Energy Governance and Selected Macroeconomic Indicators of Pakistan: A Time Series Analysis

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Abstract

Affordable energy becomes an integral part of economic growth. Affordability of energy is determined by availability of energy and proactive governance measures at upstream, midstream and downstreams of energy system. Present study empirically investiages the impact of energy governance on three selected macroeconomic indicators of Pakistan economy during the period of 1985 to 2021.There is hardly a single study that measures downstream energy governance and estimate its impact on three macroeconomic indicators (external debt, unemployment rate and national income). The first objective is related to measurements of downstream energy governance. For this purpose, study uses three dimensions of downstream energy governance. Furthermore, six indicators from three dimensions are utilized to construct energy governance index. Principal Component Analysis (PCA) methodology is used to construct a composite variable of energy governance. After tackling the measurement issues of energy governance, the study uses an amended form of neo-classical production function as an econometric model in which study introduces energy governance as a determinant factor of macroeconomic indicators. There are three models that contain three different dependent variables which are unemployment, external debt, and gross domestic product. As study uses time series data and many series are nonstationary at level but are these are stationary at first difference. The study estimate the models with the help of autoregressive distributed lag (ARDL). The first model of study measures the impact of energy governance on externa debt. Energy governance has a negative impact on external in the long run as well as in the short run. On same token, energy governance has negative and statistically significant impact on unemployment rate of Pakistan. In last model, energy governance has positive and significant impact on gross domestic product of Pakistan. At the end, study suggests that efficient energy governance decrease the energy losses and better performance of macroeconomic variables. So policy makers should improve the quality of infrastructure of downstream energy system, and streamlining regulatory frameworks that lower the energy losses.

Key words: Energy Governance **(**EG), Gross domestic product (GDP), Exchange Rate (ER), Inflation (INF), Gross Fixed Capital Formation (GFCF), Unemployment (UN), External Debt (ED) and GDP per capita

CHAPTER 01

01: Introduction

Energy is the backbone of any modern economy, and it is a vital ingredient for socio-economic progress. Energy is required for all human activities, such as education, health care, agriculture, etc. A country can't move forward without long-term sustainable energy resources. There are a variety of perspectives and theories that create the link between energy and economic growth. Industrialization will not take place if there is insufficient energy, and energy is a precarious component of their manufacturing process. Because the extension of energy sources is associated with speedy growth, scarcity is a source of economic growth slowdown. The lack of energy has a direct influence on all sectors of the economy, including agriculture, industry, and services (Irfan et al., 2019).

Since last few decades, governance has been raised as a new composite term for all social, economic, and political factors. Later, this governance is measured at aggregate level. Then many attempts by researchers to identify its sub- parts or other dimensions. In recent years energy governance term is used in literature of energy economics. Furthermore, this energy governance is categorized into three streams. But in broader perspectives poor energy governance affects economic growth path and social fabric of any society. The demand of modern energy sources in Pakistan on increasing mode like other developing countries. At exogenous level demand is increasing while on other hand endogenous factors like poor infrastructure, inefficient pricing system and institutional backwardness creates hurdle in smooth energy supply. These endogenous and exogenous factors are enhancing energy insecurity. Energy governance has become a deliberate policy address in energy security research, impacting socio-technical patterns of sustainable transformations in the twenty-first century. According to estimates, Pakistan's faltering energy sector has contributed to a 2% decline in GDP growth each year for a number of years (M. Y. Raza et al., 2020). Before understanding energy governance, it is important to know about how an energy system works in an economy. The following sub-sections discusses the energy system in broader way.

1.1 Energy Governance

The most vital aspect of both economic and social life is energy, and efficient energy governance is key to raising people's standards of living. It encourages a fair and equitable shift to renewable energy and promises that nobody is left behind. Under this fresh sector related to our governance, they put the interests of individuals first and enable them to deal with the numerous issues related to energy of the 21st century (Simionescu et al., 2021). The plan will regulate the planning and rolling out of energy-related projects through encouraging more participation among stakeholders, building specific options, and applying a data-driven strategy for a reasonably priced, accessible, strong, safe, and environmentally friendly energy future.

Energy governance plays a crucial role in ensuring macroeconomic stability by influencing various macroeconomic indicators. Efficient and transparent energy governance helps in maintaining a reliable energy supply, which is fundamental for the smooth functioning of industries and households. When energy governance improves it brings price stability. Additionally, effective energy governance promotes innovation and investment in the energy sector, fostering economic growth and job creation. Moreover, by addressing issues such as energy security and environmental sustainability, robust energy governance contributes to the overall resilience of a nation's economy, creating a foundation for long-term stability and prosperity (Becker & Fischer, 2013). Sustainable Development Goals (17SDGs) include the availability for everyone to dependable, sustainable, and modern energy services at a reasonable cost, whereas energy was not included in the Millennium Development Goals (Belaid & Elsayed, 2019).

In a certain organizational structure, the management, distribution, and utilization of energy resources are governed by a collection of principles, policies, regulations, and practices known as energy governance (Koyama, 2018). It includes the processes and frameworks used to decide on issues such as energy distribution, consumption, and environmental effects. Energy governance seeks to balance and sustain energy management while taking economic, social, and environmental factors into account.

Macroeconomic and political theories both are making significant insights that belong to the term good governance. It is applied for both a tactical perspective of the economic growth and the oversight of governmental execution (Rehman & Deyuan, 2020). To clarify and highlight the role of the term "good governance" regarding development efforts, this group is initially looking at deconstructing all the suggestions. All dimensions of how the government fulfils its responsibilities to foster societal and economic growth are referred to as "governance" in this context. It is a model of governance in which the creation and execution of policies are jointly undertaken by all governmental, non-governmental, business, and civil society sectors.

Basically, governance refers to the procedures that guide the formulation of policies and their execution.

Policies, rules, and guidelines are developed by national energy ministries or departments to direct the energy sector. They frequently monitor the creation, transfer, and use of energy. Independent regulatory agencies oversee and guarantee adherence to rules and regulations pertaining to the energy sector, fostering just competition and consumer protection. International organizations e.g., International Energy Agency (IEA) helps countries work together and conduct research to address the world's energy concerns (Florini, 2011). Bordering laws, building requirements, and financial incentives for the installation of renewable energy sources are just a few ways that local and regional governments can affect energy choices.

Energy demand is primarily driven by individuals, families, and businesses through their usage of power, heating, cooling, and transportation. Industries have high energy requirements for production, processing, and other activities (Sorrell, 2015). They might use energy-saving techniques and equipment to cut back on their consumption. Offices, retail locations, and other commercial buildings need lighting, heating, cooling, and electronic equipment, which adds to the demand for energy. Energy demand for transportation, including personal vehicles, public transportation, and freight, is substantial. The use of alternative fuels and electric vehicles may change how much energy this industry uses.

Energy governance and energy losses are distinct yet interconnected concepts within the realm of energy management. Energy governance refers to the policies, regulations, and institutional frameworks that guide the production, distribution, and consumption of energy resources. It involves decision-making processes, transparency, and accountability in the energy sector. On the other hand, energy losses pertain to inefficiencies and wastages that occur during the generation, transmission, and utilization of energy. While energy governance aims to establish effective and sustainable energy systems, addressing energy losses is a technical challenge to enhance overall efficiency. Clear and robust governance frameworks can play a pivotal role in identifying and mitigating energy losses by promoting investment in infrastructure, technology, and practices that optimize energy utilization and reduce waste, thereby fostering a more resilient and sustainable energy ecosystem (Behera, 2019).

The development of technology like energy storage, grid management, and effective energy production is what propels academic institutions and research organizations to innovate the energy supply. By assisting technologies and endeavors, financial institutions and private investors help shape the path of the energy supply. To stimulate investment in a particular energy source or technology, governments may provide subsidies, tax breaks, and grants. These stakeholders interact with one another and compete within their specific industries, affecting the evolution of more robust and sustainable energy systems as well as the overall energy landscape (Hadj Fraj et al., 2018).

1.2 Comparisons of Energy Governance of Pakistan with Other Nations

Pakistan is an economically developing country with an annual GDP per person of $1,909 in early 2019 and 58 million people without getting electricity. According to IEA report of 2021 about 6.75 billion people spend their life without electricity in 2021, and 2.3 billion people depend on harmful cooking fuels. The primary element in the economy and society is energy, and successful energy governance is key to raising people's standard of living. The demand for energy continues to rise, growing population size, and urbanism. Pakistan is more reliant on imported gas, petroleum, and most recently coal for electricity. In contrast to India or China, Pakistan is a comparatively tiny manufacture of carbon dioxide (CO_2), instead due to the energy preferences and developments it constructs, Pakistan is predicted to significantly increase its output of greenhouse gases. Pakistan having joined the Agreement on Climate Change in Paris, there have become more discusses over the area's use of coal (Raza & Afshan, 2017).

Energy governance is a multifaceted notion that emerges from the interaction of a country's economic, geopolitical, political, institutional, regulatory, and legal components. The first dimension of energy governance is economic dependency, which includes concerns about import dependency in the context of insecure energy markets, changes in primary energy mix and resource use, and energy circularity. The second factor is international relations geopolitics, which looks at how geopolitics affects energy security through combination, collaboration, or unilateral action. The political economy of energy governance is the third dimension, which looks at how natural gas and petroleum exporting and importing countries interact. The fourth component includes features of energy governance in regional, municipal, and international institutional, legal, and regulatory frameworks. (Change, et al., 2019).

In a case study of Bangladesh, three components were utilized to quantify energy governance in terms of energy security, quality of national governance, political landscape, and integration into international governance. (Zaman et al., 2017).

Coal, natural gas, nuclear energy, and sources of green energy, make up the broadened energy portfolio of the United States (Neville et al., 2019). With federal and state agencies in charge of rules, laws, and oversight, the nation has a well-established system for managing its energy supply. In the U.S., private sector involvement in energy production and delivery is encouraged and market-based processes are favored.

Germany remains at the top in the development of renewable energy, especially wind and solar power. Towards move out nuclear power and migrate to an ecologically friendly economy, the nation of Germany is putting determined measures in place, such as the Energiewende (energy transition) (Schmid et al., 2020). With a combination of government-level, state-level, and local laws and motives, Germany enjoys a centrally controlled energy governance system.

India has been investing in renewable energy sources like solar and wind due to its quickly growing energy needs (Malakar et al., 2019). Government in this country is both centralized and delegated; the federal government establishes laws and rules, but the states have some discretion over how to carry them out. To improve energy efficiency, promote renewable energy, and improve access to electricity in rural regions, India has adopted several programmes.

Considering its vast hydroelectric assets and oil wealth, Norway has a particular kind of energy governance (Bauknecht et al., 2020). The country focuses a lot of emphasis on renewable energy sources, specifically hydropower, which meets most of its electricity needs. With a governmental fund that invests oil income for the benefit of future generations, Norway's energy governance is characterized by an equal amount of both state and private ownership.

South Africa uses a variety of energy sources but relies largely on coal to produce power. But the whole country has been building up its production capacity for clean energy to broaden its sources of energy (Davies et al., 2018). Governmental agencies oversee setting up, governing, and auditing the country's regulated energy industry.

The specific energy issues Pakistan faces, such as its reliance on fossil fuels, poor infrastructure, and inconsistent access to electricity in some places, must be taken into mind while discussing Pakistan's energy administration with other countries. The capability for renewable energy has increased, and Pakistan has taken attempts to diversify its energy mix. To attract private investment, encourage energy efficiency, and increase access to electricity, the government has introduced policies and regulations. Maintaining an efficient and environmentally friendly energy supply for all its citizens, meanwhile, still presents enormous challenges.

Table 1.1 Transmission and Distribution Losses of Selected Nations in 2021

	% Production	Country
Total Transmission and distribution losses of electricity	(17%)	Pakistan
Total Transmission and distribution losses of electricity	(7%)	Japan
Total Transmission and distribution losses of electricity	(5.26%)	China
Total Transmission and distribution losses of electricity	(5%)	USA
Total Transmission and distribution losses of electricity	(0.4%)	Germany

Data source; International Energy Agency (IEA)

In developing countries like Pakistan, India facing the problems of energy issues are deprived in high inflation cost, hunger, poverty, increasing level of unemployment, and current account deficit. Instead of developed countries such as Germany, Japan, US have minimum transmission and distribution (Energy Losses) that's why their GDP is high low inflation, don't face unemployment and highest value of currency that's why their country growth is highest.

1.3 Background of Research

The research on energy governance in the case of Pakistan focuses on understanding and analyzing the governance structures, policies, and practices related to energy management and decision-making in the country. This research aims to identify the strengths, weaknesses, and challenges within Pakistan's energy sector and propose recommendations for improving governance mechanisms. The background of this research is rooted in the energy sector's significance for Pakistan's socio-economic development. Pakistan faces various energy-related issues, including energy shortages, inadequate infrastructure, inefficiencies in energy production and distribution, and high transmission and distribution losses. Keeping all these considerations in mind, the impact of energy governance, selected macroeconomic indicators in case of Pakistan in this research will be observed. These challenges impact the country's economic growth, industrial productivity, and overall quality of life.

1.4 Research Gap

The previous study estimate the effect on poverty of energy on macroeconomic indicators in Pakistan (Ali et al., 2015).The previous study estimated the multidimensional energy security index of Pakistan (Abdullah et al., 2021). The another study also measured the energy governance using the single buyer model to liberalize the electricity generation structure with the help of macroeconomic indicators in Bangladesh (R. Zaman & Brudermann, 2018). The government needs adopt policy initiatives including wind and solar power, renewable energy, and micro hydroelectricity to raise the 2030 target from a meagre 5% of total generation to at least 15 percent, according to Malik et al., (2019) assessment on Pakistan's energy security.

As per my knowledge there is not a single study that discusses the impact of energy governance on macroeconomic indicators. There is also a study (Banna et al., 2023) investigated the link between energy security and macroeconomic stability by using the robustness test. Another study by (Stavytskyy et al., 2018) explains the link between energy security and macroeconomic indicators in European countries. So, the current study to fill this gap in these ways (1) to see the impact of energy governance on selected macroeconomic indicators in case of Pakistan. Secondly, the study measures the downstream energy governance with the help of six indicators of energy sources. After normalization the six indicators, study uses Principal Component Analysis (PCA) method to develop a composite variable that is called as energy governance. Thirdly, this study estimate three models in which energy governance is used as an independent variable along with other control variables (exchange rate, inflation, total labor force, energy governance, GDP per capita, GFCF). While dependent variables are (1) external debt, (2) unemployment, and (3) GDP.

1.5 Research Objectives

- The first objective of the present study is to measure energy governance for the period of 1985 to 2021.
- The second objective is to estimate the impact of energy governance on three selected macroeconomic indicators (unemployment, external debt, GDP) of Pakistan.

1.6 Limitations of the Study

- Energy governance is a very wide concept, here study limits itself for downstream energy system.

- The study estimates the impact of energy losses on three selected macroeconomic indicators. As there are many other macroeconomic indicators in literature.

1.7 Significance of the Study

Energy governance is of paramount importance for developing countries as it plays a critical role in catalyzing multifaceted development. A robust energy governance framework is essential to address the persistent issues of energy shortages and circular debt, ensuring a reliable and efficient energy supply for industries, businesses, and households. Transparent and well-managed energy policies are key to attracting investments, driving economic growth, and creating employment opportunities.

Contemporary study will add to the existing literature in two ways. First, it will be foremost study that try to examine the role of the energy governance with the help of time series data. There hasn't been a single empirical attempt to the best of our knowledge, that has examined the impact of energy governance on selected macroeconomic indicators. Secondly, present study develops a multidimensional index of the energy governance of Pakistan by using transmission and distribution losses of oil, gas, electricity as a proxy variable of energy governance. Lastly, the present study will help the policy makers to increase GDP growth and overcome inflation and reduce unemployment. The outcome of this study will also help the policy makers to understand which policies will affect the energy governance in the reduction of unemployment, inflation, and the better performance of macroeconomic indicators.

1.8 Organization of the Study

The study is divided into the chapters that follow. Literature review is presented in the second chapter of energy governance and selected macroeconomic indicators in broader way. Chapter three consists of theoretical framework, models, and methodology of energy governance index regarding Pakistan. Chapter four contains the results and discussion that is derived from the results. The final chapter contains the study's findings as well as policy suggestions for planners and decision-makers.

CHAPTER 02

Literature Review

2.1 Introduction

A literature review serves as a comprehensive overview of prior research, encompassing the synthesis of key concepts and findings from existing scholarly works. Its primary purpose is to pinpoint areas where further investigation is needed and to establish the foundational framework for new research endeavors. This involves the identification of gaps in the existing body of knowledge, which will guide the direction of future research. Additionally, a review of the literature enables the researcher to implement fresh approaches to the chosen field's model, data, and analysis. Furthermore, it is critical for establishing a research problem.

This chapter also offers the theoretical framework and theoretical evolution insights that are essential for new research directions. This chapter assists in choosing the best research methodology by evaluating the advantages and disadvantages of methodologies employed in earlier studies as well as the best way for data analysis.

This chapter explain thoroughly the appropriate literature on the role of energy governance selected macroeconomic indicators a case study in Pakistan. Even though there is very limited literature available on energy governance and selected macroeconomic indicators.

2.2 Measurements of Energy Governance

Zhang et al., (2023) conduct an empirical analysis of the impact of eco-innovation and green energy on unemployment in China from 1995 to 2020. The Quantile ARDL regress is utilized in the study for estimation. Results showed that environmental technology and clean energy have a detrimental impact on unemployment. Additionally, the results pointed to a bidirectional, unintentional relationship between renewable energy and unemployment. The study suggested the following policy recommendations to support the adoption of environmental technologies and funding for clean energy projects to reduce the rising unemployment problem.

