Pakistan Journal of Commerce and Social Sciences
2022, Vol. 16 (1), 70-98
Pak J Commer Soc Sci

Heterogeneous Effects of Financial Development on Renewable Energy Consumption: Evidence from Global Dynamic Panel Threshold Approach

Muhammad Tariq Majeed (Corresponding author)
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: tariq@qau.edu.pk

Zubia Hussain
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: zubia@eco.qau.edu.pk

Article History

Received: 12 Jan 2022 Revised: 27 Mar 2022 Accepted: 29 Mar 2022 Published: 31 Mar 2022

Abstract

A transition from conventional energy sources to renewable energy (RE) sources remains an important concern of the present world. This transition, however, largely depends upon financial sources required for start-up investments, operating costs, and advanced infrastructure. However, an important question arises as to what is the threshold level of financial development (FD) that can boost RE consumption. To answer this, the present study empirically investigates the relationship between FD and RE consumption considering the nonlinear effects of FD. The study used broad money, domestic credit to the private sector, and domestic credit to the private sector by banks as proxy variables of FD from 1970 to 2020 at a global level of 173 countries. The study employed the econometric techniques of pooled OLS method, fixed effects, random effects, and Driscoll and Kraay regression. Additionally, the dynamic panel threshold technique is utilized to obtain the threshold value of FD for robust and reliable analysis. The analysis confirmed the presence of a U-shaped association between FD and RE consumption. The results suggest that all measures of FD boost RE consumption after reaching a certain threshold level of FD. Moreover, economic growth, urbanization, industrialization, and trade showed a significant impact on RE consumption. The study offers unique insights on threshold values of alternative measures of FD for environmental policy designs.

Keywords: Financial development, renewable energy consumption, scale effect, technique effect, threshold variable, dynamic panel threshold regression, urbanization, industrialization.

1. Introduction

One of the main challenges faced by the present world is the protection of the environment from numerous mankind activities such as rapid economic growth, industrial expansion, rising competition, and excessive energy consumption. The effects of such activities, particularly extensive energy consumption, are reflected in the poor quality of the earth's environment. According to Ge et al. (2020) energy sources particularly, heat generation, electricity, transportation, and construction make up to 75% of global greenhouse gas emissions. Energy sources based on fossil fuels contribute to environmental degradation by escalating carbon emissions. In this situation, the transition from fossil fuels to renewable energy (RE) is increasingly becoming important all over the world (Majeed & Luni, 2020). The energy transition not only supports environmental preservation but also helps in managing non-renewable energy sources' depletion. Nevertheless, the energy transition is challenging owing to various financial barriers such as credit constraints, start-up costs, advanced infrastructure, and high operating costs. Moreover, the RE initiatives carry certain risks associated with liquidity, refinancing, return, and transmission loss. These risks hinder the deployment of RE projects.

The development of the financial sector acts as a main driving force for the deployment of RE sources (Assi et al., 2021; Eren et al., 2019; Shahbaz et al., 2021). Theoretically, the scale effect concept implies that a growing financial sector decreases the demand for RE sources as initially, production depends upon fossil fuels. Contrary to this, FD also enhances the demand for RE deployment through the provision of loans, credits, capital distribution, and investment funding. FD escalates energy transition by providing capital funding, offering huge investment opportunities, and supporting the transfer of clean technology. Despite the rising role of RE sources in protecting the environment little is known about the impact of FD on RE consumption. The literature has mainly focused on the association between FD and total energy consumption, overlooking RE consumption. For instance, studies such as Sadorsky, (2011), Zang et al., (2011), Coban & Topcu, (2013), and A-Mulali & Lee, (2013) have evaluated the impact of FD on total energy consumption. However, less attention is devoted to examining the role of FD in determining RE consumption (Wu & Broadstock, 2015; Kutan et al., 2018; Eren et al., 2019; Shahbaz et al., 2021).

Another issue with the limited existing studies is that the available empirical evidence is conflicting. Some studies have provided evidence of the positive effects of FD on RE consumption (Wu & Broadstock, 2015; Eren et al., 2019; Ji & Zhang, 2019). Contrary to this, some studies have supported the negative contribution of FD to RE consumption (Wang et al., 2021). Thus, such conflicting empirical outcomes signal the existence of a threshold value of FD responsible for its heterogeneous effects on RE consumption. Theoretically, the effect of FD on RE consumption can be divided into two phases. The first phase represents the influence of FD on RE consumption through the scale effect. This effect suggests that a growing financial sector boosts such economic activities which mainly rely on non-renewable energy sources. After reaching a certain threshold level further growth in the financial sector triggers the technique effects which transits the fossil fuels-based productions towards RE sources. Thus, initially, FD reduces RE demand and

after reaching a threshold point it enhances the RE demand, portraying a non-linear relationship between FD and RE consumption.

In addition, this non-linear relationship is better estimated with the help of threshold analysis. The dynamic threshold analysis plays a major role in splitting the observations into two regimes following the estimated value of the threshold. Moreover, the estimated value of the threshold variable provides the benchmark for policymakers to split the impact of explanatory variables on the response variable. Such analysis is helpful for future targeting of economic goals. Another issue with the existing studies is the scope of empirical studies. Most studies have provided a country-specific analysis (Ji & Zang, 2019; Eren et al., 2019; Pata, 2018) or evidence from a small group of economies (Kim & Park, 2016; Anton & Nucu, 2020) which cannot be generalized globally.

The present study fills the existing gap in the previous knowledge pool by exploring the impact of FD on RE consumption by using global data. This study employs three measures of FD to provide a clearer picture and a comparative understanding of the influence of FD on RE consumption. These measures are domestic credit to private sectors, domestic credit to private sectors by the bank, and broad money. This work investigates the influence of FD on the rising portion of RE consumption as part of total energy consumption in the case of 173 countries. Besides, this study contributes to the existing literature in the following ways. First, to the best of the author's knowledge it is the first study that analyses the role of FD with its three measures in RE consumption in the case of global data of 173 countries as no study has used these three measures of FD for global data. Second, this is the first research that has investigated the link between FD and RE consumption by utilizing a different econometric approach which is the dynamic panel threshold model.

The current study attempts to address the following research questions: First, does FD influence the consumption of RE in global data? Second, do the different measures of FD affect RE consumption differently? Third, is the effect of FD on RE consumption financial regime dependent? Fourth, is there any threshold value of FD responsible for its different impacts on RE consumption?

In the literature, threshold models are widely used for estimating the non-linearities among economic variables. The basic intuition behind the dynamic threshold model is to identify whether regression equations remain the same across all sample observations or fall into separate groups/regimes. This model is helpful in detecting the unknown threshold variable which splits the data into two regimes. Thus, based on this threshold level, one can detect the reaction of the variable of interest to the response variable in one regime by comparing it with another. Estimation of dynamic panel threshold model treats threshold variable as endogenous. Thus, we can observe the effect of the threshold variable on the response variable with its different slope coefficients in different regimes. This model is more valid than other regression models for the following reasons: First, it identifies the specific value of the unknown threshold variable that acts as a turning point in showing the impact of the explanatory variable on the response variable. Second, estimates based on threshold models are more consistent as compared to other quadratic regression models and slope of regressors estimators converge at a standard square-n rate. Based on this analysis, the main implication of this work is that the impact of FD on RE consumption is threshold specific.

The remaining study is arranged as follows: the next section provides the literature review consisting of theoretical and empirical support for our analysis. Section 3 consists of data and methodology and Section 4 reports the data analysis containing results of statistical and econometric techniques. Section 5 provides the conclusion of the research work.

2. Literature Review

The rising amount of greenhouse gases in nature, owing to rapid industrialization and anthropogenic activities, is creating hazards to the environment (Majeed & Mazhar, 2019). The core factor behind these emissions is energy consumption which is largely based on conventional energy sources. The transition towards clean energy sources is the prime concern of the present world. Nevertheless, the transition is quite slow as this sector faces financial constraints. This section compiles the literature on economic growth and financial development as the core factors of RE consumption.

