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Article

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An Analysis of Electricity Generation, Supply, and Economic Growth in Selected SADC Countries

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ABSTRACT

The study analysed electricity generation, supply, and economic growth in selected SADC countries. The study utilised panel data spanning from 1990 to 2020 collected from secondary sources such as the World Bank and International Energy Agency. The study conducted unit root tests, cointegration tests, optimal lags length criterion, panel ARDL, Dumitrescu-Hurlin causality and residual diagnostics tests. The results revealed that in the short run, electricity generation and supply are insignificant determinants of economic growth. However, in the long run, electricity generation and supply are significant determinants of economic growth in selected SADC countries. The study recommends restructuring and maintaining electricity generation facilities to boost economic growth in the region.

Keywords: Electricity Generation, Electricity Supply, Economic Growth, PARDL, SADC
JEL Classifications: C1, Q41, Q43

1. INTRODUCTION

Historically, electricity has been generated from coal and water sources, which are referred to as thermal and hydroelectricity, respectively (Coridan et al., 2015). Due to lack of efficient electricity supply to satisfy rising demand, various electricity generation techniques such as gas, tidal power, and biomass have been deployed. On a worldwide scale, coal generates 36.7% of electricity, gas generates 23.5%, nuclear creates 10.4% of energy, hydropower generates 15.8%, wind generates 5.3%, solar generates 2.7%, and other renewables generate 2.5% (Ritchie and Roser, 2020). Due to lack of data on other SADC nations, this study focuses on the selected SADC countries, namely the Southern African Power Pool, the SADC country's power block.

Electricity is the backbone of the contemporary economy since it is required for transportation, information technology, banking and investment, water supply and sewage treatment services, telecommunications, national security, and the development of new technologies (Makansi, 2007). Almost all sectors of the economy today rely on energy for power and to carry out their everyday operations. Without power, an economy will most certainly grind to a halt. According to Lenoke (2017), a rise in the provision of services in economies leads to an increase in power consumption, which hinders economic growth in the end since oversupply leads to low production. Thus, electricity is critical for economic growth as well as many other elements of human development.

Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, United Republic of Tanzania, Zambia, and Zimbabwe comprise the Southern African Development Community (SADC), which was founded in Lusaka, Zambia in 1980. SADC's mission statement is to foster regional economic growth and socioeconomic development that is sustainable and equitable. Electricity generation is one of the most recent issues confronting SADC countries, as it accompanied by sluggish economic growth. Greater regional cooperation is gaining traction in diversifying SADC economies and strengthening international partnerships; however, heavy reliance on fossil fuels has been met with strong opposition to climate change, resulting in the need to commit to environmental standards affecting electricity generation (Mutanga and Simelane, 2015).

The SADC established the Southern African Power Pool (SAPP), which includes the following 12 member countries: Botswana, Mozambique, Malawi, Angola, South Africa, Lesotho, Namibia, the Democratic Republic of the Congo, Swaziland, Tanzania, Zambia, and Zimbabwe. According to SAPP (2021), the vision of the Southern African Power Pool is to: • Facilitate the development of a competitive electricity market in the SADC region; • Provide end users with a choice of electricity suppliers; • Ensure that the southern African region is the region of choice for investment by energy intensive users; and • Ensure sustainable energy developments through sound economic, environmental, and social practices.

In 2019, a total of 3 595 MW of generating capacity was added, up from 3 874 MW in 2018, with renewable energy accounting for approximately 16% of the additional power. Over the following 4 years, from 2020 to 2023, a total of 16 515 MW of generating capacity is projected to be added in the SAPP region, with 3 215MW installed in 2020. The installed power generation capacity of the area was 72 156 MW, with an additional 64 438 MW installed capacity for operational members exclusively. All members' operating generating capacity was 51 979 MW, while SAPP peak demand in 2020, including reserves, was 58 096 MW. All SAPP members had 397 MW of extra generating capacity, while all operational members had a shortfall of 1 904 MW. The thermal or coal generation mix currently accounts for 64% of the SAPP's generation mix, hydropower for 22%, solar PV for 4% and solar CSP for 1%, distillate for 4%, nuclear for 3%, wind for 266 MW, gas for 2%, biomass for 48 MW, and landfill for 21% (SAPP, 2021).

Southern Africa has numerous energy generation resources; however, it occasionally lacks growing capacity. Only 32% of rural areas have access to electricity. The SADC falls behind the rest of Africa in terms of electricity availability. Approximately half of the population in the region have access to electricity, which is comparable to Sub-Saharan Africa weighted average. The SADC region has been struggling with an electricity shortage since 2007 (SADC, 2022). Even though the shortage was supposed to be remedied by 2019, efforts to remedy it have gone behind schedule due to lack of funding. Coal accounts for 62% of Southern Africa's electricity output, but it also contributes to global warming.

Many research have been undertaken on the relationship between electricity consumption and economic growth but few studies have focused on the relationship between electricity generation, supply and economic growth. Mutanga and Simelane (2015), Schreiner and Baleta (2015), Mutambara (2013), and Mwale and Davidson (2013) all focus on electricity generation and economic integration in SADC, but none on the relationship between electricity generation, supply and economic growth, hence the relevance of this study is to analyse electricity generation, supply and economic growth in selected SADC countries. Most SADC countries are low-income developing countries that encounter several issues that impede economic growth. Recently, these nations experienced poor electricity generation and have fallen behind in terms of growing electricity generation, which is required for economic growth. SADC countries are experiencing limited economic growth due to lack of increased power generation.

The purpose of the study is to analyse electricity generation, supply, and economic growth in selected SADC countries, as well as what measures might be implemented because of the results. The study's findings will contribute to a better understanding of the impact of electricity generation, electricity supply, employment, trade, gross fixed capital formation, and CO_2 emissions in the economic growth of selected SADC nations, as well as suggestions. This research will assist SADC policymakers, investors, and governments in making decisions on electricity generation, supply, and economic growth in the SADC area.

2. LITERATURE REVIEW

This study's section includes both theoretical and empirical literature. The theoretical literature highlights economic growth theories, whilst the empirical literature provides an insight into the examination of electricity generation, supply, and economic growth in developed and emerging nations throughout the world. The empirical literature is a compilation of many researchers' journal and dissertation contributions.

2.1. Theoretical Literature

Hussein and Thirlwall (2000) highlights the Neoclassical growth model developed by Harrod (1939) and Domar (1946) as given in Domar et al. (1939) and Domar (1946). The model was later modified by Solow (1956) incorporating capital stock and labour as factors of production. Due to the weaknesses of the neoclassical growth model such as mainly concerned about developed countries and its policies and ideas having little relevance for under-developed countries, this study adopts the Endogenous growth theory that arose in response to the flaws and omissions in the Solow (1956) model. Lucas (1988) and Romer (1994) developed an endogenous growth model that focused on the role of human capital as the primary source of increasing returns and divergence in growth rates between developed and developing countries. It explains an economy's long run growth rate using endogenous factors rather than exogenous factors of neoclassical growth theory. Economists who believe the idea highlight the importance of the government providing incentives and subsidies to private-sector enterprises. It encourages businesses to invest in research and development so that they may continue to drive innovation.

Furthermore, the government should establish laws that assist entrepreneurs, resulting in the creation of new enterprises and jobs. Investments in infrastructure and manufacturing processes should also be undertaken to achieve production innovation. Intellectual property rights, such as copyrights and patents, provide incentives for firms to grow. Considering the analysis of electricity generation, supply and economic growth in selected SADC countries, this theory therefore is applicable since it promotes the development of infrastructure, research and development, education, capital, government participation, investment by private sector, and labour to increase economic growth in the region. In line with this study, improvement in the utilisation of these factors can help increase electricity generation and supply to align it with economic growth of selected SADC countries.

