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CAN REGIONAL INTEGRATION AND REMITTANCES ALLEVIATE ENERGY POVERTY? EVIDENCE FROM BRI COUNTRIES

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Abstract
Energy accessibility is crucial for achieving social welfare and sustainable development. Therefore, to reduce energy poverty policy makers should emphasize key elements. In this study we used two stages least squares (2SLS), instrumental variable method and panel fixed and random effects method and investigated the effects of workers' remittances and regional integration on energy poverty in 112 BRI countries from 2000 to 2020. Our findings revealed that energy poverty can be reduced through remittances and regional integration. Moreover, we observe that urbanization, economic growth, income poverty, and financial development are important mediating factors which effects energy poverty for both rural and urban populations. Our results also indicate that while rising income inequality and energy intensity influence energy poverty improved financial development, higher economic growth, and urbanization tend to decrease energy poverty. According to our findings, some suggestions are provided for achieving sustainable development goal no 7 to governments and policy makers which objects to the ease and accessibility of affordable and modern energy for rural and urban populations.

INTRODUCTION

Belt and Road Initiative is China's outward investment project that plays a key role in tackling global challenges and attaining sustainable development goals (SDGs) and settled by United Nations to achieve until 2030. Energy is an important driver of sustainable development goals through industrial, agricultural, and total productivity share. However, due to energy crises or higher energy prices, many people, especially in the developing world, have no access to energy use. Due to the rapidly growing world population, excess demand for energy consumption has provoked unpredictable challenges. Most BRI countries are also vulnerable to high energy poverty with a higher gap in energy demand and supply (Che et al., 2021). Eradicating energy poverty is important agendas of the United Nations Sustainable Development Goals to achieve high-quality development (UN, 2020). To attain this target foreign investment as well as aid can play a role in alleviating energy poverty (Munyanyi &

Churchill, 2022). For most of the developing countries, foreign investment and workers remittances can also play an important role in achieving sustainable development goals (OECD, 2006; IEA, 2010).

The concept of Energy Poverty originated in the early 70s in the UK, particularly in fuel use rights movements. Moreover, in the early 1980s, energy policy had become one of the biggest British government projects that further got prime importance as an important research dimension for European academia (Li et al., 2014). UNDP defined energy poverty as "a situation in which there is a lack of sufficient options to use reliable, high quality and clean energy to attain sustainable development". Early research studies define energy poverty as a situation in which people are unable to meet their living and heating expenses. Energy poverty is considered a complex multidimensional phenomenon (Sovacool et al., 2012). Energy poverty is a situation when an individual's domestic requirements related to energy consumption are not being fulfilled including basic lighting, cooking, and heating and moreover requirements for education and communication (Castaño-Rosa et al., 2019; Nussbaumer et al., 2012). In contrast, remittances have been determined as an important factor to promote physical and human capital, (Docquier & Rapoport, 2005) and hence reduces poverty (Adams Jr & Cuecuecha, 2010; Scott et al., 2022).

Energy poverty is an important issue to address because World Bank statistics 2017 indicated that 980 million population have no access to clean energy (World Bank, 2017). Most of the population has access to renewable energy but relies on conventional energy sources in developing countries which cause severe health effects (WHO, 2006). These traditional practices resulted in 114 deaths per one lack person due to health effects (Vardell, 2020) Even in this modern era of the world, approximately 580 million people in Africa have no access to electricity in 2019 and these figures are projected to rise in the coming years (IEA, 2020).

Health effects of energy poverty are even more serious in developing countries. (Sadath & Acharya, 2017) have found that energy poverty provoked asthma and tuberculosis in India. This is because energy poverty increases the burning of charcoal, and animal waste emits higher carbon emissions that affect human lungs. Increasing paraffin prices, necessary fuel for the urban poor, have reportedly driven Ethiopian homes into energy poverty (Alem & Demeke, 2020). Moreover, households also consumed a significant amount of charcoal, which has negative effects on the environment, the climate, and human health, in response to the sharp increase in kerosene prices. In addition, socioeconomic issues and gender equality were both exacerbated by energy poverty in emerging nations (Robinson, 2019). Only a 7% increase in energy consumption, according to (Chakravarty & Tavoni, 2013), would be necessary to supply all the world's energy-insecure people with their basic needs.

However, despite higher technological advancement and world development, hundreds of millions of people still lack the availability of basic energy requirements for lighting and cooking. (Aristondo & Onaindia, 2018) explored the evolution of energy poverty in Spain using time series data from 2005 to 2016. In their analysis, they captured different elements like the family desire to remain warm, past electric bill due and energy requirements for cooking and lighting. The results showed an increasing trend in energy poverty in Spain. Similar findings were computed by (Papada & Kaliampakos, 2016) for Greece. They also focused on the level of home comfort and expenditure on energy. Results pointed out that 58 percent of households in Greece are in energy poverty. (Meyer et al., 2018) conducted a different analysis than existing work on energy poverty in Belgium. The results found that almost twenty one percent of households in Belgium were facing these types of energy poverty.

