The Role of Electricity Consumption, Price, and Coal Exports on South Africa's Economic Growth

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Abstract

Coal is a key energy source and is widely traded among countries. South Africa as a developing country is one of the countries rich and heavily reliant on coal as an input for electricity generation. Electricity consumption is a crucial contributor to GDP, and conversely, GDP plays a pivotal role in driving electricity consumption. However, the country faces a critical issue with electricity rationing and escalating electricity prices, sparking growing concerns as tons of coal are being exported. The study utilized quarterly data spanning from 2016 to 2023 to investigate the impact of electricity consumption, electricity price, and coal exports on South Africa's economic growth. Through the Autoregressive Distributed Lag (ARDL), the study investigated the short and long-run relationship. Electricity consumption and price had a positive relationship with GDP at a 1% significance level in the long run whilst coal exports had a negative relationship with GDP at a 5% significance. Electricity consumption aids productivity enabling seamless operations in various sectors. High electricity prices can drive businesses and households to invest in energy-efficient technologies and practices. This can lead to innovations and advancement in energy-saving solutions, fostering new industries and job creation. The export of coal in South Africa contradicts the export-led growth hypothesis as it has not resulted in significant economic benefits which is questionable due to the dire state of the country of having loadshedding. And as seen, loadshedding has been detrimental to the economy. Thus, the findings of this research provide valuable insights for policymakers and stakeholders, guiding strategic decisions to foster sustainable economic growth and enhance the resilience of South Africa's energy sector.

Keywords: GDP, Electricity Consumption, Electricity Price, Coal Exports, South Africa.

INTRODUCTION

Coal is a key energy source and is widely traded among nations (Ambya & Hamzah, 2022). As a developing nation, South Africa is among the countries with an abundance of coal and is heavily reliant on it as an input for electricity generation (Makgetla & Patel, 2021). Theoretically, natural resources such as coal should boost economic development by broadening the production capabilities of the economy. However, Badeeb et al (2017), demonstrate an adverse relationship between economic growth and abundance of natural resources, a phenomenon referred to as the Resource curse, particularly evident in developing economies. Since 2007, South Africa has been facing challenges in the energy sector. This led ESKOM, the national utility of electricity supply,

to implement a measure to balance electricity demand with the available supply by means of electricity rationing/load-shedding (Pretorius et al, 2015).

South Africa's underperformance economically despite being rich in coal, as a major input factor to generate electricity, is in accord with the Resource curse hypothesis. However, South Africa as one of the largest coal exporters globally, has significantly gained revenue through the exportation of coal by substantially contributing to the nation's trade balance. A positive trade balance led to foreign exchange accumulation, providing stability to the country's currency and enabling investments in infrastructure and other developmental projects, further supporting long-term economic growth and hence, export-led growth. Thus, this study addresses the contradictions in the aforementioned theories within the context of South Africa, contributing to the existing literature on the energy-growth nexus.

South Africa's economic growth underperformed for the past decade, as evidenced by the fact that GDP per capita in 2019 was lower than in 2008 (OECD, 2022). In 2022, GDP decelerated to 1.9%, down from the 4.9% recorded in 2021, which was much lower than the global and African averages of between 3.4% and 3.8% (African Development Bank, 2023). This lacklustre economic performance led to various adverse effects, including increased unemployment rates and challenges in funding public services such as healthcare and education. Additionally, it hindered innovation and investor confidence (National Treasury, 2023).

As asserted by Twerefou et al (2018), economic growth is significantly influenced by growth in electricity consumption. In turn, higher electricity consumption usually corresponds with broader economic growth. Growing industries, increased urbanization, and rising standards of living contribute to a greater need for electricity and hence consumption. According to Takentsi et al (2022), energy prices are considered a vital element in facilitating economic growth. Early 2023, ESKOM was granted an 18.65% average increase in tariffs by NERSA (NERSA, 2023). This significantly lowered productivity since the cost of production was high for businesses. The country is currently making efforts to transition from the traditional use of coal to generate electricity to a greener energy mix. This shift is projected to have an unfavourable effect on the nation's GDP, particularly looking at how the downfall of the coal industry will result in a rise in unemployment and a drop in income. Unless the export-led growth theory favours South Africa, where the excess production would be exported to international markets, the outlook might be dire.

