APAEA

Barik, R., & Kayal, P. (2025). Financial Inclusion and Electricity Consumption: A Cross-Country Analysis of Higher-Middle and Lower-Middle Income Countries. *Energy RESEARCH LETTERS*, *6*(Early View). https://doi.org/10.46557/001c.142272

Peer-reviewed research

Financial Inclusion and Electricity Consumption: A Cross-Country Analysis of Higher-Middle and Lower-Middle Income Countries

Rajesh Barik[1][a], Parthajit Kayal[2]

[1] Department of Economics and Finance, Birla Institute of Technology and Science, Pilani - K. K. Birla Goa Campus, Zuarinagar, Sancoale, Goa 403726, India, [2] Madras School of Economics, Chennai, India

Keywords: Financial inclusion, Electricity consumption, Cross-country

JEL Classifications: E23 Production, E44 Financial Markets and the Macroeconomy, E69 Other

https://doi.org/10.46557/001c.142272

Energy RESEARCH LETTERS

Vol. 6, Issue Early View, 2025

This paper empirically examines how financial inclusion affects per capita electricity consumption across countries. Using annual data from 2004 to 2021, we apply various econometric models (including OLS, RE, FE, PCSE, FGLS, and GMM). The results show that financial inclusion positively impacts per capita electricity consumption across all country groups (Overall sample, Higher-Middle-Income, and Lower-Middle-Income countries).

I. Introduction

Higher levels of electricity consumption (EC) yield numerous socio-economic benefits. Access to electricity is considered a fundamental entitlement, crucial for improving health outcomes, enhancing educational attainment (Olanrele et al., 2020), and improving overall quality of life (Bridge et al., 2016). Recognizing its importance, governments worldwide have prioritized increasing electricity accessibility, leading to steady growth in access rates and per capita consumption over recent years. Despite these advances, a considerable segment of society remains without electricity access. Conversely, accessible and affordable financial services through financial inclusion (FI) have played a crucial role in poverty alleviation (Chibba, 2009; Lal, 2018), enhancing human development, and meeting basic human needs (Barik et al., 2022; Inoue, 2019; Nanda & Kaur, 2016). Research indicates that FI positively influences EC (Iqbal & Nawaz, 2021). While previous literature has largely examined the connection between FI and the consumption of renewable energy (Ababio et al., 2023; Bakhsh et al., 2023; Cui et al., 2022; Feng et al., 2022), the connection between FI and EC remains relatively unexplored. Addressing this gap, this paper aims to investigate the interplay between FI and EC across different countries.

Diverging from earlier literature, this study adds to the existing body of research in multiple ways. First, unlike prior research, this study develops a comprehensive FI index using six different proxies and empirically assesses its impact on EC. Second, given the differing levels of FI among the sampled countries, the study investigates how these differences influence EC among higher-middle-income (HMI) and lower-middle-income (LMI) nations separately, as well as for the entire sample. Third, the study employs various panel data models in its econometric analysis to enhance the robustness of the regression results.

II. Data and Methodology

A. Data

The primary objective of this study is to examine the impact of financial inclusion (FI) on per capita electricity consumption (EC) in both high-middle-income (HMI) and low-middle-income (LMI) countries. Data was collected from 31 countries (15 LMI and 16 HMI) spanning the period from 2004 to 2021. The analysis focuses on this timeframe due to data availability constraints beyond these years. Countries are classified by income level according to the World Bank's classification for the fiscal year 2023.

B. Methodology

The key goal of this paper is to empirically investigate the effect of FI on per capita EC in HMI and LMI countries. To achieve this objective, the following econometric model is proposed:

$$PCELEC_{it} = \alpha_0 + \beta_1 FIINDEX_{it} + \beta_2 CTRL_{it} + \mu_{it} \quad (1)$$

$$\begin{aligned} PCELEC_{it} = {} & \alpha_0 + \beta_1 FIINDEX_{it} + \beta_2 Enrol_{it} \\ & + \beta_3 UNEMP_{it} + \beta_4 PPL\ Grow_{it} \\ & + \beta_5 FDI_{it} + \beta_6 REMIT_{it} \\ & + \beta_7 GDPPC_{it} \\ & + \beta_8 INFLATION_{it} + \beta_9 TGDP_{it} \\ & + \beta_{10} InGDP_{it} + \mu_{it} \end{aligned} \quad (2)$$

