# Examining the Linkages Between Remittances and Electricity Consumption in Shaping Energy Security in the Philippines

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Abstract

*Energy security is widely recognised to be critical for sustainable development. Despite being a significant recipient of remittances in the Asia-Pacific region and making progress towards improving access to electricity, energy security challenges continue to be a major concern for policymakers in the Philippines. The main goal of this paper is to investigate empirically the effects of remittances on electricity consumption in Philippines using an Autoregressive Distributed Lag modelling approach using annual time series data from 1977 to 2022. The results reveal a stable cointegrating relationship between remittances, real income, financial development, and electricity consumption. We find that an increase in economic growth, financial development, and remittances tends to stimulate electricity consumption both in the long run and short run. The findings withstand robustness checks and assist policymakers in better understanding the remittances-electricity consumption nexus. These insights underscore the importance of policy reforms to encourage remittances-dependent households towards clean energy adoption and efficiency initiatives. Moreover, financial sector reforms are essential to boost efficiency and effectively facilitate investment in renewable and clean energy infrastructure projects to address existing energy security challenges.*

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*Keywords: Remittances, electricity consumption, financial development, economic growth, investment, policy reforms.*

## 1. Introduction

Achieving energy security is crucial for achieving sustainable development in developing economies. In recent years, policymakers have increasingly focused on improving access to energy, bridging the gap between rural and urban areas, reducing dependency on fossil fuels, and encouraging investment in renewable energy. Strengthening energy security has been argued to stimulate economic growth, alleviate poverty by increasing business

opportunities and creating jobs and boost global competitiveness (Subramaniam *et al* 2023a). However, several economic, financial, political, and institutional factors influence energy security and make it a challenging issue for policymakers in many developing economies. The growing significance of remittances in the global financial landscape has further stimulated keen academic and policy interest in better understanding the implications of remittances for energy security. For instance, an emerging strand of recent studies notes that remittances help improve access to energy (Gamette *et al* 2025) and alleviate energy poverty (Barkat *et al* 2023; Subramaniam *et al* 2023a; Bano *et al* 2025).

In Southeast Asian countries such as the Philippines, rising electricity demand driven by economic growth and population growth, raises serious concerns regarding the availability of an affordable and reliable supply of electricity over time. Remittances play a pivotal role in the Philippines, accounting for nearly half of the total remittances to the East Asia and Pacific region, excluding China, and are expected to increase to $42 billion by 2024 (Ratha *et al* 2023). Several empirical studies have examined the effect of remittances on income inequality and poverty (Martinez *et al* 2007; Akcay 2022), growth (Ang 2009), environmental sustainability (Karasoy 2021), household expenditure (Tabuga 2008), rural development (Ang 2009) and quality of government (Tusalem 2018). Yet, the long-run and short-run effects of remittances on electricity consumption in developing economies remains understudied.

This paper addresses the important question of the role of remittances in stimulating electricity usage, proxied by electricity consumption, using annual time series data from 1977 to 2022 (covering more than four decades) in the Philippines. We undertake an empirical analysis of the long-run and short-run relationships between remittances and electricity consumption within a multivariate framework, including financial development and real income. Several factors strengthen the case for investigating the effects of remittances on electricity consumption in the Philippines. First, the Philippines is one of the top recipients of remittances in East Asia and the Pacific, after China. In 2023, remittance inflows in the Philippines peaked at an estimated $40 billion (US) and made up 9.2 per cent of GDP (Ratha *et al* 2023). Second, the Philippines has faced electricity outages or shortages since the 1990s. Over the period 2000 to 2023, electricity consumption per capita in the Philippines has increased by 89 per cent (International Energy Agency 2025).

Affordability of electricity remains a major issue, as the Philippines has one of the highest retail electricity prices worldwide. The cost of electricity is heavily affected by fluctuations in global markets and has raised concerns about energy security in the Philippines (Manansala and Tan 2021). Hence, high electricity prices have long been identified as critical issue in the Philippines (Ravago *et al* 2019; Abrigo and Ortiz 2024). Third, the electricity sector in the Philippines suffers from unmet demand, under-investment, diminished self-sufficiency and expected elevated levels of emissions (Mondal *et al* 2018; Taniguchi 2019). In 2023, coal accounted for nearly 63.5 per cent of total electricity generated

(International Energy Agency 2025). Compared to other sources of electricity generation, the share of electricity generated from coal has increased rapidly 2000 (International Energy Agency 2025).

Theoretically, remittances tend to outweigh other types of capital flow and influence energy consumption through several channels. Higher remittances increase the inflow of financial resources available to households and enhance their purchasing power. Household spending on energy consumption activities (for example, travel) rises (Chen *et al* 2023). Chen *et al* (2023) also note that remittances can indirectly influence energy consumption. For instance, higher spending by households creates a multiplier effect, stimulates the growth of other economic sectors and raises energy demand. Furthermore, remittances can foster the growth of human capital by increasing education and health, and economic productivity, therefore, boosting energy demand.

Several recent studies have investigated the relationship between remittances and energy consumption; however, their findings have been inconclusive. For instance, some studies (Akçay and Demirtaş 2015; Ari 2022) find that remittances tend to increase energy consumption, while others find that remittances decrease energy consumption (Chen *et al* 2023; Seury *et al* 2023). Furthermore, previous empirical studies on determinants of electricity consumption have overlooked the possible role of remittances (Zaman *et al* 2012; Kwakwa 2017; Sbia *et al* 2017; Sharma and Kautish 2019; Dokas *et al* 2022).

