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Nexus between financial development, foreign direct investment, and renewable energy consumption: Evidence from SSA

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Abstract

This study examines the nexus between urbanization (UR), gross capital formation (GCF), trade openness (TO), and renewable energy consumption (REC) to understand their interplay and implications for renewable energy adoption. Analyzing the data reveals a negative correlation between UR, GCF, TO, and REC, highlighting challenges in promoting renewable energy amidst urbanization, capital formation, and global trade integration. Policy interventions are crucial to address barriers hindering renewable energy uptake. Recommendations include incentivizing foreign direct investment, enhancing technology transfer, incentivizing clean energy investments, and promoting financial literacy. Integrated urban planning and alignment of capital formation policies with renewable energy goals are essential strategies to accelerate renewable energy adoption. This study offers valuable insights for policymakers and stakeholders seeking to promote renewable energy development and sustainability.

Keywords: Financial Development; Foreign Direct Investment; Renewable Energy Consumption; SSA

1. Introduction

The nexus between financial development, foreign direct investment, and renewable energy consumption is increasingly important in today's global context. Financial development is crucial in promoting and supporting foreign direct investment in the renewable energy sector (1-4). Financial institutions, both public and private, provide the necessary funds for the development and implementation of renewable energy projects. Without adequate financial support, it becomes challenging for developing countries to transition towards renewable energy sources (5-11). This leads to a dependence on fossil fuels, which not only contributes to environmental pollution and climate change but also increases the vulnerability of these countries to fluctuations in global energy prices and geopolitical tensions(11-15). Furthermore, foreign direct investment can significantly impact renewable energy consumption. Companies from developed countries often invest in renewable energy projects in developing countries, bringing in advanced technologies and expertise. These investments help to enhance the renewable energy sector's capacity and efficiency, leading to increased consumption of renewable energy sources. The nexus between financial development, foreign direct investment, and renewable energy consumption is a complex and interconnected relationship. It requires a comprehensive and integrated approach from policymakers, financial institutions, and stakeholders to promote sustainable development and accelerate the transition towards a clean energy future (16-18). The nexus between financial development, foreign direct investment, and renewable energy consumption is becoming increasingly important (19-26). Financial development, such as the availability of credit and investment opportunities, is crucial in facilitating foreign direct investment in the renewable energy sector (27). Financial institutions provide the necessary funding for renewable energy projects, allowing developing countries to transition away from fossil fuels and towards clean, renewable energy sources (28-33). This transition is vital for mitigating climate change, reducing environmental pollution, and enhancing energy security. On the other hand, foreign direct investment brings capital, advanced technologies, and expertise into developing countries' renewable energy sector, which helps improve the efficiency and

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effectiveness of renewable energy generation and consumption. As a result, developing countries can increase their renewable energy capacity and reduce their dependence on fossil fuels, leading to improved energy security and greater environmental sustainability(34-39). Adopting renewable energy policies and developing renewable energy technologies are also crucial factors driving renewable energy consumption. These policies provide incentives and regulatory frameworks that promote renewable energy sources while technological advancements make renewable energy more accessible and cost-effective.

Furthermore, financial development and foreign direct investment can facilitate the adoption of these policies and technologies by providing the necessary funding and support. In conclusion, the nexus between financial development, foreign direct investment, and renewable energy consumption is critical in driving the transition to a clean energy future [(Lee, 2019)]. Developing countries, in particular, rely on financial development and foreign direct investment to enhance their renewable energy generation capacity, which enables them to reduce their dependence on fossil fuels and promote environmental sustainability.

2. Literature review and hypothesis development

2.1. Financial development and renewable energy consumption

In recent years, there has been an increasing focus on the correlation between financial development and the utilization of renewable energy. This literature review seeks to examine the current body of research on the impact of financial development on the adoption and exploitation of renewable energy resources. Gaining a comprehensive understanding of this correlation is of utmost importance for policymakers, investors, and stakeholders who want to promote sustainable energy transitions and alleviate the impacts of climate change. Financial development refers to the overall state of financial markets, including their depth, efficiency, stability, and accessibility to financial services. Multiple studies have emphasized the significance of financial development in facilitating the adoption of renewable energy. Beck and Nesiba (2020) discovered that nations with advanced financial systems tended to allocate more investments toward renewable energy projects, resulting in an overall rise in their use of clean energy. Access to funding is crucial for the implementation of renewable energy projects. The study (22, 40-42) argues that enhanced finance and investment accessibility empowers enterprises and people to allocate resources toward renewable energy technologies, including solar, wind, and hydroelectric power. In addition, implementing financial advancements like green bonds and venture capital financing has supported the expansion of renewable energy initiatives in several nations.

Moreover, the stability and predictability of financial markets significantly impact investor confidence in renewable energy projects. Countries with robust regulatory frameworks and favourable policies for renewable energy tend to attract higher levels of investment in this industry (43). On the other hand, uncertainty in financial markets might discourage investment in renewable energy projects, resulting in slower adoption rates. Government policies and regulations significantly influence the interplay between financial development and renewable energy use. Policy measures such as feed-in tariffs, tax incentives, and renewable energy requirements may encourage investment in clean energy projects (44, 45). Furthermore, regulatory frameworks that encourage openness, accountability, and risk reduction are crucial for attracting investments in renewable energy infrastructure (23, 46-51). Furthermore, global cooperation and collaboration are essential for advancing renewable energy objectives. The Paris Agreement and similar multilateral efforts provide a structured platform for nations to collaborate in addressing climate change and advancing the development of renewable energy sources. Financial institutions and development organizations are vital in supplying funds and technical support for renewable energy projects in poor nations (52). Overall, the existing research indicates a favourable correlation between the advancement of financial systems and the use of renewable energy sources. Access to financial resources, consistent regulations, and favourable policies are crucial factors that contribute significantly to the implementation and expansion of renewable energy projects. Nevertheless, it is necessary to confront obstacles such as unpredictable market conditions and conflicting policies to use renewable energy sources' vast capabilities fully. Future research should prioritize the identification of optimal strategies and policy interventions aimed at facilitating sustainable energy transitions on a global scale.

Addressing urgent environmental concerns, energy security issues, and the need to mitigate climate change, the study focuses on the critical importance of transitioning towards sustainable energy systems. The study seeks to elucidate the complex interconnections among financial development, FDI, and REC to recognize these relationships' significant roles in promoting the adoption of renewable energy sources amidst the global transition from fossil fuels. The study offers insights into practical approaches for achieving sustainable energy transitions, enhancing energy security, and fostering economic growth by incorporating renewable energy sources. The initiative is motivated by the pressing need to address climate change and advance sustainable development.

Research is primarily driven by the imperative to address climate change, enhance energy security, and stimulate economic growth by adopting renewable energy sources. The study examines the influence of financial development and foreign direct investment on Renewable Energy Consumption (REC) to facilitate policy decisions to accelerate the transition to renewable energy sources and address climate issues. Furthermore, the research enhances our understanding of the dynamics of the global energy transition and offers valuable guidance to stakeholders, investors, and policymakers advocating for sustainable development goals. This study seeks to pave the way for a more resilient, sustainable, and environmentally friendly energy future by examining the correlation between financial development, FDI, and REC.

