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Article

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International Journal of Energy Economics and Policy

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

Reference: Farzana, Nusrat/Qamruzzaman, Md et. al. (2023). Nexus between personal remittances, financial deepening, urbanization, and renewable energy consumption in selected Southeast Asian countries : evidence from linear and nonlinear assessment. In: International Journal of Energy Economics and Policy 13 (6), S. 270 - 287.
https://www.econjournals.com/index.php/ijeep/article/download/14872/7565/35019.
doi:10.32479/ijeep.14872.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(6), 270-287.

Nexus between Personal Remittances, Financial Deepening, Urbanization, and Renewable Energy Consumption in Selected Southeast Asian Countries: Evidence from Linear and Nonlinear Assessment

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Received: 09 July 2023 **Accepted:** 23 October 2023 **DOI:** https://doi.org/10.32479/ijeep.14872

ABSTRACT

This study examines the correlation between personal remittances, financial development, urbanization, and renewable energy utilization in Southeast Asian countries for the period 1991-2020. The study employs both linear and nonlinear analyses to examine the symmetric and asymmetric effects of these variables on renewable energy consumption. The results offer a plethora of significant insights. To commence, it is noteworthy that there exists an adverse correlation between financial deepening and the utilization of renewable energy, thereby challenging the prevailing notion that these two factors are positively interconnected. This demonstrates that the increasing financial growth in South Asian countries could potentially have adverse effects on the environment and hinder the implementation of renewable energy solutions. Furthermore, previous studies have demonstrated a positive correlation between urbanization and the utilization of renewable energy sources. The utilization of renewable energy technology is encouraged in cities due to factors such as population density, resource availability, and supportive legislation. Thirdly, personal remittances exhibit a varied impact, yielding favorable long-term consequences in Bangladesh and Pakistan, while conversely resulting in negative long-term effects in India and Sri Lanka. The findings indicate the necessity for governmental interventions aimed at mitigating the adverse effects of remittances, while simultaneously optimizing their positive influence on the utilization of renewable energy. Trade openness is positively correlated with long-term utilization of renewable energy, suggesting the potential for international trade in renewable energy resources. Nevertheless, it is worth noting that there is a negative correlation between trade liberalization and the utilization of renewable energy in the short term. This highlights the importance of implementing additional policy measures to address this issue. This study contributes to our comprehension of the intricate connections among personal remittances, financial deepening, urbanization, and energy consumption in Southeast Asian nations. It offers valuable insights for policymakers, researchers, and practitioners involved in advancing sustainable energy transitions and environmental sustainability.

Keywords: Personal Remittances, Financial Deepening, Urbanization, Renewable Energy Consumption, Southeast Asian Countries
JEL Classifications: F24, G21, R14, Q42

1. BACKGROUND OF THE STUDY

The Sustainable Development Goals (SDGs) established by the United Nations provide a comprehensive framework for global development, encompassing crucial concerns such as the elimination of poverty, the promotion of clean energy accessibility, and the pursuit of environmental sustainability (Güney, 2019; Hannan et al., 2021; Marco-Lajara et al., 2023). Renewable energy consumption is paramount in achieving various Sustainable Development Goals (SDGs), particularly Goal 7: Ensuring access to affordable, reliable, sustainable, and modern energy. Developing nations face the dilemma of meeting the increasing energy demand while mitigating the environmental impact. Renewable energy offers a sustainable solution by providing cost-effective and environmentally friendly energy sources, which have the potential to reduce greenhouse gas emissions and mitigate the adverse impacts of climate change (Wang et al., 2022b; He et al., 2022). Encouraging the utilization of renewable energy in developing nations can yield numerous benefits, including enhanced energy access, bolstered energy security, stimulated economic growth, increased employment opportunities, and improved environmental preservation (Chen et al., 2022). In addition, the utilization of renewable energy aligns with various Sustainable Development Goals (SDGs), including Goal 1: Eradicating Poverty, Goal 3: Promoting Good Health and Well-being, and Goal 13: Taking Climate Action. This integration supports broader endeavors toward achieving sustainable development. In order to promote sustainable development, address energy poverty, and foster a more environmentally sustainable and resilient future for all, governments, international organizations, and stakeholders must place the utmost importance on implementing policies and making investments that actively promote the adoption of renewable energy sources in developing nations (Büyüközkan et al., 2018; Jahanger et al., 2023).

As concerns about climate change and the need to minimize greenhouse gas emissions rise, renewable energy sources like solar, wind, and hydropower are more vital for meeting our energy needs. Reduce our reliance on fossil fuels and reap economic and environmental advantages by switching to renewable energy sources, including solar, wind, hydro, geothermal, and biomass. (Olabi and Abdelkareem, 2022; Nan et al., 2022; Miao et al., 2022; Ma and Qamruzzaman, 2022a; Liu et al., 2022; Li et al., 2022a; Li eta l., 2022; Lei et al., 2022; Khan and Su, 2022). Using renewable energy sources may boost the economy in many ways. This includes the development of new jobs, lower utility bills, greater energy independence, and overall expansion. One of the fastest-growing industries in terms of employment generation is the renewable energy industry (Yi et al., 2023; Wu et al., 2023; Wang et al., 2023a). Employment in the renewable energy sector is projected to rise, with over 11 million people worldwide working in the industry in 2018. This is according to the International Renewable Energy Agency (IRENA). The declining price of renewable energy relative to fossil fuels makes it a serious contender in the energy market. In addition, governments may improve their energy security by investing in renewable energy to lessen their reliance on imported fossil fuels. Last but not least, the expansion of the renewable energy industry has the potential to boost the economy by opening up new markets and businesses. Significant environmental advantages, such as reduced greenhouse gas emissions, less air pollution, less water waste, and greater biodiversity preservation, may result from using renewable energy sources (Karim et al., 2023; Jiakui et al., 2023; Fakher et al., 2023). For example, renewable energy sources produce significantly fewer greenhouse gas emissions than fossil fuels, which can help mitigate climate change's impacts (Rehman et al., 2023). In addition, they release much less pollution into the air than fossil fuels, which is good for the environment and people's health. In areas where water is limited, using renewable energy sources to generate power has a greater impact than fossil fuels. Finally, renewable energy projects may be created and carried out in ways that reduce negative impacts on biodiversity and even provide chances for habitat restoration (Fakher et al., 2023).

Renewable energy has numerous upsides, but it also has its share of difficulties. Some renewable energy sources, including solar and wind, may cause grid instability due to their intermittent nature, a major obstacle. However, energy storage technology and smarter grids provide a solution to this problem. Another barrier is the significant initial investment needed to implement various renewable energy technology. However, it is anticipated that the prices of renewable energy technologies will continue to fall, making them more cost-effective in the long run (Yu et al., 2022). Benefiting both the economy and the environment, renewable energy has the potential to lessen our reliance on fossil fuels dramatically. Sustainable economic development, job creation, and improved air and water quality may all result from switching to renewable energy. The use of new technology and the creation of smarter grids may help renewable energy overcome its obstacles. Thus, switching to renewable energy ensures a long-lasting and successful future (Wang et al., 2022a). Renewable sources of energy are becoming the primary source of energy for economies throughout the globe. In the case of emerging nations, access to inexpensive and dependable energy is extremely important for economic development. This is especially true in Southeast Asia. The region's economy has been booming in recent years, which means increased energy consumption. At the same time, countries in Southeast Asia are trying to utilize less fossil fuels and more renewable sources of power. This shift to renewables has numerous causes. First, sun, wind, hydropower, and geothermal energy are just some of the renewable resources that Southeast Asia possesses in spades. Second, the price of renewables is dropping to levels where they can compete with conventional fossil fuels. Thirdly, the area is dedicated to cutting down on carbon emissions and adapting to climate change. Due to these tendencies, renewable energy consumption in Southeast Asia is predicted to increase substantially over the next several years. In this post, we will look at the situation of renewable energy in Southeast Asia and the factors that have contributed to its rapid expansion in recent years (Tan and Uprasen, 2022; Syed et al., 2022).

In this investigation, we factored in financial development (FD), urbanization (UR), and remittances (PR) from home to abroad (personal) into the equation of renewable energy use (REC). Access to finance and investment, made possible by financial growth, is essential for developing renewable energy initiatives. An advanced monetary system may encourage private investment in renewable energy infrastructure. Due to increasing energy consumption rates and more options for creating renewable energy infrastructure, urbanization might create a demand for renewable power. (Su et al., 2022; Shahzadi et al., 2022). In addition, when people move into metropolitan areas, they become more conscious of environmental concerns. They are more inclined to support sustainable practices, which drives the demand for clean energy. The growth of renewable energy may also benefit from individual remittances. Renewable energy initiatives may benefit from their investment, especially in less developed nations. Rural communities may have better access to power if remittances are used to fund renewable energy initiatives, such as off-grid solar panels. (Samour et al., 2022; Rong and Qamruzzaman, 2022). Furthermore, financial development, urbanization, and personal remittances can also influence each other. For example, financial development can facilitate urbanization and the flow of personal remittances, promoting renewable energy consumption. Overall, the nexus between financial development, urbanization, personal remittances, and renewable energy consumption highlights the importance of a coordinated approach toward sustainable economic development. Policymakers should consider the interrelated nature of these factors and develop policies that promote a holistic approach toward sustainable development. This could include promoting green financing, sustainable urbanization, and incentivizing personal remittances for renewable energy projects.

