Qamruzzaman, Md

Article

Clarifying the nexus between trade policy uncertainty, economic policy uncertainty, FDI and renewable energy demand

International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Qamruzzaman, Md (2024). Clarifying the nexus between trade policy uncertainty, economic policy uncertainty, FDI and renewable energy demand. In: International Journal of Energy Economics and Policy 14 (2), S. 367 - 382.
https://www.econjournals.com/index.php/ijeep/article/download/15470/7775/36361.
doi:10.32479/ijeep.15470.

IJEEP

INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY

EJ EconJournals

ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(2), 367-382.

EJ EconJournals

Clarifying the Nexus between Trade Policy Uncertainty, Economic Policy Uncertainty, FDI and Renewable Energy Demand

Md. Qamruzzaman*

School of Business and Economics, United International University, Dhaka 1212, Bangladesh. *Email: qamruzzaman@bus.uiu.ac.bd

Received: 18 October 2023 **Accepted:** 28 January 2024 **DOI:** https://doi.org/10.32479/ijeep.15470

ABSTRACT

As the world becomes increasingly aware of the need to shift towards sustainable energy sources, China and the United States are two global superpowers leading this transition. With growing populations and increasing demand for energy, these countries have recognized the importance of renewable energy in meeting their needs while reducing carbon emissions. The motivation of the study is to evaluate the impact of trade policy uncertainty on renewal energy demean in the USA and China for the period 2000-2021 by employing linear and nonlinear assessment. The test statistics derived through the cointegration test by following Bayer-Hancked and Makki's cointegration established a long-run tie in the empirical equation. Moreover, the long-run linkage was revealed with symmetry and asymmetry investigation. Referring to the coefficients of linear assessment, the study established that uncertainties have a detrimental role in clean energy demand in the long- and short-run assessment. The asymmetric association between uncertainties and REC has been documented through the execution of a standard weld test with the null of symmetry. The directional causality test established a unidirectional linkage between trade policy uncertainty and REC [TPU←→REC], and a bidirectional linkage between economic policy uncertainty and REC [EPU←→REC].

Keywords: Renewable energy Consumption, Trade Policy Uncertainties, Economic Policy Uncertainties, Carbon Emission, Nonlinear Autoregressive Distributed Lagged

JEL Classifications: Q12; M10, O32, J35

1. BACKGROUND OF THE STUDY

Renewable energy has grown in popularity in recent years as more and more people become concerned about environmental degradation. The use of renewable energy can help to reduce the amount of pollution that is released into the environment, as well as the number of greenhouse gases that are produced (Ayad et al., 2023). This can positively affect the environment, helping to improve air quality and reduce the effects of climate change (Olabi and Abdelkareem, 2022; de Lucena et al., 2009; Eitan, 2021). The greater use of renewable energy has reduced environmental deterioration since most renewable energy sources, such as solar and wind, do not emit air or water-polluting pollutants. Furthermore, renewable energy sources often have a lesser carbon impact than conventional fossil fuels (Muhammad et al., 2021; Fakher et al., 2023). Using renewable energy may aid in reducing greenhouse gas emissions, which is one of the primary drivers of climate change. The melting of glaciers, increasing sea levels, and more severe weather occurrences result from climate change, a huge environmental issue. Increasing our use of renewable energy can decrease environmental deterioration and preserve the earth for future generations (Omri and Belaïd, 2021; Alola et al., 2019; Yan et al., 2023; Wang et al., 2023).

The expansion of our economy has increased the need for power. Sadly, conventional energy sources like fossil fuels may eventually be depleted, making their ongoing usage unsustainable. The only way to avoid negatively impacting the environment while meeting our energy demands is to seek new and innovative energy sources, such as renewable energy. Using renewable energy sources has several positive effects. Since it releases no hazardous byproducts, it is good for the environment. And it's a resource that won't ever deplete, so there's that, too. Last but not least, renewable energy has the potential to improve the economy by spawning new industries and increasing overall productivity. Despite these advantages, however, renewable energy has its share of problems. One disadvantage is that it may be more costly than conventional energy sources. Another difficulty is that renewable energy sources aren't always as dependable as conventional ones, which may lead to service outages. Yet, with forethought and financial effort, these obstacles are surmountable. A sustainable future for our world relies heavily on the widespread adoption of renewable energy sources. It will serve to both save the environment and stimulate the economy.

As a case study, we considered China and the USA to explain the effect of TPU on renewable energy demand. China and the United States are at the forefront of demand as the globe increasingly looks to renewable energy sources to satisfy its demands. The need for renewable energy in China is being pushed for several reasons, including the nation's desire to lower carbon emissions, improve air quality, and generate employment. The Chinese government has high renewable energy expansion goals and spends extensively on solar and wind energy. China is currently the world's leading manufacturer of solar panels and wind turbines. The demand for renewable energy in the United States is mainly motivated by the need to lessen reliance on fossil fuels. The United States is the most excellent oil user in the world, and a significant amount of its energy comes from unstable or unfriendly nations. The United States may lessen its susceptibility to shocks in the global oil market by diversifying its energy mix and expanding its usage of renewables (Su et al., 2023; Serfraz et al., 2023). In addition, some states have enacted Renewable Portfolio Standards (RPS), which mandate that utilities produce a specific amount of their power from renewable sources. This has generated a substantial market for renewable energy makers and innovators. As China and the United States increase their need for renewable energy, the need for new technology and inventive solutions will also increase. It is conceivable to fulfill this expanding demand while still making progress toward reducing climate change if governments and corporations continue to invest and demonstrate their commitment. As a determinant of RE inclusion and consumption in the economy, a growing number of studies has executed and revealed several macro fundaments positively foster REC, including trade openness (Sadiq et al., 2023), institutional quality, FDI, financial development, remittances, economic growth and deter the REC. The present study has considered trade policy uncertainty, economic policy uncertainty, foreign direct investment, environmental sustainability, and trade openness in the equation of renewable energy consumption in the USA and China.

In recent years, trade policy uncertainty has been a significant issue for the renewable energy sector (Zhou et al., 2022). With the Trump administration's withdrawal from the Paris Climate Agreement and its review of the Clean Power Plan, there has been much confusion about the future of U.S. climate and energy policy. This uncertainty has led to delays in investment and development in the renewable energy sector. Companies wait to see what direction federal policy will take. Existing trade policy uncertainty already impacts renewable energy demand and investment, which will likely continue. Trade policy measures imposed by the current administration, including tariffs on imported solar panels and components, have led to increased costs for developers and delayed or canceled projects. The additional tariffs on imported steel and aluminum could also raise costs for the renewables industry (Qamruzzaman and Kler, 2023; Lin and Qamruzzaman, 2023). The continued uncertainty around trade policy will likely harm the demand for renewable energy in the United States. Developers are postponing or canceling investment decisions due to the higher costs associated with tariffs and the resulting increase in project costs. The industry also faces challenges in sourcing components from overseas, as suppliers hesitate to commit to long-term contracts given the current environment of tariff threats.

Emerging as a significant factor affecting not just investment and economic growth but also the adoption of renewable energy sources, economic policy uncertainty (EPU) is a relatively recent phenomenon. As indicated by the EPU, the future economic policies of a government are seen with a high level of uncertainty (Shafiullah et al., 2021). The rate of policy shifts, the magnitude of those shifts, and the degree of disagreement among decision-makers about the economy's future are all indicators. More and more studies point to the possibility of a significant impact of EPU on renewable energy consumption, both in terms of investment levels and technologies put into use. Researchers have shown that EPU causes a shift away from capital-intensive technologies and toward less expensive energy production forms, such as renewables (Lei et al., 2022; Sohail et al., 2021). The impact of EPU on adopting renewable energy sources is likely to vary among countries and regions, depending on their unique conditions. Nonetheless, it is often believed that increasing EPU would lead to less reliance on green power sources. Meeting ambitious renewable energy goals requires corporations to plan and invest in long-term projects like renewable energy plants. However, higher levels of EPU make this more challenging (Yi et al., 2023; Qamruzzaman et al., 2023; Li and Qamruzzaman, 2023; Kor and Qamruzzaman, 2023). According to the International Renewable Energy Agency (IRENA), global investment in renewable power and technologies reached $259 billion in 2016, an increase of 27 percent from 2015. Renewable energy is now the fastest-growing primary global industry, investing more than $160 billion in new capacity in 2016 alone. The growth rate is expected to accelerate as the accelerated pace of cost declines and government support continues to spur investment in new technology, manufacturing, and business models. In addition to providing electricity at a low cost, another benefit of greater trade openness is the increased demand for renewable energy products. When you expand trade opportunities for foreign manufacturers and suppliers, they have more incentive to introduce advanced technologies into their production processes and reduce costs through partnerships with local firms or by purchasing raw materials locally instead of importing them from abroad. This will ultimately result in higher consumer demand for renewable energy products such as PV panels, wind turbines, and batteries, which will help drive up prices.

The study's contribution to the existing literature is as follows. First, as far as the nexus between TPU and REC, this is the first-ever empirical study assessing the potential effects of TPU on REC through the expectation of linear and nonlinear framework. However, referring to TPU's impact on energy consumption to date, only a few studies have implemented it. See for details (Wang and Wu, 2023; Xie et al., 2023). Second, the present study has extended the existing literature focusing on EPU effects on REC by incorporating two uncertainties, TPU and EUP, in the same equation. To our knowledge, this is the first-ever study where the effects of TPU and EPU have been documented simultaneously. The global economy is constantly changing, and with that comes a significant impact on renewable energy. The ever-evolving trade policies have created uncertainty for global renewable energy industries. This has led to decreased investment, loss of jobs, and disruption of supply chains. In this study, we will explore the relationship between trade policy uncertainty and renewable energy demand with and without the presence of environmental.

The rest of the structure is as follows. Literature surveys are displayed in section II. The definition of the variables and methodology of the study are explained in Section III. The section deals with estimation and interpretations. Discuss the study findings reported in Section IV and the conclusion and policy suggestions exhibited in Section V, respectively.

