UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

The interplay of energy access and labor market outcomes in South Africa.

A research report submitted in partial fulfillment of the requirements for the degree of

Master of Commerce (Economics, CCA01)

in the School of Economics and Finance,

University of the Witwatersrand

By

Nomathamsanqa Moyo

Student number: 2253598

Supervised by

Dr. Morakinyo Adetutu

Date: 07/01/25

Declaration:

I, Nomathamsanqa Moyo¸ declare that this research report titled “The interplay of energy access and labor market outcomes in South Africa” is my original work and has never been submitted for a degree or any other academic qualification to any university or institution.

Contents Table

ABSTRACT:

This study investigates the relationship between energy access and employment opportunities in South Africa using the Autoregressive Distributed Lag (ARDL) model, analyzing macroeconomic data spanning 1990 to 2022. Unlike previous research focused on rural areas, this study adopts a macro-level approach, encompassing both urban and rural regions. The findings reveal a positive short- and long-run association between energy access and employment, indicating that increased electricity access correlates with higher employment levels. Inflation negatively affects employment, while foreign direct investment (FDI) and gross domestic product (GDP) have positive associations. Trade is significant in the short run but becomes insignificant in the long run. These results highlight key policy implications: expanding access to electricity, particularly in underserved areas, and investing in renewable energy infrastructure can enhance employment opportunities. Attracting FDI through improved infrastructure and incentives, implementing sound monetary policies to control inflation, and supporting economic growth through small and medium enterprises and innovation are critical for sustaining employment. Additionally, addressing South Africa's high dependence on imports and promoting export-oriented industries can amplify the long-term benefits of trade on employment, emphasizing the need for targeted, structural policy interventions.

KEYWORDS: Employment, energy access, ARDL, South Africa

---

1. INTRODUCTION

In developing communities, electrical energy is essential for stimulating prosperity and economic growth. Access to affordable and reliable electricity is therefore essential in these countries for increasing productivity, boosting competitiveness, and fostering economic growth (Fell, 2017). According to Fell (2017), the benefits of electricity extend across many sectors, providing essential services like cooking, heating, lighting, mechanical power, and telecommunication. An economy's employment dynamics are significantly influenced by the accessibility of electrical power. Industries with a high reliance on electrical energy, like agriculture and manufacturing, observe a significant rise in production when they have access to a reliable supply of power (Wang et al., 2018). This is because the role of electricity within these sectors extends beyond energy intensity but also involves a fundamental transformation in the way various processes and technologies are employed. For instance, in agriculture, electricity powers irrigation systems, mechanized equipment, and cold storage facilities (Bardi et al., 2013), resulting in increased crop productivity, reduced post-harvest losses, and improved food preservation. Similarly, Adeolu & Abiodun (2020) highlight electricity as the driving force behind assembly lines, automated machinery, and precise processes in the manufacturing sector. Integrating electricity into these industries not only amplifies energy intensity but also revolutionizes operational dynamics, enhancing efficiency and productivity. Increased productivity frequently leads businesses to grow to keep up with the growing demand for their products and services, which may potentially result in the creation of jobs.

Nonetheless, it's vital to recognize that the expansion of energy access, driven by a range of energy sources, naturally leads to the introduction of new technologies and machinery reliant on electricity (Jin et al., 2018). This dynamic connection between energy access and the adoption of technology emerges from a fundamental interaction: improved access to electricity fuels the adoption of advanced technologies that depend on a reliable energy supply. Empirical investigations have indicated that increased energy access frequently results in social gains, including an upsurge in demand for electrical appliances, machinery, and equipment across residential and industrial domains (Lipscomb et al., 2013; Mottaleb et al., 2016; Richmond & Urpelainen, 2019; Poblete-Cazenave & Pachauri, 2021). For instance, the International Renewable Energy Agency (IRENA) reports that regions experiencing enhanced energy access tend to witness a proportional rise in the deployment of energy-intensive devices such as refrigeration units, electric pumps, and industrial machinery (IRENA, 2021). As industries gain access to a more reliable and continuous power supply, they are incentivized to embrace electricity-powered machinery that can amplify production efficiency and output (Wang et al., 2018).

However, this development can result in reduced employment opportunities in specific sectors. A study on automation by Graetz (2015) highlights that as businesses embrace electric machinery and equipment, their reliance on human labor for operation and maintenance may fall, potentially leading to an overall decline in employment levels. On the other hand, improvements in technology in the energy industry, particularly in renewable energy, open new employment opportunities

(Shirley et al., 2019). Owing to the development of renewable energy technology, such as wind turbines, solar panels, and energy storage systems, there was a need for qualified personnel in positions including installation, production, and maintenance (Ram et al., 2020). These emerging industries in the clean energy sector present new employment prospects, promoting job development and economic diversity. Therefore, it is important to find a balance between the likelihood of job losses in specific industries owing to energy access and the opportunity for new employment.

Poor access to electricity is expected to limit Africa's potential for growth, particularly in the Sub-Saharan Africa (SSA) region (Chirambo, 2018). This is due to the essential role of electricity in facilitating productivity in different sectors of the economy, which is a key factor in promoting economic expansion. As a result, the current inadequate levels of electrification in numerous African nations have been recognized as a barrier to achieving economic growth. The World Energy Outlook report (2017) reveals that 1.1 billion people had no access to electricity in 2015, with over half of them living in the SSA region, specifically in the rural areas. Projections for 2030 demonstrate that while the total amount of people without access to electrical energy is expected to fall due to existing and planned policies, in SSA, this number is projected to rise to over 600 million, accounting for 90% of the world's total, mainly due to the growing population (World Energy Outlook, 2017).

Numerous projects have been started since the 1990s to expand Africa's access to electricity, with support programs focusing on renewable energy, and expanding the energy market in Africa. The Power Sector Reform Program is one such example. This program, designed to enhance energy services across the African continent, encompasses a comprehensive framework of institutional and regulatory reforms within the energy sector. The objective of the Power Sector Reform Program was not solely to augment energy access but also to elevate the financial and technical efficiency of utility services (Chirambo, 2018). To achieve these goals, the reform program laid out a multifaceted set of instruments. Central to its approach was the restructuring of energy utilities, fostering a shift from centralized, state-controlled entities to more decentralized and market-driven models. This restructuring aimed to promote competition, efficiency, and innovation within the energy sector. Additionally, the program emphasized the establishment of robust regulatory frameworks that would ensure fair practices, tariff rationalization, and accountability across all sections of the energy chain. Moreover, the Power Sector Reform Program advocated for the integration of renewable energy sources into the energy mix, recognizing the potential of sustainable sources to not only expand energy access but also mitigate environmental impacts. By delving into institutional enhancements and regulatory adaptations, the Power Sector Reform Program strived to create an environment conducive to private sector participation, technological innovation, and foreign investment in the energy sector (Clark et al, 2005). These intricate measures collectively aimed at fostering energy access, economic growth, and increased efficiency in utility services, illustrating a significant step toward addressing Africa's energy challenges.

Research by Clark et al. (2005) evaluated the effect of the Power Sector Reform Program on Africa's impoverished population. The study highlighted that one of the reasons why one might argue that the measures implemented, such as the Power Sector Reform Program, have yielded only modestly positive outcomes is because of incomplete or partial implementation of reform measures. The study goes on to highlight that often, reforms within complex sectors like the power industry require significant changes to regulatory frameworks, market structures, and operational practices. If certain components of the reforms are not fully executed, the desired impacts may not materialize as expected. However, given that Sub-Saharan Africa's (SSA) electrification rate is still relatively low, one may argue that these measures have only produced modestly good results. Further efforts are needed to address the energy access gap and speed up the electrification of SSA due to the discrepancy in access to electricity and the increased demand for energy-intensive activities for economic development (Jeuland et al., 2021).

Government programs to combat energy poverty and increase access to power in rural regions have helped South Africa's energy access change through time. Targets have been set by the United Nations (UN) to expand energy access internationally through the Sustainable Development Goals (SDGs). One of these goals is to provide all people with access to sustainable and modern energy services by 2030 because it is well-understood that energy access is essential for sustainable development. According to Odhiambo (2023), there was electrification of 7.4 million households between 1994 and 2018 putting South Africa on 84.8% electrification by 2020 and resulting in it being one of the best electrified nations in Africa. The country has, however, experienced disruptions to electricity supply in increasing intensity since 2007 (Mbomvu et al., 2021).

According to (Folly, 2021) these disruptions encompass a range of issues, including inadequate maintenance of aging power infrastructure, insufficient investment in new generation capacity, inefficiencies within the energy distribution network, and an imbalance between the supply of electricity and the growing demand from an expanding population and industrial base. Several Sub-Saharan African nations, like South Africa, are therefore not advancing quickly enough to meet the 2030 target of universal energy access (Chirambo, 2018).

1.1 PROBLEM STATEMENT AND MOTIVATION

The electricity crisis in South Africa is an urgent issue characterized by a structural shortage of power supply. This predicament has major effects on the country, as it frequently leads to load shedding that has detrimental effects on the economy because it affects the amount of electrical energy citizens have access to in a day. A study by Mago & Olajuyin (2022) elaborates that the infrastructure for generating power is getting older and is getting close to needing to be replaced, which raises the possibility of load shedding in the future. The construction of new power stations, including Medupi and Kusile, has encountered various obstacles such as inadequate managerial skills, poor site management, and poor monitoring and control (Tshidavhu & Khatleli, 2020), resulting in cost overruns and delays.

As stated by Kock & Govender (2021), load shedding has become a challenge in South Africa ever since Eskom, the country's sole power provider, neglected to maintain several significant power plants in 2007. After 16 years, the deteriorating coal plants are no longer able to provide the rising demand brought on by population expansion. Small enterprises, which typically lack the funding to buy and maintain generators and inverters, are disproportionately impacted by this circumstance. Due to their inability to continue operating without a steady supply of power, several store owners were compelled to close (Kock & Govender, 2021). The energy crisis has serious economic repercussions and is not just an inconvenience. It interferes with corporate growth, stifles investor confidence, and interrupts manufacturing, all of which immediately results in job losses (Ateba et al., 2019). More jobs are therefore at risk as power disruptions persist.

For economic expansion and the generation of jobs in South Africa, access to modern energy sources like electricity is crucial. Lack of energy availability has a negative effect on the labor market, leading to decreased productivity. The insufficient availability of electricity significantly hampers various industries, exerting adverse effects on their productivity and operational capabilities. Industries heavily reliant on electrical energy, such as manufacturing and agriculture, experience notable setbacks. In manufacturing, the lack of energy access disrupts production lines and hampers the operation of machinery, leading to delays and reduced output (Ou et al, 2016). Similarly, in agriculture, the absence of energy resources affects irrigation systems, mechanized farming equipment, and storage facilities, all of which are essential for efficient crop cultivation and distribution (Walsh et al., 2021). Moreover, service industries that require consistent electricity supply, such as telecommunications, experience interruptions that hinder seamless communication and service provision. Commercial establishments, including hotels and restaurants, also face challenges in maintaining the quality of their offerings due to energy constraints affecting heating, cooling, and cooking equipment.

However, despite the distinctive social, economic, and environmental challenges faced by South Africa, there is lack of substantial information regarding how the availability of electrical energy affects employment outcomes in the nation. The link between electricity access and employment in South Africa remains largely unexplored, highlighting the need to gain insights into how variations in electrical energy access contribute to either job losses or job creation. Due to the current load-shedding crisis faced by South Africa, this study specifically focuses on electrical energy in an attempt to close this gap by examining the impact of electrical energy access on employment rates in the country. The research seeks to not only bridge this knowledge gap but also provide actionable policy recommendations to foster sustained economic expansion and job opportunities in South Africa.

The current research therefore seeks to answer the questions below:

1. Does a significant relationship exist between access to electrical energy and employment levels in South Africa?
2. What is the nature of the relationship between access to electricity and employment levels in South Africa (positive or negative)?
3. Does a causal relationship between electrical energy access and employment levels in South Africa exist? Can it be established that improved electricity access leads to higher employment rates or vice versa?

1.2 OBJECTIVE AND HYPOTHESIS

The primary objective of this paper is to examine the relationship between access to electricity and employment in South Africa. Specifically, the research will:

1. Analyze the existence and nature of the relationship between access to electricity and employment in South Africa
2. Investigate whether there is a causal relationship between electricity access and employment.
3. Determine the short-term and long-term effects of increased electricity access on employment levels.

In line with the research questions, this study posits three key hypotheses. The first hypothesis suggests that a significant relationship exists between access to electricity and employment levels in South Africa. This implies that changes in electricity access may have a significant impact on employment rates. The second hypothesis extends this by asserting that the relationship is positive, meaning that greater access to electricity is expected to lead to higher employment rates. Finally, the third hypothesis posits that a causal relationship exists between electricity access and employment. It is anticipated that improved electricity access will lead to increased employment opportunities, with the short-term effects being more pronounced than the long-term ones. These hypotheses will be tested and analyzed to determine the nature and significance of the relationship between electricity access and employment in South Africa.

The study's findings align with this hypothesis, revealing a positive relationship between energy access and employment. Specifically, in the short run, an increase of one percent in the number of individuals in South Africa who have access to electricity is associated with an increase in employment of approximately 118,000 people in South Africa. This figure slightly decreases to 44,000 people in the long run, indicating that a one-percent increase in the population with access to electricity is associated with an employment increase of around 44,000 people in the long run.

The results of this study not only add to the body of knowledge in academia but also have applications for stakeholders and policymakers. The insights gained will inform the development of targeted interventions to expand electricity access in underserved communities and foster an enabling environment for job growth.

