A sectoral approach to the electricity-growth nexus in the Eastern Cape province of South Africa

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A SECTORAL APPROACH TO THE ELECTRICITY-GROWTH NEXUS IN THE EASTERN CAPE PROVINCE OF SOUTH AFRICA

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ABSTRACT: This paper takes a sectoral, panel approach to investigating the electricity-growth nexus for the Eastern Cape province of South Africa between the period of 2003 and 2017. The empirical investigation was carried out using the Pooled Mean Group (PMG) panel estimators applied to an augmented dynamic growth model whilst the caulisty tests between electricity consumption and growth where performed using the Dumitrescu-Hurlin (2012) panel non-causality tests. The findings confirm the absence of significant long-run relationship between electricity and growth whilst finding a significant and positive effect over the short-run. Moreover, our causality tests provide strong evidence of causality running from electricity consumption to economic growth hence supporting the "growth hypothesis". In a nutshell, our results not only demonstrate the importance of performing the electricity-growth analysis at provincial level as opposed to relying on national aggregated estimates but also provides important provincial-specific policy implications and recommendations.

Keywords: Electricity consumption; Economic Growth; Provincial analysis; Eastern Cape province; South Africa.

JEL Classification Code: C13; C33; C51; Q43.

1 INTRODUCTION

In 2018, South Africa become the first African country to be an official member of the International Energy Agency (IEA). This comes as no surprise since the country's prestige as the 'energy hub' of the continent has been well documented in the literature, being reported to provide/account for approximately two-thirds of Africa's total energy use, is among the top seven utilities in the world in terms of energy generation capacity and among the top nine in terms of sales (Phiri and Nyoni, 2018). Of all South Africa's energy use, electricity consumption remains the most dynamic and important energy source and yet is simultaneously the most problematic of these energy sources. The cause of these problems is rooted in the economy's dependency on fossils fuels to provide electricity for the livelihood of economic participants and the resulting negative externalities are two-fold. On one hand, reliance on traditional methods of generating electricity has been a significant environmental threat via increased gashouse emissions, of which the country is reported to be amongst the highest emitters globally. On other hand, the country's depleting stock of coal supply has been the underlying factor of the series of 'load-shedding' strategies implemented by the domestic parastatal power utility, ESKOM.

Since the late 2007's, a series of electricity crises continuously emerged as ESKOM did not have sufficient capacity to meet demand due to supply reserves being kept below the margin. This necessitated the need for a planned, controlled and rotational load shedding, based on a pre-determined rotating schedule to protect the power system from a total collapse (Coetzee and Els, 2016). A national emergency was declared in January 2008 and load shedding was implemented until March while Eskom initiated a recovery plan (Goldberg, 2016). These load-shedding activities are in effect, last-resort measures used to relieve excessive strain placed on an electricity grid by temporarily halting the supply of electricity and purposely limiting electricity supply to users as a result of an over-demand thereof (Steenkamp et al., 2016). By switching off parts of the network in a controlled manner, the system remains stable throughout the day, and the impact is spread over a broader base of consumers (Coetzee and Els, 2016).

These load-shedding activities have caused negative externalities on the country's economic growth as well as on the daily lives of its citizens. For instance, intermittent load-shedding over extended periods of time not only impacts on production activity but also negatively affects foreign investment decisions and further raises costs due to alternative energy generation methods. These other costs include scheduling maintenance for the load-shedding period, recovering of lost production time, retailers operating even in the absence of power, or the use of generators to keep essential equipment functioning. Furthermore, there is the possibility of companies failing to pay employees during load-shedding, which could reduce economic activity on a permanent basis and lower consumer spending. The load-shedding that was experienced during the closing two months of 2014 is estimated to have reduced GDP by a maximum of 0.19 of a percentage point, and by early 2015, had reduced to 0.26 percent (IDC Economic overview: 2015).

And even more recently (i.e. December 2018), ESKOM has announced it's intention to re-implement scheduled load-shedding activities. There is much concern surrounding these scheduled nation-wide 'blackout' periods as it is widely believed that this forced reduction in electricity usage will more significantly affect poorer regions of the country as people in these less fortunate areas are not afforded access to alternative sources of energy in sustaining their livelihood. From an academic perspective, a number of authors have provided evidence of electricity consumption being an important contributor to economic growth in South Africa hence providing evidence against electricity conservation policies (Odhiambo (2009), Menyah and Wolde-Rufael (2010), Bildirici et al. (2012), Nyoni and Phiri (2016, 2018), Khobai et al. (2017), Bah and Azam (2017) and Phiri and Nyoni (2018)). Nevertheless, these studies are based on nation-wide time series data that do not recognize possible heterogeneity effects arising from economic disparities between different regions or provinces within a country. Recently, the studies of Li (2011) and Lv et al. (2012) have demonstrated that given a sufficient data on electricity consumption and output productivity series at sub-provincial analysis. With the exception of these studies there exists no literature, to the best of our knowledge, which has examined the electricity-growth nexus at a sub-national level.

