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FINANCIAL INCLUSION, DIGITAL TRANSFORMATION AND ENERGY CONSUMPTION DYNAMICS: EVIDENCE FROM OIC ECONOMIES

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ABSTRACT

This study examines the impact of digitalization and financial inclusion on energy consumption across 40 OIC member countries from 2001 to 2022. The research used several advanced panel econometric techniques, including cross-sectional dependence and slope heterogeneity tests, CIPS, IPS, and LLC unit root tests, Pedroni, Kao, and Westerlund cointegration tests, FMOLS and DOLS long-run estimators and the Method of Moments Quantile Regression (MMQR) approach. The findings indicate that digitalization and financial inclusion significantly reduce energy consumption in overall OIC countries and particularly in higher-income OIC countries by improving energy efficiency, facilitating technological innovation, and promoting the adoption of energy-efficient technologies. However, in lower-income OIC countries, digitalization and financial inclusion increase energy consumption due to increasing industrial activity, growing access to energy-dependent technologies, and rising economic participation. Furthermore, industrialization and population are found to increase energy consumption across all country groups. The interaction effect between Digitalization and financial inclusion indicates that their combined role contributes to energy sustainability, especially in higher-income OIC countries. The study highlights important policy implications for sustainable energy management in OIC economies. Policymakers should promote digital infrastructure, expand inclusive financial systems, and encourage green financing mechanisms to accelerate the adoption of energy-efficient technologies while ensuring sustainable energy transition pathways, particularly in lower-income OIC countries.

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Introduction

Global energy demand has continued to rise steadily over recent decades, placing increasing pressure on energy systems around the world. Recent evidence from the IEA Global Energy Review 2025 shows that global energy demand grew strongly during 2024, increasing by nearly 2.2 percent compared to the average annual growth recorded over the previous decade. Much of this growth was driven by expanding electricity consumption, particularly in emerging and developing economies where industrialization, urban expansion, and technological adoption are accelerating rapidly. Although renewable energy sources and nuclear power contributed significantly to electricity generation growth, fossil fuels still accounted for a substantial share of total energy use. Consumption of natural gas, oil, and coal also continued to increase, reflecting the persistent dependence of many economies on conventional energy sources (Yuan & Zhao, 2025).

OIC countries are currently experiencing rapid economic growth, urban expansion, and increasing demand for energy. At the same time, many of these economies are undergoing important digital and financial transformations. Improvements in digital infrastructure and financial access have created new opportunities for economic participation, technological innovation, and industrial development. However, several developing OIC countries still face limitations related to technological capacity, energy efficiency, and access to modern infrastructure. These challenges continue to restrict the widespread adoption of energy-efficient technologies and sustainable production systems. As a result, understanding how digitalization and financial inclusion influence energy consumption has become increasingly important for policymakers seeking to achieve sustainable economic growth and long-term energy stability (Basnayake et al., 2024; World Bank, 2024).

Despite these developments, energy consumption in many OIC countries remains dependent on conventional energy sources, while rising populations and rapid urbanization continue to exert pressure on energy infrastructure. Although financial inclusion is widely recognized for its role in poverty reduction and economic participation, its influence on energy consumption either by increasing credit driven energy demand or by supporting efficiency enhancing investments remains uncertain (Barik, R. & Kayal, P. 2025). Financial inclusion plays a critical role in reducing energy consumption by enabling investments in energy efficient technologies, renewable energy systems, and sustainable production practices. Improved access to financial services allows firms and households to overcome capital constraints and adopt clean technologies, thereby enhancing energy efficiency and lowering energy demand (Li & Wu, 2023; Agrawal et al., 2023). Moreover, Financial Inclusion amplifies policy effectiveness by facilitating widespread adoption of energy saving technologies, fostering a more sustainable and energy efficient economic system (Pata & Fareed, 2023; Sun & Long 2024).

Digitalization further complicates this relationship, as Digital tools can simultaneously reduce energy losses and trigger higher electricity consumption through expanded ICT use. Existing research seldom examines these dynamics within Muslim-majority developing economies, even though OIC countries differ substantially in economic structure, institutional capacity, and

technological readiness (Basnayake et al. 2024). Unlike carbon emissions, energy consumption directly reflects industrial production, technological utilization, and economic activities within an economy. Examining energy consumption therefore provides broader insights into the sustainability implications of Digitalization and financial inclusion, particularly in developing economies where conventional energy sources still dominate the energy mix. Previous studies predominantly focus on financial inclusion's link with carbon emissions, renewable energy expansion, or energy efficiency, leaving a clear research gap concerning its direct impact on total energy consumption especially when combined with Digitalization. To address this gap, this study contributes to the existing literature in several ways. First, it examines the direct impact of Digitalization and financial inclusion on energy consumption in OIC countries. Second, the study introduces the interaction effect between Digitalization and financial inclusion to evaluate their combined influence on energy sustainability. Third, the study provides a comparative analysis between lower-income and higher-income OIC economies to capture income-level heterogeneity. Fourth, the study applies advanced panel econometric techniques, including FMOLS, DOLS, and Method of Moments Quantile Regression (MMQR), to capture long-run and distributional heterogeneous effects across countries.

Literature Review

Financial Inclusion and Energy Consumption

Existing literature reports mixed evidence regarding the relationship between financial inclusion and energy consumption. Some studies argue that financial inclusion increases energy demand by expanding industrial production, household consumption, and access to electricity-dependent technologies (Tsaurai, 2021; Ma & Fu, 2020; Aslan et al., 2021). In contrast, other studies suggest that financial inclusion reduces energy consumption by facilitating investments in energy-efficient technologies and renewable energy systems (Elzaki, 2023; Yu & Tang, 2023; Zhong et al., 2024). These mixed findings indicate that the impact of financial inclusion may vary depending on economic development and technological capacity across countries.A growing body of literature underscores the transformative role of Digitalization and financial inclusion in reshaping energy consumption dynamics through technological efficiency, behavioral transitions, and institutional expansion. Studies demonstrate that financial inclusion operates as a critical enabler of sustainable energy adoption by mobilizing capital toward cleaner technologies, green infrastructure, and circular-economy practices, thereby reducing reliance on mineral and carbon-intensive energy systems.