2.2. Empirical Literature

Studies from developed countries such as of Ciarreta and Zarraga (2010) and Marques et al. (2016) recommends the increase in electricity generation to boost economic growth with the aid of VAR and ARDL models in Spain and France respectively. Utilising the Ridge regression on time series data from 1989 to 2018, Solarin et al. (2021) reveals that coal energy plays a positive significant role on the growth Italian economy. Likewise, Kirikkaleli et al. (2021) found a positive correlation between nuclear energy and economic growth in United Kingdom with the aid of the Toda Yamamoto causality and wavelet coherence test. However, for the United States of America, Bhattacharya et al. (2016) and Hdom (2019) found a negative relationship between electricity consumption and economic growth utilising FMOLS and PARDL models respectively.

Alt and Kum (2013) found bidirectional causality running from economic growth to electricity while Keskin and Kara (2021) discovered causality running from electricity generation and consumption to economic growth in Turkey. Lean and Smyth (2010) evaluated the relationship between energy generation and Malaysian economic development from 1970 to 2018. The ARDL and Granger causality tests were used in the study to examine the relationship between the variables. The study's findings demonstrated a positive association between the variables, with unidirectional causality extending from economic growth to power generation. The authors suggest that power generation be reduced without negatively impacting Malaysian economic development. Tang and Tan (2013) discovered unidirectional causation going from economic growth to power generation in Malaysia from 1970 to 2013, and they urge more investment in electrical infrastructure to assure enough electricity supply.

2.3. Studies from Developing Countries

Rafindadi and Usman (2021) discovered that a positive shock to economic growth increases electricity consumption utilising an NARDL model in Brazil on data spanning from 1971 to 2014. Sami and Makun (2011) utilised the UECM model and discovered that exports and electricity consumption boosts economic growth in Brazil with the aid of borrowed time series data from 1971 to 2007. Through a granger causality test, Govindaraju and Tang (2013) found unidirectional causality running from economic growth to coal consumption in India from 1965 to 2009. Abbasi et al. (2021), Zeshan (2013), and Shahbaz and Feridun (2012) employed a DARDL, VECM, and log linear ARDL models respectively and discovered that electricity consumption positively influences economic growth in Pakistan and recommend better integration electricity generation and management with the planning of economic policies to increase economic growth. However, Luqman et al. (2021) with QARDL found negative relationship between electricity generation and economic growth in Pakistan.

Chang (2010), Wang et al. (2011), Cheng et al. (2013), and Cheng et al. (2019) all found that electricity generation and consumption positively influences economic growth in China supporting the electricity leg growth notion. It is no surprising, Tamba et al. (2017) discovers no causal relationships between electricity consumption and economic growth in Cameroon utilising VAR and Granger causality models. Supporting bigas development and economic viability in Benin, Mensah et al. (2021) highlights that the project could supply up to 2% of energy imported in 2016 in the country. Oryani et al. (2020) and Sarker and Alam (2010) utilised SVAR and VAR models and discovered that electricity generation and economic growth in Iran and Bangladesh respectively. With the aid of ARDL model, Elfaki et al. (2018) discovered a negative impact of electricity consumption on economic growth in Sudan with time series data from 1984 to 2014. The neutrality notion between electricity consumption and economic growth seems to gain momentum with the studies of Adeola (2019), Olanrele (2019), and Bekun et al. (2019) discovering no causal relationship between the variables in Nigeria.

2.4. Studies from SADC Region

Studies of Menyah and Wolde-Rufael (2010), Khobai et al. (2016), Khobai (2018), Khobai and Le Roux (2017), Sunde (2018), Stungwa et al. (2022), Hlongwane and Daw (2021a), Hlongwane and Daw (2021b), Hlongwane and Daw (2023), and Hlongwane et al. (2023) utilised the ARDL and ECM models in South Africa to analyse the relationship between electricity generation, consumption and economic growth. Majority of these studies found the positive relationship between the variables except the study of Menyah and Wolde-Rufael (2010). This means that electricity generation and consumption enhance economic growth. Scholars such as Khobai et al. (2016) utilised the VECM model and found that electricity supply boosts economic growth in South Africa on time series data spanning from 1990 to 2012 citing to the fact that models does not necessarily matter when it come to the relationship between the variables.

Adebola (2011), Amusa and Leshoro (2013), and Odhiambo (2021) utilised ARDL model while Mbulawa (2017), Chingoiro and Mbulawa (2017) and Sunde (2020) utilised a VECM and VAR models respectively to analyse the relationship between the variables in Botswana. These studies found a positive relationship and unidirectional causality between electricity consumption and economic growth emphasizing that electricity is important for the growth of an economy. Albiman et al. (2015) by employing VAR model on time series data from 1975 to 2013 in Tanzania found unidirectional causality between economic growth and electricity consumption recommending conservation of electricity. Tsaurai (2013), Chikoko et al. (2018), and Sunde (2020) utilised bi-variate causality, multivariate single step ECM and VAR models respectively, while Mhaka et al. (2020) and Samu et al. (2019) utilised DOLS model to examine the relationship between the variables in Zimbabwe. Only the study by Sunde (2020) non relationship between electricity consumption and economic growth in Zimbabwe. Willie (2016) by employing an ARDL model supports the notion that electricity consumption enhances economic growth in Zimbabwe with time series data spanning from 1980 to 2011.

De Vita et al. (2006), Kandenge (2010) and Sunde (2020) utilised ARDL-ECM and VAR models and found that electricity consumption positively enhances economic growth in Namibia with the exception of Sunde (2020) who found unidirectional causality running from economic growth to electricity consumption citing energy conservation policies. Isaiah et al. (2015) with the aid of the Kalman Filter Approach on time series data spanning from 1995 to 2012 found that economic growth is the main driver electricity consumption in Lesotho. Furthermore, the studies of Bildirici (2013), Nindi and Odhiambo (2014), Sharmin and Khan (2016), Bay (2018) and Huo and St Aubyn (2021) explored the relationship between electricity consumption and economic growth in Mozambique utilising ARDL, VECM and VAR models. Majority of these studies are of the view that electricity consumption enhances economic growth, while Ramadhan et al. (2016) with the aid of OLS model recommend an improvement in the sectors of electricity supply to maintain long run economic growth. Bennett (2014) and Magongo and Sacolo (2018) emphasizes on the policies that balance electricity supply and decentralised electricity generation to vulnerable areas in Eswatini. Solarin and Shahbaz (2013), Adebola (2012), and Solarin et al. (2016) utilised ARDL and VECM models to discover that electricity consumption boost economic growth in Angola. With the aid of ARDL, FMOLS and DOLS, Odhiambo (2014) and Merlin and Chen (2021) recommend generation of cheap electricity and investment in electricity infrastructure in DRC. Milanzi and Daw (2018) highlights that Malawi depend on electricity for manufacturing to boost economic growth while Sunde (2020) confirms the neutrality hypothesis of electricity consumption and economic growth in Zambia.

The study drew on research from journal articles, textbooks, and publications to uncover the link between power generation, supply, and economic development, while also including research on the intermittent variable of CO_2 emissions. The research has highlighted the linkages between electricity generation and supply on economic growth and discovered that supply has contributed favourably to economic growth whereas generation has not been sufficient in other SADC nations, where it contributes negatively. The bulk of the empirical evidence supported increased renewable power generation as a means of boosting economic growth. Because some of the studies use electricity use and generation as proxies for power supply, the study included studies that examined the link between electricity consumption and economic growth. To examine the association between the variables, several models such as ARDL, VECM, OLS, and panel estimation approaches were used. However, in this work, a panel ARDL model is used to evaluate the association between the variables. This will aid in determining the short and long-run effects, as well as the country-specific short-run effects discussed in the subsequent section.