2.2. Foreign direct investment and renewable energy consumption

The convergence of foreign direct investment (FDI) and renewable energy consumption has received considerable attention in recent years, owing to its potential ramifications for sustainable development and climate change mitigation. The literature seeks to analyze the current body of research on the impact of foreign direct investment (FDI) on the adoption and usage of renewable energy resources in various areas and nations. Foreign direct investment is essential for the worldwide growth of renewable energy infrastructure. Multiple studies have emphasized the beneficial correlation between foreign direct investment (FDI) inflows and the use of renewable energy (53-59). Xu and Su (2018) discovered that foreign direct investment (FDI) inflows play a significant role in fostering the advancement of renewable energy projects by providing financial resources, technological advancements, and specialized knowledge. Host governments often rely on multinational companies (MNCs) to provide substantial financial support and execute renewable energy initiatives (60-63).

Furthermore, foreign direct investment (FDI) can potentially promote the transfer of technology and the dissemination of information in the renewable energy industry. Multi-national corporations (MNCs) provide cutting-edge technology and optimal methods that may improve the effectiveness and output of renewable energy initiatives (64). In addition, foreign direct investment (FDI) inflows promote competition and innovation within the renewable energy sector, decreasing costs and enhancing performance (65, 66). Moreover, the regulatory landscape and policy framework in the countries where foreign direct investment (FDI) takes place significantly influence the effect of FDI on the use of renewable energy. Countries that have favourable laws and incentives for renewable energy tend to attract a higher amount of foreign direct investment (FDI) in this particular industry ((67-69). On the other hand, obstacles imposed by regulations and ambiguity in policies might discourage the entry of foreign direct investment (FDI) and impede the progress of renewable energy projects (70).

Multilateral institutions and international collaboration are essential in allowing the use of renewable energy driven by foreign direct investment (FDI). The World Bank, International Finance Corporation (IFC), and regional development banks provide financial support and technical guidance for renewable energy initiatives in underdeveloped nations (Kumar et al., 2020). In addition, international agreements and efforts such as the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement provide a favourable atmosphere for foreign direct investment (FDI) in renewable energy. These accords demonstrate a lasting commitment to sustainability and climate action.

Although FDI-led renewable energy consumption has significant advantages, it also poses some difficulties. In order to achieve inclusive and sustainable development, it is crucial to tackle issues such as resource reliance, environmental sustainability, and social fairness, as highlighted by Leal-Arcas et al. (2019). In addition, foreign direct investment (FDI) governance and its effects on local populations and ecosystems need meticulous supervision and control (Kolk et al., 2021). Ultimately, the evidence indicates that foreign direct investment (FDI) is crucial in stimulating the global adoption of renewable energy. Capital access, knowledge transfer, and policy support are crucial factors that facilitate the growth of renewable energy via foreign direct investment (FDI). Nevertheless, to fully optimize the beneficial effects of foreign direct investment (FDI) on the transition to sustainable energy, it is imperative to tackle obstacles such as regulatory impediments and environmental concerns.

3. Data and methodology of the study

3.1. Model specification

The study aims to gauge the role of FDI and financial development in energy consumption from renewable sources in SSA. The generalized relations are as follows.

$$REC | FDI, FD \ldots\ldots\ldots\ldots(1)$$

Following the literature, the above Eq (1) has extended with the inclusion of control variables: gross capital formation, trade, and urbanization. The extended equation is as follows.

REC| FDI, FD, TO, GCF, UR …………(1)

With log transformation, the above Eq (2) can be displayed in the following manner. The regression equation would then take the following form:

$$REC = \beta 0 + \beta 1FDI + \beta 2FD + \beta 3TO + \beta 4GCF + \beta 5UR + \varepsilon$$

Here, REC is the renewable energy consumption (dependent variable).FDI, FD, TO, GCF, and UR are independent variables representing foreign direct investment, foreign aid, trade openness, gross capital formation, and unemployment rate. β0, β1, β2, β3, β4, and β5 are the coefficients representing the impact of each independent variable on REC. ε is the error term, representing the difference between the observed and predicted values of REC that the independent variables cannot explain.

The regression equation includes REC as the dependent variable, representing renewable energy consumption. The equation contains multiple independent variables that could influence REC. Let us analyze each variable and its potential impact on REC. Foreign direct investment (FDI) denotes investments made by foreign entities in domestic assets. Increased foreign direct investment can result in a rise in renewable energy consumption through different channels. For example, international investors could introduce cutting-edge technologies and specialized knowledge in renewable energy generation, enhancing efficiency and increasing capabilities (2, 71-74). Moreover, foreign direct investment can fund renewable energy initiatives, supporting their progress and execution. Financial development refers to the sophistication and accessibility of financial services within an economy. Although not explicitly stated in the regression equation, FD may indirectly impact REC. Enhanced financial development can increase access to funding for renewable energy projects via methods like loans, venture capital, and crowdfunding. Enhanced access to financing may encourage investment in renewable energy infrastructure and boost REC expansion.

Trade openness indicates an economy's integration with global trade markets. Increased trade openness can positively impact REC by enabling renewable energy technologies, resources, and knowledge transfer between countries. Enhanced access to global markets may result in implementing more effective and eco-friendly energy solutions, ultimately boosting the use of renewable energy.

The GCF represents the overall value of newly created physical assets in an economy over a defined timeframe. A higher GCF indicates a more significant commitment to investing in infrastructure, such as renewable energy projects. Investing in renewable energy infrastructure, including wind farms, solar parks, and hydroelectric plants, can increase the capacity for renewable energy generation, thereby enhancing REC levels.

Urbanization indicates the percentage of a nation's inhabitants residing in urban regions. Urbanization can impact REC in various ways. With the concentration of populations in urban centers, there is usually an increased need for energy, including renewable sources. Urban centers can act as focal points for innovation and policy experimentation, facilitating the uptake of renewable energy technologies and practices. In addition, urbanization may lead to increased investments in renewable energy infrastructure to address the energy requirements of expanding urban populations.

3.2. Estimation strategies

When doing econometrics and panel data analysis, it is essential to address issues such as slope variations and interdependence among cross-sectional units and conduct panel unit root tests to maintain the correctness and reliability of empirical findings. (75) explores the idea of slope heterogeneity, which refers to the differences in the connection between independent and dependent variables across various units or entities in a panel dataset. This phenomenon might arise due to diverse underlying traits or structural disparities among the entities under investigation. In order to address the variation in slopes, it is crucial to use appropriate statistical techniques such as fixed-effects or random-effects models. These strategies aid in controlling unit-specific effects, accurately assessing the connections being studied, and correcting variances.

As elucidated in the study of (76-80), cross-sectional dependence refers to correlations or interdependencies among the observations across different cross-sectional units in a panel dataset. This problem violates the concept of independence between observations and may lead to skewed estimates and erroneous statistical conclusions if not appropriately addressed. Techniques such as spatial econometrics or panel data models that account for cross-sectional dependencies, such as the spatial error model or the geographical lag model, are often employed to tackle this issue. Considering spatial or temporal interactions between units may result in more reliable and robust estimations of the connections under investigation.

As outlined in reference 81, panel unit root tests are statistical techniques used to determine if individual series in a panel dataset exhibit unit root characteristics, indicating non-stationarity. Conducting unit root tests is crucial for assessing the stationarity of variables across time. Non-stationary data may lead to misleading regression conclusions and erroneous deductions. Various unit root tests, such as the Levin-Lin-Chu test, the Im-Pesaran-Shin test, and Fisher-type panel unit root tests, are used to ascertain the stationarity of the panel data series. Performing panel unit root tests may enhance the dependability of results and mitigate possible challenges associated with studying non-stationary data, eventually strengthening the resilience and credibility of empirical studies.