The motivation of the study is to evaluate the impacts of explanatory variables, i.e., FD, UR and PR, on REC of selected Southeast Asian nations for the period 1991-2020.

The contribution of the study to the existing literature is as follows. First, the study comprehensively analyzes the interrelationships among financial deepening, urbanization, personal remittances, and renewable and non-renewable energy consumption. Through a comprehensive analysis of these variables, this study offers valuable insights into their intricate dynamics and interdependencies. Such insights can significantly augment our comprehension of energy consumption patterns in Southeast Asian nations. Second, this study extends the analysis to include the integration of personal remittances, a distinctive and noteworthy factor in Southeast Asia. Incorporating personal remittances into the analysis facilitates a more nuanced investigation of the effects of these monetary inflows on energy consumption trends. This integration introduces a new dimension to the current literature. It offers insights into the distinct impacts of personal remittances on renewable and non-renewable energy consumption. Third, the study offers region-specific insights and recommendations by concentrating on chosen Southeast Asian countries. Given Southeast Asia's unique challenges and opportunities regarding energy consumption, urbanization rates, and personal remittance inflows, the regional perspective presented here holds significant value. The results can provide valuable insights to policymakers and stakeholders in these nations regarding the distinctive elements that influence their energy consumption patterns. Fourth, regarding policy Implications, the study provides valuable insights that can inform policy formulation and decision-making processes to promote sustainable energy practices in Southeast Asian countries. Policymakers can optimize energy use, support renewable energy adoption, and mitigate environmental impacts by comprehending the symmetric and asymmetric effects of financial deepening, urbanization, and personal remittances on renewable and non-renewable energy consumption.

The subsequent section of the body is delineated as follows. The literature discusses the target nexus as outlined in section II. Section III defines variables, measurements, and econometric tools to analyze the nexus. The explanation regarding the estimation and interpretation of the empirical model can be located in Section IV. A thorough examination of the study can be located in section V. Section VI offers a thorough explanation of the conclusion and comprehensively presents policy suggestions.

2. LITERATURE SURVEY AND HYPOTHESIS DEVELOPMENT

2.1. Financial Deepening and Energy Consumption

Financial diversification plays a crucial role in influencing consumption patterns and promoting the growth of renewable energy (Raihan et al., 2022; Rahman and Sultana, 2022). As the financial sector evolves, it offers enhanced accessibility to financial resources, including loans, investment prospects, and specialized financial instruments. These resources are crucial in promoting the adoption and utilization of renewable energy technologies. Financial institutions, including banks and venture capital firms, can significantly contribute to allocating funds toward renewable energy initiatives and offer the necessary capital for their advancement and growth (Qamruzzaman et al., 2022; Qamruzzaman, 2022). Furthermore, implementing financial diversification stimulates innovation and research and development (R&D) endeavors within the renewable energy industry. This is achieved through the attraction of investments and the cultivation of a sustainable ecosystem. Furthermore, financial services, such as green bonds and investment vehicles focused on sustainability, allow individuals and businesses to align their financial endeavors with environmental goals. This, in turn, leads to heightened demand for renewable energy. Financial diversification is pivotal in facilitating the growth and integration of renewable energy sources, significantly contributing to the transition toward a more sustainable and environmentally friendly future.

Nowadays, energy has become the center of the discussion. Much literature is on financial development and energy consumption (Ma and Fu, 2020; Islam et al., 2013; Sadorsky, 2010; Mukhtarov et al., 2020). Research on the OECD countries by (Baloch et al., 2019), Saudi Arabia by (Mahalik et al., 2017), transitional countries by (Yue et al., 2019), MENA region by (Gaies et al., 2019) tried to explore a nonlinear relationship between financial development and energy consumption. Hence the outcome was a U-shaped inverted relation between the above two variables and economic growth and energy consumption. (Çoban and Topcu, 2013) Have done research in the EU by applying the system GMM model over the period 1990-2011 and found a significant impact of financial development on energy consumption, surprisingly only on the old members, whatever the industry. But for new members, the result is not that stronger. Banking sector development has a higher impact on energy efficiency than stock market development, supported by both the author (Çoban and Topcu, 2013; Chiu and Lee, 2020). However, the study by (Yue et al., 2019) revealed a positive impact of stock market growth on energy consumption than the banking sector. (Destek, 2017) tried to focus on the three dimensions (stock market, bond market and banking sector) of financial development and found the more significant impact of the bond market on financial development, which direct the pathway to diminish energy consumption. The same type of analysis has been done by (Lahiani et al., 2021; Sadorsky, 2011), focusing on banking-focused financial development and stock market-focused financial development on energy consumption.

Economic growth, industrialization, urbanization, globalization and financial development are interrelated and impact energy efficiency (Shahbaz and Lean, 2012). (Danish and Ulucak, 2021) found the impact of globalization and financial development on energy efficiency by applying the BARDL method. In an emerging economy, the growth in economic activities increases the growth in financial development and the soundness in energy consumption (Durusu-Ciftci et al., 2020). In the research of (Qayyum et al., 2021; Komal and Abbas, 2015), findings supported that economic growth and urbanization negatively affect energy efficiency and environmental sustainability as these factors are responsible for CO_2 emission. According to (Khan et al., 2021), trade openness, technological innovation, financial innovation and development all promote energy efficiency and reduce CO_2.

Energy efficiency ensures environmental sustainability, and its determinants are technological innovation, financial development, economic growth, renewable energy consumption etc. Again U, shaped associations are found by (Shahbaz et al., 2022) among financial development, foreign direct investment, and economic growth in renewable energy consumption. Environment quality improves when there is financial development in the developed economy. However, the impact of financial development is insignificant in improving the environmental quality of developing countries (Usman et al., 2021). On the contrary, energy efficiency sometimes accelerates financial development (Dan and Lijun, 2009). A study on Asian countries (Furuoka, 2015) found that expansion in the energy sector activities can be one of the main driving forces for financial development in this region.

2.2. Urbanization and Energy Consumption

Rapid rural-to-urban migration is a vital part of urbanization. Increasing economic development, household income, and living conditions are all ways that urbanization makes more people use more energy. Industry, innovation, and goods get better as cities grow, and this makes better use of energy. (Zhao and Wang, 2015) Urbanization generally refers to the fast shifting of individuals from the countryside to town zones. On the one hand, urbanization underwrites significantly to economic growth by raising family income and quality of life, hence boosting total energy consumption. On the other hand, it encourages manufacturing, technology, and merchandise advancement, increasing energy efficiency (Liu et al., 2017).

Several academics have researched the connection between urbanization and energy use from several aspects, and four major study strands have emerged due to the growing concern about environmental consequences and the increase in energy crises created by urbanization. The first of the four strands concentrates on the inverse association between energy usage and urbanization, the second on the causal relationship between the two, the third on the metabolism of town energy by examining a precise metropolitan arrangement from an energy perspective, and the fourth on regional variations in the influences of expansion on energy ingestion (Wang, 2014).

Another study by (Liu et al., 2017) examines how urbanization distresses energy consumption in China's regions by an upgraded spatial econometric model of Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT). Urbanization has direct and indirect impacts, according to spatial econometrics. Urbanization seems to increase energy usage. Urbanization increases energy consumption in neighboring areas, causing a positive geographical spillover effect. To upgrade the new urbanization, energy savings should be prioritized. Disaggregating China's energy consumption goals into smaller targets for specific locations might help limit energy use.

The study of (Ghosh and Kanjilal, 2014) in China indicated that urbanization and energy use may increase CO_2 emissions, and these relationships work in both directions. According to their study's findings, cutting down on CO_2 emissions also affects urbanization. Adopting laws with low carbon emission levels requires harmony between these three factors. Despite a positive one-way Granger connection between urbanization and energy use, the reverse is not always true. For this reason, China must transition to a low-carbon economy to strike a healthy balance between urbanization, energy consumption, and CO_2 discharges.

(Yang et al., 2016) explored how urbanization influences renewable energy ingestion progress using the logarithmic mean Divisia index technique in this research (RECG) (RECG). The rise in the use of renewable energy may be unevenly divided into slow, fluctuating, and rapid phases, depending on the rate at which urbanization, energy combination, energy intensity, and monetary and demographic consequences are felt. Positively, RECG was affected by the energy mix, the economy, and the population. There was a significant negative relationship between energy level and RECG. More of the rise in RECG stages' energy usage may be attributed to urbanization than to RECG itself. Urbanization and the need for renewable energy are two topics that might benefit from this study. According to study results, economic development, financial growth, urbanization, and electricity usage in the UAE cointegrated through time. A reversed U-shaped association occurs between economic progress and electricity consumption. Electricity ingestion rises as the economy grows. Urbanization increases electricity consumption; however, at a certain point, it decreases. Electricity usage and economic growth are linked in both directions. Feedback is used in financial growth and power. Granger's financial progress stimulates economic growth and vice versa. Growth and urbanization are inextricably connected. Financial development and electricity usage are both influenced by urbanization (Sbia et al., 2017).