The rest of this paper is organized as follows. The literature review is presented in section 2. Section 3 outlines our methodology. In section 4 we discuss the results and findings and section 5 provides a conclusion.

2. LITERATURE REVIEW

2.1 THEORETICAL LITERATURE

The relationship between energy access and employment is complex and diverse, touching upon various theoretical frameworks that provide insights into how access to electricity can influence labor markets. This section reviews the theoretical literature that examines the potential linkages between energy access and employment outcomes, exploring frameworks that focus on the labor market, human capital development, and economic growth. Each theory offers unique perspectives on how energy access can affect labor markets, with varying emphasis on the role of human potential, and economic growth.

The labor market theory examines the interaction between labor supply and demand, rooted in classical and neoclassical economic foundations, and explores how wages, skills, and employment levels are determined (Smith, 1776; Marshall, 1920). Energy access is integral to this framework, as it enables industrial growth and increases labor demand, particularly in energy-intensive sectors like manufacturing and agriculture. This aligns with the current study, which investigates the relationship between electricity access and employment levels in South Africa, where energy shortages hinder economic development (International Energy Agency, 2020). The theory highlights how energy infrastructure fosters job creation, as emphasized by Stiglitz (2002), but it has limitations, including oversimplifications of real-world labor markets and the neglect of external socio-economic factors like policies and global trends (Acemoglu, 2003). While the labor market theory provides a valuable lens to analyze employment implications of energy access, addressing its limitations by incorporating institutional and regional disparities is crucial to understanding South Africa’s unique challenges.

The human capital theory, developed by Becker (1964), provides a foundational framework for understanding the role of energy access in improving labor market outcomes. According to this theory, investments in education, health, and skills development are central to enhancing individual productivity and economic performance. Access to electricity, which facilitates better access to education, healthcare, and information, can enhance human capital by enabling individuals to acquire necessary skills, engage in productive activities, and improve their economic outcomes (Rahman & Alam, 2021). As a result, energy access can lead to greater participation in the labor market and higher employment rates. However, critics of human capital theory, such as Schultz (1961), argue that while education may improve human potential, it is not a remedy for employment challenges. Structural factors, such as labor market conditions and policy support, also play a crucial role in determining employment outcomes, suggesting that factors like energy access alone are insufficient to guarantee increased employment.

Building on this, economic growth theory, particularly the model proposed by Solow (1956), emphasizes the role of capital, labor, and technological progress in driving economic growth. A study by Romer (1990) shows how the economic growth theory provides a comprehensive framework for understanding how energy access can stimulate broader economic development, thus creating employment opportunities. The theory has been widely used to examine the role of infrastructure like energy infrastructure in facilitating economic activities. Energy access, as a key input to economic production, can stimulate growth in sectors such as manufacturing, services, and agriculture, all of which are major sources of employment (Stern, 2011). As a result, access to electricity will enable industries to increase productivity and efficiency, thereby creating demand for labor. This theory suggests that energy access can be a critical driver of economic development and job creation. One key criticism of this theory is that it often overlooks the unequal distribution of benefits (Aghion & Howitt, 1992), particularly in developing economies where certain sectors or regions may not experience the same level of energy access, hindering the widespread creation of jobs.

These theoretical frameworks provide valuable insights into the ways in which energy access can influence employment, but they also highlight the complexity of the relationship. Each theory offers a different perspective, from the role of labor markets to the importance of human capital development and the importance of economic growth.

2.2 EMPIRICAL LITERATURE

Building on the theoretical frameworks discussed, which explore the relationships between electricity access, economic development, and labor market dynamics, this literature review delves into empirical findings across various contexts to uncover how renewable energy adoption, rural electrification, and broader energy transitions influence employment and economic growth. Access to electrical energy serves as a critical driver of economic progress and has a profound impact on global labor market outcomes. Reliable electricity in commercial and residential areas stimulates economic activity, making initiatives aimed at improving access to electricity a high priority for governments. These initiatives often include expanding electricity infrastructure, promoting renewable energy sources like wind, hydropower, and solar, providing clean cooking technologies, and implementing energy efficiency measures (Ram et al., 2020).

In exploring these dynamics, this review examines themes such as the impact of renewable energy on job creation, the effect of rural electrification programs on employment creation, and the sector and country specific implications of energy access. By consolidating existing research on the correlation between electrical energy access and employment, the review emphasizes the importance of understanding how access to electricity influences employment rates. Through a comprehensive analysis of various studies, it aims to bridge theoretical understandings with practical outcomes, highlighting common themes, trends, and disparities in the evolving relationship between electricity access and labor market dynamics.

As part of the Just Energy Transition, many countries have embraced the adoption of sustainable and renewable energy sources such as solar and wind power. This transition is motivated by the objective of reducing carbon emissions, which contribute to global warming and changes in climate(Chirambo, 2018). Alongside the environmental benefits, researchers including Blanco & Rodrigues (2009), Shirley et al. (2019), Ram et al. (2020), and Kusi-Appiah and Essandoh (2023) have investigated the effects of electricity access through renewable sources on employment outcomes. These studies focus on investigating how increasing access to electricity through renewable energy sources can affect job creation and the overall dynamics of the labor market. According to the 2021 annual review report by the International Labor Organization (ILO) conducted in partnership with the IRENA, the renewable energy sector witnessed significant employment growth. The report reveals that the sector generated 12 million jobs around the world in 2020, surpassing the 11.5 million jobs created in 2019. This exploration of the correlation between renewable energy and employment sheds light on the broader socioeconomic consequences of transitioning to sustainable sources of energy.

Cantore et al. (2017) introduce a methodology that provides evidence for the positive influence of renewable energy and the efficiency of energy on job creation in Africa. The study indicates that transitioning to low-carbon power generation can result in additional employment opportunities. However, it acknowledges a trade-off in the form of increased costs of generating electricity associated with adopting renewable energy technologies. To apply this methodology to Africa, the authors expand upon an approach initially developed for the United States, aiming to estimate employment generated through generating electricity. The adaptation of the approach initially developed for the United States to apply to Africa raises concerns about the generalizability of the findings. Africa is a diverse continent with varying energy landscapes, socio-economic conditions, and policy contexts. Failing to account for these regional differences may limit the applicability of the results and lead to potential inaccuracies in the estimated job creation potential. Overall, this research by Cantore et al (2017) enhances our comprehension of the potential advantages associated with transitioning to cleaner and more sustainable energy systems. It emphasizes the broader implications of an environmentally friendly economy. Additionally, the study proposes that if renewable energy competes with fossil fuels while energy-efficient technologies become more affordable, it can lead to positive impacts on economic, social, and environmental sustainability.

Kusi-Appiah and Essandoh (2023) conducted a study investigating the effect of the just energy transition on employment, with a focus on Ghana's electricity sector. The study confirmed that the introduction of renewables has led to a rise in employment rates and has facilitated the creation of new jobs within the electricity sector. However, it also found the correlation between Ghana’s energy transition from 2011 to 2021 and job losses in the sector to be unclear. The article's conclusion states that the recently implemented National Energy Transition (NET) framework will actively support renewable energy sources in the energy industry. Nevertheless, it also reveals that for the foreseeable future, jobs in Ghana's energy industry will continue to be dominated by fossil fuels. The study is informative, but it has some limitations that should be considered. The study is mostly qualitative and lacks a clear description of the research methodology. There is therefore uncertainty about how the data was collected, how the study was designed, and what specific variables and procedures were followed to analyze the data. The absence of a well-defined methodology raises concerns about the reliability and validity of the findings.

Electricity access through initiatives like rural electrification is expected to exert significant influences on labor market outcomes, facilitated by three potential channels suggested by Rathi and Vermaark (2018). Firstly, providing households with electricity reduces the effort and time spent collecting and preparing fuel (Dinkelman, 2011), resulting in enhanced productivity in household tasks due to advanced technology. This, in turn, leads to increased labor supply and higher participation in market-oriented work (Dinkelman, 2011; Sadanand and Grogan, 2013). Secondly, access to electricity makes it possible to generate revenue inside of homes and opens doors to new employment outside of the domestic setting. This potential surge in self-employment and labor demand can prove advantageous for individuals (Chowdhury, 2009; Walle et al., 2015). Lastly, electrification could drive the transition of activities away from agriculture, often linked with elevated productivity and income levels (Torero, 2015). This shift is particularly pertinent in countries like India, where the rural economy is predominantly agricultural (Walle et al., 2015).

Dinkelman (2011) conducted a study exploring the impact of energy access, particularly household electrification in South Africa, on outcomes in the labor market. The study delved into three possible channels through which energy access could impact labor market results. To investigate these channels, the study utilized two empirical approaches. The first approach estimated employment growth rates at the community level for areas with and without electrification projects, using instrumental variables to tackle endogeneity issues. The second strategy employed individual-level data from household surveys to examine aspects like employment, work hours, wages, demographics, and earnings. The findings highlighted that electrification had a substantial impact on women's employment. The study revealed that electrification led to a rise in work hours for both women and men but with a reduction in female wages and an increase in male earnings. One limitation of this study is that it focuses on rural communities in KwaZulu-Natal (KZN), a subset of the South African population residing in rural areas. While this allowed for a targeted and specific analysis, it also raised questions about the applicability of the findings to other regions in South Africa with different socio-economic and demographic characteristics. Furthermore, by focusing solely on the rural context, the study might have missed potential differences that electrification has on labor market outcomes between rural and urban areas. Urban environments often have different labor market structures and opportunities, and electrification effects may vary accordingly. Due to the restriction of the sample to specific regions and community sizes, the study's ability to draw broad conclusions about the overall impact of electrification on South Africa’s labor market outcomes may be limited. It would be beneficial to consider a more diverse and representative sample to better understand the broader impact of electricity access on employment in different contexts.

Rathi & Vermaak's (2018) cross-country study aimed to explore the connection between labor market outcomes and electrification for rural populations in South Africa and India. The study used households as a unit of analysis and focused on three essential markers of labor market success: earnings, work hours, and employment. Employing both panel fixed effects estimation and propensity score matching, the study ensured robust findings. The results revealed that access to electrical energy positively impacted the yearly incomes of people engaged in paid employment, regardless of gender, in both South Africa and India. Interestingly, in India, access to electricity led to reduced work hours for both genders, signaling heightened productivity. However, in South Africa, with a less absorbent labor market, electrification did not significantly impact employment. While the aggregate effect on employment was negative for India and positive for South Africa, statistical significance was inconsistent for either country. One limitation is the uneven sample sizes between India and South Africa, which might affect statistical significance, particularly when assessing employment effects. Overall, despite these limitations, the use of two identification strategies enhanced the credibility and robustness of the findings, enabling cross-validation and addressing potential biases.

A paper by Rahman et al. (2022) reviewed electricity access’ impact on employment in three core sectors of the economy which are industry, agriculture, and service. The qualitative review explores the energy-employment relationship, investigating the impact of electrification in urban and rural Bangladesh on sectoral employment trends over 30 years spanning from 1991 to 2018. The findings indicate that rural areas progressed more swiftly in terms of electricity access compared to urban areas, resulting in increased overall access and a reduction in urban-rural disparities over time. Surprisingly, throughout the same period, the percentage of women working in agriculture fell by one-third. The study also unveiled an unexpected trend where agricultural employment increased alongside an increase in electricity access. Although employment in the service sector had a small drop from 1991 to 1997, employment in industry and services continued to rise steadily during this time. Although this review provides insightful information about the connection between electricity access and employment in Bangladesh, it has certain limitations. Their study does not establish a clear causal link between electricity access and employment changes. Other factors, such as economic policy changes, technological advancements, or demographic shifts, could potentially influence employment levels. Additionally, the review mainly relies on qualitative observations and lacks rigorous quantitative analysis. A more robust quantitative approach, such as econometric modeling or time-series analysis, could provide stronger evidence to support the claimed associations.

Tagliapietra et al. (2020) conducted a thorough investigation of the influence of electricity access on outcomes in the labor market of Nigeria from 2011 to 2015. Employing probit/bi-probit modeling and propensity score matching, the research illuminated the influence of electricity access on specific outcomes in the labor market. The study considered both male and female employment, non-agricultural and agricultural employment, and rural and urban households separately. An important consideration within the study revolves around the issue of endogeneity. The root of endogeneity arises from the potential mutual influence between households' access to electricity and various underlying factors. These factors encompass elements such as the non-random allocation of electrification programs, the selection process for villages to receive grid extensions, unobservable household characteristics that might be correlated with both decisions regarding electricity connection and employment status, as well as other regional characteristics like distance to power plants, roads, or markets. The outcomes highlighted that, after accounting for potential endogeneity concerns, electricity access positively and significantly influenced the proportion of employed household members, leading to a transition from agricultural to non-agricultural work. The effect was more pronounced in rural areas and for male-headed households compared to their urban and female-headed counterparts. This consistent shift from agricultural to non-agricultural employment of around 7% underlines how extending electricity access to unconnected households could play a substantial role in strengthening labor market participation and facilitating Nigeria's economic transformation away from agriculture. While efforts were made to address endogeneity, unobserved variables could still impact both electricity access and labor market results, potentially leading to biased outcomes. The study's focus on a specific timeframe and limited dataset also restricts the generalizability and currency of the findings. Expanding the scope and utilizing more recent data would enhance the findings' relevance and reliability.