This study explores the energy-growth nexus with the inclusion of the crucial factors that may be the cornerstone of the energy-growth nexus; that is, coal exports and electricity prices. Hence, a multivariate element incorporating energy variables. South Africa's status as a major global exporter of coal, an abundant resource, underscores the importance of examining the link. This in line with the dilemma of resource export-led growth. In South Africa, most of the energy-growth literature covers the timeframe from the early 2000s (Molele & Ncanywa, 2018; Lin et al 2014; Menyah and Wolde-Rufael,2010; Gasealahwe, 2020; Odhiambo, 2009). In this study, the

focus was from 2016 to 2023 only, which is significant looking at how the country has advanced and lacked in the same period in some areas. Particularly looking at how the current government struggled to take control of high electricity prices and electricity rationing and how the situation worsened between the time frame from 2016 to 2023 than in the early 2000s. The export of coal accelerated in the same period of the study even though power supply is still a concern. Thus, dealing with a recent year span can give a clearer directive on the future of South Africa.

Therefore, the aim of the study is to investigate the role of electricity consumption, price and coal exports on the economic growth of South Africa. Thus, the objectives are to determine the impact of electricity consumption and price on economic growth, investigate the effect of coal exports on economic growth, determine any existing causality among the variables, and lastly forecast the behaviour of economic growth from shock effects of electricity consumption, price, and coal exports. The study proceeds with a literature review, methodology, results, and finally, conclusion and recommendations.

LITERATURE REVIEW

It is believed that economists and researchers have been attempting to establish the energy-growth nexus over the years (Menegaki, 2018; Acheampong et al, 2021). These studies have utilized various theories and research methods to explore this relationship. This study adopts four theories to further comprehend the relationship inclusive of coal exports and electricity price. The first theory is the Solow growth model (1956) which is an important framework for comprehending long-term economic growth, as it highlights the significance of capital accumulation, labour, and technological progress. The export-led growth hypothesis (ELGH) is the second theory which rests on the notion that the expansion of exports is a key factor in promoting economic growth. The third theory is the resource curse theory. It simply states that economies abundant in resources, particularly minerals and fuels, may encounter economic challenges that prevent them from deriving significant benefits from their resource wealth.

The relationship between energy and growth over the years has yielded conflicting results. For example, the results of Raheem and Yusuf (2015) who employed the ARDL methodology and Molele and Ncanywa (2018) who employed the VECM approach found a negative relationship between electricity consumption and economic growth. While Faisal et al (2017) found a positive correlation between economic growth and energy consumption. The study of Berk and Yetkiner (2014) who employed the ARDL methodology revealed an inverse significant impact of energy prices on GDP per capita. Sunde (2017) employed the ARDL approach to investigate the relationship between foreign direct investment, exports and economic growth in South Africa. The results were that exports and economic growth are positively correlated in both the short and long run.

The study conducted in China by Rathnayaka *et al* (2018) found that energy consumption and economic growth have a bi-directional Granger causality in the long run. However, the results of Faisal *et al* (2017) indicate a unidirectional causal relationship spurring from GDP to energy consumption. Whereas Phiri and Nyoni (2015) found no causality between electricity consumption and economic growth. Sunde (2017) employed the VECM Granger causality, and the results showed that there is a bidirectional causality between economic growth and exports. A study in Benin employed the asymmetric approach and demonstrated that negative shock effects from electricity consumption cause negative shocks on real GDP (Dakpogan & Smit, 2018). The study of Antonakakis et al (2017) used the Impulse response function and found that a positive change in electricity consumption has a stronger relative impact on economic growth.

