

**CAPITAL UNIVERSITY OF SCIENCE AND
TECHNOLOGY, ISLAMABAD**



**Analyzing the Impact of Economic
Policy Uncertainty on Energy Poverty:
The Moderating Role of Financial
Development and Innovation**

by

Atta Ullah

A thesis submitted in partial fulfillment for the
degree of Master of Science

in the

**Faculty of Management & Social Sciences
Department of Accounting and Finance**

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I would like to dedicate this thesis to my beloved parents, whose unwavering love, endless support, and quiet sacrifices made this journey and everything before it possible.



CERTIFICATE OF APPROVAL

Analyzing the Impact of Economic Policy Uncertainty on Energy Poverty: The Moderating Role of Financial Development and Innovation

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(**Atta Ullah**)

Abstract

This study examines the nexus between economic policy and uncertainty and energy poverty in Asian countries over the period from 2000 to 2022. This study also examines the moderating role of financial development and innovation in the nexus between economic policy uncertainty and energy poverty. The empirical findings suggest that economic policy uncertainty enhances energy poverty in Asia. Moreover, financial development and innovation tend to reduce the positive effect of economic policy uncertainty on energy poverty. The findings of the study are consistent across different techniques, such as feasible generalized least squares, panel corrected standard error, and alternative measurements for energy poverty. Lastly, based on the findings, it is recommended that policymakers should focus on bringing consistency in their economic policies, and they should also consider inclusive financial strategies and higher research and development expenses.

Keywords: Economic Policy Uncertainty; Energy Poverty; Financial Development; Innovation; Asia

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Abbreviations

ACEU	Access to Electricity in Urban Areas
ACFT	Access to Clean Fuel and Technology
ATE	Access to Electricity
ATER	Access to Electricity in Rural Areas
CPI	Inflation
DCP	Domestic Credit Provision
EP	Energy Poverty
EPU	Economic Policy Uncertainty
FGLS	Feasible Generalized Least Square
GDP	Gross Domestic Product
IMF	Internal Monetary Fund
PCSE	Panel Corrected Standard Error
POP_G	Population Growth
REC	Renewable Energy Consumption

Chapter 1

Introduction

1.1 Background of Study

Energy poverty, indicating a condition where an individual or household is unable to meet the desired need at an affordable cost (Khan & Majeed, 2023; Mawutor, Gborse, Agbanyo, & Sogah, 2024), has become a worldwide issue. For example, recent crises including the incidence of both COVID-19 and the Russia-Ukraine war have significantly pushed countries and households towards higher inflation, poverty, factory shutdowns, slower economic growth, and economic recessions (Allam, Bibri, & Sharpe, 2022; Noorani, Khan, & Khan, 2024). Besides the economic consequences, these factors have also significantly contributed to bringing energy scarcity in terms of high oil prices and disrupting supply chains around the world. Moreover, in 2022, historical estimates indicate that there have been 760 million people all around the world who haven't any access to proper electricity resources, and among that there have been almost 2.3 billion people that are using harmful energy sources, namely charcoal, agricultural waste, wood, and animal dung for cooking, to fulfill their energy needs thereby leading to premature death and severe health issues in poor regions IEA 2024.

Following these arguments, previous studies have analyzed the role of various factors in affecting energy poverty. For example, Barkat, Alsamara, and Mimouni (2023) find that remittances tend to reduce energy poverty in developing countries. D. Wang, Wang, and Zong (2023) argue that digital economy has a negative and

significant impact on energy poverty. [Zhao, Dong, Dong, and Shahbaz \(2022\)](#) stated that informatization tends to reduce energy poverty globally. Even though previous studies have discussed various factors affecting energy poverty across different economies. Yet, the debate about the antecedents of energy poverty is nascent and inconclusive. Thus, this study departs from the existing literature and would analyzes the significant influence of the economic policy uncertainty (EPU) on energy poverty in Asia.

EPU, representing an undefined risk associated with government fiscal, monetary, and regulatory policies in the near future ([Al-Thaqeb & Algharabali, 2019](#)), has been considered an important factor in affecting country-level macroeconomic factors (investment, inefficiencies in resource allocation, and energy market volatility) under various circumstances. For instance, during COVID-19, EPU is considered one of the potential factors in reducing clean technology investment due to the high cost of capital, spending cuts, and financial constraints worldwide ([IEA, 2023](#)). Consistently, [Pata, Alola, Erdogan, and Kartal \(2023\)](#) find empirical evidence that have shown the negative relationship between economic policy uncertainty and renewable energy investment and the study is conducted for the G7 countries. In addition, previous studies have also analyzed the role of EPU on other outcomes such as renewable energy consumption ([Shafullah, Miah, Alam, & Atif, 2021](#)) energy import ([P. Zhang & Yu, 2024](#)); energy diversification ([Dagar, Dagher, Rao, Doytch, & Kagzi, 2024](#)); and carbon emissions ([Aslan et al., 2024](#)), among others.

These studies highlight that EPU enhances financing constraints, disrupts the supply chain, and delays/inconsistencies in government-supported policies such as subsidies, thereby leading to reduced clean energy investment, energy imports, and increased carbon emissions. Yet, the debate about the antecedents of energy poverty is nascent and inconclusive. Thus, this study departs from the existing literature and would analyzes the significant influence of the economic policy uncertainty (EPU) on energy poverty in Asia. Following these arguments, we propose that EPU may likely affect energy poverty because uncertain policies and regulations may affect investors and supportive policies, thereby limiting access to reliable energy sources and projects for the economic well-being of a country.

1.2 Problem Statement

Energy poverty is one of the emerging and critical challenges across Asia, where, despite the region's substantial share of global energy consumption (53% of global energy consumption), millions still lack access to affordable and reliable power due to infrastructural inequalities and governance issues (IEA, 2024). While previous studies have analyzed various factors that can contribute to determining the energy poverty across different countries and regions, such as green finance (H. Cheng & Taghizadeh-Hesary, 2023), urban-rural income gap (Ren, Kuang, & Klein, 2024), renewable energy technologies (Lee, Yuan, Lee, & Chang, 2022), financial development (Dong, Taghizadeh-Hesary, & Zhao, 2022), and remittances (Barkat et al., 2023), among others.

However, EPU is one of the significant yet under-researched exacerbating factors that can have a significant impact on energy poverty. The nexus between EPU and energy poverty can be better explained through the lens of real option theory (Bernanke, 1983; McDonald & Siegel, 1986), which posits that under high uncertainty, investors rationally delay large, irreversible projects—like power plants and grid extensions—because the "option to wait" for more stable policy information holds considerable value. Therefore, analyzing the relationship between EPU and energy poverty is crucial because a higher level of EPU might delay infrastructure projects, discouraging private investment in energy sectors, thereby directly contributing to deepening energy poverty.

Moreover, previous studies also overlook the moderating role of financial development and innovation in examining the relationship between various economic and social factors and energy poverty (Churchill & Smyth, 2020; Ampofo & Mabefam, 2021; Apergis, Polemis, & Soursou, 2022; Dong, Taghizadeh-Hesary, & Zhao, 2022; Lee et al., 2022; Barkat et al., 2023; Zou, Yang, & Feng, 2023). Even though EPU creates an unstable investment environment due to its role in delaying different projects, thereby minimizing the likelihood of funds availability for energy-related initiatives. Meanwhile, financial development can play a critical role in minimizing the adverse consequences of EPU by facilitating individuals' access to capital for different projects (Dong, Dou, & Jiang, 2022). Countries with modern and

well-developed financial systems provide an opportunity for individuals to access loans, grants, and other financial resources to support different projects, including energy sector projects in different regions. Similarly, during high EPU, innovation can serve as one of the critical factors in affecting energy poverty by facilitating decentralized energy systems and green technology adoption in underprivileged regions (Lee et al., 2022). Renewable energy resources such as solar systems and battery storage minimize limitations in traditional energy infrastructure, thereby providing immediate relief to communities with energy scarcity issues.

Thus, considering the energy-related problems faced by various countries in Asia, this study aims to examine the relationship between EPU and energy poverty, and how financial development and innovation affect the aforementioned nexus.

1.3 Motivation of the Study

Being a global economic powerhouse and scarcity of energy resources makes Asia a critical region for analyzing the nexus between EPU and energy poverty. Around 60% of the Asian population relies on poor energy resources such as biomass and kerosene which facilitates social and environmental challenges including health risks and environmental degradation. Consequently, EPU has the potential to limit resource allocation and undermine the continuity of proper energy projects, thereby ultimately creating energy poverty. Therefore, this study is motivated by three key issues.

First, EPU particularly varies in developing Asian countries further leads amplify household vulnerability by enhancing social insecurity and a fragmented energy market. For example, Pakistan's abrupt changes in electricity tariff policies during the economic crisis have deepened energy inequality. Therefore, understanding the role of financial development (access to credit and green financing) and innovation (renewable technology adoption) in the nexus between EPU and energy poverty is critical. Second, Asia is a diverse region that encompasses advanced economies like Japan to energy-scarce countries like Pakistan. This diversity aspect motivates us to analyze the nexus between EPU and EP by specifically focusing on the financial

development and innovation. Third, Asia accounts for 50% of carbon emissions comprising of coal-dependent countries like India which face severe challenges in adopting renewable energy. This perspective further motivates us to examine the relationship among EPU and energy poverty.

1.4 Importance of the Study

Contextually, energy poverty is a challenging factor among Asian countries due to significant differences in energy infrastructure between developed and developing economies. Therefore, this study is important in seven key Asian countries (China, India, Japan, Pakistan, Russia, Singapore, and South Korea) based on their critical role in global energy dynamics and economic development around the world. Asia is the largest energy consumer with fast-growing energy demand from emerging countries (China and India) and developed markets (Japan, Singapore, and South Korea). However, EPU poses significant challenges to energy security and accessibility across these countries. In addition, EPU generally, and especially in these Asian countries, may disrupt energy investment, enhance energy inefficiency, increase cost, and delay development, thereby limiting access to reliable and affordable energy products. For instance, in Pakistan, energy poverty issues have been enhanced due to rising costs to meet the International Monetary Fund (IMF) conditions, inefficient energy infrastructure, and unsustainable energy resources. Meanwhile, China and India are struggling to achieve universal energy access because their transition towards renewable energy is still facing energy-related challenges due to financial and policy-related hurdles. In contrast, developed countries like Japan and Singapore are not affected by energy poverty, but still, they are not immune to the consequences of EPU, which can enhance energy security issues and impede sustainable energy transition.

The above-mentioned arguments highlight that energy poverty around the world, in general, and in Asian countries in particular, is one of the significant challenges that are shaped by their distinct economic structures and policy environments. Therefore, based on these arguments, this study provides both theoretical and empirical insights into understanding the relationship between EPU and energy

poverty across Asia's key economies. The findings of this study not only provide a significant contribution to existing literature but are also expected to offer interesting insights that will help policymakers and investors focus on energy-related projects and outcomes. Moreover, by analyzing the moderating role of financial development and innovation, this study further helps policymakers across different countries with diverse financial systems and innovation backgrounds.

1.5 Research Questions

This study developed the following research questions.

- 1- What is the impact of EPU on energy poverty?
- 2- Whether financial development moderate the nexus between EPU and energy poverty?
- 3- Whether innovation moderate the nexus between EPU and energy poverty?

1.6 Objectives of the Study

This study developed the following three objectives for empirical analysis.

- 1- To analyze the relationship between EPU and energy poverty.
- 2- To analyze the moderating role of financial development in the nexus between EPU and energy poverty.
- 3- To analyze the moderating role of innovation in the nexus between EPU and energy poverty.

1.7 Significance of this Study

Our study is expected to make a significant contribution to the extant literature by engaging in the following three ways. First, focusing on the consequences of EPU, many scholars have analyzed the impact of EPU on various outcomes,

such as renewable energy consumption, renewable energy investment, carbon emission, and foreign direct investment (Hsieh, Boarelli, & Vu, 2019; Farooq, Gillani, Subhani, & Shafiq, 2023; Khan, Hassan, Kirikkaleli, Xiuqin, & Shukai, 2022; Pata et al., 2023; Shafiullah et al., 2021). On the other hand, to handle energy problems faced by countries worldwide, previous studies have shown various factors that enhance or reduce energy poverty.

These factors include education (Apergis et al., 2022), religiosity (Ampofo & Mabefam, 2021), ethnic diversity (Churchill & Smyth, 2020), remittances (Barkat et al., 2023), FD (Dong, Taghizadeh-Hesary, & Zhao, 2022), informatization (Zou et al., 2023), and renewable energy technologies (Lee et al., 2022), among others. Yet, none of the studies have analyzed how EPU, which brings adverse effects at the country level, can affect energy poverty, which is believed to be a grand challenge faced by different countries. Consequently, the current study will supplement the current body of knowledge since it will examine the relationship between economic policy uncertainty and energy poverty.

Second, financial development is considered an important factor in uncertain times in countries, and it is also suggested to play a significant role in handling energy-related issues by providing capital access and enhancing investment in critical sectors (Mengfeng, Farooq, Tabash, & Aljughaiman, 2024). Meanwhile, it is also argued that financial development plays an essential role in declining energy poverty by transferring funds toward energy-related projects and providing financial instruments to minimize the burden of energy cost for the vulnerable population (Nguyen, Su, Bui, Dang, & Nguyen, 2021). Yet, along with these advantages, the previous literature lacks any robust evidence regarding how financial development predicts the correlation between EPU and energy poverty. Hence the paper build on the current body of literature of the effect of the financial development in moderating the relationship between EPU and energy poverty.