Ubah et al.'s (2021) study delved into the employment and electricity access relationship in Nigeria, alongside the effects of technology on the Nigerian labor market. By utilizing the ARDL Bounds test approach, the researchers examined the combined influence of technological demand and electricity access on employment. The study also accounted for other independent variables like population growth and foreign direct investment (FDI) to holistically analyze their impact on employment. To establish the enduring connection between electricity access and employment in Nigeria, the study employed the ARDL Bounds technique proposed by Pesaran et al. (2001). The results revealed a direct and significant link between electricity access and employment, highlighting the necessity for effective government policies to enhance electricity supply and reduce unemployment. The study also revealed that technology has a negative impact on employment in the long run, suggesting potential job displacement effects and underscoring the importance of promoting skills that cannot be easily substituted by technology. Overall, these findings offer valuable insights for policymakers to address employment challenges and formulate strategies for the future labor market in Nigeria, highlighting the crucial role of access to electricity as a significant driver of employment growth.

The proposed study stands as a focused response to the challenge presented by the limited scope of previous research, which often confined itself to specific regions and community sizes within South Africa (Dinkelman 2011; Rathi & Vermaak 2018). By taking a macro-level approach and employing comprehensive macro data that encapsulates both urban and rural areas, the study seeks to transcend these limitations. The intent is to provide a more encompassing perspective on the relationship between electricity access and employment in South Africa. Through this analytical lens, I aim to deliver insights that can better address the broader implications of electricity access on employment outcomes in South Africa, thus offering a comprehensive understanding of the factors at play within the nation's labor market.

To establish a more robust understanding backed by evidence, the study will employ econometric techniques like the Autoregressive Distributed Lag (ARDL) model. Unlike previous studies primarily focusing on rural areas, this research will encompass both urban and rural regions, providing a holistic view of electricity access across the country. Moreover, the incorporation of control variables will enable a more precise estimation of the effect of electrical energy access on employment by controlling for other factors that could influence the relationship.

3. METHODOLOGY

3.1 THEORETICAL LABOR MODEL

A well-constructed theoretical model is fundamental to comprehending the complexities of labor market dynamics and unemployment. It establishes a conceptual foundation for the empirical analysis, offering a systematic framework to investigate the interactions among key economic factors that shape employment outcomes. This section adopts a linear functional form to articulate a labor dynamic model, effectively capturing the evolution and interplay of variables while deferring their explicit introduction to the empirical analysis.

Labor dynamics describe the relationship between the supply of and demand for labor, which determines employment and unemployment levels in an economy. At its core, this framework addresses the equilibrium condition where labor supply (L_S) equals labor demand (L_D):

$$L_S = L_D \qquad (1)$$

Here, L_S represents the total number of individuals willing and able to work at prevailing wage levels, capturing the availability of labor in the economy (Keynes, 1936). Meanwhile, L_D reflects the number of jobs offered by employers, driven by factors such as economic activity, business profitability, and labor productivity (Blanchard & Katz, 1999).

When these two forces are not in balance, unemployment (U) arises. Unemployment occurs when the number of individuals seeking work exceeds the number of available jobs $(L_s > L_D)$:

$$U = L_s - L_D \qquad (2)$$

According to Todaro & Smith (2015), this imbalance highlights the centrality of labor demand in determining employment outcomes, as it often reacts to broader economic conditions and structural shifts in the economy.

The employment rate (E) is a critical measure in labor dynamics, reflecting the proportion of the labor force that is actively employed. It is influenced by factors affecting both L_S and L_D, which evolve over time in response to macroeconomic conditions.

The employment rate is therefore modeled as a function of labor demand determinants:

$$E_t = f\left(X_{1,t}, X_{2t}, \dots, X_{n,t}\right) \quad (3)$$

Where:

- E_t is the employment rate at time *t*
- $X_{1,t}, X_{2,t}, \dots., X_{n,t}$ are determinants of labor demand at time *t*.

This functional relationship highlights that employment outcomes are not static but rather dynamic, evolving with changes in key economic and structural variables. These determinants (X_t) can include factors such as investment levels, inflation, trade activity, and economic output (Blanchard, 2006).

3.1.1 LINKING LABOR DEMAND TO EMPLOYMENT

Labor demand directly determines employment outcomes, as businesses hire workers to meet the needs of production and service delivery. The relationship can be expressed as:

$$L_{D,t} = g\left(X_{1,t}, X_{2,t}, \dots., X_{n,t}\right) \quad (4)$$

Substituting this into the equilibrium condition $(L_S = L_D)$, the employment rate (E_t) is linked to the determinants of labor demand:

$$E_t = h\left(X_{1,t}, X_{2,t}, \dots., X_{n,t}\right) \quad (5)$$

This expression formalizes how changes in labor demand determinants translate into variations in employment levels, providing a theoretical foundation for empirical analysis.

In conclusion, the labor dynamics framework articulates the essential relationship between labor supply, demand, and unemployment, positioning employment as a function of evolving economic determinants. By modeling employment in this way, the framework offers a structured approach to analyze the factors driving changes in labor market outcomes, forming a solid theoretical basis for the subsequent empirical investigation.

3.2 DESCRIPTION OF DATA

As indicated earlier, the main goal of this research is to investigate the intricate link between electrical energy access and employment, with a particular focus on South Africa. This study will focus on macroeconomic level analysis, examining the broader impact of access to electricity on the nation's employment levels. By analyzing national-level data and indicators, we aim to uncover the potential relationships and interactions between the availability of electricity and employment patterns in the country. Although the significance of this relationship has been widely recognized, there is still ongoing debate among scholars and policymakers regarding its precise nature and dynamics. This section aims to provide a comprehensive analysis by outlining the research design and methodology used in the investigation. Furthermore, it will provide an explanation of the data sources, variables, and techniques used to analyze this relationship.

A prior study by Ubah et al. (2021) served as the basis for the model specification used to analyze the relationship between energy access and employment. Nevertheless, in this study, the methodology has been adapted to incorporate additional variables that are pertinent to the current study. We express the model as follows:

$$EMP = f\,(ACC, FDI, INF, GDP, TR) \qquad (6)$$

Where:

EMP = Employment rate

ACC = Access to electricity

FDI = Foreign direct investment

INF = Inflation

GDP = Gross domestic product

TR = Trade

The study will employ yearly data from the International Monetary Fund (IMF) and World Bank databases, covering a thirty-three year span, specifically ranging from 1990 to 2022. The variables used in the study are defined and measured as shown in the table below.

Table 1: Variable definition.

Variable	Variable definition	Measurement
EMP	Number of employed persons	Count, millions of people
ACC	Percentage of the population with electricity access	Percentage
FDI	Foreign direct investment net inflows	Millions of current US Dollars
INF	Inflation rate	Percentage
GDP	GDP at current prices	Millions of current US Dollars
TR	Net trade in goods and services	Millions of current US dollars

3.3 EMPIRICAL MODEL

The linear functional form has long been a cornerstone in econometric modeling, with its origins traced back to early quantitative studies of economic relationships. The development of the Classical Linear Regression Model (CLRM), attributed to pioneers like Carl Friedrich Gauss in the 19th century and later formalized by Andrey Markov in the early 20th century, marked a significant advancement in the field of statistics and econometrics (Larocca, 2005). The CLRM provided a systematic method to estimate relationships between variables, making it an important tool for empirical research.

The linear functional form for this research is expressed as:

$$E_t = \gamma_0 + \gamma_1 X_{1,t} + \gamma_2 X_{2,t} + \cdots . + \gamma_n X_{n,t} + \in_t \quad (7)$$

Where:

- E_t is the employment rate at time t
- γ_0 is a constant term, representing the baseline level of employment when all explanatory variables are zero
- $\gamma_1, \gamma_2, \ldots., \gamma_n$ are coefficients indicating the marginal effects of the explanatory variables. Each coefficient here measures the direct impact of a one-unit change in the corresponding explanatory variable
- $X_{1,t}, X_{2,t}, \ldots., X_{n,t}$ are the explanatory variables
- $\in_t$ is the error term accounting for unobserved factors

This functional form assumes that changes in $X_{i,t}$ have a linear and additive effect on E_t

Based on the linear functional form discussed, the study utilizes the following regression model:

$$EMP_t = \gamma_0 + \gamma_1 ACC_t + \gamma_2 FDI_t + \gamma_3 INF_t + \gamma_4 GDP_t + \gamma_5 TR_t + \in_t \quad (8)$$

As noted in the research by Ubah et al. (2023) and (Aderemi et al., 2022), both empirical and theoretical literature provide evidence for incorporating the variables outlined in equation (8). In this paper, we use the number of people employed to represent employment. This choice stems from the fact that the total number of people employed indicates the working-age population, typically between the ages of 15 and 64, that is actively engaged in the labor force. It gauges the proportion of individuals within this age group who are currently employed, regardless of whether their positions are full-time or part-time (Abraham & Kearney, 2020). Rathi and Vermaark (2018) proposed including employment as one of the key indicators for assessing labor market conditions, as it provides useful insights into the overall health and functionality of the labor market. Given its importance as a frequently used indicator for examining labor market outcomes, the number of people under employment rate was utilized as the dependent variable in this study. Employment can be strongly impacted by the state of the economy and other variables, such as access to electrical energy. Inadequate access to electricity can reduce productivity, disrupt business operations, and restrict job opportunities in certain industries (Mbomvu et al., 2021)

According to Clancy and Kooijman-van Dijk (2010), the independent variable, access to electricity, describes the availability and ability of individuals, households, or communities to obtain and utilize electrical power for different purposes. Access to electricity has an essential role in job creation as it enables the functioning of various industries and businesses by providing power for machinery, equipment, and infrastructure. Manufacturing, construction, and service-related industries all depend significantly on energy, and they all need a steady and dependable power source to function properly. Increased access to electrical energy can lead to the expansion of these industries, resulting in higher employment opportunities. In addition, the expansion of the energy sector itself, particularly the adoption of green energy technology, can generate new employment possibilities in industries like the maintenance, operation, and installation of energy infrastructure (Ram et al., 2020).

Due to the significance of FDI, inflation, Gross Domestic Product (GDP), and trade in understanding labor market outcomes, they are also included as control variables in this analysis to account for any potential impact they may have on the link between access to electricity and employment. By accounting for other variables that might be associated with energy access and employment rates, the inclusion of these control variables allows for a more accurate assessment of the effect of electricity availability on employment.

Jaiblai & Shenai (2019) highlight that Foreign Direct Investment (FDI) represents investments by foreign companies in the local economy, potentially leading to increased output, job creation, and enhanced infrastructure. FDI often targets sectors with comparative advantages in the host country, resulting in increased investments, expansions, and modernization efforts (Danja, 2012). These activities can create employment opportunities and improve labor market outcomes, particularly in sectors attracting FDI. Additionally, countries with higher FDI levels tend to have more developed infrastructure, stronger institutions, and greater access to technology, directly impacting both energy access and employment opportunities. For instance, increased FDI can lead to the development of energy infrastructure, as investing countries gain access to updated equipment and materials necessary for the energy sector's development. This can improve energy access and stimulate job creation in the energy sector.

Including inflation as a control variable helps to control spurious relationships. Failure to account for inflation could lead to spurious results in the analysis, as inflation may be correlated with both energy access and employment. Firstly, high inflation rates can create uncertainty in the economy (Fischer Ball & Cecchetti, 1990; Ball, 1992), affecting business investment decisions and employment trends. According to studies like Thuku et al. (2019) and Angelov (2023), inflation can negatively affect employment by raising production costs, lowering business profitability, and discouraging investment and hiring. Secondly, inflation can significantly influence consumer behavior and purchasing power (Abaidoo, 2016). High inflation rates may lead to a decrease in consumer spending, affecting businesses and potentially resulting in job losses (Carroll, 2003). Thirdly, inflation can impact energy costs, including electricity prices, which directly affect input costs, transportation expenses, and other elements of the supply chain, leading to inflationary pressures (Masoga et al., 2022). Fluctuations in energy costs can affect businesses' operational expenses as Haider et al (2014) highlight that energy price inflation can contribute to both cost-push inflation and demand-pull inflation, influencing hiring decisions. Furthermore, fluctuating energy prices, such as those of electricity, can raise the uncertainty surrounding inflation, which can have an impact on the economy's ability to maintain price stability (Miles & Vijverberg, 2009).

The inclusion of Gross Domestic Product (GDP) was motivated by the importance of production in the labor market, especially in developing countries. GDP is a crucial measure of economic performance in a country and can influence employment outcomes and energy access. As GDP rises, there is a greater need for energy to support economic activities like manufacturing and transportation, leading to increased energy consumption (Parajuli et al., 2019). Moreover, higher GDP is linked to a surge in consumer spending as individuals have more disposable income due to economic growth, further driving economic activity (Zaharia et al., 2019). This increased consumer spending can increase the demand for electrical energy to produce goods and services and power commercial establishments. Investment also tends to rise with higher GDP, as businesses are more likely to invest in new projects and infrastructure to meet growing demand, leading to job creation (Cadoret & Padovano, 2016). Additionally, different sectors contribute differently to GDP, each with unique energy needs and employment patterns. By including GDP as a control variable, the study can account for sectoral variations and their impact on the relationship between energy access and employment.

Trade is a crucial factor to consider as a control variable in the analysis. Changes in trade patterns can cause fluctuations in labor demand across industries and impact employment levels in developing countries (Caliendo et al., 2015). Different sectors have varying degrees of trade intensity. This is seen from Acemoglu et al.'s (2015) study that highlighted that sectors heavily exposed to trade fluctuations, particularly those with high energy consumption, experienced more significant fluctuations in employment levels compared to sectors less trade sensitive. Controlling for trade therefore allows for an examination of whether trade-sensitive sectors, particularly those heavily reliant on energy access, exhibit different employment outcomes compared to sectors less exposed to trade. The demand for energy-intensive goods and services, such as manufacturing or transportation, can be influenced by trade patterns, further justifying its inclusion as a control variable.