The contribution of the present paper is as follows: While previous studies have examined the role of remittance inflows on energy consumption, only a limited number of studies have analysed the long-run and short-run implications on domestic electricity consumption. Furthermore, despite domestic energy challenges and receiving substantial remittances, past empirical studies have focused on other Asian economies and overlooked the issue for the Philippines. Unlike past studies, we consider the possible role of financial development along with remittances in influencing electricity consumption and thus avoid the omitted variable-bias problem. Furthermore, unlike most studies, we examine the robustness of our findings by using alternative measures of financial development and estimators. This enables us to draw reliable conclusions based on our empirical results. The electricity sector is a significant part of the energy landscape in the Philippines, and understanding how remittances influence electricity usage is crucial for analysing energy security challenges. Our findings will assist policymakers in better understanding electricity demand and consumption, and the energy transition, including the potential to leverage remittances to tackle challenges in the energy sector.

The rest of the paper is organised as follows. The next section briefly reviews the literature. Section 3 outlines and discusses the data and empirical methodology. Section 4 discusses the empirical findings, while Section 5 reports the results from robustness analysis. Finally, Section 6 discusses the conclusion and policy implications.

## 2. Literature review

### *2.1 Review of Theoretical Literature*

Theoretically, the role of remittances on electricity consumption can be examined from three main perspectives. Firstly, Keynesian consumption theory proposed by Keynes (1936) argues that consumption is affected by disposable income. This implies that remittances increase household income and stimulates spending on goods and services including electricity demand (Adams and Cuecuecha 2013; Gupta *et al* 2009; Lamsal *et al* 2026). Furthermore, higher household income can also increase demand for electrical appliances which in turn increases electricity usage (Houthakker 1957; Deaton and Muellbauer 1980; Lamsal *et al* 2026). Similarly, remittances as an exogeneous income, can stimulate economic activity through the multiplier effect, and indirectly raise the demand for electricity consumption in the leisure and service sectors (Keynes 1936; Samuelson 1939; Taylor 1999; Lamsal *et al* 2026).

Secondly, the New Economics of Labour Migration (Stark and Bloom 1985; Taylor 1999) considers migration and remittances as ways to overcome credit and insurance market failures in developing economies (Lamsal *et al* 2026). Therefore, in developing countries such as the Philippines, households receiving remittances might invest in housing, appliances, and small businesses (Yang 2008; Alhassan 2023), which increases demand for electricity (Lamsal *et al* 2026). Thirdly, the Time Allocation Theory of Becker (1965) also helps in understanding how remittances influence households to allocate time towards consumption, education, and utilities (Lamsal *et al* 2026). Remittances can act as insurance against income shocks (Yang and Choi 2007) and promote higher electricity usage. In addition, remittances can also increase electricity usage through housing investment, urbanization (Osili 2004) and higher educational spending and related activities such as the use of computers, internet usage and e-learning (Edwards and Ureta 2003; Lamsal *et al* 2026).

### *2.2 Review of Empirical Literature*

Over recent years, an emerging number of studies have examined the relationship between remittances and energy consumption. However, the existing empirical literature does not provide conclusive evidence on the effects of remittances on electricity consumption. At the same time, the long-run and short-run effects of remittances on electricity usage have received limited attention in the literature. Overall, the existing literature consists of time series as well as panel studies focusing the effects of remittances on energy or electricity or renewable energy consumption. A major shortcoming of the existing literature is that the majority of studies have focused on aggregate energy consumption, providing limited insights for policymakers on how remittances affect electricity consumption in remittance-dependent economies. In addition, it should be noted that inferences on the long-run relationship between the variables based on time series-based test suffer from low power (Phillips and Moon 1999; Dash 2019).

The first strand of empirical studies consists of time series studies on remittances and energy consumption. Akçay and Demirtaş (2015) investigate the relationship between remittances and energy consumption in Morocco over the period 1975 to 2010 and find evidence of a cointegrating relationship between the variables. Their findings reveal that remittances directly increase energy consumption in the long and short run, but indirectly through industrialisation and economic growth in the long run. Chakraborty (2023) employed a nonlinear ARDL approach to examine the effects of remittances on renewable energy consumption in India over the period of 1990 to 2020 and found that negative shocks of remittances reduce renewable energy consumption. Rahman and Amin (2018) investigated the relationship between remittances and energy consumption in Bangladesh from 1980 to 2015 and found evidence of cointegration between variables and unidirectional causality from remittances to energy consumption in the long run.

Subramaniam *et al* (2023b) analysed the effects of remittances on renewable energy consumption in 5 top remittance-receiving developing economies over the period 1990 to 2016 and concluded that remittances increase renewable energy consumption. On the other hand, Seury *et al* (2023) investigated the effects of remittance inflow on renewable as well as non-renewable energy consumption in Jamaica over the period 1980 to 2019 and found that an increase in remittance inflows tends to reduce renewable energy consumption, highlighting a negative cointegrating relationship between the two variables. On the other hand, higher remittances lead to higher non-renewable energy consumption in the short run, with no long-run relationship found between the two variables.

Extending the analysis, Das *et al* (2021) investigated the relationship between renewable energy consumption, remittances per capita and GDP per capita in Bangladesh over the period 1980 to 2017 and found that the three series are cointegrated and there is unidirectional causality from remittances per capita to renewable energy consumption. In the short run, the authors found bi-directional causality between remittance and renewable energy consumption: they reinforce each other. Overall, these studies have relied on different empirical specifications, varied econometric methods, focused on individual country contexts and sample periods, and have arrived at different conclusions regarding the effects of remittances on energy consumption.