The target empirical model will be performed with DCE and DCE-IV panel data estimation techniques. DCE models involve estimating heterogeneous coefficient models using common correlated effects in a dynamic panel. The model equation for DCE can be represented as:

$$y(i,t) = w0(i) + x(i,t) * w2(i) + \delta(i) * (x(i,t) - x(i,t-1)) + \sum[d(i) * z(i,s)] + e(i,t)$$

In this equation, $y(i,t)$ represents the dependent variable, $x(i,t)$ is the independent variable, $w0(i)$, $w2(i)$, and $\delta(i)$ capture long run and short run effects, respectively. The term $z(i,s)$ includes additional variables, and $e_{(i,t)}$ is the error term

DCE-IV extends DCE by incorporating instrumental variables to address endogeneity issues. The model equation for DCE-IV can be expressed as:

$$y(i,t) = b0(i) + x(i,t) * b2(i) + d(i) * z(i,t) + e(i,t)$$

These equations illustrate how DCE and DCE-IV models are structured to estimate dynamic common correlated effects in panel data analysis, considering both the immediate and lagged impacts of variables on the dependent variable while accounting for endogeneity through instrumental variables.

4. Estimation and interpretation

Before the implementation of the target mode, the study implemented a preliminary investigation with a slop of heterogeneity (75), cross-sectional dependency (76-80), and panel unit root test (81). Table 1 displays the preliminary results and exhibits the availability of heterogeneity properties, cross-sectional dependency, and variables integrated into the first-order operation.

Table 1 Slop of heterogeneity, cross-sectional dependency, and panel unit root test

Panel A: SH test of Bersvendsen and Ditzen (2021)						
	Delta Statistic	**Adjusted Delta Statistic**	**SH exits**			
Model	3.5173***	5.5115***	Yes			
	(Breusch and Pagan 1980)	Pesaran (2004)	Pesaran, Ullah et al. (2008)	Pesaran (2006)	Juodis and Reese (2022)	
REC	181.379***	45.496***	249.963***	8.911***	4.2607***	
FD	326.732***	32.441***	234.515***	20.535***	-2.377***	
FDI	202.558***	44.83***	225.848***	39.93***	- 1.5001***	
TO	353.601***	21.43***	229.298***	19.551***	0.4363***	
GCF	247.899***	17.293***	121.758***	9.905***	4.7793***	
UR	309.358***	18.692***	146.06***	22.779***	6.5844***	

Variables	CADF test statistic		CIPS test statistic		Herwartz and Siedenburg -2008	
	Level	first difference	Level	first difference	Level	first difference
REC	-1.333	-4.117***	-1.395	-7.096***	-0.8067	1.7348***
FD	-2.222	-3.877***	-2.706	-5.191***	1.2588	5.9188***
FDI	-2.723	-2.817***	-2.254	-2.672***	0.9824	8.9982***
TO	-2.127	-7.652***	-1.752	-7.803***	1.3904	-0.1907***
GCF	-2.49	-6.304***	-2.03	-2.971***	0.993	7.7116***
UR	-2.706	-4.944***	-2.562	-6.296***	1.8434	-1.3823***

Table 2 displayed the panel unit root test results and exposed a long-run association available in the empirical relations.

Table 2 Results of panel cointegration test

Model	FD--->REC	FDI--->REC	TO--->REC	UR--->REC		GCF--->REC
GT	-10.646***	-10.249***	-6.02***	-6.002***		-12.18***
Ga	-10.085***	-13.713***	-12.921***	-14.079***		-11.279***
Pt	-13.665***	-9.273***	-13.582***	-10.556***		-8.901***
Pa	-13.593***	-11.873***	-13.816***	-9.398***		-6.243***
KRCPT						
MDF	20.911***	15.563***	17.643***	21.018***		1.402***
DF	-9.9***	9.703***	21.624***	-2.971***		-0.331***
ADF	17.013***	5.112***	11.878***	6.54***		8.407***
UMDF	-10.138***	-6.287***	17.97***	4.74***		16.364***
UDF	5.703***	-7.055***	3.926***	13.213***		11.111***
PCT						
MDF	8.28***	5.149***	-0.957***	-7.327***		-8.945***
PP	9.05***	-3.642***	7.571***	3.757***		14.925***
ADF	8.071***	9.608***	10.48***	8.275***		11.332***
	no shift		mean shift		regime shift	
	LMr	LMΦ	LMr	LMΦ	LMr	LMΦ
	Stat.	stat.	stat.	stat.	stat.	Stat.
Model 1	-3.4203***	-2.587***	-3.1888***	-3.8568***	-3.7196***	-2.7206***

Model estimation: DCE and DCE-IV and their results are displayed in Table 3. The study findings revealed a negative linkage toward REC, indicating that the inflows of FDI hinder clean energy inclusion. However, the coefficient of FDI^2 was exposed positively to REC, suggesting U-invest relations, that is, after a point in time, inflows of FDI foster cleaner consumption. The study's results suggest a strong association between foreign direct investment (FDI) and the usage of renewable energy (REC). Our study aligns with the literature (12-15, 82-86). Initially, the research discovered a negative correlation, indicating that more foreign direct investment (FDI) might hinder the acceptance and use of renewable energy sources. The results align with prior studies suggesting foreign direct investment favors conventional energy industries over renewable energy. This preference is attributed to regulatory uncertainty, insufficient policies, and perceived risks associated with renewable projects (87-89).

However, the research delved further by including a squared term for Foreign Direct Investment (FDI), which revealed a more complex link with Regional Economic Cooperation (REC). The coefficient of FDI squared shows a positive association with REC. This indicates the presence of a U-shaped correlation, whereby renewable energy use is stimulated by inflows of foreign direct investment (FDI) until a certain threshold is surpassed. This finding is consistent with an "inverted U-curve" or "Kuznets curve," which proposes that economic development may initially lead to environmental damage. However, eventually, it can facilitate environmental improvements, such as the increased adoption of renewable energy technologies (29, 83, 85, 90-94). A U-shaped connection emphasizes the need to assess the timing and magnitude of foreign direct investment (FDI) inflows in relation to promoting renewable energy use. FDI may initially pose challenges to the integration of clean energy. However, suppose a certain degree of economic growth or investment maturity is achieved. Certain policies and activities may be enacted to harness FDI inflows and promote renewable energy adoption in that case. Several strategies may include promoting foreign direct investment in renewable energy projects, enhancing regulatory frameworks to promote sustainability, and fostering collaborations between international investors and local participants in the renewable energy sector (95-97). In conclusion, the study results highlight the complex connection between foreign direct investment (FDI) and regional economic cooperation (REC), demonstrating both inhibiting and facilitating dynamics. Gaining a comprehensive understanding of these complexities may assist policymakers in developing more efficient methods to harness foreign direct investment (FDI) to achieve sustainable energy transitions and meet long-term renewable energy goals.

For financial development, the coefficient revealed a negative, an adverse tie unveiled between FD and REC, implying that access to financial products and services discourages using clean energy. Whereas the coefficient of FD^2 disclosed a positive connection towards REC, postulating the beneficial effects of FD on clean energy inclusion in the energy mix, a U-invert association has been established. The findings regarding the relationship between financial development (FD) and renewable energy consumption (REC) demonstrate a noteworthy contrast, shedding light on the intricate mechanisms through which FD influences the uptake of clean energy(98-107). The initial finding of the study highlights a negative correlation between financial development (FD) and the consumption of clean energy (REC), suggesting an adverse relationship between the two. Upon initial examination, this discovery may appear paradoxical. However, it indicates that although increased access to financial products and services typically benefits economic advancement, it does not necessarily lead to greater adoption of renewable energy technology. There could be various reasons for this negative association, such as market distortions, lack of awareness about clean energy options, or insufficient legislative support for renewable energy growth in the finance sector.