2. LITERATURE SURVEY

2.1. Trade Policy Uncertainty and Renewable Energy

The effects of trade policy uncertainty on renewable energy demand are far-reaching and complex. In short, this uncertainty can decrease investment in renewable energy projects as developers and financiers become risk-averse. This, in turn, can lead to reduced deployment of renewable energy technologies and, ultimately, higher carbon emissions as the world relies heavily on fossil fuels.

For the chines economy, a study has been executed by (Wang and Wu, 2023) to assess the role of TPU on renewable energy consumption and economic growth. Inferring to study findings, it is evident that TPU has adverse effects on economic growth, export development, and overall energy consumption. Notably, for a rate of 10%, TPU will result in slower economic growth to 5.56% and renewable energy consumption dropping by 6.91%. Further Evidence can be found in the study of (Xie et al., 2023), which investigated the TPU effects on changing energy selection, precisely the energy transition. Study findings imply that firms may have immediate and long-term reactions to TPU. However, it may have a lesser impact on the industrial sector. Yet, the asymmetry research demonstrates that TPU can alter the long- and short-term stability of residential and commercial consumption (Qamruzzaman et al., 2023; Li and Qamruzzaman, 2023; Kor and Qamruzzaman, 2023; Karim et al., 2023; Ju et al., 2023; Farzana et al., 2023).

The first effect of trade policy uncertainty on renewable energy demand is decreased investment. When developers and financiers perceive greater risk, they are less likely to invest in renewable energy projects. This lack of investment can have a ripple effect, reducing the deployment of renewable energy technologies and higher carbon emissions. One study found that increased trade policy uncertainty led to a decrease in new solar photovoltaic (PV) installations in the United States (US) by 10% from 2016 to 2017. The study attributed this decline primarily to two factors: the power purchase agreement (PPA) market for new solar PV projects dried up due to policy changes at the state level, and project financing became more difficult to obtain because banks perceived greater risk associated with these types of investments. A separate analysis concluded that if the US had not withdrawn from the Paris Agreement-an international climate change pact-solar PV deployment would have been 4% higher in 2018 than it was. This highlights how important international cooperation is for meeting global climate goals-without it, progress toward a cleaner future.

In the case of China, (Li et al., 2021) investigated the effects of TPE on energy efficiency with the firm's level data. The study unveiled that energy efficiency has prompted TPE in china; the possible reasons posted by the study are that TPU discourages foreign investment and alternatively fosters innovation in the economy, which supports energy efficiency. Renewable energy is a critical component in mitigating trade policy uncertainty. Renewable energy becomes an increasingly important part of the global energy mix as the world moves away from fossil fuels. Trade policy uncertainty can have a significant impact on the demand for renewable energy, as well as the prices of renewable energy technologies. Renewable energy can help mitigate some of the impacts of trade policy uncertainty by providing a more stable and predictable energy source. Renewable energy is also less likely to be impacted by trade disputes, as it is not reliant on imported fossil fuels. To maximize the benefits of renewable energy, it is essential to have a diversified mix of renewable energy sources. This will help ensure that if one renewable energy source becomes unavailable or more expensive, others can take its place.

The neutral effects of TPU on REC in the USA have been established in the study of (Jamil et al., 2022). According to the study findings, fiscal policy uncertainty enhances renewable energy production; monetary policy uncertainty does the opposite in the short and long run.

2.2. Economic Policy Uncertainty and Renewable Energy Consumption

There has been a rise in the importance of economic policy uncertainty (EPU) as a factor affecting investment, economic growth, and the adoption of renewable energy sources. A country's economic policy EPU measures how unsure investors are about the country's economic future. It is measured by the number of policy shifts, the magnitude of those shifts, and the extent to which officials differ on the economy's future. More and more studies point to the possibility of a significant impact of EPU on renewable energy consumption, both in terms of investment and technological adoption (Alonso-Travesset et al., 2023).

For instance, research has shown that EPU causes a shift away from capital-intensive technologies and decreases investment in renewable energy projects (Qamruzzaman et al., 2023; Qamruzzaman, 2023a; Qamruzzaman, 2023c; Qamruzzaman, 2023b; Li and Qamruzzaman, 2023; Kor and Qamruzzaman, 2023; Karim et al., 2023; Ju et al., 2023; Farzana et al., 2023). There will likely be regional and national variations in how EPU affects the adoption of renewable energy sources. Nonetheless, it is generally expected that an increase in EPU would lead to a decrease in the usage of renewable energy. When EPU rises, it becomes more challenging for businesses to plan and invest in long-term projects like renewable energy installations, which are typically required to meet ambitious renewable energy targets (Yi et al., 2023).

Apergis and Payne (2010) found Evidence of a negative impact on electricity demand in Greece (Bakirtas and Cetin, 2017). They discovered a similar result for investments in Turkey's renewable energy sector. He Xu et al. (2022) et al. (2016) observed a different impact depending on the type of renewable energy; overall investment was negatively affected, while wind power specifically experienced a positive effect. The Evidence indicates that economic policy uncertainty can have multiple impacts on the development and deployment of various renewable energy sources - all of which should be considered when formulating policy decisions at both local and national levels. Further research is needed to further our understanding of this complex relationship.

Shafiullah et al. (2021) investigated the impact of EPU on REC in the USA by considering monthly data from 1986 to 2019 with a linear and nonlinear framework. The study documented an adverse linkage between EPU and REC in the long and short run, suggesting EPU dwindles the inclusion of clean energy in the economy. Inferring the asymmetric findings, the study offered a lower degree of REC due to a higher level of EPU and vice-versa. For Chinese REC, Lei et al. (2022) implemented ARDL and NARDL for the period 1990-2019 in evaluating the nexus between EPU, financial development, and REC. According to the symmetry and asymmetry assessment, the study disclosed a negative linkage between EPU and REC. At the same time, financial development has found a contributory role for REC in the long and short run.

2.3. Foreign Direct Investment and REC

As countries strive to reduce carbon emissions, many are turning towards renewable energy sources. However, financing these projects can be a challenge. This is where foreign direct investment comes into play. By investing in renewable energy projects abroad, countries can simultaneously promote sustainable development and stimulate economic growth. Numerous studies have been conducted on the relationship between FDI and renewable energy consumption. The findings of these studies are inconclusive, with some finding a positive relationship (Zhang et al., 2021; Qamruzzaman et al., 2022). For instance, in the case of African nations, (Akpanke et al., 2023) initiated an empirical assessment with a panel of 15 nations for the period 1990-2021 by employing Panel-ARDL. The study documented a positive statistically significant linkage between FDI and REC in the long and short run. Most studies suggest a positive relationship between FDI and renewable energy consumption. This means that countries with higher levels of FDI also tend to have higher levels of renewable energy consumption.

Several possible explanations exist for this nexus between FDI and renewable energy consumption. One possibility is that countries with high levels of FDI tend to be more developed and thus have more access to technology and resources needed to develop and implement renewable energy solutions. Another possibility is that countries with high levels of FDI tend to be more attractive destinations for foreign investors due to political stability, the strict rule of law, and good infrastructure. This makes it more.

In conclusion, the nexus between foreign direct investment and renewable energy consumption is linked in many ways. The two are positively related due to the increased capital investments that come with FDI, which can help fund the development of renewable energy projects. Additionally, joint ventures between domestic firms and multinational companies looking to invest in a country could also lead to technological advancements in renewables. Ultimately, this relationship between FDI and renewable energy consumption should be further explored so countries can take advantage of their potential benefits.

2.4. Theoretical Development and Justification of the Study

The consumption of renewable energy is a crucial aspect of the shift towards an energy system with low carbon emissions. Nonetheless, the renewable energy sector is confronted with various uncertainties that jeopardize its growth and adoption. Policymakers and stakeholders could potentially mitigate uncertainty and promote the development of renewable energy by examining the effects of uncertainty on the utilization of renewable energy. The utilization of renewable energy may be affected by economic uncertainty, which fluctuations in economic indicators, market conditions, and energy prices can evidence. Uncertainty regarding future energy prices and the financial viability of renewable energy projects may impact the decisions made by consumers and investors. As per (Ito and Managi, 2015) and (Huang et al., 2019) heightened economic uncertainty could impede the adoption of renewable energy. The presence of ambiguity in policy and regulation could potentially exert a significant influence on the utilization of renewable energy. The presence of ambiguity regarding the support mechanisms for renewable energy, government incentives, and regulatory frameworks could potentially hinder the progress of project development and investment. As per the findings of Jin et al. (2018) and Cai et al. (2021), consistent and favorable policies have a positive impact on the utilization of renewable energy. However, any ambiguity or unpredictability in policies may impede its progress. The technological uncertainty surrounding the development, performance, and availability of renewable energy technologies is a significant factor to consider. The presence of ambiguity regarding a technology's effectiveness, efficiency, and reliability can impact its acceptance and customer trust. (Strunz, 2014) and (Wüstenhagen and Boehnke, 2017) have reported that the reduction of technical uncertainty through research and development endeavors and technological enhancements can potentially facilitate the adoption of renewable energy sources.

The potential impact of climate change and environmental considerations on the utilization of renewable energy sources remains uncertain. The escalating apprehensions regarding climate change and environmental degradation have resulted in a surge in the requirement for renewable energy. On the other hand, ambiguity regarding the magnitude and timeline of climate ramifications could potentially impact the immediacy and inclination toward embracing renewable energy. The research conducted by Liu and Dong (2021) and (Carattini et al., 2018) has emphasized the importance of reducing environmental uncertainty as a means of promoting the adoption of renewable energy sources. Social and behavioral variables may introduce uncertainty in the utilization of renewable energy. The selection of consumers can be swayed by the public's perception, knowledge, and attitudes towards renewable energy sources. The potential impact of public approval, societal norms, and cultural issues on the adoption of renewable energy technology is uncertain. The research conducted by (Bertsch et al., 2016) as well as (Mangla et al., 2020) highlights the importance of mitigating social and behavioral uncertainties to promote the adoption of renewable energy sources.

