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**Financial Inclusion and Electricity
Consumption: A Cross-Country Study of Upper-
Middle and Lower-Middle Income Countries**

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Abstract

Electricity consumption's positive impact on household well-being, education, and quality of life is well-documented. Yet, providing accessible and affordable electricity remains a global governance challenge. This study explores the potential of financial inclusion to extend electricity consumption. Investigating the relationship empirically, we analyze the effect of financial inclusion on per capita electricity consumption across countries. Using annual data from 2004 to 2021, we employ various econometric models (such as ordinary least squares, fixed effect, random effect, panel corrected standard errors, feasible general least square, Generalized Method of Moments, and Driscoll-Kraay approach) to examine this nexus in both upper-middle and lower-middle income countries. The study unveils a positive association between financial inclusion and per capita electricity consumption across the overall sample and income subgroups. Robustness checks further underscore the consistency of our findings across income categories. In light of our findings, policymakers could consider leveraging financial inclusion initiatives as strategic measures to bolster electricity consumption across both upper- and lower-middle-income countries.

Keywords: Financial Inclusion, Electricity consumption, Cross-Country, Upper-Middle income, Lower-Middle income, Empirical Analysis

JEL Codes: O12; O13; O16; Q43; I32

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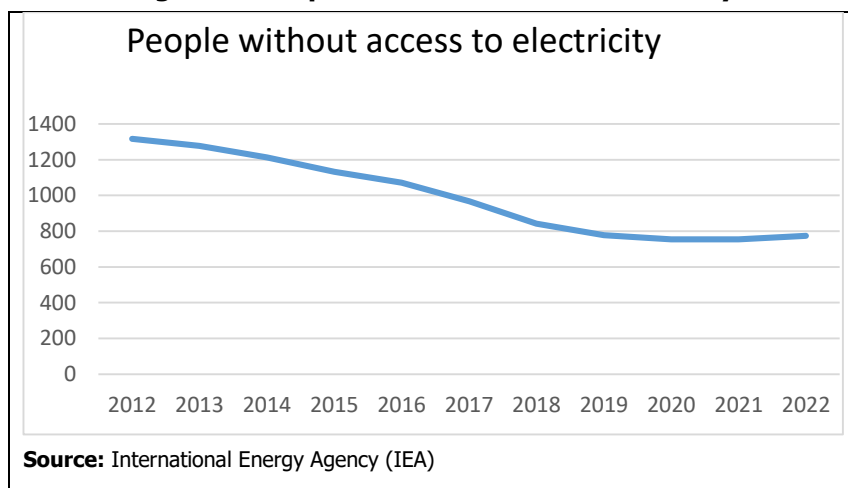
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INTRODUCTION

The manifold socio-economic advantages associated with elevated electricity consumption levels and enhanced accessibility are well-established. Global research findings underscore that increased electricity consumption and improved access contribute to bolstering economic growth (Shengfeng, 2012), alleviating poverty (Asghar et al., 2022; Rafindadi et al., 2022), and enhancing health and living standards (Chen et al., 2019). Acknowledging the pivotal role of electrification, governments worldwide have endeavoured to extend electricity access to their populations. Consequently, the percentage of individuals with electricity access and per capita electricity consumption has steadily risen in recent years. Nevertheless, despite substantial electrification progress, a considerable segment of the global population remains without electricity access. Approximately 775 million individuals worldwide lack access to electricity (see Figure 1), with the majority of these residing in Africa and Asia (IEA, 2019).

Figure 1: People without Access to Electricity



On the opposite spectrum, the availability of accessible and affordable financial services through financial inclusion has played a pivotal role in diminishing poverty, enhancing human development, and facilitating fundamental human necessities (Mookerjee & Kalipioni, 2010; Inoue, 2011; Barik et al., 2022). When considering the interplay between basic financial services and electricity accessibility, research has revealed that the former positively influences the latter. For instance, Iqbal & Nawaz (2021) conducted a study among Pakistan's ultra-poor community to gauge the impact of the cash transfer program (Benazir Income Support Programme) on electricity accessibility. Their findings indicate that the cash transfer initiative not only significantly bolsters electricity demand but also amplifies the use of essential electric appliances like washing machines and refrigerators. Similarly, one more study in Malawi (Aung et al., 2021) has found that unconditional cash transfers have helped households improve their access to electrification and cooking technologies in rural Malawi.

Worldwide numerous developing countries, akin to Pakistan and Malawi, are implementing diverse cash transfer programs to improve their citizens' welfare. In the case of Conditional Cash Transfer (CCT) schemes, there are some schemes where the government directly provides cash to impoverished households upon meeting specified criteria like institutional childbirth, minimum school attendance, and immunization participation. On the contrary, there are also some other ways where the process of cash transfer can assist the household in increasing their electricity usability. For example, in the case of India, through the Direct Benefit Transfer (DBT) scheme, people directly receive their monthly MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) wage in their bank or post office account. Furthermore, the individual receiving money through MGNREGA can spend it for

electricity consumption purposes. Similarly, people receive old age pensions, widow pensions, disability pensions, etc., directly to their bank account and are entitled to spend that money on their household welfare including electricity consumption. Likewise, there is ample literature that describes the role of microcredit in access to electricity, solar energy, and the eradication of energy poverty (Kabir et al., 2010; Groh & Taylor, 2015; Holt, 2016; Boutabba et al., 2020). Here, either the process of cash transfer through DBT or the provision of microcredit for electrification, all are part of the broader financial inclusion process. Hence, based on the above argument, it is here necessary to examine what is the role of financial inclusion in electricity consumption.

Drawing from the identified linkages between financial inclusion and electricity consumption, this study empirically scrutinizes the impact of financial inclusion on electricity consumption in selected upper- and lower-middle-income countries. The classification of countries by the World Bank, based on income, reveals that upper- and lower-middle-income countries possess a narrower income gap than low- and high-income countries. Thus, exploring how the process of financial inclusion operates within similar income groups is particularly intriguing.

Diverging from prior literature, this study offers distinct contributions. Firstly, instead of solely investigating the impact of cash transfers or microcredit on electricity consumption, it constructs a composite index of financial inclusion through six different proxies and empirically evaluates its effect on electricity consumption. The usage of these six financial inclusion indicators covers various dimensions such as availability, accessibility, and usability dimension of financial inclusion. Departing from earlier literature, this study tries to capture broader aspects of financial inclusion and try to empirically examine its impact on electricity consumption. Secondly, recognizing the varying degrees of

financial inclusion and their interplay with electrification in sample countries, the study delves into how differing degrees of financial inclusion influence electricity consumption in both upper- and lower-middle-income countries, alongside the overall sample. Thirdly, the study employs various panel data models within the econometric framework to bolster the regression outcomes. Lastly, valuable policy recommendations for policymakers are presented, elucidating how financial inclusion can serve as a strategic policy measure to enhance electricity consumption across both groups of countries.