To address the negative association, policymakers must consider strategies to overcome barriers to integrating clean energy within the financial system. One potential approach is to provide financial incentives for investments in renewable energy, enhance financial literacy initiatives to educate investors about clean energy opportunities and implement policies that promote sustainable finance behaviors. The study reveals a positive correlation between FD squared and REC, explaining their relationship more deeply. The positive correlation suggests that once a specific level of financial growth is achieved, the influence on clean energy integration becomes beneficial. This leads to a connection between financial development and renewable energy usage that adheres to an inverted U-shaped trend(108-115). In summary, the initial stages of financial growth could impede the acceptance of clean energy. However, as financial progress increases, it could facilitate the integration of renewable energy into the energy mix. Policymakers could utilize this finding to explore strategies for optimizing the positive effects of financial development on the incorporation of clean energy. One may need to advocate for innovative funding methods tailored for renewable energy projects, foster partnerships between financial institutions and clean energy entrepreneurs, and leverage financial regulations to promote sustainable investing practices. In addition, efforts to enhance market transparency and reduce investment risks associated with clean energy projects could enhance the positive impact of financial growth on Renewable Energy Certificates (RECs).

In summary, the findings on the relationship between FD and REC emphasize the intricate connections between financial growth and the implementation of clean energy. To promote sustainable energy transitions, policymakers can implement targeted measures to address obstacles and leverage opportunities. It is essential to recognize and consider the dual impact of financial development on REC, encompassing both positive and negative effects. An inverse correlation exists between the coefficients of urbanization (UR), gross capital formation (GCF), and trade openness (TO) with renewable energy consumption (REC). Analyzing the potential impact of these variables on the adoption and utilization of renewable energy sources is crucial.

Urbanization encompasses the process of population concentration and growth in urban areas. Urbanization plays a significant role in driving economic growth and increasing energy demands. This increases reliance on conventional energy sources due to existing infrastructure, energy-intensive methods, and ingrained consumption patterns within urban areas. Furthermore, rapid urbanization may result in changes in land use and environmental degradation, which could impede the implementation of renewable energy technologies. Consequently, the UR coefficient in the regression model may suggest challenges in transitioning urban energy systems to renewable sources, resulting in a negative association with REC(116-121).

The GCF represents the total investment in physical assets within an economy. Higher levels of investment are commonly associated with economic expansion. Nevertheless, the negative coefficient of GCF suggests that capital might be allocated more towards traditional energy infrastructure or non-renewable projects rather than investments in renewable energy initiatives. One potential explanation for this situation could be current investment incentives favoring traditional energy sources, apprehensions regarding risks associated with renewable energy endeavors, or limited financing options tailored for clean energy projects. Therefore, despite the general capital formation, the focus on non-renewable investments contributes to the noted negative correlation with REC(2, 122-126).

Trade openness refers to the degree of economic integration with international trade markets. International trade facilitates the interchange of goods, services, and technologies. Nevertheless, the negative coefficient of TO suggests that increased trade openness may not necessarily result in a higher uptake of renewable energy(22, 127-132). Increased trade openness could lead to heightened competition from more affordable, non-renewable energy sources in international markets, potentially reducing the demand for renewable energy options. Furthermore, trade agreements and policies may not consistently prioritize sustainability or renewable energy development, potentially hindering the connection between trade openness and REC(6, 133, 134). Overall, the negative coefficients of UR, GCF, and TO indicate the challenges associated with promoting renewable energy consumption in urbanization, capital formation, and trade openness. In order to effectively address these challenges, it is essential to implement specific policy interventions that target institutional, financial, and structural barriers. This will help facilitate the transition towards a more sustainable and renewable energy-focused economy.

Table 3 Coefficients derived with DCE and DCE-IV

	Coefficient	**Std. Error**	**t-Statistic**	**Coefficient**	**Std. Error**	**t-Statistic**
	DCE			**DCE-IV**		
FD	-0.12975	0.0195	-6.65385	-0.17329	0.0198	-8.75202
FD2	0.08544	0.0408	2.0941	0.08649	0.0285	3.0347
FDI	0.16219	0.0295	5.4979	0.17837	0.0384	4.645
FDI2	-0.18315	0.0172	-10.6482	-0.16041	0.0358	-4.4807
TO	-0.08434	0.0359	-2.3493	-0.18042	0.0217	-8.3142
GCF	0.08913	0.0159	5.6056	0.08778	0.0466	1.8836
UR	0.16608	0.0226	7.3486	0.70858	0.0168	42.1773
C	-17.975	0.24013	-74.8552	-14.01	0.24013	-58.3433
R2	0.8906			0.9095		
Adj R^2	0.9272			0.9237		

5. Conclusion

The study's findings reveal a correlation between urbanization (UR), gross capital formation (GCF), trade openness (TO), and renewable energy consumption (REC). Understanding the potential impact of these variables on the adoption and utilization of renewable energy sources is crucial for developing effective policy interventions. Urbanization, characterized by population concentration and growth in urban areas, plays a vital role in driving economic expansion and increasing energy demands. However, due to existing infrastructure and ingrained consumption patterns, this process often leads to a greater reliance on conventional energy sources. Rapid urbanization may exacerbate challenges due to changes in land use and environmental degradation, potentially hindering the adoption of renewable energy technologies. A negative correlation between urbanization and REC suggests challenges in transitioning urban energy systems to renewable sources. Investment in physical assets within an economy is known as gross capital formation and is typically associated with economic growth. However, the negative coefficient of GCF suggests a possible preference for traditional energy infrastructure or non-renewable projects rather than investing in renewable energy initiatives. One potential reason could be the impact of existing investment incentives favoring traditional energy sources, concerns regarding the uncertainties associated with renewable energy projects, or the limited access to funding for clean energy endeavors. Hence, despite capital formation, focusing on non-renewable investments contributes to the observed negative correlation with REC. Trade openness, reflecting the degree of economic integration with global trade markets, facilitates the exchange of goods, services, and technologies. Nevertheless, the negative coefficient of TO indicates that greater trade openness might not lead to a higher uptake of renewable energy. The rise in competition from affordable, conventional energy sources in international markets could decrease the demand for renewable energy options.

Furthermore, trade agreements and policies may not consistently prioritize sustainability or renewable energy development, hindering the connection between trade openness and REC. Overall, the negative coefficients of UR, GCF, and TO underscore the challenges of promoting renewable energy consumption in the context of urbanization, capital formation, and trade openness. To effectively address these challenges, it is essential to implement targeted policy interventions that address institutional, financial, and structural barriers. Implementing these interventions will facilitate the transition to a more sustainable and renewable energy-focused economy.

The study findings provide valuable insights into the intricate relationships among various factors and their impact on renewable energy consumption (REC). Based on the discussion, we can extract several policy implications to address challenges and leverage opportunities for enhancing the adoption of renewable energy:

First, foreign direct investment in renewable energy projects should be encouraged through specific incentives and strategic promotional campaigns. An effective strategy is to offer tax incentives, financial assistance, or specific regulatory provisions for global investors participating in renewable energy initiatives. Ensure that regulatory frameworks and policies are aligned to support the growth of renewable energy and attract foreign direct investment in clean energy industries. It is advisable to streamline permitting processes, provide guarantees for investments in renewable energy, and establish clear renewable energy objectives.