Various uncertainties in the economy, politics, technology, the environment, and society can potentially impact consumer behavior, investment decisions, and policy outcomes. The encouragement of greater use of renewable energy can be achieved through the recognition and minimization of risks via robust regulations, technological advancements, improved environmental forecasts, and targeted awareness campaigns. Empirical research, grounded in this theoretical framework, has the potential to provide policymakers and stakeholders with valuable insights for the development of successful policies that promote a sustainable and resilient renewable energy future.

3. DATA AND METHODOLOGY OF THE STUDY

3.1. Model Specification

The motivation of the study is to evaluate the impact of trade uncertainties on renewable energy demand for the period 2000-2021. The primary relations of the empirical nexus are given below

$$REC \equiv TU, EPC \tag{1}$$

REC, TPU, and EPU represent the uncertainty of renewable energy consumption, trade, and economic policy. The above equation (1) has extended with the incorporation of tree control variables used in literature in the equation of renewable energy consumption. Thus, the empirical equation was reproduced with the control variables as follows. Ee

$$REC \equiv TU, EPC, FDI, ES, TO \tag{2}$$

REC, TPU, EPU, FDI, ES, and TO stand for renewable energy consumption, trade policy uncertainty, economic policy uncertainty, foreign direct investment, environmental sustainability, and trade openness, respectively. Table 1 displays the proxies of research variables.

After transformation in the log formation, the above equation can be rewritten for regression in the following manner.

$$REC_t = \alpha_0 + \beta_1 TPU_t + \beta_2 EPU_t + \beta_3 FDI_t + \beta_4 ES_t + \beta_5 TO_t + \omega_t \tag{3}$$

It is anticipated that the coefficient of TPU should be negative and statistically significant, that is $\beta_1 \dfrac{REC_t}{TPU_t} < 1$. There is now a great deal of uncertainty surrounding trade policy and having a cascading effect on the utilization of renewable energy as enterprises and consumers become more unwilling to invest in this industry. This anxiety is primarily due to the Trump administration's protectionist trade stance. This has prompted calls to impose tariffs on imported solar panels, which may substantially raise costs. Consequently, this would diminish the financial attraction of renewable energy, perhaps resulting in a fall in consumption. Moreover, Brexit and the ongoing renegotiation of the North American Free Trade Agreement add to the apprehension (NAFTA). Consequently, businesses and consumers are reluctant to invest in renewable energy due to the inability to forecast future changes in trade policy. This uncertainty is anticipated to harm the usage of renewable energy in the immediate future, as people postpone investment decisions until there is more clarity. Nevertheless, suppose these Uncertainties lead to long-term changes in trade policy. In that case, they may have a more substantial long-term influence on renewable energy consumption levels.

As far as economic policy uncertainty effects on renewable energy consumption, it is anticipated that adverse effects follow from EPU to REC both in the long-run and short-run assessment $\beta_1 \dfrac{REC_t}{EPU_t} < 1$. Because of concerns that economic policy uncertainty may have a detrimental impact, using renewable energy sources has been more of a concern in recent years.

Table 1: Variables definition and measures

Variables	Notation	Definition	Units	Sources
Renewable energy consumption	REC	Renewable energy consumption as a % total	%	WDI
Trade Policy Uncertainty	TPU	Trade policy Uncertainty index	Index	
Economic policy uncertainty	EPU	Economic policy uncertainty index	Index	
Foreign direct investment	FDI	Inflows of FDI as a % of GDP	%	
Trade Openness	TO	Sum of export and imports as a % of GDP	%	
Environmental Sustainability	ES	Carbon emission	Kt	

Investing in renewable energy might be dangerous, according to various research. This uncertainty stems from the government's renewable energy program, which is secrecy-free. Investors are afraid to make long-term investments since these restrictions may be changed in the future (Qamruzzaman, 2022d). Such uncertainty impacts solar photovoltaic investment since lenders often see this technology as hazardous and unreliable. According to a recent NREL study, regulatory uncertainty is one of the biggest obstacles preventing solar PV from reaching its full potential. Policy uncertainty affects more than just investment decisions. However, suppose consumers believe that government subsidies will be reduced shortly. In that case, demand for renewable energy may be depressed. This demonstrates why governments must be more transparent about their renewable energy ambitions. If this were not in place, less investment and slower growth in the renewables business might substantially affect our ability to meet climate change targets (Jinru et al., 2022a).

According to the literature, the effects of FDI on renewable energy consumption might be positive and statistically significant, implying that foreign capital flows in the economy foster energy development, especially for the inclusion of renewable sources; thus, $\beta_3 \frac{REC_t}{EPU_t} > 1$. Foreign direct investment (FDI) seeks to benefit the investor financially. In recent years, foreign direct investment (FDI) in renewable energy projects such as wind and solar has increased. Renewable energy is often considered a more secure and long-term investment than traditional fossil fuels. Moreover, renewable energy is becoming more affordable and can compete with traditional power plants. As a result, foreign direct investment (FDI) in renewable energy projects is expected to rise further in the coming years. What does this proclivity imply? The economies and job prospects of countries that attract foreign direct investment (FDI) in renewable energy are expected to improve. This might assist impoverished nations in diversifying their energy sources and decreasing their dependency on fossil fuels. This breakthrough may also speed the global transition to a low-carbon economy.

3.2. Estimation Strategies

3.2.1. Unit root test

There are several unit root tests, each with its benefits and drawbacks. ADF, PP, DF-GLS, and KPSS are the unit root tests most often used. The ADF test is an efficient technique for identifying stationary and nonstationary processes. Nevertheless, the ADF test is subject to structural faults. Thus, care must be used when interpreting the results. The PP test is a structural breakage insensitive unit root test. Nevertheless, the PP test is inferior to the ADF test and can only detect stationary processes. The DF-GLS test combines the ADF and PP unit root tests. It can detect stationary and nonstationary activities, and its structure resists harm. Nevertheless, the DF-GLS test is inferior to the ADF test since it can only detect stationary processes. The KPSS unit root test may distinguish between stationary and nonstationary systems. Nonetheless, the KPSS test is not resistant to structural failures. It can only establish stationarity when the process lacks predictable patterns.

3.2.2. Cointegration test

The bayer-anchored cointegration test was performed to test for a long-run relationship between 2-time series. The test is based on the following equation:

Y_t = \beta X_t + u_t

Y_t is the dependent variable, X_t is the independent variable, and u_t is the error term. The test's null hypothesis is that there is no long-run relationship between the two variables, while the alternative hypothesis is that there is a long-run relationship. To conduct the test, first, the time series of both variables are regressed on an intercept. Then, the residuals from this regression are used in a second regression, with Y_t as the dependent variable and X_t as the independent variable. Finally, a third regression is performed, with Y_t as the dependent variable and a constant as the independent variable. The coefficient on X_t in this final regression is tested for significance using a t-test. The results of the bayer-Hanchored cointegration test showed that there was no evidence of a long-run relationship between stock prices and interest rates.

The Maki cointegration test is a statistical test used to check for a long-run relationship between two variables. It is based on cointegration, which says that two variables are cointegrated if they have a long-run relationship. The test was developed by Bayer and Hanck (2013) and is more potent than other tests for detecting cointegration relationships. To run the test, you must have data on two variables for at least 100 observations. The first step is to calculate the correlation between the two variables. If the correlation is statistically significant, you can proceed to the next step, calculating the coefficient of determination (R2). This measures the amount of variation in one variable that is explained by the other variable. If R2 is close to 1, then this indicates a robust linear relationship between the two variables. Once you have calculated R2, you can proceed to the Makki cointegration test. This involves regressing one variable on the other and testing whether the residuals from this regression are stationary. If they are not stationary, then this indicates a long-run relationship between the two variables, and they are cointegrated (Qamruzzaman, 2022b).

3.3. Autoregressive Distributed Lagged

The study has implemented the autoregressive distributed lagged (ARDL) initially introduced by Pesaran and Shin (1998). Further development has been executed by Pesaran et al. (2001), which is widely known as Bound testing. The objective of autoregressive distributed lagged models, a kind of econometric model, is to estimate the influence of prior observations on a current response variable while concurrently considering the impact of other variables. When studying time series, applying this model is standard practice, which may be estimated using standard regression procedures. For an ARDL model to be suitable, neither the mean nor the variance of the response variable may exhibit time-dependent trends. If the residuals of a regression model are not steady, the ARDL model is improper. After ensuring stationarity, an ARDL model may be estimated by regressing the response variable on its lag and the lags of additional predictor variables. While the other predictors may indicate variables that have an immediate impact on the answer, the lagged terms represent the impact of past values on the current value of the response variable. While estimates from an ARDL model can be interpreted similarly to those from a standard linear regression model, it is essential to remember that the lagged terms in an ARDL model are not necessarily independent. Caution should be exercised when concluding these estimates.

The targeted equation's generalized ARDL (p,q,t,r,c) follows.

$$\Delta y_t = \varnothing_1 + \gamma_1 y_{t-1} + \gamma_2 x_{t-1} + \gamma_3 z_{t-1} + \theta_1 \sum_{i=1}^{n} \Delta y_{t-1} + \theta_2 \sum_{i=1}^{n} \Delta x_{t-1} + \theta_3 \sum_{i=1}^{n} \Delta z_{t-1} + \varepsilon_{1t}$$

Considering the established nexus, the ARDL equation can be prepared in the following manners.

$$x^2_{RESET} \quad (3)$$

From the above equation (), the following hypothesis will evaluate the long-run association following the procedure offered.