RESEARCH METHODOLOGY

Data

This study employs quantitative research methodology. Quarterly data spanning from 2016 quarter 1 to 2023 quarter 3, comprising 31 observations, will be collected from Quantec for this study.

Model Specification

Empirically, electricity consumption and price can be linked to economic growth (Abbasi et al, 2021). On the other hand, Bohlmann et al (2019) suggest that there is a link between coal exports and South Africa's economic growth. Thus, the functional model for economic growth can be written as:

$$GDP_t = f(EC_t, Elec\_Price_t, CoalExp_t) \quad (1)$$

Thus, the econometric equation can be presented as follows:

$$LGDP_t = \beta_0 + \beta_1 LEC_t + \beta_2 Elec\ Price_t + \beta_3 Coal\ Exp_t + \varepsilon_t \quad (2)$$

Where GDP is a proxy for economic growth, EC represents electricity consumption, Elec Price stands for consumer price index for electricity and Coal Exp represents an index for coal exports. L represents the natural logarithm of the variables, the residual ε_t is assumed to be normally distributed and white noise and symbols $\beta_1\beta_2\beta_3$ are the coefficients of the estimated model. Only GDP and electricity consumption are in logarithm form so that the estimated coefficients can be standardized.

Estimation techniques

The estimation techniques include correlation analysis, followed by unit root/stationarity test, cointegration test, and ARDL for long and short-run analysis. Additionally, the data collection will undergo further causality, diagnostic, and stability tests.

Correlation analysis

According to Gogtay and Thatte (2017), the significance of correlation analysis lies in its ability to reveal relationships and quantify the degree of association between variables, aiding in understanding patterns and trends with the sampled data set. Essentially, the correlation coefficient will range between -1 and +1 to reveal the strength and the direction of the relationship (Senthilnathan, 2019).

Unit root test

Pesaran *et al* (2001) highlighted the importance of testing the variables for stationarity before determining their relationship in the long run. Either I (1) or I (0) must be the order in which the variables are integrated. When a variable is integrated at order I (0), it indicates that the variable is stationary at level form. For variables integrating at order I (1), this means that the variable is non-stationary at level but becomes stationary after taking the first difference. The study employs the Augmented Dickey-Fuller test to determine whether the data set is stationary (ADF, 1981). The outcomes of the ADF test will be corroborated using the Phillips-Perron test (PP, 1988). Granger and Newbold (1974) assert that the stationarity tests will assist us in preventing erroneous causality results.

ARDL Model Approach

Pesaran and Shin (1999) introduced a method called the Auto Regressive Distributed Lag approach (ARDL), which has become increasingly popular in recent times. This paper will utilize the ARDL technique to estimate the long-run and short-run relationship among the variables. This technique will therefore answer the first two study objectives. The first step is to determine if there is a long-term connection among the variables. This study employs the ARDL bounds test for cointegration which adopts the style of ADF testing, as it is based on unit root testing.

With the use of this test, precise economic decisions can be made considering the findings of cointegration testing. The advantage of using the ARDL bounds test is that both short-run and long-run relationships are captured simultaneously and the ability to incorporate small sample-sized data as well as mixed order of integration of variables. There are two bounds in the cointegration bounds test: the lower bound (I0) and the upper bound (I1). The estimated F-statistic must be significantly greater than the upper bound to reject the null hypothesis of no cointegration, according to the principles of this test. The null hypothesis of the bounds test of no cointegration is defined by the following:

$$H_0: \delta_1 = \delta_2 = \delta_3 = 0 \quad (3)$$

The alternative hypothesis of cointegration is defined by:

$$H_0: \delta_1 \neq \delta_2 \neq \delta_3 \neq 0 \quad (4)$$

The ARDL model can be expressed mathematically as:

$$\Delta Y_t = \beta + \sum_{i=1}^{n} \beta_{0i}\Delta Y_{t-i} + \sum_{i=0}^{n} \beta_{1i}X_{1_{t-i}} + \sum_{i=0}^{n} \beta_{2i}X_{2_{t-i}} + + \sum_{i=0}^{n} \beta_{3i}X_{3_{t-i}} + \delta_1 X_{1_{t-1}} + \delta_2 X_{2_{t-1}} + \delta_3 X_{3_{t-1}} + \varepsilon_t \quad (5)$$