(Anwar et al., 2021) The research study's primary purpose is to assess the impacts of urbanization, renewable energy consumption, financial development, economic growth, and agricultural productivity on CO_2 emissions in 15 nominated Asian nations between 1990 and 2014. According to the long-run coefficient estimation outcomes, urbanization, financial growth, and economic expansion are long-term contributors to environmental degradation. In divergence, the use of renewable energy reduces environmental damage. Additionally, agriculture has a positive but statistically insignificant effect on CO_2 emissions. Another significant study was conducted to evaluate the influence of urbanization on the concentration of energy use in Bangladesh using annual data from 1980 to 2015. Their investigation employed a variety of statistical and economic techniques. Long-term energy consumption intensity correlates positively with urbanization but not vice versa. However, this study did not observe any causality in the short run. The urbanization coefficient is elastic, and the long-term estimate supports the expected sign (Khan et al., 2018).

The study of (Abbasi et al., 2020) focused on eight Asian countries, all of which are experiencing rapid urbanization and economic liberalization that are having negative effects on the natural world. CO_2 emissions are used as an endogenous variable to proxy environmental harm, with energy consumption, urbanization, GDP per capita, trade openness, and financial development as explanatory factors. The findings from long-term association studies have a profound impact on ordinary least squares. CO_2 emissions favorably correlate with GDP per capita, urbanization, financial development, and energy use; nevertheless, trade openness has a negative long-term impact. People in developing countries such as Bangladesh, China, India, Malaysia, and Pakistan tend to move to urban regions for improved access to services and facilities. Especially in developing countries, deforestation may multiply CO_2 emissions by many orders of magnitude. Energy consumption, another factor, boosts economic growth, which may increase carbon emissions.

2.3. Remittance and Energy Consumption

Research into the topic of remittances is relatively few. It has never been given enough attention, despite being thought to be one of the major incoming streams that could help slow down environmental damage (Zafar et al., 2022). The cointegration and connecting relationship between foreign remittances and energy consumption in Morocco are uncovered by (Akçay and Demirtaş, 2015). There is a long-run equilibrium connection between remittances and energy use, the authors found, which may indicate a connection. According to the numbers, remittances are expanding indirectly through industrialization and economic growth and directly through their impact on people's energy usage.

Remittances, energy consumption, and globalization affected CO_2 emissions in 97 countries from 1990 to 2016 investigated by (Yang et al., 2020). Strong system GMM indicates a correlation between increasing CO_2 emissions, remittances, and energy usage. Only globalization reduced CO_2 emissions. The study split its samples into two groups, but the results were the same. (Hossain, 2012) examines the dynamic connecting relationship between economic development, power consumption, export value, and remittance for three SAARC states (India, Bangladesh, and Pakistan) between 1976 and 2009. Short-term growth and export values are bidirectional. Power consumption and remittances affect long-term economic growth more than short-term. Electricity consumption and SAARC labor remittances boost economic growth over time.

Data from India, the Philippines, Egypt, Pakistan, and Bangladesh are analyzed in this study, along with a panel of similar countries from 1980 to 2016 (Wang et al., 2021). It tries to identify the impact of remittances on CO_2 emissions by considering factors such as GDP growth, industry value added, and agricultural value added. In the long-term, ARDL carbon emissions were lowered thanks to remittances. However, in the short-term inflow, remittances raised CO_2 emissions. China, India, the Philippines, Pakistan, Bangladesh, and Sri Lanka received the most remittances, From 1982 to 2014. Rahman et al. (2019b) examine the relationship between these countries' remittances, FDI, energy use, and CO_2 emissions. Short-term and long-term increases in energy consumption result in substantial increases in CO_2 emissions for all sample countries. While India and China show no substantial association between CO_2 emissions and remittances, Sri Lanka, Pakistan, the Philippines, and Bangladesh all show a positive long-term correlation. There is, thus, a wide variation in the correlation between remittances and CO_2 output among countries. South Asia's top four remittance recipient countries (Bangladesh, India, Sri Lanka, and Pakistan) have been studied in depth (Rahman et al., 2021). Long-term correlations were found between remittances, energy use, GDP, and urbanization. Long-term causation has been established between selected factors and energy consumption, especially in Bangladesh and Pakistan, where remittances considerably affect energy consumption.

Nepal is a major aid recipient in South Asia, and the link between foreign aid, economic growth, migrant workers' remittances, and carbon dioxide emissions has recently been investigated (Sharma et al., 2019). More foreign aid and remittances reduce CO_2 emissions by allowing households to convert to clean energy or use energy-efficient appliances. The first multivariate model (Rahman and Amin, 2018) examined remittances and energy usage in Bangladesh from 1980 to 2015. This study examines short- and long-term variable cointegration and causality. They found a long-term contributing connotation between remittances and energy consumption in Bangladeshi industrialization, financial development, and economic growth, supporting the multiplier effect. It represents that country's rural households have adopted advanced renewable energy sources due to rising remittances. The causal relationships between per capita remittance inflows and renewable energy use in Bangladesh were investigated by (Das et al., 2021) using annual data from 1980 to 2017where no statistically significant correlation between the two was found.

2.3.1. Theoretical development and justification of the study

Financial deepening means the growth and betterment of financial systems, including better availability of financial services, improved capital distribution, and better risk control. The theoretical foundation for scrutinizing the bond between financial deepening and energy consumption is the income and resource allocation effects. a. Effect of Wealth: When financial resources are expanded, the economy flourishes, resulting in higher earnings and better quality of life. As tribes and trading posts experience greater prosperity, their energy needs grow, increasing energy usage. This good relation shows that more financial deepening may result in higher renewable and non-renewable energy usage. b. Resource Allocation Effect: A strong financial system can impact resource allocation, making investing in energy-efficient technologies and renewable energy sources easier. By allowing the movement of resources towards ecologically sound ventures, financial expansion can encourage a transition from non-renewable to renewable energy usage. This effect suggests that if financial deepening increases, there may be a greater proportion of renewable energy consumption than non-renewable energy.

Urbanization is the process of people gathering in urban areas, greatly affecting energy usage. The theoretical foundation for scrutinizing the correlation betwixt urbanization and energy consumption is rooted in the scale effect, the composition effect, and the technological effect. a. Scale Effect: Urban areas tend to consume more energy because of the gathering of economic activities, higher population densities, and increased infrastructure demands. As cities grow, renewable and non-renewable energy usage is expected to increase because of the vastness of urban activities.

b. Urbanization brings changes in economic structure. The shift from relying on the land for sustenance to relying on factories and services may impact how we use energy. Industries usually have more energy usage, whereas services have lower energy usage. The structure of city economies may impact the ratio of renewable and non-renewable energy usage. c. Technological Effect: Urban areas serve as centers of technological advancements, including energy-efficient infrastructure, smart grids, and renewable energy installations. Gathering knowledge and experimentation in urban areas encourages the acceptance of sustainable energy methods. Thus, urbanization may promote using sustainable energy sources and diminish dependence on non-sustainable energy.

The sending of personal remittances, the money transfers made by individuals who live and work in foreign lands to their home countries, can affect energy usage through different means. The income, investment, and consumption effects are the theoretical foundation for scrutinizing the correlation between personal remittances and energy consumption. a. Effect of Income: Personal remittances augment the income of recipient households, resulting in greater buying power and potential escalation in energy usage. b. Investment Effect: Personal remittances can be used for investments, such as the building of infrastructure, which may lead to more energy usage because of the creation and operation of energy-demanding projects. Consumption Effect: Personal remittances can also lead to increased consumption of goods, such as using energy for housing, transportation, and appliances.

Based on the theoretical framework, the following research hypotheses are proposed:

Hypothesis 1: Financial deepening positively impacts renewable and non-renewable energy consumption, reflecting the effects of income and resource allocation.

Hypothesis 2: Urbanization has a positive effect on both renewable and non-renewable energy consumption, reflecting the scale effect, the composition effect, and the technological effect.

Hypothesis 3: Personal remittances have a positive impact on both renewable and non-renewable energy consumption, reflecting the income effect, the investment effect, and the consumption effect.