H_0: $[\gamma_{11}=\gamma_{12}=\gamma_{13}=\gamma_{14}]=0$

The long-run coefficients of TPU, EPU, FDI, TO, and ES will be discovered using the following equation. The long-run ARDL (*m*, *n*, *q*, *t*, *v*, *x*, *p*) equilibrium model is as follows.

$$lnREC_t = \sigma_0 + \sum_{k=1}^{m} \beta_k ln(REC)_{t-k} + \sum_{k=0}^{n} \gamma_k ln(TPU)_{t-k} + \sum_{k=0}^{q} \delta_k ln(EPU)_{t-k} + \sum_{k=0}^{t} \mu_k ln(TO)_{t-k} + \sum_{k=0}^{v} \pi_k ln(FDI)_{t-k} + \sum_{k=0}^{x} \rho_k ln(ES)_{t-k} + \varepsilon_t \quad (4)$$

The error correction form for short-run coefficients can be derived from the following equation.

$$\Delta ln(REC)_t = \sigma_0 + \sum_{k=1}^{n} \beta_k \Delta \ln(REC)_{t-k} + \sum_{k=0}^{n} \gamma_k \Delta \ln(TPU)_{t-k} + \sum_{k=0}^{n} \delta_k \Delta \ln(EPU)_{t-k} + \sum_{k=0}^{n} \mu_k \Delta \ln(TO)_{t-k} + \sum_{k=0}^{n} \pi_k \Delta \ln(FDI)_{t-k} + \sum_{k=0}^{n} \rho_k \Delta \ln(ES)_{t-k} + \omega_t \quad (5)$$

Where the error correction term can be expressed as;

$$ECT_t = ln(REC)_t - \sigma_0 - \sum_{k=1}^{m} \beta_k \ln(RC)_{t-k} - \sum_{k=0}^{n} \gamma_k \ln(TPU)_{t-k} - \sum_{k=0}^{q} \delta_k \ln(EPU)_{t-k} - \sum_{k=0}^{t} \mu_k \ln(TO)_{t-k} - \sum_{k=0}^{v} \pi_k \ln(FDI)_{t-k} - \sum_{k=0}^{x} \rho_k ln(ES)_{t-k}$$

3.4. Asymmetric ARDL

The term "asymmetric autoregressive distributed lagged models" (also known as "NARDL") refers to a type of statistical model that is employed to analyze data that demonstrates nonlinearity and time-varying dynamics. NARDL is an acronym for "nonlinear autoregressive distributed lagged models." Since NARDL models can capture both the short-term and long-term impacts of variables on each other, they are particularly well-suited for analyzing data with a long memory because NARDL models can capture both the short-term and the long-term impacts of variables on each other. Because of this, they are pretty beneficial (Qamruzzaman, 2021). In addition to this, NARDL models can take into account changes over time, like the interactions that take place between the variables that are being studied. Because of this property, they are adaptable instruments that may be used to study large data sets.

The study expanded the empirical nexus through the execution of an asymmetric framework offered by shin. The generalized NARDL empirical equation is as follows.

$$\begin{aligned} \Delta \ln REC_t = {} & \alpha_0 + \sum_{i=1}^{n} \mu_1 \Delta \ln REC_{t-i} + \sum_{i=0}^{n} \mu_2^+ \Delta \ln POS(TPU)_{t-i} \\ & + \sum_{i=0}^{n} \mu_2^- \Delta \ln NEG(TPU)_{t-i} + \sum_{i=0}^{n} \mu_2^+ \Delta \ln POS(EPU)_{t-i} \\ & + \sum_{i=0}^{n} \mu_2^- \Delta \ln NEG(EPU)_{t-i} + \sum_{i=0}^{n} \mu_3 \Delta \ln FDI_t \\ & + \sum_{i=0}^{n} \mu_5 \ln TO_t + \sum_{i=0}^{n} \mu_6 \ln ES_t + \gamma_0 \ln REC_{t-1} \\ & + \gamma_1^+ \ln POS(TPU)_{t-1} + \gamma_1^- \ln NEG(TPU)_{t-1} \\ & + \gamma_1^+ \ln POS(EPU)_{t-1} + \gamma_1^- \ln NEG(EPU)_{t-1} \\ & + \gamma_2 \ln FDI_{t-1} + \gamma_3 \ln TO_{t-1} + \gamma_3 \ln ES_{t-1} + \omega_t \end{aligned} \quad (6)$$

The nonlinear shock of TPU and EPU has been derived by implementing the following partial-sum equations,

$$\begin{cases} POS(TPU)_t = \sum_{k=1}^{t} \ln TPU_k^+ = \sum_{K=1}^{T} MAX(\Delta \ln TPU_k, 0) \\ NEG(TPU)_t = \sum_{k=1}^{t} \ln TPU_k^- = \sum_{K=1}^{T} MIN(\Delta \ln TPU_k, 0) \end{cases} \quad (7)$$

$$\begin{cases} POS(EPU)_t = \sum_{k=1}^{t} lnFDI_k^+ = \sum_{K=1}^{T} MAX(\Delta lnEPU_k, 0) \\ NEG(EPU)_t = \sum_{k=1}^{t} lnEPU_k^- = \sum_{K=1}^{T} MIN(\Delta lnEPU_k, 0) \end{cases} \quad (8)$$

Table 2: Results of stationary tests

Variables	At level				After first difference			
	ADF	GF-DLS	PP	KPSS	ADF	GF-DLS	PP	KPSS
Panel-A: for India								
REC	−0.5764	−1.6308	−1.6142	0.7241***	−8.8279***	−7.541***	−6.8755***	0.0196
TPU	−2.1802	−2.3287	−2.2696	0.7428***	−7.0622***	−8.7209***	−7.4601***	0.0211
EPU	−1.5362	−2.284	−1.8478	0.8378***	−5.804***	−7.1464***	−7.0071***	0.0192
FDI	−0.4728	−0.5199	−2.2245	0.6109***	−9.4788***	−7.4841***	−7.0242***	0.021
TO	−2.3466	−1.1686	−0.8006	0.6233***	−7.5019***	−7.8164***	−6.615***	0.0186
ES	−0.9121	−0.3683	−2.492	0.877***	−7.5205***	−6.5386***	−8.3148***	0.0192
Ng-Perron Unit root test								
	MZa	MZt	MSB	MPT	MZa	MZt	MSB	MPT
REC	−2.627	−1.51	0.3457	7.4002	−21.937	−4.753	0.1693	4.7465
TPU	−2.6041	−1.0485	0.3265	8.5637	−21.716	−3.8896	0.1544	4.5878
EPU	−1.9877	−1.4401	0.3271	7.723	−20.464	−5.2962	0.1544	3.7673
FDI	−2.4588	−0.8161	0.3626	7.1631	−25.723	−4.3715	0.1759	3.7221
TO	−2.1183	−1.3415	0.2828	8.579	−17.916	−4.0162	0.1502	4.5826
ES	−1.77	−0.6851	0.2511	8.6324	−25.717	−4.694	0.1448	4.0729
Panel-B for china								
	ADF	GF-DLS	PP	KPSS	ADF	GF-DLS	PP	KPSS
REC	−1.7842	−2.5101	−1.9919	0.795***	−9.3816***	−6.2332***	−8.6853***	0.0185
TPU	−1.6405	−2.5726	−1.224	0.8079***	−8.4635***	−7.124***	−8.6922***	0.0189
EPU	−2.1699	−1.3977	−2.5213	0.7491***	−5.7081***	−5.7666***	−8.0838***	0.0189
FDI	−2.003	−1.6275	−2.285	0.8147***	−8.3123***	−9.5156***	−8.5413***	0.0187
TO	−1.7738	−2.339	−0.9302	0.6916***	−8.7448***	−7.7508***	−7.1868***	0.0205
ES	−0.5592	−2.0517	−0.4129	0.6194***	−9.4591***	−8.7186***	−5.6004***	0.0217
Variables	**Ng-Perron Unit root test**							
	At level							
	MZa	MZt	MSB	MPT	MZa	MZt	MSB	MPT
REC	−2.0153	−1.5444	0.3771	8.5526	−22.705	−4.9789	0.1278	3.8956
TPU	−2.4298	−1.5183	0.3405	7.868	−20.114	−5.334	0.1516	4.3038
EPU	−2.2048	−0.9857	0.289	8.0152	−19.377	−4.3926	0.1746	3.177
FDI	−2.5022	−1.6505	0.2398	7.9636	−19.702	−5.3236	0.174	3.2257
TO	−1.9272	−1.0136	0.374	7.9805	−19.919	−4.2245	0.156	5.0594
ES	−2.1391	−0.9965	0.2367	9.0687	−22.24	−4.5331	0.1784	3.8894

Table 3: Results of combined and Makki cointegration test

Estimation	Model	USA	China	CV
EG-JOH	REC|TPU	14.65	11.352	11.229
	REC|TPU, EPU	11.107	11.141	10.895
	REC|TPU, EPU, FDI	11.372	11.041	10.637
	REC|TPU, EPU, FDI, ES	10.735	10.968	10.576
	REC|TPU, EPU, FDI, ES, TO	10.562	10.667	10.419
EG-JOH-BO-BDM	REC|TPU	36.809	35.297	21.931
	REC|TPU, EPU	27.894	26.632	21.106
	REC|TPU, EPU, FDI	23.482	22.542	20.486
	REC|TPU, EPU, FDI, ES	21.01	21.545	20.143
	REC|TPU, EPU, FDI, ES, TO	20.951	20.915	19.888

Panel-B: Results of Makki cointegration

Number of Breaks Points	Test Statistics	(Critical Values)	Break Points
Tb <5: for China			
0	−7.3599	−6.306	2006,2004,2016,2003,2009
1	−8.3556	−6.494	2008,2021,2010,2011,2000
2	−8.7833	−8.869	2004,2018,2016,2019,2005
3	−8.1711	−9.482	2016,2001,2018,2004,2010
Tb <5: for the USA			
0	−9.708	−6.306	2000,2003,2021,2006,2018
1	−9.6485	−6.494	2014,2012,2002,2012,2015
2	−8.6456	−8.869	2006,2000,2004,2010,2021
3	−7.701	−9.482	2020,2000,2005,2013,2019

4. ESTIMATION AND INTERPRETATION

4.1. Unit Root Test

Several static tests have been executed to document the research variables' stationary properties. Referring to the established test statistics study, all the variables become stationary after the first difference, e, i. I(1) and none of the exposed stationary after the second difference. The results of the unit root are displayed in the Table 2.

4.2. Bayer-Hancked and Makki Cointegration Test

The long-run association between TPU, EPU, FDI, TO, ES, and REC has been evaluated through the execution of novel cointegration tests introduced by Bayer-Hancked and Makki. Table 3 exhibited the results of the cointegration test. Referring to test statistics from the combined cointegration test, the test statistics are more significant than the critical value at a 5% level, implying the rejection of no-cointegration. Furthermore, the results of Makki cointegration established long-run cointegration with five structural breaks. Thus, it is conclusive to report the long-run cointegration in the empirical nexus.