Where, ΔY_t is a vector, α_0 is a constant, β_1 , $\beta_2$and β_3 are short-run coefficients, δ_1 , δ_2 and δ_3 are long-run coefficients, and ε_t represents the error term. The subsequent step involves estimating the short-term error correction model (ECM). The ECM evaluates the speed of adjustment and the convergence of variables in the dataset towards long-term equilibrium. The error correction coefficient must be negative and significant to guarantee the convergence of the long-run equilibrium dynamics. This is specified as:

$$\Delta LGDP_t + \beta + \sum_{i=1}^{n} \beta_{0i}\Delta LGDP_{t-i} + \sum_{i=1}^{n} \beta_{1i}\Delta LEC_{t-i} + \sum_{i=1}^{n} \beta_{2i}\Delta ELEC\_PRICE_{t-i} + \sum_{i=1}^{n} \beta_{3i}\Delta COAL\_EXP_{t-i} + \delta ECM_{t-1} + \varepsilon_t \quad (6)$$

Where ECM_{t-1} is the lagged error correction term.

Granger Causality test

Causality as defined by Granger (1980) means that some past values of a time series have some information about another. According to Granger (1969), Granger causality between two variables cannot be taken as a true causal relationship but rather suggests that one variable may assist in predicting the other better. The test involves estimating the following regression models for Y and X:

$$Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=1}^{q} \beta_j X_{t-j} + \varepsilon_t \quad (7)$$

$$X_t = \gamma_0 + \sum_{i=1}^{p} \gamma_i X_{t-i} + \sum_{j=1}^{q} \delta_j Y_{t-j} + \varepsilon_t \quad (8)$$

The null hypothesis for the Granger causality test is that the coefficients of the lagged values of X in the first model are zero, $(\beta_j = 0)$ for all j values. This means that X does not granger-cause Y. Similarly, the null hypothesis for the second model is that the coefficients of the lagged values of Y are zero, $(\delta_j = 0)$ for all j values. Therefore, Y does not granger-cause X. There are four possible directions of causality: unidirectional causality running from X to Y, Unidirectional causality running from Y to X, bidirectional causality, and no causal relationship.

Diagnostic tests

The reliability and robustness of the model will be validated using various diagnostic tests, including the Normality test, Serial Correlation test, and the Heteroskedasticity tests. These tests will be carried out using EViews version 12.

Stability tests

To validate the stability of the model, this study employed the Cumulative Sum (CUSUM) and Cumulative Sum of squares (CUSUM of squares) of recursive residuals as there is a possibility of instability. This helps detect any structural breaks in the model and hence, leads to accurate forecasting. CUSUM and CUSUM of squares are tested through visual inspection. The CUSUM line must fluctuate within the 5% line of significance for the model to be deemed stable for the given period.

Empirical Results and Discussion

The study performed the correlation analysis to reveal the degree of association between variables. The results are displayed in Table 1 below.

Table 1: Correlation analysis

	LGDP	LEC	ELEC_PRICE	COAL_EXP
LGDP	1			
LEC	0.1852	1		
ELEC_PRICE	0.2303	-0.6666	1	
COAL_EXP	0.3542	-0.1573	0.5286	1

Source: Author's computation using EViews 12

According to the results, there is a weak positive correlation between electricity consumption and GDP. Electricity price also exhibits a weak positive correlation with GDP. The findings indicate that high electricity consumption and price will boost economic growth. However, the study of Takentsi et al (2022) revealed a weak negative relationship between electricity prices and economic growth. The results further reveal a moderate positive correlation between coal exports and economic growth, implying that as coal exports increase so does economic growth. Additionally, the findings show a moderate negative correlation between electricity price and electricity consumption and a weak negative correlation between coal exports and electricity consumption. Lastly, a moderate positive correlation exists between coal exports and electricity price. Hence, multicollinearity is not a concern. The study employed the ADF test to check unit root, and the results were confirmed using the PP test in Table 2.