3.4 ESTIMATION TECHNIQUE

The bounds test, also known as the ARDL model and developed by Pesaran et al. (2001), is used to evaluate the research hypothesis. This model is a widely used tool in empirical research, offering the capability to analyze both short and long-run relationships among the variables (Pesaran et al., 2001). The ARDL method also demonstrates its versatility by accommodating both small and large sample sizes (Belloumi, 2014). This is particularly advantageous for capturing the dynamic interactions between variables over time. According to Liu (2009), researchers choose it because of its flexibility, robustness, and capacity to offer insights into the short- and long-term effects of variables. Short-run dynamics might reflect immediate responses to changes in energy access, such as the impact of sudden power disruptions on employment patterns within a specific period. On the other hand, long-run effects could emerge due to more sustained changes in access to electricity, leading to shifts in industry structure, business strategies, and workforce composition over time. As stated by Kripfganz & Schneider (2020) The ARDL model accommodates these differences by including lagged variables to capture short-run adjustments and an error correction term to account for long-run equilibrium relationships. Its flexibility in accommodating various lags allows for an accurate representation of the data-generating process (Sulaiman et al., 2019).

The ARDL model has gained popularity in fields such as energy economics due to its advantages when compared to other methods such as the Engle-Granger method (Xing et al., 2018) which requires the integration of variables only up to order one. This model is particularly valuable when dealing with variables of mixed orders of integration (order zero and one) (Armeanu et al., 2022). Moreover, the ARDL model is well-suited for cointegration analysis, which is crucial for understanding the long-term equilibrium relationships between variables (Sebri & Ben-Salha, 2014). It also facilitates the exploration of causal dynamics and relationships among economic and energy-related variables (Jabari et al., 2022). Therefore, the ARDL model's capability to handle cointegration and error correction mechanisms makes it a valuable tool for investigating the dynamics of complex systems involving economic variables (Ahmed et al., 2020).

In this study, we aim to use the ARDL model to capture both the short and long-run effects of the access to electricity and employment relationship. Understanding how variables behave both in the long and short run is crucial for informing policy decisions. Interestingly, many studies (Langnel & Amegavi, 2020; Ahmed et al., 2021; Hurley & Papanikolaou, 2021) do not typically report on the lagged periods of the variables in their ARDL results. Therefore, this study will shed light and provide an interpretation of the lagged values.

It is important to recognize that the ARDL approach, while powerful, has its limitations. Specifically, it may not be suitable for variables with higher orders of integration, such as those integrated of order two or above (Kripfganz & Schneider, 2020). This limitation underscores the significance of variable selection and careful consideration of the data's integration properties when applying the ARDL technique.

3.5 STATIONARITY TESTS

Examining the variables' stationarity features is essential before moving on to the ARDL analysis. The standard assumptions for asymptotic analysis may not hold if stationarity is not satisfied, hence testing for stationarity is important. Additionally, because variables frequently display trending behavior over time, stationarity aids in detecting the presence of spurious regression. According to Brooks (2008), differencing the variables can lead to stationarity. Tests for stationarity such as the Phillips-Perron (PP) test and Augmented Dickey-Fuller (ADF) test, are conducted to find the integration order of the variables.

Both the PP and ADF tests have the same null hypothesis: non-stationarity is assumed to exist if there is a unit root in the series. If there is no unit root, stationarity is implied, which is the alternative hypothesis. Decision-making in the tests involves comparing the p-value associated with the test statistic to a chosen significance level. The null hypothesis is rejected and stationarity is implied if the p-value is less than the desired level of significance (5%). Conversely, the null hypothesis is not rejected if the p-value is above the significance level, indicating non-stationarity.

The PP test goes further by examining the variables' stationarity, whereas the ADF test primarily concentrates on determining the integration order and identifying unit roots. We considered the ADF test's flaw—too many structural breaks—and so employed both tests. Contrarily, the PP test permits error terms with different distributions (Hoffmann, 1987). We confirm the variables are correctly defined and satisfy the ARDL method requirements by doing both stationarity checks.

3.6 MODEL SPECIFICATION

Equation (9) shows the ARDL form of the regression model expressed in (8):

$$\Delta EMP_t = \vartheta_0 + \sum_{i=1}^{p} \alpha_i \, EMP_{t-i} + \sum_{i=0}^{p} \partial_i \, \Delta ACC_{t-i} + \sum_{i=0}^{p} \beta_i \, \Delta FDI_{t-i} + \sum_{i=0}^{p} \varphi_i \, \Delta INF_{t-i} + \sum_{i=0}^{p} \delta_i \, \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_i \, \Delta TR_{t-i} + \vartheta_1 EMP_{t-1} + \vartheta_2 ACC_{t-1} + \vartheta_3 FDI_{t-1} + \vartheta_4 INF_{t-1} + \vartheta_5 GDP_{t-1} + \vartheta_6 TR_{t-1} + \in_t \quad (9)$$

Equation (9) presented above represents the ARDL model, where the employment rate is a function of its lagged values. In equation (9), the first-difference operator is represented by the symbol Δ. It indicates the change or difference between consecutive observations of a variable. By applying the first-difference operator, we are examining the rate of change in the variable over time, which helps capture the dynamics and relationships between variables. The dynamic coefficients $\alpha_i, \partial_i, \beta_i, \varphi_i, \delta_i,$ $and\ \gamma_i$ capture the short-run dynamics, while the parameters $\vartheta_1, \vartheta_2, \vartheta_3, \vartheta_4, \vartheta_5,$ $and\ \vartheta_6$ represent the ARDL model's long-run multipliers. $\in_t$ shows the white noise process, and p shows the lag size. Several information criteria, including the Bayesian, Hannan-Quinn, and Akaike information criteria are used to find the lag size for the model. These criteria consider the complexities of the model, aiding in selecting the accurate optimal lag size for the analysis.

The purpose of employing the ARDL method is to examine the hypothesis that there is no long-run correlation within the variables ($H_0: \vartheta_1 = \vartheta_2 = \vartheta_3 = \vartheta_4 = \vartheta_5 = \vartheta_6$) against the hypothesis that a long-run correlation exists ($H_1: \vartheta_1 \neq \vartheta_2 \neq \vartheta_3 \neq \vartheta_4 \neq \vartheta_5 \neq \vartheta_6$) . The null hypothesis is rejected if the F-statistic is larger than the critical value in the upper bound. Conversely, if the F-statistic is below the critical value in the lower bound, the null hypothesis is not rejected. In cases where the F-statistic lies between the critical values in the upper and lower bounds, then we have an inconclusive result. This decision rule is based on the findings of Canetti and Greene (1991). The long-run estimators are derived from the ARDL error correction model, as below:

$$\Delta EMP_t = \vartheta_0 + \sum_{i=1}^{p} \alpha_i\, EMP_{t-i} + \sum_{i=0}^{p} \partial_i\, \Delta ACC_{t-i} + \sum_{i=0}^{p} \beta_i\, \Delta FDI_{t-i} + \sum_{i=0}^{p} \varphi_i\, \Delta INF_{t-i} + \sum_{i=0}^{p} \delta_i\, \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_i\, \Delta TR_{t-i} + \pi ECT_{t-1} + \in_t \qquad (10)$$

The error correction term in equation (10) is denoted by ERC. The model's process of adjusting to equilibrium is captured by the term. The error correction coefficient, represented by π, evaluates the speed at which the model corrects any disequilibrium between the dependent variable's short and long-run behaviors. The inclusion of the error correction term allows us to account for any deviations from long-run equilibrium and provides insights into the cointegration between the variables (Okodua & Olabanji, 2013). A significant negative error correction coefficient shows a long-run relationship and the tendency for the variables to move toward equilibrium in the presence of any short-term shocks or deviations.

3.7 CAUSALITY TEST

The Granger-Causality test plays an important role in uncovering potential causal connections between two-time series variables. In essence, its purpose is to determine whether variations observed in one variable, denoted as time series X, could potentially lead to corresponding changes in another variable, referred to as time series B (Granger, 1988). Granger (1988) goes on to elaborate that this statistical tool operates based on the foundational principle that if past values of time series X offer valuable insights that enhance predictions for time series B, there exists a plausible causal link between these variables.

Granger's (1969) method establishes a causal relationship between variables by examining the potential lagged responses in each variable to changes in the other. The test is specifically designed to investigate short-run associations and whether historical values of one variable can contribute to forecasting the behavior of other variables in the model.

Consequently, in this paper, the Granger test will be used to scrutinize the causal link between access to electricity and employment. The test involves a null hypothesis suggesting that access to electricity does not Granger-cause employment, while the alternative hypothesis states that access to electricity indeed Granger-causes employment. The dynamic interplay between these variables can be intricate: enhanced access to electricity may stimulate industrial growth and job creation, thereby affecting employment levels. Conversely, higher employment rates might drive economic expansion, prompting investments in energy infrastructure to meet rising demand, thus promoting new and efficient energy sources.

Nonetheless, it's imperative to acknowledge the disadvantages of this test, especially when addressing relationships involving more than three variables. Complex scenarios can potentially impact the precision of the test's results, as discussed by Diks and Panchenko (2006). It's essential to recognize that while the Granger-Causality test can reveal predictive relationships, it does not definitively establish a clear causal sequence of events.

3.8 DIAGNOSTIC TESTS

The estimated ARDL model's goodness-of-fit and overall reliability will be evaluated through various diagnostic tests will be used. The following diagnostic tests will be conducted:

- Heteroscedasticity Tests: Tests such as the White test will be used to determine if heteroscedasticity exists in the model’s residuals, indicating unequal variance.
- Breusch Godfrey Serial Correlation Test: This test will examine the residuals for evidence of serial correlation, ensuring that the model accurately captures the correlation patterns.
- Stability Test: A Cusum test for stability test will be used to assess whether the estimated model remains valid over the entire period or if there are any structural breaks or changes in the relationship.

- Normality Tests: The normality of the residuals will be assessed using tests like the Jarque Bera test. This will ensure that the assumption of normal distribution of errors in the model is satisfied.

The findings of these diagnostic tests will provide insights into the model's assumptions, confirming its suitability and enhancing our understanding of the estimated ARDL model.

4. DISCUSSION OF RESULTS

4.1 SUMMARY STATISTICS

Table 2: Summary statistics

MEASURE	EMP	ACC	FDI	INF	GDP	TR
Average	13.925	80.190	4451.885	6.658	274551.900	2530.384
Std.Dev	3.619	7.846	7146.903	3.387	114906.600	6346.098
Min	7.548	57.600	-75.722	-0.692	126048.100	-8513.751
Max	18.205	90	40658.790	15.335	458199.500	26014.240
Skewness	0.461	-1.214	4.086	0.773	0.013	1.411
Kurtosis	1.181	3.985	21.291	3.915	1.392	7.241
Obervations	29	27	33	33	33	33

The variable EMP, measured in millions of people, represents the number of people engaged in employment activities and serves as the dependent variable in our study. The variable demonstrates a mean value of 13.953 million people over the period from 1990 to 2022. This indicates that, on average, approximately 13.953 million people were employed during this timeframe. However, the standard deviation of 3,619 million people is lower than the mean, suggesting limited variability in the data. The positive skewness of 0.462 suggests a right-skewed distribution of the employment rate, indicating that more extreme values lie on the right side of the distribution.

Energy access (ACC) demonstrates a mean value of 79.82%, indicative of widespread electricity access. The standard deviation (7.75%), which is less than the average value, suggests that the data points are relatively close to the mean value and that there is limited dispersion in the data. However, the presence of a heavy left tail in its distribution, as denoted by the substantial negative skewness (-1.24), suggests that there are some regions with very low levels of energy access compared to the rest.

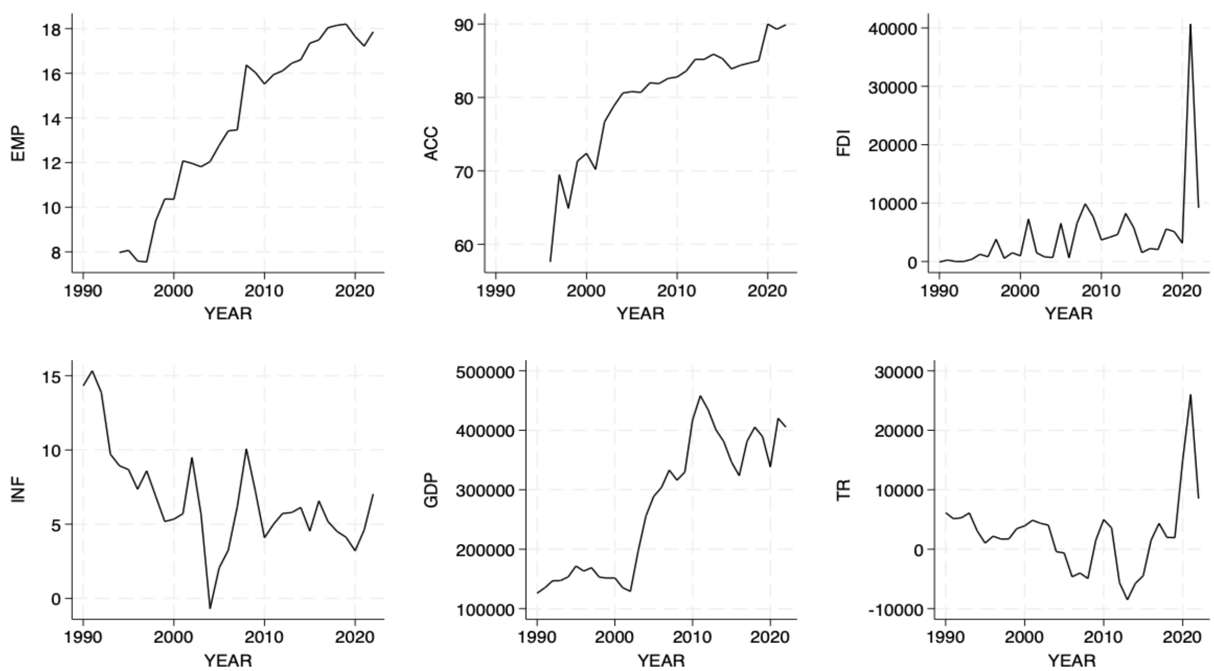
The mean of 4451.885 million dollars (i.e. 4.45 billion dollars) for FDI indicates the average level of foreign direct investment inflows. The standard deviation of 71446.903 million dollars (i.e. 7.15 billion dollars) suggests variability in FDI across the observed years. The higher standard deviation compared to the mean implies greater variability or dispersion in the data, with more data points deviating further from the average. The high positive kurtosis of 21.291 indicates a leptokurtic distribution, suggesting potential outliers in the observations.