4.3. Long-run Cointegration

Next, the study extended the cointegration assessment by employing the Cointegration test under the symmetric and asymmetric framework. The test statistics, which are Foverall, tDV, and FIDV, reveal statistical significance at a 1% level. This suggests the long-run tie between explained and explanatory variables under the linear and nonlinear framework. Their results are displayed in Table 4.

4.4. Symmetric Assessment: TPU and EPU of Respective Nations

The result of symmetric assessment displayed in Table 5. The coefficients of TPU have been revealed as statistically significant at a 1% level for both the long-run and short-run, indicating that clean energy consumption has been adversely affected due to uncertainties. More precisely, renewable energy consumption in China and India would be reduced by 1.331% and 0.8455% in the long run and by 0.855% and 0.556% in the short run due to a 10% change in TPU. The recent study which has supported the adverse connection between TPU and REC is implemented by, however, the conflicting findings in terms of literature offered by (Jamil et al., 2022).

EPU and REC in China and India have detected an adverse connection. This conclusion is validated in the long and short run. Notably, china, with a 10% change in EPU, will decrease consumption in the long run by 0.409% and by 0.622% in the short run. At the same time, the long-run and short-run renewable energy consumption has reduced in India by 1.644% and by 0.293% due to a 10% change in EPU. Our findings align with existing literature such as (Zhang and Razzaq, 2022; Khan and Su, 2022; Ivanovski and Marinucci, 2021) but contrast with the study findings offered by (Lei et al., 2022). As the world evolves, the incidence of economic policy uncertainty has grown. This is mainly attributed to globalization and economic interdependence growth. When one economy suffers, the effects are generally seen across the global economy. This unpredictable economic environment may make firms' long-term investment decisions difficult. The renewable energy business is particularly subject to the unpredictability of economic policy. Renewable energy technologies are still relatively new and need considerable initial investment. These investments offer the potential for significant long-term returns, which typically span decades. Businesses may be reluctant to invest long-term in a turbulent economic environment.

The coefficient of FDI has revealed positive and statistical significance at a 1% level on REC in the USA (a coefficient of 0.0232) and china (a coefficient of 0.09251) in the long run, suggesting that inflows of FDI in the economy foster the demand of renewable energy sources. Thus, contributory effects can be documented in the process of the inclusion of clean energy in the energy mix. Additionally, the case of the short-run assessment study unveiled a similar line of linkage between FDI and REC. However, the benefits of FDI on REC are more evident in the long run than in the short run. Our study findings of positive linkage between FDI and REC align with existing literature (Qamruzzaman, 2022c; Jinru et al., 2022b; Qamruzzaman, 2022a; Qamruzzaman and Jianguo, 2020; Kang et al., 2021; Khandker et al., 2018). (Akpanke et al., 2023).

The coefficients of error correction terms are negative and statistically significant at a 1% level in china (a coefficient of −0.2768) and the USA (a coefficient of −0.3832), suggesting the correction of long-run disequilibrium at a speed of 27.68% in China and 38.32% in the USA. Thus, it is assumed that the equilibrium point can be reached in around 04 months in china and 03 month is the USA. Furthermore, the present study has executed several residual diagnostic tests such as serial correlation, heteroskadacity, normality, and RESET test to ensure empirical estimation efficiency and consistency. Residual Diagnostic test results displayed in Panel-C produce conclusive Evidence favoring the estimation consistency and efficiency.

4.5. Asymmetric Assessment: Long-run and Short-run Coefficients

A standard wild test has been implemented with a null hypothesis of symmetry in the long-run and short-run assessment. Panel-A of Table 6 displayed the results of the symmetry test and revealed that all the test statistics are statistically significant at a 1% level, suggesting the asymmetric effects running from TPU and EPU to REC both in the long and short run. Table 5 Results of asymmetric coefficients.

Table 4: Results of long-run cointegration test

long-run cointegration	USA			China		
	$F_{overall}$	t_{DV}	F_{IDV}	$F_{overall}$	t_{DV}	F_{IDV}
ARDL	8.443***	−7.125***	6.66***	13.931***	−5.523***	9.468***
NARDL	12.852***	−6.14***	10.253***	8.46***	−4.52***	8.191***

The superscripts of ***/**/* indicates a level of significance at a 1%, 5%, and 10% respectively

Table 5: Results of asymmetric coefficients

Variables	For China			For India		
	Coff	t-stat	SE	Coff	t-stat	SE
Panel-A: Long-run coefficients						
TPU	−0.13331	0.00192	−69.4333	−0.08455	0.00747	−11.3191
EPU	−0.040918	0.004026	−10.16344	−0.16443	0.006316	−26.03388
FDI	0.023255	0.002209	10.52757	0.092511	0.00594	15.57421
ES	0.074654	0.009578	7.794331	0.088444	0.009099	9.720222
TO	0.112117	0.007072	15.85359	0.017632	0.005116	3.446364
c	−0.0791	0.01128	−7.01207	−0.1138	0.005377	−21.1651
Panel-B: Short-run coefficients						
▲TPU	−0.0853	0.0039	−21.8717	−0.0556	0.0037	15.027
▲EPU	−0.0622	0.005	−12.44	−0.0293	0.0101	−2.9009
▲FDI	0.0167	0.0117	1.4273	0.061	0.0031	19.6774
▲ES	0.0891	0.0084	10.6071	0.1089	0.0055	19.8
▲TO	0.0768	0.0024	32	0.104	0.0111	9.3693
ECT(-1)	−0.53999	0.0058	−91.571	−0.1232	0.0097	−12.5837
Panel-C: Residual Diagnostic test						
$x^2_{Autocorrelation}$		0.841			0.741	
$x^2_{Heteroskedasticity}$		0.852			0.698	
$x^2_{Normality}$		0.807			0.729	
x^2_{RESET}		0.567			0.697	

Table 6: Results of the coefficients of asymmetric estimation

	China			USA		
Panel-A: Symmetry test						
W^{TPU}_{LR}		9.444			11.348	
W^{TPU}_{SR}		11.836			9.073	
W^{EPU}_{LR}		11.853			3.017	
W^{EPU}_{SR}		10.256			10.655	
Panel-B: Long-run coefficients						
Variables	Coeff.	Std. error	t-statistics	Coeff.	Std. error	t-statistics
TPU	-0.0971	0.0026	-36.8573-	-0.0957	0.0026	-35.5899
TPU	-0.1619	0.0021	-76.6295	-0.0571	0.0059	-9.5506
EPU	0.0354	0.0083	4.2699	0.0974	0.0024	39.7933
EPU	0.0441	0.0109	4.0149	0.0645	0.0057	11.1553
FDI	0.1304	0.0068	18.9088	0.1421	0.0049	28.6708
ES	0.0411	0.0091	4.5643	0.0552	0.00202	27.3505
TO	0.0365	0.0039	9.2571	0.1101	0.0111	9.8594
Panel-C: Short-run coefficients						
TPU	-0.0335	0.0115	-2.9133	-0.0067	0.0058	-1.1551
TPU	-0.0431	0.0117	-3.6837	-0.0164	0.0074	-2.2162
EPU	0.0541	0.0108	5.0092	0.0648	0.0094	6.8936
EPU	0.0076	0.0082	0.9268	0.0491	0.0089	5.5168
FDI	0.0078	0.0097	0.8041	0.0078	0.0085	0.9176
ES	0.0308	0.005	6.1621	0.0416	0.0093	4.4731
TO	0.0083	0.0071	1.1691	0.0441	0.0046	9.5869
ECT(-1)	-0.27689	0.006907	-40.0888	-0.38322	0.002264	-169.269
Panel-D: Residual Diagnostic test						
$x^2_{Autocorrelation}$		0.673			0.804	
$x^2_{Heteroskedasticity}$		0.816			0.648	
$x^2_{Normality}$		0.485			0.768	
x^2_{RESET}		0.754			0.712	

The asymmetric coefficients of TPU on REC in China and the USA have been negatively connected in the long-run and short-run with different magnfititutes, suggesting that control trade policy uncertainties are crucial for fostering clean energy inclusion in the economy. Specifically, in the case of China, a 10% positive (negative) shock in TPU will result in decreases (increases) of REC by 0.971%(1.6118%) in the long run. In comparison, short-run assessment exposed REC reduces (augments) by 0.335% (0.431%) due to a 10% asymmetric innovation in TPU. For the USA, in the long run, REC has decreased (increased) by 0.957% (0.571%) and by 0067% (0.164%) in the short run, with positive (negative) variations in TPU. Referring to the magnitudes of asymmetric shocks, it is disclosed that adverse shocks have dominating effects on REC in China. In contrast, positive shocks have significant effects on REC in the USA. Nonetheless, the control of trade uncertainties has a critical role in promoting renewable energy inclusion; alternatively, the demand for renewable energy has intensified.

The study established an adverse linkage between EPU and energy consumption in the long run $(EPU^{+}_{USA} = -0.0354 \;\&\; EPU^{+}_{USA} = -0.0441$ $; EPU^{+}_{CHN} = -0.0974 \;\&\; EPU^{-}_{CHN} = -0.0645)$ and short-run $(EPU^{+}_{CHN} = -0.0541\; ; EPU^{+}_{USA} = -0.0648 \;\&\; EPU^{-}_{USA} = -0.0491)$ All the coefficients are statistically significant at a 1% level. Precisely, a 10% positive and negative variation in *EPU* will result in a decrease (increase) of REC in china by 0.354% (0.441%) and the USA by 0.974% (0.645%) in the long run. Moreover, in the short-run, REC has diminished by 0.354% in China, while in the USA by 0.974%. Study findings established that the asymmetric effects of EPU have produced a significant impact in the short-run compared to the long-run horizon. The possible explanation for such abrupt behavior due to uncertainties discourages economic capital investment. Referring to the control variables such as FDI, ES, and TO, the study revealed positive and statistically significant effects on REC in the long and short run. Precisely, a 10% change in FDI, ES, and too results in the amplification of REC in China by 1.304%, 0.411%, and 0.356%, and in the USA by 1.421%, 0.552%, and 1.101%, respectively in the long-run.