3. METHODOLOGY

3.1. Model Specification

The study analyses electricity generation, supply, and economic growth in South Africa by utilising gross fixed capital formation, CO_2 emission, and trade as intermittent variables. The variables are transformed into logarithms to have same unit and avoid discrepancies. This study adopts a multivariate linear regression model used in the study of Khobai et al. (2017) to investigate if renewable electricity consumption drive economic growth in South Africa. This study therefore modifies this model to incorporate economic growth, electricity generation, electricity supply, CO_2 emissions, employment, trade, and gross fixed capital formation to achieve the objectives of the study. The modified model will also help addressing the gap of the adopted model while contributing to the future study as indicated in the study. Therefore, the model used in this study can be specified as follows:

$$LGDP_t = \alpha_1 + \alpha_{LELG}\ LELG_t + \alpha_{LELS}\ LELS_t + \alpha_{LCO2}\ LCO2_t + \alpha_{LEMP}\ LEMP_t + \alpha_{LTRA}\ LTRA_t + \alpha_{LGFCF}\ LGFCF_t + \varepsilon_t \quad (1)$$

Whereby, α_1 is the slope coefficient while α_2-α_7 refers to the slope coefficients of the regressors, LGDP if the natural logarithm of GDP per capita, LELG is the logged electricity generation, LELS is the logged electricity supply, L CO_2 is the logged CO_2 emissions, LEMP is the natural logarithm of employment level, LTRA is the natural logarithm of trade, LGFCF is the natural logarithm of gross fixed capital formation and ε_t is the error term.

3.2. Data Sources

The study utilised borrowed annual panel data from 1990 to 2020 collected from World Bank data for GDP per capita, employment level, gross fixed capital formation, trade and from International Energy Agency for electricity generation, electricity supply and CO_2 emissions. Countries are selected based on the availability data for the period understudy.

3.3. Data Analysis

The study conducts the formal unit root tests of Im-Pesaran-and-Shin (2003) test, Augmented Dickey-Fuller-Fisher, Phillips-Perron-Fisher test, Levin-Lin and Chu (2002) test. Unit root are done to avoid the issue of spurious regressions and determine the order of integration of variables used in the model. The study also performs the optimal legs length criterion to determine the optimal number of lags to deploy in the model. The study also performs cointegration tests to determine the presence of long run relationship between the variables through the tests of Kao (1999) and Pedroni (1999). The study adopts the panel autoregressive distributed lags (PARDL) model developed by Pesaran and Smith (1995) and later updated by Pesaran et al. (1999). This model was used in the studies of Zeraibi et al. (2021) and Azam et al. (2021) as highlighted in the literature review. Unlike standard panel ordinary least squares models, the PARDL permits intercepts, short run coefficients, and error variances to vary freely between groups while keeping long run coefficients constant. The PARDL model can be specified as given below:

$$\Delta y_{it} = \phi_i y_{i,t-1} + \lambda'_{ij}\ \chi_{i,t-j} + \sum_{j=1}^{p-1} \xi'_{ij} \Delta\gamma_{i,t-j} + \sum_{j=0}^{q-1} \beta'_{ij} \Delta\chi_{i,t-j} \delta'_{ij} + \varphi_i t + \varepsilon_{it} \quad (2)$$

Whereby, ϕ_i is the group specific speed of adjustment, λ'_{ij} is a vector of long run relationships, error correction term is given by

$y_{i,t-1} + \lambda'_{ij}\, \chi_{i,t-j}$ and ξ'_{ij}, β'_{ij} are short-run dynamic coefficients.

The study also performs the Dumitrescu and Hurlin (2012) panel causality test to check for causal relationships between the variables.

3.4. Diagnostics Tests

The study performs the residual diagnostics test of Jarque-Bera normality test, cross section independence test of Breusch and Pagan (1980), Pesaran et al. (2008) and Pesaran et al. (2004) dependence test.

4. RESULTS AND INTERPRETATION

4.1. Panel Unit Root Test

From Table 1 above, the study conducted the LLC, IPS and ADF-Fisher panel unit root test. The results of the LLC, IPS and ADF-Fisher at level form shows that LELG and LEMP are stationary when a constant is employed, while LEMP is not stationary when a constant and trend is employed. This means that LELG and LEMP are integrated of I(0). As a result, the study performs unit root at first difference as shown in Table 2 below.

The study performed the LLC, IPS, and ADF-Fisher panel unit root test at first difference, as shown in Table 2 above. When a constant and intercept and trend are used, the variables DLGDP, DLELG, DLELS, $DLCO_2$, DLEMP, DLTRA, and DLGFCF are stationary at the 1% level of significance when the IPS and ADF-Fisher panel unit root are used. This signifies that the variables are of higher order one, that is, I(1). The LLC results show that DLEMP and DLELS are not stationary when a constant is used, except for DLELS, which is stationary at the 10% level of significance when an intercept and deterministic trend are used. This means that while estimating the PARDL model for short- and long-term relationship of electricity generation and supply on economic growth in selected SADC nations from 1990 to 2020, the study will use an intercept and differenced variables. To assess for long term correlations between the variables, the study continues to conduct a panel cointegration test, as indicated in Section 4.2 below.

4.2. Cointegration Test

The results of the Pedroni residual cointegration test in Table 3 show that when the alternate hypothesis of common AR coefficients is used, the computed statistics of panel v-Statistic and panel rho-Statistic have probability values >5%, implying that the alternate hypothesis of cointegration between the variables is rejected. This implies that the model's variables have long-run relationships. The Kao residual cointegration test is still being utilized in the study, as seen in Table 4 below.

To prevent bias, the study used the Kao residual cointegration test, as stated in Table 4 above. The outcomes show a t-statistic of −6.184062 and a probability value of 0.0000. These findings show that the null hypothesis of no cointegration is rejected at the 1% level of significance, implying that there exist long-run linkages between power generation and supply and economic development in selected SADC nations from 1990 to 2020. This means that when the study predicts the short- and long-term relationships of electricity generation and supply on economic growth in selected SADC nations, the computed coefficients will be considered significant at the 1%, 5%, and 10% levels of significance.

4.3. Optimal Leg Length Criterion

The study used the optimal lags criteria for the dependent variable, as indicated in Table 5 above, and the findings show that the LR, FPE, AIC, SC, and HQ chose two lags. As a result, the research will use two delays for estimating the PARDL model for analysing energy generation, supply, and economic growth in selected SADC nations from 1990 to 2020.

Table 1: Panel unit root test at level form

Variable	Levi-Lin-Chu (2002)		Im-Pesaran-Shin (2003)		ADFuller-Fisher	
	Constant	Trend and intercept	Constant	Trend and intercept	Constant	Trend and intercept
LGDP	1.3888	3.0632	−3.083***	−0.2477	49.810***	27.510
LELG	−0.795	0.2403	0.5490	0.7010	21.993	25.130
LELS	−1.478*	6.1926	0.4715	4.1966	18.791	9.8843
LCO_2	−0.530	1.5048	0.2425	1.0478	18.329	15.008
LEMP	70.020	124.32	3.9925	4.0130	8.5433	9.4714
LTRA	−0.389	−1.375*	−0.907	−1.898**	30.176	37.042**
LGFCF	−1.581*	−0.705	−2.392***	−0.971	43.279	27.551

Source: Authors' computation (***), (**) and (*) significance at 1%, 5% and 10%

Table 2: Panel unit root at first difference

Variables	Levi-Lin-Chu (2002)		Im-Pesaran-Shin (2003)		ADFuller-Fisher	
	Constant	Trend and intercept	Constant	Trend and intercept	Constant	Trend and intercept
DLGDP	−9.099***	−8.015***	−15.62***	−15.57***	228.83***	225.59***
DLELG	−6.781***	−6.137***	−9.507***	−8.602***	133.72***	112.51***
DLELS	2.9233	5.3651	−6.521***	−5.520***	94.015***	76.572***
$DLCO_2$	−4.677***	−3.808***	−8.656***	−7.427***	119.09***	96.752***
DLEMP	260.91	307.25	−2.286**	0.042	59.117***	44.713***
DLTRA	−6.904***	−4.517***	−9.881***	−7.895***	137.75***	102.76***
DLGFCF	−8.564***	−7.469***	−10.17***	−8.184***	142.30***	106.16***

Source: Authors' computation (***), (**) and (*) significance at 1%, 5% and 10%

The VAR optimum lags selection for explanatory variables was carried out in the study, as indicated in Table 6 above. The findings show that for DLELG, DLELS, DLEMP, and DLTRA, one lag will be used, $DLCO_2$ will use zero lags, and DLGCF will use two lags based on a comparison of the AIC and SC criteria values and selecting the minimum value of 6.114106 for the AIC criterion. As a result, we may deduce that the PARDL model used in this model will be ARDL (2,1,1,0,1,1,2). These delays will be used to determine both short and long run coefficients for analysing electricity generation, supply, and economic growth in chosen SADC nations.