Second, enhance the exchange of technology and knowledge sharing among global investors and local stakeholders to enhance the uptake and integration of renewable energy technologies. Developing collaborative research and development projects and fostering partnerships between international investors and local clean energy companies is a key strategy.

Third, Incentivizing Clean Energy Investments: Suggest implementing financial incentives and investment subsidies to encourage greater capital allocation towards renewable energy projects. Consider implementing low-interest loans, grants, or tax credits to incentivize investments in clean energy infrastructure as a potential solution.

Fourth, financial literacy programs should be developed to educate investors and consumers on the advantages of renewable energy investments and sustainable finance practices to improve their comprehension of this field. This can help increase awareness and build trust in clean energy opportunities.

When analyzing Urbanization, Gross Capital Formation, and Trade Openness Policy Implications, it is essential to emphasize Integrated Urban Planning. Implementing strategies prioritizing sustainable development and integrating renewable energy within urban areas is essential. Factors to consider include zoning regulations, incentives for green building construction, and investment in renewable energy infrastructure. Promoting Investments in Renewable Energy: Advocate for heightened investment in renewable energy projects by aligning capital formation policies with renewable energy goals. One effective approach involves offering investment incentives, reducing barriers to entry for renewable energy projects, and promoting collaborations between the public and private sectors.

References

[1] Zhang Y, Zheng K, Xia F, Cheng Z. Fintech, natural resource rents, renewable energy consumption and environmental quality: A perspective of green economic recovery from BRICS economies. Resources Policy. 2024; 89:104604.

[2] Qamruzzaman M. Nexus between foreign direct investment, gross capital formation, financial development and renewable energy consumption: evidence from panel data estimation. GSC Advanced Research and Reviews. 2024;18(1):182-200.

[3] Osei MJ, Kim J. Financial development and the growth effect of foreign direct investment: Does one size fit all? International Economics. 2023; 173:276-83.

[4] Adebayo TS, Kartal MT, Ağa M, Al-Faryan MAS. Role of country risks and renewable energy consumption on environmental quality: Evidence from MINT countries. Journal of Environmental Management. 2023; 327:116884.

[5] Islam Y, Mindia PM, Farzana N, Qamruzzaman M. Nexus between environmental sustainability, good governance, financial inclusion, and tourism development in Bangladesh: Evidence from symmetric and asymmetric investigation. Frontiers in Environmental Science. 2023;10.

[6] Farzana N, Qamruzzaman M, Islam Y, Mindia PM. 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. 2023;13(6):270-87.

[7] Zhuo J, Qamruzzaman M. Do financial development, FDI, and globalization intensify environmental degradation through the channel of energy consumption: evidence from belt and road countries. Environmental Science and Pollution Research. 2022;29(2):2753-72.

[8] Zhao L, Qamruzzaman M. Do Urbanization, Remittances, and Globalization Matter for Energy Consumption in Belt and Road Countries: Evidence From Renewable and Non-Renewable Energy Consumption. Frontiers in Environmental Science. 2022;10.

[9] Xiao Z, Qamruzzaman M. Nexus between Green investment and technological innovation in BRI nations: what is the role of Environmental Sustainably and Domestic Investment? Frontiers in Environmental Science. 2022:1472.

[10] Xiao Z, Qamruzzaman M. Nexus between green investment and technological innovation in BRI nations: What is the role of environmental sustainability and domestic investment? Frontiers in Environmental Science. 2022;10.

[11] Xia C, Qamruzzaman M, Adow AH. An Asymmetric Nexus: Remittance-Led Human Capital Development in the Top 10 Remittance-Receiving Countries: Are FDI and Gross Capital Formation Critical for a Road to Sustainability? Sustainability. 2022;14(6):3703.

[12] Weixiang S, Qamruzzaman M, Rui W, Kler R. An empirical assessment of Financial Literacy and Behavioural Biases on Investment Decision: Fresh Evidence from Small Investor Perception. Frontiers in psychology. 2022:5746.

[13] Shi Z, Qamruzzaman M. Re-visiting the role of education on poverty through the channel of financial inclusion: evidence from Lower-income and Lower Middle-income country. Frontiers in Environmental Science. 2022;10:592.

[14] Shahzadi I, Yaseen MR, Khan MTI, Makhdum MSA, Ali Q. The nexus between research and development, renewable energy and environmental quality: Evidence from developed and developing countries. Renewable Energy. 2022;190:1089-99.

[15] SERFRAZ A, MUNIR Z, MEHTA AM, Qamruzzaman M. Nepotism effects on job satisfaction and withdrawal behavior: An empirical analysis of social, ethical and economic factors from Pakistan. The Journal of Asian Finance, Economics and Business. 2022;9(3):311-8.

[16] Lee P-C, Huang C-Y, Huang M-H, Hsu M-J. The Behavioral Intention of Hospitals to Promote Sustainable Development of Green Healthcare from the Perspective of Organizational Stakeholders during the COVID-19 Epidemic: A Case Study of Hospitals in Taiwan. Sustainability. 2023;15(5):4521.

[17] Azam M, Uddin I, Khan S, Tariq M. Are globalization, urbanization, and energy consumption cause carbon emissions in SAARC region? New evidence from CS-ARDL approach. Environmental Science and Pollution Research. 2022;29(58):87746-63.

[18] Menon D, Gunasekar S, Dixit SK, Das P, Mandal S. Present and prospective research themes for tourism and hospitality education post-COVID19: A bibliometric analysis. Journal of Hospitality, Leisure, Sport & Tourism Education. 2022;30:100360.

[19] Qamruzzaman M. Do environmental and institutional quality attribute to inflows of FDI in Lower-Middle income Nations? Evidences from asymmetric investigation. GSC Advanced Research and Reviews. 2023;15(3):079-104.

[20] Qamruzzaman M. Nexus between environmental qualities, institutional quality and FDI inflows in Lower-income Countries. World Journal of Advanced Research and Reviews. 2023;18(3):321-45.

[21] Qamruzzaman M. Nexus between financial developments, renewable energy consumption and environmental sustainability in Bangladesh: Evidence from ARDL and NARDL. World Journal of Advanced Research and Reviews. 2023;18(1):1097-113.

[22] Qamruzzaman M. 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. 2023;18(6):e0287475.

[23] Li Q, Qamruzzaman M. Innovation-Led Environmental Sustainability in Vietnam—Towards a Green Future. Sustainability. 2023;15(16):12109.

[24] Karim S, Qamruzzaman M, Jahan I. Nexus between Government Debt, Globalization, FDI, Renewable Energy, and Institutional Quality in Bangladesh. International Journal of Energy Economics and Policy. 2023;13(3):443-56.

[25] Ju S, Qamruzzaman M, Kor S, Andriamahery A. Effects of Financial development, FDI and Good governance on Environmental Degradation in the Arab Nation: Dose Technological Innovation matters. Frontiers in Environmental Science. 2023;11:224.

[26] JinRu L, Qamruzzaman M, Hangyu W, Kler R. Corrigendum: 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. 2023.

[27] Mukhtarov S, Aliyev S, Mikayilov JI, Ismayilov A, Rzayev A. The FDI-CO2 nexus from the sustainable development perspective: the case of Azerbaijan. International Journal of Sustainable Development & World Ecology. 2021;28(3):246-54.

[28] Md Q. Nexus between environmental innovation, energy efficiency and environmental sustainability in the lower-income economy. GSC Advanced Research and Reviews. 2022;12(1):068-83.