The inflation variable exhibits a mean of 6.658%, indicating the average inflation rate over the observed period. The standard deviation of 3.387%, being lower than the mean, suggests limited variability in inflation rates across the years, with most values relatively close to the mean. This indicates that the inflation rates tend to cluster around the average value, with fewer extreme deviations from the mean. The positive skewness of 0.773 suggests a right-skewed distribution, meaning that there may be more extreme values on the higher end of the inflation rate spectrum. Additionally, the positive kurtosis of 3.915 indicates a leptokurtic distribution, suggesting that the inflation rate data has fatter tails and is more peaked around the mean compared to a normal distribution.

The GDP variable, with an average value of 274551.9 million (i.e. 275 billion dollars) and a standard deviation of 114906 million dollars (i.e. 115 billion dollars), indicates limited variability in GDP values across the observed period. This suggests that most GDP values are relatively close to the average, with fewer extreme deviations from the mean. The skewness of 0.013 suggests that the distribution of GDP data is nearly symmetrical. The kurtosis of 1.393 indicates a leptokurtic distribution of GDP values.

Lastly, the trade variable, with an average value of 2530.384 million dollars (i.e. 2.53 billion dollars) and a standard deviation of 6346.098 million dollars (i.e. 6.35 billion dollars), demonstrates significant variability in trade values over the observed period. This indicates that trade values vary widely from the average, showing a diverse range of values. The higher standard deviation compared to the mean implies greater variability or dispersion in the data, with trade values deviating significantly from the average. The data indicates a leptokurtic distribution, and the positive skewness of 1.411 suggests a distribution of data that is right-skewed.

Figure 1: Line graph representation



Source: Author's compilation

The line graph presented in Figure 1 gives a pictorial representation of employment trends in South Africa. It illustrates fluctuations in the number of people employed over time, offering valuable insights into the country's economic dynamics. Between 2008 and 2009, there was a noticeable increase in employment, followed by a drop in 2010. However, from 2010 to 2019, there was a general upward trend in employment, with occasional fluctuations, reaching a peak of 18.2 million people employed in 2019. Researchers like Ikwegbue et al. (2021) and Mokofe (2022) attribute this decline to the dire effects of COVID-19 on the job market. Following these declines, employment began to show signs of recovery in 2021. According to Altman (2022), the resurgence in employment can be partially credited to the adoption of the Economic Reconstruction and Recovery Plan by the South African government in October 2020. This plan aimed to stimulate economic growth in response to the pandemic and included initiatives to create public-sector-funded jobs, particularly targeting youth employment.

Energy access rates in South Africa have exhibited a consistent upward trend, indicating a gradual improvement in the percentage of the population with electricity access. The data reveals a positive trajectory, with energy access increasing steadily over the years. The lowest recorded value was 57.6% in 1996, while the highest was achieved in 2020 at 90%, reflecting significant progress in energy access. Despite fluctuations, the overall trend demonstrates a positive momentum towards greater energy access for the population.

FDI inflows, characterized by fluctuations, are influenced by various economic factors and global events. For example, the surge in FDI inflows in 2001 coincided with the introduction of the Foreign Investment Grant (FIG) in September 2000, a monetary incentive program for foreign investors. FDI peaked in 2021 when South Africa recorded inflows of USD 40 659 million (i.e. USD 40.7 billion), a significant increase from USD 3 154 million (i.e. USD 3.15 billion) in 2020. Similar to FDI, inflation also fluctuates over time. The highest inflation rate, reaching 15.3%, was observed in 1991. Conversely, a deflationary period occurred in 2004, with the recorded inflation rate dropping to -0.8%. These fluctuations in inflation rates reflect the dynamic nature of South Africa's economy, influenced by various external and internal factors such as changes in domestic demand and government policies.

The GDP variable fluctuates over time in an interesting pattern. GDP was much lower in the 1990s than in the 2000s when it rose noticeably. For example, GDP increased from USD129 088 million (i.e. USD 129 billion) in 2002 to USD 197 019 million (i.e. USD 197 billion) in 2003, showing a significant rise. This upward trend continued until it peaked at USD 45 8200 million (i.e. USD 458 billion) in 2011. However, after 2011, GDP started to decline but showed signs of improvement from 2016. Despite this improvement, fluctuations persisted, and there was a dip in GDP in 2020. According to the Statistics South Africa report (2020) and findings by Erero & Makananisa (2020), this decline in GDP during the second quarter of 2020 was attributed to the impact of COVID-19 lockdown restrictions implemented since March 2020.

Lastly, we examine the trade patterns over time. Negative values in trade indicate periods when South Africa is importing more goods and services than it is exporting, resulting in a trade deficit. The largest deficit occurred in 2013, totaling USD 8 514 million (i.e. USD 8.51 billion). Despite these deficits, trade exhibited steady fluctuations until experiencing a sharp increase in 2020, reaching its peak in 2021 at USD 26,014 million (i.e. USD 26 billion). Subsequently, trade decreased to USD 8 516 million (i.e. USD 8.52 billion) in 2022, but South Africa continued to trade at a surplus.

4.2 UNIT ROOT TESTS

Unit root testing is crucial when dealing with energy-related variables due to the distinct characteristics of many energy variables, such as energy consumption or production. These variables are believed to exhibit stochastic trends over time (Narayan & Liu, 2015; Ahmed et al., 2022; Schneider & Strielkowski, 2023), indicating random fluctuations around a long-term trend or a tendency to drift over time. Stationarity tests help monitor the behavior of energy variables and determine if shocks to these variables are permanent or temporary (Shahbaz et al., 2012). Furthermore, Kula et al. (2012) and Lee et al. (2021) emphasize that the stationarity of energy variables is crucial for formulating effective energy-related policies. Additionally, research by Rehman et al. (2021) on the energy crisis in Pakistan has utilized unit root testing to analyze the stationarity of energy-related variables, demonstrating the practical application of stationarity tests in understanding energy dynamics. Moreover, studies by Mishra & Smyth (2017) and Trokić (2016) have applied tests for unit roots to investigate stochastic convergence in energy consumption, highlighting the significance of understanding the dynamics of energy variables over time.

As detailed in the methodology section, unit root tests play a vital role in determining the integration order of time series data. These tests offer insights into the long-term patterns and trends manifested by the variables, thereby guiding subsequent analyses and interpretations. The study used the PP and ADF tests to test for unit roots and the test results are summarized in Table 3. In our analysis, all tests were conducted at a 5% significance level, with the appropriate lag length taken into consideration.

Table 3: Test for unit roots

Variable	Lags	P-value at (I (0))		P-value at (I (1))		Conclusion
		ADF	PP	ADF	PP	
EMP	1	0.621	0.568	0.002	0.001	First difference stationarity
ACC	1	0.028	0.011	-	-	Stationary in levels
FDI	0	0.001	0.001	-	-	Stationary in levels
INF	1	0.022	0.030	-	-	Stationary in levels
GDP	1	0.091	0.901	0.046	0.000	First difference stationarity
TR	3	0.113	0.028	0.001	0.001	First difference stationarity

Source: author's compilations

For EMP, GDP, and TR, the p-values at levels are both above 0.05, exceeding the chosen significance level. However, their p-values at the first difference are less than 0.05. This indicates that we reject the null hypothesis of a unit root at the first difference but not at the levels. Therefore, EMP, GDP, and TR are considered non-stationary at levels but stationary after we difference the variables. However, for ACC, FDI, and INF, the p-values at levels are all below the 5% chosen significance level. We therefore have to reject the null hypothesis of a unit root at the levels for these variables. Therefore, they are deemed stationary and do not require differencing.

In summary, based on the PP and ADF test results, all variables in the dataset were found to be integrated at either I (0) or I (1), and not at I (2). This means that the data analyzed in this research is free of unit roots and is suitable for ARDL regression analysis.

4.3 LAG ORDER SELECTION

After analyzing the stationarity and integration order for the ARDL model, we found a suitable lag length for the model. This decision is crucial as it directly affects the model's capacity to find the dynamic relationships in the variables. Table 4 outlines the criteria used to select the optimal number of lags.

According to the lag order selection criteria, which include the Bayesian, Hannan-Quinn, and Akaike information criteria, all indicators consistently recommend a lag order of 2 for our ARDL regression model. Moreover, the consistency among the criteria used enhances our confidence in the chosen model specification. This consensus among multiple criteria reinforces the robustness of our lag order selection process. The optimal lag order of 2 implies that the model includes two lagged values of the endogenous variables to capture the short-run effects in the data. This choice strikes a balance between adequately capturing autocorrelation in the data and avoiding overfitting the model with excessive lags.

In summary, based on the stated criteria for lag order selection, a lag order of 2 is deemed optimal for our ARDL regression model. This choice ensures that our model captures the essential temporal dynamics in the data while avoiding overfitting, thereby enhancing the accuracy and reliability of our analysis.

Table 4: Selecting the optimal lag

Lag	LogL	LR	AIC	SBIC	HQIC

0	-2160.355	NA	180.613	180.957	180.704
1	-1986.413	213.923	170.201	172.950	170.930
2	-1848.873	103.155*	162.823*	167.977*	164.190*

Source: Author's compilation

4.4 TEST FOR COINTEGRATION

Table 5: Results for the bounds test

F-Statistic	Significance	Critical values	
		I (0)	I (1)
	1%	3.600	4.900
F = 23.531	5%	2.870	4.000
	10%	2.530	3.590

Source: Author's compilation

The ARDL bounds cointegration test was performed to investigate the presence of a long-run relationship among the variables analyzed in this study. Its null hypothesis suggests no cointegration in the variables, indicating no long-term relationship. The decision to accept or reject this hypothesis depends on comparing the calculated F-statistic with critical values at different significance levels.

Table 5 outlines the outcomes of the bounds test, detailing the F-statistic, significance level, and critical values for different orders of integration. The F-statistic from the test is 23.531, showing cointegration among the variables. This value surpasses the critical values at the 1%, 5%, and 10% significance levels for the (1) orders of integration.

Since cointegration has been established, it suggests that our variables move cohesively in the long run, a crucial aspect for conducting meaningful regression analysis. We therefore have to estimate the long-run model, known as the error correction model (ECM). This model accounts for both short-term and long-term relationships among the variables, providing a comprehensive framework for analyzing their interactions over time.

4.5 RESULTS FOR THE SHORT AND LONG-RUN PERIODS

Table 6: Results for the short-run

Variable	Coefficient	Std. error	test-statistic	p-value
Independent variable:				
ACC	0.118**	0.048	2.458	0.044
L1	0.156***	0.073	2.128	0.071
L2	0.091***	0.045	2.022	0.083
Control variables:				
FDI	5.03e-03***	2.17e-03	2.318	0.054
L1	6.81e-03***	3.22e-03	2.115	0.072
L2	3.60e-03	2.40e-03	1.500	0.177
INF	-0.124	0.0738	-1.675	0.138
L1	-0.052	0.034	-1.355	0.218
L2	-0.098	0.065	-1.501	0.177
GDP	1.54e-03**	4.95e-04	3.110	0.017
L1	1.63e-03*	3.78e-04	4.312	0.004
L2	1.98e-03*	4.53e-04	4.371	0.003

TR	2.93e-03***	1.42e-03	2.060	0.078
L1	2.87e-04	1.93e-04	1.487	0.181
L2	-1.57e-04	1.11e-04	-1.414	0.200
constant	7.577**	2.316	3.272	0.014

, **, * implies significance at 1%, 5%, and 10% respectively.*

Source: Author's compilation

Table 7: ECM results

Variable	Coefficient	Std. error	test-statistic	p-value
Long-run dynamics				
ACC	0.044**	0.018	2.434	0.045
FDI	5.42e-03***	2.33e-03	2.326	0.053
INF	-0.212**	0.853	-2.554	0.021
GDP	2.20e-03**	0.85e-03	2.588	0.036
TR	3.70e-03	3.93e-03	0.941	0.378
ADJ(ECT)	-1.7322*	0.269	-6.435	0.000

, **, * implies significance at 1%, 5%, and 10% respectively.*

Source: Author's compilation

The ARDL model provided valuable insights into the dynamics between employment and its determinants. Table 6 summarizes the short-run results of the model and Table 7 presents the long-run results. The findings show that employment and energy access have a positive association over the short and long run, with significant coefficients at the 5% level. The positive relationship observed in the study aligns with previous findings by Sadanand and Grogan (2013), Ubah et al. (2021), and Kusi-Appiah and Essandoh (2023), which have also demonstrated that increased energy access is associated with increased employment opportunities. Specifically, the short-run coefficient of 0.118 for ACC indicates that a one percent rise in the population with access to electricity corresponds to a rise in employment of approximately 0.118 million (118,000) people. In the long run, this value slightly decreases to 0.044 million (44,000) people, implying that in the long run one-percent increase in the population with access to electricity is associated with an increase in employment of approximately 44 000 people. That is, as more people gain access to electricity, economic activities may rise, resulting in higher labor demand across various sectors.