2.1 Economic Growth and Renewable Energy Consumption

An ample body of the literature has explored the association between economic growth and total energy consumption (see, for example, Ozturk et al., 2010; Pao & Tsai, 2010; Belke et al., 2011; Akkemik & Goksal, 2012; Stern & Enflo, 2013; Caraini et al., 2015). Theoretically, the following hypotheses have been proposed to assess the relationship between economic growth and energy consumption (Apergis & Payne, 2011): First, the feedback hypothesis represents the presence of a bidirectional relationship between economic growth and energy consumption. Second, the growth hypothesis suggests the presence of unidirectional causality from energy consumption to economic growth. Third, the conservative hypothesis indicates the presence of unidirectional causality from economic growth to energy consumption. Fourth, the neutrality hypothesis shows the absence of any causality between economic growth and energy consumption.

On the empirical front, numerous studies have explored the relationship between economic growth and total energy consumption. For instance, Ozturk et al. (2010) provided evidence of the conservative hypothesis in low-income countries and the feedback hypothesis in middle-income countries in the selected sample of 51 countries from 1971 to 2005. Similarly, Amin & Alam, (2018) investigated the relationship between energy consumption and sectoral output in Bangladesh over the period 1980-2014 and supported the presence of a conservative hypothesis. Kasperowicz (2014) explained the link between electricity consumption and economic growth from 2002 to 2012. Their study outcome supported the feedback hypothesis in Poland.

Besides, the literature has established an association between economic growth and RE consumption. In this respect, Destek & Aslan, (2017) analyzed the relationship between economic growth and both renewable and non-renewable energy consumption in 17 emerging economies over the time ranging from 1980 to 2012. The bootstrapping panel causality analysis revealed the heterogeneous outcomes of different hypotheses depending upon sampled economies. The results predicted the existence of the growth hypothesis in Peru, conservative hypothesis in Colombia and Thailand, feedback hypothesis in Greece and South Korea, and neutrality hypothesis in the remaining 12 emerging selected economies. Another work by Bilgili & Ozturk, (2015) reported the existence of a growth

hypothesis in G7 countries from 1980 to 2009 and a study by Alper & Oguz (2016) confirmed the presence of a neutrality hypothesis in a few countries while the growth hypothesis is validated in a sample of European Union (EU) countries.

Similarly, on the other side, the literature also portrays the picture of the positive, negative, or insignificant role of economic growth on RE consumption. For instance, the work of Sadorsky (2009a) and Sadorsky (2009b) reported a positive impact of economic growth on RE consumption. Contrary to this, the work of Shahbaz et al. (2021) and Ergun et al. (2019) reported the negative effect of economic growth on RE consumption. The work of Attiaoui et al. (2017), however, reported the insignificant role of economic growth in explaining RE consumption. Thus, by studying literature, we can confer that the relationship between economic growth and RE consumption is unsettled and, therefore, further research is required.

2.2 Financial Development and Renewable Energy Consumption

FD is considered the core factor that influences the transition mechanism from fossil fuels to RE sources as it overcomes the various challenges associated with financing. Theoretically, the following channels are helpful in explaining the link of FD with total energy consumption (Sadorsky, 2011). First, the direct effect channel suggests that an efficient financial sector enhances financial resource availability which leads the consumers to afford durable products easily, increasing the demand for energy. Second, the business effect channel postulates that a growing financial sector enhances the affordable provision of financial capital for businesses, enhancing economic activities and demand for energy. Third, the wealth effect channel shows that a growing financial sector, particularly the stock market, improves the trust of firms and consumers in the financial sector, thereby increasing indirectly demand for energy. Collectively, these channels suggest that FD and ED are positively associated. However, these channels do not clarify the type of energy demand. Particularly, it remains unclear whether FD is associated with the RE concept.

In this respect, Meadows (1972) offers a link between FD and the type of energy demand. Rising FD leads to the increasing economic activities in the economy that results in rising conventional energy demand as already existing firms try to meet up their production with increased demand and new firms enter the market also utilize the existing method of production than adopting the new one. This is referred to as the scale effect of FD. However, the rise in FD also leads to more investment opportunities for such projects which are more energy-efficient and environmentally friendly by reallocating the resources (Samreen & Majeed, 2020). In effect, this outcome is referred to as the composition and technique effects that result in rising demand for RE consumption. Flow chart 1 depicts the proposed channel. Decomposition of scale and technique effects motivates the authors to provide empirical evidence. The past literature is short of any work which relates the FD with RE consumption under the threshold approach.

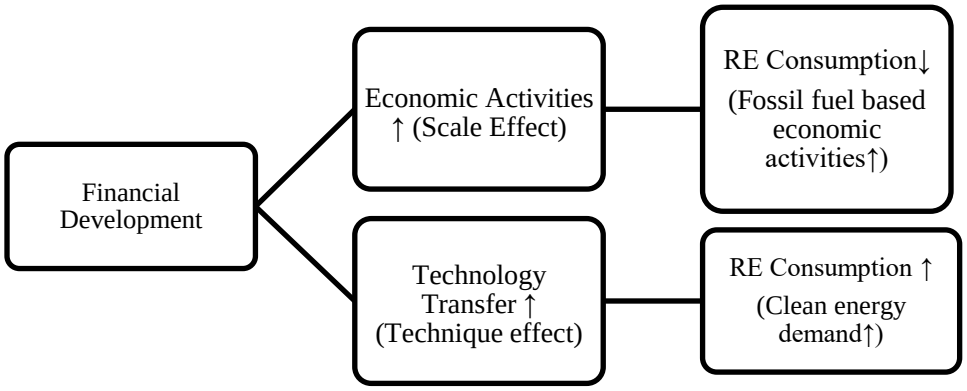

Figure 1: Flowchart

The existing literature can be divided into different sections in explaining the impact of FD on RE consumption. Many studies are reporting the positive impact of FD on RE consumption. A pioneering study in the literature linking the FD with RE consumption is by Brunnschweiler (2010) who studied this relationship for 119 non-OECD countries using the data ranging from 1980 to 2006. The analysis based on the Generalized Method of Moment (GMM) approach reported the positive impact of FD on RE consumption. The results indicate that commercial banks' assets share, amount of credit provided by financial institutions and broad money play a crucial role in determining RE technologies.

Similarly, many other studies also reported a positive influence of FD on RE consumption. For example, the study by Pata (2018) for Turkey from 1974-2014, Ji & Zhang (2019) for China from 1992 to 2013, Shahbaz et al. (2021) for 34 upper-middle-income developing countries from 1994 to 2015, Eren et al. (2019) for India over the time period 1971-2015, Wu & Broadstock (2015) for 22 emerging economies from 1990 to 2010 and Alsaleh & Abdul-Rahim, (2019) for 28 European Union countries from 1990 to 2013 have demonstrated a constructive role of FD. Moreover, there exists a positive effect of stock market association on RE consumption in the case of India, South Africa, Brazil, and China (Kutan et al.,2018). Likewise, Anton & Nucu, (2020) analyzed the role of FD on RE consumption by using a panel data set ranging from 1990-2015 for 28 EU countries. With the help of the fixed effects model, the result presented the positive impact of FD on RE consumption. Furthermore, the study by Kim & Park (2016) also supported the significant positive impact of FD on the consumption of RE. Financially developed economies provide cleaner and energy-efficient advanced technologies to the firms that play a significant role in environmental sustainability. Additionally, FD improves the energy sector by overcoming information asymmetries, providing finance, facilitating foreign direct investment, and technological innovations (Li et al., 2022).

However, the literature has also reported the negative role of FD on RE consumption. Using the ARDL-PMG model over the time period 1997-2017, Wang et al. (2021) reported

that the positive impact of FD on RE consumption is limited to the short run as this effect turns out to be negative in the long run. Similarly, the work of Kwakwa, (2020) in a case study of Ghana also reported the detrimental role of FD on the consumption of RE in the long run. These studies suggest that low-quality financial institutions hinder investment in clean energy projects. Besides, the literature also suggests that a growing financial sector mainly funds such projects which rely on non-renewable energy sources when a society prioritizes growth over environmental quality.