The coefficients of error correction terms have been found negative and statistically significant at a 1% level in china (a coefficient of −0.2768) and the USA (a coefficient of −0.3832), suggesting the correction of long-run disequilibrium at a speed of 27.68% in China and 38.32% in the USA. Thus, it is assumed that the equilibrium point can be reached in around 04 months in china and 03 month is the USA. Furthermore, the present study has executed several residual diagnostic tests such as serial correlation, heteroskadacity, normality, and RESET test to ensure empirical estimation efficiency and consistency. Residual Diagnostic test results displayed in Panel-C produce conclusive evidence favoring the estimation consistency and efficiency.

4.6. TY Causality Test: Symmetric and Asymmetric Framework

Table 7 displays the results of the TY causality test with an assumption of a symmetric framework. The study established, for china, that the feedback hypothesis holds in explaining the causal association between [EPU←→REC; FDI←→REC; ES←→. REC; & TO←→REC]), on the other hand, a unidirectional linkage was established between TPU→REC. For the case of the USA, the bidirectional linkage was unveiled for [TPU←→REC; EPU←→REC; & ES←→REC]. Additionally, a unidirectional tie was disclosed between [FDI→REC & REC--TO].

The causality under the asymmetric framework reported in Table 8 includes panel A for china and Panel-B for the USA.

4.7. Robustness Assessment

The long-run association between TPU, EPU, FDI, TO, and REC has been reassessed as a robustness test by employing both nations' dynamic OLS, fully modified OLS and CCR regression. The robustness results displayed in Table 9. referring to the sign of the coefficients derived for explanatory variables revealed conclusive evidence for supporting the long-run output derived through ARDL estimation. This conclusion is valid for the estimated output for the USA and China.

5. DISCUSSION

The impact of trade policy uncertainty on renewable energy consumption in China and the US has exposed adversely associated, suggesting that the degree of TPU created a discomfort ambiance in the case of renewable energy consumption in the economy. Our findings align with those of (Wang and Wu, 2023;

Table 7: Symmetric causality test following TY framework

Variables	REC	TPU	EPU	FDI	ES	TO
Panel-A: for China						
REC	-	7.2063**	10.7248***	4.7632*	5.5739*	10.7814***
TPU	1.1613	-	9.3669***	9.788***	2.9493	3.0154
EPU	7.745**	10.4801***	-	3.5882	8.9004***	7.4509**
FDI	6.0665**	8.1823***	5.526*	-	5.2036*	8.9618***
ES	5.4779*	2.8386	11.0529***	5.0532*	-	2.9192
TO	11.131***	10.6784***	7.587**	9.6705***	9.818***	-
Panel-BL for USA						
REC	-	6.0652**	5.1399*	5.1964*	6.4335**	10.1715
TPU	5.8433*	-	2.955	2.7892	11.9828***	11.5599***
EPU	6.305**	3.6503	-	6.345**	7.197**	7.2264**
FDI	0.8832	7.497**	2.5954	-	1.1858	4.782*
ES	7.9165**	3.1198	10.3531***	11.3043***	-	1.1885
TO	8.6894***	9.9579***	10.6763***	11.3708***	2.5494	-

The superscripts of ***/**/* indicates a level of significance at a 1%, 5%, and 10% respectively

Table 8: Results of asymmetric causality following TY framework

	REC	TPU+	TPU-	EPU+	EPU-	FDI	ES	TO
Panel-A: for China								
REC	-	5.618**	7.9479***	3.4707	3.8455*	7.038***	0.8878	6.9227***
TPU+	5.9167**	-	7.8269***	4.7634*	1.1358	2.1415	0.4587	6.925***
TPU-	2.2803	4.4483*	-	1.59	2.1234	0.4448	1.3922	3.2293
EPU+	6.7149***	0.7546	2.4558	-	0.5223	0.8789	1.4334	4.567*
EPU-	7.7378***	0.0609	7.5075***	2.1952	-	5.992**	5.8035**	2.9849
FDI	2.423	6.3054***	7.546***	5.3018**	2.6296	-	7.6388***	7.9012***
ES	0.9707	2.9225	4.3271*	4.2253*	0.8502	0.5581	-	1.1868
TO	0.0717	5.8962**	6.3667***	6.7557***	2.3756	4.4052*	4.6413*	-
Panel –B: for USA								
REC	-	4.6729*	7.5381***	0.0598	4.217*	5.4167**	7.5269***	0.5471
TPU+	5.013**	-	7.8192***	3.0978	2.026	0.1033	4.8293*	2.9352
TPU-	2.8785	2.4338	-	5.0763**	7.9897***	4.4729*	7.308***	5.7997**
EPU+	4.8751*	0.5508	7.5489***	-	0.2649	3.5232*	1.2282	2.6764
EPU-	0.5281	6.5785***	2.9945	7.9646***	-	5.804**	5.0429**	0.0845
FDI	2.7233	3.127	6.7493***	7.6625***	4.5853*	-	2.4985	0.1662
ES	2.3394	0.602	0.1631	5.5604**	2.5306	3.2302	-	2.9396
TO	6.4397***	0.0275	5.0615**	5.2521**	3.6303*	6.0657***	2.4874	-

The superscripts of ***/**/* indicates a level of significance at a 1%, 5%, and 10% respectively

Table 9: Results of robustness tests: DOLS, FMOLS, and CCR

Variables	Coefficient	Std	t-stat	Coefficient	Std	t-stat	Coefficient	Std	t-stat
Panel BAfor USA									
TPU	−0.1726	0.039	−4.4256	−0.1394	0.0897	−1.554	−0.1359	0.0533	−2.5497
EPU	−0.1717	0.0208	−8.2548	−0.172	0.0239	−7.1966	−0.1814	0.04	−4.535
FDI	0.0994	0.0548	1.8138	0.2046	0.0443	4.6185	0.21	0.0412	5.097
ES	0.0494	0.0763	0.6474	0.0837	0.0238	3.5168	0.0872	0.0506	1.7233
TO	0.1182	0.0694	1.7031	−0.024	0.0309	−0.7766	−0.1178	0.0243	−4.8477
Panel B: for China									
TPU	−0.1804	0.0308	−5.8571	−0.1099	0.0159	−6.9119	−0.1161	0.0552	−2.1032
EPU	−0.1502	0.0754	−1.992	−0.1309	0.0336	−3.8958	−0.1537	0.0139	−11.0575
FDI	0.0248	0.0485	0.5113	0.0892	0.0595	1.4991	0.0879	0.0734	1.1975
ES	0.0573	0.0537	1.067	0.0696	0.0567	1.2275	0.1052	0.0902	1.1662
TO	0.0669	0.0604	1.1076	0.1395	0.049	2.8469	0.0863	0.0235	3.6723

Xie et al., 2023). Trade policy uncertainty significantly affects the demand for renewable energy sources. By decreasing uncertainty, governments can help promote investments in renewable energy resources and reduce the risk of economic loss due to volatile market conditions. Governments need to provide transparent policies that support long-term commitments from industry stakeholders so that we can make real progress toward a more sustainable future.

The coefficients of EPU on REC under symmetric and asymmetric environments have been negative and statistically significant, indicating the discomfort in fostering renewable energy development in the economy. Our study findings are supported by the existing literature such as (Lei et al., 2022; Shafiullah et al., 2021; Sohail et al., 2021). In recent years, using renewable energy sources has become more of a concern owing to fears that economic policy uncertainty may have a detrimental impact. Investing in renewable energy may be dangerous, as shown by several studies (Qamruzzaman and Karim, 2020). The government's stance towards renewable energy is cloaked in obscurity, causing this uncertainty. Due to the possibility that these restrictions could be modified in the future, investors are cautious about making long-term investments (Tee et al., 2023; Serfraz et al., 2023; Qamruzzaman, 2023a; Li et al., 2023). EPU particularly impacts solar photovoltaic investment since lenders often consider this technology risky and unreliable. A recent NREL study revealed that regulatory ambiguity is one of the primary obstacles preventing solar PV from reaching its full potential. The influence of policy uncertainty extends beyond investment decisions. However, if buyers believe government subsidies will be reduced soon, the demand for renewable energy may decrease. This demonstrates why more government openness on their objectives for renewable energy is crucial. If this were not in place, less investment and slower growth in the renewables business might substantially affect our ability to meet climate change targets.

The study established a beneficial role of FDI for REC in the USA and China, unveiling a positive and statistically significant linkage. Remarkably, The coefficient of FDI has revealed positive and statistical significance at a 1% level on REC in the USA (a coefficient of 0.0232) and china (a coefficient of 0.09251) in the long run, suggesting that inflows of FDI in the economy foster the demand of renewable energy sources. Thus contributory effects can be documented in the process of clean energy inclusion in the energy mix (Werner and Lazaro, 2023; Shobande et al., 2023; Wang and Jia, 2022; Gozgor and Paramati, 2022; Azam et al., 2022; Musa et al., 2021). Additionally, the case of the short-run assessment study unveiled a similar line of linkage between FDI and REC. However, the benefits of FDI on REC are more evident in the long run than in the short run. Our study findings of positive linkage between FDI and REC align with existing literature (Qamruzzaman, 2022c; Jinru et al., 2022b; Qamruzzaman, 2022a; Qamruzzaman and Jianguo, 2020; Kang et al., 2021; Khandker et al., 2018) (Akpanke et al., 2023). Foreign direct investment (FDI) has significantly influenced the increase of renewable energy usage in recent years. In 2017, foreign direct investment in the renewable energy sector reached a record high of USD 285 billion, more than quadrupling since 2010. This increase in investment has been fueled by many factors, including governmental support, reducing technology costs, and the increasing competitiveness of renewable energy compared to traditional generating sources. Foreign direct investment has been vital to the rapid expansion of solar and wind power generation capacity. Between 2010 and 2017, solar PV and wind energy contributed to over two-thirds of the world's newly built renewable energy capacity. In China and India, two of the world's largest renewable energy sectors (Chen et al., 2024; Zhang et al., 2023; Yi et al., 2023; Yasmeen et al., 2023), FDI has been a key growth driver, accounting for over 70% of total solar PV capacity in both countries. In the following years, foreign direct investment is projected to play an essential role in expanding the use of renewable energy. By 2030, worldwide investment in renewables is predicted to exceed $2 trillion, with foreign direct investment accounting for a significant percentage. This will be driven by the continued fall of technical costs, the development of climate change mitigation initiatives, and the adoption of enabling government policies. Despite the troubling nature of this information, it is crucial to remember that the renewable energy sector is still in its infancy. Regardless of the economic condition, it is anticipated that investment in renewables will increase as time passes and technology continues to progress (Kor and Qamruzzaman, 2023)

6. CONCLUSION

Energy mix and selection have placed an apex position, primarily due to the adverse environmental effects of more comprehensive macroeconomic behavior. Thus, reducing carbon emissions by including clean energy has been appreciated and emphasized instead of conventional energy promotion. The study aims to gauge the impact of trade and economic policy uncertainty on renewable energy demand in the USA and China for the 2000-2021 period. The study has implemented linear and nonlinear frameworks to assess the empirical nexus and directional association.

