic growth and environmental degradation. World Dev 24:1151–1160
35. Stock JH, Watson MW (1993) A simple estimator of cointegrating vectors in higher order integrated systems.*Econometrica: Journal of the Econometric Society*,783–820
36. Tang B (2015) Real exchange rate and economic growth in China: A cointegrated VAR approach. China Econ Rev 34:293–310
37. Wang Q, Wang L (2020) Renewable energy consumption and economic growth in OECD countries: A nonlinear panel data analysis. Energy 207:118200

38. Wesseh PK Jr, Lin B (2018) Exchange rate fluctuations, oil price shocks and economic growth in a small net-importing economy. Energy 151:402–407