Third, previous studies have analyzed direct of innovation on various outcomes such as foreign direct investment (Tu, 2024), carbon emission (Y.-J. Zhang, Peng, Ma, & Shen, 2017), and energy efficiency (H. Wang & Wang, 2020) among others. These studies highlight that innovation plays an important role in removing barriers, reducing costs, and maximizing energy efficiency by providing access and

alternative energy resources. The past literature overlooks the importance of innovation in the relationship between economic policy uncertainty and energy poverty. Therefore, the research also makes an additional contribution in the current literature to the moderating role of innovation on the connection between EPU and energy poverty.

1.8 Organization of the Study

This study is divided into five different chapters. Chapter 1 is about the introduction, which discusses the background, problem statement, motivation, theoretical framework, importance, research questions, objective, and significance of the study.

Chapter 2 discusses a detailed literature review, which is composed of the theoretical and institutional context, determinants of energy poverty, consequences of EPU, and the hypothesis of the study.

Chapter 3 is about the data and methodology, which discusses the sample period, variable measurement, model, estimation methodology, and data type and estimation techniques.

Chapter 4 discusses empirical results, which are composed of descriptive statistics, cross-sectional dependence, panel unit root, cointegration, feasible generalized least squares (FGLS), and panel-corrected standard error (PCSE) tests.

Chapter 5 is about the conclusion, policy implications, limitations, and future research direction.

Chapter 2

Literature Review

This chapter discusses the detailed literature about the different variables included in the study. Section 2.1 discusses the theoretical context regarding the nexus between EPU and energy poverty. Section 2.2 highlights the institutional context. Section 2.3 provides a detailed literature review regarding the determinants of energy poverty. Section 2.4 shows a detailed literature review regarding the consequences of EPU. Section 2.5 shows a brief literature review regarding the effect of control variables on energy poverty, while Section 2.6 discusses the main hypothesis of the study.

2.1 Theoretical Context

This study follows the arguments of real option theory to analyze the nexus between EPU and energy poverty. As per this theory, decision-makers should refrain from investment during uncertain times as it leads to reduced current investment and increased future investment. Hence, to obtain a higher value, the decision-makers should reduce their current investment ([Bernanke, 1983](#); [McDonald & Siegel, 1986](#); [Xin & Xin, 2022](#)). Following these arguments, it is argued that EPU results in inconsistent regulations, and delays in policy implementation, thereby leading to enhanced financial constraints worldwide ([IEA, 2023](#)), and further affecting different economic and social outcomes such as reducing renewable energy consumption ([Shafiullah et al., 2021](#)), renewable energy investments ([Pata](#)

et al., 2023), energy imports (P. Zhang & Yu, 2024), and enhance CO2 emission (K. Khan, Su, Rehman, & Ullah, 2022). Based on real options theory and the empirical findings, this study argue that in times of high EPU, investors might be reluctant to invest in energy-related projects, as it might be very costly for them. In addition, this delaying investment tactics by investors during high policy uncertainty may a shortage of energy supply, thereby directly contributing to energy poverty.

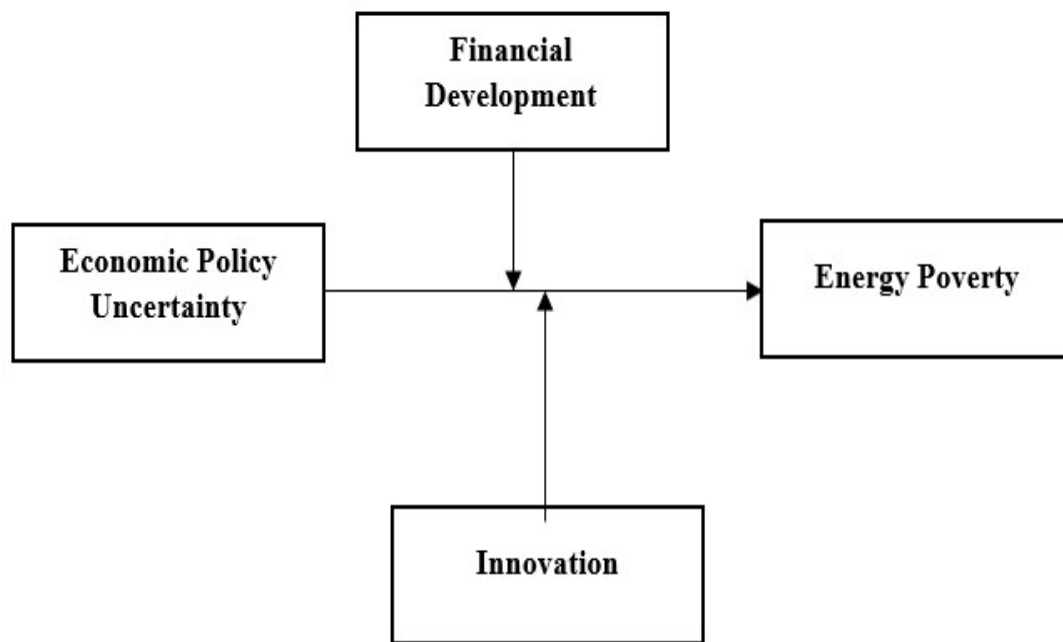


FIGURE 2.1: Theoretical Framework

This study also examines the role of financial development in the nexus between EPU and energy poverty. Financial development shows the growth and improvement in the financial system of a country, including financial markets and institutions, which facilitates efficient resource allocations (Khan & Majeed, 2023; Nguyen et al., 2021). It is argued that financial development facilitates access to credit provision, encourages saving behaviors, and enhances the exchange of products and services (Kar, Nazlıoğlu, & Ağır, 2011; Khan & Majeed, 2023). In addition, financial development is also considered an important factor in energy resources. For example, Nguyen et al. (2021) stated that financial development tends to minimize energy poverty across different countries. On the other hand, regarding the role of financial development in crisis times, (Mengfeng et al., 2024)

argued that financial development plays a positive role during EPU, thereby positively moderating the previously negative nexus between EPU and energy policy. These findings highlight that financial development provides tools such as credit, insurance, and diversified financing options that can help to minimize the adverse consequences during uncertain times, such as EPU, thereby encouraging smooth cash flows to energy-related projects. Therefore, this study demonstrate that financial development can moderate the nexus between EPU and energy poverty.

Lastly, this study also examines how innovation moderates the nexus between EPU and energy poverty. Innovation is the process of creating, developing, and implementing new ideas, methods, technologies, products, and services to bring value, solve issues, or fulfill needs more effectively and efficiently (Kahn, 2018; Rogers & Rogers, 1998). Previous studies demonstrate that innovation is vital in energy-related activities as it reduces barriers and costs, enhances energy efficiency, and improves accessibility, thereby leading to a decrease in energy poverty (Saudi, Sinaga, Roespinoedji, & Ghani, 2019; H. Wang & Wang, 2020; P. Zhang & Yu, 2024). Hence, based on these findings, this study argue that innovation might be critical in affecting energy-related activities during EPU. Hence, this study bridge the gap between EPU and the energy poverty nexus and provide a novel lens to analyze the moderating role of innovation.

2.2 Institutional Context

In light of the real option perspective, during high EPU, the investors in the developing regions in Asia may delay investment in capital-intensive renewable projects for the purpose of obtaining maximum incentives in the future, as these regions contain a significant proportion of the low-income population who are disproportionately impacted by the energy access gaps. For instance, (B. Wang, Khalid, & Mahmood, 2024) published a report arguing that there exists high energy poverty in Pakistan due to high cost and irregular supply challenges, and most of the rural families utilize unhealthy resources such as dung for their cooking and heating activities . Similarly, the Reuters report in 2025 highlights that Indian

Premier Energies holds a US solar-cell facility plan due to policy uncertainty . Figures 1 and 2 also indicate that energy that among the seven

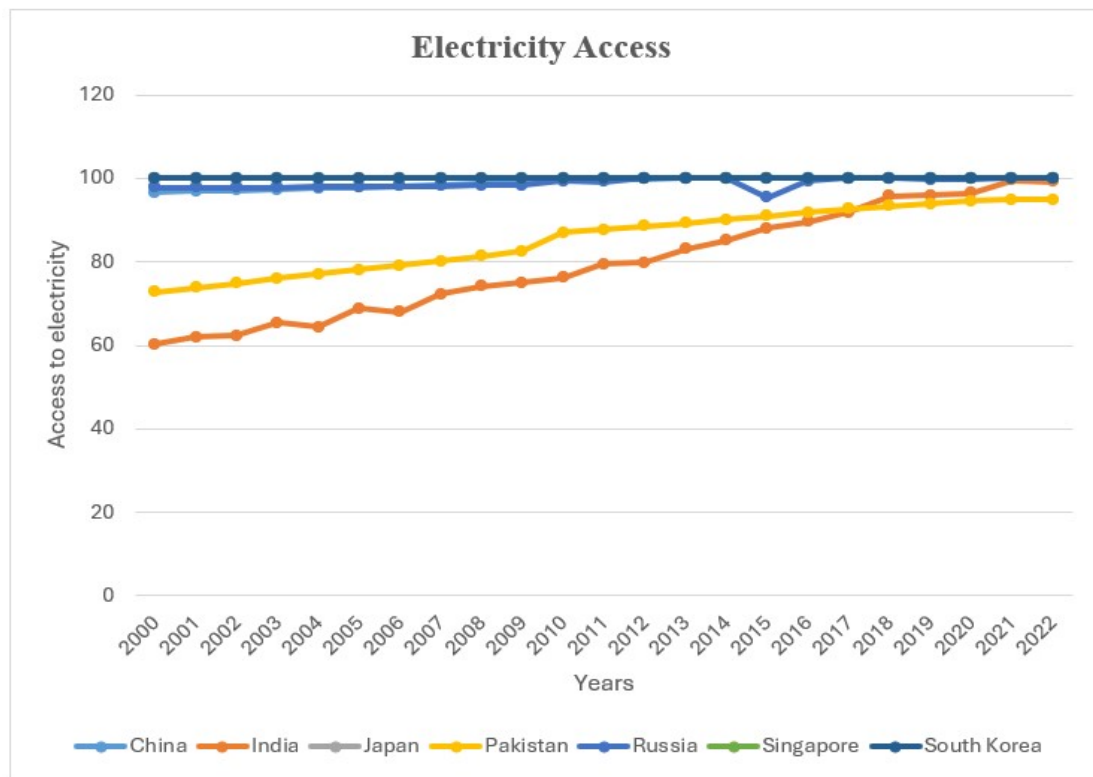


FIGURE 2.2: Access to Electricity in Asian Countries

Moreover, the high EPU has not only adversely affected energy sectors but also other macroeconomic factors across different Asian countries. For instance, the IMF report in 2024 highlights that high EPU has lowered global growth, especially in the Asian emerging economies such as China, India, and Russia . The National Business Survey in Singapore conducted in 2025 shows that the overall economic performance has considerably weakened this year as compared to previous years due to high policy uncertainty. In addition, it is also expected that the overall business performance will further worsen in the future. Riaz (2025) stated that Pakistan's fiscal policy is dictated by internally inconsistent policies and is aligned to meet the requirements of the IMF, rather than focusing on achieving constant growth. These shortcomings have created a significant business gap, which further leads to instability. Therefore, to bring economic stability and investor confidence, she further recommended that Pakistan must address the issue of EPU. Raghavan (2021) argues that high EPU has adversely affected the investors' sentiments,

and investors are unwilling to invest in the private sector in the country. This heightened EPU has left many projects either abandoned or delayed.

Therefore, taking guidelines from real option theory and institutional context, this study contends that EPU may enhance energy poverty in Asian countries because uncertainty leads to investment delays in capital-intensive projects like the energy sector that can be disadvantageous for underprivileged communities.

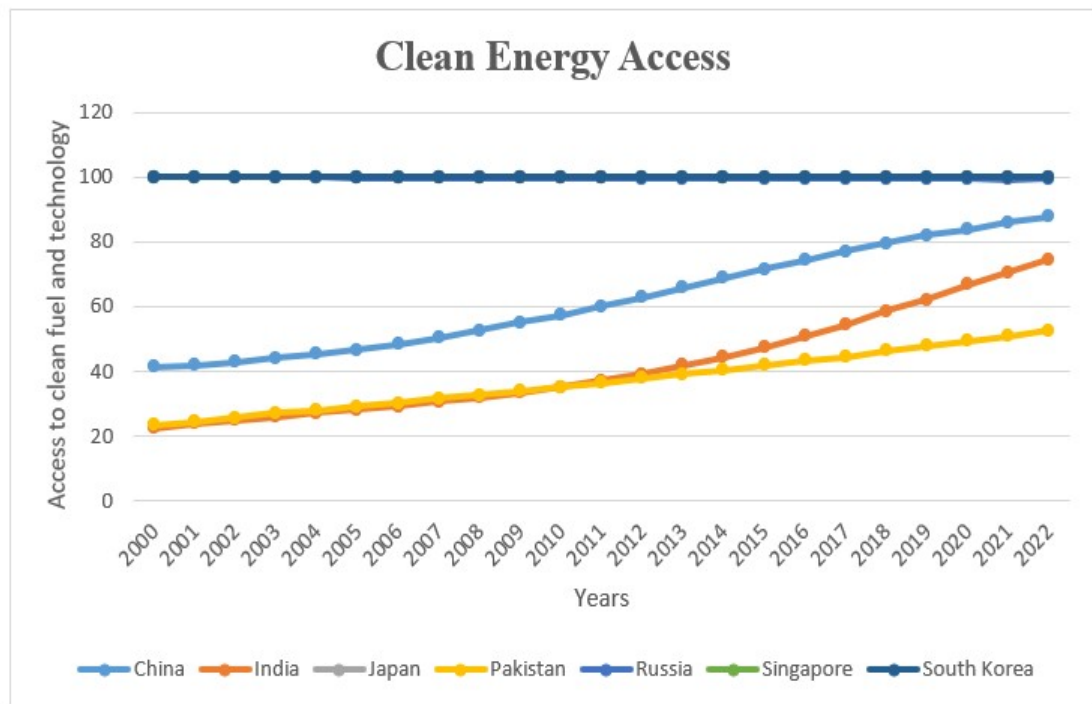


FIGURE 2.3: Access to Clean Fuel and Technologies for Cooking

2.3 Determinants of Energy Poverty

Energy is considered one of the fundamental factors in the progress and prosperity of human societies. However, given the recent crisis, energy poverty has become a global issue, limiting households and industrial access to affordable, sufficient, and quality energy resources for societal development and survival (Day, Walker, & Simcock, 2016). In addition, existing studies also highlight the negative consequences of energy poverty such as climate change (Zhao, Jiang, Dong, & Dong, 2021), economic development (Acharya & Sadath, 2019), and social well-being (Q. Zhang, Appau, & Kodom, 2021) among others. Meanwhile, existing studies

also indicate various economic and social factors that can play a significant role in enhancing or reducing energy poverty in different countries.