The key findings of the study are as follows. First, the findings of static tests established that all the variables possess the desired attributes required for efficient estimation. Second, the cointegration test following Bayer-Hancked and Makki has unveiled the long-run cointegration between explanatory and renewable energy consumption in the USA and China. Third, the coefficients of TPU and EPU exposed a detrimental role in REC consumption in both the long and short run. Fourth, the asymmetric evaluation confirmed the nonlinear linkage between TPU, EPU, and REC in the long-run and short-run horizon. Finally, the directional association revealed a unidirectional association between TPU and REC [TPU→REC] and EPU and REC [EPU←→REC].

China and the United States are at the forefront of the need for renewable energy sources to address the world's growing energy needs. China's demand for renewable energy is driven by various factors, including the country's goal to reduce carbon emissions, improve air quality, and create jobs. The Chinese government has ambitious growth ambitions for renewable energy and invests heavily in solar and wind power. China is now the global leader in producing solar panels and wind turbines. Demand for renewable energy in the United States is mainly driven by the desire to reduce dependence on fossil fuels. The United States is the world's largest oil consumer, and most of its energy originates from unstable or hostile states. By diversifying its energy mix and increasing its use of renewables, the United States may become less susceptible to shocks in the global oil market. In addition, several states have passed Renewable Portfolio Standards (RPS), which require utilities to generate a certain percentage of their electricity from renewable sources. This has created a considerable market for manufacturers and inventors of renewable energy. As China and the United States boost their need for renewable energy, there will be a growing need for innovative technologies and solutions. As long as governments and companies continue to invest and show their commitment, it is possible to meet this growing need while progressing toward minimizing climate change.

In-a-nuts-shell, despite all the policy uncertainty, there are several reasons why the demand for renewables continues to be strong. First, many countries have committed to reducing their greenhouse gas emissions, in line with the goals of the Paris Agreement. These commitments require significant investments in low-carbon technologies like renewables. Second, even without stringent climate policies, renewables have economic advantages. For example, solar and wind power are now cheaper than coal-fired in many parts of the world. As costs continue to drop, we can expect even more countries and companies to switch to renewables regardless of government policy. Third, many countries have adopted ambitious targets for transitioning to clean energy, which presents a significant opportunity for investors. Second, the cost of renewable technologies has fallen dramatically in recent years, making them more economically viable options. Finally, the scale of investment required to transition to a low-carbon economy presents a significant market opportunity for investors.

7. FUNDING

The study received a research grant from The Institute of Advanced Research (IAR), United International University (Grant Reference: UIU/IAR/01/2023/BE/31).

REFERENCES

Akpanke, T.A., Deka, A., Ozdeser, H., Seraj, M. (2023), Does foreign direct investment promote renewable energy use? An insight from West African countries. Renewable Energy Focus, 44, 124-131.

Alola, A.A., Alola, U.V., Akadiri, S.S. (2019), Renewable energy consumption in Coastline Mediterranean Countries: Impact of environmental degradation and housing policy. Environmental Science and Pollution Research, 26, 25789-25801.

Alonso-Travesset, À., Coppitters, D., Martín, H., de la Hoz, J. (2023),

Economic and regulatory uncertainty in renewable energy system design: A review. Energies, 16, 882.
Apergis, N., Payne, J. (2010), Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. Energy Policy, 38, 656-660.
Ayad, H., Sari-Hassoun, S.E., Usman, M., Ahmad, P. (2023), The impact of economic uncertainty, economic growth and energy consumption on environmental degradation in MENA countries: Fresh insights from multiple thresholds NARDL approach. Environmental Science and Pollution Research, 30, 1806-1824.
Azam, M., Uddin, I., Khan, S., Tariq, M. (2022), Are globalization, urbanization, and energy consumption cause carbon emissions in SAARC region? New evidence from CS-ARDL approach. Environmental Science and Pollution Research, 29, 87746-87763.
Bakirtas, I., Cetin, M.A. (2017), Revisiting the environmental Kuznets curve and pollution haven hypotheses: MIKTA sample. Environmental Science and Pollution Research, 24, 18273-18283.
Bayer, C., Hanck, C. (2013), Combining non-cointegration tests. Journal of Time Series Analysis, 34, 83-95.
Bertsch, V., Hall, M., Weinhardt, C., Fichtner, W. (2016), Public acceptance and preferences related to renewable energy and grid expansion policy: Empirical insights for Germany. Energy, 114, 465-477.
Cai, L., Firdousi, S.F., Li, C., Luo, Y. (2021), Inward foreign direct investment, outward foreign direct investment, and carbon dioxide emission intensity-threshold regression analysis based on interprovincial panel data. Environmental Science and Pollution Research, 28, 46147-46160.
Carattini, S., Baranzini, A., Lalive, R. (2018), Is taxing waste a waste of time? Evidence from a supreme court decision. Ecological Economics, 148, 131-151.
Chen, L., Tan, Y., Lv, G., Cai, W., Gao, X., Li, R. (2024), Uncovering the coupling effect with energy-related carbon emissions and human development variety in Chinese provinces. Journal of Environmental Sciences, 139, 527-542.
De Lucena, A.F.P., Szklo, A.S., Schaeffer, R., de Souza, R.R., Borba, B.S.M.C., da Costa, I.V.L., Júnior, A.O.P., da Cunha, S.H.F. (2009), The vulnerability of renewable energy to climate change in Brazil. Energy Policy, 37, 879-889.
Eitan, A. (2021), Promoting renewable energy to cope with climate change-policy discourse in Israel. Sustainability, 13, 3170.
Fakher, H.A., Ahmed, Z., Acheampong, A.O., Nathaniel, S.P. (2023), Renewable energy, nonrenewable energy, and environmental quality nexus: An investigation of the N-shaped Environmental Kuznets Curve based on six environmental indicators. Energy, 263, 125660.
Farzana, N., Qamruzzaman, M., Islam, Y., Mindia, P.M. (2023), Nexus between personal remittances, financial deepening, urbanization, and renewable energy consumption in selected southeast Asian countries: Evidence from linear and nonlinear assessment. International Journal of Energy Economics and Policy, 13, 270-287.
Gozgor, G., Paramati, S.R. (2022), Does energy diversification cause an economic slowdown? Evidence from a newly constructed energy diversification index. Energy Economics, 109, 105970.
Huang, C., Zappone, A., Alexandropoulos, G.C., Debbah, M., Yuen, C. (2019), Reconfigurable intelligent surfaces for energy efficiency in wireless communication. IEEE Transactions on Wireless Communications, 18, 4157-4170.
Ito, Y., Managi, S. (2015), The potential of alternative fuel vehicles: A cost-benefit analysis. Research in Transportation Economics, 50, 39-50.
Ivanovski, K., Marinucci, N. (2021), Policy uncertainty and renewable energy: Exploring the implications for global energy transitions, energy security, and environmental risk management. Energy Research and Social Science, 82, 102415.
Jamil, M., Ahmed, F., Debnath, G.C., Bojnec, S. (2022), Transition to renewable energy production in the United States: The role of monetary, fiscal, and trade policy uncertainty. Energies, 15, 4527.
Jin, L., Duan, K., Tang, X. (2018), What is the relationship between technological innovation and energy consumption? Empirical analysis based on provincial panel data from China. Sustainability, 10, 145.
Jinru, L., Qamruzzaman, M., Hangyu, W., Kler, R. (2022a), Do environmental quality, financial inclusion and good governance ensure the FDI sustainably in belt and road countries: Evidence from an application of CS-ARDL and NARDL? Frontiers in Environmental Science, 10, 936216.
Jinru, L., Qamruzzaman, M., Hangyu, W., Kler, R. (2022b), Do environmental quality, financial inclusion, and good governance ensure the FDI sustainably in Belt and Road countries? Evidence from an application of CS-ARDL and NARDL. Frontiers in Environmental Science, 10, 936216.
Ju, S., Andriamahery, A., Qamruzzaman, M., Kor, S. (2023), Effects of financial development, FDI and good governance on environmental degradation in the Arab nation: Dose technological innovation matters? Frontiers in Environmental Science, 11, 1094976.
Kang, X., Khan, F.U., Ullah, R., Arif, M., Rahman, S.U., Ullah, F. (2021), Does foreign direct investment influence renewable energy consumption? Empirical evidence from south Asian countries. Energies, 14, 3470.
Karim, S., Qamruzzaman, M., Jahan, I. (2023), Nexus between government debt, globalization, FDI, renewable energy, and institutional quality in Bangladesh. International Journal of Energy Economics and Policy, 13, 443-456.
Khan, K., Su, C.W. (2022), Does policy uncertainty threaten renewable energy? Evidence from G7 countries. Environmental Science and Pollution Research, 29, 34813-34829.
Khandker, L.L., Amin, S.B., Khan, F. (2018), Renewable energy consumption and foreign direct investment: Reports from Bangladesh. Journal of Accounting, Finance and Economics, 8, 72-87.
Kor, S., Qamruzzaman, M. (2023), Nexus between FDI, financial development, capital formation and renewable energy consumption; evidence from Bangladesh. International Journal of Energy Economics and Policy, 13, 129-145.
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, 7907-7916.
Li, H., Zheng, Q., Zhang, B., Sun, C. (2021), Trade policy uncertainty and improvement in energy efficiency: Empirical evidence from prefecture-level cities in China. Energy Economics, 104, 105691.
Li, Q., Qamruzzaman, M. (2023), Innovation-led environmental sustainability in Vietnam-towards a green future. Sustainability, 15, 12109.
Li, Z.Z., Su, C.W., Moldovan, N.C., Umar, M. (2023), Energy consumption within policy uncertainty: Considering the climate and economic factors. Renewable Energy, 208, 567-576.
Lin, J., Qamruzzaman, M. (2023), The impact of environmental disclosure and the quality of financial disclosure and IT adoption on firm performance: Does corporate governance ensure sustainability? Frontiers in Environmental Science, 11, 1002357.
Liu, Y., Dong, F. (2021), How technological innovation impacts urban green economy efficiency in emerging economies: A case study of 278 Chinese cities. Resources, Conservation and Recycling, 169, 105534.
Mangla, S.K., Luthra, S., Jakhar, S., Gandhi, S., Muduli, K.,

Bandrana, A.K. (2020), A step to clean energy - sustainability in energy system management in an emerging economy context. Journal of Cleaner Production, 242, 118462.