Energy poverty is a more serious problem, particularly in rural areas of developing countries, than in developed countries. A cross-sectional household survey analysis in 2008 reported that 58 percent of rural households were in extreme energy poverty. In the case of Ghana, although rural energy poverty decreased from 88 percent to 82 percent from 2005 to 2013, but still rural population suffers twice as urban population (Adusah-Poku & Takeuchi, 2019). Research studies have also found the adverse socio-economic and welfare effects of energy poverty (Thomson et al., 2017; Zhang et al., 2017). Besides this, researchers and policymakers have determined

that remittances are excellent development source to eradicate poverty and make poor household capable to pay the price of cleaner energy use (Ratha, 2003).

Globally, there existed many studies on energy poverty in (BRI) emerging countries. Energy poverty prevailed in many developing countries including Pakistan. (Sher et al., 2014) found that in the provincial investigation, households in Punjab, Sindh, Khyber Pakhtunkhwa, and Baluchistan were deprived of energy poverty at 47, 51, 69, and 66 percent respectively. In relation to expenditure criteria, (Sambodo & Novandra, 2019) found that 53 percent of the total population is deprived of energy poverty in Indonesia. All these findings explored that energy poverty is a serious threat to developing countries, but the question arises which factors can be important to overcome energy poverty. Recently, (Barkat et al., 2023) conducted an empirical investigation and found that to decrease energy poverty financial development and remittances are significant factors to decrease energy poverty in 105 developing countries. Their study considered only developing countries, which included 90 middle-income countries and 19 low-income countries. Moreover, for the accessibility to clean fuels and technology for cooking, rural and urban distribution is missing. Following the recent study as a baseline, this study shows how remittances affect energy poverty in BRI countries. Moreover, this study also incorporates the regional integration aspect of the Belt and Road initiative project and considers urban and rural aspects for both the variables of interest.

1. Literature Review

2.1 Global Energy Poverty Perspectives

Analysis of energy poverty has been conducted from various perspectives by researchers. Earlier researchers used the proportion of household's energy expenditures, and a household prevails in energy poverty if more than 10 percent expenditures are incurred on fuel (Boardman, 1991). Moreover, other criterion including energy use and electricity consumption (Barnes et al., 2011; Pereira et al., 2010). Many researchers indicated energy poverty as a vulnerability due to lack of access, purchasing power and availability (Chester & Morris, 2011; Gouveia et al., 2019; Okushima, 2016). Existing literature also determined remittance as an important factor to improve household consumption (Mundaca, 2009; Ratha, 2003). In recent years many researchers explored the multidimensional indicators of energy poverty instead of using a single indicator to narrow down the scope. (Nussbaumer et al., 2012) constructed the Multidimensional Energy poverty Index (MEPI) indicates the availability and accessibility of modern energy. This index was a benchmark for many other studies to explore this nexus more broadly. Following this approach, (Acharya & Sadath, 2019) investigated the nexus between MEPI and socioeconomic status and concluded that energy poverty and lower socioeconomic status are highly and positively correlated in India. (Okushima, 2017) has explored three different dimensions of energy poverty for Japanese households in terms of energy cost, household income and energy efficiency of the house. Earlier research on household level energy poverty focused on access to clean fuel and access to electricity for housing comfort. (Andadari et al., 2014) analyzed the accessibility to clean fuel for Indonesia. Findings showed that till now, traditional ways of energy consumption are still higher accounted for one third of total energy consumption. (Mirza & Szirmai, 2010) investigated energy poverty analysis by constructing composite indicators and incorporated energy type, energy shortage and household size. Results showed that 24 percent of rural households in Pakistan are not convenient to access energy sources and 97 percent of rural households faces severe energy shortage.

The most important concern regarding household comfort is electricity use. (Aristondo & Onaindia, 2018) conducted a household survey in Spain by incorporating indicators like housewarming, utility bills and heating systems availability. Findings indicated that energy poverty was increasing with time rather than decreasing. Globally, demand for energy consumption is increasing and supply is at a lower level. Even in most European countries, families have no accessibility of proper cooling facility and have negative impact on working capacity, health and overall well-being of the people. A few studies also conducted empirical analysis at firm level. (Ayodele et al., 2018) explored the nexus between electricity supply to firms and total productivity in

Nigeria. Findings showed that insufficient electric supply to firms adversely affected total productivity and business level of small and large enterprises in Nigeria. This increase in income leads to mitigating poverty and provides ease for the household to use energy services , purchasing of electric appliances and enables it to pay the prices in the form of electricity bills 。 Remittances are more commonly used to pay for the energy facilitation in Tajikistan （ World Bank 2015 ） . Moreover, in China , remittances have reduced firewood consumption for heating and cooking purposes and hence reduced energy poverty (Xiujun et al., 2012).