Table 2: Unit root test.

Order of integration	Variable	ADF		PP-test	
		Intercept	Trend and intercept	Intercept	Trend and intercept
Level	LGDP	-4.1177***	-4.1628**	-4.1177***	-4.1628***
1st difference	LGDP	-7.9399***	-7.7940***	-19.335***	-19.6762***
Level	LEC	-2.6185	-4.6824***	-2.6185	-4.2994
1st difference	LEC	-7.7855***	-7.7085***	-11.7151***	-12.8055***

Level	Elec Price	5.1884	-0.1235	4.1354	-1.4924
1st difference	Elec Price	-0.3275	-1.8307	-5.1338***	-7.1268***
Level	Coal Exp	-2.3149	-2.4598	-2.3529	-2.6007
1st difference	Coal Exp	-4.8758***	-4.8181***	-4.9644***	-4.9423***

Note: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively.
Source: Author's computations using EViews 12.

The results indicate that the GDP is stationary at both the level and the first difference. In addition, electricity consumption is stationary at the first difference. The Phillips Perron test confirms that electricity price is stationary at the first difference, while coal exports is also deemed to be stationary at the first difference. In essence, GDP integrates at order I (0) while electricity consumption, price, and Coal Exports integrate at order I (1). Therefore, since the model consists of a mixed order of integration I (0) and I (1), ARDL is the right model to check for cointegration among the variables. The results of the cointegration test are shown in Table 3 below.

Table 3: ARDL cointegration test (Bounds test).

Test Statistic	Value	K
F-statistic	9.779121	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	3.47	4.45
5%	4.01	5.07
2.5%	4.52	5.62
1%	5.17	6.36

Source: Author's computations using EViews 12

The results of the bounds cointegration test are presented in Table 2. These results indicate that the computed f-statistic of 9.7791 exceeds the lower bound critical values at all levels of significance and exceeds the upper bound critical values at all levels of significance. Therefore, there is sufficient evidence to confirm cointegration in the set model.

Table 4: ARDL long-run results

Variable	Coefficient	Std. Error	T-stat	Prob
LEC	2.277678	0.4366	5.2156	0.0000
ELEC_PRICE	0.004961	0.0010	4.6103	0.0002
COAL_EXP	-0.000314	0.0001	-2.7525	0.0127

Source: Author's computations using EViews 12

According to the findings, LEC and LGDP have a positive long-term relationship that is significant at 1%. So, the gross domestic product of South Africa will rise by 2.2776% for every 1% increase in electricity consumption, ceteris paribus. The findings are in line with the Solow growth model wherein electricity consumption, through the total factor productivity (TFP), influences economic growth. According to Chirwa and Odhiambo (2020), electricity consumption promotes the production of goods and services thus leading to economic expansion or growth. The findings support the study of Opeyemi and Paul-Francois (2019) confirming the observations. South Africa faces challenges such as electricity supply shortages and frequent load-shedding. These issues hinder economic growth by reducing productivity, increasing operating costs, and discouraging investment. Thus, increased and reliable electricity consumption is crucial for South Africa's economic growth as it drives industrial activity, fosters innovation, and supports the expansion of infrastructure. Addressing the current energy challenges is key to unlocking the country's full potential for economic growth.