The second group of empirical studies have adopted a panel data approach to investigate the link between remittances and energy consumption. The main advantages of studies using a panel data approach are that it enables more accurate inference of the model coefficients, captures complex relationships, and helps lower measurement errors that could yield biased coefficient estimates (Hsiao 2007; Fisiha and McPeak 2026). Furthermore, panel data increases the efficiency of the estimator by raising the degrees of freedom (Dash 2019). Khan *et al* (2025) examine the effects of remittances on energy use in a

panel of five South Asian economies over the period 1990 to 2023 and find that remittances positively affect energy use.

Ari (2022) investigated the influence of remittances on energy consumption in five MENA economies over the period 1977 to 2014 and found that remittances and energy consumption are cointegrated. The findings indicate that remittances positively influence energy consumption, with the existence of a bidirectional causal relationship between remittances and energy consumption. Rahman *et al* (2021) examined the influence of remittances on energy consumption in four South Asian economies over the period 1976 to 2019. The authors find that remittances, energy consumption, urbanisation and GDP are cointegrated, and a 1 per cent increase in remittances leads to a 0.045 per cent increase in energy consumption in the long run.

Chen *et al* (2023) studied the effect of remittances on energy consumption in 44 developing countries over the period 1990 to 2019 within a multivariate setting (including energy prices, education, trade, and economic growth). However, the results suggested that higher remittances and energy prices tend to lower energy consumption, while increases in education, economic growth and trade openness are associated with higher energy consumption. Karmaker *et al* (2023) examined the effect of remittances on renewable energy consumption in 25 top remittance-receiving economies for the period 1990 to 2018, using a panel two-stage least squares estimation technique, and found that remittances positively affect renewable energy consumption, with the effect being higher for developing economies. Unfortunately, the empirical findings from existing panel studies are inconclusive and limit formulation of country-specific policy strategies to enhance the relationship between remittances and electricity consumption.

Overall, a limited number of empirical studies have examined the effects of remittances specifically on electricity consumption in developing economies. Lamsal *et al* (2026) investigated the short run and long run relationship between remittances and electricity consumption in Nepal using annual data from 1993 to 2023 and found that remittances increase electricity consumption. Das and McFarlane (2022) use annual data from 1976 to 2014 to study how remittances affect electricity consumption and electric power losses in Jamaica and note evidence of the long-run relationship between the variables. In the long run, remittances increase electricity consumption but have a negative effect on electric power losses. Sahoo and Sethi (2022) examined whether remittance inflow tends to stimulate electricity consumption in India over the period 1975 to 2017. Their findings reveal a long-run relationship between variables, with remittances stimulating electricity consumption and unidirectional causality from remittance inflows to electricity consumption. Overall, a major shortcoming of the empirical literature is that the effects of remittances on electricity consumption remains understudied. This suggests that further research using a long sample period is warranted to investigate the country-specific relationship between remittances and electricity consumption.

## 3. Data and empirical methodology

### *3.1 Data*

Our sample analysis covers the period 1977–2022 and is dictated by data availability. Following Das and McFarlane (2022) the main dependent variable, electricity consumption is measured as electricity consumption per capita, which in turn is computed by dividing total electricity power consumption by the population. The total electricity power consumption (in Gwh) is compiled by the Philippines' Department of Energy, and we extracted this data from the Economic and Social Database of the Philippine Institute for Development Studies, while population data are obtained from the World Development Indicators database (World Bank 2024).[2] The data for other independent variables, economic growth, financial development, and remittances, are also obtained from the World Development Indicators database. Following previous literature (Shahbaz and Lean 2012; Mukhtarov, *et al* 2020), economic growth is measured using real GDP per capita in domestic currency, while financial development is measured using domestic credit to the private sector (% of GDP). Finally, real remittances are measured by deflating personal remittances received in US dollars using the consumer price index and then converted to local currency using exchange rates, again taken from the World Development Indicators database.

Before further empirical analysis, we converted four series into their natural logarithms. The natural log values of the series are denoted as follows: real GDP per capita ($y_t$), electricity consumption per capita ($ec_t$), financial development ($fin_t$) and remittances ($rem_t$). Table 1 reports descriptive statistics on the variables. The computed means for remittances and electricity consumption are 0.743 and -3.254, respectively. The standard deviation for remittances is 0.305 and indicates relatively high variability. The computed value for skewness for remittances is -0.455, indicating that the distribution is skewed towards the left. The calculated value for kurtosis is 1.617, indicating a leptokurtic distribution.

Table 1: Descriptive Statistics

| | $ec_t$ | $fin_t$ | $y_t$ | $rem_t$ |
|---|---|---|---|---|
| Mean | *-3.254* | *1.468* | *5.012* | *0.743* |
| Median | *-3.245* | *1.476* | *4.962* | *0.876* |
| Std. Dev. | *0.143* | *0.162* | *0.110* | *0.305* |
| Skewness | *0.093* | *-0.514* | *0.856* | *-0.455* |
| Kurtosis | *1.744* | *2.539* | *2.353* | *1.617* |
| Obs | *46* | *46* | *46* | *46* |

Table 2: Correlation Matrix

| Variables | $ec_t$ | $fin_t$ | $y_t$ | $rem_t$ |
|---|---|---|---|---|
| $ec_t$ | *1.000* | | | |
| $fin_t$ | *0.716*** | *1.000* | | |
| $y_t$ | *0.897*** | *0.697*** | *1.000* | |
| $rem_t$ | *0.935*** | *0.611*** | *0.726*** | *1.000* |

Note: *** denotes statistical significance at 1% level.