Section 2 furnishes a comprehensive review of the background literature, forging links between our research and prior investigations. In Section 3, we detail the data source and methodology utilized in this study. The empirical outcomes and ensuing discourse are presented in Section 4. The validation of our results is expounded upon in Section 5, where we discuss the robustness checks conducted. Lastly, the paper culminates in the concluding section, offering suggestions for future research endeavours.

REVIEW OF LITERATURE

The Intricate Interplay of Financial Inclusion and Socio-Economic Dynamics

A plethora of empirical studies have delved deeply into the intricate nexus between financial inclusion and multifaceted socio-economic dimensions. These studies have meticulously examined how financial inclusion reverberates across economic growth, poverty alleviation, and the intricate web of income inequality, employing a diverse spectrum of financial inclusion indicators from various corners of the global landscape. Rooted in the fundamental aspiration of extending basic banking products and services to marginalized and vulnerable strata, financial inclusion has crystallized as an indispensable policy instrument capable

of propelling a nation's economic advancement (Claessens, 2006; Claessens & Perotti, 2007). While financial inclusion is commonly associated with extending access to formal financial services, including deposit facilities, credit provisions, payment mechanisms, insurance coverage, mortgages, and other rudimentary banking amenities, its broader ramifications are far-reaching. Indeed, financial inclusion is a catalyst igniting investments, kindling job creation, and fostering the bedrock of economic growth.

In the scholarly realm, luminaries such as Mohan (2006), Anand & Chhikara (2013), Dixit & Ghosh (2013), Onaolapo (2015), Kim (2016), Sharma (2016), Lenka & Sharma (2017), Sethi & Acharya (2018), Wakdok (2018), Adedokun & Ağa (2021), Ifediora et al. (2022), and Azimi (2022) have embarked on explorations into the intricate tapestry of financial inclusion's transformative impact on economic growth. These erudite scholars have converged upon a compelling consensus, showcasing a discernible and affirmative correlation between financial inclusion initiatives and the robust expansion of economic frontiers.

In a parallel vein, the intersection of financial inclusion with the critical endeavours of poverty reduction and the amelioration of income inequality has taken centre stage in the scholarly discourse. Studies by Chibba (2009, 2013), Kim (2016), Mookerjee & Kalipioni (2010), Inoue (2011, 2018), Park & Mercado (2017), and Zhang & Posso (2017) have ventured into the realm of empirical analysis, deploying judiciously selected financial inclusion indicators attuned to data availability and contextual relevance. Their collective findings coalesce around the central premise that financial inclusion serves as a potent antidote to poverty's affliction and inequality's constraints (Williams et al., 2017; Anwar et al., 2016; Hussaini et al., 2018). This compelling body of research illuminates how the democratization of financial services

catalyzes socio-economic equity, furnishing marginalized individuals with pathways toward empowerment and upward mobility.

Untangling the Intricacies of Financial Inclusion, CO2 Emissions, and Energy Poverty

In an epoch characterized by the collective attempt to fortify environmental integrity and actualize the vision of Sustainable Development Goals (SDGs), the imperative of carbon emission reduction has acquired paramount importance. Nations across the globe have mobilized their resources to curtail carbon footprints at both national and regional scales. Within this dynamic backdrop, the scholarly community has fervently endeavoured to unveil the multifaceted tapestry that links financial inclusion and CO2 emissions. Yet, within this realm of inquiry, a mosaic of perspectives emerges, yielding divergent insights into the interplay between financial inclusion and the carbon emissions spectrum. Certain studies posit a narrative wherein financial inclusion serves as a harbinger of heightened CO2 emissions (Le et al., 2020; Zaidi et al., 2021; Zhang et al., 2022). Contrariwise, a counter-current emerges that accentuates financial inclusion's potential to ameliorate CO2 emissions (Qin et al., 2021; Shahbaz et al., 2022; Zheng and Li, 2022; Mehmood, 2022; Liu et al., 2022; Dou et al., 2023; Salman & Ismael, 2023; Zhou et al., 2023). These divergent viewpoints highlight the nuanced nature of this relationship, underscoring the necessity for a holistic understanding that accounts for contextual nuances and varying dynamics.

Parallely, at the intersection of financial inclusion and energy poverty, scholarly discourse has illuminated intriguing vistas. Pioneering investigations by Levai et al. (2011), Boutabba et al. (2020), Koomson & Danquah (2021), and Asongu & Odhiambo (2023) have traversed uncharted terrain, revealing how financial inclusion acts as a bridge, connecting underserved populations to modern energy access, and

alleviating the scourge of energy poverty. There could be various ways where the process of financial inclusion can reduce energy poverty and improve access to clean energy. One possible way is through household income. Better financial inclusion fosters formal credit of the individual, which enhances the capital flow and ultimately increases the income of the household. More income means more use of cleaner energy by the household. As a result, households will be encouraged to consume more superior energy sources for cooking and heating (Khan et al., 2023; Said & Acheampong, 2023). Similarly, greater financial inclusion could influence energy poverty through education, health, and labour market outcomes. This route specifies that better financial inclusion inspires households to capitalize more on education and health, which in turn executes a positive influence on the employment sector and thus results in higher income (Khan et al., 2023; Said & Acheampong, 2023). From the above literature review, both empirically and theoretically it is established that there is a clear-cut relationship between financial inclusion and energy access and the reduction of energy poverty. While trying to find a similar link between financial inclusion and electricity consumption, the researchers realized that there is a dearth of studies on this matter. Amidst human essentials, access to electricity stands tall as a transformative force, its impacts reverberating across daily existence and broader developmental paradigms. Remarkably, the absence of electricity access ripples across realms such as health outcomes (Olanrele et al., 2020; WHO, 2023), educational trajectories (Olanrele et al., 2020), and overall quality of life (Bridge et al., 2016). Mindful of this knowledge gap, the present study embarks on a pioneering expedition to unearth the empirical connection between financial inclusion and electricity consumption across a mosaic of countries. Focusing its lens on upper-middle and lower-middle-income nations, this study aspires to unearth insights that can catalyze the evolution of financial inclusion policies, ensuring equitable and accessible electricity for households within both

strata. Through its empirical revelations, this study envisions the transformation of lives and the amplification of opportunities, contributing to more inclusive and sustainable developmental trajectories.

DATA AND METHODOLOGY

Sampling details

The primary aim of this study is to empirically assess the influence of financial inclusion on electricity consumption across nations falling within both the upper- and lower-middle-income strata. To achieve this objective, a comprehensive dataset has been curated, encompassing 31 countries. Among these, 16 nations belong to the upper-middle-income category, while the remaining 15 are representative of the lower-middle-income bracket. Spanning the extensive timeframe from 2004 to 2021, this dataset encompasses a substantial breadth of temporal scope. Further elaboration regarding the chosen countries can be found in Table A1, as presented in the appendix section.