Table 3: Pedroni residual cointegration test

Method: Pedroni Residual Cointegration test		
Alternate hypothesis: Common AR coefficients (within-dimension)		
	Statistic	Probability
Panel v-statistic	−2.434662	0.9925
Panel rho-statistic	−2.012476	0.0221
Panel PP-statistic	−19.52613	0.0000
Panel ADF-statistic	−7.779112	0.0000
Alternative hypothesis: Individual AR coefficients (between dimension)		
Group rho-statistic	−0.895126	0.1854
Group PP-statistic	−24.59202	0.0000
Group ADF-statistic	−7.798373	0.0000

Authors' computation

Table 4: Kao residual cointegration test

Method: Kao residual cointegration test		
ADF	t-Statistic	Probability
	−6.184062	0.0000
Residual	77.64386	
HAC variance	12.06332	

Source: Authors' computation

Table 5: Optimal leg dependent variable

VAR Lag order selection criteria						
Sample: 1990-2020						
Variable: DLGDP						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	−1034.039	N/A	27.74535	6.160945	6.172306	6.165474
1	−1005.142	57.45012	23.50033	5.994891	6.017612	6.003949
2	−995.7446	18.62654*	22.35459*	5.944908*	5.978990*	5.958494*

Source: Authors' computation

Table 6: Optimal leg independent variable

VAR lag order selection criteria						
Sample: 1990-2020						
Variable	Lag	LR	FPE	AIC	SC	HQ
DLELG	0	N/A	0.033658	−0.553618	−0.542002	−0.548983
	1	15.08355*	0.032325*	−0.594038*	−0.570805*	−0.584766*
	2	1.691317	0.032354	−0.593139	−0.558290	−0.579232
DLELS	0	N/A	0.014886	−1.369449	−1.358088	−1.364920
	1	5.801536*	0.014717*	−1.380866*	−1.358145*	−1.371809*
	2	0.165360	0.014798	−1.375410	−1.341329	−1.361825
$DLCO_2$	0	N/A	0.016657*	−1.257064*	−1.245704*	−1.252536*
	1	0.446218	0.016734	−1.252448	−1.229727	−1.243391
	2	0.288182	0.016819	−1.247361	−1.213280	−1.233775
DLEMP	0	N/A	0.623888	2.366092	2.377453	2.370621
	1	30.00541*	0.573688*	2.282208*	2.304929*	2.291265*
	2	0.022789	0.577074	2.288092	2.322173	2.301678
DLTRA	0	N/A	138.2887	7.767221	7.778581	7.771749
	1	14.69221*	133.1275*	7.729185*	7.751906*	7.738242*
	2	0.222412	133.8330	7.734469	7.768550	7.748055
DLGFCF	0	N/A	26.59911	6.118755	6.130115*	6.123283*
	1	0.218231	26.74044	6.124054	6.146775	6.133111
	2	5.294926*	26.47574*	6.114106*	6.148187	6.127691

Source: Authors' computation

4.4. Estimation of Short Run and Long Run Relationships in Selected SADC Countries

Table 7 above presents the results of the short run relationships estimated from the PARDL model to check if the effects of electricity generation and supply on economic growth will differ with those of the long run. The ECT terms are all negative and statistically significant indicating that error in economic growth is corrected towards long run equilibrium. The error correction terms are too sensitive for Lesotho (−2.3041), Mozambique (−2.4374) and Botswana (−1.9713), while reasonably for South Africa (−0.7924), Malawi (−0.6472) and DRC (−0.5428). These ECT terms are consistent with the prior expectations that they should be negative and statistically significant for a model to be reliable.

Furthermore, the short run effects of electricity generation are insignificant on all selected SADC countries' economic growth. However, the influence of electricity generation on economic growth is positive for Botswana, DRC, Malawi, Tanzania,

Table 7: PARDL and short run relationships in selected SADC countries

Dependent variable: DLGDP							
Method: ARDL							
Country	Variables						
	ECT(−1)	DLELG	DLELS	$DLCO_2$	DLEMP	DLTRA	DLGFCF
Angola	−1.4187***	−73.309	64.140	16.452	−2.1200	−0.1597***	−0.2266***
Botswana	−1.9713***	0.5154	−3.6666	1.5659	−0.5012**	0.2628***	0.4130***
DRC	−0.5428***	3.3776	6.0521	−6.3505*	−3.8515**	0.2611***	−0.0180***
Eswatini	−1.2154***	−3.7562	−4.4416	−2.0307	−6.2446	−0.0541***	−0.1334***
Lesotho	−2.3041***	−9.1423	5.5445	13.892	5.7781	0.1034***	0.6497***
Malawi	−0.6472***	15.661	−12.597	2.2011	114.93	0.0142***	0.1802***
Mozambique	−2.4374***	−0.3311	−3.8456	−0.4159	0.8853	−0.0794***	0.0871***
Namibia	−1.3167***	−0.5650	35.736	31.009	−1.3011**	0.1380***	0.0255
South Africa	−0.7924***	−99.586	121.58	8.4744	0.2140*	0.2172***	−0.085
Tanzania	−1.8175***	26.667	−29.396	−3.693	−2.2036**	0.0030*	0.0913***
Zambia	−1.4077***	25.790	−25.985	−8.9659	−2.1818***	−0.0509***	0.0081
Zimbabwe	−1.2725***	−1.3151	73.7039	−41.234	0.1938	0.0661**	0.1113*

Source: Authors' computation (***), (**) and (*) significance at 1%, 5% and 10%

and Zambia, while negative for Angola, Eswatini, Lesotho, Mozambique, Namibia, South Africa, and Zimbabwe. These results entail that for those countries where the influence of electricity generation is negative, electricity generation has not been enough to be able to boost economic growth for the period understudy. This calls for the governments of Angola, Eswatini, Lesotho, Mozambique, Namibia, South Africa, and Zimbabwe to revise their electricity generation policies so it can boost economic growth and reduce blackouts. These results are consistent with the studies of Solarin and Shahbaz (2013) and Adebola (2012).

Moreso, there is an insignificant short run relationship between electricity supply and economic growth for all selected SADC countries. However, even though the results are insignificant, the influence of electricity supply on economic growth is positive for Angola, DRC, Lesotho, Namibia, South Africa, and Zimbabwe meaning that electricity supply is crucial for growth of these economies. On the other hand, the impact of electricity supply is negative for Botswana, Eswatini, Malawi, Mozambique, Tanzania, and Zambia meaning that these countries need to revise their electricity supply policies so that they can have stable supply that boosts economic growth. These results are consistent with the studies of Solarin et al. (2016), Essah and Ofetotse (2014), Odhiambo (2021).

There is a negative statistically significant short run relationships between CO_2 emissions and economic growth in DRC. A 1% increase in CO_2 emissions in the short run in DRC significantly result in economic growth declining by 6.35%, ceteris paribus. This means that DRC need to take measures and policies that reduces CO_2 emissions to boost economic growth. The effects are insignificant for the other selected SADC countries. These results are consistent with the study of Hlongwane and Daw (2022a).