Different studies analyzed the association between Financial Inclusion and Energy Consumption such as Elzaki (2023) explored the influence of Saudi Arabia's Financial Development indicators on the utilization of renewable energy. The finding showed that the financial development indicators significantly benefited renewable energy consumption (REC). The findings observing the causal association between REC and financial development measures were ambiguous. Furthermore, Usman et al., (2023) investigated the impacts of financial development and economic growth on energy consumption in developing Asian countries from 1991 to 2019 while controlling

for factors like urbanization and globalization. The data investigation showed that there was a positive effect of Energy Consumption on Energy Generation as well as the Financial Development of an economy. On the same note, Prempeh et al., (2024) investigated the effects of Financial Development on the usage of Renewable Energy in Ghana while accounting for energy pricing and EG. The outcomes showed that energy prices and EG harm renewable energy, although the use of renewable energy in Ghana was driven by financial development. Majeed & Hussain (2022) investigated the relation amongst Financial Development and Renewable Energy Consumption while considering FDs nonlinear effects. Ullah et al., (2020) explored the nexus between EC, FD, FDI, globalization, and urbanization. It was found that both urbanization and FD have a significant positive relationship with EC, indicating an energy-expanding impact from both factors. Globalization was statistically significant on energy demand, but negatively impacted it instead of positively, showing the need to be more globally interconnected for the betterment of BRI countries. Similarly, there was a weak positive correlation between EC and FDI. Nguyen et al., (2022) examined the relationship between FD and EC as well as the quality of institutions using the panel data of 112 countries between 2002 and 2014. The results showed that more financial growth leads to higher energy use, higher energy use per production unit, and less use of renewable energy. Tsaurai (2021) analyzed the effect of Financial Development on Energy Consumption for middle-income economies using panel data for the period 2001-2016. The results demonstrated that FD significantly increased the EC in middle-income countries. The research found that FD and TO significantly reduced EC. Aslan et al. (2021) found that financial development increases energy consumption in emerging economies, while banking sector development reduces energy demand in advanced countries.

Ma and Fu (2020) reported that financial development significantly increases energy consumption in emerging economies due to expanding industrial and economic activities, whereas the effect remains insignificant in developed countries.

Digitalization and Energy Consumption

Previous studies indicate that Digitalization influences energy consumption through both efficiency-enhancing and energy-expanding channels. Digital technologies improve industrial efficiency, smart energy management, and resource optimization, thereby reducing energy intensity (Liu et al., 2023; Gao et al., 2022; Dzwigol et al., 2024). However, rapid ICT expansion and increasing Digital infrastructure may also increase electricity demand and overall energy consumption, particularly in developing economies (Usman et al., 2021; Thanh et al., 2022). Existing evidence further suggests that the effects of Digitalization differ across countries depending on technological readiness and economic structure.

Digital technologies influence energy consumption through multiple channels. They improve efficiency within industrial systems, enable optimized decision-making through real time information, and reduce transaction costs, all of which have the potential to lower energy intensity. Zeng et al., (2023) examined the impact of Digital economy modernizing on Energy Consumption structure utilized the data gathered from 30 Chinese provinces from 2013 to 2019. The empirical

results established that the growth of the Digital economy can influence the structure of EC and may even have a threshold effect. Furthermore, Liu et al., (2023) explored Effects from Digital technology on Energy efficiency by applying panel data of 30 Chinese provinces during the period of 2006-2021. It evaluated how Digital technology influences energy efficiency at single-factor and total-factor levels. Yu et al., (2023) investigated the connection between ICT, FD, and REC based on panel data for 35 countries covering the years 1996 to 2018. The results showed both ICT and FD positively contribute to renewable energy. Moreover, moderation was confirmed for the relationship between EG and REC. Shahbaz et al. (2022) examined panel data of 72 countries from 2003 to 2019 and aimed to determine the effect of the Digital economy on the structure of Renewable Energy Consumption and generation. Results showed that the Digital economy positively impacts ET. The Digital economy also encourages the shift to RE by strengthening governmental governance capacities. The asymmetrical checks also showed that at larger quintiles, the favorable effect of the Digital economy on the ET was significant. Finally, heterogeneity results showed regional differences in the influence of the Digital economy on ET and that it favorably contributes to the transition to RE in higher-income countries. Usman et al. (2021) found that ICT development improves energy efficiency and significantly influences economic performance in South Asian economies.

Research Gap

Despite the growing literature on Digitalization and financial inclusion, several important gaps remain unresolved. First, most existing studies primarily focus on carbon emissions, renewable energy adoption, or environmental degradation, while limited attention has been given to total energy consumption. Second, previous studies rarely examine the interaction effect between Digitalization and financial inclusion in shaping energy consumption dynamics. Third, the existing literature largely ignores income-level heterogeneity among OIC countries, where lower-income and higher-income economies may exhibit different responses to technological and financial development. Therefore, this study attempts to fill these gaps by examining the direct and interaction effects of Digitalization and financial inclusion on energy consumption across OIC economies.

Theoretical Framework

This study is theoretically grounded in the Energy Efficiency Theory and Technological Infrastructure Perspective to explain the relationship between Digitalization, financial inclusion, and energy consumption across OIC countries.

According to the Energy Efficiency Theory, technological advancement and improved financial accessibility enhance the efficient utilization of energy resources. Digitalization promotes smart technologies, automation, optimized production systems, and energy-efficient infrastructure, which reduce energy intensity and improve overall energy efficiency. Therefore, higher levels of Digitalization and financial inclusion may contribute to lower energy consumption, particularly in higher-income OIC countries.

The Technological Infrastructure Perspective explains that the expansion of Digital infrastructure, information and communication technologies (ICT), internet services, and telecommunication systems initially increases energy demand due to infrastructure development, industrial expansion, and rising electricity consumption. Furthermore, the combined interaction between Digitalization and financial inclusion may generate heterogeneous effects on energy consumption depending on countries' level of economic development, technological readiness, and infrastructure capacity. Higher-income OIC countries benefit from efficiency-enhancing technologies and advanced Digital systems, whereas lower-income countries experience greater energy demand during the early stages of Digital and financial expansion.

Data and Research Methodology

This study examines the effect of Digitalization and financial inclusion on energy consumption from 40 OIC countries based on data availability for the period of 2001 to 2022. The data of variables Digitalization, financial inclusion, industrialization, foreign direct investment and total population is collected from OIC dataset and World development indicators. Furthermore, the OIC countries are also classified into lower-income and higher-income OIC countries to better understand the effect of Digitalization and financial innovation on energy consumption. To analyze the effect of Digitalization and financial inclusion on energy consumption in OIC countries, the following models are developed:

$$EC = f(DGI, FII, IND, FDI, TP) \quad (1)$$

Econometric Form of the Model

$$EC_{ij} = \beta_o + \beta_1 DGI_{ij} + \beta_2 FII_{ij} + \beta_3 IND_{ij} + \beta_4 FDI_{ij} + \beta_5 TP_{ij} + u_{ij} \quad (2)$$

To examine the mutual effect of FII and DGI on EC the interaction term of both variables in added in a model:

$$EC_{ij} = \beta_o + \beta_1 DGI_{ij} + \beta_2 FII_{ij} + \beta_3 IND_{ij} + \beta_4 FDI_{ij} + \beta_5 TP_{ij} + \beta_6 FII * DGI_{ij} + u_{ij} \quad (3)$$