It is pertinent to note that due to constraints posed by data availability, the analysis is confined within the bounds of the data period. This temporal limitation is a product of the data resources accessible for this study. To facilitate a clear categorization of countries based on their income, the World Bank's income-based classification for the fiscal year 2023 has been employed as a framework for this study's country division.

Execution of variables

For conducting the empirical analysis, this study categorizes variables in three sets i.e. dependent, independent, and control. Here, our dependent variable is per capita electricity consumption. The dependent variable data is collected from the US Energy Information Administration. Similarly, the financial inclusion index is used as an independent variable

in this study. This study has constructed a composite index of financial inclusion by taking six proxies. These six proxies are collected from three dimensions of financial inclusion i.e., i.e., demographic, geographic, and usage. Here, each dimension includes two proxies of financial inclusion. For example, the demographic dimension includes (a) the number of bank branches per 100,000 adult population

(b) Number of ATMs per 100, 000 adult population. Similarly, geographic dimension includes c) the number of bank branches per 1000 km² and (d) the number of ATMs per 1000 km². Finally, the usage dimension includes (e/f) outstanding deposits and credit as a percentage of GDP (See Table 1). All these proxies have been used by Lenka & Barik (2018), Barik & Lenka, (2023) in their financial inclusion index construction. Similarly, Table 2 in this study represents the summary statistics of the used variables and Table 3 provides the correlation matrix of all variables.

For constructing a composite index of financial inclusion, this study used Principal Component Analysis (PCA). As this study takes different proxies of financial inclusion with different measurement units, the authors first normalized¹ the data before constructing the index through the PCA method. In the PCA index, first, we calculate the factor scores (weights) through their eigenvalues. Then factor score of each variable is multiplied by the respective original proxy of financial inclusion. After the multiplication, we added them together to obtain a single composite index of financial inclusion for i^{th} country for a particular period t. Therefore, to find a single index of financial inclusion, the following formula (Eq. 1) is used:

¹Normalization = $X - M/SD$

$$FII_{it} = \sum_{i=1}^p w_{ji} X_{pi} \quad (1)$$

By expanding the Eq. 1, it can be expressed as in Eq. 2:

$$FII_{it} = W_{i1}X_1 + W_{i2}X_2 + W_{i3}X_3 + \dots + W_{ip}X_p \quad (2)$$

Finally, we received the financial inclusion index through the above procedure. Similarly, we constructed financial inclusion indexes for 31 countries separately (16 from upper-middle income and 15 from lower-middle income) covering the period of 2004 to 2021. The status of financial inclusion for the two groups of countries is presented in figures A1 and A2 of the appendix. The periodical trends (i.e., 2004, 2021) of financial inclusion are given to figure out the changes in the growth of financial inclusion in these two groups of countries over time.

Correspondingly, this study uses nine control variables for its analysis. The control variables are primary school enrolment, unemployment, population growth, FDI inflow, remittance received as a percentage of the county's GDP, GDP per capita, the rate of inflation, Trade (% of GDP), and Industry (% of GDP) (See Table 1). Considering the relatively sparse literature on the intersection of financial inclusion and electricity consumption across different countries, we have drawn upon research showcasing the influence of financial inclusion on CO2 emissions, energy efficiency, and associated variables to inform our choice of control variables (Le et al., 2020; Zaidi et al., 2021; Zhang et al., 2022).

Table 1: Description of Variables

Name of the Variables	Description of Variable	Data Sources
Dependent Variable		
Per-Capita Electricity Consumption	Per Capita Electricity Consumption (Billion Kilowatt Hours)	US Energy Information Administration
Access to electricity	Access to electricity (% of population)	WDI
Independent Variable		
Financial Inclusion Index (FII)	(a) Number of bank branches per 100,000 adult population (b) Number of ATMs per 100,000 adult population (c) Number of bank branches per 1000 km ² (d) Number of ATMs per 1000 km ² (e/f) Outstanding deposit and credit as a percentage of GDP	Financial Access Survey of International Monetary Fund (IMF)
Control Variables		
School Enrolment	School Enrolment primary (%gross)	WDI
Unemployment	Percentage of unemployment	
Population growth	Population growth (annual %)	
FDI Inflow	Foreign direct investment, net inflows (% of GDP)	
Remittance	Received remittance % of GDP	
Per-Cap GDP	Gross domestic product per capita	
Inflation	Inflation, consumer prices (annual %)	
Trade	Trade (% of GDP)	
Industry	Industry (% of GDP)	

Table 2: Summary Statistics of the Variables

Variables	Abbreviations	Functional Form	Obs	Mean	Std. Dev	Min	Max
Access to Electricity (%)	Elec	Logarithm	558	4.46	0.27	2.95	4.61
Per Capita Electricity Consumption	Pcelec	Logarithm	558	-13.50	0.95	-15.84	-11.88
School Enrolment, Primary (% gross)	Enrol	Logarithm	558	4.64	0.09	4.35	4.90
Unemployment	Unemp	Absolute	558	7.29	6.29	0.25	37.32
Population growth (annual %)	Pplgrowth	Absolute	558	1.02	0.87	-1.76	2.99
FDI Inflow (% of GDP)	FDI	Absolute	558	3.13	2.90	-0.99	31.23
Financial Inclusion Index	FIIndex	Logarithm	558	3.72	0.77	1.31	7.24
Remittance Inflow	Remit	Absolute	558	4.68	4.96	0.09	34.50
GDP Per capita	PCGDP	Logarithm	558	11.50	2.20	7.98	17.78
Inflation	Inflation	Logarithm	558	7.41	26.32	-2.43	557.20
Trade (% of GDP)	TGDP	Logarithm	558	4.19	0.46	3.10	5.35
Industry (% of GDP)	InGDP	Logarithm	558	3.35	0.25	2.79	3.88

Table 3: Correlation Matrix- All Variables

Variables	Elec	Pcelec	Enrol	Unemp	Pplg- rowth	FDI	FIIndex	Remit	PCGDP	Inflation	TGDP	InGDP
Elec	1.00											
Pcelec	0.65	1.00										
Enrol	0.00	-0.04	1.00									
Unemp	0.18	0.34	-0.07	1.00								
Pplgrowth	-0.48	-0.63	0.17	-0.29	1.00							
FDI	0.23	0.30	0.01	0.12	-0.27	1.00						
FIIndex	0.49	0.54	-0.15	-0.01	-0.38	0.01	1.00					
Remit	-0.08	-0.22	-0.10	-0.06	-0.17	0.04	-0.14	1.00				
PCGDP	0.17	0.07	-0.03	-0.04	-0.13	0.07	0.02	-0.14	1.00			
Inflation	-0.15	-0.10	-0.07	-0.01	0.09	-0.01	-0.07	0.06	-0.05	1.00		
TGDP	0.20	0.37	-0.12	0.08	-0.32	0.36	0.22	0.14	0.07	-0.04	1.00	
InGDP	0.32	0.22	0.17	-0.31	0.08	-0.02	0.32	-0.33	0.18	0.01	0.20	1.00