For example, [Churchill and Smyth \(2020\)](#) collected household data in Australia and analyzed the impact of ethnic diversity on energy poverty. They find that ethnic diversity tends to increase energy poverty in Australia. [Ampofo and Mabefam \(2021\)](#) analyzed the impact of religiosity on energy poverty across different countries between 1981 and 2014. They demonstrate that religiosity tends to increase energy poverty. They further argue that a positive association between religiosity and energy poverty is more pronounced in rural areas and developing countries. [Apergis et al. \(2022\)](#) examined the association between education and energy poverty in 30 developing countries over the period from 2001 to 2016. They find that education has a negative and significant impact on energy poverty in these developing countries. [Ngarava, Zhou, Ningi, Chari, and Mdiya \(2022\)](#) analyzed the gender and ethnic diversity on energy poverty by collecting household survey data in South Africa. They argued that houses with female heads mostly face energy poverty issues as compared to male-headed houses. They further find that houses with black/African and female-headed are more likely to have energy poverty issues as compared to houses with Indian/Asian, white, and colored female heads. [Chaudhry and Shafiullah \(2021\)](#) examined the effect of culture on energy poverty by collecting data from 103 countries between 1971 and 2018. By using five different measures for culture, they said that masculinity and power distance tend to enhance energy poverty while individualism and long/short-term orientation minimize the likelihood of energy poverty. They further found an ambiguous nexus between uncertainty avoidance and energy poverty. [Ren, Jiang, Narayan, Ma, and Yang \(2022\)](#) examined the association between marketisation and rural energy poverty by utilizing Chinese provincial-level data. They argued that the relationship between marketisation and rural energy poverty is heterogeneous across different Chinese regions. They also stated that from an advanced level, market-oriented reforms change the association between marketisation and rural energy poverty from promotion to suspension.

In addition, [H. Cheng and Taghizadeh-Hesary \(2023\)](#) collected data from 20 developing Asian countries between 2010 to 2021 and checked the impact of green

finance on energy poverty. They stated green and sustainable finance decreases the energy poverty gap in Asian countries. [Ren et al. \(2024\)](#) analyze the impact of the urban-rural income gap on energy poverty across 30 Chinese provinces between 2005 and 2015. They said that the urban-rural income gap has a positive and significant impact on rural energy poverty in China. [Lee et al. \(2022\)](#) examined the association between renewable energy technologies and energy poverty between 2003 to 2019 by collecting data from 30 Chinese provinces. They stated that renewable energy technologies tend to minimize energy poverty. In addition, a lower climate risk index further strengthens the negative nexus between renewable energy technologies and energy poverty.

[Domguia, Ngounou, Pondie, and Bitoto \(2024\)](#) analyzed the association between environmental taxes on energy poverty by collecting data from 52 economies from 1995 to 2020. They find that environmental tax tends to minimize energy poverty. They further stated that environmental tax uses REC and income inequality as a channel to minimize the aforementioned nexus. [Koomson and Danquah \(2021\)](#) analyzed the impact of financial inclusion on energy poverty by collecting the data between 2012 to 2017 in Ghana. They stated that financial inclusion has a negative and significant impact on energy poverty in Ghana. [Moteng, Raghutla, Njangang, and Nembot \(2023\)](#) collected data from 97 regularly sanctioned countries from 1996 to 2019 and analyzed the impact of international sanctions on energy poverty. They stated that international sanctions are more likely to exacerbate energy poverty. They further stated that UN, EU, and US sanctions often result in lower energy resource consumption. [Song, He, Sahut, and Shah \(2024\)](#) collected data from 281 cities in China over the period from 2005 to 2021 and analyzed the impact of the low-carbon city pilot policy on energy poverty. Their empirical evidences suggest that the low-carbon city pilot policy has a negative and significant impact on energy poverty. They further stated that this negative nexus is more pronounced in eastern regions as compared to western and central regions of China. [Wei, Pan, Duan, and Xie \(2024\)](#) collected data from 30 provinces across China between 2006 and 2020 and analyzed the association between new energy technology innovations and energy poverty. They found that energy technological innovation is more likely to enhance energy supply and residential incomes, which

further leads to minimizing energy poverty. Moreover, this negative nexus between energy technological innovation and energy poverty is more pronounced in provinces having developed transport systems and technological market activity.

From an economic perspective, [Dong, Dou, and Jiang \(2022\)](#) checked the impact of inclusive financial development on energy poverty in 30 Chinese provinces over the period from 2004 to 2017. They find that inclusive financial development is negatively and significantly associated with energy poverty. They further stated that technical innovation enhances the negative nexus between inclusive financial development and energy poverty in China.

[Dong, Taghizadeh-Hesary, and Zhao \(2022\)](#) examined the association between income inequalities, energy efficiency, and energy poverty across 30 Chinese provinces between 2004 to 2017. They find that improving energy efficiency leads to minimizing income inequalities and energy poverty across different regions in China.

[Dong, Jiang, Shahbaz, and Zhao \(2021\)](#) collected data across 30 Chinese provinces from 2004 to 2017 and analyzed the impact of natural gas consumption on energy poverty. They found a negative and significant relationship between natural gas consumption and energy poverty. [S. Cheng, Wei, Wang, and Zhuang \(2023\)](#) utilized the data from a general social survey conducted in China in 2015 and analyzed the impact of financial market participation on energy poverty. They found that financial market participation minimizes the likelihood of energy poverty in China.

In addition, [Nguyen and Su \(2022\)](#) examined the association between government spending and energy by collecting data between 2002 to 2015 from 56 countries. They stated that government spending first decreases and then increases (U-shaped) impact on energy poverty. [Ackermann, Churchill, and Smyth \(2023\)](#) examined the effect of access to high-speed internet on energy poverty in Australia. They found that an increase in internet users is more likely to enhance energy poverty. They further stated that social capital works as a channel that enhances the positive relationship between high-speed internet and energy poverty. [Barkat et al. \(2023\)](#) analyzed the nexus between remittances and energy poverty in 109 developing economies between 2000 and 2019. They find that remittances tend to reduce energy poverty in developing countries.

TABLE 2.1: Determinants of Energy Poverty

Authors/year	Countries/data period	Variables	Technique	Findings
Churchill and Smyth (2020)	Australia (2001-2016)	DV= energy poverty	Panel fixed effect	Positive and significant
Ampofo and Mabefam (2021)	100 countries (1981-2014)	IV= ethnic diversity DV= energy poverty	OLS	Positive and significant
Apergis et al. (2022)	30 developing countries (2001-2016)	IV= religiosity DV= energy poverty	GMM	Negative and significant
Cheng and Taghizadeh-Hesary (2023)	20 developing Asian countries (2010-2021)	IV= education DV= energy poverty	FMOLS	Negative and significant
Ren et al. (2024)	30 provinces in China (2005-2015)	IV= green finance DV= energy poverty	Two-way fixed effect	Positive and significant
Lee et al. (2022)	30 provinces in China (2003-2019)	IV= urban-rural income gap DV= energy poverty	Method of moment quantile regression	Negative and significant
Domguia et al. (2022)	52 countries (1995-2020)	IV= renewable energy technology DV= energy poverty	Fixed effect	Negative and significant
		IV= environmental tax		

Continued Table: 2.1 Determinants of Energy Poverty

Authors/year	Countries/data period	Variables	Technique	Findings
Dong et al. (2022a)	30 provinces in China (2004-2017)	DV= energy poverty IV= financial development	GMM	Negative and significant
Dong et al. (2022b)	30 provinces in China (2004-2017)	DV= energy poverty IV= energy efficiency	GMM	Negative and significant
Nguyen and Su (2022)	56 developing countries (2002-2015)	DV= energy poverty IV= government spending	GMM	U-shaped and significant
Barkat et al. (2023)	109 developing economies (2000-2019)	DV= energy poverty IV= remittances	Fixed effect, random effect, Lewbel (2012), GMM	Negative and significant
Zou et al. (2023)	93 countries (2010-2019)	DV= energy poverty IV= informatization	Fixed effect, GMM, Tobit regression	Negative and significant
Wang et al. (2023)	61 countries (2000-2014)	DV= energy poverty IV= digital economy	OLS, random effect, fixed effect, GMM	Negative and significant
Simionescu and Cifuentes-Faura (2024)	V4 countries (2005-2022)	DV= energy poverty IV= income inequality	OLS	Positive and significant
Zahonogo (2025)	20 Sub-Saharan African countries (2000-2020)	DV= energy poverty IV= tariff reduction	DOLS	Negative and significant

Wang, Wang, and Shahbaz (2023) examined the impact of digital economy on energy poverty in 61 countries between 2000 and 2014. They argue that the digital economy has a negative and significant impact on energy poverty. Zou et al. (2023) checked the nexus between informatization and energy poverty in 93 countries between 2010 and 2019. They stated that informatization tends to reduce energy poverty globally.

Lastly, Simionescu and Cifuentes-Faura (2024) collected data from the Czech Republic, Hungary, Poland, and Slovakia from 2005 to 2022 and checked the impact of income equality on energy poverty. They find that income equality has a positive and significant impact on energy poverty while economic growth tend to reduce energy poverty in these countries. (Zahonogo, 2025) collected data between 2000 to 2020 from 20 Sub-Saharan African countries and examined the nexus between tariff reduction and energy poverty. They stated that tariff reduction tends to reduce energy poverty. They further find that REC, institutional quality, and remittances also minimize energy poverty.

Concluding from the above discussion, this study state that although the preceding literature has determined various antecedents and consequences of energy poverty. However, so far, none of the studies has analyzed the impact of EPU which is believed to influence various country-level factors in different countries.

2.4 Consequence of Economic Policy Uncertainty

Recently, EPU has become a prominent agenda for different countries around the world due to political uncertainty and global issues such as COVID-19 and the Russia-Ukraine war affecting various economic factors. These global issues have significantly contributed to enhancing financial constraints, disrupting the supply chain, delaying investment, and inconsistent policy, thereby leading to increased EPU in different countries (IEA, 2023). As EPU is considered a prominent factor in affecting country-level economic outcomes, therefore, previous studies have analyzed the economic and social consequences of EPU (Aslan et al., 2024; G.-F. Feng & Zheng, 2022; Pata et al., 2023; Shafullah et al., 2021).

From a social perspective, previous studies have shown that EPU tend to significantly affect REC. For instance, (Shafiullah et al., 2021) collected monthly data in the US between 1986 and 2019 and checked the impact of EPU on REC. They find that EPU is negatively and significantly associated with REC. Qamruzzaman, Karim, and Jahan (2022) examined the impact of EPU, foreign direct investment, and government debt on REC in 13 top oil-importing nations between 1995 to 2018.

They stated that EPU tends to decrease REC in the long run while foreign direct investment and government debt are positively associated with REC (G.-F. Feng & Zheng, 2022) gathered data from 22 countries between 1985 to 2019 and analyzed the impact of EPU on renewable energy innovation. They stated that EPU tends to enhance renewable energy innovation for at least 3 years. They further argued that this positive nexus between EPU and renewable energy innovation only exists in countries with high institutional quality while the nexus is insignificant in countries with lower institutional quality.

Su, Khan, Umar, and Chang (2022) examined the impact of EPU on renewable energy in G7 countries. They argue that EPU tends to reduce renewable energy across all quantiles. Moreover, they stated that a negative association between EPU and renewable energy exists in five G7 countries, namely Canada, France, Germany, the United Kingdom, and the United States, while in Italy and Japan, the negative (positive) in the medium to upper quantile (higher to lower quantiles). Pata et al. (2023) tested the impact of income inequality, EPU, geopolitical risk, and urbanization on renewable energy investment in G7 countries. By collecting data from 2004 to 2018, they found that EPU, geopolitical risk, and urbanization have a negative and significant impact on renewable energy investment.

Yi, Raghutla, Chittedi, and Fareed (2023) collected monthly data from 2003 to 2020 from top REC countries and checked the impact of EPU and financial development on REC. The EPU decreases REC while financial development increases REC. D. Wang et al. (2023) examine the association between EPU and higher education expansion by collecting data from 18 countries between 1998 to 2019. They argued that a higher level of EPU enhances education expansion as it leads to an increase in enrollment rate. In addition, this positive nexus between EPU

and higher education expansion is more pronounced in developed countries as compared to developing ones.