Where;

EC = Energy consumption

DGI = Digitalization index

FII = Financial inclusion index

IND = Industrialization

FDI = Foreign direct investment

TP = Total population

FII*DGI = Interaction term

u_{ij} = Error term

Table 1: Variable's Description

Variables	Descriptions
Dependent Variable	
EC	Natural log of Energy use (kg of oil equivalent per capita)
Independent Variables	
DGI	Digitalization index through PCA using variables Investments and Telecommunication Services, Fixed Broadband Subscriptions per 100 Population, Fixed telephone subscriptions (per 100 people), Mobile Cellular Subscriptions per 100 Population
FII	Financial inclusion index through PCA using variables Automated Teller Machines (ATMs) per 100,000 Adults, Commercial Bank Branches per 100,000 Adults, Domestic credit to private sector (% of GDP), Domestic credit to private sector by banks (% of GDP), Monetary Sector credit to private sector (% GDP)
IND	Natural log of Industry (including construction), value added (% of GDP)
FDI	Natural log of Foreign direct investment, net inflows (% of GDP)
TP	Natural log of Population, total

Pesaran CD test is used to examine cross-sectional dependence, while Pesaran and Yamagata (2008) test is employed for slope heterogeneity.

Results and Discussion

The descriptive statistics indicate moderate variation across variables, while correlation analysis suggests significant associations among Digitalization, financial inclusion, and energy consumption.

Table 2: Descriptive Estimates

	Mean	Maximum	Minimum	S.D.	Skewness	Kurtosis
Overall OIC Countries						
EC	6.784	10.181	3.918	1.350	0.235	2.708
DGI	0.044	6.158	-2.738	1.389	1.061	4.504
FII	0.058	6.254	-2.484	1.869	0.996	3.357
IND	3.352	4.579	0.632	0.533	-0.150	3.403
FDI	0.709	4.009	-6.918	1.259	-0.994	6.276
TP	16.273	19.434	12.739	1.638	-0.106	2.309
Lower-income Countries						
EC	6.497	8.544	4.034	1.194	-0.466	2.328

DGI	-0.130	3.891	-2.738	1.308	0.657	2.455
FII	-0.474	6.020	-2.484	1.802	1.749	5.996
IND	1.073	4.009	-6.918	1.153	-1.439	11.004
FDI	3.324	4.349	1.583	0.479	-0.071	2.520
TP	16.414	19.434	14.045	1.384	0.091	2.424
Higher-income Countries						
EC	6.975	10.181	3.918	1.415	0.415	2.364
DGI	0.087	6.158	-1.842	1.435	1.243	5.243
FII	0.316	6.254	-2.281	1.847	0.622	2.511
IND	3.371	4.579	0.632	0.566	-0.208	3.620
FDI	0.466	3.489	-5.512	1.270	-0.808	4.866
TP	16.179	19.279	12.739	1.783	-0.103	2.099

A correlation coefficient is utilized to estimate the degree of association between variables. The outcomes from Table 3 illustrate that energy consumption is positively correlated with the DGI (0.684), FII (0.617), IND (0.790) and TP (0.025), while EC is negatively correlated with the FDI (-0.053) in OIC countries. While in lower-income OIC countries energy consumption is positively correlated with the DGI (0.570), FII (0.559), IND (0.031), TP (0.726) and FDI (0.394). Furthermore, in higher-income OIC countries energy consumption is positively correlated with the DGI (0.742), FII (0.629) and IND (0.829), while EC is negatively correlated with TP (-0.190) and FDI (-0.034).

Table 3: Correlation Estimates

	EC	DGI	FII	IND	FDI	TP
Overall OIC Countries						
EC	1.000					
DGI	0.684	1.000				
FII	0.617	0.653	1.000			
IND	0.790	0.505	0.328	1.000		
FDI	-0.053	0.063	0.040	-0.112	1.000	
TP	0.025	-0.035	-0.009	0.062	-0.177	1.000
Lower-income OIC Countries						
EC	1.000					
DGI	0.570	1.000				
FII	0.559	0.680	1.000			
FDI	0.031	0.068	0.055	1.000		
IND	0.726	0.394	0.305	-0.045	1.000	
TP	0.394	0.206	0.306	-0.187	0.303	1.000
Higher-income OIC Countries						
EC	1.000					
DGI	0.742	1.000				

FII	0.629	0.638	1.000			
IND	0.829	0.561	0.340	1.000		
FDI	-0.034	0.093	0.116	-0.136	1.000	
TP	-0.190	-0.141	-0.146	-0.039	-0.207	1.000

Although the correlation analysis indicates a positive association between Digitalization, financial inclusion, and energy consumption, the long-run regression estimates provide different results after controlling for macroeconomic factors, cross-sectional dependence, and cointegration effects. Correlation analysis only captures simple bivariate relationships, whereas FMOLS and DOLS estimators examine the net long-run impact of explanatory variables on energy consumption within a multivariate framework.

A cross-sectional dependence test (CSD) is employed to check the interconnectedness of variables among OIC countries. The outcomes of Pesaran CD test are given in Table 4. The outcomes show that the variables EC, DGI, FII, IND, FDI and TP have statistically significant Pesaran CD test statistic values, indicating that the hypothesis of the presence of cross-sectional dependence among variables EC, DGI, FII, IND, FDI and TP in OIC countries is accepted. It is, therefore, proposed that the variables EC, DGI, FII, IND, FDI and TP are interconnected, suggesting that shocks in OIC countries can influence the economies of other OIC countries.

Table 4: Cross-Sectional Dependence Test

Variables	Overall OIC Countries		Lower-income OIC Countries		Higher-income OIC Countries	
	Pesaran CD	Prob.	Pesaran CD	Prob.	Pesaran CD	Prob.
EC	35.3650***	0.0000	11.755***	0.0000	21.689***	0.0000
DGI	113.3768***	0.0000	44.058***	0.0000	67.488***	0.0000
FII	62.0435***	0.0000	33.133***	0.0000	29.389***	0.0000
IND	9.7047***	0.0000	8.381**	0.0322	8.045***	0.0000
FDI	9.3037***	0.0000	2.377**	0.0122	6.021***	0.0000
TP	113.0887***	0.0000	38.482***	0.0000	72.938***	0.0000

Note: ***, **, * indicates p-value < 0.01, < 0.05, and < 0.10, respectively

Furthermore, a test developed by Pesaran & Yamagata (2008) checks the heterogeneity issue in a dataset. The outcomes of the test are shown in Table 5. The results show that the Adj and ΔAdj test statistic values are statistically significant at a 1 percent level, suggesting the rejection of H_o. The outcomes confirm the existence of slope heterogeneity in a model.