The findings further illustrate a positive long-term relationship between electricity price and LGDP. The relationship is statistically significant at a 1% level. Thus, a 1% rise in the price of electricity would cause a 0.0049% boost in economic growth, ceteris paribus. The findings contradict the Solow growth model, which suggests that an increase in electricity prices adversely affects capital accumulation, a key factor for driving economic growth. Additionally, these findings contradict those of Khobai et al (2017) and Takentsi et al (2022), who indicated that prices of electricity have a detrimental long-term influence on economic growth. Nonetheless, the coefficient is rather small, signifying the almost zero elasticity of GDP response. While lower prices are beneficial, South Africa has endured high electricity prices due to factors like inefficiencies in the state-owned utility ESKOM and reliance on aging coal plants. Thus, affordable and stable electricity prices will allow South African companies, particularly in sectors like mining and manufacturing, to produce goods at lower costs.

At a 5% significance level, it was discovered that coal exports had an adverse relationship with LGDP in the long run. When coal exports rise by 1%, economic growth will decrease by 0.0003%, ceteris paribus. The findings contravene the export-led growth theory as the expansion of coal exports has not led to significant benefits for the nation. The results support the resource curse hypothesis introduced in 1993 by Auty Richard. Despite South Africa's abundant coal reserves, the country is still experiencing severe electricity rationing and high electricity prices. According to Makgetla and Patel (2021), coal exports have not yielded strong economic benefits due to the declining demand for coal globally. This was a consequence of the global technological shift that prioritized renewable energy sources for electricity production. Hence, coal exports became increasingly uncompetitive internationally. Thus, stakeholders are advised to reduce the exportation of coal to increase electricity generation and consumption within the country. Excess supply of coal reserves has the potential to reduce electricity rationing and escalating electricity prices that the country is facing. This strategy will benefit the economic prognosis of South Africa.

Table 5: Short-run and ECM Results

Unrestricted constant and unrestricted trend

Variable	Coefficient	Std. Error	t-stat	Prob
C	-4.4719	0.6641	-6.7334	0.0000
@TREND	-0.0037	0.0058	-6.4106	0.0000
D(LEC)	1.2117	0.1312	9.2321	0.0000
D(LEC (-1))	-0.4497	0.1325	-3.3945	0.0030
D(ELEC_PRICE)	-0.0004	0.0006	-0.8172	0.4239
D(ELEC_PRICE (-1))	-0.00032	0.0012	-2.6327	0.0164
CointEq (-1)*	-1.0022	0.1489	-6.7299	0.0000

Source: Author's own computation using EViews 12

In the short run electricity consumption maintained a positive relationship with LGDP at a 1% significance level. This means that a 1% increase in electricity consumption translates to a 1.2117% improvement in economic growth, ceteris paribus. The results are in line with the findings of Badamasi (2023), who found that electricity consumption positively impacts economic growth in the short and long run. Furthermore, the results indicate a negative, yet insignificant relationship between electricity price and LGDP in the short run. An increase of 1% in electricity prices is associated with a decline of 0.0004 in the rate of economic expansion. Although the relationship is insignificant, the coefficient is too small implying a zero elasticity of electricity price to LGDP.

On the other hand, coal exports did not exhibit any short-run estimation. Perhaps given the set model estimation coal is not fundamentally producing estimates worth noting. The coefficient of the cointegration equation (-1.0022) is negative as required and statistically significant at all levels. The cointegration vector shows that a short-term deviation from the long-term equilibrium is corrected by 100.22% quarterly. The ECT results align with those of Golder et al (2022), who studied the nexus between finance and growth in Bangladesh using the ARDL model. The cointegration equation above -1 indicates that the GDP model returns to long-run equilibrium relatively quickly. Table 6 presents the Granger causality results.

Table 6: Pairwise Granger Causality Test

Null hypothesis	f-statistics	P-value
LEC does not granger cause LGDP	0.0762	0.9268
LGDP does not granger cause LEC	3.9218	0.0336
ELEC_PRICE does not granger cause LEC	12.3507	0.0002
LEC does not granger cause ELEC_PRICE	7.5121	0.0029