Econometric Model

The main objective of this study is to empirically examine the impact of financial inclusion on the per capita electricity consumption among upper and lower-middle-income countries. To operationalize this idea, the following econometric model is specified:

$$PCELEC_{it} = \alpha_0 + \beta_1 FIINDEX_{it} + \beta_2 CTRL_{it} + \mu_{it} \quad (3)$$

$$\begin{aligned} PCELEC_{it} = & \alpha_0 + \beta_1 FIINDEX_{it} + \beta_2 Enrol_{it} + \beta_3 UNEMP_{it} \\ & + \beta_4 PPL\ Grow_{it} + \beta_5 FDI_{it} + \beta_6 REMIT_{it} \\ & + \beta_7 GDPPC_{it} + \beta_8 INFLATION_{it} \\ & + \beta_9 TGDP_{it} + \beta_{10} InGDP_{it} + \mu_{it} \end{aligned} \quad (4)$$

In the above equation, the dependent variable is $PCELEC_{it}$, which denotes per capita electricity consumption. Similarly, the FI Index indicates the composite index of financial inclusion and is used here as an explanatory variable. Along with dependent and explanatory variables, this study also uses some control variables such as primary school enrolment ratio (Enrol), rate of unemployment (UNEMP), percentage of population growth (PPL Grow), FDI Inflow (FDI), received remittance as a percentage of GDP (REMIT), per capita gross domestic product (GDPPC), and rate of inflation (INFLATION), Trade as a percentage of GDP (TGDP), Industry as a percentage of GDP (InGDP) and the μ_{it} refers to the error term. The subscript (i, t) denotes the cross-sectional and time dimensions of the panel.

Estimating Strategy

At first, this study employs the basic OLS model, and then both fixed-effect and random-effect models are used to assess the influence of financial inclusion on per capita electricity consumption. The final interpretation of the outcomes is based on the Hausman test, favouring the random-effect model. While the panel data predominantly

encompass temporal and cross-sectional dimensions, concerns such as autocorrelation and heteroscedasticity might arise in the dataset. To address these concerns, the study employs panel-corrected standard errors (PCSEs) and the feasible generalized least squares method (FGLS) to fortify the robustness of the findings.

However, neither PCSEs nor FGLS adequately tackle potential issues like endogeneity or variable omission. In response to these challenges, the study adopts the Generalized Method of Moments (GMM), to re-estimate the results and mitigate these concerns. Further, we use Driscoll-Kraay (DK) approach to minimize the issues like heteroscedasticity, contemporaneous correlation.

Empirical Findings and Discussion

The fundamental aim of this study is to explore the influence of financial inclusion on electricity consumption across 31 chosen countries categorized as either UMI or LMI economies. Our analysis covers the period from 2004 to 2021. Initially, we investigate the relationship between financial inclusion and electricity consumption across the entire set of 31 countries. Subsequently, the dataset is divided into two distinct subsets: UMI countries and LMI countries. Within these differentiated \ categories, the research scrutinizes the same objective with distinct perspectives. This approach of conducting separate regressions for these two categories of countries aims to discern whether regional attributes have exerted an impact on the outcomes. Given that UMI and LMI countries possess diverse social, economic, and institutional contexts in their respective regions, this segmented analysis seeks to uncover potential variations driven by these differences. In this categorization process, we adhere to the World Bank classification of countries. In our sample, the UMI category has 16 countries, while the remaining 15 countries are in the LMI category.

Financial Inclusion's Impact on Electricity Consumption Across All Countries

The comprehensive dataset encompasses information from both UMI and LMI countries. The findings of our analysis of this aggregated sample reveal a notable and statistically significant positive impact of financial inclusion on electricity consumption within the overall spectrum of countries (see Table 4). This observed positive relationship implies that an increased degree of financial inclusion in the selected countries leads to an increase in per capita electricity consumption among the populace. The surge in financial awareness and literacy makes individuals gain greater access to financial services and resources, which can result in improved economic conditions. This, in turn, leads to increased purchasing power and improved living standards among the population. This channel leads to higher electricity consumption.

Additionally, the collective improvement in financial inclusion contributes to poverty reduction, elevating the overall quality of life for citizens. This elevated quality of life is mirrored in the level of electricity consumption. The extensive adoption of digital payment mechanisms generates a demand for electronic devices, which, in turn, necessitates electricity for charging (Iqbal & Nawaz, 2021; Boutabba et al., 2020; Koomson & Danquah, 2021). The overall strengthening of financial inclusion emerges as a substantial and influential factor contributing to heightened electricity consumption across the diverse range of countries encompassed within the sample.

Upon closer analysis of the control variables, it becomes evident that Foreign Direct Investment (FDI), School enrolment, and unemployment are positively correlated with electricity consumption in the overall spectrum of countries studied. The rationale behind the FDI and School enrolment association with electricity consumption is

apparent. Higher FDI tends to stimulate increased economic activity, subsequently driving greater electricity consumption. Similarly, increased school enrollment reflects a greater number of students engaged in learning activities. This can lead to a higher demand for electricity in educational institutions and homes.

Nevertheless, the linkage between unemployment and electricity consumption might appear counterintuitive initially. However, this apparent contradiction can be elucidated by considering a range of factors that contribute to a positive relationship between these two variables. For instance, individuals facing unemployment could spend more time at home, resulting in heightened residential electricity usage. In economies characterized by elevated unemployment rates, informal sector endeavours—such as small-scale businesses and self-employment—may proliferate. These undertakings frequently depend on electricity for their operations, thereby augmenting overall consumption levels. Furthermore, governments grappling with unemployment challenges might channel efforts into infrastructure projects like construction and public works initiatives. These endeavours often necessitate considerable energy consumption for the operation of construction machinery, lighting, and other essential functions. These dynamics underline the multifaceted nature of the connection between unemployment and electricity consumption, highlighting the intricate interplay of economic, operational, and societal factors.

Inflation and population growth exhibit negative associations with per capita electricity consumption in the overall sample countries. The connection between inflation and electricity consumption is clear: elevated inflation is often accompanied by increased electricity prices, which in turn diminishes purchasing power. This translates to a decreased demand for electricity consumption. However, an inverse

relationship between population growth and electricity consumption can be attributed to several key factors including energy efficiency initiatives, urbanization trends, policy measures, technological advancements, industry shifts, cultural changes, and demographic shifts. While it might seem counterintuitive, this relationship is grounded in the complex interplay of these dynamics.