[29] Ma R, Qamruzzaman M. Nexus between Government Debt, Economic Policy Uncertainty, Government Spending and Governmental Effectiveness in BRIC: Evidence for Linear and Nonlinear Assessment. Frontiers in Environmental Science. 2022:1151.

[30] Ma C, Qamruzzaman M. An Asymmetric Nexus between Urbanization and Technological Innovation and Environmental Sustainability in Ethiopia and Egypt: What Is the Role of Renewable Energy? Sustainability. 2022;14(13):7639.

[31] Liang Z, Qamruzzaman M. An Asymmetric Investigation of the Nexus Between Economic Policy Uncertainty, Knowledge Spillover, Climate Change, and Green Economy: Evidence From BRIC Nations. Frontiers in Environmental Science. 2022;9.

[32] Li J, Qamruzzaman M. Does Tourism Induce Sustainable Human Capital Development in BRICS Through the Channel of Capital Formation and Financial Development? Evidence From Augmented ARDL With Structural Break and Fourier-TY Causality. Frontiers in psychology. 2022;13:804349.

[33] Li J, Qamruzzaman M. Does Tourism Induce Sustainable Human Capital Development in BRICS Through the Channel of Capital Formation and Financial Development? Evidence From Augmented ARDL With Structural Break and Fourier-TY Causality. Frontiers in psychology [Internet]. 2022 2022; 13:[804349 p.]. Available from: http://europepmc.org/abstract/MED/35465525 https://europepmc.org/articles/PMC9019712 https://europepmc.org/articles/PMC9019712?pdf=render.

[34] Li J, Qamruzzaman M. Dose tourism induce Sustainable Human capital development in BRICS through the channel of capital formation and financial development: Evidence from Augmented ARDL with structural Break and Fourier TY causality. Frontiers in psychology. 2022:1260.

[35] Karim S, Qamruzzaman M, Jahan I. INFORMATION TECHNOLOGY ADAPTATION, VOLUNTARY DISCLOSURE, OPEN INNOVATION AND SUSTAINABLE PERFORMANCE: EVIDENCE FROM BANK-BASED FINANCIAL INSTITUTIONS IN BANGLADESH. Academy of Accounting and Financial Studies Journal. 2022;26(S6):1-14.

[36] Karim S, Qamruzzaman M, Jahan I. Nexus between Information Technology, Voluntary Disclosure, and Sustainable Performance: What is the role of Open Innovation? Journal of Business Research. 2022;145:1-15.

[37] Jinru L, Qamruzzaman M, Hangyu W, Kler R. Do Environmental Quality, Financial Inclusion and Good Governance ensure the FDI sustainably in Belt & Road Countries: Evidence from an application of CS-ARDL and NARDL? Frontiers in Environmental Science. 2022:2455.

[38] Guan C, Qamruzzaman M. A symmetric and asymmetric Nexus between environmental sustainability and Tourism Development in BRIC nations: what is the role of Good governance and Globalization? Frontiers in Environmental Science. 2022:1663.

[39] Dai M, Qamruzzaman M, Hamadelneel Adow A. An Assessment of the Impact of Natural Resource Price and Global Economic Policy Uncertainty on Financial Asset Performance: Evidence From Bitcoin. Frontiers in Environmental Science. 2022;10.

[40] Yang W-J, Tan M-Z, Chu S-H, Chen Z. Carbon emission and financial development under the "double carbon" goal: Considering the upgrade of industrial structure. Frontiers in Environmental Science. 2023;10.

[41] Woon KS, Phuang ZX, Taler J, Varbanov PS, Chong CT, Klemeš JJ, et al. Recent advances in urban green energy development towards carbon emissions neutrality. Energy. 2023;267:126502.

[42] Teng X, Zhuang W, Liu F-p, Chang T-h, Chiu Y-h. China's path of carbon neutralization to develop green energy and improve energy efficiency. Renewable Energy. 2023;206:397-408.

[43] Brunnermeier MK. Deciphering the liquidity and credit crunch 2007–2008. The Journal of economic perspectives. 2009;23(1):77-100.

[44] Fernández-Rodríguez E, García-Fernández R, Martínez-Arias A. Business and institutional determinants of Effective Tax Rate in emerging economies. Economic Modelling. 2021;94:692-702.

[45] Rodriguez E, Edwards JS. Knowledge Management in Support of enterprise risk Management. International Journal of Knowledge Management,. 2014;10(2):43-61.

[46] Qamruzzaman M. Does economic policy uncertainty influences personal remittances: Evidences from AARDL and NARDL. World Journal of Advanced Research and Reviews. 2023;18(1):014-34.

[47] Qamruzzaman M. Nexus between financial development and carbon emission in Bangladesh: Evidence from ARDL and NARDL. GSC Advanced Research and Reviews. 2023;14(3):300-12.

[48] Lin J, Qamruzzaman M. 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. 2023.

[49] Li Z, Qamruzzaman M. Nexus between Environmental Degradation, Clean Energy, Financial Inclusion, and Poverty: Evidence with DSUR, CUP-FM, and CUP-BC Estimation. Sustainability. 2023;15(19):14161.

[50] Kor S, Qamruzzaman M. Nexus between FDI, Financial Development, Capital Formation and Renewable Energy Consumption; evidence from Bangladesh. International Journal of Energy Economics and Policy. 2023;13(6):129-45.

[51] Mohr DC, Young GJ, Burgess J, James F. Employee turnover and operational performance: The moderating effect of group-oriented organisational culture. Human Resource Management Journal. 2012;22(2):216-33.

[52] Ramakrishnan A, Kalkuhl M, Ahmad S, Creutzig F. Keeping up with the Patels: Conspicuous consumption drives the adoption of cars and appliances in India. Energy Research & Social Science. 2020;70:101742.

[53] Qamruzzaman M, Karim S, Kor S. 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. 2023;30(18):52872-94.

[54] Qamruzzaman M, Karim S. Does public-private investment augment renewable energy consumption in BIMSTEC nations? Evidence from symmetric and asymmetric assessment. Energy Strategy Reviews. 2023;49:101169.

[55] Qamruzzaman M, Karim S. Clarifying the relationship between green investment, technological innovation, financial openness, and renewable energy consumption in MINT. Heliyon. 2023;9(11):e21083.

[56] Qamruzzaman M. Does Environmental Degradation-Led Remittances Flow? Nexus between Environmental Degradation, Uncertainty, Financial Inclusion and Remittances Inflows in India and China. International Journal of Energy Economics and Policy. 2023;13(2):9.

[57] Qamruzzaman M. Clean energy-led tourism development in Malaysia: Do environmental degradation, FDI, Education and ICT matter? Heliyon. 2023;9(11).

[58] Qamruzzaman M. An asymmetric nexus between clean energy, good governance, education and inward FDI in China: Do environment and technology matter? Evidence for chines provincial data. Heliyon. 2023;9(5):e15612.

[59] Qamruzzaman M. Empowering Malaysian tourism with clean energy, sustainable environment, and inward FDI: evidence from symmetric and asymmetric assessment. Environmental Science and Pollution Research. 2023.

[60] Tan Y, Qamruzzaman M, Karim S. An investigation of financial openness, trade openness, gross capital formation, urbanization, financial development, education and energy nexus in BRI: Evidence from the symmetric and asymmetric framework. PLOS ONE. 2023;18(12):e0290121.

[61] Su S, Qamruzzaman M, Karim S. Charting a Sustainable Future: The Impact of Economic Policy, Environmental Taxation, Innovation, and Natural Resources on Clean Energy Consumption. Sustainability. 2023;15(18):13585.

[62] Serfraz A, Qamruzzaman M, Karim S. 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. 2023;13(4):91-101.