Table 5: Slope Homogeneity Test

Variables	Overall OIC Countries	Lower-income OIC Countries	Higher-income OIC Countries
Adj	21.402***	13.696***	16.735***

ΔAdj	25.919***	16.587***	20.267***

Note: ***, **, * indicates p-value < 0.01, < 0.05, and < 0.10, respectively

To evaluate the integration order of variables, in this study, CIPS, IPS and LLC tests are employed and estimates are displayed in Table 6. The results show that the variables EC, FDI and TP are integrated at order I(0), whereas the variables DGI, FII, and IND are integrated at 1st order I(1), signifying the mixed integration order of variables in a model. While in lower-income OIC countries the variables EC, DGI, FDI and TP are integrated at order I(0), whereas the variables FII, and IND are integrated at 1st order I(1). Furthermore in higher-income OIC countries the variables EC, FDI and TP are integrated at order I(0), whereas the variables DGI, FII, and IND are integrated at 1st order I(1).

Table 6: CIPS Unit Root Test Estimates

	CIPS		IPS		LLC		Results
Variables	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	
Overall OIC Countries							
EC	-3.633***	-6.772***	-4.146***	17.628***	-5.473***	-16.636***	I(0)
DGI	-1.266	-3.687***	2.523	-5.983***	-4.364***	-4.805***	I(1)
FII	-0.672	-3.361***	0.2856	-6.836***	-3.352***	-8.641***	I(1)
IND	0.182	-3.940***	0.412	-11.563***	-0.224	-12.207***	I(1)
FDI	-2.758***	-7.788***	-6.265***	-14.892***	-6.152***	-7.746***	I(0)
TP	-2.328***	-4.672***	-3.676***	-2.213**	-7.995***	-3.425***	I(0)
Lower-income OIC Countries							
EC	-2.150*	-8.767***	-4.631***	-12.607***	-4.217***	-11.772***	I(0)
DGI	-3.891***	-6.632***	1.891	-4.449***	-2.134**	-4.252***	I(0)
FII	0.998	-3.240***	0.709	-4.830***	-1.997**	-3.134***	I(1)
IND	-0.771	-3.861***	-0.695	-6.391***	-1.142	-7.002***	I(1)
FDI	-3.442***	-10.01***	-7.194***	-12.012***	-8.304***	-9.166***	I(0)
TP	-2.862**	-2.777**	-5.069***	-1.124	-8.611***	-2.515***	I(0)
Higher-income OIC Countries							
EC	-3.296***	-9.009***	-1.570*	-12.465***	-3.894***	-12.170***	I(0)
DGI	-1.112	-3.403***	1.713	-4.091***	-3.815***	-2.686***	I(1)
FII	-0.782	-3.718***	-0.210	-7.211***	-2.691***	-6.540***	I(1)
IND	0.228	-4.165***	1.100	-9.261***	0.534	-10.033***	I(1)
FDI	-2.593***	-3.728***	-2.198**	-9.417***	-1.569*	-1.871**	I(0)
TP	-2.511***	-8.629***	1.938**	-1.933**	-2.337***	-2.332***	I(0)

Note: ***, **, * indicates p-value < 0.01, < 0.05, and < 0.10, respectively

Table 7 show that panel PP, ADF and group PP and ADF tests have statistically significant P-values, implying that the null hypothesis of long-run cointegration among variables in a model is accepted. In addition, the Kao cointegration test and Westerlund cointegration statistic values are

also found to be statistically significant, implying the presence of cointegration among variables in a model.

Table 7: Cointegration Test Estimates

Alternative hypothesis: common AR coefs. (within-dimension)						
	Overall OIC Countries		Lower-income OIC Countries		Higher-income OIC Countries	
Test	Statistic	Prob.	Stat.	P-Value	Stat.	P-Value
Panel v-Statistic	-1.6768	0.9532	0.1762	0.2446	-2.1522	0.7189
Panel rho-Statistic	4.5124	1.0000	2.4803	0.9637	3.7530	0.2659
Panel PP-Statistic	-3.8461***	0.0001	-3.3104***	0.0001	-2.3555***	0.0000
Panel ADF-Statistic	-5.0439***	0.0000	-3.8365***	0.0000	-3.4763***	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)						
Group rho-Statistic	5.1073	1.0000	3.5055	0.9121	3.7313	0.5782
Group PP-Statistic	-16.3314***	0.0000	-10.826***	0.0000	-12.243***	0.0000
Group ADF-Statistic	-7.6110***	0.0000	-7.1598***	0.0000	-3.9798***	0.0000
Kao Test						
ADF	-2.1296**	0.0481	-2.872**	0.0211	-3.323***	0.0030
Westerlund Test						
Variance Ratio	-3.7821***	0.0000	-2.2822**	0.0282	-1.9872*	0.0722

Note: ***, **, * indicates p-value < 0.01, < 0.05, and < 0.10, respectively

This section analyzes the effect of Digitalization and financial inclusion on energy consumption in OIC countries. For this purpose, the fully modified ordinary least square method (FMOLS) and dynamic ordinary least square method (DOLS) are used for data estimation as both methods produce better estimates in the presence of CSD and slope heterogeneity. Table 8 demonstrates that industrialization and population are positively and significantly associated with energy consumption in OIC countries while financial inclusion and DGI are negatively linked to the EC in OIC countries. In addition, FDI is positively but insignificantly associated with the energy consumption in OIC countries. DGI's coefficient indicates the EC decreases by 4.23 (FMOLS) and DOLS (17.42) percent for a one percent increase in DGI. It suggests that Digital technology increases the efficiency and flexibility of energy systems (Maroufkhani et al., 2022). Digital technology's capacity to gather and analyze data makes gadgets smarter. Smart cities can lower energy consumption in public transport and infrastructure by leveraging Digital technologies (Lee