For the remaining control variables, the observed signs exhibit variation, contingent on the specific econometric model employed and the level of estimation precision achieved. In a comprehensive view, variables such as PCGDP, TGDP, InGDP, and Remittance Inflow are anticipated to exert a positive influence on electricity consumption. This expectation arises from the fact that an increase in these variables corresponds to heightened economic activity and augmented purchasing power. However, it's important to acknowledge that statistical outcomes can at times defy intuition. This is often attributed to the intricate interplay of multifaceted dynamics that underlie the relationship between these variables and electricity consumption.

Financial Inclusion's Impact on Electricity Consumption in UMI Countries

The impact of financial inclusion on electricity consumption among upper-middle-income (UMI) countries is elucidated in Table 5. Similar to the findings of the aggregated sample, our analysis for UMI countries exhibits a statistically significant (at the 1 percent level) positive influence of financial inclusion on electricity consumption. This relationship highlights that as financial awareness and literacy proliferate, individuals attain enhanced access to financial services and resources, consequently fostering better economic circumstances. Consequently, increased economic activity, an augmentation in purchasing power, and an elevation in living standards ensue among the populace, ultimately

culminating in increased electricity consumption. Further, the proliferation of digital payment mechanisms and the availability of credit through formal financial channels empower individuals to invest in electric and electronic devices. These advancements lead to higher electricity consumption due to the widespread adoption of electric and electronic devices (see Iqbal & Nawaz, 2021; Boutabba et al., 2020; Koomson & Danquah, 2021). Furthermore, increased financial inclusion often corresponds with urbanization and economic growth, characteristic of UMI countries. As urban areas expand and commercial and industrial sectors flourish, there is heightened demand for electricity to power various activities, ranging from manufacturing to services.

Regarding the relevant control variables in the context of UMI countries, school enrollment exhibits a positive yet non-significant impact. This observation is primarily attributed to the fact that UMI countries boast a higher median/average in school enrollment figures, albeit with limited variance. Additionally, our examination reveals that coefficients for unemployment and FDI are positively and significantly correlated, consistent with our initial observations within the aggregate sample.

Furthermore, the variable of population growth consistently presents negative and significant coefficients across most of the employed econometric estimation techniques. This outcome reaffirms the established direction and nature of the relationship between population growth and electricity consumption.

Additionally, the influence of per capita GDP, serving as an indicator of economic development, is found to exert a robust and significant positive impact on electricity consumption. Notably, the coefficients associated with inflation display positive trends, albeit lacking

statistical significance in most instances. This phenomenon is likely attributed to the generally low and relatively stable levels of inflation prevalent within UMI countries. Given the overall high per capita GDP in these nations, fluctuations in inflation appear to have a limited impact on electricity consumption patterns.

Concurrently, other control variables exhibit varying patterns in terms of coefficient sign and significance across distinct econometric techniques, rendering it challenging to unequivocally establish their relationships with electricity consumption. Considering this variability, a subset of these variables is omitted from the analysis, followed by their reevaluation across diverse econometric methodologies. This methodological approach is aimed at bolstering the robustness and reliability of our findings through a comprehensive set of checks.

Financial Inclusion's Impact on Electricity Consumption in LMI Countries

Within the context of lower-middle-income countries, this section elucidates the interrelationship between financial inclusion and electricity consumption. Our findings closely align with those observed in the aggregate data and data from upper-middle-income (UMI) countries. Notably, we discern positive and statistically significant coefficients (at the 1 percent level) for the financial inclusion index variable. This reaffirms the central tenet of our hypothesis that financial inclusion indeed exerts a positive impact on electricity consumption.

This phenomenon transpires as individuals gain access to formal financial services, leading to heightened economic activity and augmented purchasing power. This, in conjunction with technological progress and the surge in digital transactions, precipitates a heightened demand for electricity to power an array of devices, infrastructural

components, and burgeoning enterprises. Augmented living standards and investments in energy-efficient technologies further amplify energy consumption levels (see Iqbal & Nawaz, 2021; Boutabba et al., 2020; Koomson & Danquah, 2021). Concurrently, the forces of urbanization and industrialization contribute to this dynamic relationship. Collectively, financial inclusion fosters an environment conducive to elevated electricity consumption, reflecting the intricate interplay of economic advancement, technological adoption, and enhanced lifestyles.

Beyond the central variable of financial inclusion, the outcomes related to control variables within LMI countries closely mirror those observed in UMI countries. Similar to UMI countries, the positive association of unemployment and the negative correlation of population growth with electricity consumption are evident in LMI countries. The positive and significant coefficient attributed to remittances holds profound significance. Remittances play a pivotal role in lower-income economies by furnishing essential economic support, alleviating poverty, spurring consumption and investment, and ultimately contributing to heightened electricity consumption.

The coefficients associated with inflation, while negative, lack statistical significance. Notable variability is apparent among other control variables in terms of coefficient sign and significance across diverse econometric techniques, posing challenges in definitively establishing their relationships with electricity consumption. Considering this variability, a subset of these variables is omitted from the analysis, followed by their reevaluation across a range of econometric methodologies towards the robustness checks in the next section.

Table 4. Impact of Financial Inclusion on Electricity Consumption For Full Sample Countries from 2004 to 2021

Variables	(1) OLS	(2) RE	(3) FE	(4) PCSEs	(5) FGLS	(6) GMM	(7) DK
Enrol	0.645** (0.289)	0.623*** (0.116)	0.519*** (0.0929)	0.645*** (0.180)	0.645** (0.286)	2.668*** (0.580)	0.111 (0.0960)
Unemp	0.0334*** (0.00428)	0.00831*** (0.00308)	0.0147*** (0.00254)	0.0334*** (0.00169)	0.0334*** (0.00424)	0.124*** (0.0118)	0.00823*** (0.00132)
Pplgrowth	-0.508*** (0.0347)	-0.103*** (0.0224)	-0.0471** (0.0183)	-0.508*** (0.0209)	-0.508*** (0.0343)	-0.0652 (0.0661)	-0.0946*** (0.0139)
FDI	0.0378*** (0.00902)	0.00163 (0.00281)	0.00518** (0.00226)	0.0378*** (0.00909)	0.0378*** (0.00893)	0.00511 (0.0128)	0.0144*** (0.00332)
FIIIndex	0.332*** (0.0375)	0.0898*** (0.0199)	-0.0435** (0.0177)	0.332*** (0.0244)	0.332*** (0.0371)	1.037*** (0.0905)	0.101*** (0.0237)
Remit	-0.0412*** (0.00549)	0.0172*** (0.00379)	0.0217*** (0.00307)	-0.0412*** (0.00387)	-0.0412*** (0.00544)	0.120*** (0.0373)	0.00367** (0.00168)
PCGDP	-0.0236** (0.0113)	0.627*** (0.0405)	1.108*** (0.0434)	-0.0236*** (0.00425)	-0.0236** (0.0111)	0.0514 (0.0845)	0.00896*** (0.00288)
Inflation	-0.000497 (0.000911)	-0.000188 (0.000254)	-5.50e-05 (0.000203)	-0.000497 (0.000440)	-0.000497 (0.000902)	-0.000747* (0.000454)	-0.00105*** (0.000198)
TGDP	0.235*** (0.0603)	-0.0208 (0.0420)	0.0786** (0.0347)	0.235*** (0.0330)	0.235*** (0.0597)	-0.0915 (0.133)	-0.0673*** (0.0119)
InGDP	0.558*** (0.121)	-0.0680 (0.0772)	-0.0753 (0.0622)	0.558*** (0.107)	0.558*** (0.120)	-0.700*** (0.192)	0.358*** (0.0658)
Constant	-19.96*** (1.380)	-23.66*** (0.704)	-28.74*** (0.634)	-19.96*** (0.950)	-19.96*** (1.366)	-29.01*** (2.912)	2.532*** (0.345)
Observations	558	558	558	558	558	558	558
R-squared	0.664		0.740	0.664			0.469
Number of Economy		31	31	31	31	31	31