Moreover, a statistically significant relationship between employment and economic growth in Botswana, DRC, Namibia, South Africa, Tanzania, and Zambia. A 1% increase in employment significant result in 0.21% increase in economic growth in South Africa, ceteris paribus. However, a 1% increase in employment in the short run significantly in 0.5%, 3.85%, 1.30%, 2.20% and 2.18% decrease in economic growth in Botswana, DRC, Namibia, Tanzania, and Zambia respectively, ceteris paribus. These results entail that Botswana, DRC, Namibia, Tanzania, and Zambia needs to revise their employment policies so it can boost economic growth. These results are inconsistent with the results of Merlin and Chen (2021) that found a positive relationship.

Trade is the most significant determinant of economic growth in all the selected countries with only the difference being the negative or positive effects. A 1% increase in trade in the short run will significantly result in economic growth rising by 0.26%, 0.26%, 0.10%, 0.01%, 0.14%, 0.22%, 0.003%, and 0.06% in Botswana, DRC, Lesotho, Malawi, Namibia, South Africa, Tanzania, and Zimbabwe respectively, ceteris paribus. On the other hand, a 1% increase in trade will significantly result in economic growth declining by 0.16%, 0.05%, 0.08%, and 0.05% in Angola, Eswatini, Mozambique, and Tanzania respectively, ceteris paribus. These results entail that trade plays an important role on economic growth where its effects are positive while in countries where its effects are negative it means that these countries need to revise their trade policies to boost economic growth.

Investment is one of the variables encouraged by economists to boost economic growth in SADC countries recently. In this study, it was found that gross fixed capital formation has both significant and insignificant impact on economic growth in the selected SADC countries. A 1% increase in gross fixed capital formation in the short run significantly result in economic growth rising by 0.41%, 0.65%, 0.18%, 0.09%, 0.09% and 0.11% in Botswana, Lesotho, Malawi, Mozambique, Tanzania, and Zimbabwe respectively, ceteris paribus. These results are consistent with the study of Taele et al. (2012). This entail that investment is playing an important role on the growth of these economies. On the other hand, a 1% increase in gross fixed capital formation in the short run significantly result in economic growth declining by 0.23%, 0.02%, and 0.13% in Angola, DRC and Eswatini respectively, ceteris paribus. This entail the revision of investment policies so it can be able to boost economic growth.

According to the findings in Table 8, there is a statistically significant positive association between power generation and economic growth in a subset of SADC nations. A 1% increase in power generation translates in a 1.57% rise in economic growth, all else being equal. This means that power generation is critical to the growth of some SADC countries. These findings corroborate those of Khobai and Le Roux (2018), Stungwa et al. (2022), and Adebola (2011), who discovered a favourable association between energy generation and economic growth in South Africa and Botswana. These findings further support the endogenous growth hypothesis used in this study, emphasizing the necessity to expand power generation in order to improve economic growth.

The findings also demonstrate that in selected SADC nations, there is a negative statistically significant long run relationship between electricity supply and economic growth. A 1% increase in the supply of electricity results in a 3.48% decrease in economic growth, all else being equal. These findings imply that the electricity supply has not been adequate to support economic growth in the chosen SADC nations. These findings are both consistent and contradictory to those of Essah and Ofetotse (2014) and Khobai et al. (2016), who discovered a negative and positive relationship between electricity supply and economic growth in Botswana and South Africa, respectively, due to loadshedding and unstable electricity supply.

Furthermore, the findings show a statistically significant positive link between CO_2 emissions and economic growth in a subset of SADC nations from 1990 to 2020. A 1% rise in CO_2 emissions results in a 2.83% increase in economic growth, all else being equal. These findings imply that CO_2 emissions from heat and energy sources have a major impact on the growth of specific SADC nations. These findings contradict the findings of Hlongwane and Daw (2022a), who discovered a negative association between CO_2 emissions from power generation and South African economic growth.

Table 8: PARDL and long run relationships in selected SADC countries

Method: ARDL				
Dependent variable: DLGDP				
Variable	Coefficient	Std. Error	t-statistic	Probability
LELG	1.572467	0.649740	2.420149	0.0168
LELS	−3.483215	1.182913	−2.944608	0.0038
LCO_2	2.833766	0.962284	2.944833	0.0038
LEMP	0.716944	0.123263	5.816354	0.0000
LTRA	−0.042612	0.015099	−2.822267	0.0055
LGCFC	−0.065364	0.019733	−3.312454	0.0012

Source: Authors' computation (***), (**) and (*) significance at 1%, 5% and 10%

Furthermore, the findings show that there is a statistically significant association between the amount of employment and economic growth in a subset of SADC nations. A 1% increase in employment will result in an increase in economic growth of 0.72%, everything else being equal. These findings imply that a rise in employment or the number of persons employed is perfect for the prosperity of these SADC countries. This necessitates that the governments of these chosen SADC nations develop and execute policies that raise the amount of employment to promote the region's economic growth.

Table 8 also demonstrates a negative statistically significant long run relationship between gross fixed capital creation and economic growth in selected SADC countries from 1990 to 2020. A 1% increase in gross fixed capital creation will result in a 0.04% decline in economic growth in the chosen SADC nations, everything else being equal. These findings imply that gross fixed capital creation can increase economic growth in the long run, and this necessitates policymakers enacting policies that can result in gross fixed capital formation supporting economic growth in the region. According to endogenous growth theory, the governments of these countries must examine the nature of gross fixed capital formation in their economies to increase the capital stock required to increase electricity generation and supply in the region and boost economic growth. The findings are congruent with the findings of Khobai et al. (2016), who advocate for more investment in electrical supply infrastructure. As indicated in Section 5.3.8 of the study below, the study continues to perform panel causality correlations.

4.5. Estimation of Causal Relationship in Selected SADC Countries

The study used the Dumitrescu-Hurlin panel causality test, as shown in Table 9 above, to examine the causation relationship among the variables in the model using two lags, as used in the

Table 9: Dumitrescu-Hurlin panel causality tests

Pairwise Dumitrescu Hurlin Panel Causality Test			
Sample: 1990-2020			
Lags: 2			
Null hypothesis (Ho)	W-Stat	Zbar-Stat	Probability
DLELG does not homogeneously cause DLGDP	3.5354	1.8891	0.0589
DLGDP does not homogeneously cause DLELG	2.4372	0.3318	0.7401
DLELS does not homogeneously cause DLGDP	1.7033	−0.7002	0.4838
DLGDP does not homogeneously cause DLELS	1.9922	−0.2850	0.7756
$DLCO_2$ does not homogeneously cause DLGDP	2.5442	0.5085	0.6111
DLGDP does not homogeneously cause $DLCO_2$	3.2715	1.5538	0.1202
DLEMP does not homogeneously cause DLGDP	3.5256	1.9191	0.0550
DLGDP does not homogeneously cause DLEMP	2.1435	−0.0676	0.9461
DLTRA does not homogeneously cause DLGDP	3.9063	2.4663	0.0137
DLGDP does not homogeneously cause DLTRA	3.1680	1.4051	0.1600
DLGCFC does not homogeneously cause DLGDP	2.9585	1.1039	0.2696
DLGDP does not homogeneously cause DLGCFC	5.5373	4.8106	0.0000

Source: Authors' computation

Table 10: Jarque-bera residual normality test

Jarque-Bera normality test of residuals			
Null hypothesis: Residuals are normally distributed			
Sample: 1990 to 2020			
Test	Statistic	Probability	Decision
Jarque-Bera	447.7933	0.0000	Fail to accept Ho

Source: Authors' computation

Table 11: Cross section independence test

Cross-section dependence test			
Null hypothesis (Ho): No cross-section dependence (correlation)			
Sample: 1990-2020			
Test	Statistic	Probability	Decision
Breusch-Pagan LM	56.25431	0.7982	Fail to reject Ho
Pesaran scaled LM	−0.848254	0.3963	Fail to reject Ho
Bias-corrected scaled LM	−1.070476	0.2844	Fail to reject Ho
Pesaran CD	0.704731	0.4810	Fail to reject Ho

Source: Author's computation

PARDL model. The findings reveal that, at a 10% and 5% level of significance, electricity generation, level of employment, and trade affects economic growth and that the relationship between electricity generation and economic growth is unidirectional. These findings agree with those Tsaurai (2013), Sunde (2018), and Samu et al. (2019), who discovered unidirectional causation flowing from energy generation to economic growth. These findings imply that actions affecting energy generation in certain SADC nations will have a causal influence on economic growth. On the other hand, economic growth unidirectionally causes gross fixed capital formation in South Africa. This implies that economic growth is direly needed for attracting investment in the SADC region.