2.2 Channels of Remittances and Energy Poverty Alleviation

Human Development, education and Energy Poverty

This section summarizes the nexus between human development , education, and energy poverty. The problem of energy also varies based on geographic and demographic conditions. (Liu et al., 2020) analyzed that increase in the proportion of clean energy does not increase household's total expenditure. Another finding revealed that the more education is, cleaner will be the cooking fuels will be and vice versa. Moreover, (Amin et al., 2020) indicated that in the long run, education significantly increases economic growth, while energy poverty has a negative and significant effect on economic growth. Abbas (2020) also investigated the impact of education and energy poverty for seven Asian countries. He applied Tobit and OLS model for empirical investigation and concluded that education has negative relation with energy poverty. Rahut (2019) also found that higher education creates health consciousness and motivates the use of cleaner energy sources for cooking. Moreover, in this dimension, (Sharma et al., 2021) argues that more expenditures on education are directly associated with energy poverty in India. Particularly in case of households having lower income, expenditures on education are lower because of energy poverty. (Acharya & Sadath, 2019) investigated the nexus between education, human development, and energy poverty in India for two different time spans from 2000 to 2005 and 2011-2012. They constructed a multidimensional energy poverty index and findings showed that education imposes higher effects in reducing energy poverty as compared to income. (Koomson & Danquah, 2021) investigated that financial inclusion reduces energy poverty by increasing affordability range for energy use.

Income Poverty Chanel

Many empirical studies have reported positive effects of remittances on household income in recipient countries. Remittances increase income level and make them capable of paying the price of energy use in the form of electricity and gas bills, purchasing appliances, lighting sources and availing better cooking facilities. Moreover, for short and long-term energy consumption remittances are used and higher energy consumption leads to industrialization and enhances total productivity (Akçay & Demirtaş, 2015).

Similarly in China, remittances have decreased firewood consumption in rural areas and have positive impact on education and health. Moreover, reduced firewood burning has overcome deforestation and protected nature (Xiujun et al., 2012).

Income Inequality Chanel

Over the past few decades, numerous studies have investigated the effects of remittances on developed and developing economies. However, till now empirical findings are not conclusive. (Gustafsson & Makonnen, 1993) conducted a micro-level study by collecting sample survey data from 1986 to 1987. Findings showed that remittances reduce income inequality in Lesotho. (Barham & Boucher, 1998) conducted survey analysis in Nicaragua and examined that remittances have negative effect on inequality when they are taken as exogenous factors and have positive effect when taken as endogenous factor. At macro level, (Acosta et al., 2008) investigated the impact of remittances on poverty and income inequality in Latin American and Caribbean countries and found that remittances significantly reduce poverty and income inequality in selected countries. Portes (2009) have also found similar findings while analyzing for a panel data set of 46 countries from 1970 to 2000.

Similarly, Anyanwu and Erhijakpor (2010) investigated the remittances and poverty nexus in 33 African countries from 1990 to 2005. In another study, (Satti et al., 2016) also conducted similar analysis for Pakistan and concluded that economic growth and remittances significantly reduces poverty in Pakistan. Recently, (Barkat et al., 2023) conducted panel data analysis for 109 developing countries and concluded that remittances significantly decrease rural and urban energy poverty.

Economic Growth Chanel

Empirical evidence on growth remittance nexus has got more attention from research scholars. Most of the recent studies have found positive effects of remittances on economic growth especially in developing countries (Bashir, 2020; Bucevska, 2022; Chaudhary, 2022; Safdar et al., 2022). Moreover, in the case of developing countries in Asia (Hien et al., 2020) have found positive and significant effect of remittances on economic growth. (Jena & Sethi, 2020) have found positive and significant effects of remittances on exchange rate and economic growth. Lawal et al. (2020) and (Salisu et al., 2021) have conducted the remittances and growth nexus for African developing countries and have found positive and significant effect of remittances on economic growth.

Theoretical Framework, Data and Methodology

3.1 Theoretical Framework

3.1.1 Vicious Circle of Energy Poverty

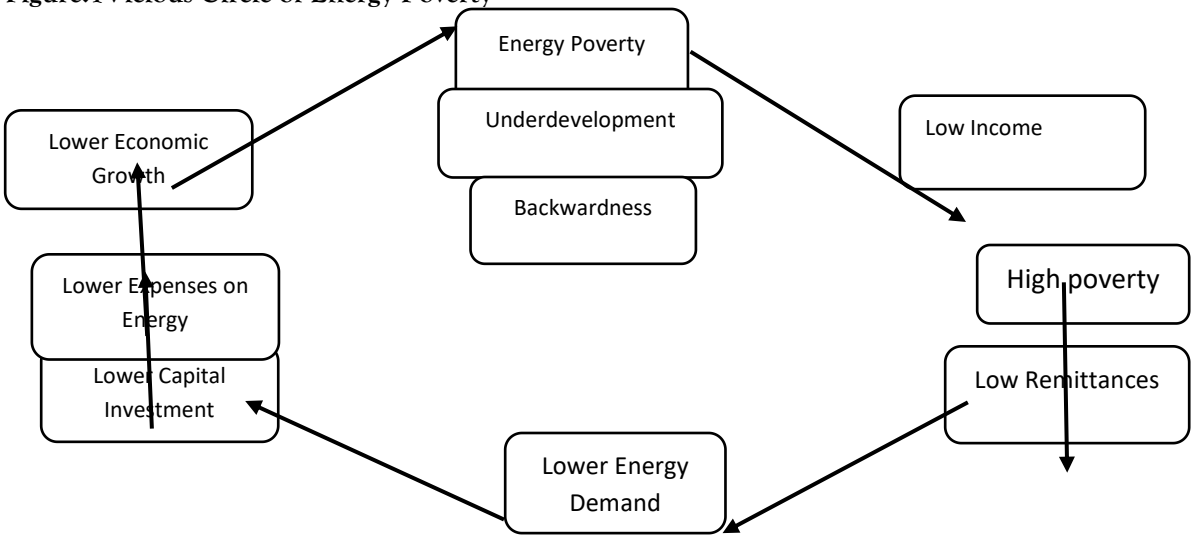
This study extends Nurkse's model of Vicious Circle of poverty which says that "A country is poor because it is poor". However, according to Nurkse, this poverty is divided into two types:

1). Vicious circle in demand side

2). Vicious circle in supply side

In the supply side vicious circle, in case of under developing countries, individuals have lower level of savings due to lower income. This lower income leads to a lower level of investment which reflects lower total productivity and in turn this phenomenon is largely due to lack of capital. The demand side of the vicious circle of poverty reflects the purchasing power of the people which is again lower due to lower productivity. This lower level of productivity is related to the lower level of capital utilized in the production process. Due to lower income, demand will be lower and again the circle of vicious poverty will be repeated. Following this model as the baseline, the present study incorporates a vicious circle of energy poverty and determined some exogenous and endogenous factors to break the vicious circle of energy poverty. Based on existing literature on energy poverty, a country is energy poor because it has lower level of remittances (Barkat et al., 2023) which leads to lower economic growth (Safdar et al., 2022) Such lower economic growth enhances lower level of income (Gaaliche & Gaaliche, 2014) and increased income inequality (Satti et al., 2016). This situation of poverty and inequality pushes the individuals not to afford energy facilities and hence energy poverty prevails。

Figure.1Vicious Circle of Energy Poverty



From the existing literature support, energy poverty is linked with the lower income level of households, and in such a situation extreme poverty prevails. In a situation of higher poverty, people have lower energy demand because they focus on the necessities of life like food, health and shelter. When there is lower demand for energy, then a lower level of capital will be invested in energy. In such a situation, there will be low economic growth and hence energy poverty。When the situation of energy poverty continues，households remain backward and underdeveloped。Therefore，a continuous circle related to energy poverty remains in operation which keeps the household poor in energy consumption。

Data and Methodology

Data Description

Our sample consists of 112 BRI countries which are divided into three income groups from the period 2000 to 2020 according to the World Bank classification. (For list of countries and classification with respect to income groups See table A in the appendix).

Existing studies have used different proxies of energy poverty based on micro and macro level analysis. At micro level surveys data have been collected from households regarding availability and usage of energy while at macro level, more commonly used proxies to measure energy poverty are access to clean fuel technology for cooking and access to electricity (Nguyen & Nagase, 2019)An increase in the accessibility of these variables indicates a decline in energy poverty. For explanatory variables personal remittances (REM) as variable of interest and additional control variables include GDP at constant US$ 2015, Gini index as measure of income inequality, energy intensity（EI），urban population（UP），（FD）is the financial development which measures as percentage of GDP the share of domestic credit to private sector and additionally，regional integration（RI）as dummy variable and selected 0 before 2013 and 1 after 2013.

3.2.1 Model and Estimation Methodology

We used fixed effect and random effect models as benchmark estimation techniques and for econometric reliability pooled OLS and Two stages least squares instrumental variable techniques are also used. The model specified for this study is mentioned as：

$$E_{it} = \beta o + \beta 1 REM_{it} + \beta 2 Z_{it} + \mu_i + \epsilon_{it} \quad (1)$$

Where E_{it} is the measure of energy poverty as described earlier，“i” presents countries and “t” indicates time（2000 to 2020）. REM denotes personal remittances, and Z denotes set of control variables，μ_i indicates unobserved specific effects and ϵ_{it} indicates error term.

Endogeneity Problem and Sources

The endogeneity problem is the most common and serious issue particularly in panel data analysis.

It is important to address this problem because it leads to biased and inconsistent estimates when ignored (Li et al., 2021 ; Ullah et al., 2021). We employ two stages least squares (2SLS) instrumental variable techniques to address the endogeneity problem. We follow the study of (Barkat et al., 2023) and used poverty and education as exogenous factors to control endogeneity issue for energy poverty. Moreover, we applied (ivreg2) command which is recently modified in STATA and gives post estimation results for over and under identification, Validity of instruments and removal of collinear variables.

Table 1 Descriptive Statistics:

Table 1 presents the descriptive statistics of the selected variables used in this study。Access to clean fuel technology have mean value of 56.79 which seems quite lower in selected BRI countries。For urban population the average value of access to clean technology for cooking is 67.87 while for rural areas its average value is 46.92 which indicates that rural energy poverty is much higher and a hard challenge to tackle。 Similarly, access to electricity for the overall population has an average value of 73.56 but for urban population its average value is 86.64 and for rural population its value is 64.84 which is quite lower in comparative sense。 These statistics indicate that both the proxies of energy poverty have lower values and particularly for rural areas energy poverty is a crucial issue to be addressed and tackled. The statistics for all the variables are given below in table 1.

Table 2 presents the effects of remittances on access to clean fuel technology on the overall population using pooled OLS, fixed and random effects as baseline and 2SLS instrumental variable results. Hausman test reported random effect model as appropriate for the selected model therefore only random effect model results will be discussed with pooled OLS and 2SLS technique.