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5. Impact of financial inclusion on electricity consumption for UMI countries from 2004 to 2021

Variables	(1) OLS	(2) RE	(3) FE	(4) PCSEs	(5) FGLS	(6) GMM	(7) DK
Enrol	0.545 (0.512)	-0.0103 (0.149)	0.0427 (0.136)	0.545 (0.403)	0.545 (0.503)	0.277 (0.330)	0.0120 (0.0488)
Unemp	0.0209*** (0.00483)	0.00662** (0.00263)	0.0107*** (0.00248)	0.0209*** (0.00228)	0.0209*** (0.00474)	0.0233*** (0.00578)	-0.00227*** (0.000554)
Pplgrowth	-0.270*** (0.0455)	-0.0303 (0.0234)	-0.00788 (0.0216)	-0.270*** (0.0447)	-0.270*** (0.0447)	-0.140*** (0.0242)	-0.0211*** (0.00517)
FDI	0.0271*** (0.0102)	0.00219 (0.00254)	0.00376 (0.00232)	0.0271*** (0.00929)	0.0271*** (0.00997)	0.0283*** (0.00521)	0.00447*** (0.000888)
FIIndex	0.407*** (0.0491)	0.153*** (0.0298)	0.0568* (0.0297)	0.407*** (0.0288)	0.407*** (0.0482)	0.581*** (0.0632)	0.0193*** (0.00368)
Remit	-0.0432*** (0.00675)	0.0272*** (0.00432)	0.0310*** (0.00397)	-0.0432*** (0.00544)	-0.0432*** (0.00663)	-0.0666*** (0.00927)	-0.00101** (0.000370)
PCGDP	0.0545*** (0.0179)	0.571*** (0.0513)	0.836*** (0.0582)	0.0545*** (0.0116)	0.0545*** (0.0176)	0.122*** (0.0161)	0.00907*** (0.00233)
Inflation	0.00870 (0.00906)	0.00534** (0.00237)	0.00499** (0.00215)	0.00870 (0.0103)	0.00870 (0.00889)	-0.0137 (0.00872)	-0.00420*** (0.000716)
TGDP	0.220*** (0.0798)	-0.136*** (0.0484)	-0.0690 (0.0454)	0.220*** (0.0608)	0.220*** (0.0784)	0.203*** (0.0693)	0.00707 (0.00813)
InGDP	0.125 (0.174)	-0.140 (0.119)	-0.120 (0.110)	0.125 (0.111)	0.125 (0.171)	-0.280*** (0.101)	-0.0148 (0.00963)
Constant	-18.99*** (2.785)	-19.19*** (0.968)	-22.52*** (0.976)	-18.99*** (2.103)	-18.99*** (2.735)	-17.67*** (1.765)	4.397*** (0.264)
Observations	306	306	306	306	306	306	306
R-squared	0.565		0.727	0.565			0.285
Number of Economy		17	17	17	17	17	17

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 6. Impact of financial inclusion on electricity consumption for LMI countries from 2004 to 2021

Variables	(1) OLS	(2) RE	(3) FE	(4) PCSEs	(5) FGLS	(6) GMM	(7) DK
Enrol	-1.390*** (0.312)	1.129*** (0.203)	0.697*** (0.124)	-1.390*** (0.419)	-1.390*** (0.304)	1.004** (0.412)	-0.657* (0.346)
Unemp	0.0495*** (0.00824)	-0.00862 (0.0103)	-0.00358 (0.00636)	0.0495*** (0.00851)	0.0495*** (0.00805)	0.0633** (0.0278)	0.0439*** (0.00398)
Pplgrowth	-0.390*** (0.0433)	-0.244*** (0.0464)	-0.169*** (0.0283)	-0.390*** (0.0337)	-0.390*** (0.0423)	-0.259*** (0.0937)	-0.0741*** (0.0215)
FDI	0.00517 (0.0134)	-0.0122 (0.00811)	-0.0158*** (0.00480)	0.00517 (0.0154)	0.00517 (0.0131)	-0.00437 (0.0119)	0.0459*** (0.00582)
FIIIndex	0.350*** (0.0383)	0.154*** (0.0282)	-0.0931*** (0.0207)	0.350*** (0.0299)	0.350*** (0.0374)	0.562*** (0.0495)	0.173*** (0.0228)
Remit	0.0313*** (0.00863)	-0.0112 (0.00752)	-0.00779* (0.00451)	0.0313*** (0.00934)	0.0313*** (0.00843)	0.0408** (0.0201)	0.0215*** (0.00650)
PCGDP	-0.0345** (0.0133)	0.231*** (0.0464)	1.231*** (0.0586)	-0.0345* (0.0178)	-0.0345*** (0.0130)	-0.0685*** (0.0259)	0.0345*** (0.00263)
Inflation	-0.000731 (0.000639)	-0.000104 (0.000330)	0.000166 (0.000196)	-0.000731 (0.000606)	-0.000731 (0.000624)	-0.000242 (0.000280)	-0.000838*** (0.000163)
TGDP	0.425*** (0.0699)	-0.0313 (0.0744)	0.149*** (0.0471)	0.425*** (0.0505)	0.425*** (0.0682)	0.223* (0.125)	-0.122*** (0.0302)
InGDP	0.859*** (0.133)	0.0809 (0.118)	-0.113 (0.0711)	0.859*** (0.105)	0.859*** (0.130)	-0.168 (0.271)	0.341*** (0.0778)
Constant	-13.09*** (1.332)	-22.26*** (1.042)	-31.19*** (0.770)	-13.09*** (1.641)	-13.09*** (1.301)	-20.60*** (1.286)	5.341*** (1.231)
Observations	238	238	238	238	238	238	238
R-squared	0.801		0.842	0.801			0.712
Number of Economy		14	14	14	14	14	14

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Robustness Checks

To ensure the credibility and accuracy of the outcomes derived from our econometric model, we conduct a series of thorough robustness assessments. Through these assessments, a significant correlation between financial inclusion and electricity consumption is consistently identified across various countries considered in our analysis.