4.6. Residual Diagnostics Tests

According to the data in Table 10, the null hypothesis of residual normality fails to hold since the likelihood of the Jarque-Bera is significant at the 1% level of significance. This is predicted, as indicated by Papadopoulos (2013), because the panel is imbalanced due to missing observations in the data collected, and Oladele (2016) discovered non-normal residuals. To check for serial correlation, the study continues to execute the cross-sectional dependency test, as expressed in Section Table 11 below.

Table 11 displays the cross-section dependent tests with statistics >0.1 on all tests. This suggests that the null hypothesis of no cross-section dependency among the model's residuals was not rejected at the 0.01, 0.05, and 0.1 level of significance. As a result, the study indicates that the residuals are free of serial correlation and may be trusted. As a result, the study continues to provide stud conclusions, as demonstrated in Section 5 below.

5. CONCLUSION AND RECOMMENDATION

An analysis of electricity generation, supply and economic growth is selected SADC countries has been explored by employing a panel autoregressive distributed lags model on panel data spanning from 1990 to 2020. SADC region has been severely affected by poor electricity generation and unstable electricity supply that hampered economic growth. This study area has raised interest and debate among scholars, researchers, policymakers, and governments. The study utilised panel unit root tests to avoid spurious regressions, optimal lags model to determine the optimal number of lags to utilise in the model, cointegration tests to determine long run relationships and residual diagnostics tests to determine reliability of the results and avoid multicollinearities.

Based on empirical evidence, the study has formulated the following objectives. Firstly, restructuring and maintaining electricity generation facilities in the region. Countries such as Angola, Eswatini, Lesotho, Mozambique, Namibia, South Africa, and Zimbabwe need to build new reliable electricity generation power plants that will help generate enough electricity that can boost economic growth. Electricity generation power plants are old and lack proper and timeously maintenance hence there is a problem of electricity generation and power cuts. Some of the newly built power plants in South Africa are not yet fully operational due to technical defaults and lack of funds so that they may generate electricity and feed in the SADC grid.

Secondly, there is an essential change required in deregulating the electricity supply industry to meet the SAPP vision of a competitive electricity market and giving the end user a choice of electricity supplier. Currently, electricity supply industry is dominated by the state-controlled enterprises that need to be demonopolized to allow competition and efficiency in the supply of electricity. Reliable electricity supply has the advantage of allowing business owners access to online information and resources, increasing working hours, reducing costs on power, and expanding the number and variety of job opportunities available that boost economic growth.

Thirdly, there is a need to increase the pace of renewable energy sources and reducing CO_2 emissions. This calls for the government, policymakers, and private sector to work together to facilitate an increase in the pace of renewable electricity generation facilities. These renewable electricity generation facilities will help to smooth electricity generation in periods of droughts and wet weather where thermal and hydroelectric may not be sufficient to balance electricity demand respectively.

Fourthly, there is a need to promote an environment friendly for the creation of gross fixed capital formation. This call for the government and policymakers to revise policies on economic growth so that it can be able to help improve business confidence and create an environment favourable for capital formation. The current investment policies need to be reviewed and revised so we can have an increase in investment of electricity generation and supply infrastructure, information, and communication technology.

Fifthly, the study notes the revision of employment policies in selected SADC region so they can boost economic growth. The study analysed electricity generation, supply, and economic growth in selected SADC countries from 1990 to 2020 and discussed them in detail. The study achieved its objective through the deployment of a PARDL model and found that in the short run the influence of electricity generation and supply is insignificant while significant in the long run. The study therefore recommends that in the future, researchers must consider other models when conducting the same study.

REFERENCES

Abbasi, K.R., Shahbaz, M., Jiao, Z., Tufail, M. (2021), How energy consumption, industrial growth, urbanization, and CO_2 emissions affect economic growth in Pakistan? A novel dynamic ARDL simulations approach. Energy, 221, 119793.

Adebola, S.S. (2011), Electricity consumption and economic growth: Trivariate investigation in Botswana with capital formation. International Journal of Energy Economics and Policy, 1(2), 32-46.

Adebola, S.S. (2012), Electricity Consumption, Urbanisation and Economic Growth: Evidence from Angola. In. Proceedings of USM-AUT International Conference 2012 Sustainable Economic Development: Policies and Strategies. p753.

Adeola, I. (2019), Structural breaks, electricity generation and economic growth in Nigeria. Economics, 6(2), 170-177.

Albiman, M.M., Suleiman, N.N., Baka, H.O. (2015), The relationship between energy consumption, CO_2 emissions and economic growth in Tanzania. International Journal of Energy Sector Management, 9, 361-375.

Alt, H., Kum, M. (2013), Multivariate Granger causality between electricity generation, exports, prices and economic growth in Turkey. International Journal of Energy Economics and Policy, 3, 41-51.

Amusa, K., Leshoro, T.L. (2013), The relationship between electricity consumption and economic growth in Botswana. Corporate Ownership and Control, 10(4), 401-406.

Azam, A., Rafiq, M., Shafique, M., Yuan, J. (2021), Renewable electricity generation and economic growth nexus in developing countries: An ARDL approach. Economic Research-Ekonomska Istraživanja, 34(1), 2423-2446.

Bay, A. (2018), Energy consumption and economic growth nexus in Mozambique: 1975-2016. American Journal of Energy Research, 6(1), 19-22.

Bekun, F.V., Emir, F., Sarkodie, S.A. (2019), Another look at the relationship between energy consumption, carbon dioxide emissions, and economic growth in South Africa. Science of the Total Environment, 655, 759-765.

Bennett, M.S. (2014), Electricity consumption and economic growth in Swaziland. International Journal of Recent Research in Interdisciplinary Sciences (IJRRIS), 1(2), 1-12.

Bhattacharya, M., Paramati, S.R., Ozturk, I., Bhattacharya, S. (2016), The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. Applied Energy, 162, 733-741.

Bildirici, M.E. (2013), The analysis of relationship between economic growh and electricity consumption in Africa by ARDL method. Energy Economics Letters, 1(1), 1-14.

Breusch, T.S., Pagan, A.R. (1980), The Lagrange multiplier test and its applications to model specification in econometrics. The Review of Economic Studies, 47(1), 239-253.

Chang, C.C. (2010), A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. Applied Energy, 87(11), 3533-3537.

Cheng, S., Wu, Y., Chen, H., Chen, J., Song, M., Hou, W. (2019), Determinants of changes in electricity generation intensity among different power sectors. Energy Policy, 130, 389-408.

Cheng, Y.S., Wong, W.K., Woo, C.K. (2013), How much have electricity shortages hampered China's GDP growth? Energy Policy, 55, 369-373.

Chikoko, L., Ngundu, T., Kupeta, K. (2018), Economic growth and electricity consumption in a multivariate framework: A case of Zimbabwe 1980 to 2016. Acta Universitatis Danubius, OEconomica, 14(5), 20-33.

Chingoiro, S., Mbulawa, S. (2017), Electricity consumption and economic growth in Botswana: A vector error correction approach. Advances in Management and Applied Economics, 7(2), 105-120.