3. DATA AND METHODOLOGY OF THE STUDY

3.1. Model Specification

The motivation of the study is to gauge the potential impact of financial deepening, urbanization and personal remittances on renewable able energy consumption in selected southeast countries. Considering the research variables, the generalized empirical nexus is as follows.

$$REC \int FD, UR, PR \quad (1)$$

Where REC, FD, UR and PR stands renewable energy consumption, financial deepening, urbanization, and personal remittances, respectively. Considering the literature dealing with the nexus between REC and macro fundamentals, the present study extended Eq (1) by including two control variables: trade openness and foreign direct investment. The above Eq (1) rewrite the following ways.

$$REC \int FD, UR, PR, FDI, \& TO \quad (2)$$

After natural log transformation, Eq (2) can be displayed in the regression form for coefficients extraction.

$$REC_t = \alpha_0 + \beta_1 lnFD_t + \beta_2 lnUR_t + \beta_3 lnPR_t + \beta_4 lnFDI_t + \beta_5 lnTO_t + \omega_1 \quad (3)$$

It is anticipated that financial deepening can significantly impact renewable energy consumption. $\frac{lnREC}{LnFD} > 1$. A well-developed financial sector can facilitate the flow of capital to renewable energy projects, enabling them to be developed and operated more efficiently. This can lead to increased renewable energy consumption. Moreover, financial development can lead to greater innovation in renewable energy technologies, driving down costs and increasing adoption rates. Urbanization can also have a significant impact on renewable energy consumption. As more people move to cities, energy demand increases, creating a greater need for renewable energy sources. Cities also tend to have higher levels of air pollution, making renewable energy sources that do not produce emissions more attractive. Additionally, urban areas often have more businesses and industries, which can benefit from on-site renewable energy generation and storage. Existing literature has explained inconclusive pieces of evidence for the nexus between urbanization and renewable energy consumption that is $1 < \frac{lnREC}{LnUR} or \frac{lnREC}{LnUR} > 1$. Personal remittances or money individuals send to their families or friends in other countries, can also influence renewable energy consumption. Remittances can be a source of financing for renewable energy projects, particularly in developing countries with limited access to capital. This can help to increase the availability and adoption of renewable energy sources. Additionally, remittances can increase energy consumption overall, which may increase the demand for renewable energy sources. Thus it is anticipated that remittances foster REC alternatively.. Financial development, urbanization, and personal remittances can all significantly impact renewable energy consumption. By facilitating the flow of capital to renewable energy projects, promoting innovation in renewable energy technologies, and increasing energy demand, these factors can contribute to the growth of renewable energy consumption. As such, policymakers should consider these factors when designing renewable energy policies and strategies.

3.2. Estimation Strategies

To implement robust econometric tools, it is necessary to have appropriately integrated research variables. Thus, the present study has executed a test of stationary following the techniques familiarized and commonly known as Dickey and Fuller (1979)- ADF test, Phillips and Perron (1988)- PP test, Elliott et al. (1996) and Kwiatkowski et al. (1992)- (KPSS) tests are commonly employed to assess the stationarity of a time series. According to the Dickey-Fuller model, the ADF test aids in assessing whether a time series possesses a unit root, thereby indicating non-stationarity. The regression model is estimated by incorporating lagged differences of the series and subsequently testing the statistical significance of the coefficient associated with the lagged difference term. If the coefficient is negative and statistically significant, it implies the existence of a unit root, thereby indicating non-stationarity. The PP test can be considered similar to the ADF test, as it incorporates an additional term to address the potential presence of serial correlation. The issue of serial correlation in residuals is effectively addressed, and an alternative approach for testing unit roots is proposed.

In contrast, the KPSS test evaluates the null hypothesis of stationarity in a given time series. The purpose of this test is to determine the presence of a unit root by examining whether the series is trend-or difference-stationary. If the null hypothesis of stationarity is rejected, it implies the presence of a unit root and, therefore, indicates that the series is not stationary.

For long-run assessment, the present study implemented the novel combined cointegration test, familiarized by Bayer and Hanck (2013), with the null hypothesis of a no-cointegration test, the following Fishers' equation is considered in deriving the test statistics for detecting long-run association.

EG–JOH = –2 [LN (PEG) + LN (PJOH)]

EG–JOH–BO–BD = –2 [LN (PEG)–ln(PJPH) + ln(PBO) + ln(PBDM)]

Furthermore, the Maki (2012) cointegration test has deployed with an unknown structural break. The test statistics for long-run assessment have been tested by executing the following equation.

3.3. Autoregressive Distributed Lagged (ARDL)

The ARDL approach has become popular among empirical researchers studying long-term connections since then (Qamruzzaman and Jianguo, 2020; Qamruzzaman and Jianguo, 2018; Karim et al., 2022; Pu et al., 2021; Yang et al., 2021; Nawaz et al., 2021). One advantage of ARDL estimation over standard cointegration testing is that it produces a consistent estimate regardless of sample size (Ghatak and Siddiki, 2001). 2) capable of handling mixed-order variable integration with delayed requirements for improved model stability and efficiency (Pesaran et al., 2001). Finally, long-term and short-term elasticity tests should be conducted objectively. Based on Banerjee Banerjee et al. (1993). Following Pesaran et al. (2001), the generalized ADRL model for the study was considered for detecting long-run and short-run coefficients by performing the following equation. The null hypothesis for long-run test displayed in Table 1.

$$\begin{aligned}\Delta lnREC_t &= \alpha_0 + \sum_{i=1}^{n}\mu_1 \Delta lnREC_{t-i} + \sum_{i=0}^{n}\mu_2 \Delta lnFD_{t-i} \\ &+\sum_{i=0}^{n}\mu_3 \Delta lnUR_{t-i} + \sum_{i=0}^{n}\mu_4 \Delta lnPR_t + \sum_{i=0}^{n}\mu_5 \Delta lnFDI_{t-i} \\ &+\sum_{i=0}^{n}\mu_6 \Delta lnTO_t + \gamma_1 lnREC_{t-i} + \gamma_2 lnFD_{t-1} \\ &+\gamma_3 lnFDI_{t-1} + \gamma_4 lnGCF_{t-1} + \gamma_5 lnFDI_{t-1} \\ &+\gamma_6 lnTO_{t-1} + \omega_{1t}\end{aligned} \tag{4}$$

The study implemented the following equation with error correction terms to capture the short-run dynamics.

$$\begin{aligned}\Delta lnREC_t &= \alpha_2 + \sum_{i=1}^{n}\beta_1 \Delta lnREC_{t-i} + \sum_{i=0}^{n}\beta_2 \Delta lnFD_{t-i} \\ &+\sum_{i=0}^{n}\beta_3 \Delta lnUR + \sum_{i=0}^{n}\beta_4 \Delta lnPR_t + \sum_{i=0}^{n}\beta_4 \Delta lnFDI_t \\ &+\sum_{i=0}^{n}\beta_4 \Delta lnTO_t + \rho ECT_{t-1} + \omega_{1t}\end{aligned} \tag{5}$$

We used several approaches to narrow down the potential diagnoses. The Harvey test was first used to determine whether the residuals from the refined ARDL model were heteroscedastic. Following this, we used the Breusch-Godfrey Serial Correlation LM test to look for serial correlation in the residuals. We then used the Ramsey RESET test to ensure our model parameters were correct. The Jarque-Bera normality test was then used to check whether the model residuals were normally distributed. In conclusion, the CUSUM and CUSUM of squares tests were used to demonstrate the stability of the model.

The following nonlinear equation to be implemented for exploring the asymmetric elasticities of government debt, Globalization, foreign direct investment, and financial development on institutional quality which is derived by following the asymmetric framework introduced by Shin et al. (2014).

$$\begin{aligned}REC_t &= (\pi^+ FD_{1,t}^+ + \pi^- FD_{1,t}^-) + (\beta^+ UR_{1,t}^+ + \beta^- UR_{1,t}^-) \\ &+(\gamma^+ PR_{1,t}^+ + \gamma^- PR_{1,t}^-) + \varepsilon_t\end{aligned} \tag{6}$$

Where π^+, π^-, β^+, β^-, and γ^+, γ^- Stands for the long-run asymmetric coefficient of financial deepening, urbanization and remittances.

The decomposition of explanatory variables can be derived in the following manner.

$$\begin{cases} POS(FD)_{1,t} = \sum_{k=1}^{t} lnFDI_k^+ = \sum_{K=1}^{T} MAX(\Delta lnFDI_k, 0) & ; \\ NEG(FD)_t = \sum_{k=1}^{t} lnFD_k^- = \sum_{K=1}^{T} MIN(\Delta lnFD_k, 0) & ; \\ POS(UR)_{1,t} = \sum_{k=1}^{t} lnUR_k^+ = \sum_{K=1}^{T} MAX(\Delta lnUR_k, 0) & \\ NEG(UR)_t = \sum_{k=1}^{t} lnUR_k^- = \sum_{K=1}^{T} MIN(\Delta lnUR_k, 0) & \end{cases}$$

$$POS(PR)_{1,t} = \sum_{k=1}^{t} lnPR_k^+ = \sum_{K=1}^{T} MAX(\Delta lnPR_k, 0) ;$$
$$NEG(PR)_t = \sum_{k=1}^{t} lnPR_k^- = \sum_{K=1}^{T} MIN(\Delta lnPR_k, 0)$$

The following equation documents the asymmetric coefficients in the long- and short-run assessments.

$$\begin{aligned} \Delta REC_t = {} & \partial U_{t-1} + (\pi^+ FD_{1,t-1}^+ + \pi^- FD_{1,t-1}^-) \\ & + (\beta^+ UR_{1,t-1}^+ + \beta^- UR_{1,t-1}^-) + (\gamma^+ PR_{1,t-1}^+ + \gamma^- PR_{1,t-1}^-) \\ & + \sum_{j=1}^{m-1} \lambda_j \Delta REC_{t-j0} + \sum_{j=1}^{n-1} (\pi^+ \Delta FD_{1,t-1}^+ + \pi^- \Delta FD_{1,t-1}^-) \\ & + \sum_{j=1}^{n-1} (\mu^+ \Delta UR_{1,t-1}^+ + \mu^- \Delta UR_{1,t-1}^-) \\ & + + \sum_{j=0}^{m-1} (\beta^+ \Delta PR_{1,t-1}^+ + \beta^- \Delta PR_{1,t-1}^-) + \varepsilon_t \end{aligned} \quad (7)$$