Muhammad, B., Khan, M.K., Khan, M.I., Khan, S. (2021), Impact of foreign direct investment, natural resources, renewable energy consumption, and economic growth on environmental degradation: evidence from BRICS, developing, developed and global countries. Environmental Science and Pollution Research, 28, 21789-21798.

Musa, M.S., Jelilov, G., Iorember, P.T., Usman, O. (2021), Effects of tourism, financial development, and renewable energy on environmental performance in EU-28: Does institutional quality matter? Environmental Science and Pollution Research, 28, 53328-53339.

Olabi, A.G., Abdelkareem, M.A. (2022), Renewable energy and climate change. Renewable and Sustainable Energy Reviews, 158, 112111.

Omri, A., Belaïd, F. (2021), Does renewable energy modulate the negative effect of environmental issues on the socio-economic welfare? Journal of Environmental Management, 278, 111483.

Pesaran, M.H., Shin, Y. (1998), An autoregressive distributed-lag modelling approach to cointegration analysis. Econometric Society Monographs, 31, 371-413.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001), Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16, 289-326.

Qamruzzaman, M. (2021), Nexus between remittance, trade openness and inequality in South Asian countries: New evidence from the nonlinear unit root, nonlinear OLS, and NARDL, and asymmetry causality test. Contaduría y Administración, 66, 1-27.

Qamruzzaman, M. (2022a), Nexus between energy intensity and environmental quality SSA: Evidence from GMM. World Journal of Advanced Research and Reviews, 16, 193-210.

Qamruzzaman, M. (2022b), Nexus between FDI and globalization-led energy diversification in BRICS: Fresh evidence from a newly constructed Energy diversification index. Energy Strategy Reviews, 44, 100997.

Qamruzzaman, M. (2022c), Nexus between renewable energy, foreign direct investment, and agro-productivity: The mediating role of carbon emission. Renewable Energy, 184, 526-540.

Qamruzzaman, M. (2022d), Symmetric and asymmetric nexus between economic policy uncertainty, oil price and renewable energy consumption in the USA, China, India, Japan, S. Korea: Does technological innovation influence? Frontiers in Energy Research, 10, 973557.

Qamruzzaman, M. (2023a), Does economic policy uncertainty influences personal remittances: Evidences from AARDL and NARDL. World Journal of Advanced Research and Reviews, 18, 14-34.

Qamruzzaman, M. (2023b), Does financial innovation foster financial inclusion in Arab world? examining the nexus between financial innovation, FDI, remittances, trade openness, and gross capital formation. PLOS One, 18, e0287475.

Qamruzzaman, M. (2023c), Nexus between financial development and carbon emission in Bangladesh: Evidence from ARDL and NARDL. GSC Advanced Research and Reviews, 14, 300-312.

Qamruzzaman, M., Jianguo, W. (2020), The asymmetric relationship between financial development, trade openness, foreign capital flows, and renewable energy consumption: Fresh evidence from panel NARDL investigation. Renewable Energy, 159, 827-842.

Qamruzzaman, M., Karim, S. (2020), ICT investment impact on human capital development through the channel of financial development in Bangladesh: An investigation of quantile ARDL and Toda-Yamamoto test. Academic Journal of Interdisciplinary Studies, 9, 112.

Qamruzzaman, M., Karim, S., Jahan, I. (2022), Nexus between economic policy uncertainty, foreign direct investment, government debt and renewable energy consumption in 13 top oil importing nations: Evidence from the symmetric and asymmetric investigation. Renewable Energy, 195, 121-136.

Qamruzzaman, M., Karim, S., Kor, S. (2023), Does environmental degradation matter for poverty? Clarifying the nexus between FDI, environmental degradation, renewable energy, education, and poverty in Morocco and Tunisia. Environmental Science and Pollution Research, 30, 52872-52894.

Qamruzzaman, M., Kler, R. (2023), Do clean energy and financial innovation induce SME performance? Clarifying the nexus between financial innovation, technological innovation, clean energy, environmental degradation, and SMEs performance in Bangladesh. International Journal of Energy Economics and Policy, 13, 313-324.

Sadiq, M., Ou, J.P., Duong, K.D., Van, L., Ngo, T.Q., Bui, T.X. (2023), The influence of economic factors on the sustainable energy consumption: evidence from China. Economic Research-Ekonomska Istraživanja, 36, 1751-1773.

Serfraz, A., Qamruzzaman, M., Karim, S. (2023), Revisiting the nexus between economic policy uncertainty, financial development, and FDI inflows in Pakistan during covid-19: Does clean energy matter? International Journal of Energy Economics and Policy, 13, 91-101.

Shafiullah, M., Miah, M.D., Alam, M.S., Atif, M. (2021), Does economic policy uncertainty affect renewable energy consumption? Renewable Energy, 179, 1500-1521.

Shobande, O.A., Ogbeifun, L., Tiwari, A.K. (2023), Re-evaluating the impacts of green innovations and renewable energy on carbon neutrality: Does social inclusiveness really matters? Journal of Environmental Management, 336, 117670.

Sohail, M.T., Xiuyuan, Y., Usman, A., Majeed, M.T., Ullah, S. (2021), Renewable energy and non-renewable energy consumption: Assessing the asymmetric role of monetary policy uncertainty in energy consumption. Environmental Science and Pollution Research, 28, 31575-31584.

Strunz, S. (2014), The German energy transition as a regime shift. Ecological Economics, 100, 150-158.

Su, S., Qamruzzaman, M., Karim, S. (2023), Charting a sustainable future: The impact of economic policy, environmental taxation, innovation, and natural resources on clean energy consumption. Sustainability, 15, 13585.

Tee, C.M., Wong, W.Y., Hooy, C.W. (2023), Economic policy uncertainty and carbon footprint: International evidence. Journal of Multinational Financial Management, 67, 100785.

Wang, F., Wu, M. (2023), How does trade policy uncertainty affect China's economy and energy? Journal of Environmental Management, 330, 117198.

Wang, Y., Qamruzzaman, M., Serfraz, A., Theivanayaki, M. (2023), Does financial deepening foster clean energy sustainability over conventional ones? Examining the nexus between financial deepening, urbanization, institutional quality, and energy consumption in China. Sustainability, 15, 8026.

Wang, Z., Jia, X. (2022), Analysis of energy consumption structure on CO_2 emission and economic sustainable growth. Energy Reports, 8, 1667-1679.

Werner, D., Lazaro, L.L.B. (2023), The policy dimension of energy transition: The Brazilian case in promoting renewable energies (2000-2022). Energy Policy, 175, 113480.

Wüstenhagen, R., Boehnke, J. (2017), Business models for sustainable energy. In: System Innovation for Sustainability 1. United Kingdom: Routledge, p80-89.

Xie, Y., Cao, Y., Li, X. (2023), The importance of trade policy uncertainty to energy consumption in a changing world. Finance Research Letters, 52, 103566.

Xu, B., Li, S., Afzal, A., Mirza, N., Zhang, M. (2022), The impact of financial development on environmental sustainability: A European perspective. Resources Policy, 78, 102814.

Yan, H., Qamruzzaman, M., Kor, S. (2023), Nexus between green investment, fiscal policy, environmental tax, energy price, natural resources, and clean energy-a step towards sustainable development by fostering clean energy inclusion. Sustainability, 15, 13591.

Yasmeen, R., Zhang, X., Tao, R., Shah, W.U.H. (2023), The impact of green technology, environmental tax and natural resources on energy efficiency and productivity: Perspective of OECD rule of law. Energy Reports, 9, 1308-1319.

Yi, S., Raghutla, C., Chittedi, K.R., Fareed, Z. (2023), How economic policy uncertainty and financial development contribute to renewable energy consumption? The importance of economic globalization. Renewable Energy, 202, 1357-1367.

Zhang, R.J., Razzaq, A. (2022), Influence of economic policy uncertainty and financial development on renewable energy consumption in the BRICST region. Renewable Energy, 201, 526-533.

Zhang, Y., Qamruzzaman, M., Karim, S., Jahan, I. (2021), Nexus between economic policy uncertainty and renewable energy consumption in BRIC nations: The mediating role of foreign direct investment and financial development. Energies, 14, 4687.

Zhang, Z., Hao, L., Linghu, Y., Yi, H. (2023), Research on the energy poverty reduction effects of green finance in the context of economic policy uncertainty. Journal of Cleaner Production, 410, 137287.

Zhou, X., Jia, M., Altuntaş, M., Kirikkaleli, D., Hussain, M. (2022), Transition to renewable energy and environmental technologies: The role of economic policy uncertainty in top five polluted economies. Journal of Environmental Management, 313, 115019.