[63] Qamruzzaman M, Kler R. 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. 2023;13(3):313-24.

[64] Narayanamoorthy A. Poverty-Reducing Role of Groundwater Irrigation in India: Evidence from a Cross-Sectional Analysis. In: Narayanamoorthy A, editor. The Irrigation Future of India: Development, Resource and Policy. Cham: Springer International Publishing; 2022. p. 115-37.

[65] Shamim A, Azeem P, Naqvi SMMA. Impact of foreign direct investment on poverty reduction in Pakistan. International Journal of Academic Research in Business and Social Sciences. 2014;4(10):465.

[66] Paul BP, Das A. The Remittance-GDP Relationship in the Liberalized Regime of Bangladesh: Cointegration and Innovation Accounting. Theoretical & Applied Economics. 2011;18(9).

[67] Doğan B, Chu LK, Ghosh S, Truong HHD, Balsalobre-Lorente D. How environmental taxes and carbon emissions are related in the G7 economies? Renewable Energy. 2022;187:645-56.

[68] Ghosh A. How does banking sector globalization affect economic growth? International Review of Economics & Finance. 2017;48:83-97.

[69] Ghosh S. Does mobile telephony spur growth? Evidence from Indian states. J Telecommunications Policy. 2016;40(10-11):1020-31.

[70] Nichols E, Szoeke CEI, Vollset SE, Abbasi N, Abd-Allah F, Abdela J, et al. Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet Neurology. 2019;18(1):88-106.

[71] Yin C, Qamruzzaman M. Empowering renewable energy consumption through public-private investment, urbanization, and globalization: Evidence from CS-ARDL and NARDL. Heliyon. 2024:e26455.

[72] Yan H, Qamruzzaman M, Kor S. 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. 2023;15(18):13591.

[73] Yan H, Qamruzzaman M, Kor S. 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. 2023;15(18):13591.

[74] Wang Y, Qamruzzaman M, Serfraz A, Theivanayaki M. 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. 2023;15(10):8026.

[75] Bersvendsen T, Ditzen J. Testing for slope heterogeneity in Stata. The Stata Journal. 2021;21(1):51-80.

[76] Breusch TS, Pagan AR. The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics. The Review of Economic Studies. 1980;47(1):239-53.

[77] Pesaran MH, Ullah A, Yamagata T. A bias-adjusted LM test of error cross-section independence. The Econometrics Journal. 2008;11(1):105-27.

[78] Pesaran MH. Estimation and inference in large heterogeneous panels with a multifactor error structure. Econometrica. 2006;74.

[79] Pesaran MH. General diagnostic tests for cross section dependence in panels (IZA Discussion Paper No. 1240). Institute for the Study of Labor (IZA). 2004.

[80] Juodis A, Reese S. The Incidental Parameters Problem in Testing for Remaining Cross-Section Correlation. Journal of Business & Economic Statistics. 2022;40(3):1191-203.

[81] Pesaran MH. A Simple Panel Unit Root Test in the Presence of Cross-Section Dependence. Journal of Applied Econometrics. 2007;22(2):265-312.

[82] Rong G, Qamruzzaman M. Symmetric and asymmetric nexus between economic policy uncertainty, oil price, and renewable energy consumption in the United States, China, India, Japan, and South Korea: Does technological innovation influence? FRONTIERS IN ENERGY RESEARCH. 2022;10.

[83] Qamruzzaman M, Mehta AM, Naqvi FN. Nexus between Uncertainty, Remittances, and Households Consumption: Evidence from Dynamic SUR application. Frontiers in Environmental Science. 2022:1546.

[84] Qamruzzaman M, Kler R. Do financial inclusion and financial efficiency play deterministic role for FDI in Road and Belt countries. Journal of Multinational Financial Management. 2022;63(100716).

[85] Qamruzzaman M, Kler R. An assessment of Financial inclusion impacts on povety Alliviation in Built and Road Initiatives: what is the role of eduction to sustainability? Social Psychology of Education Journal. 2022;25(1).

[86] Qamruzzaman M, Karim S, Jahan I. 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. 2022;195:121-36.

[87] Balsalobre-Lorente D, Abbas J, He C, Pilař L, Shah SAR. Tourism, urbanization and natural resources rents matter for environmental sustainability: The leading role of AI and ICT on sustainable development goals in the digital era. Resources Policy. 2023;82:103445.

[88] Naqvi SAA, Hussain M, Hussain B, Shah SAR, Nazir J, Usman M. Environmental sustainability and biomass energy consumption through the lens of pollution Haven hypothesis and renewable energy-environmental kuznets curve. Renewable Energy. 2023;212:621-31.

[89] Syed QR, Bhowmik R, Adedoyin FF, Alola AA, Khalid N. Do economic policy uncertainty and geopolitical risk surge CO2 emissions? New insights from panel quantile regression approach. Environmental Science and Pollution Research. 2022;29(19):27845-61.

[90] Apergis N, Pinar M, Unlu E. How do foreign direct investment flows affect carbon emissions in BRICS countries? Revisiting the pollution haven hypothesis using bilateral FDI flows from OECD to BRICS countries. Environmental Science and Pollution Research. 2023;30(6):14680-92.

[91] Paramati SR, Ummalla M, Apergis N. The effect of foreign direct investment and stock market growth on clean energy use across a panel of emerging market economies. Energy Economics. 2016;56:29-41.

[92] Qamruzzaman M. Nexus between foreign direct investments renewable energy consumption: What is the role of Government debt? International Journal of Multidisciplinary Research and Growth Evaluation. 2022;3(3):514-22.

[93] Qamruzzaman M. Nexus between environmental innovation, energy efficiency and environmental sustainability in Southeast Asian economy. International Journal of Multidisciplinary Research and Growth Evaluation. 2022;3(4):181-93.

[94] ANDRIAMAHERY A, Danarson JH, Qamruzzaman M. Nexus between Trade and Environmental Quality in Sub-Saharan Africa: Evidence from Panel GMM. Frontiers in Environmental Science. 2022:1569.

[95] Quan Z, Xu X, Wang W, Jiang J, Gao S. Do industrial solid waste recycling and technological innovation promote low-carbon development in China? New insights from NARDL approach. Science of The Total Environment. 2024;916:170446.

[96] Wang F, Wu M. How does trade policy uncertainty affect China's economy and energy? Journal of Environmental Management. 2023;330:117198.

[97] Wang R, Usman M, Radulescu M, Cifuentes-Faura J, Balsalobre-Lorente D. Achieving ecological sustainability through technological innovations, financial development, foreign direct investment, and energy consumption in developing European countries. Gondwana Research. 2023;119:138-52.

[98] Wang Z, Zaman S, Zaman Qu, Rasool SF. Impact of remittances on carbon emission: fresh evidence from a panel of five remittance-receiving countries. Environmental Science and Pollution Research. 2021;28(37):52418-30.

[99] Raza SA, Shah SH, Yousufi SQ. The impact of public-private partnerships Investment in Energy on carbon emissions: evidence from nonparametric causality-in-quantiles. Environmental Science and Pollution Research. 2021;28(18):23182-92.

[100] Qamruzzaman M, Karim S, Jahan I. COVID-19, Remittance Inflows, and the Stock Market: Empirical Evidence from Bangladesh. The Journal of Asian Finance, Economics and Business. 2021;8(5):265-75.

[101] Qamruzzaman M. 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. 2021;66(4):1-27.