Muiderman et al.,(2023) examine it is important to learn that possible outcomes and various additional anxious steps interfere with contemporary governance decisions. The investigation of how the excitement operations arrangement future alternatives is not getting much experimental attention to detail. The current research examines that through an array of prediction activities with particular emphasis on global warming, convictions about the coming years allow for or breakdown predictive governance behaviors. The initiative was effective across four regions. Adopting a model of analysis that differentiates four different methods related to predictive governance, researchers relate this concept to the emergence and locking of opportunity zones of intervention. This study concludes that during the four areas, numerous prescient methods encourage discussion of serious challenges and more diversified opinions that ultimately finish up driving just techno, ordered works in today's world. It is also interesting to note that in the Central American its proper context, prescient reject this sequence with greater regularity, notably when progressive goals are stated. The concentration on broader technological futures contracts, straightforward scheduling tactics, but emphasis upon the just North-based international forecasts sector could close apart higher socioeconomically and legally wide-ranging and geographically suitable subsequent viewpoints in planning operations.

Hampton et al.,(2023) evaluate acclimatization and diminishment of the environmental crisis rely heavily on small and medium-sized businesses (SMEs). Moreover, countries are particularly impacted by consequences of global warming, which includes adverse weather conditions, and their combined outflow is vast. On top of that, SMEs have an immense effect on how consumers, residents, and commercial business entities act in relation to the natural world. Most climate initiatives throughout all sorts of authority, despite this, have been largely dismissed by these bodies. The millions of SMEs are confronted with an imminent danger of being a result of a string of overseas disasters, such as the COVID-19 pandemic, conflict in Europe and the eastern Mediterranean region, along with price fluctuations for energy peaks. These crises also served as an impulse for the temporary and ongoing modification of the relationship between the private sector, the public sector, and the government. This study suggests that, to navigate this volatile environment, we should also pay attention to the governance of SME reducing carbon emissions. They assess tactical choices, pinpoint deficiencies in knowledge that obstruct optimal feedback, present key problems dealing with legislators along with other governance participants and suggest academic possibilities. Finally, outlined the main components of an updated societal dense governing interactions between the government.

Petrovics et al.,(2022) identifying the function performed by various efforts is becoming a more essential research concern as the multidimensional structure of climate change policies becomes much clearer. Governments' measures to promote sustainable energy have grown in the last few years, regarding the sense of amount and quality. It persuasive but faulty description of the ways in which such efforts get started, establish, or reproduce throughout various circumstances are offered by the polycentric rule ideas. The objective of this paper is to focus on the situations that make it possible multiple green energy cooperatives to establish themselves. The design specifies 23 separate scenarios according to an in-depth examination of the research and then divided into three distinct groups: internally, in-between, and independent associated their efforts. This paper highlights useful strategies for assisting and guiding the creation of fresh projects for the community, and it also enriching an idea of governance with multiple focuses.

Rehman et al.,(2021) conducted a comprehensive research project that delved into the relationship between coal energy consumption and the economic progress of Pakistan. Their study encompassed an extensive dataset spanning from 1972 to 2019, allowing for a thorough examination of how coal energy usage has influenced Pakistan's economic development. Study used annual time series data from 1972 to 2019, to investigate the impact of coal energy usage on Pakistan's economic advancement. The stationarity of the three variables was tested through ADF. The interaction of the variables with economic growth was tested using the integration test. The findings from this regression analysis indicate that although total energy consumption is positively associated with economic growth, there is a detrimental impact associated with the utilization of coal in both the brick industry and the electrical sector. Pakistan is still suffering from severe energy shortages because of a lack of inexpensive energy generation. Furthermore, we must adopt better policies to strengthen the energy industry, as well as pay attention to alternative energy sources to accelerate economic growth.

Ramirez, (2021) this study provides policymakers with information on how to develop renewable energy partnerships and create a public policy framework for energy democratic governance to fulfil the United Nations' Sustainable Development Goals. Investing in renewable energy by MNEs and government agencies promotes energy democracy and decarburization. However, I believe that energy democracy necessitates more than simply allowing large-scale renewable energy investments to enter the market. By analyzing wind-energy investments on Mexico's Isthmus of Tehuantepec from 2013 to 2020. This research looks on the challenges that come with implementing energy democracy. Collaborations with indigenous peoples in the Isthmus of Tehuantepec on energy democracy and renewable energy. Because of a lack of effective government, corruption, insufficient accountability, and limited access to energy and environmental data. Wind-energy investments linked to the Partnerships for the Goals section of the 2030 Agenda for Sustainable Development. This research offers practical ideas for attaining universal access to power while also decreasing climate change.

Azam et al., (2020) conclude that this study provides long- term solution of electricity of for the problem with energy has assumed significant status in the supply and demand of electricity over the long run period. The data obtained from Ministry of Finance, Pakistan during the period from 1990 to 2015 in Pakistan. The study employs Johnson co-integration analysis and

Granger causality testing methodologies to extract meaningful findings. Moreover, ECM is also used to find the short form of model. This study finds co-integration among electricity supply, EC, and export in case of Pakistan. At the end study provides some policy recommendation that persisted electricity supply may prove and more productive.

Malik et al., (2019) examine that almost three percent of Pakistan's energy needs are met by imports of LNG, coal, and other petroleum-based energy sources. Pakistan's import-driven energy plan cannot be maintained, leaving the country with future energy danger. It reduces its currency holdings in also risking the economy to upheavals in the price of energy globally, harming it through hyperinflation. Inflationary pressures weaken the country's export competitiveness, making paying for energy imports even more onerous. From 2011 to 2017, a comprehensive study was conducted to assess Pakistan's energy security using the 4As framework, which includes evaluating availability, applicability, acceptability, and affordability. The 4A approach serves as a tool to monitor changes in a region's energy security across these four dimensions. The findings of this research indicate that Pakistan's energy security witnessed improvement during the initial three years of the study but subsequently deteriorated over the following three years. Despite substantial investments in energy infrastructure within the past five years, Pakistan continues to grapple with energy insecurity. The study underscores the pressing need to address energy instability promptly. To achieve this, it recommends the swift adoption of green energy solutions, such as distributed solar power generation and smart metering. Additionally, it emphasizes the importance of increasing conservation efforts, including the implementation and enforcement of building insulation requirements.

Nawaz et al., (2018) discuss the impact of energy security in shaping the country's electricity and natural gas demand development path. Data from the Global Institute of Energy and the United States Chamber of Commerce from 1984 to 2015. Using secondary data, the study concludes that energy insecurity is harmful to the environment and socioeconomic conditions. This study suggests that Pakistan should prioritize existing renewable resources such as solar and wind in coastal areas, as well as water in KP and AJK, to reduce energy security risks and improve environmental and socioeconomic circumstances.

Mahmood & Ayaz, (2018) explore the connection between energy security and economic development in Pakistan from 1980 to 2012. The Error Correction Model (ECM) was employed in this study 5 to look at the short and long-term causation between energy and economic growth. Energy gaps have a negative link with economic growth, which could be the outcome of rising energy demand or falling energy supply. According to the findings, the government should improve its energy demand and supply management system.

Zaman & Brudermann, (2018) highlight governance issues are important when discussing energy security perceptions, especially in emerging Asia. The major goal of this research is to determine the Bangladesh power system's security prospects in terms of energy governance parameters. This research is being carried out in two stages. According to this context, the first phase involved a three-stage procedure, assessment process, and second phase history technique utilized to qualitatively examine the Bangladesh power industry. This article concludes that a strong debate ability is needed to protect international investments in power arrangements and to adopt justifiable energy resources.

Anwar, (2016) investigate the potential impact of decreasing energy imports by 5%, 10%, and 15% on various facets of Pakistan's energy landscape spanning from 2005 to 2050. Employing a comprehensive, long-term integrated energy system model and a market allocation framework, the analysis yielded intriguing insights. According to the findings, a reduction in energy imports would lead to a marginal dip in the primary energy supply, but it would be accompanied by a substantial 24% increase in cumulative renewable energy generation. This reduction in energy imports, by 3%, would significantly enhance Pakistan's energy resource diversity, increasing it by 1.1 times and consequently reducing vulnerability by 9%. Importantly, the cost associated with importing fuels would witness a notable 10% decrease, while greenhouse gas emissions would exhibit an 8% decline, underlining a significant positive shift towards reduced emissions and enhanced energy security for Pakistan. Furthermore, the study employed a comprehensive set of eleven energy security indicators to gauge the overall influence of the energy import reduction initiative. These indicators collectively demonstrated marked improvements in energy security, further reinforcing the importance and benefits of reducing energy imports for Pakistan's sustainable energy future.

Holley et al., (2017) discuss the impact of energy security on the environment. With the use of interviews with individuals, this article characterizes a single in-depth case study into electricity sector policy in Hong Kong city for the purpose of special administrative region (HKSAR). Our findings' policy recommendations underscore the unique issues that cities face due to geographic constraints. Furthermore, critical predictors of urban energy transitions broaden their lenses to include energy governance both within and outside of city bounds and investigate ways for governing various energy generation and consumption measurements.

Erahman et al., (2016) measures Indonesia's energy security index for the years 2008 to 2013, to analyze the country's performance. The availability, price, accessibility, acceptability, and efficiency of energy security are all factors considered in this study. These dimensions were chosen after a research of prior publications' energy security concepts. The 14 indicators that make up the dimensions are used to measure energy security. The performance of energy security was evaluated in 71 nations in this study. The indicators were graded using principal component analysis or equal weighting after being standardized using the min e max approach. According to the findings, Indonesia's energy security performance improved between 2008 and 2013, due to improvements in the areas of availability, cost, and accessibility. Indonesia's energy security index has an average value of 0.473 across the years selected. Indonesia is ranked 55th out of 71 nations in the ESI.

Tongsopit et al., 2016) investigate under the 4-A's framework, look at ASEAN's energy security. The ASEAN Economic Community (AEC) accord, which was signed in 2015, reemphasized the importance of energy security and sustainability in the region. In this study use quantitative methodology to analyze development in various categories, such as availability, acceptability, affordability, and application. From 2005 to 2010, key criteria include CO_2 emissions documentation, energy access measures, and energy supply reserves. Using historical data from the IEA and the World Bank, we identify significant energy indicators. In the previous five-year planning period (2005–2010), ASEAN made little progress on creating energy security, regressing in all categories except applicability. As a result, we believe that accelerating the development of renewable energy and energy efficiency technologies can help ASEAN achieve its energy security and sustainability goals.

Thangavelu et al., (2015) estimate energy costs, GHG emissions, and renewable contributions based on predicted energy usage, fuel prices, and other considerations. When anticipated over a period of 15 to 30 years, uncertainty in forecasted variables such as energy demand, volatile fuel pricing, and the growth of renewable technologies would impact energy costs. Energy security could be jeopardized by inaccuracy in forecasting aspects, resulting in higher energy expenditures, more emissions, and a lack of security. Energy security refers to a generator's ability to supply future demand. A generic method for determining an appropriate energy mix over a 15-year period is offered to mitigate the threats. Nuclear power contributed to a 26.7

percent reduction in total energy prices, a 53.2 percent reduction in GHG emissions, and the possibility to meet 79 percent of future energy demand scenarios by incorporating it into the energy mix.

Chen et al., (2014) examined energy efficiency performance and their impact on contemporary green governance measures and their consequences in diverse locations in the case study of China. It also considers future green governance models, methodologies, and development orientations in China. The total efficiency of the industrial system improved during the study period. The manufacturing and wastewater stages have seen major improvements, but the solid and gas waste treatment stages have seen no significant improvements. Chinese emissions of greenhouse gases are the highest in the world, but the country has also made considerable expenditures in renewable energy. The nation has an organized structure for managing energy, with the government taking a significant part in establishing energy policies, rules, and goals. In addition to primarily depending on coal, China has been working on increasing its capacity for renewable energy sources like wind and solar.

Shin et al., (2013) estimate a model based on quality function deployment (QFD) and system dynamics (SD) is presented for application in public policymaking in emerging economies. Experts are guided by QFD in identifying essential energy security components, such as indicators and regulations, and ensuring that these components are consistent, focused, and tailored to each country. Using these components as inputs, we construct an intermediate complex system dynamics model with a limited number of essential interactions. The improvement of important indicators is simulated and evaluated for major policies. Our approach provides a cohesive, relevant, and tailored energy security management model to enable policymakers to better manage national energy security, even with limited data. The model is used to demonstrate its benefits by using the Korean gas industry as a sample.

Kruyt et al., (2009) produced a list of long-term supply security indicators and support open source (SOS). We developed four components of energy security, including energy availability, accessibility, cost, and acceptability, and then used this taxonomy to categorize indicators for energy security. There is no one-size-fits-all approach to energy security because it is context-dependent. Multiple signs, on the other hand, aid in gaining a more complete picture. Increased global consumption has accelerated the depletion of currently known fossil fuels, according to a model-based scenario study that took these variables into account. In comparison to 2008, international trade in energy carriers is anticipated to have increased by

142% by 2050. This is due to the widening gap between consumption and output. Oil production is predicted to become increasingly concentrated in a few countries until 2030, when the output of other regions diversifies the market. Under strong climate laws, diversification may not be achievable due to declining oil consumption. Climate policy could result in more fuel diversification and a slower depletion of fossil resources.

Florini & Sovacool, (2009) examine the energy issues that society is experiencing from the standpoint of global governance. It claims that the concept of "global energy governance," defined as international collective action attempts to manage and distribute energy resources and deliver energy services, provides a suitable framework for examining energy-related concerns. This study hunt through into the realms of governance theories, global governance, and global energy governance, scrutinizing the landscape of extant institutions responsible for formulating and upholding regulations and standards governing global energy matters. It also explores the manifold possibilities available to policymakers regarding the design of these institutions. This study sheds light on the merits and limitations inherent in a diverse array of institutional frameworks, ranging from intergovernmental organizations and summit procedures to multilateral development banks and global action networks, in addressing energy-related issues. Furthermore, the study proceeds to analyze how distinct approaches to global governance manifest their efficacy in addressing and resolving global energy challenges. In the existing literature, there is a lack of studies that demonstrated the relationship between energy governance and selected macroeconomic indicators in case of Pakistan.

2.3 Relationship Between Energy Governance, Energy Security and Macroeconomic Indicators

Banna et al., (2023) examines how energy security risk (ESR) may affect the stability of the economy. Present empirical data from 68 nations covering the years 1980 to 2021 using several worldwide datasets. The findings show that a high ESR lowers the global GDP growth rate (GDPG). In robustness testing, this effect holds up well across several specifications based on non-U.S. samples, national income level, alternative measure of economic stability, and a series of endogeneity tests based on propensity score matching estimation. Energy insecurity is particularly severe in nations with historically low GDPG. Additional experiments show that numerous assessments of institutional quality that are specific to a country reduce the effect. Finally, the negative effects of ESR are made worse by years of high inflation, geopolitical instability, and escalating war risks. To create a more sustainable energy system that improves the security of the energy supply and the stability of the economy and supports international collaborations.

Mawutor et al., (2023) examine the threshold of governance quality and its modulating effect on the cost of living-energy poverty nexus. A two-step System Generalized Methods of Moment empirical model was generated that included a linear relationship between the expense of living and the effectiveness of the government. Data spanning 20 years (2000-2019) and 40 African nations were used in this study. The study demonstrates that there is a negative conditional effect of inflation on energy poverty. As a result, once a certain threshold is crossed, the relationship between inflation and energy poverty is moderated by governance quality. The study's main practical conclusion is that governance quality reverses inflation's positive unconditional effect on energy poverty and that governance quality may be increased beyond thresholds set by policy to reduce energy poverty. However, unless governance quality exceeds the threshold of 0.03, 0.02, and 0.07, it will not initially drive the required reduction in energy poverty. According to this analysis, governments should start implementing measures that would guarantee greater access to sustainable energy.

Bercu et al., (2019) analyzed the long-term association between energy consumption, economic growth, and good governance for 14 Central and Eastern European countries, over the period 1995–2017. The study highlights the fact that flaws in the energy system cause economic growth to slow down by providing empirical evidence of a causal relationship between power use and growth. Additionally, the study demonstrates how GDP consumption and electricity are influenced by good governance. As a result, governments in Central and Eastern Europe must restore economic governance to foster investment in the energy sector, which will boost competition and lessen inefficiencies in the energy sector's production, transmission, and distribution.

Bazilian et al., (2014) examine global energy governance, which underscores the significance of various actors, institutions, and processes in addressing a range of challenges, including security, climate change, and environmental sustainability. However, it is crucial to highlight that there has been limited attention given to this subject from the perspective of impoverished populations. Given the vast scale of energy deprivation affecting billions of individuals who still lack access to modern energy services, the implications for economic development, health, education, the environment, and gender equality are substantial. This oversight is particularly notable. The aim is to investigate how different facets of the energy poverty issue are managed at various levels, be it global, regional, or local, and assess the effectiveness of these energy governance mechanisms in meeting the needs of disadvantaged communities. With a specific focus on Sub-Saharan Africa, a region grappling with persistent energy governance challenges, this investigation resolves how both nation-states, and the international community can collaborate to enhance the tools, regulatory frameworks, and institutions associated with energy provision.

2.4 Literature Gap

There is not a single study that discuss the impact of energy governance on macroeconomic indicators in case of Pakistan. (Bazilian et al., 2014) examine global energy governance, which underscores the significance of various actors, institutions, and processes in addressing a range of challenges, including security, climate change, and environmental sustainability. (Ahmed, 2015) examined the impact of energy poverty on Pakistan's macroeconomic indexes. Another study, (Abdullah et al., 2021) investigated Pakistan's multidimensional energy security index. To liberalize the structure of power generation in Bangladesh, (Zaman & Brudermann, 2018) measured energy governance using the single buyer model and macroeconomic indicators. Banna et al., (2023) investigated the link between energy security and macroeconomic stability by using the robustness test. Another study (Stavytskyy et al., 2018) explain the link between energy security and macroeconomic indicators in Europe countries. To the best of our knowledge, no previous research has examined the effect of energy governance on macroeconomic indicators in the case of Pakistan, hence the current study fills this gap.