Table 2 reports the correlation matrix between the variables. The correlation between remittances and electricity is 0.935, indicating a high positive correlation. The correlation between electricity and economic growth is 0.897, also indicating high correlation. All three variables are individually highly positively correlated with electricity consumption in the Philippines at the 1 per cent significance level.

*3.2 Econometric Methodology*

Following a review of the empirical literature, we specify the following multivariate model to examine the effects of remittances on electricity consumption.

$$ec_t = \alpha + \beta fin_t + \pi y_t + \varphi rem_t + v_t \quad (1)$$

where, α, β, π, φ are the coefficients to be estimated and $v_t$ is the error term. The empirical specification enables us to avoid the pitfalls of bivariate analysis by incorporating two additional control variables: economic growth (Chen *et al* 2023; Karmaker *et al* 2023; Khan *et al* 2025) and financial development (Dokas *et al* 2022). The effect of financial development on electricity consumption is an empirical matter. Financial development includes increased FDI inflows, a better stock market and bank activities and reforms, domestic credit to the private sector, and enhanced financial infrastructure which stimulates economic growth and raises demand for energy, including electricity (Sadorsky 2010; Shahbaz and Lean 2012; Shahbaz *et al* 2013). In addition, financial development increases access to financial resources that increase demand for big ticket (consumer durable) items that raise energy demand. This also indirectly stimulates commercial activities, and therefore increases energy use including electricity usage (Sadorsky 2011; Shahbaz *et al* 2013). In contrast, some studies have suggested that financial development can reduce energy consumption including electricity through the provision of easier and less costly capital for accessing energy-friendly technologies (Tamazian *et al* 2009; Islam *et al* 2013; Chang 2014; Mahalik and Mallick 2014; Durusu-Ciftci *et al* 2020).

To examine the long-run relationship between economic growth, electricity consumption and remittances, this study employs an autoregressive distributed lag modelling approach developed by Pesaran et al. (2001). This approach,

also known as the bounds test, is well-suited to small samples and robust to endogeneity and serial correlation. Furthermore, the approach allows the regressors to be either I(0) or I(1) and has been widely used in recent studies (e.g., Vyas *et al* 2023; Temsas 2024). However, the ARDL approach does have shortcomings. First, this approach cannot be used if the series are I(2) since this invalidates the use of the *F*-statistic and critical values which are computed for I(0) and/or I(1) series (Ali *et al* 2016; Menegaki 2019). Second, if the computed *F*-statistic falls between the critical value bounds for I(0) and I(1) series, then inference regarding the presence of cointegration is inconclusive (Pesaran *et al* 2001). Third, ARDL is a single equation approach and is inappropriate in the presence of multiple cointegrating relationships between the variables (Kripfganz and Schneider 2023).

We use augmented Dickey-Fuller (ADF) (Dickey and Fuller 1979, 1981) and Phillips-Perron (PP) (Phillips and Perron 1988) unit root tests to determine the order of integration of variables. The details of these tests are well-known and not provided here to conserve space. The ARDL regression approach involves estimating the following:

$$\Delta ec_t = a_0 + \sum_{i=1}^{p} b_i \Delta ec_{t-i} + \sum_{i=1}^{p} c_i \Delta fin_{t-i} + \sum_{i=1}^{p} d_i \Delta y_{t-i} + \sum_{i=1}^{p} e_i \Delta rem_{t-i} + \varphi_1 ec_{t-1} + \varphi_2 fin_{t-1} + \varphi_3 y_{t-1} + \varphi_4 rem_{t-1} + u_t \quad (2)$$

where $\Delta$ is the first difference operator, $p$ is the maximum lag length, and $u_t$ is the disturbance term. The first step in the ARDL bounds test involves determining if the variables are cointegrated. This involves testing the null hypothesis, $H_0$: $\varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = 0$ using equation (2) and then comparing the computed *F*-statistic with the *F*-critical value. If the computed *F*-statistic is greater than the *F*-critical value, we can reject the null hypothesis of no long-run relationship between the variables. Only when there is evidence of a long-run relationship do we proceed to estimate the long-run and the short-run elasticities. The long-run elasticities are estimated using a maximum lag of 2 using the Schwartz Bayesian Criterion with the following equation:

$$ec_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 ec_{t-i} + \sum_{i=0}^{n} \alpha_2 fin_{t-i} + \sum_{i=0}^{p} \alpha_3 y_{t-i} + \sum_{i=0}^{q} \alpha_4 rem_{t-i} + v_t \quad (3)$$

The short-run elasticities are estimated using:

$$\Delta ec_t = \alpha_0 + \sum_{i=1}^{m} \alpha_1 \Delta ec_{t-i} + \sum_{i=0}^{n} \alpha_2 \Delta fin_{t-i} + \sum_{i=0}^{p} \alpha_3 \Delta y_{t-i} + \sum_{i=0}^{q} \alpha_4 \Delta rem_{t-i} + \delta ECT_{t-1} + \varepsilon_t \quad (4)$$

The coefficient of the lagged ECM is expected to be negative and indicates the speed of adjustment parameter. If the coefficient is statistically significant, this confirms earlier evidence of a long-run relationship between the variables.