a Corresponding author email: rajeshbarik195@gmail.com

Table 1. Variable description

Variables' Name	Description of Variable	Data Sources
	Dependent Variable	
Per-Cap Electricity Consumption ($PCELEC$)	Per Capita Electricity Usage (Billion Kilowatt Hours)	US Energy Information Administration
	Independent Variables	
Financial Inclusion Index (FII)	(a) Bank branches per 1 lakh adults (b) ATMs per 1 lakh adults (c) Bank branches per 1 thousand km^2 (d) ATMs per 1 thousand km^2 (e/f) Outstanding deposit and credit as a % of GDP	IMF-Financial Access Survey
	List of Control Variables	
School Enrolment ($Enrol$)	School Enrolment primary (%gross)	WDI
Unemployment (UNEMP)	Percentage of unemployment	
Population growth ($PPL\ Growth$)	Population growth (annual %)	
FDI Inflow (FDI)	FDI net inflows (% of GDP)	
Remittance (REMIT)	Received remittance % of GDP	
Per-Cap GDP (GDPPC)	GDP per capita	
Inflation (INFLATION)	Annual consumer prices Inflation (%)	
Trade (TGDP)	Trade (% of GDP)	
Industry (InGDP)	Industry (% of GDP)	

This table provides details of all variables used in this study.

In the equation above, the dependent variable, $PCELEC_{it}$, represents per capita EC. The explanatory variable, the FI Index, represents the composite index of FI, developed through principal component analysis (PCA) utilizing six distinct FI indicators. Along with these variables, the study incorporates control variables, which are outlined in Table 1.

C. Estimating Strategy

Initially, this study employs the basic Ordinary Least Square (OLS) model, followed by fixed-effects (FE) and also random-effects (RE) models to analyze the impact of FI on per capita EC. The selection of the final model is guided by the Hausman test, which favours the random-effects model. Given the panel data's temporal and cross-sectional dimensions, concerns such as autocorrelation and heteroscedasticity may arise. To address such problems, this paper uses panel-corrected-standard-errors (PCSEs) and the feasible generalized-least-squares-method (FGLS) to strengthen the robustness of the findings. However, these methods may not fully address potential problems such as endogeneity or omitted variables. To address these concerns, this paper utilizes the Generalized-Method-of-Moments (GMM) for re-estimation, thereby further enhancing the analysis.

III. Empirical Findings

The dataset includes data from both HMI and LMI countries. Our analysis of this combined sample shows a statistically significant positive effect of FI on EC across all countries (see Table 2). This relationship suggests that increased FI improves financial accessibility, enhances economic conditions, and boosts buying capacity, which ultimately leads to a higher per capita EC and improved standards of living.

Upon examining the control variables, it is evident that Foreign Direct Investment (*FDI*), school enrollment, and unemployment are positively associated with EC across the countries studied. Higher *FDI* stimulates economic activity, leading to greater electricity demand. Similarly, increased school enrollment indicates more students engaged in learning activities, increasing electricity demand in educational institutions and households.

Though the connection between unemployment and EC seems counterintuitive, this apparent contradiction can happen due to several factors, such as unemployed individuals spending more time on household activities like lighting, heating, cooling, gaming, watching television, cooking, etc., which may increase the usage of household appliances.

Inflation and population growth show negative associations with per capita EC across the sample countries. The impact of inflation on EC is straightforward: higher inflation typically leads to increased electricity prices, reducing purchasing power and thus decreasing electricity demand. In contrast, the opposite relationship between population growth and EC can be attributed to factors such as energy efficiency measures, urbanization trends, policy interventions, technological advancements, changes in industrial practices, cultural shifts, and demographic changes.