et al., 2018). Because it promotes technological innovation, changes the industrial structure, and boosts production efficiency, Digitalization is a powerful instrument for energy conservation and efficiency improvement (Han et al., 2016). Dzwigol et al., (2024), Lin & Huang (2023), and Thanh et al., (2023) also found a negative correlation between DGI and EC. Furthermore, FII's coefficient indicates the EC decreases by 1.26 (FMOLS) and DOLS (6.46) percent for a one percent increase in FII. It suggests that a sound financial system makes it possible for credit to be distributed efficiently, which promotes growth and progressively raises the energy required by private companies. Negative relationship between FII and EC was also confirmed by Sadorsky (2011); Yu & Tang (2023) and Zhong et al., (2024). The FDI's coefficient indicates the EC increases by 0.78 (FMOLS) and DOLS (0.50) percent for a one percent increase in FDI. It implies that FDI inflows driven the economic growth of hosting countries and that raise energy consumption. The positive link between FDI and EC was also confirmed by Polat (2018) and Shinwari et al., (2024). The IND's coefficient indicates the EC increases by 11.38 (FMOLS) and DOLS (35.64) percent for a one percent increase in IND. These outcomes suggest that industrialization requires more energy to run heavy machineries, therefore, greater industrialization in an economy lead to high EC. Positive link between IND and EC was also found by Pan et al., (2019); Rahman et al., (2023); Sadorsky (2014); Muzayanah et al., (2022) and Li et al., (2019). The TP's coefficient indicates the EC increases by 35.16 (FMOLS) and DOLS (7.48) percent for a one percent increase in TP. It suggests that rapid population growth is interlinked with more economic activities, urbanization, transportation and power for homes, all these aspects lead to more energy demand in OIC countries. The positive link between TP and EC was also found by Mombekova et al., (2024); Muzayanah et al., (2022); Liddle (2014) and Liu et al., (2015). In addition, the study also incorporated the interaction terms of FII and DGI (FII*DGI) to evaluate the mutual effect of these variables on EC in OIC countries. The results of FMOLS and DOLS models show that FII*DGI is negatively and significantly linked to the EC in OIC countries. It implies that Digitalization coupled with financial inclusion is crucial to maintain energy sustainability in OIC countries as financial inclusion helps households and firms to replace high energy consuming technologies with energy-efficient technologies and appliances; therefore, lead to a reduction in energy consumption in OIC countries.

Table 8: FMOLS and DOLS Estimates in OIC countries

Dependent Variable: Energy Consumption (EC)				
Variable	Model-I		Model-II	
	FMOLS	DOLS	FMOLS	DOLS
DGI	-0.0423***	-0.1742***	-0.0778***	-0.0399**
	(0.0109)	(0.0272)	(0.0123)	(0.0167)
FII	-0.0126***	-0.0646**	-0.0411***	-0.2791***
	(0.023)	(0.0309)	(0.0154)	(0.0572)
FDI	0.0078	0.0050	0.0072	0.0052
	(0.0042)	(0.0244)	(0.0081)	(0.0547)
IND	0.1138***	0.3564**	0.1016**	1.8725***
	(0.0260)	(0.1522)	(0.0434)	(0.1982)

TP	0.3516***	0.0748**	0.0467**	0.0436**
	(0.0803)	(0.0362)	(0.0198)	(0.0136)
FII*DGI	--	--	-0.0175***	-0.0520**
			(0.0042)	(0.0233)

Note: ***, **, * indicates p-value < 0.01, < 0.05, and < 0.10, respectively

Table 9. demonstrates the estimates of FMOLS and DOLS models in lower-income and higher-income OIC countries. The outcomes show that Digitalization, financial inclusion, industrialization and population are positively and significantly associated with energy consumption in lower-income OIC countries. The effect of FDI on EC is also positive but statistically insignificant in lower-income countries. In contrast, the effect of Digitalization and financial inclusion on energy consumption is found to be negative and statistically significant in higher-income OIC countries. On the other hand, the effect of industrialization, population and FDI turn out to be positive and statistically significant on EC in higher-income OIC countries.

Table 9: FMOLS and DOLS Estimates in Low and Higher-income OIC countries

Lower-income Countries					Higher-income Countries			
Variable	Model-I		Model-II		Model-I		Model-II	
	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS
DGI	0.0391***	0.0790**	0.0414***	0.0653***	-0.1051***	-0.1071***	-0.1481***	-0.0706***
	(0.0142)	(0.0293)	(0.0142)	(0.0178)	(0.0155)	(0.0233)	(0.0149)	(0.0279)
FII	0.0383***	0.1125***	0.0318**	0.0520***	-0.0488***	-0.0598***	-0.0852***	-0.1728**
	(0.0146)	(0.0321)	(0.0152)	(0.0127)	(0.0181)	(0.0284)	(0.0172)	(0.0741)
FDI	0.0310	0.0176	0.0201	0.0989	0.1811***	0.8026***	0.1139**	2.1937***
	(0.059)	(0.0144)	(0.059)	(0.0997)	(0.0546)	(0.1444)	(0.0488)	(0.1629)
IND	0.0864**	0.3545***	0.0903***	0.1063*	0.0328**	0.0422***	0.0160*	0.1300**
	(0.0349)	(0.0933)	(0.0348)	(0.05019)	(0.0104)	(0.0197)	(0.0092)	(0.0635)
TP	0.5483***	0.9060***	0.6199***	0.6680***	0.1771**	0.1878*	0.2422***	0.2461***
	(0.1237)	(0.2240)	(0.2232)	(0.1022)	(0.0723)	(0.1088)	(0.0646)	(0.0358)
FII*DGI	--	--	0.0183***	0.0625**	--	--	-0.0363***	-0.0291***
			(0.0065)	(0.0355)			(0.0049)	(0.0032)

The method of moment quantile regression (MMQR) is used for robustness estimation. MMQR approach examines the heterogeneous effects of DGI, FII, FDI, IND, TP and FII*DGI on energy consumption. The outcomes of the MMQR approach are given in Table 10. The MMQR approach captures heterogeneous effects of Digitalization and financial inclusion across different levels of energy consumption. The varying signs and magnitudes across quantiles indicate that the impact of Digitalization and financial inclusion differs according to countries' economic structure, technological development, and energy intensity levels. In lower quantiles, Digital expansion may increase energy demand due to infrastructure development and rising access to energy-dependent technologies. However, in higher quantiles, Digitalization contributes to energy efficiency improvements, optimized resource allocation, and smart energy management systems, thereby reducing energy consumption. The outcomes point out that DGI is directly linked to EC at scale,

location, and 25th quantile. However, at 50th, 75th and 90th quantile, the effect of DGI on EC is negative in OIC countries maintaining that DGI reduces the transportation by providing online services, promote energy efficient technologies and therefore, lead to a reduction in energy consumption in OIC countries. In addition, FII is directly linked to EC at scale, location, and 25th quantile. However, at 50th, 75th and 90th quantile, the effect of FII on EC is negative in OIC countries maintaining that FII provide access to finance so the people can use energy-efficient technologies that lead to a reduction in energy consumption in OIC countries. The results also show that FDI is positively but significantly related to the EC at location and scale. Similarly, from lowest (Q25) to highest (Q90) quantile FDI is positively but insignificantly linked to the EC on OIC countries. The results also show that IND is positively and significantly related to the EC at location, scale, Q25th, Q50th, Q75th and Q90th quantile in OIC countries, indicating that industrial activities require more energy and lead to increased energy consumption in OIC countries. The results also show that TP is positively and significantly related to the EC at location, scale, Q25th, Q50th, Q75th and Q90th quantile in OIC countries, suggesting that as the population grows, the demand for energy for cooking, heating, and appliances also increases, which leads to augments the EC in OIC countries. Lastly, the results show that FII*DGI is negatively and significantly related to the EC in location and scale. The effect of FII*DGI on EC at Q25th and Q50th is positive and significant; however, the effect of FII*DGI on EC at Q75th and Q90th is negative and statistically significant in OIC countries implying that financial inclusion and Digitalization mutually promote the energy-efficient technologies that lead to reduce the energy consumption in OIC countries.