## 4. Empirical findings

### *4.1 Unit root results*

Table 3 presents the ADF and PP unit root test results. In all three cases, the null hypothesis of a unit root is not rejected in levels. This is indicated by the computed test statistic being below the critical values. However, the null hypothesis of a unit root is rejected in the first difference as the test statistics for all four series are statistically significant. Therefore, the variables are I(1). However, the ADF and PP unit root tests do not accommodate structural breaks, given various economic, political, and nature-based shocks. Consequently, these two tests are likely to be biased towards non-rejection of the unit root hypothesis. Perron (1989) has argued that ignoring structural breaks reduces the power of unit root tests to reject the unit root hypothesis. Therefore, we also employ a unit root test with a single structural break, developed by Zivot and Andrews (1992). Since the assumption of a single structural break might be too restrictive, we also extend the analysis and employ a unit root test with multiple endogenous structural breaks, proposed by Lee and Strazicich (2003). The results indicate that all the series are I(1). To conserve space, the detailed results are not provided here but are available upon request. Therefore, we can confidently employ the ARDL cointegration approach to assess and estimate the long-run relationship.

Table 3: Unit root test results

*ADF unit root test*

| *At Level* | *t-statistic* | *Prob.* | *At First Difference* | *t-statistic* | *Prob.* |
|---|---|---|---|---|---|
| $ec_t$ | -2.648 | 0.262 | $\Delta ec_t$ | -6.403*** | 0.000 |
| $fin_t$ | -2.590 | 0.287 | $\Delta fin_t$ | -4.146** | 0.011 |
| $y_t$ | -1.130 | 0.912 | $\Delta y_t$ | -4.983*** | 0.001 |
| $rem_t$ | 2.178 | 1.000 | $\Delta rem_t$ | -3.586** | 0.043 |

*Phillips-Perron unit root test*

| *At Level* | *t-statistic* | *Prob.* | *At First Difference* | *t-statistic* | *Prob.* |
|---|---|---|---|---|---|
| $ec_t$ | -2.788 | 0.209 | $\Delta ec_t$ | -6.627*** | 0.000 |
| $fin_t$ | -2.070 | 0.548 | $\Delta fin_t$ | -4.093** | 0.013 |
| $y_t$ | -1.212 | 0.896 | $\Delta y_t$ | -4.853*** | 0.002 |
| $rem_t$ | 2.532 | 1.000 | $\Delta rem_t$ | -3.608** | 0.041 |

Notes: constant and trend are included. The optimal lag length was selected using AIC criteria. *** and ** denotes significance at 1 per cent and 5 per cent levels, respectively.

*4.2 Cointegration results*

Table 4 reports the ARDL bounds test results for cointegration. When electricity consumption is the dependent variable, the computed F-statistic is greater than the *F*-critical value. Thus, the null hypothesis of no cointegration between the variables is rejected at the 1 per cent level, and we conclude that electricity consumption, economic growth, financial development, and remittances are cointegrated. This implies there is a long run cointegrating relationship between the three series. Economic growth, financial development and remittances are the long-run variables that influence electricity consumption.

Table 4: Cointegration test results

| *Dependent Variable* | | *Computed F-statistic* |
|---|---|---|
| $ec_t$ | | *7.131**** |
| $fin_t$ | | *3.504* |
| $y_t$ | | *1.504* |
| $rem_t$ | | *3.046* |
| *Critical Value* | *I(0)* | *I(1)* |
| *1%* | *4.865* | *6.360* |
| *5%* | *3.500* | *4.700* |
| *10%* | *2.873* | *3.973* |

Notes: Critical values are extracted from Narayan (2005). *** denotes significance at the 1 per cent significance level.

We also examine whether there is a cointegrating relationship when economic growth, financial development or remittances are individually considered as dependent variables. In all cases, the computed *F*-statistic is less than the *F*-critical value at the 1 per cent level, indicating that the null hypothesis of no cointegration between the variables cannot be rejected. Overall, the ARDL cointegration results reveal that there is a unique cointegrating relationship between electricity consumption, remittances, and economic growth in the Philippines over the period 1977 to 2022.

Table 5 reports the estimated long-run effect of remittances and economic growth on electricity consumption. In the long run, remittances have a positive effect on electricity consumption, implying that an increase in remittances possibly enhances the purchasing power of households, supports human capital growth, and increases electricity consumption. A 1 per cent increase in remittances leads to a 0.09 per cent increase in electricity consumption, holding other factors constant. This finding confirms empirically that remittances tend to boost electricity consumption. Consistent with our earlier theoretical expectation, an increase in remittances is likely to stimulate economic activity, promote human capital or financial capital formation and therefore indirectly

increase electricity consumption. This finding is consistent with the results of previous studies (see, for example, Chen *et al* 2023; Khan *et al* 2025).

Table 5: Estimated elasticities

| *Long-run (Dependent variable $ec_t$)* | | | *Short-run (Dependent variable: $\Delta ec_t$)* | | |
|---|---|---|---|---|---|
| *Variable* | *Coefficient* | *t-ratio* | *Variable* | *Coefficient* | *t-ratio* |
| $fin_t$ | 0.185** | 2.224 | $\Delta fin_t$ | 0.055*** | 3.024 |
| $y_t$ | 0.468*** | 4.129 | $\Delta y_t$ | 0.486*** | 3.715 |
| $rem_t$ | 0.092*** | 5.473 | $\Delta rem_t$ | 0.027** | 2.405 |
| *Constant* | -6.900*** | -14.469 | $ect_{t-1}$ | -0.296*** | -3.366 |

Notes: *** and ** denote statistical significance at the 1 per cent and 5 per cent significance level, respectively. The model diagnostics results with p-values in parentheses are as follows: $\chi^2_{Auto}$ (1) = 0.568 (0.451); $\chi^2_{Norm}$ (1) = 2.087 (0.352); $\chi^2_{RESET}$ (1) = 2.664 (0.103); $\chi^2_{HETERO}$ (1) = 1.147 (0.371).