In our study, we provide a case study for the Eastern Cape province of South Africa, which is popularly known as the birthplace of Nobel peace prize-winner Nelson Mandela. Since the historical democratic elections of 1994, in which Nelson Mandela became South Africa's first black president, the Eastern Cape Province has recorded a combination of the lowest economic growth rates accompanied with the highest unemployment rates at a sub-national level. This provides one of our motivations for investigation the effects of electricity conservation policies on economic productivity for a 'poor' province within a middle-income Sub-Saharan African (SSA) country. Due to data availability and constraints, we opt to perform a panel cointegration analysis on sectoral time series data collected for electricity consumption and economic growth in the Eastern Cape province. To the best of our knowledge, our use of sectoral-based data as opposed to provincial-aggregated data presents a novelty in the electricity-growth literature and is an important one in our case since panel sectoral data provides a sufficient amount of observations for empirical use. Our empirical estimates are based on the PMG model of Pesaran and Shin (1999) and the panel causality test of Dumitrescu-Hurlin (2012) over annual time series for four productive sectors in the Eastern cape province between 1996 and 2016.

The remainder of our study is arranged as follows. The following section provides a review of the associated empirical literature. Section 3 of the paper provides an overview of trends in electricity usage and economic growth in the sub-provincial productivity sectors in the Eastern Cape. Section 4 outlines our econometric methodology whereas section 5 presents the empirical results. The study is concluded in section 6.

2 REVIEW OF RELATED LITERATURE

Following the seminal work of Kraft and Kraft (1978), the relationship between electricity consumption and economic growth has been extensively studied for several countries, using different econometric techniques applied over varying spans of time periods (see Ozturk (2011) for an extensive international review of the empirical literature). Whilst a bulk majority of the existing studies are in consensus of the existence of at least a positive relationship between electricity consumption and growth (Mozumder and Marathe (2007), Narayan and Smyth (2009), Menyah and Wolde-Rufael (2010), Yoo and Kwak (2010), Ozturk (2010), Karanfil and Yuanjing (2015) and Osman et al. (2016)), ambiguity surrounds the direction of causality between the variables. The literature has thus proposed four causal hypotheses, each carrying its own policy implication.

The first of these hypotheses is the 'neutrality hypothesis' which supposes the absence of any significant causal relations between electricity consumption and growth. Evidence of 'neutrality' implies that policymakers need not be too concerned with implementing electricity conservation or expansive policies as they will not exert any direct impact on economic growth. The second hypothesis is the 'growth hypothesis' in which uni-directional causality runs from electricity consumption to economic growth. The growth hypothesis implies that policymakers are offered a trade-off between high electricity consumption – high growth or low electricity consumption – low growth. In other words, energy authorities should encourage electricity expansion programmes and discourage electricity conservation programmes. The third hypothesis is the conservation hypothesis which assumes reverse uni-directional causality from economic growth to electricity consumption. This hypothesis supposes that economic development, which is most commonly measured by GDP growth, determines the level of electricity consumed by economic units. Therefore, electricity consumption is assumed to be high in more industrialized economies due to high economic development whilst electricity consumption is low in less developed countries due to low economic development. Henceforth, policymakers in developing nations should concentrate on activities which promote economic development, such as infrastructure projects, before engaging in electrification programmes. The final hypothesis is the 'feedback hypothesis' in which electricity consumption and economic growth are jointly determined (i.e. bi-directional causality). This hypothesis implies that within the design of macroeconomic policies, policymakers should not treat the variables as two separate entities and should rather formulate electricity-growth objectives co-jointly.

A survey of the available empirical literature exclusively for the South African economy is summarized in Table 1 below. To the very best of our search efforts, we are able to find 10 studies, a majority which have used ARDL or VECM cointegration models (Odhiambo (2009), Menyah and Wolde-Rufael (2010), Bildirici et al. (2012), Dlamini et al. (2015), Nyoni and Phiori (2016), Khobai et al. (2017) and Molele and Ncanywa (2018)) whilst the remaining studies use nonlinear cointegration methods (Phiri and Nyoni, 2018) or various causality tests (Dlamini et al. (2015) and Bah and Azam (2017)). Out of these 10 studies, 8 studies show a positive cointegration relationship (Odhiambo (2009), Menyah and Wolde-Rufael (2010), Bildirici et al. (2012), Nyoni and Phiri (2016), Bah and Azam (2017), Khobai et al. (2017) and Nyoni and Phiri (2018)) whereas the remaining two studies establish no such relationship (Dlamini et al. (2015) and Molele and Ncanywa (2018)). By default, only the studies of Dlamini et al. (2015) and Molele and Ncanywa (2018) advocate for the neutrality hypothesis in South Africa. On the other hand, the feedback hypothesis receives the most empirical support in the literature (Odhiambo (2009), Khobai et al. (2017) and Nyoni and Phiri (2018)), whilst the conservation hypothesis (Bildirici et al., 2012) and the growth hypothesis (Menyah and Wolde-Rufael, 2010) receive less empirical support. All-in-all, it is safe to assume that there exists no consensus on the electricity-growth nexus for South Africa and the literature is heterogenous.