CHAPTER 03

Data and Methodology

3.1 Introduction

The chapter is containing three distinct segments, the first segment that elaborates the theoretical underpinnings of energy governance, second, develop models that capture the role of energy governance, and thirdly discuss the methodological aspects to estimate the models of present study. The model and methodology have significant role which are used in any research. This chapter is divided into numbers of sections. Section 3.2 of this Chapter discusses theoretical framework and conceptual framework. Section 3.3 elaborates the empirical models. Section 3.4 illustrates the description of variables. Section 3.5 discusses the measurements issues of energy governance. Section 3.6 explain Principal Component analysis (PCA). Section 3.7 gives details of methods that are used to estimate the models.

3.2 Theoretical Framework, Conceptual Framework

The theoretical framework serves as a foundational stone for any academic research. A conceptual framework is a structure or a set of interrelated concepts that provides a foundation for understanding and analyzing a particular phenomenon or problem (Balconi et al., 2007). It is a theoretical model that helps to organize and guide research, analysis, and interpretation within a specific field of study. The conceptual framework serves as a lens through which researchers or scholars can view and make sense of the subject matter. Many studies emphasize the crucial role of energy in driving economic growth. Access to abundant and affordable energy resources is often considered a prerequisite for industrialization and economic development (Simpson et al., 2020).

Energy, as a primary factor of production, fuels industrial processes, powers transportation, and supports the infrastructure essential for economic activities. To determining a country's economic growth over time and over the space, Solow's economic growth model serves as the foundation (Sağlam & Yetkiner, 2012). Solow growth model highlights the significance of technology and capital (Mohsin et al., 2021). After Solow’s contributions, there is a stream of research that tries to explore the engines of economic growth. On non-declining profits on basic components of production like human resources and development and research (D&R), new growth models can be constructed (Barro, 1989). Then different studies inspected the directional link between use of energy and output of the economy (Stern, 1993). Hereafter, researchers focus on energy efficiency as an engine of sustainable growth. The concept of energy efficiency introduced by William S. Jevons (1865) ,(Missemer, 2012). After that ,Amory Lovin's, an American physicist, environmental scientist, and founder of the Rocky Mountain Institute, is promoted energy efficiency as a strategy for promoting both economic growth and sustainability (Koomey et al., 2011). Since the 1970s, he has been a promoter of energy efficiency and has written widely on this topic. This energy efficiency is generated through effective energy governance.

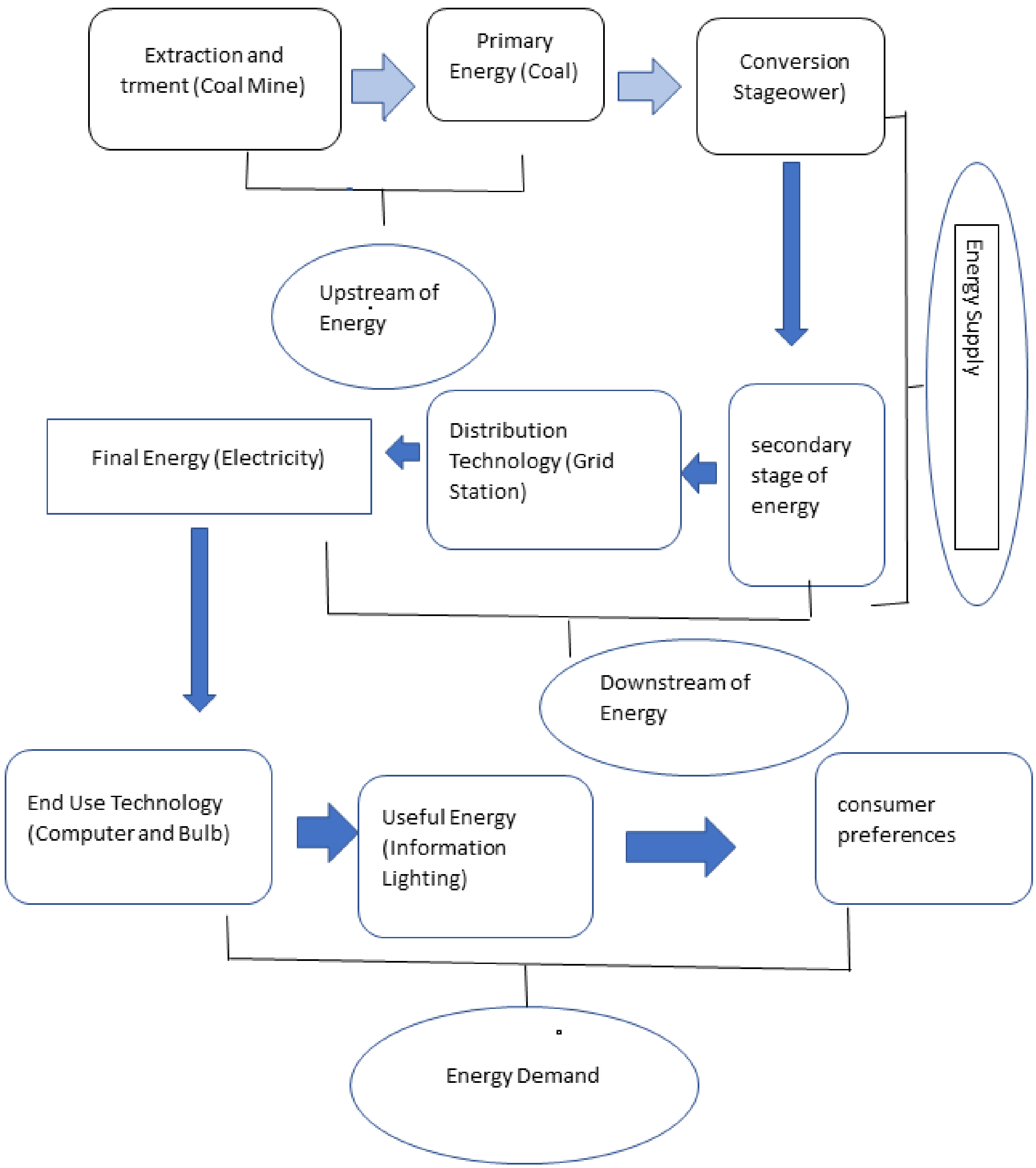
Energy efficiency comes from upstream, midstream, and downstream energy systems. Energy governance is an effective tool for energy efficiency. In literature, a few studies highlighted the importance of energy governance. After that (Kraft & Kraft, 1978) discussed the energy as a source of economic growth. Furthermore, energy is considered as an endogenous factor of growth.

Energy serves as a major factor for both economic and social endeavors. Energy governance is an essential element to improve the living standard of the people. According to the (Dobravec et al., 2021) , human rights are promoted while letting people first deal with the serious energy issues the 21st century is enduring.

Economic determinants like the terms of trade or the Balassa-Samuelson "productivity theory" emphasized how real exchange rates are determined in oil-exporting nations. According to these research, real oil prices are frequently used to estimate terms of trade (Klosterman & Schantz, 2000), (Backus & Crocin, 1998) and some have referred to this as "oil money" or "petrocurrency" to highlight how important they are in explaining changes in actual exchange rates.

Energy and economic growth have a relationship with each other, different studies estimate the link between energy and economic growth. In following a schematic way, how downstream energy supply improvements affect the overall energy demand. More improvements in energy demand it's becomes more efficient and macroeconomics indicators will be improved. Energy and economic growth have a relationship with each other, different studies, downstream energy has the role rather than others economic growth with all macroeconomics indicators. It's my contribution so in a schematic way, how downstream energy supply improvements affect the overall energy demand. More improvements in energy demand it's becomes more efficient and macroeconomics indicators will be improved (Koomey et al., 2011).

Figure 3.1 Schematic Diagram of Energy System



(Ullah et al., 2022;Grubler, 2012)

This figure illustrates the orderly flow of energy system from the energy supply to the energy demand. First, the supply of energy is split into two streams: upstream and downstream. Anything relating to the discovery and production of coal is referred to as upstream. Coal mine extraction is also a part of it. To find coal mines, it entails the employment of big machinery to remove the topsoil and overburden, or layers of rock. To access coal sources, mountaintop removal is a type of surface mining. The next phase in the process of converting the primary energy in coal is combustion, which entails burning coal in a power plant or boiler to produce heat. The steam created by this heat is then used to power turbines that produce energy. Downstream of energy is followed by a second stage of energy supply. The transportation, distribution, and final use of the energy generated from coal are often included in the downstream of coal energy. Coal is a major fuel source used to generate electricity, which is fed into the power grid and distributed to homes (Bulb, machines), businesses (computers), and industries (industrial mechanical tools).

The three major phases are upstream actions, midstream tasks, and downstream activities. Petroleum derivatives and natural gas get generated in the context of the upstream system of energy by pumping and investigation. Seismic, cutting down, and technology used for drilling serves as essential for upstream profitability (Foramitti et al., 2021).

The downstream oil and gas sector, which includes petrochemicals, refining, and processing, is under pressure. According to the International Energy Agency, the downstream refining sector will face substantial changes over the next five years as the consequences of excess processing capacity begin to erode profits through supply and demand economics. A unique risk profile is created by the combination of expanding global demand for refined products, tightening regulatory and sustainability limitations, and capital-intensive operations necessitating more investment in plants and refineries (Foramitti et al., 2021). Because data availability is limited in the case study of Pakistan, we use downstream energy to quantify energy governance.

A study in Pakistan has utilized numerous proxies to evaluate energy governance T&D losses (billion kWh), imports of energy, net (percentage of energy consumption) by using a variety of proxies. (Ullah et al., 2021). Another study used four dimensions to assess energy security: availability (share of imported oil, gas, coal, and hydro power generation), acceptability (share of nuclear and renewable energy in power generation, CO_2 emissions per capita, and global CO_2 emissions), applicability (gas power generation efficiency), and affordability energy supply per capita , gas price, electricity price, gasoline price (Malik, Qasim, Saeed, Chang, et al., 2019).

With the use of a theoretical framework, Bangladesh measures energy governance along four dimensions: institutional arrangements and regulatory paradigm, national political regime, international landscape, and infrastructure quality. Because data is scarce in Pakistan due to corruption and electricity theft, we will rely on proxy variables, which have been utilized in earlier research to assess energy governance in Pakistan and Bangladesh. The present study is going to use various proxy variables such as electricity (transmission and distribution losses), gas (transmission and distribution losses) and oil (transmission and distribution losses).

3.3 Empirical Models

$$UN_t = \alpha_0 + \alpha_1 Inf_t + \alpha_2 GDPpc_t + \alpha_3 EG_t + \varepsilon_t \quad (3.1)$$

The dependent variable of this model is unemployment while inflation, GDP per capita and energy governance are the independent variables. According, to Phillips curve which states that there is negative relationship between inflation and unemployment in the short run when inflation increase unemployment tends to low (Phillips, 1958). Okun's law explain the negative relationship among unemployment and GDP as unemployment decrease economic output level also increase (Cuaresma, 2003).

$$ED_t = \beta o + \beta_1 EG_t + \beta_2 GDPPC_t + \beta_3 ER_t + \beta_4 GFCF_t + \mu_t \quad (3.2)$$

The dependent variable is external debt while energy governance, gross domestic product per capita, exchange rate and gross fixed capital formation are the independent variables of this model. Overhang theory suggests that external debt could hinder gross domestic product by diverting resources away from investment. External debt in the short run is gain and in long run pain. The only way to get writ from the external debt to improve national income. So, it is consistent with the theory that as national income increases the external debt also decreases. High debt burden can also make it difficult for a country to obtain new loans further hindering growth (Abdullahi et al., 2016). Debt driven growth theory explains that external debt can stimulate economic growth by increasing consumption and investment in the short run, which can lead to higher gross fixed capital formation.

$$GDP_t = \gamma o + \gamma_1 EG_t + \gamma_2 ER_t + \gamma_3 TLF_t + v_t \quad (3.3)$$

The dependent variable of this model is gross domestic product while energy governance, exchange rate, and total labor force are the independent variables of this model. Purchasing Power Parity (PPP) theory suggests that exchange rates should reflect the relative prices of goods and services in different countries, so that the purchasing power of one currency is equal to another (Al-Zyoud, 2015). When exchange rates deviate from their PPP values, there is the potential for trading opportunities that can lead to changes in exchange rates. Under this theory, GDP and prices are considered important determinants of exchange rates.

This study uses three models which are illustrated as. First, model is to measure the impact of energy governance on unemployment of Pakistan, one dependent variable that is unemployment and three independent variables inflation, GDP, energy governance. Second, model is to measure the impact of energy governance on external debt of Pakistan. The dependent variable of the model is external debt and independent variables of the model are energy governance, gross domestic product, exchange rate and gross fixed capital formation. Third, model of the present study is to measure the impact of energy governance on gross domestic product (GDP) of Pakistan.

Table 3.1 Variables and Data Sources

Name of Variable	**Abbreviation**	**Measurement Unit**	**Data Sources**
	Dependent variable		
External debt	ED	(% of GNI)	WDI
Unemployment	UN	(% of total labor force)	WDI
Gross domestic product	GDP	Current US$	WDI
	Independent variables		
GDP per capita	GDPPC	Constant $	WDI
Inflation	INF	(Annual %)	WDI
Exchange rate	ER	LCU per US$	WDI
Gross fixed capital formation	GFCF	Current US$	WDI
Total labor force	TLF	Measured in millions	WDI
Energy Governance	EG	Index	PEB (various issues)

*World Development Indicator (WDI)

*Pakistan Energy Book (PEB) various issues

After discussing the models that contain various variables. In the coming section variables, definition construction and sources are discussed. Description of data is suitable for understanding and interpretations of results.

3.4 Variable: Definition Construction and Sources

The dependent variables of the present study are unemployment, external debt, and gross domestic product. The second independent variable is gross fixed capital formation, factor Input 'K' considers gross fixed capital. The concept employed here to assess the impact of capital expansion on GDP is also frequently used in other studies (Alharthi & Hanif, 2020; Faridi & Murtaza, 2013). Capital stocks are created using one of the most used methods for estimating capital stock the accounting system approach. A detailed analysis of capital created during a specific time, usually one year, is provided by gross capital formation. It includes investments in capital expenditures and the net increase in stocks made by an economy. In general, GDP represents the total economic output of a country, encompassing both population size and overall economic activity. On the other hand, GDP per capita, obtained by dividing the GDP by the population, offers a measure of average income.

Total labor force is another independent variable as Pakistan has a large population and a large labor force. In industrialized nations, the labor force plays a vital role in economic growth, productivity, and overall wealth. Production in the economy is driven by the labor force. The production of goods and services by workers across a variety of sectors and industries boosts the country's gross domestic product (GDP) and economic output. It includes all employees searching for employment who are interested in participating in the manufacture of products and services in addition to people seeking jobs who are interested in working in the manufacturing of things. Workers in advanced education and skills are frequently involved in technological innovation in advanced economies. They work on research and development, which results in the invention of fresh goods, methods, and tools that increase efficiency and productivity. The labor force also covers people that are temporarily or habitually jobless and are looking for permanent jobs based on their developed abilities and training. The terms "workforce" and "labor force" are commonly used in literature. Moreover, variables are selected based on earlier research, such as (Kaur & Sethi, 2013; Nkoro & Uko, 2016a; Mahmoudi, 2021).

The fourth independent variable is inflation, different statistical techniques and variety of economic indicators are frequently used to measure inflation. The Consumer Price Index (CPI) changed as a percentage is the most popular method for measuring inflation. But the most frequent method (that is used in literature and headlines) is CPI. The CPI from the current period (month, quarter, or year) is contrasted with the CPI from the prior period to calculate the inflation rate. A positive inflation rate signifies that prices have gone up, while a negative rate suggests that prices have gone down (deflation). Although the CPI is a commonly used indicator of inflation, economists and central banks also utilize alternative inflation indices and techniques to evaluate price fluctuations in various economic sectors (Yolanda, 2017b).

The fifth independent variable is Exchange Rate (ER), the value of one country's currency in relation to another is referred to as the exchange rate. It explains how much of one currency you can acquire in exchange for a specific amount of another currency (Abbasi et al., 2021). Paul Krugman and Maurice Obstfeld (1996) stated that the price of a currency against other currencies is known as the exchange rate. Puspopranoto (2004) stated that the price at which a country's currency is exchanged for another country is known as the exchange rate (Yolanda, 2017b). Timothy (1997) states that "an exchange rate is an articulation of the value of one country's currency in the term other country's currency." It details the ratio of one unit of one country's currency to one unit of the other country's currency.

The dependent variable is external debt which defines as it is a crucial source of funding. The total outstanding debt that a country owes to foreign creditors, including both public and private sector liabilities. Formula: External Debt-to-GDP Ratio = (External Debt / GDP) x 100. External debt is mostly utilized to supplement internal funding options for the development of an economy and other requirements. These foreign creditors may be other countries, international institutions, commercial banks, or foreign investors. A nation's ability to pay back its debts to foreign governments and organizations is strongly correlated with its level of external debt. these studies used external debt as an independent variable are (Agyapong & Bedaubing, 2020; Abdelaziz et al., 2019; Doka et al., 2017).