The positive relationship between remittances and electricity consumption reflects negative spillovers of remittances for households receiving remittances, as they end up consuming more electricity (Chen *et al* 2023). An increase in remittances tends to boost income, promoting the purchase and import of high electricity-consuming appliances (Chen *et al* 2023). Remittances can boost electricity consumption through the financial development and industrialisation channel (Rahman and Amin 2018). Moreover, higher remittances can also boost industrialisation, improve access to credit and therefore increase electricity consumption. Moreover, remittances can enhance household savings which eventually ends up with the financial institutions and boosts lending to electricity projects, resulting higher electricity consumption (Chen *et al* 2023). Thus, our finding of the positive effects of remittances on electricity consumption is consistent with previous studies by Das and McFarlane (2022) and Sahoo and Sethi (2022).

Economic growth also has a positive effect on electricity consumption in the long run. A 1 per cent increase in economic growth is associated with a 0.47 per cent increase in electricity consumption in the long run, *ceteris paribus*. This finding is consistent with results obtained by previous studies focusing on Asian economies (see for example, Aqeel and Butt 2001; Yoo 2005; Chandran *et al* 2010; Shahbaz and Lean 2012; Solarin *et al* 2021). This implies that higher economic growth in the Philippines also stimulates electricity consumption, as an expansion of economic activities tends to drive higher electricity demand (Khan *et al* 2025). The positive relationship between economic growth and electricity consumption suggests that electricity policy frameworks in the Philippines should be developed and adopted in a manner that supports economic growth (Aqeel and Butt 2001; Zaman *et al* 2012).

Financial development also positively affects electricity consumption in the long run. We find that holding other factors constant, a 1 per cent increase in

domestic credit to the private sector tends to raise electricity consumption by 0.19 per cent in the Philippines. Financial development can also boost electricity consumption by increasing private sector financing towards electricity projects (Dokas *et al* 2022). The finding also suggests that financial development in the Philippines promotes business activities and increases demand for electricity-consuming appliances and therefore results higher electricity usage. The estimated positive effect of financial development on electricity consumption is consistent with Sbia *et al* (2017) and Solarin *et al* (2021) but contradicts evidence of an inverse relationship as obtained by Ansu-Mensah and Kwakwa (2022).

Table 5 also reports the estimated short-run elasticities. In the short run, we find that economic growth and remittances still have a positive influence on electricity consumption. In addition, financial development has a positive effect on electricity consumption in the short run. Thus, based on our findings reported in Table 5, we conclude that remittances, financial development, and economic growth stimulate electricity consumption in the Philippines both in the long run and short run. The coefficient of -0.296, for instance, implies that a deviation from long-run electricity consumption in this period is corrected by about 30 per cent in the following year – an indication that once shocked, convergence to equilibrium is moderately slow. The highly significant error-correction term also provides further evidence of the long-run relationship between variables (Banerjee *et al* 1998).

*4.3 Model diagnostics*

Table 5 also reports the model diagnostics results. The computed test statistics and the *p*-values suggest that our estimated model is well-behaved as it does not suffer from serial correlation, heteroscedasticity, or mis-specification. We also present CUSUM and CUSUM of Squares plots to examine the stability of the long-run relationship between the variables (see appendix). The plots indicate that the estimated relationship between electricity consumption, remittances and economic growth is stable over the period 1977 to 2022.

## 5. Robustness checks

*5.1 Using an alternative measure of financial development.*

We further reassess the sensitivity of our results by using an alternative measure of financial development – domestic credit to the private sector by banks (% of GDP), from the World Development Indicators database. The computed F-statistic when electricity consumption is the dependent variable is 7.718, confirming our results. The long-run and short-run elasticities are reported in Table 6. The estimated long-run and short-run coefficients are remarkably similar to our earlier findings summarised in Table 5. Financial development, economic growth and remittances positively influence electricity consumption both in the long run and short run. Hence, our findings are robust to this alternative measure of financial development.

Table 6: Using alternative measure of financial development (Robustness 1)

| *Long-run (Dependent variable $ec_t$)* | | | *Short-run (Dependent variable: $\Delta ec_t$)* | | |
|---|---|---|---|---|---|
| *Variable* | *Coefficient* | *t-ratio* | *Variable* | *Coefficient* | *t-ratio* |
| $fin_t$ | 0.186** | 2.233 | $\Delta fin_t$ | 0.055*** | 3.038 |
| $y_t$ | 0.468*** | 4.136 | $\Delta y_t$ | 0.486*** | 3.715 |
| $rem_t$ | 0.092*** | 5.489 | $\Delta rem_t$ | 0.027** | 2.411 |
| *Constant* | -6.898*** | -14.496 | $ect_{t-1}$ | -0.297*** | -3.374 |

Note: *** and ** denote statistical significance at the 1 per cent and 5 per cent significance level, respectively.