Table 10: MMQR Estimates

Quintile	Location	Scale	Q25	Q50	Q75	Q90
Overall OIC Countries						
DGI	-0.182***	-0.029**	0.156***	-0.185***	-0.208***	-0.224***
	(0.023)	(0.014)	(0.027)	(0.023)	(0.026)	(0.030)
FII	-0.217***	-0.008***	0.224***	-0.216***	-0.210***	-0.206***
	(0.015)	(0.003)	(0.017)	(0.015)	(0.017)	(0.019)
FDI	0.021	0.007	0.016	0.022	0.027	0.031
	(0.017)	(0.010)	(0.019)	(0.017)	(0.019)	(0.022)
IND	1.518***	0.164***	1.662***	1.504***	1.371***	1.281***
	(0.050)	(0.029)	(0.058)	(0.050)	(0.055)	(0.065)
TP	0.046***	0.024	0.067***	0.044***	0.024*	0.031*
	(0.013)	(0.008)	(0.015)	(0.013)	(0.014)	(0.017)
FII*DGI	-0.003**	-0.009*	0.002**	0.009***	-0.025***	-0.025**
	(0.001)	(0.005)	(0.001)	(0.003)	(0.010)	(0.012)
Lower-income OIC Countries						
DGI	0.121***	0.048**	0.093**	0.121***	0.145***	0.169***
	(0.040)	(0.021)	(0.042)	(0.040)	(0.046)	(0.057)
FII	0.193***	0.037**	0.210***	0.193***	0.178***	0.163***
	(0.030)	(0.016)	(0.032)	(0.030)	(0.035)	(0.043)

FDI	0.351	0.095	0.045	0.050	0.0270	1.190**
	(0.086)	(0.096)	(0.091)	(0.087)	(0.100)	(0.124)
IND	0.048**	0.035**	0.072**	0.078**	0.066**	0.085**
	(0.012)	(0.017)	(0.034)	(0.032)	(0.037)	(0.046)
TP	0.109***	0.026*	0.115***	0.109***	0.104***	0.099**
	(0.029)	(0.016)	(0.031)	(0.029)	(0.034)	(0.042)
FII*DGI	0.038**	0.034***	0.004	0.038**	0.067***	0.095***
	(0.015)	(0.008)	(0.016)	(0.015)	(0.017)	(0.021)
Higher-income OIC Countries						
DGI	-0.195***	-0.065**	-0.168***	-0.193***	-0.226***	-0.248***
	(0.040)	(0.030)	(0.038)	(0.039)	(0.055)	(0.071)
FII	-0.210***	-0.034**	-0.207***	-0.210***	-0.214***	-0.216***
	(0.022)	(0.017)	(0.021)	(0.022)	(0.031)	(0.040)
FDI	1.538***	0.201***	1.694***	1.547***	1.358***	1.229***
	(0.083)	(0.062)	(0.079)	(0.081)	(0.113)	(0.147)
IND	0.041**	0.038**	0.001	0.039**	0.086***	0.094***
	(0.026)	(0.019)	(0.025)	(0.026)	(0.036)	(0.046)
TP	0.081***	0.037***	0.109***	0.082***	0.048**	0.064**
	(0.017)	(0.013)	(0.017)	(0.017)	(0.024)	(0.031)
FII*DGI	-0.029**	-0.030**	-0.009	-0.039***	-0.040**	-0.060***
	(0.015)	(0.011)	(0.014)	(0.015)	(0.021)	(0.027)

Note: ***, **, * indicates p-value < 0.01, < 0.05, and < 0.10, respectively

Dumitrescu Hurlin (DH) panel causality test is applied to examine the causal association between variables. The results show a unidirectional causality between DGI, EC, and IND and EC. Furthermore, bidirectional causality is found between FII and EC, FDI and EC, and TP and EC in OIC countries. While in lower-income OIC countries the results show a unidirectional causality between DGI and EC, and FII and EC. Furthermore, bidirectional causality is found between TP and EC in lower-income OIC countries. No causality is found between IND and EC, and FDI and EC in lower-income OIC countries. Furthermore, unidirectional causality is found between DGI and EC, and IND and EC while bidirectional causality is found between FDI and EC, FII and EC, and TP and EC in higher-income OIC countries.

Table 11: Dumitrescu Hurlin Panel Causality Tests

Null Hypothesis	Overall OIC Countries		Lower-income OIC Countries		Higher-income OIC Countries	
	W-Stat.	Zbar-Stat.	W-Stat.	Zbar-Stat.	W-Stat.	Zbar-Stat.
DGI ≠ EC	2.7952	1.1443	3.057**	2.112	2.620	0.569
EC ≠ DGI	3.7130***	3.2982	3.143	1.239	4.093***	3.245
FII ≠ EC	3.6375***	3.1211	4.145***	2.727	3.299*	1.802
EC ≠ FII	4.1766***	4.3863	2.918	0.906	5.015***	4.922

IND ≠ EC	2.3338	0.0613	2.380	0.108	1.950	-0.649
EC ≠ IND	3.6733***	3.2050	2.727	0.623	3.626**	2.397
FDI ≠ EC	3.3264**	2.3910	2.908	0.892	3.957***	2.998

Note: ***, **, * indicates p-value < 0.01, < 0.05, and < 0.10, respectively

Conclusions and Policy Implications

This study investigates the impact of Digitalization and financial inclusion on energy consumption across OIC countries over the period 2001–2022 by applying advanced panel econometric techniques. The empirical findings reveal that Digitalization and financial inclusion contribute to reducing energy consumption in overall OIC countries and particularly in higher-income OIC economies. The results suggest that technological advancement, smart infrastructure, and improved access to financial services enhance energy efficiency and encourage the adoption of energy-saving technologies. In contrast, Digitalization and financial inclusion increase energy consumption in lower-income OIC countries due to expanding industrial activities, growing access to electricity-dependent technologies, and increasing economic participation. Furthermore, industrialization and population growth are found to increase energy consumption across all country groups. The interaction effect between Digitalization and financial inclusion indicates that their combined role supports sustainable energy management, especially in higher-income OIC countries.

The findings provide several important policy implications for sustainable energy transition in OIC economies. Policymakers should strengthen Digital infrastructure and expand inclusive financial systems to facilitate investment in energy-efficient technologies and renewable energy projects. Governments should also promote green financing mechanisms, Digital banking services, and financial accessibility for households and small businesses to accelerate sustainable energy adoption. In lower-income OIC countries, special attention should be given to improving energy-efficient Digital infrastructure and encouraging clean technology investment in order to prevent excessive energy demand arising from rapid Digital expansion and industrial growth. In addition, energy policies should integrate technological innovation with environmental sustainability objectives to ensure balanced economic and energy development.