Moreover, the literature has also declared an insignificant impact of FD on RE consumption. For example, Assi et al. (2021) explained the determinants of RE consumption in the ASEAN+3 group. By analyzing data over the time period of 1998-2018 and using the panel ARDL approach the authors reported an insignificant impact of FD on RE consumption. Lei et al. (2022) also reported an inconsiderable impact of FD on RE in the case of China. On the other side, limited studies have explored the non-linear links between FD and RE consumption. By using panel data of 39 countries overtime the period of 2000-2019 and employing the CS-ARDL model, Shahbaz et al. (2022) reported a U-shaped link between FD and RE consumption. Raza et al. (2020) also predicted a similar outcome supporting the U-shaped link between FD and RE.

In addition, we can divide the literature showing a link between FD and RE consumption based on sample selection. One strand of the literature focuses on country-specific analysis. For example, studies by Burakov (2017), Ji & Zang (2019), Eren et al. (2019), Pata (2018), Kwakwa (2020), and Wang et al. (2021) focused on Russia, China, India, Turkey, Ghana, and China, respectively. The other strand of the studies focuses on countries in group form or panel data such as Brunnschweiler (2010), Wu & Broadstock (2015), Kim & Park (2016), Anton & Nucu (2020), and Shahbaz et al. (2021).

It can be concluded from the above literature review that the association between FD and RE consumption is not yet settled down. In effect, the past studies could not portray a clearer picture of the FD and RE consumption nexus. The existing studies have certain limitations such as they have provided narrow evidence focusing on a country-specific analysis. Besides, the past studies have ignored a regime-specific relation assuming a linear relationship irrespective of the stage of FD. The existing literature is biased in using proxy variables for FD as most studies have utilized a single indicator of FD, providing inconsistent and vague results. This study is adopting a different methodological approach (dynamic panel threshold model) to achieve its mentioned objective. Besides, this study contributes to the existing literature by employing three proxies of FD together in the same analysis and providing analysis at the global level.

3. Data and Methodology

3.1 Data

To estimate the FD impact on RE consumption, the panel data for 217 countries is selected over the period 1970-2020. The data series for RE consumption and FD were missing for most of the countries and, therefore, the final sample size is limited to 173 countries. The list of these countries is provided in appendix table A. The data on all indicators used for the analysis is derived from World Development Indicators (WDI), an online database of the World Bank (2021). The description of selected variables is provided in table 1.

Table 1: Data Description

Variables	Symbols	Unit
Renewable Energy Consumption	REC	Percentage
Financial Development Measures:	FD	
Broad Money	BM	Percentage
Domestic Credit to Private Sector	DCP	Percentage
Domestic Credit to Private Sector by Banks	DCPB	Percentage
GDP per capita	GDP	Constant 2015 US$
Trade	TRADE	Percentage
Urbanization	URB	Annual percentage
Industrialization	IND	Percentage

The dependent variable RE is measured as % of total final energy consumption and in literature, it is the most used variable for RE consumption (Lin et al., 2016; Mukhtarov et al., 2020). The study contains the core variable of interest FD with its three measures. All three measures are measured as a percentage of GDP. The first proxy variable is domestic credit to the private sector (DCP) which is defined as: "Financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment" (World Bank, 2021).

The next proxy variable for FD is domestic credit to the private sector by banks (DCPB) defined as: "Financial resources provided to the private sector by other depository corporations (deposit taking corporations except central banks), such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment" (World Bank, 2021). The third proxy used for FD is broad money (BM) and it is explained as: "Sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than the central government; bank and traveler's checks; and other securities such as certificates of deposit and commercial paper" (World Bank, 2021).

Economic growth is measured by using the log of GDP per capita (constant 2015 US$). Trade is the sum of exports and imports as a percentage of GDP. Urbanization and industrialization are also incorporated in the study as determinants of FD. Urbanization is measured as urban population growth in percentage while industry value added is employed as an indicator of industrialization. It is also measured as a percentage of GDP.

3.2 Econometric Model

The relationship between RE consumption and FD is empirically tested by various studies such as Assi et al., (2021); Eren et al., (2019); Shahbaz et al. (2021). The present study follows the standard empirical model by considering broad money, domestic credit to the private sector, and domestic credit by banks as a percentage of GDP as our core variable

of interest and RE consumption as a dependent variable. The econometric model is given as follows:

$$REC_{it} = \beta_1 + \beta_2 FD_{it} + \beta_3 FD_{it}^2 + \beta_4 GDP_{it} + \beta_5 IND_{it} + \beta_6 TRADE_{it} + \beta_7 URB_{it} + v_{it} + u_{it} + e_{it} \quad (1)$$

Where:

Subscript t represents the time period, i shows the cross-section unit the parameter β_1 shows the intercept term. FD_{it} represents the financial development containing its different measurement indicators. REC_{it} shows the renewable energy consumption. The slope coefficient β_2 measures the marginal effect of FD_{it} on RE consumption. All other variables are taken as explanatory variables. The term e_{it} is the error term, v_{it} captures the country specific unobservable effects while u_{it}captures the temporal effects.

3.3 Estimation Method

In beginning, for estimation we used the traditional panel data techniques pooled OLS, random effects, and fixed effects for investigating the empirical link between RE consumption and FD. Moreover, for obtaining the robust estimates in the existence of heteroscedasticity, serial and cross-sectional dependence we used Driscoll and Kraay (1998) standard errors approach. In addition, to understand the clear effect of FD on RE consumption and to obtain the threshold value of FD we employed "Hansen Panel Threshold Model". We estimated the dynamic panel model (Seo & Shin, 2016) which is an extended form of Hansen threshold model. The method is applied on balanced panel data. Basic intuition behind choosing this model is that it is helpful in investigating the spatial heterogeneity of FD on RE consumption while other econometric techniques are failed to capture this feature. Moreover, it also identifies the unknown specific value of the selected threshold variable that acts as a turning point in showing the impact of the explanatory variable on the response variable. Current study also utilizes this threshold model to test the non-linear linkage between FD and RE. This method divides the regression model into two different regimes depending upon the estimated threshold variable. Unlike traditional econometric techniques, this model allows for asymmetric effects of independent variables depending upon the value of threshold variable. Thus, this regression approach is more reliable and consistent for examining non-linear relationship as it conveys extra information unlike quadratic approach. Present work uses this method by considering FD as threshold variable to investigate the heterogeneous role of FD on RE consumption at a global level.

The dynamic panel threshold model can be specified as follows:

$$REC_{it} = \mu_i + \beta_1 I.X_{it}(q_{it} \leq \gamma) + \beta_2 I.X_{it}(q_{it} > \gamma) + e_{it} \quad (2)$$

Where the subscript i represents the cross-section units and t represents the time period. REC_{it} Represents the dependent variable, X_{it} consists of lagged value of REC, financial development and other regressors namely economic growth, trade, urbanization and industrialization while q represents the threshold variable which is financial development in our analysis. Γ is an estimated threshold value and I. () represents the indicator function that indicates the regime defined by threshold variable and its level.

An alternative way of writing equation 2 is:

$$x_{it}(\gamma) = \begin{pmatrix} x_{it}\, I(q_{it} \leq \gamma) \\ x_{it}\, I(q_{it} > \gamma \end{pmatrix}$$

& $\beta = (\beta_1 \beta_2)$ *so that equation 2 becomes:*

$$REC_{it} = \mu_i + \beta\, x_{it}(\gamma) + e_{it} \quad (3)$$

Also, we can write the structural equation of our analysis by breaking the equation 2 as:

$$REC_{it} = \begin{cases} \mu_i + \beta_1\, x_{it} + e_{it}, & q_{it} \leq \gamma, \\ \mu_i + \beta_2\, x_{it} + e_{it}\,, q_{it} > \gamma. \end{cases} \quad (4)$$

In all the above equations observations are divided into two regimes depending upon the threshold values i.e., whether the covariates are above or below threshold value γ. While β_1 and β_2 represents the slope parameters that vary across each regime.

However, the panel dynamic model also consists of bootstrap algorithm in order to test the presence of threshold effect in the model (presence of non-linearity). This test works under following hypothesis:

Null Hypothesis: $\beta_1 = \beta_2$

Alternative Hypothesis: $\beta_1 \neq \beta_2$

Non-linear regression fails to accept the null hypothesis of no threshold in model thus presence of threshold is accepted. Simply, it can be concluded that p-value below 0.05 represents the existence of threshold variable in estimation at 5% level of significance.