Similarly, preceding literature also suggests that EPU significantly affects CO₂ emissions. For example, [Amin and Dogan \(2021\)](#) collected data from 1980 to 2021 and examined the association between EPU and environmental-related activities in China. They said that during high EPU periods, governments are less likely to implement policies regarding environmental protection, thereby enhancing carbon emissions in China. [Liu and Zhang \(2022\)](#) collected the data between 2003 to 2017 from different regions in China and examined the impact of EPU on carbon emissions. They stated that EPU minimized carbon emission, while they further found that this negative association between EPU and carbon emission is insignificant across western and central regions in China.

[K. Khan et al. \(2022\)](#) collected data from 4 East Asian countries from 1997 to 2020 and examined the impact of EPU on CO₂ emission. They stated that EPU has a positive impact on CO₂ emissions in these 4 countries. [Xue, Shahbaz, Ahmed, Ahmad, and Sinha \(2022\)](#) examined the effect of EPU on environmental sustainability by collecting data in France over the period from 1987 to 2019. They argued that a higher level of EPU poses significant challenges to environmental sustainability because it increases carbon emissions.

[Farooq et al. \(2023\)](#) examined the association between EPU and environmental degradation by collecting data over the period from 2000 to 2019 from BRICS countries. They find that EPU has a positive and significant impact on CO₂ emissions. They further stated that political stability minimizes the positive nexus between EPU and CO₂ emissions. [Aslan et al. \(2024\)](#) gathered data between 1995 to 2018 in G7 countries and checked the impact of EPU on CO₂ emissions. They stated that EPU has a U-shaped relationship with CO₂ emissions at all quantile levels.

From an economic perspective, studies suggest that EPU tends to significantly affect economic-related outcomes such as economic growth, investment, foreign direct investment. For example, [Sahinoz and Erdogan Cosar \(2018\)](#) examined the relationship between EPU and economic activity in Turkey. They find that

high EPU leads to a reduction in consumption, economic growth, and investment. [Abaidoo \(2019\)](#) analyzed the impact of EPU on international trade activities in the US, China, and the EU. He argued that EPU tends to negatively affect international trade dynamics in the US and China. He further argued that the negative effect of EPU on international trade dynamics is more severe if it originates from the US than from China.

[Phan, Iyke, Sharma, and Affandi \(2021\)](#) analyzed the relationship between EPU and financial stability by collecting the data between 1996 to 2016 from 23 countries. They said that EPU has a negative and significant impact on financial stability. They further stated that the aforementioned negative nexus is stronger in countries having lower regulatory capital, higher competition, and a smaller financial system.

Moreover, [P. Zhang and Yu \(2024\)](#) collected monthly data in China between 2010 and 2023 and checked the impact of EPU and geopolitical risk on energy imports. They said that EPU has a negative and significant impact on energy import while the association between geopolitical risk and energy import is positive. [Dagar et al. \(2024\)](#) gathered data from 26 countries from 1995 to 2023 and examined the impact of EPU on energy diversification. Their results suggest that EPU is more likely to increase energy diversification in these countries.

Lastly, [Canh, Binh, Thanh, and Schinckus \(2020\)](#) checked the association between EPU and foreign direct investment in 21 countries between 2003 to 2013. They find that EPU has a negative and significant impact on foreign direct investment. [Hsieh et al. \(2019\)](#) examined the relationship between EPU and outward foreign direct investment. They stated that EPU has a positive and significant impact on outward foreign director flow. They further recommended that different countries, especially the US, should focus on the relevance of EPU as it helps policymakers to effectively affect many economic outcomes in a country.

Despite numerous studies investigating the impact of EPU on various outcomes, to the best of our knowledge, none of the studies have yet explored the impact of EPU on energy poverty. Thus, this gap in literature presents an opportunity for further research in this area.

TABLE 2.2: Consequences of Economic Policy Uncertainty

Authors/year	Countries/data period	Variables	Technique	Findings
(Shafiullah et al., 2021)	US (1986-2019)	DV= renewable energy consumption IV= EPU	Granger causality analyses	Negative and significant
(Qamruzzaman et al., 2022)	13 top oil-importing countries 1995 to 2018	DV= renewable energy consumption IV= EPU	Panel ARDL	Negative and significant
(G.-F. Feng & Zheng, 2022)	22 countries (1985-2019)	DV= energy innovation IV= EPU	Panel regression	Positive and significant
(Su et al., 2022)	G7 countries (2001-2006)	DV= renewable energy IV= EPU	Wavelet quantile-on-quantile method	Negative and significant
(Pata et al., 2023)	G7 countries (2004-2018)	DV= renewable energy investment IV= EPU	AMG method	Negative and significant
(Yi et al., 2023)	Top renewable energy consumption countries (2003-2020)	DV= renewable energy consumption IV= EPU	CS-ARDL	Negative and significant
(Liu & Zhang, 2022)	30 provinces in China (2003-2017)	DV= carbon emission IV= EPU	Fixed effect and Driscoll-Karay standard error	Negative and significant

Continued Table: 2.2 Consequences of Economic Policy Uncertainty

Authors/year	Countries/data period	Variables	Technique	Findings
(Khan et al., 2022)	4 East Asian countries (1997-2020)	DV= carbon emission IV= EPU	FMOLS	Positive and significant
(Farooq et al., 2023)	BRICS countries (2000-2019)	DV= carbon emission IV= EPU	FMOLS/DOLS	Positive and significant
(Phan et al., 2021)	23 countries (1996-2016)	DV= financial development IV= EPU	Fixed effect	Negative and significant
(P. Zhang & Yu, 2024)	China (2010-2023)	DV= energy import IV= EPU	TVP-SA-VAR method	Negative and significant
(Dagar et al., 2024)	26 countries (1995-2023)	DV= energy diversification IV= EPU	Quantile regression	Positive and significant
(Canh et al., 2020)	21 countries (2003-2013)	DV= foreign direct investment IV= EPU	SELPDM and GMM	Negative and significant
(Hsieh et al., 2019)		DV= foreign direct investment IV= EPU		

2.5 Control Variables

In addition to the main independent variable, this study also uses different control variables that can also play a significant role in determining energy poverty across different countries. These variables include gross domestic product (GDP), population growth, inflation, domestic credit provision (DCP), and renewable energy consumption (REC). GDP indicates the level of economic development in a country (Zhao et al., 2022). Higher GDP leads to higher infrastructural development in terms of different factors, including the energy sectors. Therefore, countries with higher GDP are more likely to have less energy poverty (Zhao et al., 2022; Barkat et al., 2023). Population growth represents the annual growth rate in population by country. Higher population growth can play a significant role in exacerbating by straining limited energy resources due to a rise in energy demand, leaving more households without reliable electricity or clean cooking fuels (B. Zhang, Liu, Wang, & Zhang, 2023). Therefore, this study expects a negative association between population growth and energy poverty. Inflation is a condition of consistent increases in the general prices of goods and services across time.

Previous studies show that inflation tends to negatively affect various macroeconomic factors, including energy resources (Barro, 1995; Durani et al., 2024). However, besides the adverse consequences, it is also argued that high inflation may prompt governments to implement their support for vulnerable households, which helps in improving the household's ability to afford energy prices, thereby reducing energy poverty (Mawutor et al., 2024; Bardazzi et al., 2024). Therefore, this study expects both positive and negative nexus between inflation and energy poverty. DCP also plays a significant role in determining energy poverty as it provides resources to the citizens to access energy resources (Khan & Majeed, 2023). However, it might be possible that DCP may enhance energy scarcity due to high transaction costs, high credit risk, and other challenges (Purkayastha, 2019).

Hence, this study expects both positive and negative impacts of DCP on energy poverty. Recently, scholars have examined the role of REC on energy poverty due to the recent focus on the clean energy industry worldwide (Lee et al., 2022; Zhao et al., 2022). On one hand, it is believed that REC might help in eradicating energy

poverty by providing an alternative solution in some countries with dispersed populations, primitive energy infrastructure, and conventional energy resources (W. Wang, Xiao, & Bai, 2022). In contrast, Zhao et al. (2022) find that REC tends to enhance energy poverty in the Asia-Pacific. They argue that this positive nexus between REC and energy poverty is due to energy uneven distribution and immature technologies, and diverse economic development. Thus, this study expects a positive nexus between REC and energy poverty.

2.6 Hypothesis of the Study

2.6.1 Economic Policy Uncertainty and Energy Poverty

Real option theory demonstrates that an uncertain environment leads investors and decision-makers to examine large-scale investment as a real option, which means that they prefer to delay their investment decisions till the issue of uncertainty is resolved (Bernanke, 1983; McDonald & Siegel, 1986; Xin & Xin, 2022). Previous empirical literature has developed their arguments based on real option theory and argued that EPU, resulting in delay or different investment decisions, exchange rate volatility, and expensive resources provision, may lead to adverse consequences (Pata et al., 2023; Shafiullah et al., 2021). For instance, Shafiullah et al. (2021) found a negative impact of EPU on REC in the US. K. Khan et al. (2022) found a positive and significant relationship between EPU and CO₂ emission in East Asia. Pata et al. (2023) reported a negative relationship between EPU and renewable energy investment.

In the same vein, existing literature on energy poverty posits that country and regional-level factors play a significant in determining energy poverty. For example, previous studies highlighted that ethnic diversity (Churchill & Smyth, 2020), religiosity (Ampofo & Mabefam, 2021), financial development (Dong, Taghizadeh-Hesary, & Zhao, 2022), education (Apergis et al., 2022), and remittances (Barkat et al., 2023) plays a crucial role in determining energy poverty.

Even though the studies above provide an initial understanding regarding the consequences of EPU and determinants of energy, however, they ignore the role of

EPU in energy poverty which has been a central issue faced by different countries around the world. Meanwhile, understanding this nexus is important in the Asian context due to high energy demand, lack of access to energy resources, and costly techniques of alternate energy production.

Drawing conclusion from real option theory and the adverse consequences of EPU (Bernanke, 1983; McDonald & Siegel, 1986; Pata et al., 2023; Shafiullah et al., 2021; Xin & Xin, 2022), this study demonstrate that higher EPU may likely to increase energy poverty in Asia due to delaying investment and economic policy-making in energy sectors, increasing the cost of energy production, and limiting access to energy resources, thereby leading to enhance energy poverty. This study have developed the following hypothesis.

H1: there is a positive and significant relationship between EPU and energy poverty.

2.6.2 Moderating Impact of Financial Development

Financial development is a significant source of efficient resource allocation due to its contribution to a healthy financial system, including financial markets and institutions (Khan & Majeed, 2023; Nguyen et al., 2021). Existing studies highlight that financial development brings economic resilience and weakens the challenges faced by an economy through efficient resource allocations (Mengfeng et al., 2024; Yu, Gan, Zhou, & Dai, 2024). For example, De Gregorio and Guidotti (1995) found that financial development has a positive and significant impact on economic growth across different countries. Schich and Pelgrin (2002) collected data from OECD countries between 1970 to 1997 and found that financial development tends to enhance investment in these countries. Park and Shin (2017) stated that financial development and income inequality have a U-shape relationship. It means that financial development tends to minimize income inequality up to a certain point; however, it enhances income inequality after that specific point. Jamel and Maktouf (2017) collected data from 40 European countries over the period from 1985 to 2014 and found a bidirectional Granger causality between financial development and trade openness. Inoue (2018) collected data from 120 developing

countries between 1980 to 2013 and checked the impact of financial development on poverty reduction. He found that financial development leads to a reduction in poverty in developing countries. [Acheampong, Amponsah, and Boateng \(2020\)](#) used a panel data of 83 countries between 1985 to 2014 and examined the impact of financial development on carbon emissions. They find that financial development plays an important role in reducing carbon emissions in both developed and developing economies. However, they also found inverse relationships between financial development and carbon emissions in frontier financial economies.

On the other hand, previous studies also demonstrate that financial development is an important lubricant in providing efficient energy resources. For example, [Shahbaz, Topcu, Sarigül, and Vo \(2021\)](#) collected data from 34 upper-middle-income countries between 1994 to 2015 and examined the effect of financial development on renewable energy demand. By employing fully modified least squares (FMOLS), they found that financial development enhances renewable energy demand in the long run. [Nguyen et al. \(2021\)](#) took global data from 65 countries between 2002 and 2015. They argued that financial development reduces energy poverty. [Dimnwobi, Madichie, Ekesiobi, and Asongu \(2022\)](#) collected time series data from Nigeria and reported that financial development increases REC. ([C. Feng, Liu, & Yang, 2024](#)) took data from 1995 and 2019 from 60 countries around the world and examined the impact of financial development on energy security. By using a functional data analysis method, they said that the nexus between financial development and energy security is not singular. For instance, they argue that financial development has enhanced energy security between 2010 and 2015, while the nexus between financial development and energy security was negative between 2013 and 2017.

Besides the direct impact of financial development on different macroeconomic factors, including energy-related outcomes, previous studies have analyzed the moderating role of financial development during the time of high EPU. For example, [Mengfeng et al. \(2024\)](#) examine the moderating impact of financial development in the nexus between EPU and energy policy in G7 countries between 1997 and 2019. They argued that financial development positively moderates the previously negative nexus between EPU and energy policy. [Yu et al. \(2024\)](#) analyzed how

financial development moderates the association between EPU and resource rent in BRIC countries. They found that financial development helps in easing the negative effect of EPU on resource rent. All these arguments suggest that financial development is not only an important factor during normal times, but it also plays a crucial role during high EPU.