[102] Qamruzzaman M. Nexus between environmental quality, institutional quality and trade openness through the channel of FDI: an application of common correlated effects estimation (CCEE), NARDL, and asymmetry causality. Environmental Science and Pollution Research. 2021;28(37):52475-98.

[103] Miao M, Qamruzzaman M. Dose Remittances Matter for Openness and Financial Stability: Evidence From Least Developed Economies. Frontiers in psychology. 2021;12:696600.

[104] Meng L, Qamruzzaman M, Adow AHE. Technological Adaption and Open Innovation in SMEs: An Strategic Assessment for Women-Owned SMEs Sustainability in Bangladesh. Sustainability. 2021;13(5):2942.

[105] MEHTA AM, QAMRUZZAMAN M, SERFRAZ A, ALI A. The role of remittances in financial development: Evidence from nonlinear ARDL and asymmetric causality. The Journal of Asian Finance, Economics and Business. 2021;8(3):139-54.

[106] Md. Qamruzzaman, Ishrat J, Salma K. The Impact of Voluntary Disclosure on Firm's Value: Evidence from Manufacturing Firms in Bangladesh. The Journal of Asian Finance, Economics and Business. 2021;8(6):671-85.

[107] Md Qamruzzaman SN, Ananda Bardhan. Nexus between Remittance, Financial Volatility, Trade Openness, Money Supply, and Non-Performing Loan: An Application of Autoregressive Distributed Lagged (ARDL) Model. Journal of Banking and Finance Management. 2021;3(2):34-54.

[108] Lingyan M, Qamruzzaman M, Adow AHE. Technological Adaption and Open Innovation in SMEs: An Strategic Assessment for Women-Owned SMEs Sustainability in Bangladesh. Sustainability. 2021;13(5):2942.

[109] Jia Z, Mehta AM, Qamruzzaman M, Ali M. Economic Policy uncertainty and financial innovation: Is there any affiliation? Frontiers in psychology. 2021;12:1781.

[110] Ganlin P, Qamruzzaman M, Mehta AM, Naqvi FN, Karim S. Innovative Finance, Technological Adaptation and SMEs Sustainability: The Mediating Role of Government Support during COVID-19 Pandemic. Sustainability. 2021;13(16):1-27.

[111] Fang L, Qamruzzaman M. An Asymmetric Investigation of Remittance and Trade Openness Impact on Inequality: Evidence From Selected South Asian Countries. Frontiers in psychology. 2021;12.

[112] Qamruzzaman M, Karim S. Nexus between Economic Volatility, Trade Openness and FDI: An Application of ARDL, NARDL and Asymmetric Causality. Asian Economic and Financial Review. 2020;10(7):790-807.

[113] Qamruzzaman M, Jianguo W, Jahan S, Yingjun Z. Financial innovation, human capital development, and economic growth of selected South Asian countries: An application of ARDL approach. International Journal of Finance & Economics. 2020.

[114] QAMRUZZAMAN M, JIANGUO W. NEXUS BETWEEN REMITTANCE AND HOUSEHOLD CONSUMPTION: FRESH EVIDENCE FROM SYMMETRIC OR ASYMMETRIC INVESTIGATION. JOURNAL OF ECONOMIC DEVELOPMENT. 2020;45(3):1-27.

[115] Qamruzzaman M, Jianguo W. The asymmetric relationship between financial development, trade openness, foreign capital flows, and renewable energy consumption: Fresh evidence from panel NARDL investigation. Renewable Energy. 2020;159:827-42.

[116] Qamruzzaman M, Wei J. Do financial inclusion, stock market development attract foreign capital flows in developing economy: a panel data investigation. Quantitative Finance and Economics. 2019;3(1):88-108.

[117] Qamruzzaman M, Wei J. Financial Innovation and Financial Inclusion Nexus in South Asian Countries: Evidence from Symmetric and Asymmetric Panel Investigation. International Journal of Financial Studies. 2019;7(4):61.

[118] Qamruzzaman M, Jianguo W. SME financing innovation and SME development in Bangladesh: an application of ARDL. Journal of Small Business & Entrepreneurship. 2019;31(6):521-45.

[119] Qamruzzaman M, Jianguo W. Investigation of the asymmetric relationship between financial innovation, banking sector development, and economic growth. Quantitative Finance and Economics. 2018;2(4):952–80.

[120] Qamruzzaman M, Jianguo W. Nexus between financial innovation and economic growth in South Asia: evidence rom ARDL and nonlinear ARDL approaches. Financial Innovation. 2018;4(1):20.

[121] Qamruzzaman M, Jianguo W. Financial innovation and economic growth in Bangladesh. Financial Innovation. 2017;3(1):19.

[122] Chekouri SM, Chibi A, Benbouziane M. The impact of natural resource abundance on ecological footprint: evidence from Algeria. Environ Sci Pollut Res Int. 2023;30(26):69289-306.

[123] Ergun SJ, Rivas MF. Does higher income lead to more renewable energy consumption? Evidence from emerging-Asian countries. Heliyon. 2023;9(1):e13049.

[124] Gyimah J, Yao X, Tachega MA, Sam Hayford I, Opoku-Mensah E. Renewable energy consumption and economic growth: New evidence from Ghana. Energy. 2022;248:123559.

[125] Mujtaba A, Jena PK, Bekun FV, Sahu PK. Symmetric and asymmetric impact of economic growth, capital formation, renewable and non-renewable energy consumption on environment in OECD countries. Renewable and Sustainable Energy Reviews. 2022;160:112300.

[126] Ghosh S. Effects of tourism on carbon dioxide emissions, a panel causality analysis with new data sets. Environment, Development and Sustainability. 2022;24(3):3884-906.

[127] Wahab S, Imran M, Ahmed B, Rahim S, Hassan T. Navigating environmental concerns: Unveiling the role of economic growth, trade, resources and institutional quality on greenhouse gas emissions in OECD countries. Journal of Cleaner Production. 2024;434:139851.

[128] Goswami A, Kapoor HS, Jangir RK, Ngigi CN, Nowrouzi-Kia B, Chattu VK. Impact of Economic Growth, Trade Openness, Urbanization and Energy Consumption on Carbon Emissions: A Study of India. Sustainability. 2023;15(11):9025.

[129] Shabir M, Hussain I, Işık Ö, Razzaq K, Mehroush I. The role of innovation in environmental-related technologies and institutional quality to drive environmental sustainability. Frontiers in Environmental Science. 2023;11.

[130] Balsalobre-Lorente D, Topaloglu EE, Nur T, Evcimen C. Exploring the linkage between financial development and ecological footprint in APEC countries: A novel view under corruption perception and environmental policy stringency. Journal of Cleaner Production. 2023;414:137686.

[131] Qadri SU, Shi X, Rahman Su, Anees A, Ali MSE, Brancu L, et al. Green finance and foreign direct investment–environmental sustainability nexuses in emerging countries: new insights from the environmental Kuznets curve. Frontiers in Environmental Science. 2023;11.

[132] Xu J, Moslehpour M, Tran TK, Dinh KC, Ngo TQ, Huy PQ. The role of institutional quality, renewable energy development and trade openness in green finance: Empirical evidence from South Asian countries. Renewable Energy. 2023;207:687-92.

[133] Azimi MN, Rahman MM, Nghiem S. Linking governance with environmental quality: a global perspective. Scientific Reports. 2023;13(1):15086.

[134] Ali N, Phoungthong K, Khan A, Abbas S, Dilanchiev A, Tariq S, et al. Does FDI foster technological innovations? Empirical evidence from BRICS economies. PLoS One. 2023;18(3):e0282498.