The error correction term of the above equation is as follows

$$\begin{aligned} \Delta REC_t = {} & \partial e_{t-1} + \sum_{j=1}^{m-1} \lambda_j \Delta REC_{t-j0} + \sum_{j=1}^{n-1} (\pi^+ \Delta FD_{1,t-1}^+ + \pi^- \Delta FD_{1,t-1}^-) \\ & + \sum_{j=1}^{n-1} (\mu^+ \Delta UR_{1,t-1}^+ + \mu^- \Delta UR_{1,t-1}^-) \\ & + + \sum_{j=0}^{m-1} (\beta^+ \Delta PR_{1,t-1}^+ + \beta^- \Delta PR_{1,t-1}^-) + \varepsilon_t + \varepsilon_t \end{aligned} \quad (8)$$

4. ESTIMATION AND INTERPRETATION

When choosing econometric instruments for empirical analysis, it is essential to consider the order of variable integration as a critical piece of information. In order to assess non-stationarity, a unit root test was performed using the methodologies suggested by Dickey and Fuller (1979), Elliott et al. (1996), and Phillips and Perron (1988). Furthermore, we have implemented the methodology suggested by Kwiatkowski et al. (1992) to assess the presence of stationarity. The results of the unit root analysis are presented in Table 2. After the first difference, all variables exhibit stationarity, which is advantageous for model selection, as evidenced by the test statistic.

The cointegration test utilized in the research drew upon the works of Bayer and Hanck (2013) and Maki (2012). Its purpose was to establish evidence of a long-term relationship between the explained and explanatory factors. All test statistics in the study exhibit significance at the 5% level, indicating a long-term association following the researchers' rejection of the null hypothesis of no cointegration. The results of the cointegration test are presented in Tables 3 and 4.

4.1. Auto-regressive Distributed Lagged (ARDL) Estimation

The study performed a standard Wald test to reveal the long-run cointegration in the empirical equation under the symmetric framework. Referring to the test statistics reported in Table 5, it is apparent that all test statistics are greater than the critical value offered by Pesaran, Shan and suggest long-run relations between REC, FD, UR, PR, FDI, and TO. Once the long-run association has been disclosed, the study documents the coefficients of explanatory variables in the long-run and short-run.

Table 6 displayed the results of long-run and short-run coefficients in all four empirical models exhibiting the long-run coefficients in Panel –A, short-run coefficients in Panel –B, and residual diagnostic test in Panel –C.

The coefficients of financial deepening have revealed positive and statistically significant at a 1% level in long-run and short-run estimation of BD (a coefficient of 0.1698; 0.0458), IND (a coefficient of 0.182; 0.0507), PAK (a coefficient of 0.1651; 0.0282), and SL (a coefficient of 0.1004; 0.044) on renewable energy consumption. The findings above illustrate a positive correlation between the level of financial development and the utilization of renewable energy sources. Positive coefficients indicate a positive correlation, suggesting that a more advanced financial system enables increased investment and financing in renewable energy initiatives. Including statistical significance and carefully considering both long-term and short-term estimates enhance the reliability and applicability of these findings. It is important to emphasize that the interpretation of these results can vary depending on the specific context, variables, and methodologies utilized in this study. However, the collective findings significantly enhance our comprehension of financial diversification's impact on advancing and endorsing renewable energy sources.

Urbanization has exposed a beneficial role in augmenting the clean energy inclusion in the energy mix in elected Southeast Asian economy, implying a positive linkage between urbanization and renewable energy consumption both in the long-run and short-run assessment. Precisely, a 10% change in UR will result in further inclusion of clean energy in the long-run (short-run) by 0.716% (0.274%) in BD, by 1.716% (0.279%) in IND, by 0.931% (0.22%) in PSK, and by 0.989% in SL, respectively. Urbanization is often

Table 1: The null hypotheses for all three tests are defined as follows

Cointegration test	Null hypothesis	Alternative hypothesis
F-bound test	$\gamma_1=\gamma_2=\gamma_3=\gamma_4=\gamma_5=\gamma_6=0$	Any, $\gamma_1,\gamma_2,\gamma_3,\gamma_4,\gamma_5,\gamma_6\neq0$
a t-test on the lagged dependent variable	$\gamma_1=0$	$\gamma_1\neq0$
F-test on the lagged independent variable	$\gamma_2=\gamma_3=\gamma_4=\gamma_5=\gamma_6=0$	Any, $\gamma_2,\gamma_3,\gamma_4,\gamma_5,\gamma_6\neq0$

Table 2: Results of *unit* root test

	At level				After first difference			
	ADF	GF-DLS	PP	KPSS	ADF	GF-DLS	PP	KPSS
For Bangladesh								
IQ	−1.3516	−1.2412	−0.5293	0.7972***	−6.8678***	−5.3237***	−5.7855***	0.0211
DEBT	−1.9963	−1.4605	−1.4393	0.7059***	−8.7876***	−5.3599***	−6.386***	0.0216
EPU	−0.6877	−1.2493	−2.4722	0.587***	−8.6225***	−8.8573***	−8.9924***	0.0185
GS	−0.6943	−1.7589	−1.2422	0.6***	−8.0758***	−8.3292***	−8.1317***	0.0211
FD	−0.7283	−0.6725	−2.1121	0.7267***	−5.7974***	−8.0547***	−7.6461***	0.0189
FDI	−1.8606	−1.7387	−2.3583	0.6261***	−7.5005***	−7.3618***	−8.8815***	0.0191
For India								
IQ	−1.6127	−2.0698	−0.7351	0.6908***	−7.5697***	−8.5806***	−9.5343***	0.0192
DEBT	−0.5205	−0.762	−1.3091	0.9296***	−9.1488***	−6.2404***	−7.572***	0.0214
EPU	−0.8168	−1.7062	−2.3323	0.6015***	−5.5988***	−5.4304***	−9.1025***	0.0195
GS	−1.3493	−1.0664	−1.8405	0.5654***	−8.9829***	−6.8792***	−8.4816***	0.0208
FD	−0.9282	−2.3026	−1.1762	0.7172***	−8.86***	−6.5641***	−5.2945***	0.0193
FDI	−0.301	−1.8453	−0.4539	0.9101***	−5.9377***	−8.2853***	−5.3701***	0.0185
For Pakistan								
IQ	−0.8466	−0.3131	−1.4751	0.8058***	−7.4269***	−5.7366***	−9.2661***	0.02
DEBT	−1.0217	−1.243	−1.7625	0.8126***	−6.6833***	−8.5313***	−8.9156***	0.0203
EPU	−2.5026	−0.6173	−2.4746	0.9029***	−8.5499***	−9.4061***	−5.5307***	0.0186
GS	−1.0382	−0.4885	−0.6981	0.6527***	−7.9449***	−7.922***	−7.3741***	0.0192
FD	−2.1162	−2.0254	−1.7406	0.6283***	−8.6061***	−6.2495***	−6.8373***	0.02
FDI	−2.4845	−2.4936	−0.5052	0.8652***	−5.591***	−6.0325***	−8.0825***	0.0214
For Srilanka								
IQ	−2.4538	−2.0709	−1.4019	0.7998***	−7.901***	−8.861***	−9.4216***	0.0213
DEBT	−0.7655	−0.5009	−0.6134	0.6111***	−5.983***	−6.0528***	−7.2942***	0.02
EPU	−1.0929	−0.4013	−1.508	0.8322***	−6.5232***	−6.0318***	−5.4695***	0.0205
GS	−1.885	−0.9932	−0.5896	0.7962***	−6.6752***	−9.0088***	−8.3632***	0.0207
FD	−0.8565	−1.7645	−0.7049	0.5628***	−8.2114***	−6.7742***	−6.297***	0.021
FDI	−1.5735	−2.5162	−0.9839	0.8479***	−5.5358***	−8.1927***	−7.7075***	0.0218

Table 3: Results of Bayer-Hancked and Maki cointegration test

		BD	IND	PAK	SL	CV
EG-JOH	1	14.283	15.154	12.297	13.022	11.229
	2	10.989	10.929	11.011	11.037	10.895
	3	10.946	11.289	10.88	10.743	10.637
	4	10.875	10.916	10.96	10.837	10.576
	5	10.682	10.673	10.625	10.566	10.419
EG-JOH-BO-BDM	1	36.734	28.137	37.481	29.645	21.931
	2	27.352	24.088	25.599	27.631	21.106
	3	24.455	23.609	22.137	23.491	20.486
	4	21.439	22.249	21.065	21.931	20.143
	5	20.864	20.866	20.932	20.895	19.888

linked to the expansion of urban populations and the subsequent rise in economic activity. With the expansion of urban areas, there is a corresponding rise in the energy demand for powering different sectors, such as residential, commercial, and industrial. The growing need for energy offers a promising opportunity for renewable energy sources to sustainably and effectively meet rising energy demands.