*5.2 Accounting for the Asian financial crisis*

We also extend the analysis and control for the Asian financial crisis in 1997 by including a dummy variable. Ang *et al* (2009) noted that the Asian financial crisis had a negative impact on remittance inflows into the Philippines from 1998 to 2001. We re-estimate the model using the ARDL estimation approach and report the long-run and short-run elasticities in Table 7. Comparing the elasticities in Table 5 and Table 7, we observe remarkably similar signs and sizes for both, in the long run and short run. The computed *F*-statistic when electricity consumption is the dependent variable was 7.026, again supporting the presence of a cointegrating relationship between the variables. The estimated long-run and short-run effects of remittances on electricity consumption remain positive and statistically significant. This confirms our earlier finding that remittances stimulate electricity consumption in the Philippines. Similarly, the estimated coefficients of financial development and economic growth are quite close. Hence, our findings are robust and not affected by the exclusion of the Asian financial crisis in the main model.

Table 7: Controlling for Asian financial crisis (Robustness 2)

| *Long-run (Dependent variable $ec_t$)* | | | *Short-run (Dependent variable: $\Delta ec_t$)* | | |
|---|---|---|---|---|---|
| *Variable* | *Coefficient* | *t-ratio* | *Variable* | *Coefficient* | *t-ratio* |
| $fin_t$ | 0.200* | 1.940 | $\Delta fin_t$ | 0.057*** | 2.798 |
| $y_t$ | 0.445*** | 3.027 | $\Delta y_t$ | 0.477*** | 3.517 |
| $rem_t$ | 0.093*** | 5.304 | $\Delta rem_t$ | 0.027** | 2.309 |
| *AFC1997* | -0.009 | -0.273 | *AFC1997* | -0.003 | -0.282 |
| *Constant* | -6.809*** | -11.277 | $ect_{t-1}$ | -0.289*** | -3.110 |

Notes: ***, **, * denote statistical significance at the 1 per cent, 5 per cent, 10 per cent significance level, respectively. We also included dummy variables for COVID-19 and the Global financial crisis and found similar results. The results are not reported here to conserve space but are available from the authors upon request.

*5.3 Using Alternative Estimators*

We next re-estimate the long-run elasticities using four different estimators. The estimated coefficients and their associated *p*-values are reported in Table 7. All the coefficients retain the same size. The size of the coefficients for all variables is quite close to our initial estimates. Therefore, the results in Table 7 confirm that financial development, economic growth, and remittances tend to positively influence electricity consumption.

Table 8: Alternative estimators (Robustness 3)

| *Variable* | *OLS* | *DOLS* | *FMOLS* | *CCR* |
|---|---|---|---|---|
| $fin_t$ | 0.049 | 0.072** | 0.063** | 0.060** |
| | (1.644) | (2.248) | (2.247) | (2.292) |
| $y_t$ | 0.556*** | 0.464*** | 0.542*** | 0.544*** |
| | (11.058) | (7.306) | (11.408) | (10.775) |
| $rem_t$ | 0.115*** | 0.113*** | 0.113*** | 0.113*** |
| | (16.712) | (15.595) | (16.511) | (17.150) |
| *Constant* | -7.416*** | -6.961*** | -7.327*** | -7.341*** |
| | (-37.544) | (-24.354) | (-39.437) | (-37.075) |
| *R-squared* | 0.976 | 0.991 | 0.977 | 0.977 |

Notes: *** and ** indicate statistical significance at the 1 per cent and 5 per cent levels, respectively. The reported values are coefficients. Figures in brackets are t-statistics.

## 6. Conclusion and policy implications

Energy security is key to sustainable development in developing economies. The surge in remittance inflows in developing economies, particularly in Southeast Asia, has sparked considerable discussion on their effects on the energy sector. In this paper, we have sought to investigate the linkages between remittances and electricity consumption in the Philippines. Our analysis helps answer the empirical question of how remittances affect electricity consumption in one of the major recipients of remittances, not just in Southeast Asia but globally.

Based on the time series analysis using annual data from 1977 to 2022, we have investigated the relationship between remittances and electricity consumption within a multivariate framework. By using advanced time series analysis to determine the cointegrating relationship between the variables and a series of robustness checks, we have presented a nuanced assessment of the long-run and short-run linkage between remittances and electricity consumption in the Philippines. The empirical results reveal that remittances, electricity consumption, economic growth, and financial development are cointegrated – implying that in the long run, they share a common meaningful economic relationship. We find that remittances, economic growth, and financial development are positively related to electricity consumption. This suggests that an increase in remittances, economic growth and financial development

is likely to positively influence electricity consumption in the long run and short run. We find the empirical results to be robust to different variable measurements and the use of alternative estimators.

Our results offer several important empirical insights for policymakers and, given the significance of electricity in the energy sector, suggest that remittances can play a critical role in addressing energy security challenges in the Philippines. Our findings suggest that a surge in migrant remittances, alongside economic growth, and financial development in the future, is likely to be positively correlated with higher electricity consumption, and therefore electricity demand. This necessitates significant sustained investment in renewable electricity infrastructure over the coming years to meet demand and ensure energy security. This could be achieved by encouraging diaspora investment in the renewable energy sector, by streamlining existing policies, removing unnecessary bottlenecks, and promoting public-private partnerships, including community-based energy projects, which will assist in building resilient energy infrastructure and ensuring energy security.