4. Data Analysis

4.1 Descriptive Statistics

For understanding of basic features of our panel data Table 2 presents the descriptive statistics. Targeted variable represents the average value of 30.467% with a maximum value of 98.34% and minimum value of 0. The statistics present that the minimum and maximum value of broad money, domestic credit to private sector and domestic credit to private sector by banks is 2.857%, 0, 0 and 452.548%, 304.575%, 304.575%, respectively while the mean value for the same variables is 47.82%, 41.22% and 37.22%. Similarly, the descriptive statistics for remaining covariates are mentioned in table 2.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
BM	6834	47.82	38.013	2.857	452.548
Trade	7654	81.104	54.439	.021	863.195
GDP	8569	12392.306	19204.293	138.631	183244.61
REC	6071	30.467	30.688	0	98.343
IND	7467	26.882	12.563	3.15	90.513
Urb	10931	2.659	3.009	-187.142	48.936
DCP	6146	41.222	39.362	0	304.575
DCPB	7220	37.218	35.071	0	304.575

4.2 Correlation Analysis

To check the association between variables of interest, table 3 presents the correlation between RE consumption and FD along with other covariates. All the three measures of core independent variable (FD) have negative correlation with target variable (RE consumption). Meanwhile, the correlation between RE consumption and broad money is relatively high (-0.502) than domestic credit to private sector by banks (-0.458) and domestic credit to private sector (-0.453). This negative association between RE ad FD measures are in line with the analysis reported by Kwakwa (2020) and Wang et al. (2021). Both studies reported the negative association between FD and RE consumption in long run. While the relationship between economic growth and renewable energy consumption is also reported to be negative.

Table 3: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) DCP	1.000							
(2) DCPB	0.948	1.000						
(3) BM	0.768	0.782	1.000					
(4) REC	-0.458	-0.453	-0.502	1.000				
(5) GDP	0.678	0.673	0.457	-0.387	1.000			
(6) Trade	0.272	0.339	0.420	-0.329	0.223	1.000		
(7) IND	-0.013	-0.005	-0.062	-0.202	0.039	0.034	1.000	
(8) Urb	-0.330	-0.326	-0.252	0.508	-0.295	-0.173	0.096	1.000

4.3 Econometric Analysis

Following sub-sections present the results of all estimated models.

4.3.1 Results of Pooled OLS, Fixed Effects & Random Effect Models

Column 1 of tables 4, 5 and 6 reports the results of pooled OLS technique for analyzing the impact of different measures of FD on RE consumption. However, the pooled OLS model does not take into consideration the temporal and country specific effects as this model treats all cross-sectional unit as homogenous. To overcome this issue, the estimates of fixed and random effects models are reported in column 2 and 3, respectively in tables 4, 5 and 6. Fixed effects model takes into consideration the own intercept for each cross-section units while random effects model considers that error terms may vary across each country. In addition, Driscoll and Kraay regression method is used as estimation by D & K is helpful in consideration of heteroscedasticity, serial and cross-sectional dependency in data and yields robust estimates.

Table 4 shows the effect of DCP on RE consumption in global data. In all the estimated models the DCP contributes negatively to the RE consumption. The estimated coefficient values show that by keeping all other factors constant one percent rise in FD lead to 0.59%, 0.153%, 0.145% and 0.598% decline in share of RE consumption following pooled OLS, fixed effects, random effects and Driscoll & Kraay models, respectively. This finding suggests that the rise in DCP initially boosts up the economic activities which lead to high demand of conventional energy. This find is consistent with direct effect, business effect and wealth effect mechanisms which suggest energy demand escalating effect of FD. Moreover, this finding is consistent with scale effect theory. The reason behind fossil fuel-based production is that as the setup businesses are already working by using fossil fuels energy from past decade, so the transition is not feasible due to high risks associated with it. Besides, the project based on fossil fuel sources has lower up-front cost, short leads time and best track record. However, the coefficient of square term of DCP represents the

positive association between RE consumption and FD as after crossing certain limit the DCP start contributing to energy transition by providing loans and investment opportunities in energy efficient technologies. The results showing positive relationship between FD and RE consumption are consistent with the work of Eren et al. (2019); Lin et al. (2016); Mukhtarov et al. (2020). Both the estimated coefficients for all models are statistically significant at 1% level of significance. Thus, it indicates the presence of U-shaped relationship between DCP and RE consumption supporting the Financial Kuznets curve (Shahbaz et al., 2022). Similarly economic growth results in decline in RE consumption as shown by estimated coefficient of POLS and D & K models while in other two models the impact of economic growth is positive on RE consumption. Trade and industrial value-added have a negative impact on RE consumption while urbanization exerts a positive influence on RE consumption in all models.

Table 4: Models (Domestic Credit to private sector & REC)

Models	**POLS**	**FE**	**RE**	**D & K**
Dep. Variable	REC	REC	REC	REC
Predictors	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
DCP	-0.598***	-0.145***	-0.153***	-0.598***
	(0.030265)	(0.0127)	(0.0129)	(0.0571)
DCP^2	0.00239***	0.000505***	0.000541***	0.00239***
	(0.000166)	(5.71e-05)	(5.80e-05)	(0.000312)
GDP	-9.04e-05**	0.000231***	0.000163***	-9.04e-05**
	(3.07e-05)	(3.19e-05)	(3.11e-05)	(3.35e-05)
IND	-0.594***	-0.178***	-0.199***	-0.594***
	(0.0385)	(0.0254)	(0.0254)	(0.0478)
URB	5.794***	0.637***	0.721***	5.794***
	(0.2760)	(0.104)	(0.106)	(0.465)
TRADE	-0.0855***	-0.000770	-0.00442	-0.0855***
	(0.00599)	(0.00597)	(0.00598)	(0.00819)
Constant	65.37***	41.34***	40.14***	65.38***
	(2.928)	(0.960)	(1.930)	(2.928)
Observations	3,426	3,426	3,426	3,426
R-squared	0.499	0.077	0.074	0.499

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Moreover, our findings are sensitive to country specific effects as POLS overestimated the coefficients values while the estimated coefficients are almost same for fixed and random effects. However, R^2 suggests that in case of POLS model 49.9% of variation in REC is explained by the chosen explanatory variables while this value is approximately equal for random and fixed effects reporting the 7% variation in REC through explanatory variables.

The results for second measure of FD (DCPB) are reported in table 5. The estimated coefficients reveal the presence of U-shaped curve between DCPB and RE consumption across all models. The magnitude of coefficients associated with DCPB are relatively higher than DCP. The results are in line with the view that rising DCPB at first increases the economic growth by scale effect. This leads to decline the consumption of RE to work on production expansion at the cost of environment. Later, after crossing certain level rising DCPB increases the RE consumption by technique effect. That is, well-developed financial sector offer incentive to transit towards RE consumption. Similarly economic growth and urbanization are positively linked with RE consumption while industrialization is negatively linked with response variable based on all models as shown in table 5. However, trade is statistically insignificant in explaining its role for consumption of RE in fixed and random effects models but in POLS model and Driscoll & Kraay analysis its role is negative in effecting RE consumption.

Table 5: Models (REC & Domestic Credit to Private Sector by Banks)

Models	**POLS**	**FE**	**RE**	**POLS**
Dep. Variable	REC	REC	REC	REC
Predictors	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
DCPB	-0.605***	-0.160***	-0.165***	-0.605***
	(0.03203)	(0.0119)	(0.0120)	(0.0467)
$DCPB^2$	0.00262***	0.000593***	0.000620***	0.00262***
	(0.000205)	(5.61e-05)	(5.68e-05)	(0.000301)
GDP	-0.000109***	0.000175***	0.000114***	-0.000109***
	(3.12e-05)	(3.09e-05)	(3.01e-05)	(2.85e-05)
IND	-0.622***	-0.136***	-0.154***	-0.622***
	(0.03415)	(0.0237)	(0.0237)	(0.0411)
URB	5.764***	0.708***	0.781***	5.769***
	(0.2704)	(0.0956)	(0.0966)	(0.440)
TRADE	-0.0879***	-0.00566	-0.00905	-0.0880***
	(0.00594)	(0.00570)	(0.00570)	(0.00686)
Constant	65.35***	41.24***	40.45***	65.35***
	(1.561)	(0.887)	(1.902)	(2.705)
Observations	3,961	3,961	3,961	3,961
R-squared	0.476	0.076	0.074	0.477

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Based on fixed effects, random effects and pooled OLS regression analysis, BM is also influential in affecting the RE consumption as represented by table 6. Just like other measures of FD this measure also exhibits U-shaped curve with RE consumption. Rising money in banking sector provides better loan opportunities to the businesses thus improving the financial sector and promoting eco-friendly technologies. Other covariates also affect the RE consumption significantly. Economic growth and urbanization play a positive role in promoting RE consumption while trade and industrialization play a negative role in RE consumption across all models. All the variables are statistically significant in all four types of models except trade which is significant in pooled OLS and Driscoll & Kraay models.