Source: Author's computations using EViews 12

The results obtained reveal a unidirectional causality running from GDP to electricity consumption. This implies GDP can be used to predict electricity consumption. The results are congruent with those reported by Yusuf (2018) and Khabai (2017). As such, a high rate of economic growth would be accompanied by increased consumption of electricity. Typically, as the production of businesses increases due to economic growth, more energy will be required to sustain growth and thus the consumption of electricity will increase. Additionally, the Granger Causality outcomes demonstrated a bidirectional causality involving electricity price and electricity consumption. So, electricity consumption does not only influence electricity price, but electricity price also affects electricity consumption. When electricity consumption increases, demand for electricity then may exceed the supply capacity, which leads to higher electricity prices. Conversely, when electricity prices are high, consumers and businesses may reduce their electricity consumption to lower their energy bills thus lowering the productivity rate. This study conducted diagnostic tests to validate the model's reliability and robustness. Table 7 presents the results.

Table 7: Diagnostic tests

Item	Applied test	Null Hypothesis	p-value	Decision
Normality	JarquaBera	Variables are normally distributed	0.2405	We fail to reject H_0, the residuals are normally distributed
Serial correlation	LM test	No autoregressive serial correlation	0.8882	We fail to reject H_0, there is no serial correlation among variables.
Heteroskedasticity	Breusch pagan Godfrey	No heteroskedasticity	0.2525	We fail to reject H_0, there is no heteroscedasticity
Heteroskedasticity	Harvey	No heteroskedasticity	0.6424	We fail to reject H_0, there is no heteroscedasticity

Source: Author's computations using EViews 12.

Based on the results, we cannot reject the null hypothesis that there is no autocorrelation and heteroscedasticity. Additionally, the residuals follow a normal distribution, not serial correlation and heteroskedasticity concerns.

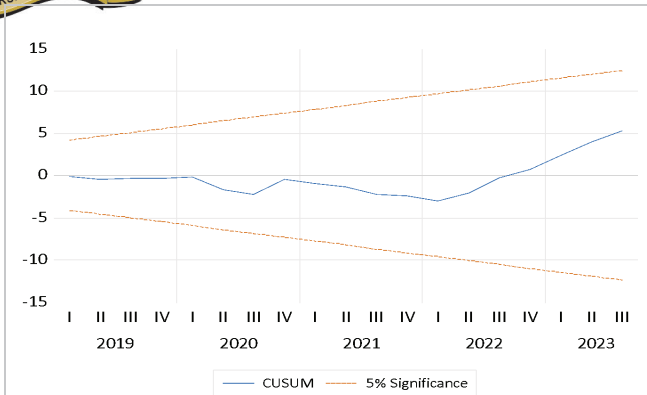

FIGURE 1: CUSUM TEST

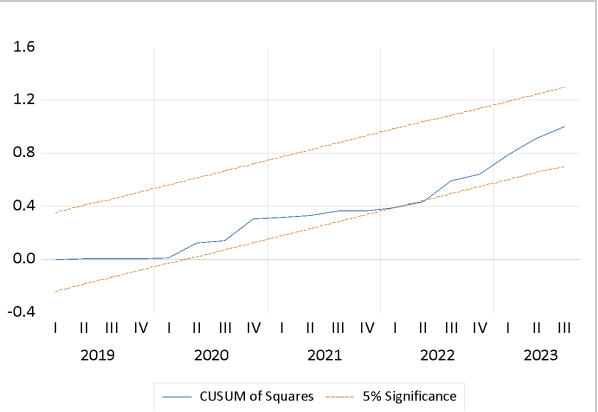

FIGURE 2: CUSUM OF SQUARES TEST

Source: Author's computations using EViews 12

Based on the CUSUM test in Figure 1, the model appears to be stable as the CUSUM line fluctuates within the 5% significance line for the given period. As for the CUSUM of squares test in Figure 2, the model is stable as the CUSUM line fluctuates within the 5% significance line. Although the CUSUM line touched the 5% line, it did not exceed it.