The study further highlights significant income-level heterogeneity among OIC countries. While higher-income economies benefit from efficiency-enhancing effects of Digitalization and financial inclusion, lower-income economies experience higher energy demand because Digital and financial expansion is still associated with infrastructure development and industrial transformation. This difference indicates that uniform policy strategies may not produce similar outcomes across all OIC countries. Therefore, energy and Digitalization policies should be designed according to the economic structure and development level of each country group.

Despite providing important insights, this study has certain limitations that offer directions for future research. The analysis is limited to aggregate energy consumption and does not distinguish between renewable and non-renewable energy consumption. Moreover, institutional quality,

governance effectiveness, environmental regulations, and green finance indicators are not incorporated into the analysis. Future studies may extend the framework by examining renewable energy transition, green technological innovation, institutional quality, and nonlinear relationships to provide deeper insights into sustainable energy development within OIC economies.

References

Agrawal, R., Agrawal, S., Samadhiya, A., Kumar, A., Luthra, S., & Jain, V. (2024). Adoption of green finance and green innovation for achieving circularity: An exploratory review and future directions. Geoscience frontiers, 15(4), 101669.

Adedoyin, F. F., Satrovic, E., & Kehinde, M. N. (2022). The anthropogenic consequences of energy consumption in the presence of uncertainties and complexities: evidence from World Bank income clusters. Environmental Science and Pollution Research, 29(16), 23264-23279.

Ahmad, S., Khan, D., & Magda, R. (2022). Assessing the influence of financial inclusion on environmental degradation in the ASEAN region through the panel PMG-ARDL approach. Sustainability, 14(12), 7058.

Atiq-ur-Rehman, M., Ramzan, A., ul Hassan, K. H., Popescu, V., Birau, R., Nioata, R. M., & Margaritescu, S. (2025). Dynamics of ICT, Natural Resource, Green Innovation, and Environmental Sustainability in Developing-8 organization of Economic Cooperation Countries: A Cross-Sectional ARDL Approach. International Journal of Energy Economics and Policy, 15(6), 325-333.

Allen, F., Demirguc-Kunt, A., Klapper, L., & Peria, M. S. M. (2016). The foundations of financial inclusion: Understanding ownership and use of formal accounts. Journal of financial Intermediation, 27, 1-30.

Baskaya, M. M., Samour, A., & Tursoy, T. (2022). THE FINANCIAL INCLUSION, RENEWABLE ENERGY AND CO 2 EMISSIONS NEXUS IN THE BRICS NATIONS: NEW EVIDENCE BASED ON THE METHOD OF MOMENTS QUANTILE REGRESSION. Applied Ecology & Environmental Research, 20(3).

Sumaira, B. R., & Bibi, R. (2022). Banking sector development and economic growth in south Asian countries: dynamic panel data analysis. J Environ Sci Econ, 1(1), 52-57.

Barik, R., & Kayal, P. (2025). Financial Inclusion and Electricity Consumption: A Cross-Country Study of Upper-Middle and Lower-Middle Income Countries (No. 2025-277).

Bibi, R., Khan, I., Rong, Z., Sadiq, F., & Oanh, L. T. K. (2022). The nexus between energy consumption, carbon dioxide emission and technological innovation in the Global panel: Evidence from Panel quantile regression. J. Technol. Innov. Energy, 1, 1-9.

Basnayake, D., Naranpanawa, A., Selvanathan, S., & Bandara, J. S. (2024). Financial inclusion through Digitalization and economic growth in Asia-Pacific countries. International Review of Financial Analysis, 96, 103596.

Basnayake, B. M. K., Zhao, Z., Huo, C., & Chandio, A. A. (2024). Digitalization, technological readiness, and sustainable energy transition: Evidence from developing economies. Energy Economics, 129, 107214.

Chaudhry, I. S., Yusop, Z., & Habibullah, M. S. (2022). Financial inclusion-environmental degradation nexus in OIC countries: new evidence from environmental Kuznets curve using DCCE approach. Environmental Science and Pollution Research, 29(4), 5360-5377.

Chibba, M. (2009). Financial inclusion, poverty reduction and the millennium development goals. The European Journal of Development Research, 21, 213-230.

Cao, Y., Qu, S., Zheng, H., Meng, J., Mi, Z., Chen, W., & Wei, Y. M. (2023). Allocating China's CO2 emissions based on economic Welfare gains from environmental externalities. Environmental Science & Technology, 57(20), 7709-7720.

Dev, S. M. (2006). Financial inclusion: Issues and challenges. Economic and political weekly, 4310-4313.

Dincer, I. (2000). Renewable energy and sustainable development: a crucial review. Renewable and sustainable energy reviews, 4(2), 157-175.

Dogan, E., & Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. Renewable and Sustainable Energy Reviews, 60, 1074-1085.

Dzwigol, H., Kwilinski, A., Lyulyov, O., & Pimonenko, T. (2024). Digitalization and energy in attaining sustainable development: impact on energy consumption, energy structure, and energy intensity. Energies, 17(5), 1213.

Elzaki, R. M. (2023). Impact of financial development shocks on renewable energy consumption in Saudi Arabia. Sustainability, 15(22), 16004.

Fauzia, L. R., & Trinugroho, I. (2022). The Financial Inclusion-Environmental Quality Nexus: Do Information and Communication Technologies Make a Difference? International Journal of Business and Society, 23(3), 1588-1599.

Gao, D., Li, G., & Yu, J. (2022). Does DGlitization improve green total factor energy efficiency? Evidence from Chinese 213 cities. Energy, 247, 123395.

Haldar, A., & Sethi, N. (2022). Environmental effects of Information and Communication Technology-Exploring the roles of renewable energy, innovation, trade and financial development. Renewable and Sustainable Energy Reviews, 153, 111754.

Inamullah, M., & Rehman, A. (2022). The Impact of Financial Sector Development on Environmental Degradation (Carbon Dioxide Emission) in Pakistan. Journal of Economic Impact, 4(3), 244-251.

International Energy Agency. (2025). Global Energy Review 2025.

Iqbal, S., & Bilal, A. R. (2022). Energy financing in COVID-19: how public supports can benefit? China Finance Review International, 12(2), 219-240.

Khan, H., Weili, L., & Khan, I. (2022). Examining the effect of information and communication technology, innovations, and renewable energy consumption on CO2 emission: evidence from BRICS countries. Environmental Science and Pollution Research, 29(31), 47696-47712.

Khan, S. A. R., Yu, Z., Belhadi, A., & Mardani, A. (2020). Investigating the effects of renewable energy on international trade and environmental quality. Journal of Environmental management, 272, 111089.