A further dependent variable is unemployment, it is defined as a situation of having no job, he or she is willing to do work. The number of individuals in a specific population who are willing and able to work, actively seeking employment, but are currently without a job. Formula:

Unemployment Rate = (Number of Unemployed / Labor Force) x 100. It is a crucial economic metric that shows the percentage of the labor force that is available, willing, and capable of working but is not right now. Unemployment is frequently used in empirical research as well as showing the real situation of the economy. Moreover, the unemployment rate is a proxy variable to identify the situation of actual unemployment in an economy. As a major indicator of the state of the economy, unemployment is often used. The unemployment rate is the most popular way to quantify unemployment. By dividing the total work force's size by the amount of unemployed people, multiply by 100 it is estimated by (Cahuc & Malherbet, 2002; Rafiq et al., 2008; Collins, 2009; Kamran et al., 2014).

The last dependent variable of our econometric model is gross domestic product. Gross domestic product (GDP) is a measure of economic activity which quantifies the total monetary value of all goods and services produced within a nation's borders and abroad during a given period, usually a year, by all its citizens (both individuals and businesses). It is an important gauge used to assess and contrast the economic performance of various nations' is measured by three different methods e.g., production method, income method and expenditure method. but all measurement methods provide the same results. (Shahbaz et al., 2007; Muhammad Shahbaz & Faridul Islam, 2011.; Ahmed, 2015). The total market value of all final goods and services produced within a country's borders in a specific time period, usually measured annually or quarterly. Formula: GDP = C + I + G + (X - M) (where C = Consumption, I = Investment, G = Government Spending, X = Exports, M = Imports).

3.5 Measurement Issues of Energy Governance

Energy governance (EG) is a new concept in the field of energy. Better energy governance provides a signal of efficient energy system. EG is a very vogue concept. There are various issues to measure governance like what are exact variables that contribute to governance, variable of upstream, midstream, and bureaucratic bottle necks may also matter. According to, (Karlsson-Vinkhuyzen, 2010) Energy governance involves the supervision and regulation of energy resources and their distribution to ensure reliable, sustainable, and equitable access to energy. Still, several measurement issues can hinder effective energy governance. Here are some of the key measurement issues related to energy governance. To effectively handle energy transitions and environmental concerns, long-term planning and expenditures are needed. But short-term political periods can occasionally result in decisions that prioritize short-term profits above long-term aims, making it challenging to meet targets for sustainable energy. With the introduction of new technology and ideas, the energy sector is constantly evolving. It can be difficult to predict how developing technologies will affect energy governance, and it may be necessary to change measuring frameworks frequently. Due to the unavailability of data, the present study takes six indicators of downstream of energy system to construct a composite variable. All types of efficiencies can be observed from the product. So, in contemporaneous study, these six indicators are valid sources to show the energy governance situation over the time.

Table 3.2 Energy Governance (EG Index)

	Dimensions	Indicators	Percentage	Year	Data Source
Energy Losses	Electricity	Total transmission and distribution losses(kwh)	18%	2022	PEB
	Gas	Total transmission and distribution losses (mw)	14%	2022	PEB
	Oil	Total transmission and distribution losses(tons)	23%	2022	PEB

*Pakistan Energy Book (PEB) various issues

Energy governance typically refers to the set of rules, policies, and regulations that guide the management and use of energy resources within a particular region or country. It encompasses a wide range of aspects, including energy production, distribution, consumption, and conservation. Energy losses can occur at various stages of the energy supply chain, including generation, transmission, and distribution. While transmission and distribution losses are significant contributors to overall energy losses, they are not the only aspects of energy governance that deal with losses (Queiroz et al., 2012). Transmission and distribution losses occur when electricity is transmitted over long distances from power plants to end-users. These losses are mainly due to resistance in power lines and transformers. Effective energy governance involves implementing measures to minimize these losses, such as using efficient equipment and optimizing the grid infrastructure.

A comprehensive approach to energy governance also includes addressing losses in other stages, such as improving the efficiency of power generation technologies, promoting energy conservation and efficiency measures among consumers, and investing in research and development for new technologies that reduce overall energy losses.

In instant, while transmission and distribution losses are essential considerations in energy governance, a holistic approach should address energy losses across the entire energy system. This includes aspects related to generation, consumption, and overall system efficiency to ensure sustainable and effective energy management. Transmission and distribution losses (T&D) are a proxy that explains the situation of any energy system. Here is a further explanation of (T&D losses) in the following section.

3.5.1 Transmission and Distribution Losses of Electricity

According to Powanga & Kwakwa, (2023) three vertical concepts, (T&D) is used to define the country's national energy supply system. The energy losses that take place as electricity is transferred from power plants to final customers are referred to as "transmission and distribution losses." Resistance and leakage are the principal causes of these losses, which are a natural component of the electrical grid.

Resistance is caused by electricity as it travels via cables and power lines. Due to the resistance, some energy is lost during the process of turning electrical energy into heat. The resistance losses in the transmission and distribution lines increase with the amount of current flowing through them. Power lines and cables can "leak" electricity or release it as electromagnetic energy. The reduction of current levels through effective power factor correction and load management is crucial because higher current levels result in higher resistance losses (Sadovskaia et al., 2019). The overall losses may be impacted by the transformers and substations, as well as the design, age, and state of the electrical infrastructure. Adopting certain measures to cut back on T&D losses. To increase total energy efficiency and lessen environmental effects, the electrical system must minimize energy losses. These techniques are used to lessen these losses.

Reduced resistance losses can be achieved by using higher voltages for long-distance transmission. Losses can be decreased by using conductors that have low resistance and superior materials, such copper or aluminum. Power factor adjustment techniques are put into use to increase power efficiency and lower losses (Naseem & Khan, 2015). A better management of the flow of electricity is made possible by smart grids and digital monitoring systems, which results in fewer losses. By balancing energy demand and supply, load management techniques minimize wasteful losses. Losses can be reduced by making sure that the grid infrastructure is well-maintained and functional. Even if T&D cannot be eliminated, by putting these techniques into place, the overall effectiveness of the electrical grid can be increased, and their effects are greatly diminished.

The main reasons of transmission and distribution losses in developing nations are the poor infrastructure lack of efficient technology of governance issues and due to the international writ. According to the National -Transmission & Dispatch -Company (NTDC), report T& D is allowed only 2.63% during 2021 to 2022 (state of the industry Report, 2021). According to a report that is submitted by the Distribution company (DISCOs) and Krachi Electric (KE) Pakistan's per capita annual electricity uses of 644 kWh which is the lowest in the world needs, 18% T&D losses in Pakistan ,7% in developed countries and 12% in China. One of the significant aspects measuring a country's level of living condition includes in the per capita energy consumption from its population majority of the developing nations are emerge poor countries and measure the T&D losses enhance the energy poverty of its population.

3.5.2 Gas

The Pakistan gas sector is playing a crucial role in the nation's energy system. Pakistan is one of the top consumers of natural gas in the Asia-Pacific region and significantly relies on it for a variety of uses, including the production of electricity, industrial activities, and household consumption. The provinces of Sindh and Baluchistan hold many Pakistan's sizable natural gas reserves (H. Raza, 2014). The nation has been generating natural gas from both conventional and unconventional sources, with both getting concentrated in recent years. The state-owned Oil and Gas Development Company Limited (OGDCL) and Pakistan Petroleum Limited (PPL), along with a few other privately owned companies, are the main participants in the production of gas.

If we talk about distribution of natural gas in Pakistan and it is maintained by a vast network of gas pipelines from production fields to consumers. Sui Southern Gas Company (SSGC) and Sui Northern Gas Pipelines Limited (SNGPL) are the two major player of supplying gas to country (Malik et al., 2011). For a sizeable share of Pakistan's energy requirements, natural gas is a crucial energy source. It is used in a variety of industries, such as power production, industrial processes (such as those for fertilizer, cement, and textiles), and residential use for cooking and heating.

Even though Pakistan has its own gas supplies, the scarcity of current sources and rising consumption have made it difficult for Pakistan to supply the expanding demand. Liquified natural gas (LNG), which may be imported through a variety of ports and contracts with foreign providers, has being used by Pakistan to fill this shortfall. The country's energy requirements have been largely satisfied by LNG imports since last decade (Kharal et al., 2014). The import of energy at high cost then provides it at low prices creates debt or it is called circular debt. Now a days start from there a plan is approved by Pakistan Economic Co-ordination Committee (PECC) in (2023). International Monetary Fund (IMF) and Pakistan are right now discussing a strategy to reduce Pakistan suffers from a sort of public debt known as cyclical in nature debt, which grows in the power industry because the consequence of missed payments and incentives. The committee, led by Finance Minister Ishaq Dar, also agreed a further tariff of Rs 1 per unit of electricity for the fiscal year 2023–24 to cover around 76 billion Pakistani rupees ($282.81 million) in burdens in the power industry. A persistent issue in Pakistan's energy sector, is one of the difficulties the country's gas sectors has had to deal with. In the energy distribution system, circular debt develops when payments are postponed or missed by several parties, creating financial limitations, and preventing investment in infrastructure and research. The government has been attempting to solve this problem and enhance the sector's financial stability.

In terms of gas T&D losses, Pakistan is still dealing with serious issues in 2021. The nation is suffering from significant losses because of leaks, ageing infrastructure, and non-technical losses (such theft and unauthorized use). The availability of petrol for genuine customers was also impacted by these losses, which not only caused economic inefficiencies. By improving pipelines, installing leak detection systems, and attempting to reduce theft, the Pakistani government and gas firms are attempting to address these problems. Depending on variables including infrastructure quality, technical improvements, regulatory frameworks, and economic conditions, gas T&D losses vary greatly between country to country. By making investments in modern leak detection systems, new infrastructure, and efficient laws, several nations have succeeded in reducing losses. There are 14 % gas T&D losses in Pakistan in 2022.

For instance, because their extensive infrastructure and strict regulations, European nations often experience reduced gas T&D losses. Developing nations may suffer greater losses because of difficulties in maintaining and improving infrastructure.

3.5.3 Oil

The major oil marketing structure in Pakistan is called Pakistan State Oil (PSO). Under the Ministry of Energy (previously the Ministry of Petroleum and Natural Resources), it was established in 1976 as a state-owned organization. PSO oversees the country's petroleum product acquisition, storage, distribution, and marketing. To maintain a consistent supply of energy goods throughout Pakistan, including motor petrol, diesel, fuel oil, jet fuel and liquefied petroleum gas (LPG), the company is essential. Across the nation, PSO runs a huge network of terminals, retail locations, and storage facilities. Ahmed & Obaid, (2012) serve many economic sectors, including industrial, commercial, agricultural, and residential consumers, PSO has grown its activities and varied its service offerings over time. The business partners with several well-known worldwide oil and gas corporations and engages in international commerce as well.

Pakistan has both onshore and offshore oil fields, and the nation is actively searching for new supplies to lessen its reliance on imports. The sector has been actively explored by significant domestic and foreign oil and gas firms. Despite having large oil reserves, Pakistan's production has been unable to keep up with the country's rising demand. To satisfy its energy requirements, the nation has become a net importer of crude oil. Numerous oil refineries exist in Pakistan, where crude oil is processed to create a variety of petroleum products, including petrol, diesel, jet fuel, and others. The demand for petroleum products has been continuously rising in Pakistan, like it has in many emerging nations, because of population growth and economic progress. The largest consumer of petroleum goods, including road cars, is the transportation sector. Pakistan has relied largely on importing crude oil and petroleum products from other countries due to an imbalance between domestic production and consumption, which can negatively affect its trade balance (Rehman & Deyuan, 2020).

The Pakistan government has been working to increase domestic production by luring international investment into the oil and gas industry. Further, they have been developing regulations to boost the oil industry's effectiveness and encourage the use of renewable and alternative energy sources to lessen reliance on fossil fuels. Security issues in some areas, outdated infrastructure, fluctuating oil prices worldwide, and geopolitical reasons are just a few of the difficulties Pakistan's oil industry faces. Current T&D losses of oil in Pakistan are 23% in 2022. The infrastructure for transporting and distributing oil is ineffective or badly maintained in many developing nations. Pipelines, warehouses, and automobiles come under this category. Conflicts and political instability may disrupt the oil supply chain in several developing countries, which could result in losses. Some developing countries struggle to make investments in the modernization of their oil infrastructure due to financial or political issues. Corruption can result in losses through theft, poor management, and inefficiencies in the oil supply chain. Oil losses during transportation may be impacted by environmental factors like bad weather or robust location.

3.5.4 Electricity

Electricity sector in Pakistan faced several challenges and was undergoing significant changes to meet the growing demand for electricity and improve its overall performance. Charged particles (such electrons and protons) can exist and produce electricity, which is a type of energy. It is an essential source of energy that powers many elements of modern life, including transportation, businesses, and residences (Arshad & Muhammad Shamshad, 2022). Electricity has a vast and complex system where public and private sectors are involved from production to distribution. The mixture of public and private sector also a source problem. The term "Generation Companies" is shortened to "GENCO’s." These are the organizations in charge of producing power. They own and manage power facilities that generate electricity from a range of resources, including coal, natural gas, water, nuclear power, solar, wind, etc. For example, "Distribution Companies" is abbreviated as "Discos." These are the corporations in charge of delivering power to final users, including residences, businesses, and industries. Discos obtain electricity from GENCO’s and transmit it over their distribution systems.

The Pakistan Electric Power Company, or PEPCO for short, is a government-owned organization in Pakistan in charge of organizing and managing the nation's electrical power generation and distribution. PEPCO oversees the operations of several electricity generation and distribution businesses, including the Water and Power Development Authority (WAPDA) and other public and private sector entities engaged in the production and distribution of electricity. This organization is crucial to Pakistan's power sector. The word (WAPDA) stands for "Water and Power Development Authority." Managing Pakistan's water and energy resources falls under the purview of this government-owned company. WAPDA works to build and run dams, hydroelectric power plants, and distribute electricity to different parts of Pakistan. While these concepts are applicable to the global energy industry and are used in several locales, the precise names of enterprises and groups may change depending on the nation or location.

Pakistan's National Transmission and Dispatch Company (NTDC), a state-owned company, oversees Pakistan's power transmission and distribution. By assuring the dependable and effective transmission of electricity from power producing sources to distribution businesses and consumers, NTDC plays a crucial role in the nation's power industry. To guarantee a consistent supply of electricity to customers throughout Pakistan, NTDC works in conjunction with other organizations in the power sector, such as the Ministry of Energy and Power, the Pakistan Electric Power Company (PEPCO), and numerous distribution businesses. PEPCO, DISCOs, GENCO, WAPDA and NTDC are complex structures or overburdened system is also a source of poor governance where no one can highlight to fix the problem actor among these players.

Nasir et al., (2008) discuss Pakistan has been suffering its worst electrical shortage in history for the previous year. At only one extreme, the price of oil at the worldwide platform is having a negative effect on the overall community, as well as the power outage is weakening the government. The government is undertaking several steps to tackle this issue. In this manner, the lack of power is shown as an imaginative instead of a black side to the image. This would be interesting to know the empirical relationship of energy requirements to check the accuracy of this opinion. Similarly, it is assumed that a rise in the cost of each energy unit will result in a loss in generation capacity. For this reason, the component charges for electricity differ based on the range of product utilization. As a result, income elasticity is also predicted. A large population boom is also believed to play a key role in the increase in the need for energy.

3.6 Principal Component Analysis to Construct EG

Principal component analysis (PCA), a technique for decreasing the size of huge amounts of data, works by condensing a large collection of variables into a smaller set that maintains most of the information of the larger set of indicators. The quality of a data set inherently suffers when the number of variables is minimized, but the strategy in noise removal is to accept a little quality for simplification. Since there are fewer superfluous variables to deal with and relatively small data sets make investigation and analysis easier, algorithmic approaches for deep learning can examine data considerably more quickly and effectively (Schmidtlein et al., 2008). Hence, to summarize, the goal of PCA is to lessen the number of variables in a time series and maintain as much validity.

This stage standardizes the overall distribution of the prolonged response variables with the objective of making sure that each one contributes equally to the investigation. Further notably, the fact that PCA is extremely sensitive to the variances of the starting data is the main justification for normalization being undertaken before PCA (Abeyasekera, 2000). In other words, if there are wide variations in the starting parameter, the wider spanned variables will predominant over the lower numbered values, resulting to skewed outcomes. As an example, a variable with a range of 0 to 100 will prefer over a variable with a range of 0 to 1. To avoid this issue, the data should be transformed to equivalent scales.

Measurements are often scaled down after standardized so that the mean is 0 and 1-unit variance (Zheng & Wang, 2014). As the study exploits three indicators oil, gas, electricity, each variable having different scales, directions, and properties, the first task is to descale these indicators to make a homogenous index of energy governance. For this purpose, the data has been normalized with the help of this formula which is written as (Ejaz et al., 2014). For each value of each variable, this can be accomplished mathematically by dividing by the standard deviation and removing the mean.

The loading factor in PCA refers to the coefficients that represent the relationship between the original variables and the principal components. These loading factors indicate the contribution of each variable to the principal components. The loading factor of PCA is the correlation between a given variable and the principal component (PC). It represents the contribution of each variable to the creation of the PC. In PCA, the first PC has the highest loading factor, as it explains the largest amount of variance in the data. The second PC has the second-highest loading factor, and so on.