CONCLUSION

This study examined the role of electricity consumption, electricity price, and coal exports on the economic growth of South Africa for the period 2016Q1 to 2023Q3. The research outcomes of this study can be used to inform energy policy decisions, fostering the development of strategies that promote economic growth while ensuring sustainable energy practices. The study further adds to the academic literature by contributing both empirical evidence and theoretical advancements. This study adopted the ARDL methodology. The ARDL bounds cointegration test revealed a long-term connection between electricity consumption, price, and coal exports.

The ARDL results revealed that electricity consumption and price had a positive influence on economic growth in the long run, while coal exports had a negative impact. The results are in line with the apriori expectation, where an electricity consumption increase implies an expansion of economic production. Whereas the country's wealth of coal has not led to significant benefits for the nation, which is concerning given the country's frequent load shedding. Economic expansion requires a reliable electricity source. In the short run, electricity consumption maintained a positive relationship with economic growth. However, there was a negative yet insignificant relationship between electricity price and economic growth.

The Granger causality test was employed to determine if one variable may be used to predict another. The results indicated a unidirectional causality from GDP to electricity consumption. These results were consistent with the findings of Yusuf (2018) and Khabai (2017), confirming that economic growth spurred electricity consumption, but not vice versa. As the economy expands, electricity consumption increases due to increased industrial activity, greater demand for services, and rising energy needs for both households and businesses. Additionally, the outcomes revealed a bidirectional causality running from electricity price to electricity consumption and vice versa. This is to say that electricity consumption and price have a mutual influence. Increased electricity consumption signals high demand, which therefore leads to higher electricity prices due to supply constraints. Conversely, when electricity prices rise substantially, consumers may reduce their electricity consumption in response to the higher costs. Finally, the Granger causality outcomes revealed the non-existence of a causal association between coal exports and economic growth. Thus, economic growth and coal exports cannot be predicted from one another.

According to the study, there is a substantial positive correlation between economic growth and electricity consumption over the long and short run. This suggests that a robust and reliable supply of electricity is crucial to promote the efficient output of goods and services, leading to economic expansion. In light of these findings, the study recommends that the government take proactive steps to diversify the country's energy mix. In addition to maintaining the conventional usage of coal for electricity generation, it is critical to promote the advancement of renewable energy projects including solar, wind, and hydroelectric power. By investing in these renewable resources, the government can enhance the overall electricity supply, making it more sustainable and reliable. Furthermore, broadening the energy mix will support international initiatives to minimize greenhouse gas emissions and fight climate change while also reducing reliance on fossil fuels. Implementing a more diverse energy strategy will contribute to the stability of the energy sector and provide long-lasting benefits to the economy. Ultimately, prioritizing renewable energy sources will help ensure that the country can meet its energy needs while fostering economic growth and sustainability for future generations.

Additionally, the findings revealed a positive relationship between electricity price and economic growth. The coefficient is however small, signifying minimal response of GDP to changes in electricity price. High electricity prices remain a burden for both consumers and producers. The study therefore recommends implementing smart grid technology to enhance energy management, reduce transmission losses, and improve the overall efficiency of electricity distribution. This approach can help prevent unnecessary costs from being passed on to consumers through elevated electricity prices. Additionally, strengthening governance and financial management within the electricity sector is essential for stabilizing electricity prices. Addressing issues such as corruption and enhancing financial sustainability within Eskom, while also enforcing transparent procurement processes, can help prevent the cost escalations that are frequently transferred to consumers.

The study further established a negative relationship between coal exports and economic growth in the long run. Since in South Africa coal remains a crucial component of electricity production, the study suggests that diverting coal resources from export markets to domestic electricity generation can yield economic benefits. This would ensure a more stable and sufficient supply for power generation, thereby mitigating load shedding across the country. Increased electricity availability would, in turn, stimulate economic activities, attract investment, and support business expansion, leading to long-term economic growth. To implement this strategy effectively, the government should introduce policies that incentivize coal suppliers to prioritize local power plants over export markets. This can be achieved through regulatory measures such as export levies and quotas or negotiated agreements with coal producers. Nonetheless, the use of both green energy and coal can coexist as relayed above.

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