For the remaining control variables, the observed effects vary depending on the specific econometric model used and the level of estimation precision achieved. Generally, variables such as Per Capita GDP (*PCGDP*), Trade GDP (*TGDP*),

Table 2. The effect of FI on EC - full sample

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**OLS**	**RE**	**FE**	**PCSEs**	**FGLS**	**GMM**
Enrol	0.645**	0.623***	0.519***	0.645***	0.645**	2.668***
	(0.289)	(0.116)	(0.0929)	(0.180)	(0.286)	(0.580)
Unemp	0.0334***	0.00831***	0.0147***	0.0334***	0.0334***	0.124***
	(0.00428)	(0.00308)	(0.00254)	(0.00169)	(0.00424)	(0.0118)
Pplgrowth	-0.508***	-0.103***	-0.0471**	-0.508***	-0.508***	-0.0652
	(0.0347)	(0.0224)	(0.0183)	(0.0209)	(0.0343)	(0.0661)
FDI	0.0378***	0.00163	0.00518**	0.0378***	0.0378***	0.00511
	(0.00902)	(0.00281)	(0.00226)	(0.00909)	(0.00893)	(0.0128)
FIIndex	0.332***	0.0898***	-0.0435**	0.332***	0.332***	1.037***
	(0.0375)	(0.0199)	(0.0177)	(0.0244)	(0.0371)	(0.0905)
Remit	-0.0412***	0.0172***	0.0217***	-0.0412***	-0.0412***	0.120***
	(0.00549)	(0.00379)	(0.00307)	(0.00387)	(0.00544)	(0.0373)
PCGDP	-0.0236**	0.627***	1.108***	-0.0236***	-0.0236**	0.0514
	(0.0113)	(0.0405)	(0.0434)	(0.00425)	(0.0111)	(0.0845)
Inflation	-0.000497	-0.000188	-5.50e-05	-0.000497	-0.000497	-0.000747*
	(0.000911)	(0.000254)	(0.000203)	(0.000440)	(0.000902)	(0.000454)
TGDP	0.235***	-0.0208	0.0786**	0.235***	0.235***	-0.0915
	(0.0603)	(0.0420)	(0.0347)	(0.0330)	(0.0597)	(0.133)
InGDP	0.558***	-0.0680	-0.0753	0.558***	0.558***	-0.700***
	(0.121)	(0.0772)	(0.0622)	(0.107)	(0.120)	(0.192)
Constant	-19.96***	-23.66***	-28.74***	-19.96***	-19.96***	-29.01***
	(1.380)	(0.704)	(0.634)	(0.950)	(1.366)	(2.912)
Observations	558	558	558	558	558	558
R^2	0.664		0.740	0.664		
Countries		31	31	31	31	31

Note: The standard errors are presented in parentheses. ***, **, and * denotes statistical significance at 1%, 5%, and 10% levels, respectively.

Industry GDP (*InGDP*), and Remittance Inflow are expected to positively influence EC. This expectation arises from their correlation with increased economic activity and enhanced purchasing power.

Table 3 highlights the effect of FI on EC in HMI countries. Similar to the findings for the aggregated sample, our analysis of HMI countries reveals a strong positive impact of FI on EC, statistically significant at the 1 percent level.

Regarding the control variables specific to HMI countries, school enrollment shows a positive but non-significant impact. This observation is primarily due to the higher median/average school enrollment rates in HMI countries, albeit with limited variation. Additionally, our analysis indicates that coefficients for unemployment and Foreign Direct Investment (*FDI*) are positively and significantly correlated, consistent with our findings in the aggregate sample.

Furthermore, population growth consistently presents negative and significant coefficients across the majority of econometric models used. This reaffirms the established relationship between population growth and EC.

Moreover, per capita GDP, as an indicator of economic development, exhibits a robust and significant positive impact on EC. It is noteworthy that while coefficients associated with inflation show positive trends, they often lack statistical significance in our analysis.

This section explores the linkage between FI and EC within the context of LMI countries. Our findings closely align with those observed in the aggregate and HMI country data. Specifically, we observe positive coefficients for the FI index, statistically significant at the 1 percent level.

Additionally, the outcomes related to control variables within LMI countries closely resemble those observed in HMI countries. Similar to HMI countries, we observe a positive association between unemployment and EC, while population growth exhibits a negative correlation with EC in LMI countries (see Table 4).

Furthermore, the positive and significant coefficient associated with remittances is particularly noteworthy. Remittances play a crucial role in lower-income economies by providing essential economic support, alleviating poverty, stimulating consumption and investment, and ultimately contributing to increased EC (see Table 4).