Ciarreta, A., Zarraga, A. (2010), Electricity consumption and economic growth in Spain. Applied Economics Letters, 17(14), 1417-1421.

Coridan, R.H., Nielander, A.C., Francis, S.A., McDowell, M.T., Dix, V., Chatman, S.M., Lewis, N.S. (2015), Methods for comparing the performance of energy-conversion systems for use in solar fuels and solar electricity generation. Energy and Environmental Science, 8(10), 2886-2901.

De Vita, G., Endresen, K., Hunt, L.C. (2006), An empirical analysis of energy demand in Namibia. Energy Policy, 34(18), 3447-3463.

Domar, E.D. (1946), Capital expansion, rate of growth, and employment. Econometrica Journal of the Econometric Society, 14, 137-147.

Domar, R.H.E., Recession, C., Depression, Д., Lagging, З. and Coincident, B. (1939), Economic Dynamics. LBC 65 P 17:68.

Dumitrescu, E.I., Hurlin, C. (2012), Testing for Granger non-causality in heterogeneous panels. Economic Modelling, 29(4), 1450-1460.

Elfaki, K.E., Poernomo, A., Anwar, N., Ahmad, A.A. (2018), Energy consumption and economic growth: Empirical evidence for Sudan. International Journal of Energy Economics and Policy, 8(5), 35-41.

Essah, E.A., Ofetotse, E.L. (2014), Energy supply, consumption and access dynamics in Botswana. Sustainable Cities and Society, 12, 76-84.

Govindaraju, V.C., Tang, C.F. (2013), The dynamic links between CO_2 emissions, economic growth and coal consumption in China and India. Applied Energy, 104, 310-318.

Harrod, R. (1939) An Essay in Dynamic Theory. Economic Journal, 49, 14-33.

Hdom, H.A. (2019), Examining carbon dioxide emissions, fossil and renewable electricity generation and economic growth: Evidence from a panel of South American countries. Renewable Energy, 139, 186-197.

Hlongwane, N.W., Daw, O.D. (2021), The challenges and opportunities of electricity generation on economic growth in South Africa: An ARDL approach. International Journal of Energy Economics and Policy, 12, 64-174.

Hlongwane, N.W., Daw, O.D. (2021), An Increase of Electricity Generation can Lead to Economic Growth in South Africa, MPRA Paper 111018. Germany: University Library of Munich.

Hlongwane, N.W., Daw, O.D. (2022), Carbon dioxide emissions from electricity power generation and economic growth in South Africa. International Journal of Energy Economics and Policy, 12(1), 250-257.

Hlongwane, N.W., Daw, O.D. (2023), Renewable electricity consumption and economic growth: A comparative study of South Africa and Zimbabwe. International Journal of Energy Economics and Policy, 13(3), 197-206.

Hlongwane, N.W., Daw, O.D., Sithole, M.S. (2023), Renewable Electricity Generation and Government Expenditure on Economic Growth of South Africa and Botswana, MPRA Paper 116497. Germany: University Library of Munich.

Huo, T., St Aubyn, M. (2021), Electricity, Exergy and Economic Growth in Mozambique, 1971-2014.

Hussein, K., Thirlwall, A. (2000), The AK model of "new" growth theory is the Harrod-Domar growth equation: Investment and growth revisited. Journal of Post Keynesian Economics, 22(3), 427-435.

Isaiah, T.R., Zachia, T.L., Molefi, T.T. (2015), Dynamics of electricity demand in Lesotho: A Kalman Filter approach. Studies in Business and Economics, 10(1), 130-139.

Kandenge, F.T. (2010), Public and private investment and economic growth in Namibia (1970-2005). Botswana Journal of Economics, 7(11), 2-15.

Kao, C. (1999), Spurious regression and residual-based tests for cointegration in panel data. Journal of Econometrics, 90(1), 1-44.

Keskin, A., Kara, B. (2021), The relationship between trade openness, foreign trade tax revenues and GDP in Turkey: ARDL bounds test approach for 1993-2019 period. Turkish Studies-Economics, Finance, Politics, 16(4), 1297-1315.

Khobai, H. (2018), The Causal Linkages Between Renewable Electricity Generation and Economic Growth in South Africa, MPRA Paper 86485. Germany: University Library of Munich.

Khobai, H., Abel, S., Le Roux, P. (2016), An investigation into the electricity supply and economic growth nexus for South Africa. International Journal of Energy Economics and Policy, 6(4), 701-705.

Khobai, H., Le Roux, P. (2018), Does renewable energy consumption drive economic growth: Evidence from Granger-causality technique. International Journal of Energy Economics and Policy, 8(2), 205-212.

Khobai, H., Mugano, G., Le Roux, P. (2017), The impact of electricity price on economic growth in South Africa. International Journal of Energy Economics and Policy, 7(1), 108-116.

Khobai, H., Sanderson, A., Le Roux, P. (2016), Co-integration between electricity supply and economic growth in South Africa. International Journal of Energy Economics and Policy, 6(3), 637-645.

Kirikkaleli, D., Adedoyin, F.F., Bekun, F.V. (2021), Nuclear energy consumption and economic growth in the UK: Evidence from wavelet coherence approach. Journal of Public Affairs, 21(1), e2130.

Lean, H.H., Smyth, R. (2010), Multivariate Granger causality between electricity generation, exports, prices and GDP in Malaysia. Energy, 35(9), 3640-3648.

Lenoke, M. (2017), The Impact of Load Shedding on the Economic Growth of South Africa. South Africa: North-West University.

Lucas, R.E. Jr. (1988), On the mechanics of economic development. Journal of Monetary Economics, 22(1), 3-42.

Levin, A., Lin, C.F. and Chu, C.S.J., (2002), Unit root tests in panel data: asymptotic and finite-sample properties. Journal of Econometrics, 108(1), pp.1-24.

Luqman, M., Li, Y., Khan, S.U.D., Ahmad, N. (2021), Quantile nexus between human development, energy production, and economic growth: The role of corruption in the case of Pakistan. Environmental Science and Pollution Research, 28(43), 61460-61476.

Magongo, T., Sacolo, T. (2018), The economic costs of electrical power outages in Eswatini. African Review of Economics and Finance, 10(2), 97-119.

Makansi, J. (2007), Lights Out: The Electricity Crisis, the Global Economy, and What it Means to you. Hoboken: John Wiley and Sons.

Marques, A.C., Fuinhas, J.A., Nunes, A.R. (2016), Electricity generation mix and economic growth: What role is being played by nuclear sources and carbon dioxide emissions in France? Energy Policy, 92, 7-19.

Mbulawa, S. (2017), The Impact of Economic Infrastructure on Long Term Economic Growth in Botswana. Available from: https://localhost:8080/xmlui/handle/123456789/178

Mensah, J.H.R., Silva, A.T.Y.L., dos Santos, I.F.S., de Souza Ribeiro, N., Gbedjinou, M.J., Nago, V.G., Barros, R.M. (2021), Assessment of electricity generation from biogas in Benin from energy and economic viability perspectives. Renewable Energy, 163, 613-624.

Menyah, K., Wolde-Rufael, Y. (2010), Energy consumption, pollutant emissions and economic growth in South Africa. Energy Economics, 32(6), 1374-1382.

Merlin, M.L., Chen, Y. (2021), Analysis of the factors affecting electricity consumption in DR Congo using fully modified ordinary least square (FMOLS), dynamic ordinary least square (DOLS) and canonical cointegrating regression (CCR) estimation approach. Energy, 232, 121025.

Mhaka, S., Runganga, R., Nyagweta, D.T., Kaseke, N., Mishi, S. (2020), Impact of rural and urban electricity access on economic growth in Zimbabwe. International Journal of Energy Economics and Policy, 10(6), 427-434.

Milanzi, S., Daw, D. (2018), The Impact of Electricity Supply in Malawi on Economic Development. In: International Conference on Public Administration and Development Alternatives.