Drawing a conclusion from the above arguments, this study argue that financial development can minimize the positive effect of EPU on energy poverty due to its feature of economic resilience and stable financial market, thereby leading to increased efficient investment and decreased energy price volatility and costs, especially in times of high EPU. Accordingly, this study have developed the following hypothesis.

H2: Financial development negatively and significantly moderates the nexus between EPU and energy poverty.

2.6.3 Moderating Impact of Innovation

Innovation is one of the fundamental drivers of economic prosperity by enhancing productivity, competitiveness, and long-term growth (Grossman & Helpman, 1993; Ciocanel & Pavelescu, 2015). The introduction of new technologies, products, and processes not only helps in efficient business operation but also plays a significant role in positively contributing to the macroeconomic factors of a country (Khan et al., 2022; Kakeu, Wendji, Kouhomou, & Kamdoum, 2024; Tu, 2024). In light of these arguments, previous empirical studies have analyzed the impact of innovation on various macroeconomic factors. For instance, Pece, Simona, and Salisteanu (2015) examined the association between innovation and economic growth by collecting data from CEE countries from 2000 to 2013. They stated that innovation-related measurements, such as the number of patents and trademarks, and research and development expenditure, enhance economic growth in CEE countries. Kakeu et al. (2024) analyzed the impact of innovation on poverty reduction by collecting data from 36 Sub-Saharan African countries between 2008 and 2019. They find that innovation tends to mitigate poverty in these countries. They further argued that the negative nexus between innovation and poverty is

more pronounced in low urbanization countries. [Tu \(2024\)](#) analyzed the nexus between innovation and foreign direct investment in 66 developing countries between 2013 to 2021. He stated that innovation is more likely to attract foreign direct investment in developing countries. [Y.-J. Zhang et al. \(2017\)](#) analyzed the role of innovation in carbon emissions reduction by collecting Chinese provincial-level data from 2000 to 2013. They find that innovation plays a positive and significant role in reducing carbon emissions in China.

Moreover, existing literature also highlight that innovation is a critical factor in addressing energy-related issues of a country by bringing enhancing renewable energy transition, minimizing energy barriers and costs, and providing accessibility, thereby improving energy efficiency ([Dong, Taghizadeh-Hesary, & Zhao, 2022](#); [K. Khan et al., 2022](#); [H. Wang & Wang, 2020](#)). Based on these arguments, previous literature has analyzed the role of innovation on various energy-related factors. For example, [H. Wang and Wang \(2020\)](#) took the data between 2001 and 2013 in 284 cities in China and examined the impact of innovation on energy efficiency. They said that innovation has a positive and significant impact on energy efficiency. [K. Khan et al. \(2022\)](#) collected the data from Germany and found that innovation has a positive and significant impact on renewable energy. ([P. Zhang & Yu, 2024](#)) collected regional-level data in China between 2001 to 2020 and reported that innovation tends to alleviate energy poverty in China. In addition, regarding the moderating role of innovation, [Dong, Taghizadeh-Hesary, and Zhao \(2022\)](#) argued that innovation strengthens the positive association between financial development and energy poverty.

Concluding the above findings, this study contends that innovation may weaken the positive nexus between EPU and energy poverty due to its role in bringing advanced energy technologies, bringing renewable energy resources, reducing costs and barriers, and further increasing energy efficiency. Accordingly, this study have developed the following hypothesis.

H3: Innovation negatively and significantly moderates the nexus between EPU and energy poverty.

Chapter 3

Research Methodology

3.1 Sample

First, to check the impact of EPU on energy poverty, this study aimed to collect data from all Asian countries. However, it was not possible because the EPU index developed by (Baker, Bloom, & Davis, 2016) contains the data of only seven Asian countries, namely China, India, Japan, South Korea, Pakistan, Russia, and Singapore. Therefore, for final analysis, this study collected data from these seven Asian countries between 2000 to 2022. This study selected this period because the data for most of our independent, dependent, moderating, and control variables were available from 2000 onwards.

Moreover, this study followed various studies and collected data from different databases. For instance, following Barkat et al. (2023), this study collected the dependent and control variables data from the World Development Indicators (WDI). WDI is a comprehensive database maintained by the World Bank. This study followed Ngo, Trinh, Haouas, and Ullah (2022) and collected the financial development data from the IMF, which provides reliable and standardized indicators.

For the empirical analyses of this study, the study used the methods. First, this study winsorized all continuous variables at 1% level to minimize the extreme value effect. Second, this study dropped all missing values for all variables to obtain more robust findings. By applying these steps, this study obtained a final sample of 158 observations.

3.2 Variable Measurement

3.2.1 Economic Policy Uncertainty

This study employs the [Baker et al. \(2016\)](#) EPU index for the main independent variable (EPU), which is a recognized measure of policy uncertainty across different countries. [Baker et al. \(2016\)](#) measured the monthly EPU index for different countries around the world. As the rest of the variables' data in the study, such as energy poverty, GDP, and population growth, are annual. Hence, it is necessary to convert the monthly EPU data into an annualized measure to ensure consistency across variables in the study. To obtain an annual EPU index for each country and year, this study took the mean value of the monthly EPU index in a specific year for a specific country. This method of calculation shows the overall EPU in a given year without losing the variability in the data.

3.2.2 Energy Poverty

In order to measure the dependent variable (energy poverty), this study follows previous studies ([Apergis et al., 2022](#); [Barkat et al., 2023](#)) and uses four different proxies for energy poverty. First, this study uses access to electricity (ATE) as a percentage of the population as a proxy for energy poverty. Second, energy poverty is measured through access to electricity in rural areas (ATER) as a percentage of the rural population. Third, this study measures energy poverty by access to clean fuel and technology (ACFT) for cooking as a percentage of the population. Lastly, this study uses access to electricity in urban areas as a percentage of the urban population (ATEU) as the fourth proxy for energy poverty. Here, it is important to note that WDI provides this data on an annual basis and calculates these specific variables as access to electricity in a specific area divided by the total population in that area and then multiplied by 100. The adoption of these four different proxies enhances the reliability of the study findings. In addition, the usage of national, urban, rural, and cooking-related proxies for energy access can better provide a clear understanding of the nexus between EPU and energy poverty in the Asian countries.

3.2.3 Financial Development

This study follows [Ngo et al. \(2022\)](#) to measure financial development. This study uses financial development index data provided by the IMF. They stated that the financial development of a country is a complex phenomenon involving multiple factors that cannot be explained by a single factor. They further recommended that the IMF index can better cover the development of a country's financial institutions and financial markets, including their depth, access, and efficiency.

3.2.4 Innovation

In order to measure the moderating impact of innovation, this study follows [Khan et al. \(2022\)](#) and measures innovation by the total research and development (R&D) expenditure as a percentage of GDP by a country in a specific year. [K. Khan et al. \(2022\)](#) argue that if a country invests more in R&D they are more likely to be innovative as the purpose of such activities is to bring innovation.

3.2.5 Control Variables

Following previous studies ([Barkat et al., 2023](#); [Mawutor et al., 2024](#); [Zhao et al., 2022](#)), this study uses a set of control variables (economic, demographic, financial, and environmental) that are expected to affect energy poverty. The selection of these variables is based on previous theoretical and empirical literature relevant to energy poverty. First, GDP per capita, measured as the natural logarithm of GDP per capita, is one of the fundamental factors in analyzing energy resources because higher GDP maximizes individuals' ability to afford modern energy resources by enabling governments to invest in energy projects. Second, population growth, which is calculated as the annual population growth rate, is a significant factor in influencing energy-related projects because a higher population restricts access to energy resources due to increased demand. Third, inflation, measured as the natural logarithm of the annual change in the consumer price index (CPI), may reduce individual purchasing power, thereby affecting their ability to afford energy resources.

TABLE 3.1: Variable Measurement

Variables	Measurement	Source	Author
Dependent			
Energy poverty	a) ATE: Access to electricity (% of population)	WDI	Apergis et al. (2022)
	b) ATER: Access to electricity, rural (% of rural population)		Barkat et al. (2023)
	c) ACFT: Access to clean fuels and technologies for cooking (% of population)		
	d) ATEU: Access to electricity, urban (% of urban population)		
Independent			
EPU	Economic policy uncertainty index	policyuncertainty.com	Baker et al. (2016)
Moderating			
FD	Financial development index	IMF	Ngo et al. (2022)
INN	R&D expenditure	WDI	Khan et al. (2022)
Control			
Ln.GDP	Natural log of GDP per capita (constant 2015 US\$)	WDI	Barkat et al. (2023)
POP_G	Annual population growth rate	WDI	Mawutor et al. (2024)
Ln.CPI	Consumer price index	WDI	Mawutor et al. (2024)
DCP	Domestic credit to private sector (% of GDP)	WDI	Barkat et al. (2023)
REC	renewable energy consumption in the final total energy consumption	WDI	Zhao et al. (2022)

On the other hand, higher inflation also leads the government to implement different policies in support of vulnerable individuals, thereby affecting individuals' ability to afford energy resources. Fourth, DCP, measured as the domestic credit to the private sector as a percentage of GDP, plays a significant role in energy poverty by providing resources to individuals in accessing energy resources. Fifth, REC measured as shares of REC in the final total energy consumption is one of the significant factors in providing an alternate energy solution to a wide range of populations, thereby affecting energy poverty.

The data of all these control variables is taken from WDI, and their selection ensures the multidimensional determinants of energy poverty by controlling the effect of these economic, demographic, financial, and environmental factors.

3.3 Model and Estimation Methodology

This study follows (Nguyen, Le, & Su, 2020) and employ FGLS and PCSE models to check the nexus between EPU and energy poverty. This study develops our models as follows:

$$EP_{it} = \alpha_0 + \beta_1 EPU_{it} + \beta_2 Controls_{it} + \beta_3 Year_t + \beta_4 Country_i + \epsilon_{it} \quad (3.1)$$

$$EP_{it} = \alpha_0 + \beta_1 EPU_{it} + \beta_2 FD_{it} + \beta_3 EPU_{it} \times FD_{it} + \beta_4 Controls_{it} + \beta_5 Year_t + \beta_6 Country_i + \epsilon_{it} \quad (3.2)$$

$$EP_{it} = \alpha_0 + \beta_1 EPU_{it} + \beta_2 INN_{it} + \beta_3 EPU_{it} \times INN_{it} + \beta_4 Controls_{it} + \beta_5 Year_t + \beta_6 Country_i + \epsilon_{it} \quad (3.3)$$

Equation 1 shows the impact of EPU on energy poverty. In this equation, EP_{it} shows energy poverty in country 'i' during the time 't', EPU_{it} indicates EPU in

country 'i' during the time 't', Controlsit shows the list of control variables in country 'i' during the time 't', Yeart represents time effect, while countryi shows country effect. Equation 2 represents the moderating impact of FD on the nexus between EPU and energy poverty.

In this equation, FDi_t indicates the FD level in country 'i' during the time 't'. EPUit × FDi_t shows the moderating impact of FD. Equation 3 represents the moderating impact of innovation on the nexus between EPU and energy poverty. In this equation, INNit indicates the innovation level in country 'i' during the time 't'. EPUit × INNit shows the moderating impact of innovation.

3.4 Data Type and Estimation Techniques

This study uses panel data by collecting data from seven Asian countries, namely China, India, Korea, Pakistan, Russia, and Singapore. These countries are selected because of the availability of EPU index data developed by (Baker et al., 2016), which is crucial in examining the nexus between EPU and energy poverty. The panel data is composed of cross-sectional and time-series characteristics, which effectively control for unobserved heterogeneity and provide more robust estimates. Moreover, to empirically analyze the hypothesis, this study follows a structural approach to ensure methodological consistency.

First, this study begins the empirical analysis with descriptive statistics such as the total number of observations, mean, standard deviation, and percentile values. This step helps in the identification of variables' characteristics, such as their distribution and possible outliers in the data. The understanding of these basic characteristics is mandatory to perform further complex econometric techniques.

Second, cross-sectional dependence is one of the significant issues in panel data analysis, as the detection of cross-sectional dependence across panels can lead to biased regression results. Therefore, to address this issue, this study employs (Pesaran, 2004), which is particularly useful in panel data having smaller cross-sections and larger time periods.

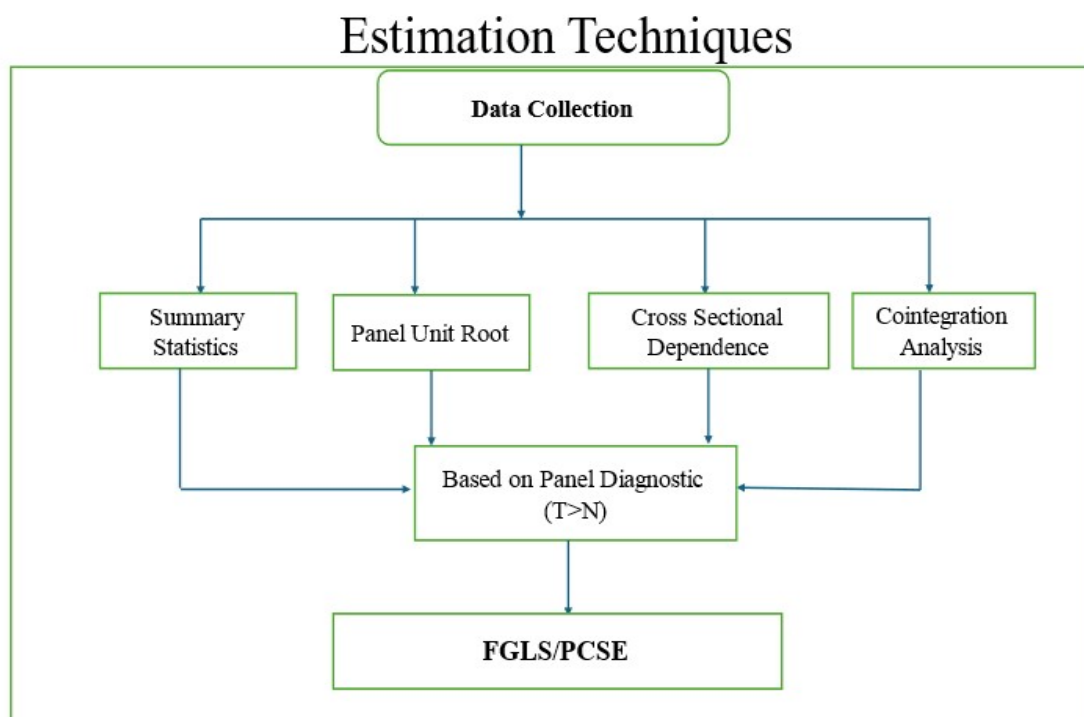


FIGURE 3.1: Estimation Techniques

Third, the variables of the study must be stationary either at the level or in first difference to minimize the issue of spurious regression findings. Therefore, to ensure the reliability of regression findings, this study employs (Im, Pesaran, & Shin, 2003) test, which is specifically designed to examine the unit-root issue in panel data. After addressing this issue, the next step is to determine cointegration among variables in the long run.