Table 2 shows that remittances have positive and highly significant coefficient from all the estimates. Gross domestic products, financial development, and urbanization have positive and significant relations with dependent variables. Coefficients of gini and energy intensity are negative and significant in relation to accessibility to clean fuel technology. As income inequality increases, accessibility decreases as expected and higher energy intensity also decreases accessibility. More importantly, dummy variable for regional integration in BRI countries have positive and significant relation with dependent variable. This finding reveals that the BRI project is more important in reducing energy poverty in selected countries because value of coefficients from all estimates shows higher effects (2.01 to 5.96 percent). Some diagnostic tests are also conducted for under-identification, validity of instruments and weak

Variables	Obs.	Mean	Std. Dev	Min	Max
ACT	2352	56.79	39.18	0.1	100
ACTU	2352	67.87	37.34	0.2	100
ACTR	2352	46.92	41.20	0.7	100
AE	2352	73.56	32.37	1.25	100
AEU	2352	86.64	20.73	3.42	100
AER	2352	64.82	39.01	0.52	100
FD	2352	41.07	35.66	0.18	254.66
GDP	2352	7250.107	12330.59	255.10	112417.9
GINI	2352	38.69	8.005	1.254	67.7
EI	2352	5.36	3.27	1.33	28.2
POV	2352	16.46	21.14	0	91.5
REM	2352	4.80	6.91	0.98	53.83
UP	2352	50.67	20.48	8.25	95.51

instruments. Anderson Canon LM statistics value is significant which indicates there is no problem of under identification. Cragg-Donald Wald F-statistics is greater than all critical values indicate instruments are not weak. Sargan test is used to check either equation is over or under identified and statistics shows that selected instruments are valid, and equation is exactly identified.

Table 2. Access to clean fuel technology for cooking (Percentage of total population)

Variables	Pooled OLS Estimates	Fixed Effect Estimates	Random Effect Estimates	2SLS- IV Estimates
REM	0.703*** 0.737	0.205*** 0.380	0.209*** 0.381	5.59*** 0.484
GDP	0.000198** 0.000717	0.000718 0.0007	0.00016* 0.00067	0.00050*** 0.00089
GINI	-0.819* 0.0641	-0.097* 0.040	-0.096* 0.039	-0.315*** 0.118
FD	0.295*** 0.161	0.032*** 0.009	0.035*** 0.009	0.296*** 0.027
EI	-0.978*** 0.158	0.772*** 0.471	0.841*** 0.044	-0.515** 0.271
UP	1.093 0.028	-0.285*** 0.083	-0.278*** 0.084	1.416*** 0.057
RI	2.62** 1.03	2.38*** 0.29	2.01*** 0.283	5.969*** 1.77
Constant	22.41***	19.22 (0.000)	14.93 (0.000)	-46.40 (0.000)
R^2	0.63	0.56	0.56	0.66
Adj. R^2	0.63	0.55	0.56	
Anderson. Canon LM. Stat				156.81 0.000
Cragg-Donald F-stat				166.720
Sargan. Stat				0.000
No of Obs.	2352	2352	2352	2352
F-Stat P-value	577.55 (0.000)	169.96 (0.000)	1309.17 (0.000)	215.47(0.000)

****, ** and * presents P-value less than 0.01, 0.05 and 0.1 respectively*

Table 3 reports the results of access to clean fuel technology for cooking in urban population. Remittances exert a positive and significant effect on accessibility of urban population. Financial development, urbanization and regional integration imposes positive and significant effects from all the estimates. Gini coefficient shows insignificant relation with access to clean fuel technology for cooking in urban population because no matters how much inequality is, yet maximum population have accessibility to clean fuel technology. As expected, regional integration dummy shows highly positive and significant effect explaining the importance of BRI in removing energy poverty. One point increase in regional integration increases accessibility from 1.81 to 5.76 percent.

Table.3
Access to clean fuel technology (Percentage of urban population)

Variables	Pooled OLS Estimates	Fixed Effect Estimates	Random Effect Estimates	2SLS- IV Estimates
REM	0.050* 0.039	0.050* 0.039	0.063* 0.401	5.322*** 0.574
GDP	-0.00018** 0.000753	-0.00018* 0.000754	-0.000834 0.000715	0.00044*** 0.000105
GINI	0.0511 0.042	0.051 0.049	0.055 0.042	0.0961 0.14
FD	0.038*** 0.104	0.038*** 0.020	0.041*** 0.010	0.306*** 0.032
EI	-0.570*** 0.104	-0.571*** 0.089	-0.56*** 0.088	-0.90*** 0.321
UP	0.545*** 0.049	0.545*** 0.50	0.619*** 0.046	1.322*** 0.068
RI	2.21*** 0.304	2.22*** 0.303	1.815*** 0.298	5.76*** 1.90
Constant	53.08*** 3.33	94.33 (0.000)	-11.606 (0.000)	-53.76(0.000)
R^2	0.98	0.39	0.85	0.62
Adj. R^2	0.97	0.38	0.78	
Anderson. Canon Corr. LM. stat				156.181 0.000
Cragg-Don F-stat				166.720
Sargan Statistics				0.000
No of Obs.	2352	2352	2352	2352
F-Stat P-value	967.13 (0.000)	94.33 (0.000)	784.76 (0.000)	123.89(0.000)