Li, N., & Wu, D. (2023). Nexus between natural resource and economic development: How green innovation and financial inclusion create sustainable growth in BRICS region?. Resources Policy, 85, 103883.

Le, T. H., Chuc, A. T., & Taghizadeh-Hesary, F. (2019). Financial inclusion and its impact on financial efficiency and sustainability: Empirical evidence from Asia. Borsa Istanbul Review, 19(4), 310-322.

Liu, L. J., Jiang, H. D., Liang, Q. M., Creutzig, F., Liao, H., Yao, Y. F., ... & Wei, Y. M. (2023). Carbon emissions and economic impacts of an EU embargo on Russian fossil fuels. Nature Climate Change, 13(3), 290-296.

Lee, C. C., Yuan, Z., & Wang, Q. (2022). How does information and communication technology affect energy security? International evidence. Energy Economics, 109, 105969.

Maroufkhani, P., Desouza, K. C., Perrons, R. K., & Iranmanesh, M. (2022). Digital transformation in the resource and energy sectors: A systematic review. Resources Policy, 76, 102622.

Mehmood, U., Tariq, S., Aslam, M. U., Agyekum, E. B., Uhunamure, S. E., Shale, K., ... & Khan, M. F. (2023). Evaluating the impact of Digitalization, renewable energy use, and technological innovation on load capacity factor in G8 nations. Scientific Reports, 13(1), 9131.

Mukalayi, N. M., & Inglesi-Lotz, R. (2023). Digital financial inclusion and energy and environment: Global positioning of Sub-Saharan African countries. Renewable and Sustainable Energy Reviews, 173, 113069.

Muhammad, M., Audu, B., & Ahmed, S. I. (2025). Investigating the CO2 Emissions Convergence and its Nexus with Growth, Renewable Energy, and Energy Intensity in OIC Countries. Muslim Business and Economics Review, 4(1), 1-31.

Mukalayi, N. M., & Inglesi-Lotz, R. (2023). Digital financial inclusion and energy and environment: Global positioning of Sub-Saharan African countries. Renewable and Sustainable Energy Reviews, 173, 113069.

Ozturk, I., & Ullah, S. (2022). Does Digital financial inclusion matter for environmental sustainability? Evidence from emerging economies. Environmental Science and Pollution Research, 29(45), 68484–68497.

Ozili, P. K. (2018). Impact of Digital finance on financial inclusion and stability. Borsa Istanbul Review, 18(4), 329-340.

Ozili, P. K. (2020). Theories of financial inclusion. In Uncertainty and challenges in contemporary economic behaviour (pp. 89-115). Emerald Publishing Limited.

Ozturk, I., & Ullah, S. (2022). Does Digital financial inclusion matter for economic growth and environmental sustainability in OBRI economies? An empirical analysis. Resources, Conservation and Recycling, 185, 106489.

Prempeh, K. B., Kyeremeh, C., Yeboah, S. A., & Danso, F. K. (2024). Asymmetric impact of financial development on renewable energy consumption in Ghana. SN Business & Economics, 4(9), 100.

Pata, U. K., & Fareed, Z. (2023). Quantifying the asymmetric and dependence structure between financial inclusion and energy efficiency: evidence from quantile methods. Energy Efficiency, 16(3), 16.

Ramzan, M., HongXing, Y., Abbas, Q., & Fatima, S. (2024). Do financial inclusion, inclusive Digitalization and growth promote clean energy portfolio? Clean Technologies and Environmental Policy, 26(8), 2687-2705.

Robeena Bibi, S. (2022). The relationship between trade openness, financial development and economic growth: evidence from Generalized method of moments. Journal of environmental science and economics.

Salahuddin, M., Alam, K., & Ozturk, I. (2016). The effects of Internet usage and economic growth on CO2 emissions in OECD countries: A panel investigation. Renewable and Sustainable Energy Reviews, 62, 1226-1235.

Salman, D., & Ismael, D. (2023). The effect of Digital financial inclusion on the green economy: the case of Egypt. Journal of Economics and Development, (ahead-of-print).

SESRIC (2019) OIC Economic Outlook. In: Statistical. Economic and Social Research and Training Centre for Islamic Countries (SESRIC), Ankara

Shahzad, S. J. H., Kumar, R. R., Zakaria, M., & Hurr, M. (2017). Carbon emission, energy consumption, trade openness and financial development in Pakistan: a revisit. Renewable and Sustainable Energy Reviews, 70, 185-192.

Tsaurai, K., & Chimbo, B. (2019). The impact of information and communication technology on carbon emissions in emerging markets. International journal of energy economics and policy, 9(4), 320-326.

Wang, R., Usman, M., Radulescu, M., Cifuentes-Faura, J., & Balsalobre-Lorente, D. (2023). Achieving ecological sustainability through technological innovations, financial development, foreign direct investment, and energy consumption in developing European countries. Gondwana Research, 119, 138-152.

Wang, C., Wei, Y., & Liu, X. (2010). Determinants of bilateral trade flows in OECD countries: evidence from gravity panel data models. The World Economy, 33(7), 894-915.

Wang, W., Rehman, M. A., & Fahad, S. (2022). The dynamic influence of renewable energy, trade openness, and industrialization on the sustainable environment in G-7 economies. Renewable Energy, 198, 484-491.

Weili, L., Khan, H., Khan, I., & Han, L. (2022). The impact of information and communication technology, financial development, and energy consumption on carbon dioxide emission: evidence from the Belt and Road countries. Environmental Science and Pollution Research, 1-16.

World Bank. (2017). Global Financial Development Report 2017/2018: Bankers without Borders. The World Bank.

World Bank. (2024). World Development Indicators 2024. Washington, DC: World Bank.

Yi-Fan Zhang & Haoxing Zhao (2025) The effect of E-commerce on Digital inclusive finance: evidence from the E-commerce boom in rural China, Cogent Economics & Finance, 13:1, 2460082, DOI: 10.1080/23322039.2025.2460082.

Zhang, Y., & Umair, M. (2023). Examining the interconnectedness of green finance: an analysis of dynamic spillover effects among green bonds, renewable energy, and carbon markets. Environmental Science and Pollution Research, 30(31), 77605-77621.

Zhang, W., Liu, X., Wang, D., & Zhou, J. (2022). Digital economy and carbon emission performance: Evidence at China's city level. Energy Policy, 165, 112927.

Zhao, H., Yang, Y., Li, N., Liu, D., & Li, H. (2021). How does Digital finance affect carbon emissions? Evidence from an emerging market. Sustainability, 13(21), 12303.

Zhong, S., Shen, H., Niu, Z., Yu, Y., Pan, L., Fan, Y., & Jahanger, A. (2022). Moving towards Environmental Sustainability: Can Digital Economy Reduce Environmental Degradation in China? International Journal of Environmental Research and Public Health, 19(23), 15540.