Fourth, to examine the cointegration among variables in the long run, this study employs the first and second-generation cointegration tests such as (Kao, 1999; Pedroni, 1999; Westerlund, 2007, 2007). The Kao and Pedroni are first-generation cointegration tests where the former one (Kao test) assumes a homogenous cointegration vector, while the latter (Pedroni, 1999) assumes heterogeneity across cross-sections. On the other hand, the Westerlund test is a second-generation cointegration test, and it is one of the more recent tests that provides more reliable results in the presence of panel-level heterogeneities. Overall, these three different tests examine a long-run association among the variables of the study.

Fifth, due to small cross-sections (seven Asian countries) and larger time period (2000 to 2022), this study employs feasible generalized least square (FGLS) as the

estimation technique, which is specifically designed in handling panel data having such characteristics (Liao & Cao, 2013; Nguyen et al., 2020). FGLS adjusts for auto correlation and error variance across panels, thereby providing robust and unbiased regression results.

Sixth, to ensure the robustness FGLS findings, this study also employs another panel data technique, which is also effective in dealing with small cross-sections and large time period, namely panel corrected standard error (PCSE) (Beck & Katz, 1995; Marques & Fuinhas, 2012; Nguyen et al., 2020). PCSE offers more accurate and unbiased regression results as compared to techniques by correcting standard errors across panel data. Thus, the use of both these techniques enhances the credibility of empirical findings by providing cross-validation.

Seventh, energy poverty is a multidimensional phenomenon where reliance on a single proxy often leads to an inconsistent conclusion. Therefore, besides these estimation techniques, this study further employs two additional proxies (ACFT and ATEU) for energy poverty to enhance the robustness of empirical findings. The selection of these proxies is based on previous literature (discussed in the variable section), thereby providing a more comprehensive understanding of energy poverty dynamics.

Overall, the adoption of these techniques ensures that the empirical findings of the study are statistically significant and economically meaningful.

Chapter 4

Results and Findings

4.1 Descriptive Statistics

Table 4.4 shows the results of descriptive statistics for independent, dependent, moderating, and control variables used in the study. This table shows the total number of observations, mean, standard deviation, and percentile values for each variable. As per this table, the total observations in our data is 158 for all variables except innovation, where the total number of observations is 138. This difference in innovation observations is because of data unavailability. This issue mostly exists in panel data studies. The mean value of the main dependent variable (ATE) is 94.72, indicating that, on average, 94 percent of the individuals in the Asian countries have access to electricity. This value suggests that most of the countries in the sample study have made significant progress in energy availability. The mean value of the independent variable (EPU) is 127.8, which suggests high policy uncertainty in the sample, exceeding the average of 100. This higher value of EPU shows that the sample countries experience frequent fluctuation in their economic policies, which can have implications regarding economic stability and investment decisions. Moreover, the mean value of control variables such as GDP, population growth, inflation, DCP, and REC are 9.052, 0.812, 4.617, 93.13, and 13.88, respectively.

Lastly, regarding the moderating variable, the 0.594 mean value of financial development shows that financial institutional sectors are moderately developed in the

sample countries. This value implies that some countries in the sample study may have a well-established financial institution system, while some countries might be in a financial deepening process. In addition, the mean value of innovation shows that Asian countries spent around 2% of their GDP on research and development, indicating that these countries allocate a modest share of their economic output to innovation.

TABLE 4.1: Descriptive Statistics

Variables	N	Mean	S.D	P25	P50	P75
ATE	158	94.72	9.682	95	100	100
EPU	158	127.8	82.62	73.09	102.3	145.5
Ln_GDP	158	9.052	1.412	7.493	9.158	10.4
POP_G	158	0.812	1.074	0.089	0.578	1.409
Ln_CPI	158	4.617	0.358	4.456	4.633	4.776
DCP	158	93.13	56.47	43.63	103.2	134.8
REC	158	13.88	14.5	2.9	4.7	29.99
FD	158	0.594	0.205	0.45	0.56	0.79
INN	138	1.572	1.14	0.725	1.164	2.127

Note: this table shows the descriptive statistics (N, mean, sd, p25, p50, p75) of dependent, independent, control and moderating variables of the study. The definitions of the variables are provided in Table 3.3.

4.2 Cross-Sectional Dependence

In panel data, before employing any econometric techniques, it is crucial to determine whether or not the selected variables exhibit any cross-sectional dependence among variables such as energy poverty, EPU, GDP, population growth, inflation, DCP, and REC. Cross-sectional dependence arises when unobserved common factors are correlated across different units (countries or regions) in the data. Hence, ignoring this issue can lead to biased regression results, especially in macroeconomic studies.

To check cross-sectional dependence, this study employed the (Pesaran, 2004) test on the main variables of this study. The findings in Table 4.5 suggest that most variables are cross-sectionally dependent because the values of energy poverty,

EPU, GDP, population growth, DCP, and REC are statistically significant. However, the p-value of cross-sectional dependence for inflation is insignificant, which may be due to different economic conditions and country-specific economic policies. Thus, based on these findings, this study rejects the null hypothesis, which argues that there is no cross-sectional correlation between countries.

TABLE 4.2: Cross-Sectional Dependence

<i>Variables</i>	<i>CD-test</i>	<i>P-values</i>
<i>ATE</i>	38.026***	0.00
<i>EPU</i>	13.907***	0.00
<i>Ln_GDP</i>	41.657***	0.00
<i>POP_G</i>	29.450***	0.00
<i>Ln_CPI</i>	-1.141***	0.254
<i>DCP</i>	40.602***	0.00
<i>REC</i>	41.024***	0.00

Note: this table indicates the cross-sectional results. *,**,*** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

4.3 Panel Unit Root Test

It is important to examine the stationarity of data, as non-stationary variables can lead to spurious regression findings in panel data, thereby invalidating the statistical inferences. Following these recommendations, this study tested the data stationarity through (Im et al., 2003) unit root test. This test is more reliable as compared to other unit root tests because it allows for individual unit root processes. The empirical findings in Table 4.6 show that ATC, EPU and GDP per capita, and population growth are stationary at the level. These findings suggest that these variables do not exhibit a unit root issue in their original form, thereby making them suitable for further empirical analysis without any transformation. On the other hand, DCP and REC are non-stationary at the level, but they became

stationary at first difference. This indicates that these two variables contain a unit root issue in their level form. Therefore, it is mandatory to check cointegration to examine a long-run relationship among variables; otherwise, the application of the regression method would produce misleading results.

Overall, based on these findings, it can be concluded that our data may not provide spurious regression results as all variables are either stationary at the level or first difference. In addition, before proceeding to panel data analysis, these results highlight the significance of conducting panel unit root tests because overlooking this issue can lead to a wrong conclusion.

TABLE 4.3: Panel Unit Root

Variables	Level		First Difference	
	Statistic	P-value	Statistic	P-value
ATE	-7.886***	0	-11.850***	0.00
EPU	-5.003***	0	-9.737***	0.00
Ln_GDP	-3.0821***	0.001	-4.342***	0.00
POP_G	-9.042***	0	-10.896***	0.00
Ln_CPI	1.349	0.911	-2.684***	0.003
DCP	0.332	0.63	-9.055***	0.00
REC	-0.453	0.325	-8.874***	0.00

Note: this table indicates panel unit root results at level and first difference. *, **, *** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

4.4 Cointegration Test

It is crucial to note that the variables of the study must be cointegrated in order to examine the nexus between them in the long run. Thus, in Table 4.7, this study employs first and second-generation cointegration tests to examine the presence of a long-term relationship. The first generation cointegrating tests are commonly

used panel cointegration techniques such as (Kao, 1999; Pedroni, 1999). The empirical findings through the Kao and Pedroni cointegration tests suggest that there exists a long-term relationship between the variables of interest, as the P-values are significant across all tests except the Augmented Dickey-Fuller test conducted through Pedroni.

However, one of the key limitations of first-generation cointegration techniques is their inability to ignore cross-sectional dependence among variables, which arises due to the unobserved common factors across panels. To minimize this concern, this study further employed (Westerlund, 2007) method, which is specifically designed to address the cross-sectional dependence issue. The empirical findings of of Westerlund test further corroborate the first-generation techniques (Kao and Pedroni) by showing that some panels are cointegrated. Therefore, the consistency across all techniques strengthens the conclusion of this study regarding the existence of a long-term relationship between variables.

TABLE 4.4: Panel Cointegration Analysis

	Statistics	P-values
Kao test for cointegration		
Modified Dickey-Fuller t	2.370***	0.008
Dickey-Fuller t	-2.550***	0.005
Augmented Dickey-Fuller t	1.871**	0.030
Unadjusted modified Dickey Fuller t	-4.350***	0.000
Unadjusted modified Dickey Fuller t	-8.977***	0.000
Pedroni test for cointegration		
Modified Phillips-Perron t	3.615***	0.000
Phillips-Perron t	-1.841**	0.0328
Augmented Dickey-Fuller t	0.993	0.160
Westerlund test for cointegration		
Variance ratio (some panels are cointegrated)	65.913***	0.000
Variance ratio (all panels are cointegrated)	-1.062	0.144

Note: this table indicates panel cointegration analysis by employing first and second-generation cointegration techniques. *, **, *** shows the significance level at 10%, 5%, and 1%.

4.5 Feasible Generalized Least Square Analysis

In Table 4.8, this study analyzes the impact of EPU on energy poverty in Asian countries by employing the FGLS technique. In columns 1 and 2, this study uses the first proxy of energy poverty, while in columns 3 and 4, the second proxy of energy poverty has been employed. Moreover, in columns 1 and 3, this study only checks the nexus between EPU and energy poverty without adding control variables, while in columns 3 and 4, this study adds control variables to check the aforementioned nexus. The empirical results by considering both proxies of energy poverty indicate that EPU negatively and significantly affects (coefficients = -0.038, -0.050 and p-values = 0.000, 0.000) people's access to electricity. Since lower access to energy resources in specific areas or regions indicates higher energy poverty. Therefore, based on these findings, it can be argued that EPU tends to contribute to enhancing energy poverty in Asian countries.

The inclusion of control variables in columns 2 and 4 shows that GDP has a positive and significant impact on energy poverty. These findings are in line with the notion that higher GDP leads to better infrastructural development, thereby reducing energy poverty (Zhao et al., 2022; Barkat et al., 2023). Population growth has a negative and significant impact on energy poverty. These findings are consistent with the arguments that a higher population exacerbates energy resources because of high energy demand, which further leads to energy scarcity in the different regions (B. Zhang et al., 2023). The positive and significant relationship between inflation and energy poverty is consistent with the argument that government offer their support for the underprivileged section in times of higher inflation, which leads to minimizing energy poverty (Mawutor et al., 2024; Bardazzi et al., 2024).

The negative and significant relationship between DCP and energy poverty is consistent with the notion that a higher level of DCP may bring energy scarcity in a region due to high transaction costs, credit risk, and other challenges, which further enhance energy poverty (Purkayastha, 2019). Lastly, the negative and significant relationship between REC and energy poverty is consistent with the argument that REC may lead to uneven energy distribution and immature technologies in the Asia-Pacific region (Zhao et al., 2022).

Overall, the findings of this study are in line with both theoretical and empirical studies (Bernanke, 1983; McDonald & Siegel, 1986; Shafiullah et al., 2021; Xin & Xin, 2022). Theoretically, these findings are consistent with real option theory, which posits that a higher level of EPU results in delaying investment decisions, exchange rate volatility, and expensive resource provision. Specifically, such delays and cost escalation in the energy sector lead to hindering infrastructural development, restricting supply, which further results in energy poverty. Empirically, these findings provide fresh insights into the consequences of EPU (Aslan et al., 2024; K. Khan et al., 2022; P. Zhang & Yu, 2024), and determinants of energy poverty (Apergis et al., 2022; S. Cheng et al., 2023; Nguyen & Su, 2022), by demonstrating that higher EPU may likely to increase energy poverty in Asia due to delaying investment and economic policymaking in energy sectors, increasing the cost of energy production, and limiting access to energy resources, thereby leading to enhance energy poverty.