Sample selection and sensitivity: Initially, we conducted our analysis on the entire dataset before subsequently partitioning it into distinct categories: upper-middle-income countries and lower-middle-income countries. Upon re-running our analysis on these segmented groups, the outcomes remained steadfast and consistent, underscoring the stability of our findings across diverse sample sets.

Different Estimation Techniques: We employ an array of six distinct Estimation Techniques, including OLS, RE, FE, PCSEs, FGLS, and GMM. These techniques are applied to both the entire dataset and its subdivisions into two distinct groups. While the coefficient values may vary across the different estimation methods, our primary variable (financial inclusion index) consistently retains its significance at the 1 percent level, displaying a consistent directional effect across all estimation techniques and sample groups (see Tables 4-7).

Data Changes and Multicollinearity: In this phase, we take divergent approaches. Initially, we substitute the dependent variable—namely, per capita electricity consumption—with access to electricity (% of the population), followed by the reiteration of our analysis. Subsequently, we strategically omit certain explanatory variables to mitigate the potential influence of Multicollinearity. This entails the execution of our analysis across three distinct combinations. In the first scenario, we exclude two variables—Trade (% of GDP) and Industry (% of GDP)—due to their potential direct correlation with GDP per capita. In the second instance, we eliminate population growth, as its linear correlation with the financial inclusion index has the potential to distort our findings. Lastly, in the third case, we remove all three variables—population growth, Trade (% of GDP), and Industry (% of GDP). This comprehensive analysis encompasses two distinct independent variables: per capita electricity consumption and access to electricity (% of population). The outcomes,

including coefficient values and standard errors for the pivotal variable, financial inclusion index, are presented in Table 7. For the sake of conciseness, we have exclusively reported the estimated values derived from the GMM technique. Across all scenarios, it becomes evident that the financial inclusion index maintains its significance at the 1 percent level.

Outlier Treatment: We implement all the outlined scenarios from the preceding section using winsorized data, aiming to mitigate the potential influence of outliers on our outcomes. As depicted in [Table 7](#), we present the estimated values obtained through the GMM technique for the financial inclusion index. Notably, the discernible pattern of a positive and statistically significant association between the financial inclusion index and electricity consumption persists. This attests to the robustness of our estimation process and its decreased susceptibility to the distorting effects of outliers.

Autocorrelation, Cross-Sectional Dependence, Heterogeneity, and Endogeneity: We acknowledge the potential presence of several challenges in our panel data analysis, including Autocorrelation, Cross-Sectional Dependence, Heterogeneity, and Endogeneity. These challenges can introduce distortions into our estimated outcomes. Consequently, it is of paramount importance to address these issues effectively to uphold the credibility and soundness of our panel data analysis results. In our analytical approach, we deploy a suite of sophisticated estimation techniques, specifically FE, PCSEs, FGLS, and GMM, as previously mentioned. These methodologies have been chosen to systematically counteract potential biases that may arise due to these challenges, thus enhancing the robustness and reliability of our findings. Furthermore, we utilize the DK approach to mitigate issues such as heteroscedasticity and contemporaneous correlation. In all examined

scenarios, it becomes apparent that the significance of the financial inclusion index persists at the 1 percent level.

Table 7. Various robustness checks

		Reduced control variables	Full Sample	UMI Countries	LMI Countries
<i>Not winsorised Data</i>					
<i>Dependent</i>	less TGDP and InGDP		0.747*** (0.0875)	0.539*** (0.0586)	0.546*** (0.0415)
<i>Variable: PCElec</i>	Less Pplgrowth, TGDP, and InGDP		0.792*** (0.1142)	0.589*** (0.0452)	0.565*** (0.0456)
	less Pplgrowth		0.974*** (0.0829)	0.695*** (0.0920)	0.659*** (0.0558)
<i>Dependent</i>	less TGDP and InGDP		0.185*** (0.0249)	0.0913*** (0.0098)	0.246*** (0.0234)
<i>Variable: elec</i>	Less Pplgrowth, TGDP, and InGDP		0.224*** (0.0296)	0.081*** (0.0101)	0.256*** (0.0211)
	less Pplgrowth		0.236*** (0.0258)	0.119*** (0.0119)	0.237*** (0.0258)
<i>Winsorized Data</i>					
<i>Dependent</i>	less TGDP and InGDP		0.751*** (0.0951)	0.597*** (0.0743)	0.538*** (0.0455)
<i>Variable: PCElec</i>	Less Pplgrowth, TGDP, and InGDP		0.951*** (0.1203)	0.753*** (0.0496)	0.609*** (0.0515)
	less Pplgrowth		1.070*** (0.0750)	0.859*** (0.0866)	0.644*** (0.0514)
<i>Dependent</i>	less TGDP and InGDP		0.157*** (0.0225)	0.097*** (0.0090)	0.240*** (0.0249)
<i>Variable: elec</i>	Less Pplgrowth, TGDP, and InGDP		0.208*** (0.0270)	0.077*** (0.0098)	0.268*** (0.0216)
	less Pplgrowth		0.233*** (0.0203)	0.103*** (0.0083)	0.236*** (0.0260)

Conclusion and Policy Implications

This paper investigates the intricate relationship between financial inclusion and electricity consumption across UMI and LMI countries. The study emerges from the recognition of the vital roles played by electricity consumption and financial inclusion in enhancing economic development and improving human well-being. The empirical investigation employs an aggregate panel data analysis encompassing 31 countries and spanning the years from 2004 to 2021. The findings exhibit a consistent and robust positive impact of financial inclusion on electricity consumption across all examined countries.

Furthermore, the research delves into the specific contexts of UMI and LMI countries. Within UMI countries, financial inclusion maintains its positive and significant association with electricity consumption, highlighting the interconnected dynamics of economic growth, technological advancement, and lifestyle improvements. The control variables corroborate this relationship, with variables like unemployment and population growth exhibiting consistent patterns of influence. Similarly, in LMI countries, financial inclusion exerts a substantial positive influence on electricity consumption. The role of remittances emerges as noteworthy in contributing to elevated electricity consumption among lower-income populations.

The robustness checks applied to the empirical analysis validate the consistency of the findings. Multiple estimation techniques, control variable analyses, and sensitivity tests reinforce the observed positive relationship between financial inclusion and electricity consumption across different income groups.