The loading factor can be positive or negative, depending on the direction of the relationship between the variable and the PC. Positive loading means that the variable increases as the PC increases, while negative loading means that the variable decreases as the PC increases (Erahman et al., 2016). The loading factor is used to determine which variables are most important in creating the PC and can be used to interpret the meaning of each PC. Higher loading factors of a variable indicate that it has a stronger relationship with the PC, and therefore, a more significant contribution to the overall structure of the data. The loading factor of a variable (i) on a principal component (j) in PCA can be calculated using the following formula:

$$\text{Loading Factor } (i,j) = \text{ Correlation Coefficient } (i,j) \text{ x sqrt (Eigenvalue of the jth Component)} \tag{3.4}$$

The correlation coefficient (i, j) is the correlation between variable i and principal component j. The eigenvalue of the jth component is the amount of variance explained by the jth principal component. By multiplying the correlation coefficient by the square root of the eigenvalue, we can determine the weight/importance of each variable in the formation of the principal components. The larger the loading factor of a variable on a principal component, the stronger its effect on that component. A positive loading factor means that the variable positively contributes to the formation of the component, while a negative loading factor indicates that the variable has a negative influence on the principal component (Dien et al., 2005; Reckien, 2018).

After the variables have been standardized, they will all be scaled to the same degree (Suykens et al., 2003). This last stage aims to reorganize the data from its initial directions to those that comprise the principal components using the vector of features generated with the eigenvalues of the matrix of covariance (thus the term Principal Components Analysis). To do this, multiply the transpose of the feature vector by the transpose of the original data set.

$$FinalDataSet = FeatureVextor^{T} * StandardizedOrigionalDataSet^{T} \tag{3.5}$$

No matter the analysis method, information about a signal cannot be retrieved from a data set with high measurement noise (Shlens, 2014). All noise is assessed relative to the signal strength because there is no absolute scale for noise. The signal-to-noise ratio (SNR), or a ratio of variances σ^2, is a widely used metric.

$$SNR = \frac{\sigma^2 signal}{\sigma^2 noise} \tag{3.6}$$

An accurate measurement is indicated by a high SNR (> 1), whereas extremely noisy data is indicated by a low SNR. The present study collects data of the variables from authentic sources. EG is constructed by three indicators of downstream energy sources of Pakistan. As time series data is utilized, data analysis plays a very crucial role when someone have time series data.

3.7 Methods to Estimate the Models

For analysis there are two approaches, which are quantitative and qualitative approaches. This study uses the quantitative approach as study uses time series data. The present study selects the proper methodology, which is Auto-Regressive Distributed-Lag model (ARDL). The data for this study are collected from various sources like World Development Indicators (WDI) and Pakistan

Energy Yearbook (different issues) from 1985 to 2021 during this time span. The basic problem with time series data is (a) trend, (b) inertia, (c) seasonality and (d), structural breaks. Whenever there is problem of non-stationarity in data, then estimated models may not produce robust results. So, first check the stationery then suitable technique to estimate the model.

3.7.1 Stationary and Non-stationary Time Series

Econometric models primarily focus on the stationary aspect of the data to produce a valid result, whether it be for forecasting or dynamic analysis; otherwise, spurious regression may appear. If the stationarity of the variables cannot be checked, robust regression results may not be obtained. In a layman's words, a stationary series has time invariant variance and mean and finite covariance. Such series is also referred as a white noise process also referred to as the white noise process (Alharthi & Hanif, 2020). The series therefore implies a mean-reverting feature and a limited memory. Finding the stationarity level is essentially an effort to identify the data generation process (DGP). Forecasting and predicting future results are simple and will be easy task when someone know the DGP.

Non-stationarity behavior that may arise due to time series is regarded as non-stationary, however, if one or more of the previously mentioned components fluctuate over time. Time series data that are non-stationary frequently exhibit seasonality (repeating patterns) as well as trends (either upward or downward). The nonstationary time series will therefore not offer accurate forecasts. Second, many useful analytical techniques and statistical model assume that data are stationary (Jalil & Feridun, 2011). In time series analysis, determining stationarity or non-stationarity is a crucial step since it directs the choice of suitable modelling approaches and helps to ensure that the outcomes are accurate and understandable. If the requirement of stationarity of time series is not maintained then, a regression model may provide incorrect results. One may be misled by a such model, and the conclusion drawn from it will be technically erroneous. To verify the stationarity level or unit root testing, there are various tests. The chosen tests to test the unit root level are covered in the coming section.

3.7.2 Unit Root Test

In econometrics unit root test is used to examine the statistical properties of a series which is used in research. A non-stationary series contains variance and mean time. While a stationary series contains variance and mean time invariant. Various kinds of test that are used to check the unit root or nonstationary of variables of model (Zhong, 2015). Present study uses Augmented –Dickey – Fuller (ADF) and PP (Phillips Peron), (Phillips, 1958) tests to check the stationarity of the data. The idea of the ADF test is first proposed by economists David Dickey and Wayne Fuller in 1979 (Dickey & Fuller, 1979).

In time series analysis, stationarity is a key concept. A stationary time series contains statistical characteristics that remain constant across time, such as a constant mean and variance as well as the absence of regular trends. A non-stationary time series, in contrast, demonstrates variations in statistical characteristics over time, frequently with a trend or random walk behavior. A time series data with a unit root is non-stationary because it has a stochastic trend. Practically, unit root test indicates that the series is highly persistent and is probably influenced by its prior values, which makes accurate modelling and forecasting difficult (Nelson & Plosser, 1982).

Meese & Singleton, (1982) unit root tests help researchers and analysts identify the nature of a time series, enabling them to choose appropriate modeling techniques and apply necessary transformations to achieve stationarity if needed. Stationary time series in general is easier to develop model, and forecast compared to non-stationary series, and unit root tests play a crucial role in making these distinctions.

3.7.3 Augmented Dickey Fuller Test of Unit Root

In time series analysis, stationarity testing is the first step to deal with data. Tests can be administered using a variety of techniques, such as the Dickey-Fuller (DF) test from 1979, the Augmented Dickey-Fuller (ADF) test from 1981, and the Philip-Perron (PP) test from 1988, among others. To verify series stationarity, PP test is utilized. PP test successfully accommodates the higher order autocorrelation in case of small data set (Amin et al., 2020).

The most popular unit root test for time - series data is proposed by Dickey - Fuller (1979) and is called DF test. This test is made for first order auto - regressive system. The DF test is improved at by Said & Dickey in (1984); (Said & Dickey, 1984). By including the extra lags length of the dependent variables ADF test to remove the issue of autocorrelation this suitable principle is used by Akaike Information Criterion (AIC) or Schwarz Information Criterion (SIC) (Org et al., 2013). ADF has one or more lag-values along the dependent variable while independent variable called an auto-regressive (Ng & Perron, 2001). The main distinction between the DF and ADF tests is the use of more lags. The ADF test is frequently employed in time series analysis and econometrics to determine whether a time series contains a unit root. With a unit root, the series is non-stationary and has a stochastic trend, making it difficult to especially analyze and model. The time series having a unit root, which denotes non-stationarity, is the null hypothesis of the ADF test.

Such studies are based on the assumptions that the defects either are poorly dependent or weak unbiased, with impartial and same dispersion. So, several experimental actions that take place in the economic and financial disciplines do not properly fit some of the mentioned categories.

ADF test mathematically can be written as

$$y_t - y_{t-1} = \alpha_0 + \alpha_1 t + \rho Y_{t-1} + \mu_t \quad (3.7)$$

$$\Delta y_t = \alpha_0 + \alpha_1 t + \rho y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta y_{t-1} + \mu_t \quad (3.8)$$

The above equation is an example of an AR (P) process, where Δ is used for difference and y_{t-1} shows the first lag, μ_t is an error term (Engle & Granger, 2019; Karim et al., 2021). The equation of model can be rewritten as follows:

$$\Delta Y_t = \alpha_0 + (\rho - 1)Y_{t-1} + \mu_t = \alpha_0 + \delta Y_{t-1} + \varepsilon_t \quad (3.9)$$

Assuming that the series in question is non-stationary, the model is estimated in different form. Dickey and Fuller both performed the same action. Only the AR (1) procedure is addressed by the traditional Dickey and Fuller test (Mushtaq, 2011). Shocks in Y_t will only last a short while and disappear with the passage of time if the value of is less than one (Pesaran et al., 2001). In that instance, the series will have a fixed structure. Second, if is equal to one, shocks in Y_t are permanent in nature and do not fade away with passing time (Engle & Granger, 2019).

$$\Delta Y_t = \alpha_0 + \alpha_1 t + (\rho - 1)Y_{t-1} + \varepsilon_t \quad (3.10)$$

Time trend is represented by $\alpha_1 t$ in the equation above. Only the AR (1) process is addressed by the Dickey Fuller test, however the AR (ρ) process affects most time series. Augmented Dickey Fuller is the best strategy for incorporating such a high level of autocorrelation (ADF). This ADF equation is as follows.

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \delta Y_{t-1} + \sum_{j=2}^{p} \alpha_j Y_{t-j} + \varepsilon_t \quad (3.11)$$

Augmented Dickey Fuller (ADF) is essentially Equation (3.11). One could contend that the estimated equation does not produce reliable results if the trend and intercept of the equation are ignored. This is a valid criticism that should be carefully examined. As a result, one can include intercept and trend, in ADF as it is indicated in equation (3.11), (3.12).

To make things clearer, the ADF test is chosen since it parametrically corrects the higher order correlation by taking a larger number of lags on the right-hand side of the equation. It is generally agreed that a practical solution to the preceding equation would be to add more lags on the right-hand side. To eliminate autocorrelation in the residuals, applied econometricians often advise researchers to build their models with enough lags (Jalil & Rao, 2019). Yet occasionally it is useless because adding lags results in a reduction in degree freedom. ADF also has the drawback of not accounting for structural changes in the data series under analysis.

3.7.4 Phillips Perron Test

Org et al., (2013) explain that Phillips Perron (PP) test is used in time series data and panel data to deal the statistical problems like autocorrelation (Phillips & Perron 1988). PP test is proposed by Peter C.B. Phillips and Pierre Perron in 1988 and is an expansion of the more well-known Dickey-Fuller test. The Phillips-Perron test offers a modified version of the test statistics to address some of the problems that arise with finite samples. It can be used, like the Dickey-Fuller test, to determine whether a time series is stationary after being differentiated to a particular order. The Phillips-Perron test's alternative hypothesis is that the time series is stationary, whereas the null hypothesis is that it has a unit root (i.e., it is non-stationary). Calculating test statistics based on the estimated parameters requires first estimating the data's autoregressive parameters. These test statistics' critical values are derived from pre-tabulated tables or by using scaling techniques. The PP test evaluates heteroscedasticity and autocorrelation in the error terms and differentiates it from ADF test. More residuals have an impact on the strength of the level of freedom when there is high ;frequency heterogeneity and limited information. In this scenario, PP leads over ADF in comparability. PP test is a widely used and it is validated test for determining the unit root in time series data analysis.

PP test equation is given below.

$$Y_t = \alpha + \delta y_{t-1} + \varepsilon_t \qquad (3.12)$$

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \delta Y_{t-1} + \sum_{j=2}^{p} \alpha_j Y_{t-j} + \varepsilon_t \quad (3.13)$$

3.7.5 Auto Regressive distributed Lag Model; Equation and Explanation

Based on unit root order, there are different techniques to estimate the model. Like, if all variables of the model are integrated at first difference, then different technique is recommended. On the other hand, side when some variables are integrated at first difference while some are at level then ARDL technique to estimate the model is widely used in empirical literature. The long-term associations between variables are examined using an econometric model called an autoregressive distributed lag (ARDL) model. It is frequently used in time series analysis and can be considered an improvement over the classical autoregressive model (AR). The ARDL model makes it possible to conduct a more thorough examination of the dynamics between variables, which is particularly helpful when dealing with variables that could have both immediate and long-term effects on one another. The ARDL model allows for different orders of lagged dependent and independent variables, which makes it flexible and versatile for various time series data.

The model is estimated using various techniques such as ordinary least squares (OLS) regression, and the selection of lag orders (p and q) is often determined using statistical criteria like the Akaike Information Criterion (AIC) or Schwarz Bayesian Criterion (SBC) to find the best-fitting model.

Pesaran, Shin, and Smith introduced the idea of the Autoregressive Distributed Lag (ARDL) model in 2001. Specifically, when the variables are non-stationary (i.e., they have a unit root), the model is designed to analyze the long-run relationship between variables in a time series data. (Pesaran et al., 2001). The present study used Auto Regressive Distributed Lag (ARDL) bond testing strategy to check the long-run relationship among energy governance, unemployment, labor force, inflation, GDP per capita, GDP, exchange rate, GFCF and external debt in case of Pakistan during period 1985 to 2020. With the help of energy governance improves all macroeconomic indicators that we used in our study, by using this approach we get certain benefits. The advantages by using this methodology to reduce inflation and overcome unemployment and increase GDP per capita in Pakistan.

Firstly, measure the long run and short run coefficients relationship variables which have mixed integration relation i.e. I (0), I(1), I(0) and I(1) some variables are stationary at level and some variables are stationary at 1st difference. If ARDL approach have mixed stationarity like I(0) and I(1) autocorrelation it also deals the issue of heterogeneity (Shahbaz et al., 2011). The selection of lag length criteria is best for regression analysis. The ARDL approach is more reliable it works very well small amounts of data in contrast to the most of traditional cross protocols, which are applicable for higher data populations (Al-Malkawi et al., 2012; Nkoro & Uko, 2016b; Ozcicek & Douglas McMillin, 1999). ARDL approach used the Akaike Information Criteria (AIC).

To examine the role of energy governance and selected macroeconomic indicators in case of Pakistan, three different models based on macroeconomic indicator is constructed which are on the following. First, model is the impact of energy governance on unemployment in case of Pakistan. Second, model is the impact of energy governance on external debt in case of Pakistan. Third, model is the impact of energy governance on gross domestic product in case of Pakistan.

3.7.6 Bound Testing

The concept of bond test is introduced by Stephen Bond and Manuel Arellano back in 1991. This test is used in both situations when variables are level and first difference stationary. The Bound F-statistic (bound test of cointegration) is estimated at the first stage of the study to determine whether there is a long-run relationship exists between the variables or not. Each of the variables is subjected to this bound F-statistic as an endogenous variable, while others are regarded as exogenous variables. In real-world applications, evaluating the relationship between the forcing variable(s) in the ARDL model entails evaluating the long-term relationship among the underlying variables. This excludes the underlying variables most recent values from the ARDL model approach to cointegration (Arellano & Bond, 1991). This step describes how to conduct the bound test, also known as the cointegration test, in the context of ARDL. The ARDL modelling approach is being used in the current investigation. The ARDL conceptual model equation is as follows.

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta Y_{t-i} + \beta_1 \Delta K_{t-i} + \lambda_1 L_{t-i} + \pi_1 EG_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=1}^{q} \theta_j \Delta K_{t-i} + \sum_{i=1}^{l} \varphi_i \Delta L_{t-i} + \sum_{i=1}^{k} \omega_i \Delta EG_{t-i} + \varepsilon_t \quad (3.14)$$

where $ß_1$, γ_1, α_1 and π_1 are long run coefficients, α_0 is intercept and $€_i$ are white noise errors .

$$\Delta UN_t = \alpha_0 + \alpha_1 \Delta UN_{t-i} + \beta_1 \Delta INF_{t-i} + \lambda_1 GDPpc_{t-i} + \pi_1 EG_{t-1} + \sum_{i=1}^{p} \delta_i \Delta UN_{t-i} + \sum_{i=1}^{q} \theta_j \Delta INF_{t-i} + \sum_{i=1}^{l} \varphi_i \Delta GDPpc_{t-i} + \sum_{i=1}^{k} \omega_i \Delta EG_{t-i} + \varepsilon_t \quad (3.15)$$

$$\Delta ED_t = \alpha_0 + \alpha_1 \Delta ED_{t-i} + \beta_1 \Delta EG_{t-i} + \lambda_1 GDPpc_{t-i} + \pi_1 ER_{t-1} + \gamma_1 GFCF_{t-1} + \sum_{i=1}^{p} \delta_i \Delta ED_{t-i} + \sum_{i=1}^{q} \theta_j \Delta EG_{t-i} + \sum_{i=1}^{l} \varphi_i \Delta\, GDPpc_{t-i} + \sum_{i=1}^{k} \omega_i \Delta ER_{t-i} + \sum_{i=1}^{k} \delta_i \Delta GECF_{t-i} + \varepsilon_t \qquad (3.16)$$

$$\Delta GDP_t = \alpha_0 + \alpha_1 \Delta GDP_{t-i} + \beta_1 \Delta EG_{t-i} + \lambda_1 ER_{t-i} + \pi_1 LF_{t-1} + \sum_{i=1}^{p} \delta_i \Delta GGPpc_{t-i} + \sum_{i=1}^{q} \theta_j \Delta EG_{t-i} + \sum_{i=1}^{l} \varphi_i \Delta\, ER_{t-i} + \sum_{i=1}^{k} \omega_i \Delta LF_{t-i} + \varepsilon_t \qquad (3.17)$$

In order to determine whether there is a long-term link between the variables, the limits test process involves estimating the equation (3.17), using ordinary least squares (OLS), and then doing an F-test for the joint significance test of the coefficients $ß_{1,}$ $\gamma_{1,}$ α_1 and π_1 . As a result, the alternative ($H_1 : ß_1 \neq \gamma_1 \neq \alpha_1 \neq \pi_1 \neq 0$) is evaluated against the null hypothesis of no co-integration($H_1 : ß_1 \neq \gamma_1 \neq \alpha_1 \neq \pi_1 \neq 0$). The results offered two asymptotic critical values for the co-integration test when the independent I(m) where 0≤m≤. The regressors are assumed to be I(0) for lower values and I(1) for higher values, respectively. Whatever the orders of integration for the time series, the null hypothesis will be rejected if the estimated F-statistic (test statistic) is higher than the upper bound critical value (Adeel-Farooq et al., 2018). On the other hand, the null hypothesis cannot be rejected if the test statistic is lower than the lower bound critical value. Finally, the outcome is inconclusive if the test statistic is inside the critical value ranges.