TABLE 4.5: The Impact of EPU on Energy Poverty

Variables	-1 ATE	-2 ATE	-3 ATER	-4 ATER
EPU	-0.038*** [0.000]	-0.039*** [0.000]	-0.050*** [0.000]	-0.051*** [0.000]
Ln_GDP		3.438 [0.141]		6.453** [0.025]
POP_G		-0.741** [0.010]		-0.933*** [0.009]
Ln_CPI		11.832*** [0.000]		15.938*** [0.000]
DCP		-0.074*** [0.000]		-0.104*** [0.000]
REC		-0.583*** [0.000]		-0.651*** [0.000]
Constant	96.414*** [0.000]	40.236** [0.043]	94.898*** [0.000]	2.26 [0.927]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	158	158	158	158

Note: this table indicates FGLS results regarding the impact of EPU on energy poverty. *, **, *** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

In light of these findings, policymakers in Asian countries should bring stability to their economic policies to minimize the adverse consequences of EPU. Moreover, the countries should also focus on improving energy infrastructure development, and consistent regulations may encourage private sector participation in energy-related projects.

4.6 Panel-Corrected Standard Error Analysis

In Table 4.9, this study examines the nexus between EPU and energy poverty by employing the PCSE technique. In this Table, this study followed a similar procedure as in Table 4.8. In columns 1 and 3, the study first examines the relationship between EPU and energy poverty by adding only the dependent (energy poverty) and independent (EPU) variables, while columns 3 and 4 show a similar nexus by adding control variables.

The empirical findings also show a negative and significant relationship (coefficients = -0.038, 0.050 and p-values = 0.000, 0.000) between EPU and people's access to electricity resources. These findings further confirm our main results that a higher level of EPU limits people's access to energy resources, which further leads to an enhancement of energy poverty in Asian countries. Moreover, the empirical results are also consistent with FGLS findings. For instance, GDP and inflation have a positive and significant relationship with energy poverty, while population growth, DCP, and REC have a negative and significant relationship with energy poverty.

Overall, these results are aligned with the FGLS findings, which further demonstrate the robustness of our hypothesis regarding the negative association between EPU and energy poverty. Moreover, the empirical results are also consistent with FGLS findings. For instance, GDP and inflation have a positive and significant relationship with energy poverty, while population growth, DCP, and REC have a negative and significant relationship with energy poverty. In addition, the consistency in empirical findings across different techniques strengthens the argument of this study that policy uncertainty is one of the significant barriers to people's access to energy resources in different countries, especially in Asian economies.

TABLE 4.6: The Impact of EPU on Energy Poverty

Variables	-1 ATE	-2 ATE	-3 ATER	-4 ATER
EPU	-0.038*** [0.000]	-0.039*** [0.000]	-0.050*** [0.000]	-0.051*** [0.000]
Ln.GDP		3.438 [0.154]		6.453** [0.033]
POP_G		-0.741*** [0.000]		-0.933*** [0.000]
Ln.CPI		11.832*** [0.000]		15.938*** [0.000]
DCP		-0.074*** [0.000]		-0.104*** [0.000]
REC		-0.583*** [0.000]		-0.651*** [0.000]
Constant	96.414*** [0.000]	40.236* [0.053]	94.898*** [0.000]	2.26 [0.931]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	158	158	158	158
R-squared	0.813	0.938	0.827	0.947

Note: this table indicates PCSE results regarding the impact of EPU on energy poverty. *, **, *** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

4.7 Moderating Role of Financial Development

In Table 4.10, this study examines the moderating impact of financial development in the nexus between EPU and energy poverty. Specifically, the moderating effect has been tested by introducing an interaction term (EPU*FD) in the regression analysis. The FGLS empirical results of the interaction term (EPU*FD) are positive and significant (coefficients = 0.114, 0.142, and p-values = 0.000, 0.000), indicating financial development positively moderates the nexus between EPU and people's access to energy resources. The PCSE results of the interaction term (EPU*FD) are also consistent with the FGLS findings. These findings suggest that while EPU generally exacerbates energy poverty by limiting access to energy

resources, higher levels of financial development counteract this negative nexus between EPU and energy poverty, thereby improving energy access. Therefore, these findings support H2, where this study argues that financial development negatively moderates the relationship between EPU and energy poverty.

Overall, these findings are in line with previous studies (C. Feng et al., 2024; Mengfeng et al., 2024; Nguyen et al., 2021; Yu et al., 2024). For instance, Mengfeng et al. (2024) argue that financial development enhances energy security by stabilizing investment flows during periods of economic uncertainty. Moreover, from a policy perspective, these findings underscore the importance of strengthening financial systems to combat energy poverty, particularly in economies prone to policy instability.

TABLE 4.7: The Moderating Impact of Financial Development

	Generalized Square	Least	Panel Corrected	Stan- dard Error
Variables	-1 ATE	-2 ATER	-3 ATE	-4 ATER
EPU	-0.104*** [0.000]	-0.132*** [0.000]	-0.104*** [0.000]	-0.132*** [0.000]
FD	-12.002** [0.032]	-13.990** [0.044]	-12.002*** [0.009]	-13.990** [0.015]
EPU * FD	0.114*** [0.000]	0.142*** [0.000]	0.114*** [0.000]	0.142*** [0.000]
Ln_GDP	2.907 [0.240]	5.618* [0.067]	2.907 [0.168]	5.618** [0.035]
POP_G	-0.541* [0.057]	-0.695** [0.048]	-0.541*** [0.005]	-0.695*** [0.004]
Ln_CPI	13.731*** [0.000]	18.437*** [0.000]	13.731*** [0.000]	18.437*** [0.000]
DCP	-0.090*** [0.000]	-0.123*** [0.000]	-0.090*** [0.000]	-0.123*** [0.000]
REC	-0.666*** [0.000]	-0.755*** [0.000]	-0.666*** [0.000]	-0.755*** [0.000]
Constant	45.919** [0.017]	9.76 [0.682]	45.919** [0.015]	9.76 [0.681]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	158	158	158	158
R-squared			0.944	0.952

Note: this table indicates the FGLS and PCSE results regarding the moderating impact of financial development in the nexus between EPU and energy poverty. *, **, *** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

4.8 Moderating Role of Innovation

This section of the study shows the empirical results of H3, which argues that innovation negatively and significantly moderates the relationship between EPU and energy poverty. The moderating of innovation has been examined through an interaction term (EPU*INN) in Table 4.11. In this Table, columns 1 and 2 show the FGLS results while columns 3 and 4 present PCSE results. The findings of FGLS show that the interaction of EPU and innovation (EPU*INN) is positive and significant (coefficients = 0.012, 0.14, and p-values = 0.000, 0.000), indicating that innovation positively moderates the previous negative association between EPU and people's access to energy resources.

Moreover, the PCSE findings in columns 3 and 4 also show similar findings, which further confirm the robustness of empirical results across different estimation techniques. The results of the control variables are also consistent with previous findings. Hence, these findings also support H3, which posits that innovation negatively moderates the relationship between energy poverty.

Overall, these findings are consistent with previous studies ([Dong, Taghizadeh-Hesary, & Zhao, 2022](#); [K. Khan et al., 2022](#); [Dong, Taghizadeh-Hesary, & Zhao, 2022](#); [K. Khan et al., 2022](#); [H. Wang & Wang, 2020](#); [P. Zhang & Yu, 2024](#)). For instance, Wang and Wang (2020) provide empirical evidence by arguing that higher levels of technological innovation drives the advanced energy related technological adoption which further helps in reducing energy poverty. Similarly, [X. Zhang, Meng, and Su \(2024\)](#) further corroborated these findings by showing a negative and significant relationship between innovation and energy poverty. Therefore, this study further extends and contributes to the previous by arguing that innovation is one of the critical factors in providing advanced energy technology, including

renewable energy resources, enhancing energy efficiency through cost and barrier minimization, thereby more likely to play an important role in times of EPU in reducing energy poverty. Lastly, from a policy perspective, these findings underscore the importance of innovation investment in energy technologies to combat energy poverty by providing an alternate source of energy for the vulnerable population, particularly in economies prone to unstable economic policies.

TABLE 4.8: The Moderating Impact of Innovation

	Generalized Square	Least	Panel Corrected Standard Error	Stan- dard Error
Variables	-1 ATE	-2 ATER	-3 ATE	-4 ATER
EPU	-0.057*** [0.000]	-0.073*** [0.000]	-0.057*** [0.000]	-0.073*** [0.000]
INN	-3.090*** [0.003]	-3.457*** [0.008]	-3.090*** [0.002]	-3.457*** [0.004]
EPU * INN	0.012*** [0.005]	0.014*** [0.006]	0.012*** [0.006]	0.014*** [0.008]
Ln_GDP	0.99 [0.627]	3.54 [0.162]	0.99 [0.670]	3.54 [0.220]
POP_G	-6.794*** [0.000]	-8.426*** [0.000]	-6.794*** [0.000]	-8.426*** [0.000]
Ln_CPI	9.571*** [0.000]	13.561*** [0.000]	9.571*** [0.000]	13.561*** [0.000]
DCP	-0.040** [0.049]	-0.060** [0.016]	-0.040** [0.030]	-0.060*** [0.008]
REC	-0.642*** [0.000]	-0.721*** [0.000]	-0.642*** [0.000]	-0.721*** [0.000]
Constant	75.395*** [0.000]	42.454* [0.067]	75.395*** [0.000]	42.454 [0.113]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	138	138	138	138
R-squared			0.96	0.965

Note: this table indicates the FGLS and PCSE results regarding the moderating impact of innovation in the nexus between EPU and energy poverty. *, **, *** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

4.9 Alternate Proxies

To further check the robustness of the main findings, this study followed (Barkat et al., 2023) and employed two additional proxies for energy poverty. Table 4.12, columns 1 and 2 utilize the third proxy of energy poverty, access to clean fuels and technologies for cooking (ACFT), measured as the percentage of the population with access to clean fuels and technologies for cooking while in columns 3 and 4 incorporate the fourth proxy, access to electricity in urban areas (ATEU), defined as the percentage of the urban population with access to electricity. In this Table, the main regression technique, namely FGLS, has been employed across all columns.

The empirical results across all columns show that EPU has a negative and significant association with these two additional measures of energy poverty. Specifically, these findings also show that a high level of EPU tends to minimize people's access to ACFT and ATEU. Hence, people having lower to ACFT and ATEU will ultimately enhance energy poverty.

Overall, these findings mitigate the concerns about measurement bias and enhance the credibility of the main findings by demonstrating that the relationship between EPU and energy poverty is not contingent on a single measurement approach, but the adverse effect of EPU still even after measuring energy poverty through different proxies. These findings also align with the main results of the study, which suggest EPU exacerbate energy poverty by restricting individual access to reliable energy resources. To check the robustness of H2, this study further employed the alternate proxies (ACFT and ATEU) for energy poverty. In Table 4.13, columns 1 and 2 show the empirical results regarding the moderating impact of financial development in the nexus between EPU and energy by using FGLS, while columns 3 and 4, this study further uses the PCSE technique.

TABLE 4.9: Alternate Proxies (H1)

	-1	-2	-3	-4
Variables	ACFT	ACFT	ATEU	ATEU
EPU	-0.019*	-0.035***	-0.010***	-0.010***
	[0.062]	[0.000]	[0.000]	[0.000]
Ln_GDP		48.275***		0.017
		[0.000]		[0.981]
POP_G		-0.354		-0.195**
		[0.360]		[0.028]
Ln_CPI		7.082***		3.354***
		[0.000]		[0.000]
DCP		-0.200***		-0.016**
		[0.000]		[0.012]
REC		0.242*		-0.179***
		[0.095]		[0.000]
Constant	54.809***	-348.514***	99.217***	90.798***
	[0.000]	[0.000]	[0.000]	[0.000]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	158	158	158	158

Note: this table indicates the FGLS results regarding impact EPU on energy poverty. *, **, *** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

The empirical findings of the interaction term (EPU * FD) in column 1 show that financial development positively but insignificantly moderates the nexus between EPU and energy poverty. The findings in the rest of the columns, such as columns 2, 3, and 4, are positive and significant. Overall, these findings further validate the argument of this study regarding our second hypothesis that financial development minimizes the adverse consequences of EPU, thereby leading to enhanced people's access to energy resources.

TABLE 4.10: Alternate Proxies (H2)

Variables	Generalized Square		Least Panel Corrected Standard Error	
	-1 ACFT	-2 ATEU	-3 ACFT	-4 ATEU
EPU	-0.064*** [0.008]	-0.025*** [0.000]	-0.025*** [0.000]	-0.025*** [0.000]
FD	16.483** [0.034]	-2.817 [0.111]	-2.817** [0.044]	-2.817** [0.044]
EPU * FD	0.051 [0.217]	0.027*** [0.004]	0.027*** [0.001]	0.027*** [0.001]
Ln_GDP	44.198*** [0.000]	-0.109 [0.889]	-0.109 [0.883]	-0.109 [0.883]
POP_G	-0.55 [0.162]	-0.148* [0.099]	-0.148*** [0.005]	-0.148*** [0.005]
Ln_CPI	10.808*** [0.000]	3.802*** [0.000]	3.802*** [0.000]	3.802*** [0.000]
DCP	-0.201*** [0.000]	-0.020*** [0.002]	-0.020*** [0.000]	-0.020*** [0.000]
REC	0.192 [0.186]	-0.199*** [0.000]	-0.199*** [0.000]	-0.199*** [0.000]
Constant	-336.806*** [0.000]	92.137*** [0.000]	92.137*** [0.000]	92.137*** [0.000]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	158	158	158	158
R-squared			0.907	0.907

Note: this table indicates the FGLS and PCSE results regarding the moderating impact of financial development in the nexus between EPU and energy poverty. *, **, *** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

In Table 4.14, this study further followed a similar process of alternate measurements and examined H3 regarding the moderating impact of innovation in the association between EPU and energy poverty. In this Table, columns 1 and 2 show the FGLS results while columns 3 and 4 show PCSE findings.