****, ** and * presents P-value less than 0.01, 0.05 and 0.1 respectively*

Table 4 presents the results of estimates for rural population. As expected, remittances, GDP growth, financial development and urbanization show positive and significant effects for rural population. Energy intensity and gini coefficients show negative and significant effects for access to clean fuel technology for cooking in rural population. Regional integration shows highly positive and significant results as 1 point increase in regional integration increases rural population accessibility by 2.7 and 2.25 percent from the estimates 。These findings highlight the importance of BRI project regarding energy poverty in rural areas. Diagnostics tests show that instruments are strong, valid and equation is exactly identified.

Table. 4 Access to clean fuel technology (Percentage of rural population)

Variables	Pooled OLS Estimates	Fixed Effect Estimates	Random Effect Estimates	2SLS- IV Estimates
REM	0.328*** 0.046	0.33*** 0.05	0.326*** 0.05	4.499*** 0.456
GDP	0.00029*** 0.000874	0.00029*** 0.0008	0.00042*** 0.000816	0.000718*** 0.0008
GINI	-0.283***	-0.279***	-0.281***	-0.88***

	0.0487	0.047	0.051	0.111
FD	0.033*** 0.012	0.041*** 0.013	0.038*** 0.013	0.317*** 0.025
EI	-0.303*** 0.102	-0.3*** 0.1	-0.284*** 0.2	-0.15* 0.25
UP	0.533*** 0.057	0.512*** 0.06	0.630*** 0.052	1.18*** 0.054
RI	2.762*** 0.352	2.81*** 0.352	2.251*** 0.343	5.13*** 1.67
Constant	17.65*** 3.86	26.18 (0.000)	20.28 (0.000)	-21.33(0.000)
R^2	0.97	0.56	0.53	0.63
Adj. R^2	0.97	0.56	0.53	
Anderson. C. F-tat				156.181 (0.000)
Cragg-Donald F.stat				166.720
Sargan Stat				0.0000
No of Obs.	2352	2352	2352	2352
F-Stat P-value	874.90 (0.000)	117.93 (0.000)	920.41 (0.000)	247.79 (0.000)

****, ** and * presents P-value less than 0.01, 0.05 and 0.1 respectively*

Table 5 presents the estimates of the second proxy of energy poverty used in this study (access to electricity) . Remittances , financial development and urbanization have positive and significant relationships to electricity accessibility. One percent increase in remittances increases electricity access between 0.124 to 6.39 percent. Gini coefficient and energy intensity shows negative and significant effect to the dependent variable. Dummy variable for regional integration again shows a highly positive and significant relation with electricity accessibility. Diagnostics show that instrumental variables applied are strong, valid and equation is exactly identified.

Table.5

Access to electricity (Percentage of total population)

Variables	Pooled OLS Estimates	Fixed Effect Estimates	Random Effect Estimates	2SLS- IV Estimates
REM	1.143*** 0.054	0.326*** 0.046	0.124*** 0.045	6.39*** 0.49
GDP	2.87*** 0.532	0.000427*** 0.000816	-0.00045 0.000755	0.00016*** 0.0009
GINI	-0.664*** 0.047	-0.281*** 0.0485	-0.254*** 0.046	-0.51*** 0.12
FD	0.076*** 0.0132	0.038*** 0.012	0.048*** 0.011	0.277*** 0.027
EI	-0.617*** 0.125	-0.248*** 0.102	-0.342*** 0.099	-1.40*** 0.277
UP	0.390*** 0.025	0.630*** 0.052	1.065*** 0.048	1.18*** 0.058

RI	0.925* 0.342	2.25*** 0.343	4.133*** 0.328	3.87** 1.82
Constant	-38.52(0.000)	20.2869 (0.000)	30.291(0.000)	-5.02 (0.000)
R^2	0.70	0.53	0.43	0.73
Adj. R^2	0.70	0.53	0.42	
Anderson. C. F-stat				156.181 0.000
Crac.Don F-st				166.720
Sargan stat				0.000
No of Obs.	2352	2352	2352	2352
F-Stat P-value	813.65(0.000)	920.41 (0.000)	1772.18 (0.000)	145.42 (0.000)

****, ** and * presents P-value less than 0.01, 0.05 and 0.1 respectively*

Table 6 presents the results of estimates for urban population having access to electricity. As expected, remittances , financial development , and urbanization show positive and significant relation with electricity access in urban population. One percent increase in remittances increases accessibility between 0.05 to 4.64 percent. Increase in the value of gini coefficient and energy intensity significantly decreases urban electricity access。More specifically, regional integration significantly increases urban population accessibility from all estimates。Again, as per expected, BRI project in the form of regional integration significantly increases urban access to electricity and hence removes energy poverty. Diagnostics test results show that instruments are strong, valid and equation is exactly identified.