Table 6: Models (REC & Broad money)

Models	**POLS**	**FE**	**RE**	**POLS**
Dep. Variable	REC	REC	REC	REC
Predictors	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients	Estimated Coefficients
BM	-0.559***	-0.185***	-0.190***	-0.559***
	(0.0225)	(0.0114)	(0.0115)	(0.0290)
BM^2	0.00141***	0.000340***	0.000356***	0.00141***
	(0.000009)	(4.36e-05)	(4.41e-05)	(0.000138)
GDP	-0.000101***	0.000223***	0.000171***	-0.000101***
	(3.53e-05)	(3.19e-05)	(3.13e-05)	(2.96e-05)
IND	-0.675***	-0.138***	-0.159***	-0.675***
	(0.0348)	(0.0244)	(0.0244)	(0.0437)
URB	6.152***	0.635***	0.704***	6.152***
	(0.2975)	(0.0972)	(0.0984)	(0.441)
TRADE	-0.0726***	0.000695	-0.00185	-0.0726***
	(0.00721)	(0.00620)	(0.00622)	(0.0115)
Constant	70.87***	45.81***	45.24***	70.87***
	(1.6645)	(0.926)	(2.000)	(3.565)
Observations	3,638	3,638	3,638	3,638
R-squared	0.506	0.113	0.112	0.507

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results based on BM measures of FD is more consistent as the estimated coefficients exhibit the same sign along with high R^2 value across all models as compared to models containing other proxies of FD. Moreover, regarding our control variables, the results in all models are mixed. First control variable (economic growth) shows the positive and significant effect on RE consumption in the case of fixed and random effects models. The fact behind this is that rising economic activities lead to the high demand of energy sources for production process. Our results are consistent with the studies of Sadorsky (2009a) and Chen et al. (2019) as these studies also reported the positive influence of economic growth on RE consumption. Similarly, role of trade in contributing to RE consumption is negative based on POLS, fixed effects, random effects, and Driscoll & Kraay. These outcomes are inconsistent with the outcomes of Amri, (2017) and Sebri & Ben-Salha (2014) who

reported the positive influence of trade on share of RE consumption in total energy consumption.

The third control variable industrial value added is also estimated to have negative influence on share of RE consumption that is consistent with the results of Raza et al. (2020). According to study by Raza et al. (2020) industrial value-added effects the RE consumption negatively in low growth regime as compared to high growth regime. However, our results are inconsistent if we look at the work of Salim & Shafiei (2014) as according to their findings industrial value-added effects the consumption of both renewable and non-renewable energy sources positively. Similarly, findings of Shahzad et al. (2021) also supported the positive influence of industrialization on RE consumption. While our findings can be supported with the view that industry is energy driven sector thus foundation of these industries are still based on fossil fuels input at the cost of environment. Current study predicts the positive role of urbanization on RE consumption. This outcome is in line with the work of Salim & Shafiei (2014) who reported the positive effect of urbanization on renewable and non-renewable energy consumption however the results were insignificant in case of RE consumption. Similarly, Yang et al. (2015) also reported the positive influence of urbanization on RE consumption.

Regarding our main variable we can conclude from POLS, FE, RE and Driscoll & Kraay models that there is evidence of non-linear link between FD and RE consumption supporting the U-shaped curve relationship between them as:

β_2 <0 and β_3 >0

The next section traces out that specific value of FD that cuts the data into two regimes and converting the relationship between FD and RE consumption as U-shaped curve.

4.3.2 Results of Panel Threshold Model

The dynamic panel threshold model detects the break point at which the FD affects differently the consumption of RE. The results of threshold model considering all measures of FD are reported in tables 7, 8 and 9. Table 7 shows the estimated dynamic panel threshold model in the case of domestic credit to private sector as a measure of FD. Equation 2 in this context takes the form as:

$$REC_{it} = \mu_i + \beta_2 I.X_{it}(DCP_{it} \leq \gamma) + \beta_3 I.X_{it}(DCP_{it} > \gamma) + e_{it} \quad (5)$$

Firstly, the p-value of bootstrap represents the evidence of non-linear association between our variables, validating the model. Furthermore, the value of threshold variable (DCP) is estimated to be 7.64% which is statistically significant at 5% level of significant thus it divides the analysis of other variables coefficient into two regimes. The rise in DCP results in decline of consumption of RE below threshold value while after crossing that threshold value DCP results in positive influence on RE consumption, supporting the existence of U-shaped link between them. Our results linking RE consumption with FD are consistent with the study of Shahbaz et al. (2022).

Regarding the impact of economic growth on RE consumption we conclude that economic growth in those countries with well-established financial system plays a positive role in RE consumption as compared to countries with less developed financial system. This finding helps to understand the heterogenous effects of economic growth on RE in a global setting.

The influence of economic growth on RE consumption also turns out to be FD regime specific. Similarly, the trade and urbanization are statistically significant regressors in explaining the RE consumption by affecting the RE consumption positively and negatively in below and above threshold value of DCP respectively while effect of industrial value-added on the RE consumption is negative in both regimes of DCP.

Table 7: Dynamic Threshold Model (Threshold Variable=DCP)

Variables	**Below Threshold**	**Above Threshold**
$\mathbf{REC}_{t-1}$	0.991* (0.0019)	-0.081* (0.0011)
DCP	-0.008* (0.0004)	0.007* (0.0005)
GDP	-0.586* (0.0387)	0.267* (0.0262)
TRADE	-0.122* (0.0205)	0.025* (0.0035)
IND	-0.023* (0.0009)	-0.0120* (0.0009)
URB	-0.005* (0.0012)	0.051* (0.0066)
Threshold Value	7.647% (p-value=0.013)	
N	173	
T	51	
Bootstrap p-value for linearity	0.000	

Standard errors in parentheses * p<0.01, ** p<0.05, *** p<0.1

Table 8 provides the estimate of dynamic panel threshold for second measure of financial development (DCPB).

$$REC_{it} = \mu_i + \beta_2 I.X_{it}(DCPB_{it} \leq \gamma) + \beta_3 I.X_{it}(DCPB_{it} > \gamma) + e_{it} \quad (6)$$

The model reveals the presence of threshold value of DCPB as 52.1% which is significant at 1% level of significance. Regarding the coefficient of our core variable of interest, the results show that lower DCPB has negative impact on RE consumption while after crossing the threshold value of 52.1% DCPB starts playing a positive role in RE consumption. Thus,

outcome is providing clear evidence of U–shaped link between DCPB and RE. This analysis supports the existence of Financial Kuznets Curve implying that FD at initial stages promotes economic development at the cost of environment and after achieving certain threshold it starts diverting resources towards eco-friendly and energy efficient projects. Meanwhile economic growth and trade also play a crucial role in determination on RE consumption which can be seen by the estimated coefficients, both variables affect the RE consumption positively and negatively below and above the threshold value. Just like DCP analysis industrialization in case of DCPB threshold also affect the RE consumption negatively in both divided regime and urbanization affect the RE consumption positively and negatively in below and above threshold value.