In summary, this study offers valuable insights into the nexus between financial inclusion and electricity consumption. The outcomes

underscore the importance of financial inclusion as a catalyst for economic growth, technological advancement, and improved living standards, all of which culminate in heightened electricity consumption. The findings provide governments, policymakers, and stakeholders with a deeper understanding of how enhancing financial inclusion can drive positive changes in electricity consumption, contributing to the overall socio-economic development of nations. The implications of this research call for targeted policies aimed at promoting financial inclusion to not only improve access to financial services but also to bolster energy consumption patterns and foster sustainable development.

Appendix

Table A1: Number of Countries Selected for the Analysis

SL. NO	Economy	WB Classification	SL. NO	Economy	WB Classification
1	Brazil	UMI	17	Egypt	LMI
2	Bulgaria	UMI	18	India	LMI
3	China	UMI	19	Indonesia	LMI
4	Costa Rica	UMI	20	Kenya	LMI
5	Ecuador	UMI	21	Morocco	LMI
6	Guatemala	UMI	22	Pakistan	LMI
7	Kazakhstan	UMI	23	Philippines	LMI
8	North Macedonia	UMI	24	Tunisia	LMI
9	Malaysia	UMI	25	Ukraine	LMI
10	Mexico	UMI	26	Vietnam	LMI
11	Peru	UMI	27	Zimbabwe	LMI
12	Russian Federation	UMI	28	Bangladesh	LMI
13	Serbia	UMI	29	Bhutan	LMI
14	South Africa	UMI	30	Ghana	LMI
15	Thailand	UMI	31	Sri Lanka	UMI
16	Moldova	UMI			

Table A2: Causality Test Results

Null Hypothesis ²	Stats.	Prob.
Pcelec $\neq$ Enrol	3.0325**	0.0024
Pcelec $\neq$ Unemp	6.7822***	0.0000
Pcelec $\neq$ Pplgrowth	6.6234***	0.0000
Pcelec $\neq$ FDI	1.3825	0.1668
Pcelec $\neq$ FIIndex	10.1667***	0.000
Pcelec $\neq$ Remit	3.9926***	0.0001
Pcelec $\neq$ PCGDP	5.9382***	0.0000
Pcelec $\neq$ Inflation	3.3965***	0.0007
Pcelec $\neq$ TGDP	7.3266***	0.0000
Pcelec $\neq$ InGDP	2.3843*	0.0171

Note: Significance level: *** (1%) | ** (5%) | * (10%)

² “ $\neq$ ” implies does not cause

Figure A1: Status of Financial inclusion among upper-middle-income countries

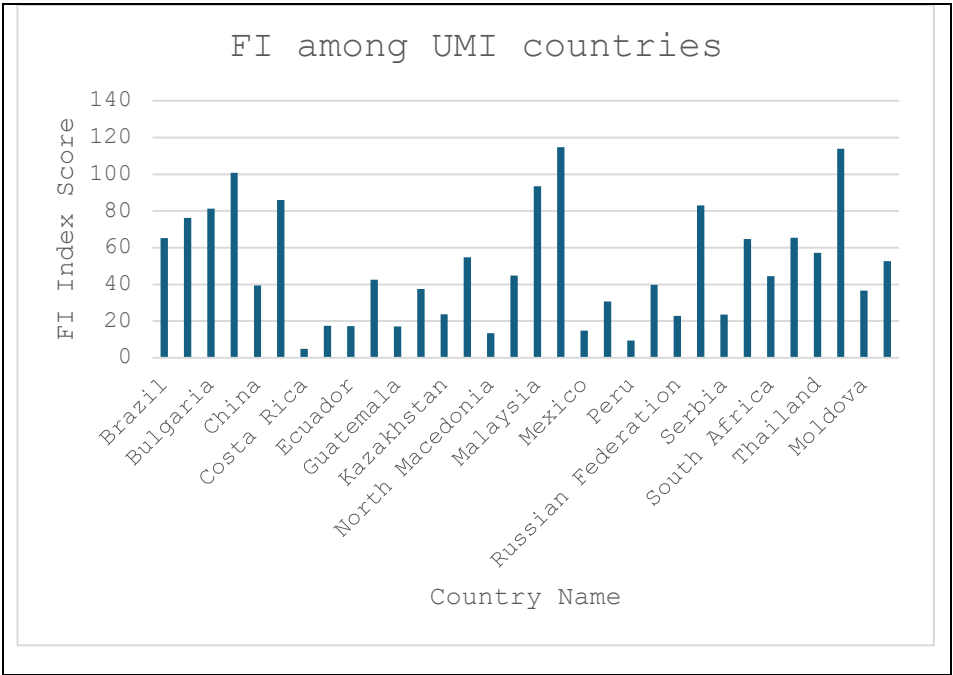
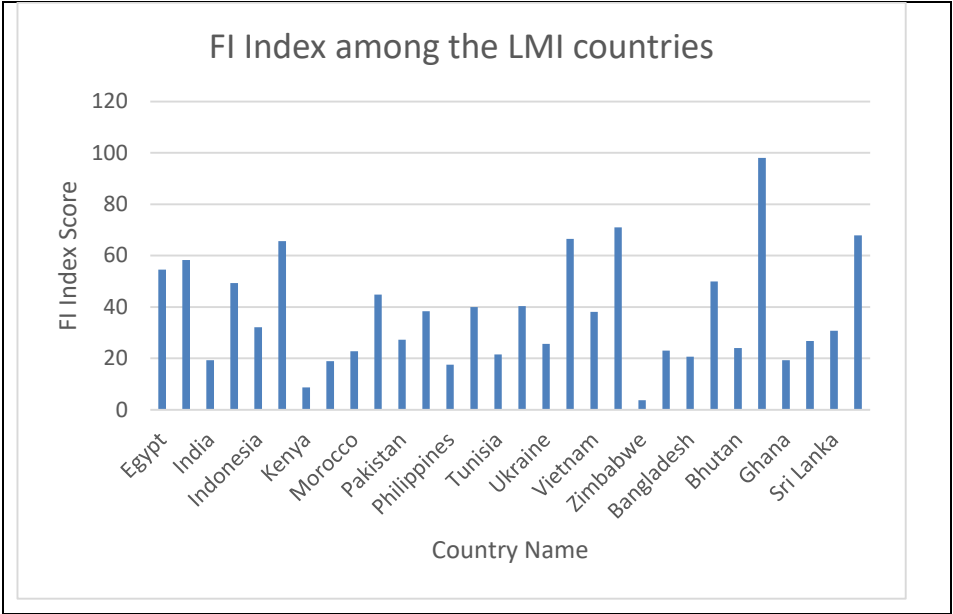


Figure A2: Status of Financial inclusion among lower-middle-income countries



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