Moreover, studies by Osunmuyiwa & Ahlborg (2019) and Vernet et al. (2019) have shown that improved electricity access can stimulate entrepreneurship, as reliable electricity encourages individuals to start businesses that rely on electricity, such as small-scale manufacturing or service-oriented ventures. Additionally, electrifying more villages and towns enables more efficient participation in agriculture, contributing to job creation (Lewis & Severnini, 2020), which supports the positive relationship we found. These findings are consistent with the earlier proposed hypotheses and suggest that expanding access to electricity can boost economic activities, leading to greater demand for labor across the nation.

The lagged effects further clarify how energy access and employment are related. The coefficient for ACC at lag 1 (L1) indicates that if electricity access increases by one percent in the previous period then employment will increase by 0.156 million (156,000) people in the current period. Similarly, the coefficient for ACC at lag 2 (L2) suggests that a one-percent increase in energy access two periods ago is associated with an employment increase of 0.091 million (91,000) people in the current period. The positive relationship observed in the lagged periods reinforces our result, confirming that the relationship between energy access and employment is significant and positive.

We find that FDI has a short-run coefficient of 5.03e-03, signifying that a one-million-dollar rise in FDI amounts to a 0.00503 million (5,030) increase in employed persons. This finding is significant at 10%. The coefficient at the first lag is 6.81e-03, suggesting that the impact of FDI on employment persists into the next period, with a one-million-dollar increase in FDI leading to a 0.00681 million (6,810) increase in employed persons in the next period. This result is also statistically significant at 10%. The coefficient in the second lag is 3.60e-03, suggesting that the impact of FDI on employment continues into the following period, with a one-million-dollar increase in FDI leading to a 0.00360 million increase in employment in the subsequent period. However, this result is not significant.

The coefficient of 5.42e-03, in the long run, highlights that a one-million-dollar increase in FDI is linked to a 0.00542 million (5,420) increase in employed persons. This value is slightly above the short-run increase, indicating that as we move from the short to the long run, the same one-million-dollar increase in FDI leads to 390 more people being employed. The long-run coefficient is significant at 10%. The positive coefficients for FDI indicate that a rise in FDI tends to lead to a rise in employment, aligning with the findings of studies such as Nunnenkamp & José (2007), Rong et al. (2020), and Khan et al. (2022) that FDI can stimulate economic activity and create job opportunities.

The results offer an intriguing insight into the relationship between inflation and employment. In the short run, a one percent increase in inflation is associated with a decrease of approximately 0.124 million (124,000) employed individuals, although this finding lacks statistical significance. This implies that, in the short term, inflation may not significantly impact employment levels. However, as we shift to the long run, the relationship becomes significant at 5%. Specifically, a one percent rise in inflation is linked to a decrease of about 0.212 million (212,000) employed individuals. This shows that the effect of inflation on employment varies over time, with a less pronounced and statistically insignificant impact in the short run, but a potentially significant effect as we move into the long run.

Moreover, neither the first nor the second lag of inflation is statistically significant. The coefficient of -0.052 for the first lag suggests that a one percentage point increase in inflation in the previous period translates to a decline of 0.052 million (52,000) employed persons in the current period, but this result is not significant. Similarly, the coefficient of -0.098 for the second lag suggests a decrease of 0.098 million (98,000) employed persons in the current period, which is also not statistically significant.

The consistent negative impact of inflation on employment suggests a potential economic phenomenon known as the cost-push effect. This aligns with the observations of Javed et al. (2010), who suggest that higher inflation can increase production costs for businesses, potentially leading to workforce reductions and lower employment levels as businesses aim to maintain profit margins. This also resonates with the findings of Khan & Gill (2010) and Asare et al. (2013), who note that persistently high inflation can erode consumers' purchasing power over time, leading to reduced spending and lower demand for services and products. This can push firms to make cost reductions, such as laying off employees, to stay competitive.

The results demonstrate a significant positive association between GDP and employment. In the short run, a one million dollar increase in GDP corresponds to a 1.54e-03 million (1 540) increase in employed persons, with a statistically significant p-value of 0.017. Similarly, the first lag of GDP exhibits a coefficient of 1.63e-03 (1 630 people) and a statistically significant p-value of 0.004, indicating a positive association with employment. The second lag of GDP also shows a significant positive coefficient of 1.98e-03 (1 980 people). These results suggest that higher GDP levels are linked to increased employment in the short run.

In the long run, a one million dollar rise in GDP is associated with a 2.20e-03 million (2 200) increase in employed persons. These results suggest that the concept of jobless growth, defined by Sodipe & Ogunrinola (2011) as a scenario where economic growth is negatively correlated with employment levels, does not relate to the economy of South Africa during the period of study. Instead, the findings indicate a sustained positive relationship between GDP and employment over time. These results align with economic theory and are consistent with previous research by Sodipe & Ogunrinola (2011) and Ferede & Kebede (2015), suggesting that higher GDP levels reflect increased economic activity and employment opportunities.

Trade and employment appear to be positively correlated. In the short run, a one million dollar rise in trade is associated with an increase of 2.93e-03 million (293) people employed, which is significant at 10%. The first lag of trade shows a coefficient of 2.87e-04 and a p-value of 0.181, indicating a positive relationship with employment, but not statistically significant. Similarly, the second lag of trade also shows a positive coefficient of 1.57e-04, which is not significant.

However, while the net trade variable is significant in the short run, it is not significant in the long run. In the long run, a one million dollar increase in net trade of goods and services is associated with a 3.70e-03 million (370) increase in employed persons. These results suggest that while there may be a positive relationship between trade and employment, this relationship is not significant.

The small coefficients for the short and long run (2.93e-03 million and 3.70e-03 million, respectively) suggest that the impact of trade on employment is relatively low, approximately equivalent to 293 people in the short run and 370 people in the long run. One possible explanation could be that a significant portion of trade involves imports rather than exports. If the imports are replacing goods produced locally, it could indicate that the domestic industry is not benefiting significantly from trade, leading to limited positive effects on employment. Supporting this notion, a study on South Africa by Edwards (2021) reveals that export volumes per capita grew at an annualized rate of only 0.45% from 1960 to 2019, and South Africa's proportion of exports decreased from 1.56% in 1962 to 0.4% in 2019. This suggests that the small changes in employment when trade increases by one million dollars could be due to higher imports, as exports are low. Furthermore, the United Nations report on Africa for 2019 notes that between 2015 and 2017, South Africa was one of the top African importers of fuel, machinery, and transport equipment, indicating a high reliance on imports in these sectors (United Nations, 2019).

The adjustment coefficient, also known as the error correction term (ECT), quantifies the speed at which employment adapts to variances from its long-run equilibrium path caused by changes in the independent variables. The ECT has a coefficient of -1.7322, which indicates a rapid transition from short-term fluctuations to long-term equilibrium. This means that approximately 173% of the discrepancy from shocks in the previous year is corrected each year, showing a rapid convergence back to long-run equilibrium. The coefficient has a negative sign, which suggests a reversion to long-run equilibrium. The coefficient is significant, further supporting the notion of a strong and significant adjustment process.

Economically, the results of the ECT imply that the South African labor market adjusts relatively quickly to deviations from its long-run equilibrium. For instance, according to the adjustment coefficient, employment will decline by around 173% every period until it achieves its long-run equilibrium level in the event of a positive shock to employment (such as an increase in FDI). Conversely, if there is a negative shock to employment, the adjustment coefficient suggests that employment will adjust upward by about 173% each period until it returns to its long-run equilibrium level.

4.7 GRANGER CAUSALITY RESULTS

We used the Granger test to find the causal relationship between employment and energy access. This test assesses the short-run association and investigates whether previous values of a variable can assist in predicting another variable.

For our analysis, we set up two cases:

1. Whether employment Granger causes energy access.
2. Whether energy access Granger causes the employment rate.

The first case's null hypothesis was that employment does not granger cause energy access, while the alternative hypothesis was that employment does Granger cause energy access. The p-value obtained for this case was 0.9492, which is greater than the significance level of 5%. Consequently, we failed to reject the null hypothesis, highlighting that employment does not Granger cause energy access at the 5% significance level. The test indicates that employment does not Granger-cause energy access. This suggests that past levels of employment are not significant predictors of future energy access levels. This could imply that changes in employment do not lead to immediate or significant changes in energy access.

In the second case, the null hypothesis stated that energy access does not Granger cause employment, while the alternative hypothesis was that energy access Granger causes inflation. Here, we found the p-value to be 0.0974, which is also higher than 5%. Thus, we were unable to rule out the null hypothesis and came to the conclusion that energy access does not Granger cause the employment rate. This implies that past levels of energy access are not significant predictors of future employment levels.

Table 8: Results from the Granger causality test

Null Hypothesis	p-value	Conclusion

Employment does not Granger cause energy access	0.9492	Fail to reject null hypothesis
Energy access does not Granger cause employment	0.0974	Fail to reject null hypothesis

In conclusion, the Granger causality results point to the lack of a substantial causal association between employment and energy access in either direction, suggesting that historical data on one variable is not a useful tool for forecasting future data on the other.

4.8 DIAGNOSTIC RESULTS

In our study, we conducted several diagnostic tests to assess the validity of the model assumptions and the robustness of our findings. These tests included the cumulative sum (Cusum) stability test, the Breusch Godfrey test for correlation, the Jarque-Bera test for normalcy, and White's test for heteroskedasticity. Table 8 provides a summary of the diagnostic test results.

Table 9: Diagnostic results

Test applied	The null hypothesis of the test	p-value	Conclusion
White test for heteroskedasticity	Error variance is constant across observations.	0.844	The error variance is constant across observations (homoscedasticity)
Jarque Bera test for normality	The data follows a normal distribution.	0.250	The data follows a normal distribution
Breusch Godfrey Serial Correlation Test	There is no serial correlation in the residuals.	0.176	No serial correlation in the residuals.

Cumulative sum stability test	There are no structural changes in the data.	0.443	There are no structural breaks, and the parameters are stable

Source: Author's compilation

White's test for heteroskedasticity examined whether the error variance is constant across observations (homoscedasticity). While the alternative hypothesis supports heteroskedasticity, the null hypothesis states that the error variance is constant, implying homoskedasticity. We are unable to rule out the null hypothesis with a p-value of 0.844, suggesting that the error variance is consistent across data.

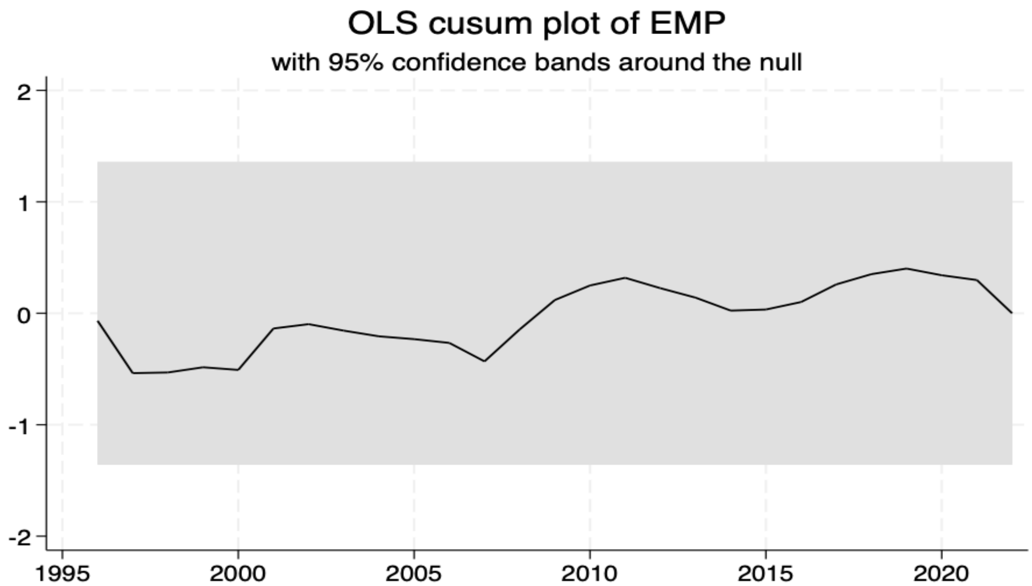
The Jarque-Bera test was employed for normality testing to determine whether the data is normally distributed. The alternative hypothesis asserts that the distribution is not normally distributed, in contrast to the null hypothesis. The test yielded a p-value of 0.250, which means that the data follows a normal distribution.

The objective of the Breusch-Godfrey correlation test was to identify any serial correlation present in the residual data. The alternative hypothesis proposes that serial correlation is there, while the null hypothesis argues that there is none. We are unable to rule out the null hypothesis with a p-value of 0.176, showing no serial correlation in the residuals.

Finally, the Cusum stability test was used to investigate structural breaks in the data. The test's null hypothesis states that the data does not exhibit a structural break, which suggests that the time series regression's coefficients are stable across time. For the null hypothesis to be rejected, the test statistic needs to be greater than the crucial value of 5%, which corresponds to the selected significance level. In our case, the test statistic of 0.443 is smaller than the 5% critical value of 0.797. Consequently, we are unable to reject the null hypothesis and come to the conclusion that the parameters are stable over time and that the series has no structural breaks.