Table 8: Dynamic Threshold Model (Threshold Variable=DCPB)

Variables	**Below Threshold**	**Above Threshold**
$\mathbf{REC_{t-1}}$	0.910* (0.0007)	0.0565* (0.0019)
DCPB	-0.007* (0.0006)	0.005* (0.0011)
GDP	-1.703* (0.0292)	2.362* (0.0461)
TRADE	-0.388* (0.0315)	4.766* (0.0728)
IND	-0.019* (0.0019)	-0.070* (0.0062)
URB	0.010* (0.0014)	-0.185* (0.0216)
Threshold Value	52.10% (p-value=0.000)	
N	173	
T	51	
Bootstrap p-value for linearity	0.000	

Standard errors in parentheses * p<0.01, ** p<0.05, *** p<0.1

Similarly, Table 9 reports the panel dynamic threshold model by considering broad money as a threshold variable.

$$REC_{it} = \mu_i + \beta_2 I.X_{it}(BM_{it} \leq \gamma) + \beta_3 I.X_{it}(BM_{it} > \gamma) + e_{it} \quad (7)$$

The threshold analysis predicts the existence of statistically significant threshold value of 58.01%. The model provides the evidence of U-shaped curve between BM and RE

consumption as below threshold the coefficient of BM is negative and above threshold it is positive. According to this outcome, BM declines the RE consumption by following scale effect. Rising BM can provide entry opportunities for inefficient, dirty, and traditional firms to the economy which results is declining the demand of RE and pollute the environment. However, after 58.01% of BM, rising BM increases the demand of RE sources by following technique effect. The result is parallel to the study of Shahbaz et al. (2022) who stated that at initial stages FD restricted the projects based on RE technologies which after the evolution of technique effect fosters the RE consumption. Economic growth shows the positive role on rising share of RE consumption both in below and above threshold regime and industrialization shows the negative impact on RE consumption in both regimes. However, impact of trade on RE consumption is negative in below threshold region while in above threshold region its coefficient is statistically insignificant. In the case of urbanization, the coefficient is insignificant in below threshold region and effect is positive in upper threshold region.

Table 9: Dynamic Threshold Model (Threshold Variable=BM)

Variables	**Below Threshold**	**Above Threshold**
REC_{t-1}	0.942*	-0.126*
	(0.0015)	(0.0029)
BM	-0.030*	0.031*
	(0.0018)	(0.0020)
GDP	0.348*	0.151*
	(0.0378)	(0.0885)
TRADE	-0.097*	0.0826
	(0.0187)	(0.0670)
IND	-0.012*	-0.037*
	(0.0031)	(0.0385)
URB	0.001	0.205*
	(0.0011)	(0.0385)
Threshold Value	58.01% (p-value=0.000)	
N	154	
T	51	
Bootstrap p-value for linearity	0.000	

Standard errors in parentheses * p<0.01, ** p<0.05, *** p<0.1

A comparison of three proxy measures of FD supports the view that DCP has more influential impact on RE consumption as compared to other two measures as the credit availability plays crucial role in FD. Thus, establishing loan schemes can ensure the improvement in transition of energy sector towards RE sources. Moreover, banking system also plays an influential role in creating demand for RE based sources. This is in line with the view that firms willing to work under RE source need long term loans because the start-up cost for operation is higher than the payback returns (Brunnschweiler 2010). However, our analysis supports the Financial Kuznets Curve in case of global data. According to this curve firstly, rising FD led to rise the economic activities to meet the rising demand due to expansion of FD sector at the cost of environment quality. Thus, investors use the existing method of energy source (fossil fuels) for generating the domestic production.

Additionally, it can be argued that improved financial sector of any state results in efficient capital distribution to domestic firms. This leads to raise the industrial activities that in turn raises the total energy demand. Thus, projects based on non-renewable energy sources flourish which lead to lessen the demand of RE. Along with it FD makes the consumers capable to purchase luxury goods which are mostly fossil fuels energy driven products. Thus, below certain threshold value financial developing economies work under dirty energy projects at the cost of ecosystem quality. This view is empirically supported by the work of Usman et al. (2022) as their analysis predicted the detrimental effect of FD on ecological state. Shortly, the scale effect results in declining demand of RE consumption. Secondly, after achieving certain threshold the FD results in dominancy of technique effect i.e., FD provides incentive through investment opportunities and loans to energy efficient, clean and eco-friendly production projects along with research and development activities in the economy that is helpful in rising demand for RE consumption. Thus, rising FD provides financial services to the firms for adopting clean technology.

Similarly economic growth also moves towards the clean production process after FD crosses certain threshold as financially poor states use energy inefficient, poor, and cheap ways for production process. Financially developed economies exploited energy consumption more efficiently as compared to less financially developed economies due to technological innovations. Financially developed economies work under the strict environmental regulations with efficient institutions, and they diverted their funding and resource allocation towards eco-friendly projects as compared to financially poor economies. These views also provide the basis of Financial Kuznets Curve thus applicable to current study outcomes. The outcome obtained from dynamic panel threshold model is summarizes in figure 2.

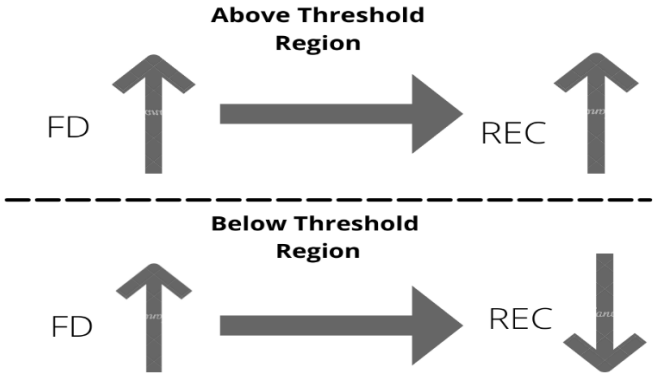

Figure 2: The Impact of FD on Renewable Energy Consumption (REC)

5. Conclusion

This study examines the link between RE consumption and FD in response to the rising environmental issues related to the use traditional energy sources. To achieve the mentioned goal, the study uses the panel data of 173 countries ranging from 1970 to 2020. Focused variable FD is proxied using three measures namely broad money, domestic credit to private sectors and domestic credit to private sector by banks while other variables economic growth, industrial value-added, trade and urbanization are used as control variables. The empirical analysis is conducted using various econometric techniques i.e., Pooled OLS, fixed effects, random effects, Driscoll & Kraay regression and dynamic panel threshold approach. In all the models the estimated coefficients reveal the presence of non-linear (U-shaped curve) between three measures of FD and RE consumption. The threshold values for broad money, domestic credit to private sector and domestic credit to private sector by banks are reported as 58.01%, 7.64% and 52.10%, respectively, which divides all the data into two regimes. The results of our all models are consistent and statistically significant.

The study concludes that after achieving certain threshold point the rise in FD will be helpful in rising the transition from fossil fuels to RE consumption demand as well established financial sector is responsible for credit allocation for RE projects. While FD before that threshold level is responsible for rising fossil fuels energy demand as the direct, business, wealth, and scale effects of FD dominate the technique effect. As the availability of financing and loans through FD leads the consumer to buy more goods like automobiles which in turn also rise the demand of energy by firms to fulfill the demand of consumers. However, later after crossing the threshold level this FD results in transition to clean mechanism of economic activities thus technique and composition effects dominate. Moreover, the findings also reveal the presence of strong impact of domestic credit to private sector on RE consumption as compared to other two measures of FD. In addition, control variables also play a significant role in explaining the response variables. Particularly, economic growth and trade play a positive role in RE consumption in sample countries with well-developed financial sector

Our analysis reveals the strong impact of FD on RE consumption as the provision of loans and funding will improve the financial condition of different entities of economy which will divert their use of energy from traditional energy sector to RE sector. Also, the FD is helpful in clean technological transfer due to availability of different investment opportunities which lead to the further use of energy efficient mechanism for production.

5.1 Contribution of the Study and Its Implication

It is evident from the past literature that FD is crucial for RE consumption of RE, yet the literature is unable to clarifying this nexus at global level. This study is the first study that empirically examines the impact of FD on RE consumption at global data set of 173 countries. Unlike other existing literature which rely on a single measure of FD, this study uses three measures of FD to capture the clear impact of FD on RE. Mostly literature is dominant in explaining linear linkage between FD and RE consumption while this study analyses the non-linear association between our variables of interest. Regarding this issue, it is the first study that exploits the advance econometric technique of dynamic panel threshold model to estimate the threshold value of FD. This approach is more helpful in explaining heterogeneous impacts of different measures of FD on RE consumption.