Table 3. The effect of FI on EC - HMI countries

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**OLS**	**RE**	**FE**	**PCSEs**	**FGLS**	**GMM**
Enrol	0.545	-0.0103	0.0427	0.545	0.545	0.277
	(0.512)	(0.149)	(0.136)	(0.403)	(0.503)	(0.330)
Unemp	0.0209***	0.00662**	0.0107***	0.0209***	0.0209***	0.0233***
	(0.00483)	(0.00263)	(0.00248)	(0.00228)	(0.00474)	(0.00578)
Pplgrowth	-0.270***	-0.0303	-0.00788	-0.270***	-0.270***	-0.140***
	(0.0455)	(0.0234)	(0.0216)	(0.0447)	(0.0447)	(0.0242)
FDI	0.0271***	0.00219	0.00376	0.0271***	0.0271***	0.0283***
	(0.0102)	(0.00254)	(0.00232)	(0.00929)	(0.00997)	(0.00521)
FIIndex	0.407***	0.153***	0.0568*	0.407***	0.407***	0.581***
	(0.0491)	(0.0298)	(0.0297)	(0.0288)	(0.0482)	(0.0632)
Remit	-0.0432***	0.0272***	0.0310***	-0.0432***	-0.0432***	-0.0666***
	(0.00675)	(0.00432)	(0.00397)	(0.00544)	(0.00663)	(0.00927)
PCGDP	0.0545***	0.571***	0.836***	0.0545***	0.0545***	0.122***
	(0.0179)	(0.0513)	(0.0582)	(0.0116)	(0.0176)	(0.0161)
Inflation	0.00870	0.00534**	0.00499**	0.00870	0.00870	-0.0137
	(0.00906)	(0.00237)	(0.00215)	(0.0103)	(0.00889)	(0.00872)
TGDP	0.220***	-0.136***	-0.0690	0.220***	0.220***	0.203***
	(0.0798)	(0.0484)	(0.0454)	(0.0608)	(0.0784)	(0.0693)
lnGDP	0.125	-0.140	-0.120	0.125	0.125	-0.280***
	(0.174)	(0.119)	(0.110)	(0.111)	(0.171)	(0.101)
Constant	-18.99***	-19.19***	-22.52***	-18.99***	-18.99***	-17.67***
	(2.785)	(0.968)	(0.976)	(2.103)	(2.735)	(1.765)
Observations	306	306	306	306	306	306
R^2	0.565		0.727	0.565		
Countries		17	17	17	17	17

The standard errors are presented in parentheses. ***, **, and * denotes statistical significance at 1%, 5%, and 10% levels, respectively.

IV. Conclusion

This study explores the intricate relationship between FI and EC across both HMI and LMI countries. Using aggregate panel data from 31 countries spanning 2004 to 2021, this work empirically demonstrates that FI positively impacts per capita EC across all three groups of countries (Overall sample, HMI Countries, and LMI Countries). This paper recommends the development of targeted FI policies to enhance per capita EC and promote sustainable livelihoods in both HMI and LMI countries.

Submitted: January 30, 2024 AEST. Accepted: February 18, 2025 AEST. Published: September 07, 2025 AEST.

Table 4. The effect of FI on EC - LMI countries

Variables	(1) OLS	(2) RE	(3) FE	(4) PCSEs	(5) FGLS	(6) GMM
Enrol	-1.390***	1.129***	0.697***	-1.390***	-1.390***	1.004**
	(0.312)	(0.203)	(0.124)	(0.419)	(0.304)	(0.412)
Unemp	0.0495***	-0.00862	-0.00358	0.0495***	0.0495***	0.0633**
	(0.00824)	(0.0103)	(0.00636)	(0.00851)	(0.00805)	(0.0278)
Pplgrowth	-0.390***	-0.244***	-0.169***	-0.390***	-0.390***	-0.259***
	(0.0433)	(0.0464)	(0.0283)	(0.0337)	(0.0423)	(0.0937)
FDI	0.00517	-0.0122	-0.0158***	0.00517	0.00517	-0.00437
	(0.0134)	(0.00811)	(0.00480)	(0.0154)	(0.0131)	(0.0119)
FIIndex	0.350***	0.154***	-0.0931***	0.350***	0.350***	0.562***
	(0.0383)	(0.0282)	(0.0207)	(0.0299)	(0.0374)	(0.0495)
Remit	0.0313***	-0.0112	-0.00779*	0.0313***	0.0313***	0.0408**
	(0.00863)	(0.00752)	(0.00451)	(0.00934)	(0.00843)	(0.0201)
PCGDP	-0.0345**	0.231***	1.231***	-0.0345*	-0.0345***	-0.0685***
	(0.0133)	(0.0464)	(0.0586)	(0.0178)	(0.0130)	(0.0259)
Inflation	-0.000731	-0.000104	0.000166	-0.000731	-0.000731	-0.000242
	(0.000639)	(0.000330)	(0.000196)	(0.000606)	(0.000624)	(0.000280)
TGDP	0.425***	-0.0313	0.149***	0.425***	0.425***	0.223*
	(0.0699)	(0.0744)	(0.0471)	(0.0505)	(0.0682)	(0.125)
InGDP	0.859***	0.0809	-0.113	0.859***	0.859***	-0.168
	(0.133)	(0.118)	(0.0711)	(0.105)	(0.130)	(0.271)
Constant	-13.09***	-22.26***	-31.19***	-13.09***	-13.09***	-20.60***
	(1.332)	(1.042)	(0.770)	(1.641)	(1.301)	(1.286)
Observations	238	238	238	238	238	238
R^2	0.801		0.842	0.801		
Countries		14	14	14	14	14