3.7.7 Estimating the Long-Run and Short run form of Model

ARDL technique contains two components to estimate a model the first component is long run form of estimated model while the second component is short run form or ECM form. In the ECM, the short-run dynamic and long-run connection are shown. ECM (-1) specifies the long-term relationship, and the negative sign of ECM guarantees that model is dynamically stable. The adjustment parameter is another name for it (Shahbaz et al., 2007). The long-run relationship is determined by the short-run ECM term. The convergence rate to equilibrium is shown by the adjustment parameter EC (-1). The error correction must be negative and lies between zero and minus one. After estimation the long run and short run forms of model next step is to check the model diagnostic and stability of the model.

3.7.8 Stability Diagnostics

Stability diagnostics are the evaluation and examination of an economic system's stability, such as an economy of a country or a particular market, to determine its ability to recover to deal with shocks or disturbances. The objective of stability diagnostics is to pinpoint potential weak points, dangers, and vulnerabilities in the economic system so that policymakers and economists may make informed choices and take the necessary action to preserve or reestablish stability. Stability diagnostic test is recursive estimates (OLS) is selected and then apply Cusum test and Cusum sequare test of over model value is linked between upper and lower bond. In case of Cusum square if value is laid between upper and lower bond it means model is best fitted. The cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUM) square tests are employed to determine the model's robustness because the autoregressive model is particularly sensitive to the number of lags (Maria Caporale & Pittis, 2004) .

The comprehensive description of research methodology and theoretical and conceptual framework used for this research study has been examined in this chapter of the study. The next step is to explain the functional form of econometric model. After that explain the description o of the variables. Discuss the measurement issue of energy governance briefly. After that explain Principal Component Analysis (PCA) to normalize the data of energy governance. The main part of this chapter discusses the unit root tests to check stationery and nonstationary, (Augmented Dickey Fuller) and (Phillips Perron) test. At the end, the study applies ARDL bound testing approach is used to investigate the long run relationship on energy governance in case of Pakistan.

CHAPTER 04

Results and Discussion

4.1 Introduction

Results and their discussion with reference to theory are two important branches of any academic empirical research. Based on results, one can authenticate the theory test hypothesis. This chapter starts with descriptive statistics then moves towards advanced techniques which are based on inferential analysis. The discussion part of the present study is the interpretations of the findings. The empirical results of three models that are discussed in previous chapter are obtained with the help of Auto Regressive Distributed Lag (ARDL) technique.

The data's descriptive statistics is covered in section 4.2. Section 4.3 contains the unit root tests e.g., Augmented Dickey Fuller and Phillips Perron. Section 4.4 discusses the impact of energy governance on external debt. Section 4.5 illustrates the impact of energy governance on unemployment. Section 4.6 contains the impact of energy governance on gross domestic product of Pakistan.

4.2 Descriptive Statistics

Present study takes the data from World Development Indicator (WDI), Pakistan Statistical Yearbook for the period of 1985 to 2021. Data starts from 1985 to onward because energy related data starts from 1985. Although, the data of remaining indicators are available before 1985 to onward. This is also the limitation of a present study. A country with a high energy score has excellent energy production, consumption, and total energy efficiency. It shows that the nation relies on a variety of sustainable energy sources, has a strong energy infrastructure, and uses energy effectively to meet its economic and social demands. A high energy score can indicate high levels of energy security, a decrease reliance on fossil fuels, and a decreasing negative impact on the environment in terms of greenhouse gas emissions and other pollutants.

Descriptive statistics is used to properly represent the data by describing the variables of a sample. Relevant statistical comparisons should never be performed before computing descriptive statistics, which is a crucial initial step in empirical research. Namely, descriptive statistics covers frequency, central tendency, dispersion/variation, and location statistics in addition to basic, continuous, period, and ration measurements. Descriptive statistics has ability to reduce data into a more understandable overview that enables decision-makers to assess certain populations in a more effective manner ((Kaur et al., 2018) et al., 2018a).

The value known as the central tendency is used to express the full set of data as a measurable statistic. The mean, median, and mode are the three main statistics for assessing central tendency (Biostatistics Year et al., 2018). Since this measure of central tendency is highly influenced by extremes and skewed distributions, the mean should only be presented with interval or ratio data that are properly distributed it looks like a bell-shaped curve. The median, when the data are arranged from highest to lowest, is the midpoint in the distribution (or vice versa). The median is the average of both middle number when there are an even number of values as opposed to an odd number of values, which allows the median to be the exact middle value(Kaur et al., 2018b).

The variance and standard deviation are scattered indicators that show how near each significance level is to the dataset's average mean. Most values are close to the mean in data with a small spectrum, which results in less variance and standard deviation. Sets of data having a broader variety of values ranging from the mean, therefore, have a greater deviation and variance. Hence, when all values of a database are homogeneous, its variance and standard deviation are both equal to zero.

It is a measure of the asymmetry in the distribution of the set of data. For example, the income is skewed as some people might be earning between a standard range while others will be way higher or lower to that range. The skewness can be positive, negative, or undefined. When a distribution is skewed to the right, that is, the tail of the curve on the right-hand side is longer than that to the left, and the mean value > the mode, this is called a positive skewed. When a distribution is skewed to the left, that is, the tail of the curve on the left-hand side is longer than that to the right, and the mean value < the mode, this is called a Negative Skew and for a perfect normal distribution, the tails on each side of the curve are the same (Sharma Sohil, 2019). The following table 4.1 covers the descriptive statistics of the variables of the model of contemporary study.

Table 4.1 Descriptive Statistic

	EG	TLF	UN	ER	GDPPC	GFCF	INF	GDP	ED
Mean	0.07	7.74	0.78	62.7	4.66	1.69	9.06	1.40	40.4
Median	0.06	7.72	0.06	58.8	4.63	7.71	7.68	1.12	41.3
Maximum	1.20	7.87	1.20	161.8	4.79	1.10	38.5	1.06	55.9
Minimum	-0.83	7.53	0.83	15.9	4.52	1.03	0.40	1.02	25.7
Std. Deviation	0.37	0.09	0.37	38.2	0.75	1.91	6.69	9.15	9.97

Skewness	0.59	-0.58	0.59	0.74	0.09	1.23	2.56	0.41	-0.06
Kurtosis	4.90	2.41	4.80	2.92	1.95	3.31	11.6	1.65	1.52
Observation	36	36	36	36	36	36	36	36	36

The mean, median, maximum, minimum, standard deviation, skewness, and kurtosis are presented for nine variables of the study (Kaur et al., 2018c). The normalization process transforms the data to a common scale, typically between 0 and 1, by adjusting each data point relative to the overall range of values. In this case, the Energy Governance Index, with its range from -0.83 to 1, undergoes normalization to bring all values within a consistent and interpretable framework. This facilitates a more accurate understanding of the relative performance across different entities or time periods, as it removes the influence of varying scales. A normalized Energy Governance Index allows for a more meaningful interpretation and comparison of the data, enabling researchers, policymakers, and stakeholders to gain insights into the energy governance landscape with a standardized and normalized perspective.

The mean value of total labor force is 7.74 and its median value is 7.72 it shows that mean greater than mode and it is asymmetric, the mean of a variable is a measure of central tendency, or it tells us where the center of a value distribution is (Nicholas, 2006). Its range lies between maximum to minimum value 7.78 to 7.53. The value of standard deviation is 0.09. The skewness co-efficient and kurtosis of LF are, respectively, -0.58 and 2.41. Skewness is a measure of symmetry, or more precisely, its absence. A distribution or data set is said to be symmetric if it appears symmetric to the left and right of the center point. The skewness value may be undefined or either positive or negative. If the coefficient of skewness equals 0, the data is regarded as perfectly symmetric (Clay, 2004). If the skewness is more than one or less than one, the distribution is significantly skewed. If the skewness of the distribution is between -1 and -0.5, or between 0.5 and 1, then it is severely skewed. If the distribution's skewness is between -0.5 and 0, it is generally symmetric (Cain et al., 2017).

The mean value of unemployment is 0.78 that shows the average of the data, and its median value is 0.06, which shows the center of data. The maximum value of the data is 1.20 it shows the highest observations, and the minimum value of the data is 0.83, shows the lowest observations of the data it shows how much change in unemployment. The value of standard deviation is 0.37, that shows the spread or dispersion of the data from the average value that shows the less variability in in the unemployment from the average value. The skewness value is 0.59 which confirms that the behavior rightly skewed. The value of kurtosis is 4.80 which shows the distribution tends to leptokurtic peaked curve (Vetter, 2017). The mean value of the exchange rate is 62.7 and its median value is 58.8, standard deviation is 38.2. The maximum value is 161.8 to 15.9. The Kurtosis value of exchange rate is 2.92 which is negative kurtosis, flatted curve, more lower values, and skewness value is 0.74 positively skewed long right tail and more higher values. Kurtosis is related to a distribution's extrema, shoulder, and tail. Kurtosis typically rises when a curve is topped and diminishes when it is plain. (Decarlo, 1997) clarifies that it has more to do with a distribution's shoulder and tails than it does with its peak.

The mean value of gross domestic product is 4.66 and median value is 4.63, ranges lie between 4.79 to 4.52, standard deviation value is 0.75, skewness value 0.09 which is equal to 0 normally skewed and kurtosis value of GDP per capita is 1.95, negative kurtosis platykurtic flatted curve (Fisher & Marshall, 2009). The mean value of inflation is 9.06, median value is 7.68, maximum value of inflation is 38.5, minimum value is 0.40, standard deviation is 6.69, skewness value is 2.56 positive skewness long right tail more higher values, kurtosis value is 11.6 leptokurtic positive kurtosis flatted curve which leads more lower values.

The mean value of GFCF is 1.69, maximum value of gross fixed capital formation is 1.10, minimum value is 1.03, standard deviation is 1.91, skewness value is 1.23 positive skewness, long right tail, kurtosis value is 3.31 it is positive leptokurtic peaked curve(Morgan, 2016). Mean value of GDPis 1.40, median value is 1.12 maximum value of gross domestic income is 1.06, minimum value is 1.02, standard deviation is 9.15, skewness value is 0.41 positive skewness, long right tail, kurtosis value is 1.65 negative kurtosis platykurtic flat curve. The average value of external debt is 40.4, median value is 41.3, maximum value of ED is 55.9, minimum value is 25.7, standard deviation is 9.97, skewness value is -0.06 negatively skewness l which is long left tail which leads more lower values, kurtosis value is 1.52 it is negative platykurtic kurtosis flat curve (Pérez-Vicente & Expósito Ruiz, 2009).

The different aspects of the data are summarized in these statistics. Using the two numerical metrics of skewness and kurtosis, normality can be statistically tested. Non-stationarity of the data could be a problem if it is not regularly distributed. Our data is not normally distributed since the values of skewness and kurtosis in both Pakistan are not in ideal conditions. As a result, the next stage of the investigation will employ several stationarity tests to establish which one provides the greatest fit for the data.

4.3 Unit Root Test

Augmented Dickey Fuller (ADF) and Phillips Perron (PP) (Leybourne & Newbold, 1999) tests are applied to check stationarity of the variables. Generally, in the case of large data both PP and ADF test provide similar findings. But in the case of small data PP perform relatively better (Org et al., 2013).

Table 4.2 Augmented Dickey -Fuller Unit Root Test

	At Level	1st Difference

Variables	t. statistics value	t. critical value	P value	t. statistics value	t. critical value	P value	Remarks
EG	-4.33	-3.63	0.00**	-9.89	-3.63	0.00**	I(0)
TLF	-1.17	-3.63	0.67	-5.33	-3.63	0.00**	I(1)
INF	-5.43	-3.63	0.00**	-6.83	-3.64	0.00**	I(0)
ED	-1.25	-3.63	0.64	-4.86	-3.63	0.00**	I(1)
GDPpc	0.01	-3.64	0.95	-3.76	-3.65	0.00**	I(1)
GDP	-0.68	-3.63	0.83	-3.13	-3.63	0.03*	I(1)
ER	2.12	-3.64	0.99	-3.96	-3.64	0.00**	I(1)
GFCF	-2.77	-4.25	0.21	-3.80	-4.25	0.02*	I(1)
UNE	-2.06	-3.63	0.25	-7.28	-3.63	0.00**	I(1)

Note: p value. * Indicates that the variables are significant at 5% level of significance.

Note: p value. ** Indicates that the variables are significant at 1% level of significance.

Basically, ADF is performing well in large sample size. The results of ADF energy governance, total labor force, inflation gdp deflator, external debt, gross domestic product, GDP per capita, official exchange rate, gross fixed capital formation, and unemployment are presented in above Table 4.2. Energy governance is significant at 1% and stationary at both level and 1st difference. Total labor force is nonstationary at level after that take the 1st difference again test the ADF and then it became stationary at 1st difference at 1% level of significance. Inflation is stationary on both levels and 1st difference at level of 1%. External debt is nonstationary at level, and it becomes stationary at 1st difference.

Gross domestic product is also nonstationary because probability value is greater than 1 on level after applying again ADF on 1st difference its stationary on level of 1$^{\%.}$ On the same vein GDP per capita is also nonstationary because probability value is greater than 1 on level after applying again ADF on 1st difference its stationary on level of 5$^{\%.}$ Official Exchange rate, gross fixed capital formation, and unemployment also these all variables are nonstationary at level and its stationary at level of 1% on 1st difference. With the help of the ADF results two variables are stationary at level and seven variables are stationary at 1st difference (Al-Malkawi et al., 2012). The next step is to apply the PP to test the unit root of the model's variables, which is important in non-parametric analysis but does not require serial correlation like the ADF does. Additionally, it makes t statistic correction easier to complete homoscedasticity and autocorrelation.

Table 4.3 Phillips -Perron Unit Root Test

	At Level			**1st Difference**			
Variables	**t. statistics value**	**t. critical value**	**P value**	**t. statistics value**	**t. critical value**	**P value**	**Remarks**
EG	-4.37	-3.63	0.00**	-19.41	-3.63	0.00**	I(0)
TLF	-1.18	-3.63	0.67	-5.33	-3.63	0.00**	I(1)
INF	-5.42	-3.63	0.00*	-16.93	-3.63	0.00**	I(0)
ED	-1.25	-3.63	0.64	-4.80	-3.63	0.00**	I(1)
GDP	-0.09	-3.64	0.94	-3.76	-3.65	0.00**	I(1)
GDPpc	-0.12	-3.63	0.93	-3.07	-3.63	0.03*	I(1)
ER	2.60	-3.63	1.00	-2.97	-3.63	0.04*	I(1)
GFCF	-2.21	-4.24	0.46	-3.57	-4.25	0.04*	I(1)
UNE	-1.95	-3.63	0.30	-7.38	-3.63	0.00**	I(1)

Note: p value. * Indicates that the variables are significant at 5% level of significance.

Note: p value. ** Indicates that the variables are significant at 1% level of significance

After using the ADF test, the PP test is used to find out the unit root level of all the variables of the models. The alternative hypothesis in this test rejects the null hypothesis based on the p-value, which was the null hypothesis in this test (Çağlayan Akay et al., 2020). Based on PP results two variables energy governance and inflation are stationary on both level and 1st difference at 1%. While total labor force, external debt, GDP, exchange rate, unemployment is nonstationary at level and all these variables are stationary at 1st difference at 1% level. GDP per capita and GFCF are not stationary at level but both variables are stationary at 1st difference at level of 5%. Table 4.2 and 4.3 explain that variables are non-stationery and orders of integration is mixed. So, in such circumstances ARDL technique is recommended in literature (Chandio et al., 2019; Daka et al., 2017;Qamruzzaman & Jianguo, 2018; Abbasi et al., 2021; Muhammad Shahbaz & Faridul Islam, 2011). The present study applies ARDL approach in our results to test the short run and long run relationship on energy governance and selected macroeconomic indicators the case study of Pakistan.

4.4 Impact of Energy Governance on External Debt of Pakistan

ARDL approach continue with these steps bound test, long run, short run, Cusum and Cusum square test. The dependent variable is external debt and independent variables of the above model is energy governance, GDP per capita, official exchange rate and gross fixed capital formation.

Table 4.4 ARDL Bound Testing

Test statistics	**Value**	**K**
F- Statistics	9.73	4
Critical Value Bounds		
Significance	**I(0) Bound**	**I(1) Bound**
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

The bound test is used to check the existence of cointegration. In the above Table F. statistics value is 9.73 which is greater than lower bound and upper critical bound value which are 2.86 to 4.01 at 5% level of significance, it means there is long run relationship exist among the variables of model (Pesaran et al., 2001). So, study rejects the null hypothesis and accepts alternative hypothesis that implies there is long run relationship among the variables. The optimal lag order for the variables in the current investigation is determined by the Akaike Information Criterion (AIC). When computing the ARDL (F-statistic) to establish whether cointegration exists, the right selection of variables lag duration is helpful. The test findings show that the variables in the model have an established long-term relationship. Finding a long run model is the next step after cointegration has been confirmed. The long and short-term results of this model are shown in the tables below.