It is also vital for policymakers to promote the use of clean and renewable energy and improve households' access to efficient modern energy appliances. Furthermore, raising awareness on electricity-saving initiatives at the community level in rural areas and outer islands will be useful. By providing households with incentives to adopt clean and renewable energy, policymakers can improve the availability and reliability of electricity supply in the outer islands, without undermining economic expansion and environmental sustainability. Policymakers should also provide incentives for private investment in modern renewable technologies such as solar, wind, hydro, and geothermal energy systems. This could be in the form of various fiscal incentives, such as a zero VAT-rating on the sale of renewable electricity, allowing the duty-free import of renewable energy equipment, increasing the availability of tax rebates on the purchase of renewable energy equipment and cash incentives for rural renewable electrification projects. Furthermore, regulatory reforms to address renewable policy implementation delays and complicated permitting issues, can facilitate efficient movement of funds towards investment in clean energy, reduce fossil fuel dependency, and address existing energy challenges in the Philippines.

Another major policy implication is that policymakers should develop and implement innovative policies to improve financing by: (1) encouraging the flow of money transfers through formal financial systems; (2) reducing risks and transparency involved with formal transfers; (3) promoting financial inclusion, and financial literacy for remittances receiving households and competition in related markets; (4) modernising the regulatory environment in the financial system to support financial innovation; and (5) reducing the cost of remittance transfer. By carefully channelling remittance inflows into the energy sector using a blend of policy incentives, the Philippines can make significant progress towards achieving energy security.

By providing a nuanced analysis of the relationship between remittances and electricity consumption, this paper offers practical recommendations for leveraging remittances to support energy transition, address existing energy security challenges, and ultimately promote sustainable development in the Philippines. One limitation of this paper is that it has not examined the different channels through which remittances stimulate electricity consumption. Future studies should investigate the different channels through which remittances stimulate electricity consumption and renewable energy consumption and extend the analysis to other countries in Asia.

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**Data availability statement**
Data will be made available upon request.

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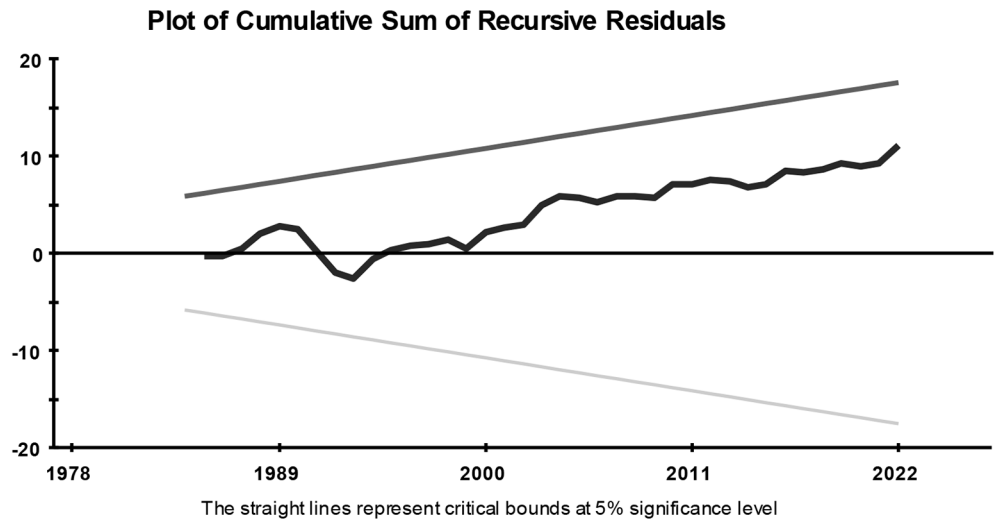
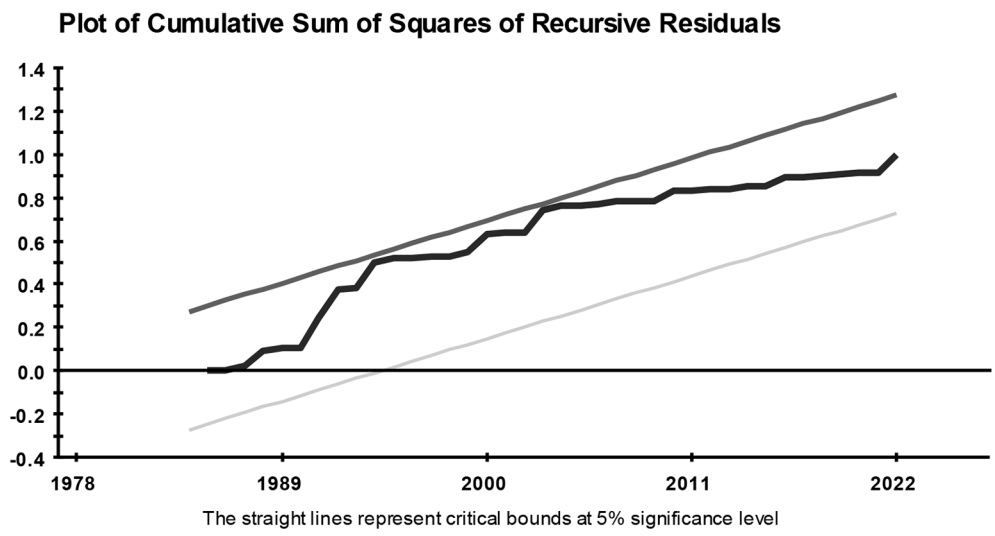
Appendix: Figure A1 – CUSUM and CUSUM of Square Plots






## Endnotes

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2. Full details of the definition of the electricity consumption is available at https://www.pids.gov.ph/databases.

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