The standard errors are presented in parentheses. ***, **, and * denotes statistical significance at 1%, 5%, and 10% levels, respectively.

References

Ababio, J. O. M., Yiadom, E. B., Mawutor, J. K., Tuffour, J. K., & Attah-Botchwey, E. (2023). Sustainable energy for all: the link between financial inclusion, renewable energy and environmental sustainability in developing economies. *International Journal of Energy Sector Management*, *18*(5), 1088–1108. https://doi.org/10.1108/IJESM-07-2023-0012

Bakhsh, S., Zhang, W., Ali, K., & Anas, M. (2023). Can digital financial inclusion facilitate renewable energy consumption? Evidence from nonlinear analysis. *Energy & Environment*, 0958305X231204029.

Barik, R., Lenka, S. K., & Parida, J. K. (2022). Financial Inclusion and Human Development in Indian States: Evidence from the Post-Liberalisation Periods. *Indian Journal of Human Development*, *16*(3), 513–527. https://doi.org/10.1177/09737030221141241

Bridge, B. A., Adhikari, D., & Fontenla, M. (2016). Electricity, income, and quality of life. *The Social Science Journal*, *53*(1), 33–39. https://doi.org/10.1016/j.soscij.2014.12.009

Chibba, M. (2009). Financial inclusion, poverty reduction and the millennium development goals. *European Journal of Development Research*, *21*, 213–230. https://doi.org/10.1057/ejdr.2008.17

Cui, L., Weng, S., & Song, M. (2022). Financial inclusion, renewable energy consumption, and inclusive growth: Cross-country evidence. *Energy Efficiency*, *15*(6), 43. https://doi.org/10.1007/s12053-022-10051-y

Feng, J., Sun, Q., & Sohail, S. (2022). Financial inclusion and its influence on renewable energy consumption-environmental performance: the role of ICTs in China. *Environmental Science and Pollution Research*, *29*(35), 52724–52731. https://doi.org/10.1007/s11356-022-19480-9

Inoue, T. (2019). Financial inclusion and poverty reduction in India. *Journal of Financial Economic Policy*, *11*(1), 21–33. https://doi.org/10.1108/JFEP-01-2018-0012

Iqbal, N., & Nawaz, S. (2021). Cash transfers and residential demand for electricity: insights from BISP, Pakistan. *Environmental Science and Pollution Research*, *28*(12), 14401–14422. https://doi.org/10.1007/s11356-020-11384-w

Lal, T. (2018). Impact of financial inclusion on poverty alleviation through cooperative banks. *International Journal of Social Economics*, *45*(5), 808–828. https://doi.org/10.1108/IJSE-05-2017-0194

Nanda, K., & Kaur, M. (2016). Financial inclusion and human development: A cross-country evidence. *Management and Labour Studies*, *41*(2), 127–153. https://doi.org/10.1177/0258042X16658734

Olanrele, I. A., Lawal, A. I., Dahunsi, S. O., Babajide, A. A., & Iseolorunkanmi, J. O. (2020). The impact of access to electricity on education and health sectors in Nigeria's rural communities. *Entrepreneurship and Sustainability Issues*, *7*(4), 3016–3035. https://doi.org/10.9770/jesi.2020.7.4(30)