Table 4.5 Long Run Results

Variable	Coefficient	Std. Error	t. statistic	Prob
EG	-4.66**	1.89	-2.45	0.02
GDP per capita	0.35**	0.12	-2.64	0.01
ER	0.30	0.18	1.67	0.10
GFCF	133.57**	45.92	-3.24	0.01
C	1784.29**	496.91	3.59	0.02

*Shows the 1% level of significance

** shows 5% level of significance

Before interpreting the long run coefficients, it is important to explain the sign of the coefficients of explanatory variables. In the case of the long run GFCF has a positive and significant impact on external debt. When GDP per capita increase it also decrease the external debt in case of Pakistan. Positive and higher GFCF lead to economic growth and increased productivity, which can boost a country's capacity to generate income, and in turn, help manage external debt. Some empirical studies found a positive and negative relationship between external debt and gross fixed capital formation. The empirical studies by ; (Samuel, 2015 ;Anita Chaudhari, Brinzel Rodrigues, 2016 ; Kocha et al., 2021) found the positive relationship among external debt and GFCF. The estimated variable GDPis negative and statistically significant impact on external debt in the long run. The empirical studies shows the negative relationship between gross domestic product and external debt are (Rahman & Dey, 2015; Daka et al., 2017; Moh'd AL-Tamimi & Jaradat, 2019). The key variable of this study is energy governance has a negative and significant influence on external debt. (Qamruzzaman & Jianguo, 2018) suggest that negative and statistically significt energy governance shows when EG is improved it will decrease the external debt in case of long run. As study discussed in chapter 01 shows that energy governance promotes economic growth and further leads to lower the volume of debt. If we compare Pakistan with other developing nations (those who are good in energy governance) and found that energy governance is better, it also decreases external debt.

Table 4.6 ARDL Short Run Results

Variable	Coefficient	Std. error	t. statistics	Prob
D(EG)	-0.65**	0.27	-2.07	0.02
D (ER)	-0.02	0.11	-0.18	0.82
D (GFCF)	12.53	16.30	0.76	0.45
D(GDP per capita)	-0.36*	0.21	1.72	0.00
CointEq (-1)	-0.42**	0.12	-3.32	0.04
R^2	0.97	**Adjusted R^2**		0.95
Akaike info	4.62	**DW statistics**		1.40

** shows 5% level of significance

* shows 1% level of significance

In this model external debt is dependent variable. Energy governance is negative but significant impact on t external debt, as energy losses decrease external debt decreased in short run dynamic model, exchange rate is negative and insignificant impact in short run (Adb, 2021). ECM value is negative -0.42% and statistically significant based on probability value and t-statistic. ECM value is converged to equilibrium at the rate of 42%. The ECM requirements are defined by how quickly the dynamic model will react to reestablish equilibrium. The ECM values indicate the speed at which variables achieve equilibrium and it is statistically significant (Worthington, 2005). There is evidence of a long-run equilibrium link between external debt and the other independent variables in this study, as shown by the significance and negative sign of the ECM. The value of

R^2 and adjusted R^2 0.97 and 0.95 respectively that show our model is good fit. Durbin Waston results show inconsistent results to check out the LM test.

Table 4.7 Breusch – Godfrey Serial Correlation LM Test

F. Statistics	2.1756	0.1425
Obs* R-squared	6.6190	0.1365

Serial correlation is tested through a model diagnostic test. This shows that the model is not suffering from autocorrelation, and it can be used for policies (Okafor et al., 2016). If the probability value of f. Statistics is greater than 10% so we accept the null hypothesis it means, there is no problem of serial correlation that exists in our model. The Breusch-Godfrey LM test is used to determine whether the serial autocorrelation in our model contains any serial correlation. Because the probability value is more than 5%, we are unable to reject the null hypothesis.

Figure 4.8 Cusum Test

Cusum test measure the total of the recursive residuals. At a 5% significance level, the straight lines represent critical bounds. Our model is dynamically stable.

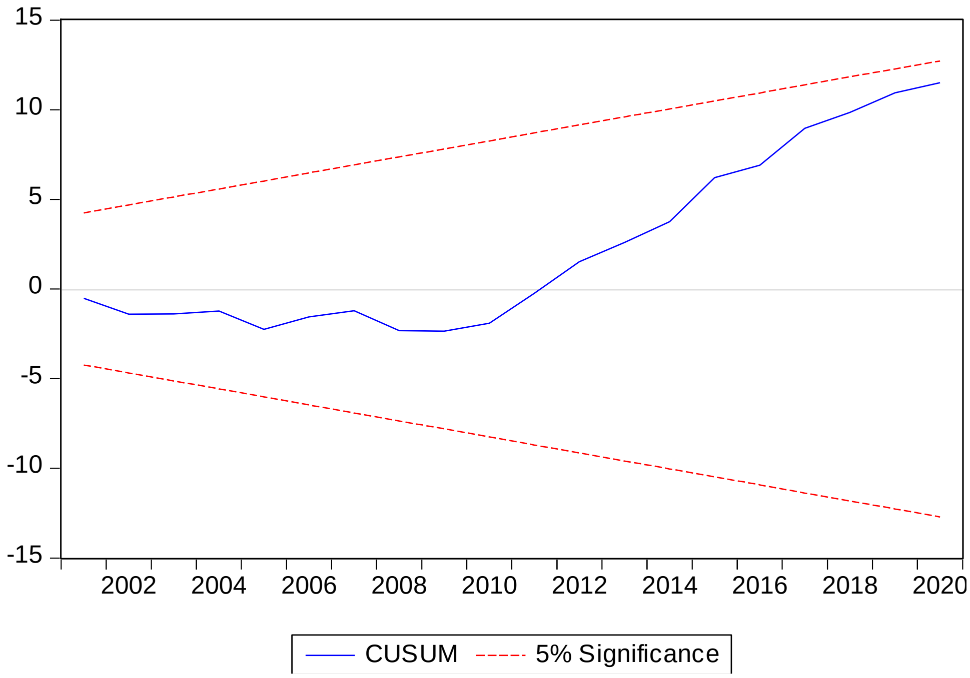
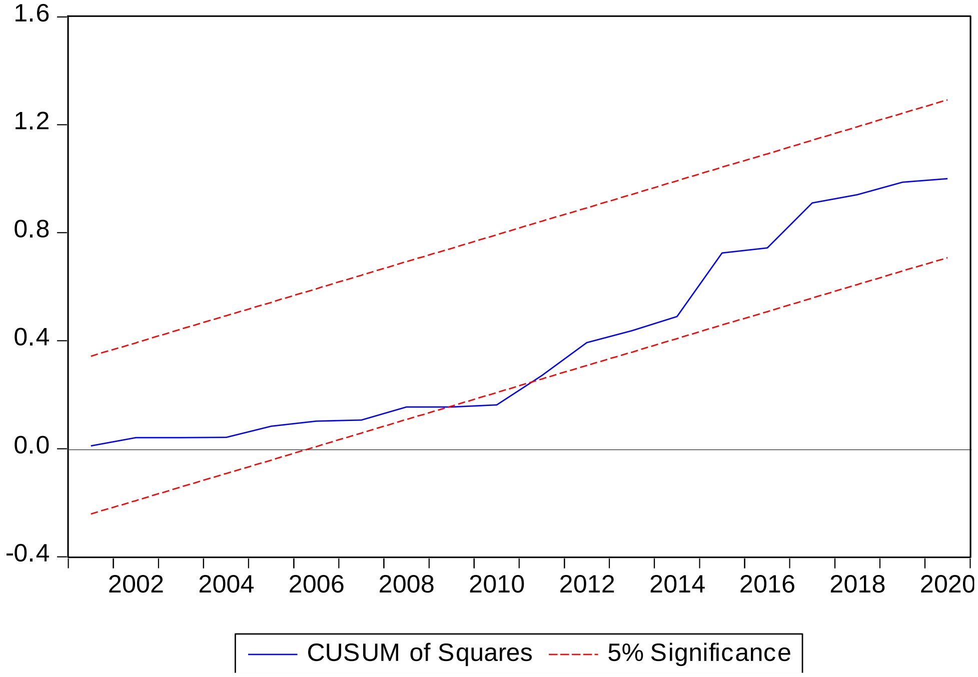


Figure 4.9 Cusum square Test



From 2009 to 2011, Pakistan was hit by a severe energy crisis that was characterized by prevalent electricity and natural gas shortages. The many economic sectors, daily living, and general development were all significantly impacted by this crisis. This energy crisis was caused by several kinds of issues: The supply of natural gas and electricity was consistently insufficient to meet demand. Rapid population expansion, urbanization, and rising industry all contributed to the mismatch between supply and demand. Power plants and distribution networks of Pakistan's energy infrastructure were neglected and undermaintained. As a result, there were inefficiencies and capacity reductions, which frequently led to failures and load shedding. The nation had a lack of fuels like oil and gas, which were needed to run power plants. As a result, the energy crisis got worse and power producing capacity was lowered. As a result of government debt to power producing and distribution companies and their inability to pay fuel suppliers, Pakistan's power sector faced serious financial difficulties. Investment and upkeep in the energy sector were hampered by this "circular debt" predicament. The energy sector's poor management, inefficiencies, and corruption also had a role. Effective policy and reform implementation was hampered by these problems. The issue was made worse by a lack of strategic planning for long-term energy requirements and insufficient investment in energy infrastructure. The manufacturing and distribution of energy were also impacted by the political and security climate in Pakistan at this time. Attacks and acts of sabotage on energy infrastructure hampered operations and supply chains. These causes contributed to the energy crisis from 2009 to 2011, which resulted in frequent and protracted power outages (load shedding) across the nation (Kessides, 2013). This has significant effects on several markets, companies, households, and overall economic expansion. The Pakistani government acted in response to the energy crisis by encouraging renewable energy sources, launching energy conservation initiatives, and looking for foreign investment to modernize the country's energy infrastructure. The energy sector in Pakistan still faces difficulties that necessitate constant care and improvements, and it took several years for the situation to seriously improve. Cusum sum of the square measures the total of the recursive residuals. At a 5% significance level, the straight lines represent critical bounds. Our model is dynamically stable.

4.5 Impact of Energy Governance on Unemployment

Unemployment is the dependent variable, while energy governance, GDP per capita and inflation are the independent variables.

Table 4.10 ARDL Bounds Testing

Test statistics	**Value**	**K**
F- Statistics	6.25	3
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

The findings of the ARDL bound test, which are used to test whether there is co-integration exists or not present in the above table. Based on Akaike information criteria first is selected the lag length of the variables and second F- statistic is greater than upper boundary value. The outcomes imply that the model's variables have a long-term relationship at the level of 1%. In this model F. statistic value 6.25 is largely relative by the upper bound value of F- statistic the rejection of null hypothesis of no cointegration accept alternative hypothesis (Smith, 1999).

Table 4.11 Long Run Results

Variable	**Coefficient**	**Std. error**	**t. statistics**	**Prob**

EG	-3.52**	0.02	-3.18	0.01
GDP per capita	0.02**	0.09	-2.10	0.04
Inf	0.07	0.09	0.73	0.46
C	1.16*	0.50	2.29	0.02

** shows 5% level of significance

The above table contains the long run coefficient, standard error, t- statistics and probabilities value of explanatory variable. There are three variables in our model which estimated. The dependent variable is unemployment. The transmission of energy governance into unemployment and GDP involves several interconnected channels. First, the energy sector directly impacts economic activity and employment through its contribution to GDP. Investments in renewable energy, for instance, can stimulate job creation and economic growth. Second, energy prices influence production costs, affecting industries differently. High energy costs may lead to reduced profitability, potential job losses, and decreased economic output. Third, energy efficiency measures can enhance productivity, potentially boosting GDP while minimizing energy-related expenses for businesses. Additionally, shifts towards cleaner energy sources can influence regulatory frameworks and policies, creating new markets and jobs in emerging sectors (Edelstein & Kilian, 2009). Conversely, poor energy governance, characterized by inefficiency or inadequate infrastructure, can hinder economic development, exacerbate unemployment, and constrain GDP growth. Therefore, effective energy governance plays a pivotal role in shaping the intricate relationship between energy, employment, and economic performance.

The estimated variable GDP per capita is statistically significant. The value of GDP per capita coefficient 0.02 when economic growth of the country will increase it causes the unemployment will decrease it increase job opportunities due to the increase in economic growth. The empirical studies which shows negative relationship between GDP per capita and unemployment are (Rafiq et al., 2008; Chowdhury & Hossain, 2014). The last variable of this model is inflation which is positive and statistically insignificant. The value of inflation coefficient is 0.07 which denotes that the positive relationship between inflation and unemployment expresses that when inflation increases unemployment will increase. The empirical results show positive relationship between inflation and unemployment are (Pilinkus & Boguslauskas, 2009;Mohseni & Jouzaryan, 2016; Ur

Rehman et al., 2018). When energy losses decrease it also decrease the unemployment in case of long run.

Table 4.12 Short Run Results

Variable	Coefficient	Std. error	t. statistics	Prob
D(EG)	-0.08**	0.02	-2.97	0.01
D (GDPpc)	0.0076	0.0072	1.05	0.30
D (INF)	0.0068	0.0092	0.73	0.46
CointEq (1)	-0.50**	0.17	-3.43	0.02
R^2	0.74	**Adjusted R^2**		0.64
Akaike info	0.85	**DW statistics**		2.01

** shows 5% level of significance

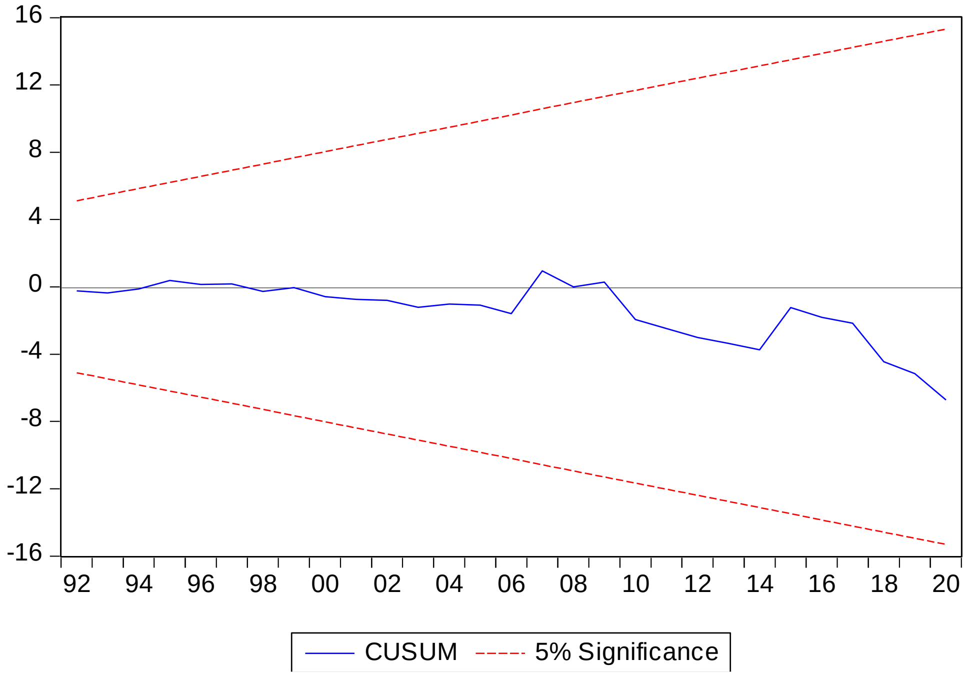
The relationship between energy governance and unemployment is negative. The relationship between inflation and unemployment is often described by the Phillips curve, which suggests an inverse relationship between the two in the short run. This means that, in the short term, an increase in inflation is associated with a decrease in unemployment, and vice versa. But this relationship is only held in the case of bivariant model. Its means when unemployment is dependent variable and inflation, is independent side it shows negative relationship between inflation and unemployment. But in this case unemployment is a dependent variable while energy governance, inflation, and GDP per capita as independent variables, when we add these variables in our model this relationship is reverse. Results which are explained in the above table show that there is negative sign which is -0.50 convergence taking place in each year towards equilibrium. The study shows the null hypothesis of no cointegration in short run is rejected by the evidence of ARDL ECM. According to these results, the unemployment divergence from the long-term growth rate will be corrected by 50% in the next year. R^2 and adjusted R^2 values show that the model fits the data well. A higher r-squared often indicates that the model fits the data better. Additionally, the Durban-Watson (D-W) score indicates that there is no autocorrelation in this research model. If DW equals 2, there is no autocorrelation (Nkoro & Uko, 2016).

Table 4.13 Breusch – Godfrey Serial Correlation LM Test

F. Statistics	0.9783	0.3888
Obs* R-squared	2.3651	0.3065

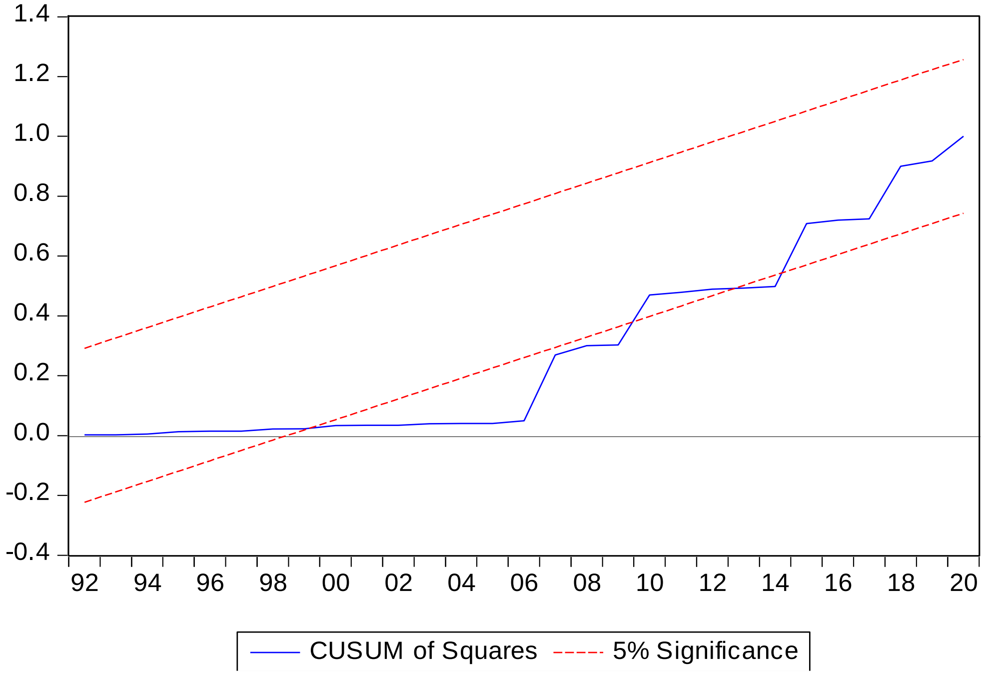
LM test is used to determine whether a model has serial correlation or auto-correlation. The null hypothesis of LM test states that there is no autocorrelation. Because the probability value is more than 5%, the results of the LM test accept the null hypothesis at a level of significance of 5%. (Alharthi& Hanif, 2020).