Empirical outcomes of current research provide the evidence of presence of threshold value of FD. This analysis is supporting the heterogeneous impact of different measures of FD on RE consumption. Before threshold level of FD, development in financial sector is proved to be destructive for RE projects and utilization while after crossing threshold level, it becomes helpful in rising the demand of RE. Thus, it can be concluded that financially developed economies can work under eco-friendly projects by transmitting its resources towards energy efficient and clean technologies as compared to less financially stable economies. Thus, implication can be drawn on the basis this outcome that advance level of FD is helpful in raising demand of RE which in turn prove to be helpful in eco-friendly projects. The results of our study are consistent with the theory of financial Kuznets curve which links the financial development with environment quality.

5.2 Limitations of Study and Future Directions

The mentioned study contains some limitation which need to be addressed by future work. The study contains only three measures of FD however the future studies can incorporate the comprehensive measure of FD in the form of financial sector development index. Merging more comprehensive indicator for measuring FD is more helpful in explaining the relationship between FD and RE as it incorporates different dimensions of FD. Similarly, this study is providing broad picture of impact of FD on RE consumption by considering global data set. Global analysis is unable to predict the country specific impact, or it hides the information linked with individual country. Thus, in future, this study can be extended at individual country level or different country groups can be compared. Besides, future studies can do a disaggregated analysis of FD and RE consumption according to the type of RE sources such as solar, geothermal, wind, biomass and hydropower energy modes.

5.3 Policy Recommendations

Our analysis supports the positive role of FD after crossing its threshold level in consumption of RE. Thus, it provides various policy implication for future. Countries

laying below the threshold level of FD need to boost up their financial sector by providing investment opportunities, loans and credit to both the new and existing firms, private sectors and companies. Furthermore, incentives in the form of tax exemption, installment and funding can be provided to the firms and businesses to transit their production process from non-renewable sector to renewable sector. Government can impose carbon taxes on the firms working under non-renewable energy sources. However, the countries above the threshold level of FD may provide loans on low interest payment and relaxation to the firms and businesses who are currently working by utilizing RE source. Current analysis supports the technique effect in case of high threshold level of FD thus government needs to promote technological innovations by providing funds.

Research Funding

Researchers received no research grant or funds for this research project.

REFERENCES

Akkemik, K. A., & Goksal, K. (2012). Energy consumption-GDP nexus: Heterogeneous panel causality analysis. *Energy Economics*, *34*(4), 865-873.

Al-Mulali, U., & Lee, J. Y. (2013). Estimating the impact of the financial development on energy consumption: Evidence from the GCC (Gulf Cooperation Council) countries. *Energy*, *60*, 215-221.

Alper, A., & Oguz, O. (2016). The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renewable and Sustainable Energy Reviews*, *60*, 953–959.

Alsaleh, M.; Abdul-Rahim, A.S. (2019). Financial Development and Bioenergy Consumption in the EU28 Region: Evidence from Panel Auto-Regressive Distributed Lag Bound Approach. *Resources*, *8(1)*, 1-13.

Amin, S. Bin, & Alam, T. (2018). The Relationship Between Energy Consumption and Sectoral Output in Bangladesh: An Empirical Analysis. *The Journal of Developing Areas*, *52*(3), 39–54.

Amri, F. (2017). Intercourse across economic growth, trade and renewable energy consumption in developing and developed countries. *Renewable and Sustainable Energy Reviews*, *69*, 527-534.

Anton, S.G.; Afloarei Nucu, A.E. (2019). The effect of financial development on renewable energy consumption. A panel data approach. *Renewable Energy*, *147*, 330–338.

Anton, S. G., & Nucu, A. E. A. (2020). The effect of financial development on renewable energy consumption. A panel data approach. *Renewable Energy*, *147*, 330-338.

Apergis, N., & Payne, J. E. (2011). The renewable energy consumption–growth nexus in Central America. *Applied Energy*, *88*(1), 343-347.

Assi, A. F., Zhakanova Isiksal, A., & Tursoy, T. (2021). Renewable energy consumption, financial development, environmental pollution, and innovations in the ASEAN + 3 group: Evidence from (P-ARDL) model. *Renewable Energy*, *165*, 689–700.

Attiaoui, I., Toumi, H., Ammouri, B., & Gargouri, I. (2017). Causality links among renewable energy consumption, CO 2 emissions, and economic growth in Africa: evidence from a panel ARDL-PMG approach. *Environmental science and pollution research*, *24*(14), 13036-13048.

Bashir, M. F., Ma, B., Bashir, M. A., Radulescu, M., & Shahbaz, U. (2021). Investigating the role of environmental taxes and regulations for renewable energy consumption: evidence from developed economies. *Economic Research-Ekonomska Istraživanja*, *34*(1), 1-23.

Belke, A., Dobnik, F., & Dreger, C. (2011). Energy consumption and economic growth: New insights into the Cointegration relationship. *Energy Economics*, *33*(5), 782-789.

Bilgili, F., & Ozturk, I. (2015). Biomass energy and economic growth nexus in G7 countries: Evidence from dynamic panel data. *Renewable and Sustainable Energy Reviews*, *49*, 132–138.

Brunnschweiler, C. (2010). Finance for renewable energy: An empirical analysis of developing and transition economies. *Environment and Development Economics*, 15(3), 241-274.

Burakov, D. (2017). Financial development, economic growth and renewable energy consumption in Russia: A vector error correction approach. *International Journal of Energy Economics and Policy*, 7(6), 39-47.

Caraiani, C., Lungu, C. I., & Dascălu, C. (2015). Energy consumption and GDP causality: A three-step analysis for emerging European countries. *Renewable and Sustainable Energy Reviews*, *44*, 198-210.

Chen, Y., Wang, Z., & Zhong, Z. (2019). CO2 emissions, economic growth, renewable and non-renewable energy production and foreign trade in China. *Renewable energy*, *131*, 208-216.

Chireshe, J. (2021). Finance and renewable energy development nexus: Evidence from Sub-Saharan Africa. *International Journal of Energy Economics and Policy*, *11*(1), 318-325.

Coban, S., & Topcu, M. (2013). The nexus between financial development and energy consumption in the EU: A Dynamic Panel Data Analysis. *Energy Economics*, 39, 81–88.

Destek, M. A., & Aslan, A. (2017). Renewable and non-renewable energy consumption and economic growth in emerging economies: Evidence from bootstrap panel causality. *Renewable Energy*, *111*, 757–763.

Driscoll, J. C., & Kraay, A. C. (1998). Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data. *The Review of Economics and Statistics*,*80* (4), 549–560.

Eren, B. M., Taspinar, N., & Gokmenoglu, K. K. (2019). The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. *Science of the Total Environment, 663*, 189–197.

Ergun, S. J., Owusu, P. A., & Rivas, M. F. (2019). Determinants of renewable energy consumption in Africa. *Environmental Science and Pollution Research*, *26*(15), 15390-15405.

Fangmin, L.; Jun, W. (2011). Financial system and renewable energy development: Analysis based on different types of renewable energy situation. *Energy Procedia* 2011, 5, 829–833.

Ge, M., Friedrich, J., & Vigna, L. (2020). 4 charts explain greenhouse gas emissions by countries and sectors. Washington DC: World Resources Institute.

Ji, Q., & Zhang, D. (2019). How much does financial development contribute to renewable energy growth and upgrading of energy structure in China? *Energy Policy*, *128*, 114-124.

Kasperowicz, R. (2014). Electricity consumption and economic growth: Evidence from Poland. *Journal of International Studies*, *7*(1), 46–57.

Kim, J. & Park, K. (2016). Financial development and deployment of renewable energy technologies. *Energy Econ*. 2016, 59, 238–250.

Kutan, A. M., Paramati, S. R., Ummalla, M., & Zakari, A. (2018). Financing renewable energy projects in major emerging market economies: Evidence in the perspective of sustainable economic development. *Emerging Markets Finance and Trade*, *54*(8), 1762–1778.

Kwakwa, Paul Adjei. (2020). What determines renewable energy consumption? Startling evidence from Ghana. *International Journal of Energy Sector Management*, *15*(1), 101-118

Lei, W., Liu, L., Hafeez, M., & Sohail, S. (2022). Do economic policy uncertainty and financial development influence the renewable energy consumption levels in China? *Environmental Science and Pollution Research*, *29*(5), 7907-7916.