The study documented positive and statistically significant linkage between inflows of remittances receipts and the demand for renewable energy consumption with a coefficient of 0.2367 (0.0587) in BD, a coefficient of 0.2236 in IND, a coefficient of 0.0823 in PAK, and a coefficient of 0.2146 in SL for the long-run (short-run) estimation. The presence of a positive correlation implies that there is a direct relationship between the increase in remittance receipts and the increase in demand for renewable energy. This observation suggests that households that receive remittances tend to invest in renewable energy sources and technologies. The recognition of the positive correlation between remittance receipts and the consumption of renewable energy can provide valuable insights for the formulation and execution of policies and programs. Governments can promote the adoption of renewable energy technologies by implementing various strategies. These strategies may include offering incentives and subsidies and conducting educational campaigns targeted toward households that receive remittances. In regions that heavily rely on remittances, development agencies can support initiatives to enhance financial literacy, facilitate access to renewable energy financing, and promote technology transfer.

Table 7 displayed the results of asymmetric estimation, including panel –A for long-run coefficients with symmetry test, panel –B for short-run coefficients with symmetry test, and residual diagnostic tests displayed in Panel –C, respectively.

Table 4: Results of the Maki cointegration test

Number of Breaks Points	Test Statistics	[Critical Values]	Break Points
Tb<5			
For Bangladesh			
0	−7.8112	−6.306	1995, 2000, 1995, 2011, 2000
1	−9.0713	−6.494	2011, 2019, 2017, 2010, 2000
2	−8.8898	−8.869	2018, 2007, 2015, 2003, 2013
3	−8.1408	−9.482	2006, 2019, 2015, 2014, 2018
For India			
0	−8.3225	−6.306	1995, 2003, 1992, 2019, 1991
1	−9.3384	−6.494	2006, 1993, 2004, 1996, 2007
2	−8.1687	−8.869	1990, 2018, 1996, 2004, 2015
3	−8.314	−9.482	1991, 2004, 2005, 2007, 1991
For Pakistan			
0	−9.6921	−6.306	2018, 2005, 2002, 1993, 1991
1	−8.4912	−6.494	2014, 1995, 2000, 1993, 2011
2	−9.6514	−8.869	2005, 2013, 2014, 2009, 2006
3	−9.6475	−9.482	2014, 2011, 2019, 1996, 1991
For Srilanka			
0	−9.5722	−6.306	2000, 1991, 2000, 2017, 2006
1	−8.3339	−6.494	2015, 2015, 2014, 2000, 1995
2	−7.5849	−8.869	2007, 2017, 2001, 2010, 1998
3	−8.739	−9.482	1997, 2003, 2012, 2005, 1992

Table 5: Results of ARDL-Bound testing: Long-run association

Country	$F_{overall}$	t_{DV}	F_{IDV}
Model: *REC*|*FD, UR, PR, FDI, and TO*			
For Bangladesh	11.262***	−5.663***	10.021***
For India	12.729***	−5.939***	8.472***
For Pakistan	14.919***	−6.999***	9.384***
For Srilanka	15.289***	−6.951***	6.979***

The asymmetric coefficients of financial deepening exposed positively connected to renewable energy consumption both in the long-run and short-run estimation for BD (a coefficient of $LR_{+}=0.0453$; $LR_{-}=0.0488$, and $SR_{+}=0.0225$; $SR_{-}=0.0221$), for IND (a coefficient of $LR_{+}=0.112$; $LR_{-}=0.0173$, and $SR_{+}=0.0215$; $SR_{-}=0.0247$), for PAK (a coefficient of $LR_{+}=0.0384$; $LR_{-}=0.0582$, and $SR_{+}=0.0095$; $SR_{-}=0.0668$), and for SL (a coefficient of $LR_{+}=0.1732$; $LR_{-}=0.0521$, and $SR_{+}=0.0404$; $SR_{-}=0.0216$). The study's findings indicate a positive correlation between the use of renewable energy and the asymmetric coefficients of financial deepening, representing positive and negative shocks. This suggests that fluctuations in financial depth, whether positive or negative, impact the implementation and utilization of renewable energy sources. The results suggest that implementing financial deepening measures may facilitate the transition to renewable energy by promoting the adoption of sustainable energy sources. Policymakers, financial institutions, and energy stakeholders stand to gain valuable insights by delving into the asymmetric effects of financial deepening. Armed with this knowledge, they can effectively develop strategies and policies to bolster the proportion of renewable energy within the energy mix (Wang et al., 2023b; Lei et al., 2022; Bolarinwa et al., 2021; Faisal et al., 2021; Adagunodo and Akintunde, 2021).

Referring to the asymmetric coefficient of urbanization that is for BD (a coefficient of $LR_{+}=0.0447$; $LR_{-}=0.0591$, and $SR_{+}=0.0123$; $SR_{-}=0.0518$), for IND (a coefficient of $LR_{+}=0.1366$; $LR_{-}=0.0511$, and $SR_{+}=0.0445$; $SR_{-}=0.0161$), for PAK (a coefficient of $LR_{+}=0.0571$; $LR_{-}=0.1414$, and $SR_{+}=0.0362$; $SR_{-}=0.0232$), and for SL (a coefficient of $LR_{+}=0.018$; $LR_{-}=0.021$, and $SR_{+}=0.0263$; $SR_{-}=0.0451$), indicating a deterministic role of renewable energy demand expansion both in the long-run and short run. The study's findings indicate that urbanization is linked to positive and negative impacts on renewable energy. This statement suggests that urbanization, in any form, has a positive impact on the adoption and utilization of renewable energy sources. The current body of literature substantiates these findings. Numerous studies have underscored the positive correlation between urbanization and the utilization of renewable energy sources. For example, (Xu et al., 2022; Lee et al., 2022) found that urbanization positively impacted the advancement and adoption of renewable energy technologies within urban regions. The argument posits that the concentration of population and economic activity in urban areas fosters opportunities to adopt renewable energy. This is primarily attributed to the heightened demand for energy and technological advancements. Furthermore, Khan et al. (2023); Zhang et al. (2022a) et al. (2019) have uncovered a noteworthy association between urbanization and the implementation of renewable energy infrastructure, specifically solar PV installations. This correlation arises from urban settings providing favorable conditions for developing renewable energy initiatives.

The research findings suggest a positive correlation between remittance inflow shocks, whether positive or negative and renewable energy. This demonstrates that remittances positively impact the adoption of renewable energy, regardless of their magnitude. Extensive research has been conducted on the impact of remittances on economic growth and poverty reduction in recipient nations (De and Ratha, 2012; Ratha and Mohapatra, 2007), 2019). According to, it has been demonstrated that remittances can improve living standards by increasing family income and consumption. A higher disposable income allows for a larger allocation within the budget for sustainable energy solutions.

Table 6: Results of Long-run and short-run coefficients: ARDL estimation

Variables	Model [1]: BD	Model [2]: IND	Model [3]: PAK	Model [4]: SL
Panel –A: long-run coefficients				
FD	0.1698 (0.1558) [3.0146]	0.182 (0.378) [2.3333]	0.1651 (0.0312) [5.282]	0.1004 (0.0151) [6.6435]
UR	0.0716 (0.0175) [4.0892]	0.1716 (0.0751) [2.2837]	0.0831 (0.0406) [2.0454]	0.0989 (0.0272) [3.6292]
PR	0.2367 (0.0606) [3.9023]	0.2236 (0.1008) [2.2171]	0.0823 (0.0336) [2.4469]	0.2146 (0.0841) [2.5527]
TO	0.1702 (0.0864) [1.9705]	0.4604 (0.2515) [1.8302]	0.0167 (0.0507) [0.3299]	0.0435 (0.0675) [0.6453]
FDI	0.0087 (0.0039) [−2.2033]	0.0074 (0.0108) [−0.6887]	0.0654 (0.018) [3.6218]	0.0013 (0.0015) [0.912]
Panel-B short-run coefficients				
C	13.4891 (1.6547) [8.1518]	2.7346 (0.4519) [6.0506]	−11.0814 (1.1707) [−9.4649]	−60.2928 (6.2202) [−9.6929]
@TREND	0.0136 (0.002) [6.6456]	−0.0006 (0.0008) [−0.7682]	−0.0324 (0.0042) [−7.6795]	0.0182 (0.0017) [10.1405]
ΔFD	0.0458 (0.0375) [1.2216]	0.0507 (0.0605) [0.8383]	0.0282 (0.0028) [10.0315]	0.044 (0.0148) [2.9602]
ΔUR	0.0274 (0.0186) [1.4706]	0.0279 (0.0152) [1.8298]	0.0022 (0.0064) [0.3445]	0.268 (14.4423) [0.0957]
ΔPR	0.0587 (0.0199) [2.9399]	0.3048 (2.8049) [0.1694]	−0.0022 (0.0064) [−0.3445]	−0.0143 (23.4727) [0.0564]
ΔTO	−0.0093 (0.0014) [−6.6341]	−0.0485 (0.0182) [−2.6556]	0.044 (0.0072) [6.038]	−0.093 (0.0557) [−1.6684]
ΔFDI	0.0078 (0.0016) [4.8408]	0.0478 (0.0333) [1.4363]	0.0789 (0.0355) [2.2193]	−0.0163 (0.0228) [−0.7176]
CointEq(−1)	−0.1754 (0.1439) [−1.2192]	−0.3408 (0.0502) [−6.7867]	0.0222 (0.002) [10.7765]	−1.2266 (0.1266) [−9.6875]
Panel –C: Residual diagnostic test				
Breusch-Godfrey LM test	0.821	0.5	0.716	0.763
Breusch-Pagan-Godfrey test	0.711	0.821	0.592	0.775
Arch test	0.497	0.726	0.509	0.501
Ramsey RESET test	0.788	0.795	0.58	0.773
Jarque-Bera test	0.876	0.588	0.838	0.502

Note: the values in () and [] explained the std. error and T-statistics of each coefficient

Consequently, this may expand the range of choices available to households for investing in renewable energy technology (Jongwanich, 2007).