Figure 4.14 Cusum Test



In Cusum test our model is dynamically stable at level of 5%

Figure 4.15 Cusum Squared Test



During this period from 2014 Pakistan is facing serious energy crises. Pakistan's biggest problem is recognized as the energy crisis due to terrorism and no economic activities of governance that's why unemployment increase and these structural brakes down occur. The global energy crisis is obviously a problem that affects all nations, but the situation in Pakistan is diverse. If the energy problem is not adequately managed, it will have a negative influence on the nation's citizens, societies, and economy. Similarly, it will make things worse and put the lives of regular people in danger. Thus, corrective measures must be put in place to address the impending energy problem; else, the nation would be doomed to perpetual darkness (Bhutta & Suleman, 2016). So, grieving about spilt milk isn't going to be necessary. Every issue has several root causes. Like that, Pakistan is facing an energy crisis, which has a wide range of causes and consequences.

The inadequate measures of the prior administration to address the energy problem are one of the main causes of the catastrophe. Daily energy consumption growth is accelerating, but production has stayed flat (Aftab, 2014). The government must address these problems immediately, yet it appears that energy production is not a top priority. In the end, Pakistan's energy dilemma is a result of this ignorance and failed policies. Lack of political agreement to construct additional dams and storage tanks is another factor contributing to the oncoming energy crisis. Since the 1960s, Pakistan has not constructed a single water reservoir, and the division among lawmakers and legislators over the building of new dams is increasing and worsening the problem. The lawmakers are deeply opposed, and they forbid the building of new dams. The Kalabagh Dam serves as the best illustration in this connection. They claim that till they are living; this dam cannot be built. Yet if this dam is built, it will protect against flood events as well as ease the energy issue (Arshad & Muhammad Shamshad, 2022).

4.6 Impact of Energy Governance on Gross domestic product

In this model gross domestic product is the dependent variable instead of energy governance, official exchange rate and total labor force are independent variables.

Table 4.16 Bounds Testing Results

Test statistics	**Value**	**K**
F- Statistics	7.20	3
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

The results demonstrate that the calculated F statistics is 7.20, which is higher than the lower critical bound value and upper critical value, which are, at a 1% significance level, 4.29 and 5.61 respectively. As a result, the null hypothesis of no cointegration is rejected, suggesting that there are long-term cointegration links between the variables (Hedi et al., 2013). In the current investigation, the variables' proper lag order was determined by the Akaike information criterion (AIC). To calculate the ARDL (F-statistic), which determines whether cointegration exists, it is helpful to choose the variables' lag lengths properly. The test's findings show that the model's variables still have a long-term link.

Table 4.17 Long Run Results

Variable	Coefficient	Std. error	t. statistics	Prob
EG	0.03**	0.01	2.56	0.02
ER	0.0021	0.0023	0.92	0.36
LF	2.62**	0.77	3.36	0.01
C	-9.15	5.86	-1.55	0.13

** shows 5% level of significance

This model also consists of three explanatory variables. The dependent variable of the model is gross domestic product. The determinants of gross domestic product are energy governance, exchange rate and total labor force. The estimated variable is energy governance which has a positive impact on gross domestic product and is statistically significant at the level of 5%. When energy governance is better and positive it increases the output level of the gross domestic product of the country. The empirical studies by (Abanda et al., 2012; Zubair et al., 2020; Liu, 2020) found the positive relationship between energy governance and GDP. The second estimated variable of this model is the exchange rate which is positive and statistically insignificant. When the exchange rate has a positive impact on the economy it also increases the economic growth of the country. The empirical studies by (Omankhanlen, 2011) (Sharifi-Renani & Mirfatah, 2012) found positive relationship between exchange rate and gross domestic product. The last variable of the model is labor force which is positive and statistically significant at the level of 5%. Positive sign of the coefficient of labor force shows that skilled labor force also increases the gross domestic product of the country. The empirical studies by (Pampel & Tanaka, 1986 ; Mohey-ud-din, 2007 ; Hashim et al., 2019) found positive relationship between labor force and gross domestic product. The findings revels that there is strong impact of energy governance and labor force in long term in case of Pakistan (Alharthi & Hanif, 2020).

Table; 4.18 Short Run Results

Variable	Coefficient	Std. error	t. statistics	Prob
D(EG)	0.0044	0.0051	0.86	0.40
D(ER)	-0.0045***	0.0024	-1.84	0.08
D (TLF)	0.63	0.58	1.08	0.29
CointEq (1)	-0.56***	0.29	-1.93	0.07
R^2	0.99	**Adjusted R^2**	0.98	
Akaike Info	-3.45	**DW statistic**	1.93	

*** shows 10% level of significance

The long run and short run coefficient are almost the same instead of exchange rate which is negative it shows negative impact on GDP in short run. When energy losses decrease it also increase the economic growth and increase the exchange rate in case of short run. Exchange rate is negative in short run but statistically significant. The negative relationship in the short run shows the impact if the exchange rate decreases at the 10% level it also affects the gross domestic product of the country. The empirical studies which shows the negative relationship between the exchange rate and gross domestic product are (Danmola, 2013) (Nyangarika et al., 2018). The labor force is positive and statistically insignificant in the short run if one percent change in labor force it also changes the dependent variable. Error correction term is 56% and significant at level of 10% it tells us speed of adjustment in 4.5 year after covering this period it converged to equilibrium. Durbin – Watson value shows that the above model has not the problem of serial correlation. The model is well-fitted, as seen by the values of R^2 and adjusted R^2. A greater r-squared often denotes a better model fit.

Table 4.19 Breusch – Godfrey Serial Correlation LM Test

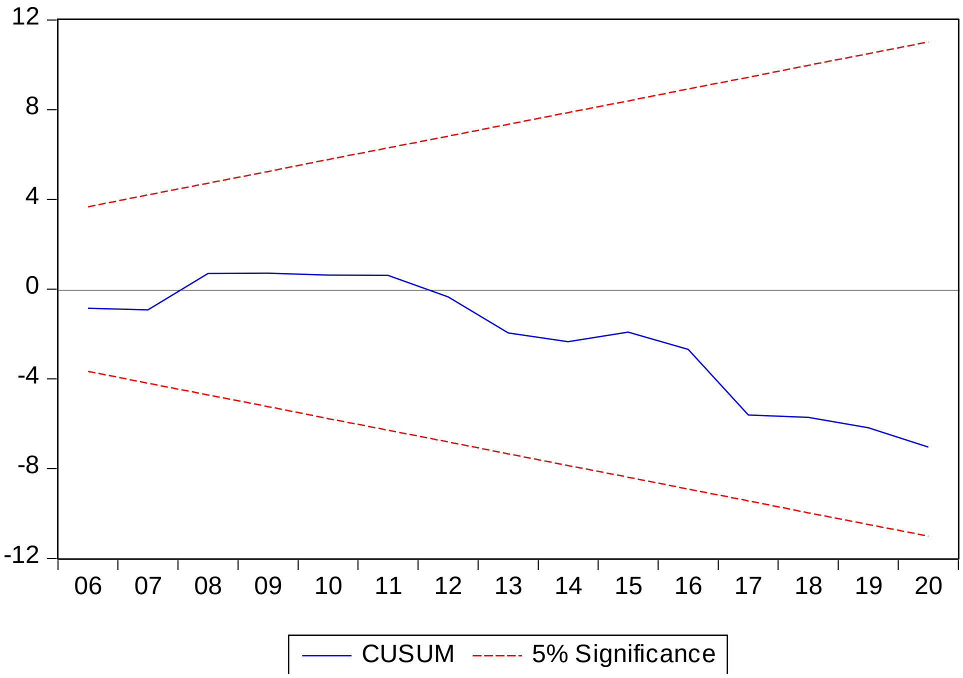
F. Statistics	2.7979	0.0976

Obs* R-squared	9.6294	0.0812

The LM test is used to determine whether a model has serial correlation or auto-correction. There is no serial correlation. Because the probability value is more than 5%, the results of the LM test accept the null hypothesis (Shahbaz et al., 2011).

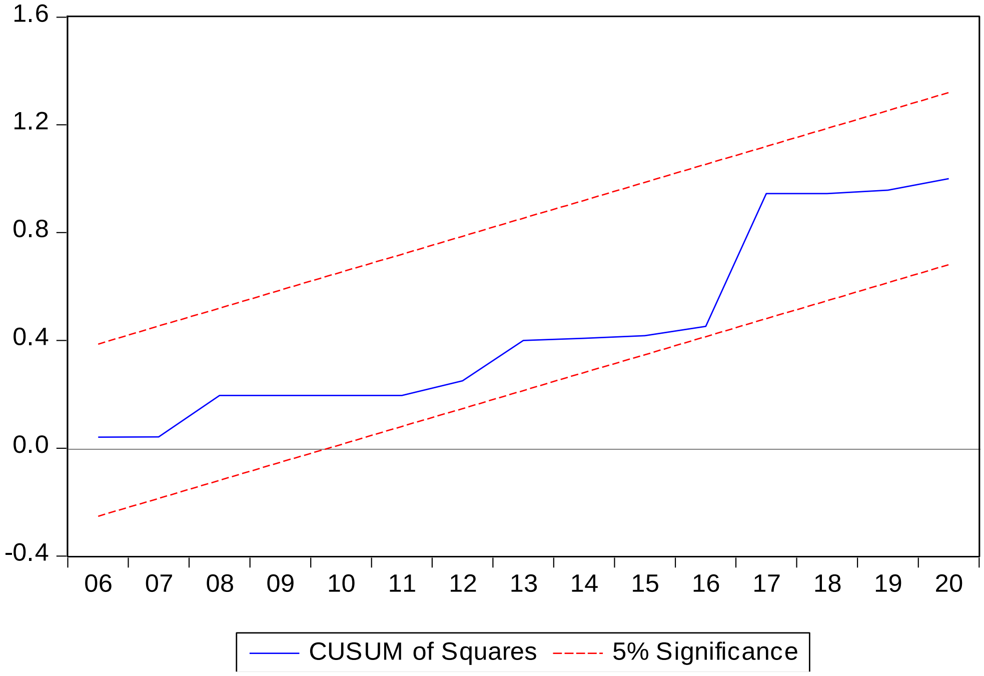
Figure 4.20 Cusum Test

Both models have typically passed all diagnostic tests, according to the findings of the stability and diagnostic tests, and there is no indication of autocorrelation. The error terms are clearly marked. The error correction model's coefficients are stable, as demonstrated by the CUSUM and CUSUM square stability tests.



The Cusum test states that our model is dynamically stable at level of 5%.

Figure 4.21 Cusum Squared Test



Cusum of the square is also stable at 5% level of significance.

Discussion

In this chapter discuss the first step is to explain the descriptive statistic. The next step is to apply the unit root test, ADF and PP. The last step is to apply the ARDL approach on three models of the study to test the long run short run impact and all diagnostic checking apply in appropriate manner to measure the long run relationship between the dependent and independent variables.

CHAPTER 5

Conclusion and Policy Recommendations

5.1 Conclusion

The primary goal of this study is to investigate the impact of energy governance on selected macroeconomic indicators of Pakistan. Being a developing country, we are facing many energy losses but energy governance can boost newely emerging losses like oil, gas and electricity transmission and distribution losses. Energy governance is not a clear indicator, there are many measurement issues. The dimensions oil, gas and electricity energy losses need to be focused more for achiving the better performance of selected macroeconomic indicators. As energy losses is an important phenomenon. Economist has been trying hard to find out the factors of energy governance. Here in this research energy governance is used as a proxy of energy losses. First of all, we construct an index of energy governance on the basis of major dimensions i.e. oil, gas and electricity transmission and distribution losses as energy losses.

These dimensions are further divided into different macroeconomic variables that show the performance of its dimension. The long run integration coefficients of energy governance index that three selected macroeconomic indicator (external debt, unemployment and GDP) are playing vital role on energy losses. Pakistan has comparative advantage in energy governance over other regional nations. If energy losses controls properly to extract maximum benefits from it to make better performance on selected three macroeconomic indicators. Although, energy governance is an underutilized concept and there are grave issues in data availability plus some proper policy making to use it effectively.

Secondaly, the research uses Auto Regressive Distributed Lag (ARDL) technique to analyze the impact of EG on three selected macroeconomic indicators (external debt, unemployment and GDP) of Pakistan. To check stationarity of the variables, unit root test is applied at level and 1st difference. Two variables are stationary EG and inflation at level. While GDP per capita, exchange rate, external debt, total labor force, unemployment, GDP, and GFCF are stationary at 1st difference. ARDL technique includes bound testing that actually, confirm the long run relationship between dependent variable. Short run coefficients also measured. Further, stability diagnostic test , LM serial correlation test apply in all three models of the study. The calculated value of LM test is 2.36 and critical value is 0.97. Calculated value is grater than critical value its means there is no problem of serial correlation exists in our model. The results of Cusum test is dynamically stable at 5% level. But, in the first model which is the impact of EG on external debt of Pakistan the results of cusum square many structural brakes down in different years and Pakistan economy face serious energy crises electricity and gas shortages. But in second model that is the impact of energy governance on unemployment the results of cusum square from 2009 to 2011 Pakistan face energy crises these energy crises occurs due to the terrorism and no economic activity then many economic sectors, general development daily livings significantly impacted (Bhutta & Suleman, 2016). Lastly the results of cusum of square test in the third model that is the impact of EG on GDP on Pakistan, dynamically stable at level of 5%.

The present study estimates the impact of energy governance on three macroeconomic indicators. If improve in energy governance means decrease the energy losses it also decreases the external debt, unemployment and increase the economic growth in case of Pakistan. The real problem of Pakistan economy in present time is external debt. Basically, external debt causes the default of the economy while on the other hand local debt not creates the default.To our best knowledge, no empirical attempt has been taken that measure it and critically estimate. Although some studies have attempted to analyze other governance from this perspective.

The dependent variable of this model is ED while (EG, ER, GFCF, GDP per capita) are independent variables. The findings of the Pakistan study indicated that the computed F statistics of 9.73 is higher than the lower critical bound value and upper critical value, which were 3.74 and 5.06, respectively, at the 1% significant level (Grin Linton, 2017). As a result, the null hypothesis that there is no cointegration is rejected, suggesting that the variables have long-term cointegration associations. In the instance of Pakistan, the calculated F-statistics were 9.73. The table shows that the F-statistic is more significant than the upper bond value at both the 1% and 2.5% levels of significance (Ur Rehman et al., 2018). The short run results are ED has negative impact on EG and significant. ED has negative but insignificant on exchange rate and GDP per capita while GFCF has positive but insignificant (Qamruzzaman & Jianguo, 2018). In the long run ED has negative impact on EG and GDP per capita but significant, while ER and GFCF has positive impact and significant. The researchers employed the traditional neoclassical production function's growth accounting paradigm (Worthington, 2005).

This is the second model to find the impact of energy governance on unemployment. The dependent variable of this model is unemployment, while (EG, GDP per capita, INF) are independent variables. The findings of the Pakistan study indicated that the computed F statistics of 6.25 was higher than the lower critical bound value and upper critical value, which were 2.72 and 3.77, respectively, at the 5% significant level. As a result, the null hypothesis that there is no cointegration is rejected, suggesting that the variables have long-term cointegration associations. The calculated F-statistics were 6.25. The table shows that the F-statistic is more significant than the upper bond value at the 5% levels of significance. The variables' appropriate lag order has been determined through AIC (Asghar & Abid, 2007). In short run unemployment has negative impact on EG while GDP and inflation has positive impact on unemployment (Durguti et al., 2021). When EG (energy losses) improves unemployment decrease, it is inverse relation. In long run unemployment has negative impact on EG, GDP per capita has also negative impact, but inflation has positive impact on long run (K. Zaman et al., 2011).

The third model of the present study is to measure the impact of energy governance on gross domestic product. The dependent variable of this model is GDP and (EG, ER, LF) are independent variables. The results demonstrate that the calculated F statistics is 7.20, which is higher than the lower critical bound and upper critical value which is 5%. So, we reject null hypothesis and accept alternative hypothesis (Hedi et al., 2013). After verification of long run relationship between gross domestic product and served as independent variables energy governance, exchange rate and labor force, we calculated both the long and short run form of the ARDL model. In the short run GDP has a positive impact on energy governance, while exchange rate has negative impact, but inflation has positive impact on GDP. In long run GDP has positive impact on (EG, ER, LF) (Ali et al., 2015).

5.2 Policy Recommendations

Findings of present study confirms that energy governance determines the macroeconomic indicators of Pakistan economy. Pakistan economy to perform to its potential level, the energy sectors requires significant development. The following are some actions are suggested to improve the quality of macoeconomy of Pakistan.

- Implement and strengthen policies to ensure efficient energy governance. This includes investing in energy infrastructure, and streamlining regulatory frameworks that lower the energy losses.
- Authorities should focus on control the energy losses when theses energy losses control it creates job at national level.
- Energy governance (energy losses) have a positive impact on reducing the external debt. The government of Pakistan should adopt the policies to enhance transparency, efficiency, and sustainability in the energy sector as it lowers the external debt.

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