Li, X., Ozturk, I., Majeed, M. T., Hafeez, M., & Ullah, S. (2022). Considering the asymmetric effect of financial deepening on environmental quality in BRICS economies: Policy options for the green economy. *Journal of Cleaner Production*, *331*, 129909.

Lin, B., Omoju, O. E., & Okonkwo, J. U. (2016). Factors influencing renewable electricity consumption in China. *Renewable and Sustainable Energy Reviews*, *55*, 687–696.

Majeed, M. T., & Luni, T. (2020). Renewable energy, circular economy indicators and environmental quality: A global evidence of 131 countries with heterogeneous income groups. *Pakistan Journal of Commerce and Social Sciences*, *14*(4), 866-912.

Majeed, M. T., & Mazhar, M. (2019). Financial development and ecological footprint: A global panel data analysis. *Pakistan Journal of Commerce and Social Sciences*, *13*(2), 487-514.

Meadows D, Meadows DL, Randers J, Behrens-III, William W. The limits to growth: a report for the club of Rome's project on the predicament of mankind. New York: Universe Books; 1972.

Mukhtarov, S., Humbatova, S., Hajiyev, N. G. O., & Aliyev, S. (2020). The financial development-renewable energy consumption nexus in the case of Azerbaijan. *Energies*, *13*(23), 1–14.

Ozturk, I., Aslan, A., & Kalyoncu, H. (2010). Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. *Energy Policy*, *38*(8), 4422-4428.

Pan, X., Uddin, M. K., Han, C., & Pan, X. (2019). Dynamics of financial development, trade openness, technological innovation and energy intensity: Evidence from Bangladesh. *Energy*, *171*, 456-464.

Pao, H. T., & Tsai, C. M. (2010). CO2 emissions, energy consumption and economic growth in BRIC countries. *Energy policy*, *38*(12), 7850-7860.

Pata, U. K. (2018). Renewable energy consumption, urbanization, financial development, income and CO2 emissions in Turkey: Testing EKC hypothesis with structural breaks. *Journal of Cleaner Production*, *187*, 770–779.

Raza, S. A., Shah, N., Qureshi, M. A., Qaiser, S., Ali, R., & Ahmed, F. (2020). Non-linear threshold effect of financial development on renewable energy consumption: evidence from panel smooth transition regression approach. *Environmental Science and Pollution Research*, *27*(25), 32034–32047.

Sadorsky, P. (2009a). Renewable energy consumption and income in emerging economies. *Energy policy*, *37*(10), 4021-4028.

Sadorsky, P. (2009b). Renewable energy consumption, CO2 emissions and oil prices in the G7 countries. *Energy Economics*, *31*(3), 456-462.

Sadorsky, P. (2011). Financial Development and Energy Consumption in Central and Eastern European Frontier Economies. Energy Policy, *39*(2), 999–1006.

Salim, R. A., & Shafiei, S. (2014). Urbanization and renewable and non-renewable energy consumption in OECD countries: An empirical analysis. *Economic Modelling*, *38*, 581-591.

Samreen, I., & Majeed, M. T. (2020). Spatial econometric model of the spillover effects of financial development on carbon emissions: A global analysis. *Pakistan Journal of Commerce and Social Sciences, 14*(2), 569-602.

Sebri, M., & Ben-Salha, O. (2014). On the causal dynamics between economic growth, renewable energy consumption, CO2 emissions and trade openness: Fresh evidence from BRICS countries. *Renewable and Sustainable Energy Reviews*, *39*, 14-23.

Seo, M. H., & Shin, Y. (2016). Dynamic panels with threshold effect and endogeniety. *Journal of Econometrics*, *195*(2), 169-186.

Shahbaz, M., Topcu, B. A., Sarıgül, S. S., & Vo, X. V. (2021). The effect of financial development on renewable energy demand: The case of developing countries. *Renewable Energy*, *178*, 1370–1380.

Shahbaz, M., Sinha, A., Raghutla, C., & Vo, X. V. (2022). Decomposing scale and technique effects of financial development and foreign direct investment on renewable energy consumption. *Energy*, *238*, 121758.

Shahzad, U., Lv, Y., Doğan, B., & Xia, W. (2021). Unveiling the heterogeneous impacts of export product diversification on renewable energy consumption: new evidence from G-7 and E-7 countries. *Renewable Energy*, *164*, 1457-1470.

Stern, D. I., & Enflo, K. (2013). Causality between energy and output in the long-run. *Energy Economics*, *39*, 135-146.

Usman, M., Balsalobre-Lorente, D., Jahanger, A., & Ahmad, P. (2022). Pollution concern during globalization mode in financially resource-rich countries: Do financial development, natural resources, and renewable energy consumption matter? *Renewable Energy*, *183*, 90-102.

Wang, J.; Zhang, S.; Zhang, Q. (2021).The relationship of renewable energy consumption to financial development and economic growth in China. Renew. *Energy*, 170, 897–904

World Bank (2021). World Development Indicators. Washington, DC: World Bank. [Online] Available at: http://data.worldbank.org/products/wdi (February 28th, 2022).

Wu, L., & Broadstock, D. C. (2015). Does economic, financial and institutional development matter for renewable energy consumption? Evidence from emerging economies. *International Journal of Economic Policy in Emerging Economies*, *8*(1), 20-39.

Yang, J., Zhang, W., & Zhang, Z. (2015). Impacts of urbanization on renewable energy consumption in China. *Journal of Cleaner Production*, *114*, 443-451.

Zhang, Y., Fan, J., & Chang, H. (2011). Impact of China's stock market development on energy consumption: An empirical analysis. Energy Procedia, 5, 1927–1931.

Appendix

Table A. List of Sample Countries

Afghanistan	Chile	Guyana	Mauritania	Senegal
Albania	China	Haiti	Mauritius	Serbia
Algeria	Colombia	Honduras	Mexico	Seychelles
Angola	Comoros	Hong Kong	Micronesia, Fed.	Sierra Leone
Antigua and Barbuda	Congo, Dem. Rep.	Hungary	Moldova	Singapore
Argentina	Congo, Rep.	Iceland	Mongolia	Slovak Republic
Armenia	Costa Rica	India	Montenegro	Slovenia
Aruba	Cote d'Ivoire	Indonesia	Morocco	Somalia
Australia	Croatia	Iran	Mozambique	South Africa
Austria	Cyprus	Iraq	Myanmar	South Sudan
Azerbaijan	Czech Republic	Ireland	Namibia	Spain
Bahamas	Denmark	Israel	Nepal	Sri Lanka
Bahrain	Djibouti	Italy	Netherlands	Sudan
Bangladesh	Dominica	Jamaica	New Zealand	Suriname
Barbados	Dominican Republic	Japan	Nicaragua	Sweden
Belarus	Ecuador	Jordan	Niger	Switzerland
Belgium	Egypt, Arab Rep.	Kazakhstan	Nigeria	Tajikistan
Belize	El Salvador	Kenya	North Macedonia	Tanzania
Benin	Equatorial Guinea	Korea, Rep.	Norway	Thailand
Bhutan	Estonia	Kuwait	Oman	Timor-Leste
Bolivia	Eswatini	Kyrgyz Republic	Pakistan	Togo
Bosnia and Herzegovina	Ethiopia	Lao PDR	Panama	Tonga
Botswana	Fiji	Latvia	Papua New Guinea	Tunisia
Brazil	Finland	Lebanon	Paraguay	Turkey
Brunei Darussalam	France	Lesotho	Peru	Uganda
Bulgaria	Gabon	Libya	Philippines	Ukraine
Burkina Faso	Gambia	Lithuania	Poland	United Arab Emirates
Burundi	Georgia	Luxembourg	Portugal	United Kingdom
Cabo Verde	Germany	Macao	Qatar	United States
Cambodia	Ghana	Madagascar	Romania	Uruguay
Cameroon	Greece	Malaysia	Russian Fed.	Uzbekistan
Canada	Guatemala	Maldives	Rwanda	Vanuatu
Central African Republic	Guinea	Mali	Samoa	Vietnam
Chad	Guinea-Bissau	Malta	Saudi Arabia	West Bank & Gaza
Yemen, Rep.	Zambia	Zimbabwe		