5. DISCUSSION

South Asian nations have the world's fastest economic growth rates. The area saw a disproportionately high rate of population expansion, particularly among the middle class, with a significant rise in prime energy consumption and per capita income (Kang et al., 2021). To check whether the impact of financial deepening and urbanization on renewable and non-renewable energy consumption in South Asian countries, we apply the ARDL technique. Table reports the impact of financial deepening, remittance, and urbanization on energy consumption in the long run and short run. Theoretically, there should be a positive correlation between financial development and renewable emergency consumption (Durusu-Ciftci et al., 2020). As the country is heading towards development, it should be more concerned about environmental degradation and natural calamity. They will emphasize the use and investment in renewable energy. However, in the case of our analysis of South Asian developing countries, the picture is quite different. The analysis shows that for all the countries (Bangladesh, India, Pakistan, and Sri Lanka), the coefficient is negative regarding financial development. That represents that in all the South Asian countries, financial development does not promote renewable energy consumption; the inverse relationship portrays that the more financial development or growth is experienced in these countries, the more environmental degradation will happen, and the people will be more reluctant to consume renewable energy. This conclusion is consistent with the study of (Usman et al., 2021), who reveals that financial development is not significant for developing countries to improve environmental quality. Economic growth declines energy consumption significantly.

This study highlights the asymmetric impacts of financial deepening on renewable energy consumption. This implies that both positive and negative disruptions to financial development favorably impact the adoption and utilization of renewable energy sources. The findings presented here

Table 7: Results of Asymmetric estimation: *REC∫FD+FD– UR+UR– PR+PR–*

Variables	BD	IND	PAK	SL
Panel –A: long-run coefficients				
FD^{+}	0.0453 (0.0066)	0.112 (0.007)	0.0384 (0.0086)	0.1732 (0.01)
	[6.7755]	[15.9952]	[4.4519]	[17.176]
FD^{-}	0.0488 (0.0023)	0.0173 (0.0053)	0.0582 (0.007)	0.0521 (0.0053)
	[21.173]	[3.2457]	[8.2722]	[9.6734]
UR^{+}	0.0447 (0.0056)	0.1366 (0.0083)	0.0571 (0.0118)	0.018 (0.0024)
	[7.8566]	[16.2903]	[4.8108]	[7.481]
UR^{-}	0.0591 (0.0055)	0.0511 (0.0098)	0.1414 (0.0074)	0.021 (0.0036)
	[10.5949]	[5.1991]	[18.8953]	[5.7747]
PR^{+}	0.1468 (0.002)	0.1145 (0.009)	0.1029 (0.0079)	0.0963 (0.0081)
	[71.2152]	[12.6204]	[12.9249]	[11.7807]
PR^{-}	0.0662 (0.0022)	0.0862 (0.0101)	0.0446 (0.0059)	0.0694 (0.005)
	[29.2418]	[8.4798]	[7.503]	[13.6795]
FDI	0.0915 (0.0104)	0.0732 (0.0073)	0.0337 (0.0033)	0.0978 (0.0101)
	[8.7965]	[9.9208]	[10.207]	[9.6879]
TO	0.0501 (0.0117)	0.0717 (0.0027)	0.0521 (0.0042)	0.0902 (0.0033)
	[4.2835]	[26.37]	[12.1402]	[27.0164]
	0.0269 (0.0111)	0.0542 (0.009)	0.0809 (0.0096)	0.0268 (0.0073)
	[2.4082]	[6.0119]	[8.366]	[3.6524]
W^{FD}	12.77	12.025	8.503	10.438
W^{UR}	9.843	13.068	3.827	10.888
W^{PR}	7.74	10.521	6.781	3.98
Panel B: Short-run coefficients				
ΔFD^{+}	0.0225 (0.0078)	0.0215 (0.0068)	0.0095 (0.0041)	0.0404 (0.0022)
	[−2.8846]	[−3.1617]	[2.317]	[18.3636]
ΔFD^{-}	0.022 1 (0.0105)	0.0247 (0.0063)	0.0668 (0.0108)	0.0216 (0.0103)
	[2.1047]	[3.9206]	[6.1851]	[2.097]
ΔUR^{+}	0.0123 (0.0049)	0.0445 (0.0078)	0.0362 (0.0067)	0.0263 (0.0058)
	[2.5102]	[5.7051]	[5.4029]	[4.5344]
ΔUR^{-}	0.0518 (0.0022)	0.0161 (0.0117)	0.0232 (0.0072)	0.0451 (0.0058)
	[23.5454]	[1.376]	[3.2222]	[7.7758]
ΔPR^{+}	0.0507 (0.0062)	0.0693 (0.0031)	0.067 (0.0036)	0.0225 (0.0058)
	[8.1774]	[22.3548]	[18.6111]	[3.8793]
ΔPR^{-}	0.0076 (0.01)	0.0158 (0.0058)	0.0178 (0.0056)	0.0329 (0.0082)
	[0.76]	[2.7241]	[3.1785]	[4.0121]
ΔFDI	0.0646 (0.0096)	0.0181 (0.006)	0.039 (0.0033)	0.0264 (0.005)
	[6.7291]	[3.0166]	[11.8181]	[5.28]
ΔTO	0.0249 (0.0026)	0.0557 (0.0077)	0.0175 (0.0097)	0.0499 (0.008)
	[9.5769]	[7.2337]	[1.8041]	[6.2375]
ECT (–1)	−0.3358 (0.0039)	−0.4705 (0.003)	−0.2315 (0.0113)	−0.3089 (0.0086)
	[−84.3012]	[−156.0543]	[−20.3359]	[−35.7876]
W^{FD}	8.664	11.466	13.308	8.841
W^{UR}	9.472	5.86	4.82	10.842
W^{PR}	3.103	6.63	3.726	6.28
Breusch-Godfrey LM test	0.501	0.559	0.835	0.705
Breusch-Pagan-Godfrey test	0.514	0.544	0.749	0.579
ARCH test	0.581	0.51	0.688	0.644
Ramsey reset test	0.749	0.752	0.686	0.58
Jarque-Bera test	0.538	0.55	0.503	0.588

challenge the widely held belief that only positive disruptions or advancements in financial deepening are responsible for driving renewable energy consumption. The statement posits that implementing financial diversification can effectively bolster the advancement and utilization of renewable energy, even amid economic downturns or financial instability. The study's long-term estimation demonstrates a consistent positive relationship between financial development and renewable energy consumption (Qamruzzaman, 2023a; Karim et al., 2023; Zhuo and Qamruzzaman, 2022; Zhao and Qamruzzaman, 2022). This suggests that as financial systems advance and become more sophisticated, they effectively promote adopting and utilizing renewable energy sources in the long run. The findings suggest that implementing financial diversification initiatives can lead to enduring alterations in energy consumption patterns, thus facilitating the transition towards a more sustainable energy future. The short-term estimation of the study demonstrates an immediate positive correlation between financial disruptions and renewable energy consumption (Muneeb et al., 2022; Ma and Qamruzzaman, 2022b). This statement implies that changes in financial deepening can influence the adoption of renewable energy technologies, even within a short timeframe. The findings indicate that prompt policy measures and financial innovations aimed at enhancing the financial system can yield immediate and measurable impacts on the utilization of renewable energy (Miao and Qamruzzaman, 2021; Meng et al., 2021; Jia et al., 2021).

The study's findings indicate that urbanization is linked to positive and negative impacts on renewable energy. This statement suggests that in its various forms, urbanization has a positive impact on adopting and utilizing renewable energy sources. The existing literature supports the findings presented. Numerous studies have underscored the positive correlation between urbanization and the utilization of renewable energy sources. For example, Chen (Pan et al., 2022) et al. (2020) found that urbanization positively impacted the advancement and adoption of renewable energy technologies within urban regions. The authors contend that the concentration of population and economic activity in urban areas presents opportunities for implementing renewable energy sources primarily due to the heightened energy demand and technological advancements. Furthermore, (Khan et al., 2023; Zhang et al., 2022a) have uncovered a noteworthy association between urbanization and the implementation of renewable energy infrastructure, specifically solar PV installations. This correlation arises due to the favorable conditions that urban environments provide for developing renewable energy initiatives.

Furthermore, the positive correlation between urbanization and the utilization of renewable energy can be ascribed to several supplementary factors. Urban areas generally have greater access to renewable energy resources, such as solar and wind, due to their advantageous geographic conditions. The availability of this resource promotes the adoption of renewable energy technologies (Akpanke et al., 2023; Islam et al., 2023). Furthermore, the elevated population density in urban areas leads to a corresponding rise in energy consumption, fueling the need for sustainable energy solutions (Sovacool, 2016). Finally, it should be noted that urban areas typically exhibit a higher prevalence of advantageous policies and regulations, such as incentives and subsidies, which serve to stimulate the uptake and financial commitment toward renewable energy sources (Yang et al., 2022b).