Figure 2 shows a pictorial representation of the Cusum test. The graph in Figure 2 shows that the residuals stay in the chosen 95% confidence interval. Therefore, we fail to reject the null hypothesis, suggesting the absence of structural breaks in the series and that the parameters remain constant over time. This conclusion is further supported by the graphical representation of the Cusum test, which shows that the residuals remain within the chosen 95% confidence interval.

Figure 2: Results of the cusum test



Source: Author's compilation

Based on these diagnostic tests, we conclude that the assumptions of the ARDL model are valid, and our findings are robust.

5. CONCLUSION AND POLICY RECOMMENDATIONS

South Africa's electricity crisis poses a critical challenge, marked by a persistent shortage of power supply and frequent load shedding. This situation has profound implications for the economy, limiting citizens' access to electrical energy and hindering economic expansion and job creation. This important issue has motivated me to explore the broader implications of electrical energy access on the labor market in South Africa, aiming to shed light on how electricity access affects employment outcomes.

The study used the ARDL technique to examine the relationship between energy access and employment in South Africa. Unlike previous research, which focused solely on rural areas in South Africa, this study took a macro-level perspective, encompassing both urban and rural regions by using macroeconomic data. This broader approach allowed for a broader view of the relationship between energy access and employment across the entire country.

Employment served as the dependent variable in the study, while energy access was treated as the independent variable. Additionally, control variables such as inflation, GDP, trade, and FDI were incorporated to provide a comprehensive analysis of the factors influencing employment dynamics. The research was conducted over 33 years, from 1990 to 2022, ensuring the relevance and applicability of the findings to the current economic landscape.

The data underwent rigorous quality checks to ensure its reliability. Stationarity tests, including the PP and ADF tests, were conducted, revealing that the variables exhibited mixed integration orders of zero and one. Determining the optimal lag for the model involved assessing criteria such as the Hannan-Quinn, Bayesian, and Akaike information criteria, which indicated a lag order of two. Moreover, the cointegration test verified the presence of a long-term relationship within the variables. The model's robustness was confirmed by the use of several diagnostic tests, such as the cumulative sum stability test, Jarque-Bera test for normalcy, Breusch-Godfrey test for correlation, and White's test for heteroskedasticity.

We found energy access to be positively related to employment. The findings of this paper have several important policy implications for South Africa. The positive relationship between energy access and employment suggests that policies aimed at improving access to electricity could positively impact employment levels. This could involve investing in infrastructure to expand electricity access to rural and underserved areas, as well as promoting renewable energy sources to ensure sustainable and reliable energy supply.

The positive relationship between FDI and employment highlights the importance of attracting foreign investment to stimulate job creation. Policies that create a favorable environment for FDI, such as improving infrastructure and providing incentives for investors could help boost employment in the country.

Furthermore, the positive link between GDP and employment highlights how crucial economic expansion is to the creation of jobs. More job possibilities could be created in the nation through policies that encourage sustainable economic growth, such as funding education and skill development, assisting small and medium-sized firms, and encouraging innovation and the use of new technologies.

On the other hand, the negative impact of inflation on employment underscores the need for sound monetary policies to control inflation rates. The central bank could implement measures to control inflation, such as adjusting interest rates to manage money supply and demand. This can help stabilize prices and support sustainable economic growth, which is crucial for job creation. High inflation rates can erode the purchasing power of consumers and lead to reduced spending, which can negatively affect businesses and result in lower employment levels. Therefore, policies that aim to maintain price stability and control inflation are crucial for supporting employment growth.

The study revealed a significant relationship between trade and employment in the short run, but this relationship was found to be insignificant in the long run. This suggests that while trade may have some immediate impact on employment levels, this effect does not persist over time. One possible explanation for this phenomenon is the high dependence on imports in South Africa, particularly in sectors such as fuel, machinery, and transport equipment. This indicates that while trade may be driving economic activity, it may not be leading to substantial job creation.

To address this issue and potentially enhance the positive impact of trade on employment, policymakers could consider implementing measures to promote exports and reduce reliance on imports. This could involve supporting local industries through incentives and infrastructure development, which could stimulate domestic production and create more job opportunities in the long term.

The study acknowledges several limitations that could impact the robustness of its findings. One significant limitation is the omission of key variables that could influence both energy access and employment outcomes. Factors such as energy prices and government policies play crucial roles in shaping energy access levels and employment opportunities but were not included in the analysis. Future research should consider incorporating these variables to provide a more comprehensive understanding of the relationship between energy access and employment in South Africa.

The study's use of aggregated macroeconomic data raises the possibility of aggregation bias, which is another limitation. While macro-level data offers a broad overview, it might overshadow regional or provincial variations in energy access and employment dynamics. To address this limitation, future studies could adopt a more granular approach by analyzing data at provincial levels. This approach would allow for a more refined analysis, considering the specific needs and challenges faced by different regions within South Africa.

Moreover, the segmentation of data at the provincial level could provide valuable insights for policymakers. By identifying regions with specific energy access or employment challenges, policymakers can tailor interventions to address these issues more effectively. For example, provinces with limited energy access could benefit from targeted infrastructure investments, while those facing high unemployment rates could benefit from job creation initiatives.

REFERENCES

Abaidoo, R. (2016). Inflation expectations, economic policy ambiguity and micro-level consumer behavior. *Journal of Financial Economic Policy*, 8(3), 377-395.

Abraham, K. G., & Kearney, M. S. (2020). Explaining the decline in the US employment-to-population ratio: A review of the evidence. *Journal of Economic Literature*, *58*(3), 585–643.

Acemoglu, D. (2003). *Patterns of skill premia*. Review of Economic Studies, 70(2), 199-230.

Acemoglu, D., Autor, D. H., Dorn, D., Hanson, G. H., & Price, B. (2015). Import competition and the great U.S. employment sag of the 2000s. *National Bureau of Economic Research Working Paper Series,* 20395.

Adeolu, O., M., & Abiodun, O., O. (2020). Causality nexus between electricity consumption and growth in Nigeria manufacturing sector. *Research on Humanities and Social Sciences*, *10*(6).

Aderemi, T., Omitogun, O., & Osisanwo, B. (2022). Effect of FDI inflows on employment generation in selected ECOWAS countries: Heterogeneous panel analysis. *Central Bank of Nigeria Journal of Applied Statistics*, *13*(1).

Aghion, P., & Howitt, P. (1992). *A Model of Growth through Creative Destruction*. Econometrica, 60(2), 323-351.

Ahmed, F., Kousar, S., Pervaiz, A., & Ramos-Requena, J. P. (2020). Financial development, institutional quality, and environmental degradation nexus: new evidence from asymmetric ARDL co-integration approach. *Sustainability*, 12(18), 7812.

Ahmed, Z., Zhang, B., & Cary, M. (2021). Linking economic globalization, economic growth, financial development, and ecological footprint: Evidence from symmetric and asymmetric ARDL. *Ecological Indicators*, 121, 107060.

Ahmed, M., Azam, M., & Khan, A. M. (2022). Testing stationarity of per capita energy consumption across the globe: a better picture using the wavelet framework. *Environmental Science and Pollution Research*, 29(43), 65334–65352.

Altman, M. (2022). Trajectories for South African employment after COVID-19. *South African Journal of Science*, 118(5/6).

Angelov, I. (2023). Inflation and employment: exploring the dynamic relationship in the labor markets. *Journal of Education, Society and Behavioral Science*, 36(5), 18-23.

Armeanu, D., Joldeș, C. C., & Gherghina, Ş. C. (2022). How energy sector reacted to the covid-19 pandemic? empirical evidence from an emerging market economy. *Discrete Dynamics in Nature and Society*, 2022, 1-26.

Asare , O., Bonsu, Y., & Eghan, M. (2013). Food price inflation and consumer welfare in Ghana. *International Journal of Food and Agricultural Economics*, *01*(1).

Ateba, B. B., Prinsloo, J. J., & Gawlik, R. (2019). The significance of electricity supply sustainability to industrial growth in South Africa. *Energy Reports*, *5*, 1324–1338.

Ball, L. and Cecchetti, S. G. (1990). Inflation and uncertainty at short and long horizons. *Brookings Papers on Economic Activity*, 1990(1), 215.

Ball, L. (1992). Why does high inflation raise inflation uncertainty? J*ournal of Monetary Economics*, 29(3), 371-388.

Bardi, U., El Asmar, T., & Lavacchi, A. (2013). Turning electricity into food: the role of renewable energy in the future of agriculture. *Journal of Cleaner Production*, *53*, 224–231.

Becker, G. S. (1964). *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. University of Chicago Press.

Belloumi, M. (2014). The relationship between trade, FDI and economic growth in Tunisia: An application of the autoregressive distributed lag model. *Economic Systems*, *38*(2), 269–287.

Blanchard, O., & Katz, L. F. (1999). Wage dynamics: Reconciling theory and evidence. *American Economic Review*, *89*(2), 69-74.

Blanchard, O. (2006). Macroeconomics. *Prentice Hall*.

Blanco, M. I., & Rodrigues, G. (2009). Direct employment in the wind energy sector: An EU study. *Energy Policy*, *37*(8), 2847–2857.

Brooks, C. (2008). Introductory econometrics for finance 2nd edition. New York: *Cambridge University Press*. *Bulletin*, December: pp. 28-29.

Caliendo, L., Dvorkin, M. A., & Parro, F. (2015). The impact of trade on labor market dynamics. *FRB St. Louis Working Paper*, *2015*(9).

Canetti, E., & Greene, J. E. (1991). Monetary growth and exchange rate depreciation as causes of inflation in African countries: An empirical analysis. *IMF Working Papers*, *91*(67), 1.

Cantore, N., Nussbaumer, P., & Wei, M. (2017). Promoting renewable energy and energy efficiency in Africa: A framework to evaluate employment generation and cost-effectiveness. *FEEM Working Paper*, *2016*(5).

Carfora, A., Pansini, R. V., & Scandurra, G. (2019). The causal relationship between energy consumption, energy prices and economic growth in Asian developing countries: A replication. *Energy Strategy Reviews*, *23*, 81–85.

Carroll, C. D. (2003). Macroeconomic expectations of households and professional forecasters. *The Quarterly Journal of Economics*, 118(1), 269-298.

Chirambo, D. (2018). Towards the achievement of SDG 7 in sub-Saharan Africa: Creating synergies between Power Africa, Sustainable energy for all and climate finance in-order to achieve universal energy access before 2030. *Renewable and Sustainable Energy Reviews*, *94(2018)*, 600–608.

Chowdhury, S. K. (2009). Impact of infrastructures on paid work opportunities and unpaid work burdens on rural women in Bangladesh. *Journal of International Development*, *22*(7), 997–1017.

Clark, A., Eberhardt, A., Mark, D., Gratwick, K., & Wamukonya, N. (2005). Power sector reform in Africa: assessing the impact on poor people. *Energy Sector Management Assistance Program (ESMAP), ESM (*306/05.).

Clancy, J., & Kooijman-van Dijk, A. L. (2010). Impacts of electricity access to rural enterprises in Bolivia, Tanzania and Vietnam. *Energy for Sustainable Development*, *14*(1), 14–21.

Cadoret, I. and Padovano, F. (2016). The political drivers of renewable energies policies. *Energy Economics*, 56, 261-269.

Danja, K. (2012). Foreign direct investment and the Nigerian Economy. *American Journal of Economics*, *2*(3), 33–40.

Diks, C., & Panchenko, V. (2006). A new statistic and practical guidelines for nonparametric Granger causality testing. *Journal of Economic Dynamics and Control*, *30*(9–10), 1647–1669.

Dinkelman, T. (2011). The effects of rural electrification on employment: New evidence from South Africa. *American Economic Review*, *101*(7), 3078–3108.

Edwards, L. (2011). South Africa's international trade. *Policy Research on International Services and Manufacturing*, PRISM WorkingPaper, 2021-1.

Erero, J. L., & Makananisa, M. P. (2020). Impact of Covid-19 on the South African economy: A CGE, Holt-Winter and SARIMA model's analysis. *Turkish Economic Review*, 7(4).

Fell, M. J. (2017). Energy services: A conceptual review. *Energy Research & Social Science*, *27*, 129–140.

Ferede, T., & Kebede, S. (2015). Economic growth and employment patterns, dominant sector, and firm profiles in Ethiopia: Opportunities, challenges and Prospects. *Swiss Programme for Research on Global Issues for Development*, Working Paper, 2015/2.

Folly, K. A. (2021). Local Electricity Markets: Chapter 20 - Competition and restructuring of the South African electricity market. *Academic Press, Vol. Pages 355-366*.

Graetz, G. (2015). Rise of the Machines: The Effects of labor-saving innovations on jobs and wages. *IZA Discussion Paper*, 8836.

Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, *37*(3), 424.

Granger, C. (1988). Causality, cointegration, and control. *Journal of Economic Dynamics and Control*, *12*(2–3), 551–559.

Haider, A., Ahmed, Q. M., & Jawed, Z. (2014). Determinants of energy inflation in Pakistan: An empirical analysis. *The Pakistan Development Review*, 53(4II), 491-504.

Hoffmann, R. (1987). Damodar Gujarati: Basic Econometrics. McGraw-Hill, 1978. *Brazilian Review of Econometrics*, *7*(1), 83.

Hurley, D. T., & Papanikolaou, N. (2021). Autoregressive Distributed Lag (ARDL) analysis of U.S.-China commodity trade dynamics. *The Quarterly Review of Economics and Finance*, 81, 454–467

Ikwegbue, P., Enaifoghe, A., Maduku, H., & Agwuna, L. (2021). The Challenges of COVID-19 pandemic and South Africa's response. *African Renaissance*, 18(1), 271–292.