The empirical results of the interaction term (EPU * INN) across all columns are positive and significant, suggesting that innovation positively moderates the relationship between EPU and energy poverty. These findings also support this argument that technological innovation provides an opportunity for an alternate

energy solution, which helps in minimizing energy poverty for the vulnerable population.

TABLE 4.11: Alternate Proxies (H3)

	Generalized Square	Least	Panel Corrected	Standard Error
Variables	-1 ACFT	-2 ATEU	-3 ACFT	-4 ATEU
EPU	-0.049*** [0.000]	-0.014*** [0.000]	-0.049*** [0.000]	-0.014*** [0.000]
INN	1.174 [0.377]	-0.955*** [0.006]	1.174 [0.389]	-0.955*** [0.006]
EPU * INN	0.011** [0.037]	0.003** [0.048]	0.011* [0.069]	0.003** [0.047]
Ln_GDP	45.995*** [0.000]	-0.602 [0.379]	45.995*** [0.000]	-0.602 [0.453]
POP_G	-7.967*** [0.000]	-1.654*** [0.000]	-7.967*** [0.000]	-1.654*** [0.000]
Ln_CPI	9.185*** [0.000]	2.528*** [0.000]	9.185*** [0.000]	2.528*** [0.000]
DCP	-0.147*** [0.000]	-0.009 [0.172]	-0.147*** [0.000]	-0.009 [0.115]
REC	0.19 [0.107]	-0.194*** [0.000]	0.19 [0.116]	-0.194*** [0.000]
Constant	-339.235*** [0.000]	101.064*** [0.000]	-339.235*** [0.000]	101.064*** [0.000]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	138	138	138	138
R-squared			0.992	0.924

Note: this table indicates the FGLS and PCSE results regarding the moderating impact of innovation in the nexus between EPU and energy poverty. *, **, *** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

4.10 Fixed and Random Effect Models

This study further followed Barkat et al. (2023) and employed fixed and random effect models in Table 4.15. Both of these models are very important in panel data analysis because they address the heterogeneity issue across different cross sections, thereby mitigating the biased and omitted variables issue. This Table is divided

into 4 different columns, where the empirical results of the fixed effect model are shown in columns 1 and 2, while the random effect model results are shown in columns 3 and 4. In this table, we used two main proxies (ATE and ATER) of energy poverty. The empirical results of the fixed effect model, which is mostly used to control the effect of time-invariant characteristics across each panel, show that EPU has a negative and significant impact on energy resources. The results of the random effect model, which assumes that unobserved heterogeneity does not correlate with explanatory variables, also show the negative and significant relationship between EPU and energy poverty. The random effect model also supports fixed effect results. Overall, the empirical results in these columns also support our main findings by showing that a higher level of EPU has a negative and significant impact on people's access to ATE and ATER. Therefore, these findings further validate our main hypothesis, which argues that a higher level of EPU leads to a delay in investment in different projects by creating an uncertain environment, thereby enhancing the likelihood of energy poverty.

TABLE 4.12: Fixed and Random Effect (H1)

Variables	Fixed Effect		Random Effect	
	-1 ATE	-2 ATER	-3 ATE	-4 ATER
EPU	-0.039*** [0.000]	-0.051*** [0.000]	-0.039*** [0.000]	-0.051*** [0.000]
Ln_GDP	3.438 [0.196]	6.453* [0.051]	3.438 [0.193]	6.453** [0.049]
POP_G	-0.741** [0.025]	-0.933** [0.023]	-0.741** [0.023]	-0.933** [0.021]
Ln_CPI	11.832*** [0.000]	15.938*** [0.000]	11.832*** [0.000]	15.938*** [0.000]
DCP	-0.074*** [0.002]	-0.104*** [0.001]	-0.074*** [0.002]	-0.104*** [0.000]
REC	-0.583*** [0.000]	-0.651*** [0.000]	-0.583*** [0.000]	-0.651*** [0.000]
Constant	29.803 [0.212]	-12.217 [0.679]	40.236* [0.074]	2.26 [0.935]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	158	158	158	158
R-squared	0.819	0.837	0.819	0.837

Note: this table indicates the fixed and random effect models results regarding impact EPU on energy poverty. *,**,*** shows the significance level at 10%, 5%, and 1%.

Tables 4.16 and 4.17, this study also used fixed random effects models to analyze how financial development and innovation moderate the association between EPU and energy poverty. In both Tables, the empirical findings of interaction terms (EPU * FD and EPU * INN) in columns 1 and 2 show the empirical results of the fixed effect model, while columns 3 and 4 indicate random effect model findings. The empirical results regarding the moderating impact of financial development while using fixed and random effects models also show positive and significant coefficients. Similarly, the empirical results regarding the interaction term (EPU * INN) of innovation and EPU are also positive and significant, suggesting that innovation also positively moderates the nexus between EPU and energy poverty. Thus, these findings further support the H2 and H3 of this study.

TABLE 4.13: Fixed and Random Effect (H2)

Variables	Fixed effect		Random effect	
	-1 ATE	-2 ATER	-1 ATE	-2 ATER
EPU	-0.104*** [0.000]	-0.132*** [0.000]	-0.104*** [0.000]	-0.132*** [0.000]
FD	-12.002* [0.064]	-13.990* [0.081]	-12.002* [0.061]	-13.990* [0.078]
EPU * FD	0.114*** [0.001]	0.142*** [0.001]	0.114*** [0.001]	0.142*** [0.001]
Ln_GDP	2.907 [0.306]	5.618 [0.111]	2.907 [0.304]	5.618 [0.109]
POP_G	-0.541* [0.099]	-0.695* [0.086]	-0.541* [0.096]	-0.695* [0.084]
Ln_CPI	13.731*** [0.000]	18.437*** [0.000]	13.731*** [0.000]	18.437*** [0.000]
DCP	-0.090*** [0.000]	-0.123*** [0.000]	-0.090*** [0.000]	-0.123*** [0.000]
REC	-0.666*** [0.000]	-0.755*** [0.000]	-0.666*** [0.000]	-0.755*** [0.000]
Constant	35.127 [0.131]	-5.141 [0.858]	45.919** [0.036]	9.76 [0.720]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	158	158	158	158
R-squared	0.836	0.852	0.836	0.852

Note: this table indicates the fixed and random effect models results regarding the moderating impact of financial development in the nexus between EPU and energy poverty. *,**,*** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

TABLE 4.14: Fixed and Random Effect (H3)

Variables	Fixed effect		Random effect	
	-1 ATE	-2 ATER	-3 ATE	-4 ATER
EPU	-0.057*** [0.000]	-0.073*** [0.000]	-0.057*** [0.000]	-0.073*** [0.000]
INN	-3.090** [0.012]	-3.457** [0.024]	-3.090** [0.011]	-3.457** [0.022]
EPU * INN	0.012** [0.017]	0.014** [0.021]	0.012** [0.015]	0.014** [0.019]
Ln_GDP	0.99 [0.677]	3.54 [0.232]	0.99 [0.676]	3.54 [0.230]
POP_G	-6.794*** [0.000]	-8.426*** [0.000]	-6.794*** [0.000]	-8.426*** [0.000]
Ln_CPI	9.571*** [0.000]	13.561*** [0.000]	9.571*** [0.000]	13.561*** [0.000]
DCP	-0.040* [0.093]	-0.060** [0.040]	-0.040* [0.090]	-0.060** [0.038]
REC	-0.642*** [0.000]	-0.721*** [0.000]	-0.642*** [0.000]	-0.721*** [0.000]
Constant	68.886*** [0.003]	33.199 [0.234]	75.395*** [0.000]	42.454 [0.115]
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Observations	138	138	138	138
R-squared	0.888	0.898	0.897	0.888

Note: this table indicates the FGLS and PCSE results regarding the moderating impact of innovation in the nexus between EPU and energy poverty. *,**,*** shows the significance level at 10%, 5%, and 1%. The definitions of the variables are provided in **Table 3.3**.

Chapter 5

Discussion and Conclusion

5.1 Conclusion

The recent global crisis (COVID-19 and Russia-Ukraine) has significantly contributed to various economic and social issues such as inflation, unemployment, economic recessions, and energy scarcity. Considering these crises, the energy sector, which plays an important role in fulfilling the economic and social needs of individuals, households, and corporations, has gained significant attention from scholars and policymakers around the world. Meanwhile, existing empirical literature has found that economic and social factors play a significant role in enhancing or reducing energy poverty in different economies. These social and economic factors include ethnic diversity, religiosity, education, green finance, urban-rural income gap, renewable energy technologies, environmental taxes, financial development, income inequalities, among others. Thus, contributing to the existing literature, this study examines the relationship between EPU and energy poverty. This study argues that EPU may significantly affect energy poverty because of the EPU adverse social and economic consequences due to delaying infrastructure projects, discouraging private investment. In addition, this study further examines how financial development and innovation moderate the nexus between EPU and energy poverty.

To examine the research questions, this study collected data between 2000 to 2022 from seven Asian countries, namely China, India, Japan, South Korea, Pakistan,

Russia, and Singapore. For empirical analysis, this study uses different econometric techniques. For example, the cross-sectional dependence among the variables has been tested through the Pesaran test. The stationarity of the data has been tested through the Im, Pesaran, and Shin unit root test. For cointegration analysis, this study has employed both first and second-generation techniques, such as Kao, Pedroni, and Westerlund tests. Lastly, this study has employed FGLS and PCSE tests to analyze the relationship between EPU and energy poverty. Overall, the findings of the study suggest that EPU tends to increase energy poverty. In addition, I further found that financial development and innovation weaken the positive association between EPU and energy poverty.

5.2 Policy Implications

Based on the findings, this study offers the following policy implications. First, the uncertain environment created policy instability may adversely affect various economic and social outcomes, including the enhancement of energy poverty. The inconsistency in economic policies can create difficulties for investors in long-term investment in different projects, especially those related to energy sectors, as they need huge investments. Therefore, governments around the world, especially in these seven Asian countries, should strive for transparent and consistent economic policies to minimize uncertainty. Economic policy stability can help in providing a clear roadmap for energy transition, thereby ensuring that all key stakeholders, including policymakers and investors, can align their strategies and investment decisions to achieve long-term goals. In addition, this creation of a credible environment can ultimately help in reducing energy poverty, especially in developing countries.

Second, consistent with the previous literature, the findings of the study suggest that financial development plays a critical role in minimizing the negative consequences of EPU. Therefore, based on these findings, it is recommended that policymakers should promote an inclusive financial system, such as microfinance and low-interest loans, as it will help households and organizations to afford a

clean energy system. In addition, improvement in the financial system will help in investor confidence, which will further enhance capital flow to different projects, thereby ultimately helping the underprivileged communities to access energy resources.

Third, the findings of the study also suggest that innovation plays a crucial role during high EPU. It can also be argued that the negative consequences of EPU are ultimately borne by the marginalized population. Therefore, based on the findings of this study, it is recommended that policymakers should enhance research and development expenses, as it will help in bringing energy-efficient technologies that will efficiently cover less developed populations and regions. In addition, in the crisis period, high research and development expenses by policymakers can help in bringing modern energy-related technologies with a lower cost can further contribute to mitigating energy poverty.

5.3 Limitations of the Study

Even though this study offers valuable insights regarding the role of EPU in energy poverty in Asian countries. However, this study also has certain limitations that can limit the generalizability of the findings.

First, one of the basic limitations of this study is its specific focus on EPU, which is deliberate and central to our research question. This focus is deliberate in the sense that EPU might be a significant factor in enhancing energy poverty due to its role in delaying investment in different sectors, including the energy-related sector.

Second, based on the scope of this study, it only considers how EPU affects energy poverty. However, besides energy poverty, some other social and economic factors, such as financial stability, poverty, and environmental degradation, may be adversely affected due to EPU. However, this study ignores the contribution of EPU in these social and economic outcomes.

Third, the prime objective of this study was to examine the association between EPU and energy poverty by including all Asian countries. However, EPU is largely

measured through a comprehensive and widely used index developed by (Baker et al., 2016), which only contains the data of these seven Asian countries. Therefore, due to data limitations, examining the aforementioned nexus was not possible.

5.4 Future Research Directions

The limitations of this study offer an avenue for future research that can help in enhancing our understanding of the consequences of EPU and the determinants of energy poverty. A few of the future research directions are discussed below.

First, this study urges scholars to expand the scope of this study by analyzing the role of diverse economic and social factors, such as economic complexity and social trust in energy poverty. Economic complexity represents the production capabilities and technological advancement in a country. Hence, higher economic complexity in countries around the world may enhance the likelihood of investment in energy-related projects, thereby affecting energy poverty. Similarly, social trust represents social norms and values that can be meaningful in affecting energy-related policies and investment, which can further affect energy poverty. Therefore, the analysis of these dimensions will further help policymakers in addressing energy poverty in different countries.

Second, this study recommends that future studies should further analyze the role of EPU on various economic and social outcomes. For example, high EPU may adversely affect financial stability by constraining household incomes. Financial instability will further minimize the capacity of individuals, especially the marginalized population, to afford different items, including energy services. Therefore, analyzing such relationships will deepen our understanding of the consequences of EPU.

Third, energy poverty is a global challenge; however, the underlying causes may be different across countries/regions due to different governance mechanisms, economic development, energy markets, and social dynamics. Therefore, this study recommends that future research should further explore the similar nexus in other countries, as it will help in the overall generalizability of these findings.

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