In the long run, the expected coefficient on personal remittance is positive in Bangladesh and Pakistan but negative in India and Sri Lanka. However, in the short run, the coefficient is positive in Bangladesh and India but negative in Pakistan and Sri Lanka. The empirical research indicated that long- and short-term remittance positively promotes renewable energy consumption in Bangladesh. Being one of the greatest remittances received country among the selected countries, Bangladesh has exhibited a significant and stable relationship for a long time. Bangladesh's high remittance boosts the need for renewable energy, especially solar residential systems, and the impact is vice-versa (Das et al., 2021). Because the study found that an increase in remittances raises demand for greater industrial production, which in turn leads to the utilization of fossil fuels, the coefficient is negative in the long run for India. This is because of what the study found.

In contrast to Bangladesh, the widespread usage of this fossil fuel in India hurts the environment, even though the nation has a positive impact in the short run (Zhang et al., 2022b). On the other hand, Pakistan displays a different pattern than India, with a long-term positive influence of remittances on renewable energy consumption and a short-term negative impact. This indicates that the influx of remittances may quickly increase the recipient family's energy demand. However, if appropriate policies and incentives are implemented, the negative effects of remittances can be mitigated over time (Ali et al., 2022). In both the short and the long run, sending money back home consistently negatively affects Sri Lanka's ability to invest in renewable energy. The use of renewable energy has not increased despite the rise in money being sent back home. Instead, it raises the requirement for using conventional energy sources, which leads to excessive CO_2 emissions (Rahman et al., 2019a). Several factors could increase the likelihood of families who receive remittances transitioning to renewable energy sources. To enhance investments in renewable energy infrastructure and appliances, it has been suggested that remittances can significantly promote financial inclusion and facilitate access to finance (Qamruzzaman et al., 2023; Qamruzzaman, 2023b; Ju et al., 2023). Due to their transnational connections and exposure to sustainable practices in host countries, individuals who depend on remittances to meet their needs are more inclined to comprehend the significance of renewable energy sources (Xu et al., 2021; Ahsan and Haque, 2017). The acquisition of new knowledge has the potential to influence individuals' energy consumption habits and motivate them to transition toward renewable sources (Lin and Qamruzzaman, 2023b; JinRu et al., 2023). The potential synergy between remittances and renewable energy sources complements broader sustainable development objectives. Using renewable energy sources enables sustainable development, reduction of carbon emissions, and mitigation of the impacts of climate change (Xia et al., 2022; Apergis and Apergis, 2019). Given that remittances contribute to economic growth and poverty reduction, it is logical to consider that transitioning to renewable energy could serve as a dual solution for economic advancement and environmental sustainability (Wang et al., 2023b; Serfraz et al., 2023; Qamruzzaman and Kler, 2023; Lin and Qamruzzaman, 2023a).

In the long run, variable foreign direct investment (FDI), except for Pakistan, in the case of all other countries, the coefficient is negative, which reflects the inverse relation between FDI and REC. In the case of Bangladesh, India and Sri Lanka, a 1% increase in the variable FDI, respectively, reduced the REC by −0.0087%, −0.0074%, −0.0013%, whereas for Pakistan, REC increased by 0.065%. The use of renewable energy and FDI are negatively correlated. It might be because FDI has the potential to boost economic growth by easing the integration of new technologies and through some spillover effects and productivity increases. Improved managerial abilities and technological advancements may make it easier for host nations to rely less on renewable energy (Kang et al., 2021). In the case of Bangladesh and India, the computed coefficient for long-run urbanization is negative, suggesting that a rise in urbanization of 1% results in a decline in renewable energy consumption of −2.8811% in Bangladesh and −1.0862% in India. It is favorable for Sri Lanka and Pakistan, with a 1% rise in urbanization, increasing REC by 5.2513% in Pakistan and 18.4189% in Sri Lanka. The results align with (Khan, 2018) that environmental damage will worsen in Bangladesh as the economy grows, cities grow, and more energy is used. Bangladesh is becoming more urban quickly and without a plan. The country is growing at a good rate, but there is no way to keep track of environmental damage.

The calculated coefficient for long-run trade openness is statistically significant and positive for all the countries, indicating that trade openness significantly contributes to rising renewable energy consumption. The empirical outcome is consistent with research by (Yang et al., 2022a) that a significant favorable long-run relationship exists between economic growth, renewable energy consumption (REC), and trade openness. Furthermore, this suggests that when these nations remove trade barriers, cross-border commerce in renewable energy might occur, resulting in using renewable energy resources (Murshed, 2018). However, in the short run, the results show a negative relationship between trade liberalization and renewable energy consumption, except in Pakistan. According to FMOLS and DOLS estimates, trade openness negatively affects renewable energy consumption. More trade openness in a few South Asian countries could help reduce reliance on polluting energy sources while lowering demand for renewables (Kang et al., 2021).

6. CONCLUSION

The study's results offer fascinating new insights into the effects of urbanization, remittances, and trade openness on the utilization of renewable energy in South Asian countries. The results highlight the intricate nature of these interactions, as they demonstrate that both financial development and urbanization have positive and negative impacts on the utilization of renewable energy. The research also highlights the significance of remittances, showcasing a nuanced pattern of both advantageous and detrimental effects on the utilization of renewable energy in different countries. Furthermore, it has been discovered that trade openness exerts a significant long-term positive influence on the utilization of renewable energy, albeit with a short-term adverse effect. Additionally, the study's results contribute to the existing body of knowledge by shedding light on the specific dynamics of these connections within the context of South Asian nations. It is imperative to remember that additional research is necessary to validate and enhance our understanding of these connections. In order to comprehensively examine the intricate connections among financial deepening, urbanization, remittances, trade openness, and renewable energy usage, it is recommended that future research consider additional variables and incorporate more expansive datasets.

7. POLICY SUGGESTIONS AND FUTURE DIRECTION OF THE STUDY

Based on the discourse, the ensuing policy recommendations can be put forth:
First, it is advisable to promote financial diversification to address the disparate impacts of financial deepening on adopting renewable energy. Therefore, it is recommended that authorities prioritize initiatives to foster financial diversification. This involves developing a comprehensive and resilient financial framework that can promote and leverage renewable energy sources, even during economic downturns or financial instability. By leveraging various financial tools and incentives, promoting innovation and investment in renewable energy projects can potentially expedite the transition towards a more sustainable energy future.

Second, Urbanization and the Integration of Renewable Energy: In light of the significant correlation between urbanization and adopting renewable energy sources, authorities must prioritize urban planning methods that facilitate the seamless integration of renewable energy technology. This objective can be achieved by promoting sustainable urban development practices, which entail integrating renewable energy infrastructure into urban areas, offering incentives for adopting renewable energy in building codes and allocating resources to smart city initiatives that optimize energy efficiency and the utilization of renewable energy.

Third, capitalizing on the Potential of Remittances: In light of the potential synergy between remittances and renewable energy, governments must explore strategies that leverage remittance inflows to foster investment in renewable energy. Enabling the financial inclusion and credit accessibility of remittance recipients may allow them to invest in renewable energy infrastructure and equipment. Moreover, enhancing awareness and educating households that receive remittances about the benefits of renewable energy could potentially facilitate the transition towards sustainable energy consumption practices.

Fourth, In order to achieve a harmonious equilibrium between Foreign Direct Investment (FDI) and the utilization of renewable energy, it is imperative for policymakers to diligently evaluate the impact of FDI on the adoption and implementation of renewable energy sources. While Foreign Direct Investment (FDI) has the potential to contribute to economic development, it is crucial to undertake measures to guarantee its alignment with long-term energy objectives. This could involve implementing policies and incentives to promote foreign direct investment (FDI) in the renewable energy sectors while fostering technology transfer and facilitating information exchange between international investors and local renewable energy firms.

Fifth, Policymakers ought to adopt a well-balanced approach toward trade openness and the utilization of renewable energy. Although trade liberalization has the potential to facilitate the international exchange of renewable energy resources, it is imperative to acknowledge and mitigate any adverse effects that may arise, particularly the heightened reliance on environmentally harmful energy sources. Policies ought to prioritize the establishment of a conducive regulatory framework that fosters the growth of renewable energy, concurrently diminishing trade barriers and promoting international collaboration in renewable energy research and development.

South Asian nations can potentially expedite their transition towards sustainable energy systems, thereby mitigating environmental degradation and effectively achieving their economic and environmental sustainability objectives. This can be accomplished by adhering to the following policy recommendations. Future studies should also examine the underlying processes and consider potential policy implications. Policymakers can effectively foster sustainable energy transitions by acquiring a comprehensive comprehension of the factors that both facilitate and impede the adoption of renewable energy within the framework of urbanization, financial development, and remittances. Furthermore, analyzing the impact of trade regulations and international accords on the utilization of renewable energy can offer valuable perspectives for stakeholders and policymakers seeking to enhance the uptake of renewable energy while ensuring sustainable economic growth.

RESEARCH FUNDING

The study has received financial support from the Institutions for Advanced Research (IAR), United International University, under Supplementary publication Grant – IAR/2023/PUB/049

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