International Energy Agency. (2020). *Energy Access Outlook 2020: Sustainable Energy for All*. Paris: IEA. Available at: International Energy Agency (2020) World Energy Outlook 2020 IEA Paris - Excerpts

International Renewable Energy Agency (IRENA), Renewable energy and jobs – Annual review. (2021). *IRENA & International Labour Organization. Avalable at:* https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Oct/IRENA_RE_Jobs_2021

Jabari, M. S., Ağa, M., & Samour, A. (2022). Financial sector development, external debt, and turkey's renewable energy consumption. *Plos One*, 17(5), e0265684.

Jaiblai, P., & Shenai, V. (2019). The determinants of FDI in Sub-Saharan economies: A study of data from 1990–2017. *International Journal of Financial Studies*, *7*(3), 43.

Javed, H. J., Farooq, M., & Akram, S. (2010). Cost-push shocks and inflation: An empirical analysis from the economy of Pakistan. *Journal of Economics and International Finance*, *2*(12).

Jeuland, M., Fetter, T. R., Li, Y., Pattanayak, S. K., Usmani, F., Bluffstone, R. A., Chávez, C., Girardeau, H., Hassen, S., Jagger, P., Jaime, M. M., Karumba, M., Köhlin, G., Lenz, L., Litzow, E. L., Masatsugu, L., Naranjo, M. A., Peters, J., Qin, P., . . . Toman, M. (2021). Is energy the golden thread? A systematic review of the impacts of modern and traditional energy use in low- and middle-income countries. *Renewable and Sustainable Energy Reviews*, *135*, 110406.

Jin, L., Duan, K., & Tang, X. (2018). What is the relationship between technological innovation and energy consumption? Empirical analysis based on provincial panel data from China. *Sustainability, 10*(2), 145.

Keynes, J. M. (1936). *The General Theory of Employment, Interest and Money*. Macmillan.

Khan, R. E. A., & Gill, A. R. (2010, July). Determinants of inflation: A case of pakistan (1970-2007). *Journal of Economics, 1*(1), 45–51.

Khan, I., Xue, J., Zaman, S., & Mehmood, Z. (2022). Nexus between FDI, economic growth, industrialization, and employment opportunities: Empirical evidence from Pakistan. *Journal of the Knowledge Economy*, *14*(3), 3153–3175.

Kock, Z., & Govender, K. K. (2021). Load-shedding and the declining energy availability factor: A case study of a South African power station. *Mediterranean Journal of Social Sciences*, *12*(6), 128.

Kripfganz, S., & Schneider, D. C. (2020). ARDL: Estimating autoregressive distributed lag and equilibrium correction models. *TUPD Discussion Papers*, *006*.

Kula, F., Aslan, A., & Ozturk, I. (2012). Is per capita electricity consumption stationary? Time series evidence from OECD countries. *Renewable and Sustainable Energy Reviews*, 16(1), 501–503.

Kusi-Appiah, F., & Essandoh, A. S. (2023). Climate change and energy transition impact on employment transition in the Ghanaian energy sector. *The Journal of World Energy Law & Business, 16*(3), 219–240.

Larocca, R. (2005). Reconciling Conflicting Gauss-Markov Conditions in the Classical Linear Regression Model. *Political Analysis*, *13*(2), 188–207.

Langnel, Z., & Amegavi, G. B. (2020). Globalization, electricity consumption and ecological footprint: An autoregressive distributive lag (ARDL) approach. *Sustainable Cities and Society*, 63, 102482.

Lee, C. C., Ranjbar, O., & Lee, C. C. (2021). Testing the persistence of shocks on renewable energy consumption: Evidence from a quantile unit-root test with smooth breaks. *Energy*, 215, 119190.

Lewis, J., & Severnini, E. (2020). Short- and long-run impacts of rural electrification: Evidence from the historical rollout of the U.S. power grid. *Journal of Development Economics*, *143*, 102412.

Lipscomb, M., Mobarak, A. M., & Barham, T. (2013). Development effects of electrification: Evidence from the topographic placement of hydropower plants in Brazil. *American Economic Journal: Applied Economics*, *5*(2), 200–231.

Liu, Y. (2009). Exploring the relationship between urbanization and energy consumption in China using ARDL (autoregressive distributed lag) and FDM (factor decomposition model). *Energy*, 34(11), 1846-1854.

Mago, S., & F Olajuyin, O. (2022). Effects of load-shedding on the performance of small, medium and micro enterprises in Gqeberha, South Africa. *Management and Economics Research Journal*, *8*(4), 1–8.

Marshall, A. (1920). *Principles of Economics*. London: Macmillan and Co., Ltd.

Masoga, M., Kumalo, T., Qeqe, B., & Naape, B. (2022). Do energy prices drive inflation in south africa? An unrestricted VAR approach. *Journal of Applied Economics and Business Studies*, 6(2), 1-14.

Miles, W. and Vijverberg, C. C. (2009). Changing inflation dynamics and uncertainty in the United States. *Southern Economic Journal*, 75(3), 736-749.

Mishra, V., & Smyth, R. (2017). Conditional convergence in Australia's energy consumption at the sector level. *Energy Economics*, 62, 396–403.

Mokofe, W. M. (2022). From precarity to pandemic: How the Covid-19 pandemic has exacerbated poverty, unemployment, and inequality in South Africa. *Law, Democracy, and Development*, 26(2022).

Mottaleb, K. A., Krupnik, T. J., & Erenstein, O. (2016). Factors associated with small-scale agricultural machinery adoption in Bangladesh: Census findings. *Journal of Rural Studies*, *46*, 155–168.

Mbomvu, L., Hlongwane, I. T., Nxazonke, N. P., Qayi, Z., & Bruwer, J. (2021). Load shedding and its influence on South African small, medium and micro enterprise profitability, liquidity, efficiency and solvency. *Business Re-Solution Working Paper, 2021*(001).

Narayan, P. K., & Liu, R. (2015). A unit root model for trending time-series energy variables. *Energy Economics*, 50, 391–402.

Nunnenkamp, P., & José, J. (2007). FDI in Mexico: An empirical assessment of employment effects. *Kiel Institute for the World Economy,* Kiel Working Paper, 132.

Odhiambo, N. M. (2023). A symmetric impact of energy consumption on economic growth in South Africa: New evidence from disaggregated data. *Energy Nexus*, *9*, 100174.

Okodua, H., & Olabanji, E. O. (2013). Stock market performance and sustainable economic growth in Nigeria: A bounds testing co-integration approach. *Journal of Sustainable Development*, *6*(8).

Osunmuyiwa, O., & Ahlborg, H. (2019,). Inclusiveness by design? Reviewing sustainable electricity access and entrepreneurship from a gender perspective. *Energy Research & Social Science*, 53, 145–158.

Ou, P., Huang, R., & Yao, X. (2016). Economic impacts of power shortage. *Sustainability*, *8*(7), 687.

Parajuli, R., Joshi, O., & Maraseni, T. (2019). Incorporating forests, agriculture, and energy consumption in the framework of the environmental kuznets curve: a dynamic panel data approach. *Sustainability*, 11(9), 2688.

Pesaran, M. Hashem, Yongcheol Shin, and Richard J. Smith. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289-326.

Poblete-Cazenave, M., & Pachauri, S. (2021). A model of energy poverty and access: Estimating household electricity demand and appliance ownership. *Energy Economics*, *98*, 105266.

Rahman, M.M., & Alam, K. (2021). The role of access to electricity, female education, and public health expenditure on female health outcomes: Evidence from SAARC-ASEAN countries. *BMC Women's Health*, *21*(383).

Rahman, S. M., Kirshner, J., Groh, S., & Rahman, S. M. (2022). A review of the energy-employment nexus in Bangladesh: Rural-urban electrification and sectoral occupation patterns. *Strategic Planning for Energy and the Environment*, *41*(3), 317–344.

Ram, M., Aghahosseini, A., & Breyer, C. (2020). Job creation during the global energy transition towards 100% renewable power system by 2050. *Technological Forecasting and Social Change*, *151*, 119682.

Rathi, S. S., & Vermaak, C. (2018). Rural electrification, gender and the labor market: A cross-country study of India and South Africa. *World Development*, *109*, 346–359.

Rehman, A., Ma, H., Radulescu, M., Sinisi, C. I., & Yousaf, Z. (2021). Energy crisis in Pakistan and economic progress: Decoupling the impact of coal energy consumption in power and Brick Kilns. *Mathematics*, 9(17), 2083.

Richmond, J., & Urpelainen, J. (2019). Electrification and appliance ownership over time: Evidence from rural India. *Energy Policy*, *133*, 110862.

Romer, P. M. (1990). *Endogenous Technological Change*. Journal of Political Economy, 98(5), S71-S102.

Rong, S., Liu, K., Huang, S., & Zhang, Q. (2020). FDI, labor market flexibility and employment in China. *China Economic Review*, *61*, 101449.

Sadanand, A., & Grogan, L. (2013). Rural electrification and employment in poor countries: Evidence from Nicaragua. *World Development*, *43*, 252–265.

Schneider, N., & Strielkowski, W. (2023). Modelling the unit root properties of electricity data—A general note on time-domain applications. *Physica A: Statistical Mechanics and Its Applications*, 618, 128685.

Schultz, T. W. (1961). *Investment in Human Capital*. American Economic Review, 51(1), 1-17.

Sebri, M. and Ben-Salha, O. (2014). On the causal dynamics between economic growth, renewable energy consumption, co 2 emissions and trade openness: fresh evidence from BRICS countries. *Renewable and Sustainable Energy Reviews*, 39, 14-23.

Shahbaz, M. S., Tiwari, A. K. T., & Khan, S. K. (2012). Is Energy consumption per capita stationary? Evidence from first and second generation panel unit root test. Munich Personal RePEc Archive, 41607(2012).

Shirley, R., Lee, C., Njoroge, H. N., Odera, S., Mwanzia, P. K., Malo , I., & Dipo-Salami , D. (2019). Powering jobs: The employment footprint of decentralized renewable energy technologies in Sub Saharan Africa. *Sustainable Energy for Development*, *2*(1), e200001.

Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*. London: W. Strahan and T. Cadell.

Sodipe, S. O., & Ogunrinola, O. O. (2011). Employment and economic growth nexus in Nigeria. *International Journal of Business and Social Science*, *2*(11).

Statistics South Africa. (2020). Gross domestic product: Second quarter 2020. *Statistical release P0441*. Available at: P04412ndQuarter2020.pdf (statssa.gov.za)

Stern, D. I. (2011). The role of energy in economic growth. *Ecological Economics Reviews*, *1219*, 26–51.

Stiglitz, J. E. (2002). *Globalization and Its Discontents*. New York: W.W. Norton.

Sulaiman, A., Baharin, R., & Al-Hadi, A. (2019). Impact of import and export on GDP of Egypt: application of ARDL model. *International Journal of Asian Social Science*, 9(1), 1-10.

Tagliapietra, S., Occhiali, G., Nano, E., & Kalcik, R. (2020). The impact of electrification on labour market outcomes in Nigeria. *Economia Politica*, *37*(3), 737–779.

Thuku, G. K., Omolo, J., & Muniu, J. (2019). Drivers of employment elasticities in Kenya. *Journal of Economics and Sustainable Development,* 10(16), 2222-2855.

Todaro, M. P., & Smith, S. C. (2015). *Economic Development* (12th ed.). Pearson.

Torero, M. (2015). The impact of rural electrification: Challenges and ways forward. *Revue D'économie Du Développement*, *23(HS)*, 49–75.

Tshidavhu, F., & Khatleli, N. (2020). An assessment of the causes of schedule and cost overruns in South African megaprojects: A case of the critical energy sector projects of Medupi and Kusile. *Acta Structilia*, *27*(1), 119–143.

Ubah, J. I., Bowale, E. K., Ejemeyovwi, J. O., & Okereke, Y. (2021). Effects of technological diffusion and access to electricity on employment in Nigeria. *International Journal of Energy Economics and Policy*, *11*(2), 227–233.

United Nations. (2019). Economic Report on Africa 2019: fiscal policy for financing sustainable development in Africa. *Economic Commission for Africa.* Available at: https://hdl.handle.net/10855/41804

Vernet, A., Khayesi, J. N., George, V., George, G., & Bahaj, A. S. (2019). How does energy matter? Rural electrification, entrepreneurship, and community development in Kenya. *Energy Policy*, *126*, 88–98.

Walle, D., Ravallion, M., Mendiratta, V., & Koolwal, G. (2015). Long-term gains from electrification in rural India. *World Bank Policy Research Working Paper*, 6527.

Walsh, K., Theron, R., & Reeders, C. (2021). Estimating the economic cost of load hhedding in South Africa. *Biennial Conference of the Economic Society of South Africa*, *8*(2021).

Wang, Z. X., Li, Q., & Pei, L. L. (2018). A seasonal GM(1,1) model for forecasting the electricity consumption of the primary economic sectors. *Energy*, *154*, 522–534.

World Energy Outlook. (2017). Energy access 2017: From energy to poverty. *International Energy Agency*. https://iea.blob.core.windows.net/assets/9a67c2fc-b605-4994-8eb5-29a0ac219499/WEO2017SpecialReport_EnergyAccessOutlook.pdf

Xing, S., Lu, J., Zhang, C., & Sun, S. (2018). Does line loss broaden the deviation between the added value of industry and the industrial electricity consumption in China? *Environment, Development and Sustainability*, 21(4), 1635-1648

Zaharia, A., Diaconeasa, M. C., Brad, L., Lădaru, G., & Ioanăş, C. (2019). Factors influencing energy consumption in the context of sustainable development. *Sustainability*, 11(15), 4147.