Mutambara, E. (2013), Perceptions of Organisational Politics and its Impact on Managerial Practices at the National Electricity Provider in the Southern African Development Community (SADC). Dissertation. South Africa: North West University.

Mutanga, S., Simelane, T. (2015), Electricity Generation: A Driver of SADC Regional Integration? Available from: https://hdl.handle.net/20.500.11910/9398

Mwale, S.J., Davidson, I.E. (2013), Security Analysis of Electric Power Supply in SADC Region. In: 2013 Africon. New Jersey: IEEE. p1-6.

Nindi, A.G., Odhiambo, N.M. (2014), Energy consumption and economic growth in Mozambique: An empirical investigation. Environmental Economics, 5(4), 83-92.

Odhiambo, N.M. (2014), Electricity consumption, exports, and economic growth in the Democratic Republic of Congo: An ARDL-Bounds testing approach. Journal of Developing Areas, 48, 189-207.

Odhiambo, N.M. (2021), Energy consumption and economic growth in Botswana: Empirical evidence from disaggregated data. International Review of Applied Economics, 35(1), 3-24.

Oladele, M.F. (2016), An Investigation of the Relationship Between Economic Growth and Government Expenditure: The Case of South Africa. South Africa: North-West University.

Olanrele, I.A. (2019), Structural breaks, electricity generation and economic growth in Nigeria. The Economics and Finance Letters, 6(2), 170-177.

Oryani, B., Koo, Y., Rezania, S. (2020), Structural vector autoregressive approach to evaluate the impact of electricity generation mix on economic growth and CO_2 emissions in Iran. Energies, 13(16), 4268.

Papadopoulos, S. (2013), Confirmatory factor analyses on non-normal panel data: An application to banking. International Journal of Computational Economics and Econometrics, 3(3-4), 124-145.

Pedroni, P. (1999), Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxford Bulletin of Economics and Statistics, 61(S1), 653-670.

Pesaran, M.H., Schuermann, T., Weiner, S.M. (2004), Modeling regional interdependencies using a global error-correcting macroeconometric model. Journal of Business and Economic Statistics, 22(2), 129-162.

Pesaran, M.H., Shin, Y., Smith, R.P. (1999), Pooled mean group estimation of dynamic heterogeneous panels. Journal of the American statistical Association, 94(446), 621-634.

Pesaran, M.H., Smith, R. (1995), Estimating long-run relationships from dynamic heterogeneous panels. Journal of Econometrics, 68(1), 79-113.

Pesaran, M.H., Ullah, A., Yamagata, T. (2008), A bias-adjusted LM test of error cross-section independence. The Econometrics Journal, 11(1), 105-127.

Rafindadi, A.A., Usman, O. (2021), Toward sustainable electricity consumption in Brazil: The role of economic growth, globalization and ecological footprint using a nonlinear ARDL approach. Journal of Environmental Planning and Management, 64(5), 905-929.

Ramadhan, A.A., Jian, Z.H., Pasific, Y. (2016), Impact of FDI on GDP: A comparative study of Mozambique and South Africa. Journal of Economics and Sustainable Development, 7(2), 183-188.

Ritchie, H., Roser, M. (2020), Energy. Available from: https://www.ourworldindata.org

Romer, P. (1994), New goods, old theory, and the welfare costs of trade restrictions. Journal of Development Economics, 43(1), 5-38.

SADC. (2022), Protocol on Energy. Available from: https://www.sadc.int/themes/infrastructure/en/electricity-generation/#:~:text=at%20 present%2c%20most%20electricity%20in,and%20along%20the%20zambezi%20river [Last accessed on 2022 Mar 06].

Sami, J., Makun, K.K. (2011), The relationship between exports, electricity consumption and economic growth: Empirical evidence from Brazil. World Review of Business Research, 1(5), 28-37.

Samu, R., Bekun, F.V., Fahrioglu, M. (2019), Electricity consumption and economic growth nexus in Zimbabwe revisited: Fresh evidence from Maki cointegration. International Journal of Green Energy, 16(7), 540-550.

SAPP. (2021), Southern African Power Pool (SAPP), Energising the Region for Economic Development. Harare, Zimbabwe: Southern African Power Pool. Available from: https://www.sapp.co.zw/sites/default/files/r11-sapp%20monthly%20report%20nov%202021.pdf [Last accessed on 2022 Feb 21].

Sarker, A.R., Alam, K. (2010), Nexus between electricity generation and economic growth in Bangladesh. Asian Social Science, 6(12), 16-22.

Schreiner, B., Baleta, H. (2015), Broadening the lens: A regional perspective on water, food and energy integration in SADC. Aquatic Procedia, 5, 90-103.

Shahbaz, M., Feridun, M. (2012), Electricity consumption and economic growth empirical evidence from Pakistan. Quality and Quantity, 46(5), 1583-1599.

Sharmin, F., Khan, M.R. (2016), A causal relationship between energy consumption, energy prices and economic growth in Africa. International Journal of Energy Economics and Policy, 6(3), 477-494.

Solarin, S.A., Bello, M.O., Bekun, F.V. (2021), Sustainable electricity generation: The possibility of substituting fossil fuels for hydropower and solar energy in Italy. International Journal of Sustainable Development and World Ecology, 28(5), 429-439.

Solarin, S.A., Shahbaz, M. (2013), Trivariate causality between economic growth, urbanisation and electricity consumption in Angola: Cointegration and causality analysis. Energy Policy, 60, 876-884.

Solarin, S.A., Shahbaz, M., Shahzad, S.J.H. (2016), Revisiting the electricity consumption-economic growth nexus in Angola: The role of exports, imports and urbanization. International Journal of Energy Economics and Policy, 6(3), 501-512.

Solow, R.M. (1956), A model of balanced growth. Quarterly Journal of Economics, 70, 65-94.

Stungwa, S., Hlongwane, N.W., Daw, O.D. (2022), Consumption and supply of electricity on economic growth in South Africa: An econometric approach. International Journal of Energy Economics and Policy, 12(1), 266-274.

Sunde, T. (2018), The interaction of energy consumption and economic growth in South Africa: Assessment from the bounds testing approach. International Journal of Sustainable Economy, 10(2), 170-183.

Sunde, T. (2020), Energy consumption and economic growth modelling in SADC countries: An application of the VAR Granger causality analysis. International Journal of Energy Technology and Policy, 16(1), 41-56.

Taele, B., Mokhutšoane, L., Hapazari, I. (2012), An overview of small hydropower development in Lesotho: Challenges and prospects. Renewable Energy, 44, 448-452.

Tamba, J.G., Nsouandélé, J.L., Fopah Lélé, A., Sapnken, F.E. (2017), Electricity consumption and economic growth: Evidence from Cameroon. Energy Sources, Part B: Economics, Planning, and Policy, 12(11), 1007-1014.

Tang, C.F., Tan, E.C. (2013), Exploring the nexus of electricity consumption, economic growth, energy prices and technology innovation in Malaysia. Applied Energy, 104, 297-305.

Tsaurai, K. (2013), Is there a relationship between electricity consumption and economic growth in Zimbabwe? Corporate Ownership and Control, 10, 283-290.

Wang, S.S., Zhou, D.Q., Zhou, P., Wang, Q. (2011), CO_2 emissions, energy consumption and economic growth in China: A panel data analysis. Energy Policy, 39(9), 4870-4875.

Willie, A. (2016), Modelling the Impact of Energy Use on Economic Growth: The Case of Zimbabwe. Zimbabwe: University of Zimbabwe.

Zeraibi, A., Balsalobre-Lorente, D., Murshed, M. (2021), The influences of renewable electricity generation, technological innovation, financial development, and economic growth on ecological footprints in ASEAN-5 countries. Environmental Science and Pollution Research International, 28, 51003-51021.

Zeshan, M. (2013), Finding the cointegration and causal linkages between the electricity production and economic growth in Pakistan. Economic Modelling, 31, 344-350.