Table. 6 Access to electricity (Urban Population)

Variables	Pooled OLS Estimates	Fixed Effect Estimates	Random Effect Estimates	2SLS- IV Estimates
REM	0.545*** 0.044	0.050* 0.039	0.062* 0.040	4.64*** 0.382
GDP	2.48*** 0.436	-0.00018 0.000754	-0.000834 0.000715	0.00011*** 0.0007
GINI	-0.463*** 0.039	0.051 0.042	0.055 0.042	-0.265*** 0.093
FD	0.049*** 0.011	0.038*** 0.010	0.041*** 0.010	0.163*** 0.021
EI	-0.85*** 0.102	-0.570*** 0.088	-0.564*** 0.088	-1.16*** 0.21
UP	0.136*** 0.020	0.545*** 0.049	0.619*** 0.046	0.66*** 0.045
RI	1.201** 0.623	2.216*** 0.303	1.82*** 0.298	2.30* 1.40
Constant	36.50*** 3.84	40.016 (0.000)	35.27 (0.000)	38.45(0.000)
R^2	0.52	0.39	0.41	0.87
Adj. R^2	0.51	0.38	0.41	
Anderson C LM. stat				156.18(0.000)
Cragg-Don W F-stat				166.720
Sargan Stat				0.000
No of Obs.	2352	2352	2352	2352

F-Stat **P-value**	364.34 (0.000)	94.33 (0.000)	784.76 (0.000)	84.46 (0.000)

****, ** and * presents P-value less than 0.01, 0.05 and 0.1 respectively*

Table 7 presents the estimates of electricity access for rural population。Remittances, GDP and financial development significantly increase rural population access to electricity and hence removes energy poverty. Similarly, gini coefficient and energy intensity shows negative and significant relation with rural population accessibility to electricity. Regional integration in the form of BRI project significantly increases access to electricity. As 1 point increase in regional integration increases the rural population electricity accessibility between 2.25 to 4.89 which is higher than rural population. This means that regional integration through BRI project is more important to overcome energy poverty particularly for urban population. Diagnostic test results indicate the validity as well as strength of instruments used in the model.

Table. 7 Access to electricity (Rural population)

Variables	Pooled OLS Estimates	Fixed Effect Estimates	Random Effect Estimates	2SLS- IV Estimates
REM	0.101** 0.058	0.328*** 0.046	0.326*** 0.046	5.22*** 0.576
GDP	4.463*** 0.042	0.00029*** 0.000874	0.000427*** 0.000816	0.00034*** 0.00010
GINI	-0.269*** 0.061	-0.279*** 0.048	-0.281*** 0.048	-0.88*** 0.141
FD	0.048*** 0.015	0.0335*** 0.012	0.038*** 0.012	0.389*** 0.032
EI	0.049*** 0.03	-0.303*** 0.102	-0.284*** 0.102	-1.15*** 0.322
UP	0.74*** 0.074	0.533*** 0.057	0.630*** 0.052	1.14*** 0.068
RI	3.69*** 0.4487	2.76*** 0.3522	2.251*** 0.343	4.89*** 2.11
Constant	-43.41(0.000)	26.18 (0.000)	20.26 (0.000)	-9.00 (0.000)
R^2	0.96	0.54	0.54	0.60
Adj. R^2	0.96	0.53	0.53	
Anderson canon Corr. LM. stat				156.181 0.000
Cragg-Donald Wald F-stat				166.720
Sargan Stat				0.000
No of Obs.	2352	2352	2352	2352
F-Stat **P-value**	487.76 (0.000)	117.91(0.000)	929.41 (0.000)	140.96(0.000)

****, ** and * presents P-value less than 0.01, 0.05 and 0.1 respectively*

4.1 Robustness Checks

We explore the empirical validity of our analysis by using some robust tests. We run instrumental variable two stages least square regression and check the validity of instruments. (Anderson. Cannon. Corr LM. Statistics, Cragg-Donald Wald Stats, and Sargan Statistics).

Results based on income groups show that remittances have more significant and higher effects on energy poverty. Gross domestic products, financial development and urbanization significantly

increase energy accessibility and hence remove energy poverty. More importantly, regional integration in the form of BRI project shows interesting results. In case of low-income countries, one point increase in regional integration increases access to clean fuel technology and access to electricity by 3.69 and 6.49 percent respectively while for middle-income countries, 4.15 and 2.87 percent respectively. For high income countries, regional integration shows insignificant relation with accessibility for both variables.

Following Barkat et al., (2023), we employ Hausman test to check the presence of endogeneity and rejects the null hypothesis at 1 percent significance level for three income groups implying that remittances which are a variable of interest may be endogenous within the specified model. Therefore, a suitable instrumental variable is required to overcome it. The results of the three income groups are reported in table 8 given below:

Table. 8
Income Based 2SLS-IV Estimates

Variables	Low-Income ACT	Low-Income AE	Middle-Income ACT	Middle-Income AE	High Income ACT	High Income AE
REM	0.101** 0.058	2.85*** 0.38	3.9*** 0.47	3.21*** 0.39	1.09** 0.56	1.01* 0.46
GDP	4.463*** 0.042	0.012*** 0.002	0.006*** 0.0004	0.004*** 0.0003	4.89 0.79	3.56 0.77
GINI	-0.269*** 0.061	0.22 0.167	-0.49*** 0.10	-1.02*** 0.08	-0.12*** 0.02	-0.13*** 0.02
FD	0.048*** 0.015	0.044 0.121	0.16*** 0.028	0.22*** 0.023	0.002 0.004	0.007* 0.003
EI	0.049*** 0.03	-0.69*** 0.102	1.18** 0.28	-1.15*** 0.24	0.60 0.137	0.55** 0.11
UP	0.74*** 0.074	0.03 0.068	1.10*** 0。062	0.74*** 0.05	0.01*** 0.015	0.01 0.013
RI	3.69*** 0.4487	6.49*** 1.42	4.15* 1.73	2.87** 1.46	0.08 0.29	0.55* 0.23
Constant	-43.41(0.000)	-2.44(0.000)	-41.06 (0.000)	38.31.00 (0.000)	98.34(0.000)	98.53(0.000)
R^2	0.96	0.87	0.82	0.92	0.98	0.98
Adj. R^2	0.96	0.53	0.53			
Anderson canon Corr. LM. Stat		38.26 0.000	71.28 0.000	71.289 0.000	16.01 0.000	16.02 0.000
Cragg-Donald Wald F-stat		40.75	74.83	74.83	16.82	16.98
Sargan Stat		0.000	0.000	0.000	0.000	0.000
No of Obs.	504	504	1344	1344	504	504

F-Stat P-value	487.76 (0.000)	130.17(0.000)	156.22 (0.000)	121.71(0.000)	19.69(0.000)	31.55(0.000)

****, ** and * presents P-value less than 0.01, 0.05 and 0.1 respectively*

Conclusion and policy implications

This study investigates the impact of remittances and regional integration on energy poverty for BRI countries and explored rural and urban populations in this context. This study includes 112 BRI countries classified into low-, middle- and high-income countries covering the time 2000 to 2020. Our study shows that workers' remittances and regional integration in the form of BRI project are key determinants in improving energy poverty in BRI countries.

We also investigated several channels across which remittances can alleviate energy poverty. The study shows that increasing economic growth and financial development and decreasing poverty and inequality can overcome energy poverty to a greater extent.

Our empirical findings help policy makers and governments in BRI countries to support inflow of investment from China and provide opportunities to labor to maximize remittances to achieve SDG 7.1 aimed to guarantee the availability and accessibility of modern and reliable energy services. In this context, our research suggests policy makers an important roadmap for poverty alleviation. In the first step, policy makers in BRI countries should promote remittances, as our empirical findings indicate that increase in remittances significantly increases accessibility to energy and hence remove energy poverty. These remittances should be used in funding for energy related projects such as solar energy and home usage solar systems. Moreover, governments in these countries should provide subsidies and reduced prices of energy technologies to overcome this problem at household level. In this context, Mexico's 3*1 project can also be an example for BRI countries. Secondly, governments and policy makers in BRI countries should provide ease and access to investor country (China) to complete belt and road project as this investment increases regional integration and our empirical findings reveals that regional integration in the form of BRI project highly and significantly influence energy poverty.

Our study concretes the way for new researchers when data for more countries is available to them. Moreover, no percentage of remittances allocated to energy use is currently available and even a proxy has been found to measure regional integration for the BRI project. Future research can be conducted by analyzing these two important dimensions. Furthermore, this study presents another step forward to the factors that increase accessibility to energy sources. These findings are important for all those countries and regions that are suffering from energy poverty, can enhance remittances and regional integration to overcome energy poverty.

Appendix. Table A1

Benin	Sierra Leone	Cameroon	Kazakhstan	Myanmar	Uzbekistan	Lithuania	
Burundi	Tajikistan	China	Kenya	Namibia	Domin. Rep	Panama	
Chad	Tanzania	Congo. Rep	Kyrgyz	Nicaragua	Malaysia	Poland	
Comoros	Togo	Cost Arica	Lao PDR	Nigeria	Antigua &	Portugal	
Congo. Dem	Uganda	Cote d'Ivoire	Lesotho	North	Barbuda	Seychelles	
Ethiopia	Yemen	Djibouti	Maldives	Macedonia	Austria	Slovak Rep	
Gambia. The	Zimbabwe	Ecuador	Mauritania	Pakistan	Barbados	Slovenia	
Guinea	Albania	Egypt Arab	Moldova	Papua New Gui	Chile	UAE	
Liberia	Angola	El Salvador	Mongolia	Peru	Croatia	Uruguay	
Madagascar	Argentina	Fiji	Montenegro	Philippines	Cyprus	Luxemburg	
Malawi	Armenia	Gabon	Sudan	Romania	Czech Rep	Malta	
Mali	Azerbaijan	Georgia	Thailand	Russian Fed	Estonia		
Mozambique	Bangladesh	Ghana	Timor-Leste	Samoa	Greece		
Nepal	Belarus	Indonesia	Tonga	Serbia	Hungary		
Niger	Bolivia	Iran	Tunisia	Solomon Island	Italy		
Rwanda	Botswana	Iraq	Turkey	South Africa	Korea		
Senegal	Cabo Verde	Jamaica	Morocco	Sri Lanka	Latvia		
				Ukraine	Lithuania		

List of countries.

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