An immediate solution to this observed hetereogeneity in the literature would be to consider a more disaggregated analysis of the electricity-growth relationship at a provincial level. For instance, Li (2011) preforms a panel cointegration and causality analysis for 28 Chinese provinces between 1985 and 2008 by segregating the panel into three sub-regions namely East, Middle and West regions and is able to find discrepancies between the sub-regional and 'whole panel' estimates. Moreover, Lv et al. (2012) study the electricity-growth relationship for the Guangdong Province of China using error-based cointegration and causality tests. The authors highlight discrepancies between their findings and those found in previous nationwide Chinese empirical studies. Our study builds upon those Li (2011) and Lv et al. (2012) by further disaggregating the analysis to a panel sectoral approach for the electricity-growth relationship for the Eastern Cape province of South Africa. An overview of electricity distribution through to four major growth sectors in the Eastern Cape is presented next.

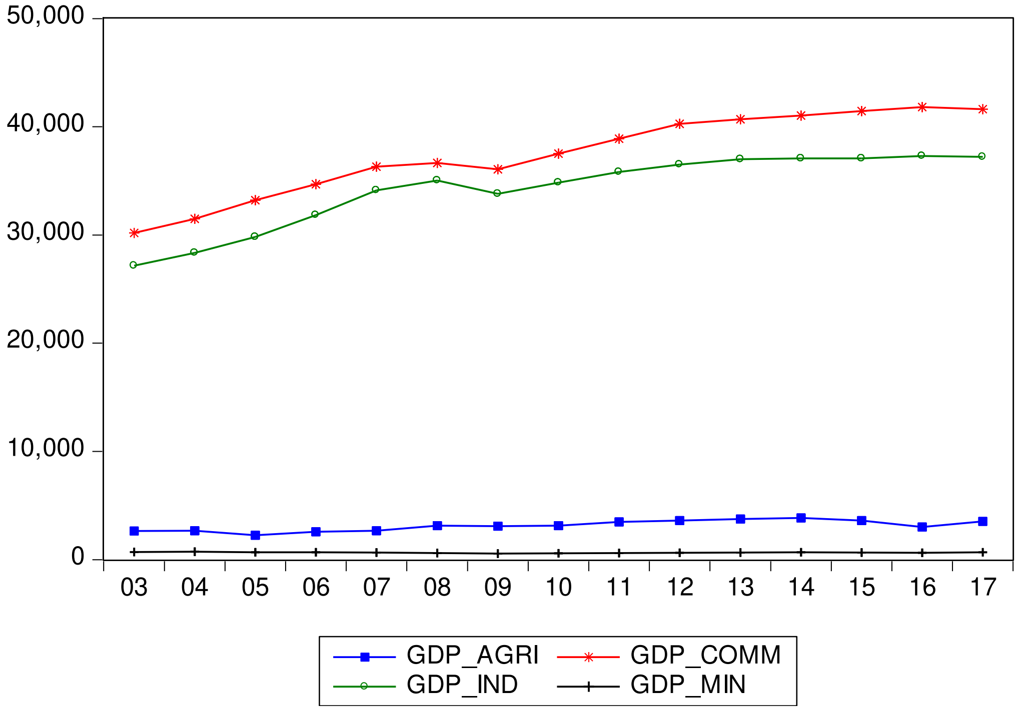
Table 1: Summary of previous South African studies

Author	Period	Methodology	Relationship	Causality
Odhiambo (2009)	2009	Granger Causality, ARDL	positive	Bidirectional
Menyah and Wolde-Rufael (2010)	1965-2000	Bounds Test Augmented Granger Causality	positive	Unidirectional EC to EG
Bildirici et al. (2012)	1978-2012	ARDL	Positive	Unidirectional EG to EC
Dlamini et al. (2015)	2015	Granger Causality, Parameter Stability tests, Bootstrap Rolling Window estimation	None	None
Nyoni and Phiri (2016)	1994-2014	VECM and causality tests	Positive	None
Bah and Azam (2017)	1971-2012	ARDL bounds test Toda Yamamoto augmented Granger causality test	Some cointegration	None
Khobai et al. (2017)	2017	VECM ARDL bounds test	positive	Bidirectional
Molele and Ncanywa (2018)	1980-2012	VECM, Johansen cointegration	negative	None
Nyoni and Phiri (2018)	1983-2016	MTAR cointegration and causality tests	positive	Bi-directional

3 A SYNOPSIS OF GROWTH SECTORS AND ELECTRICITY USAGE IN THE EASTERN CAPE

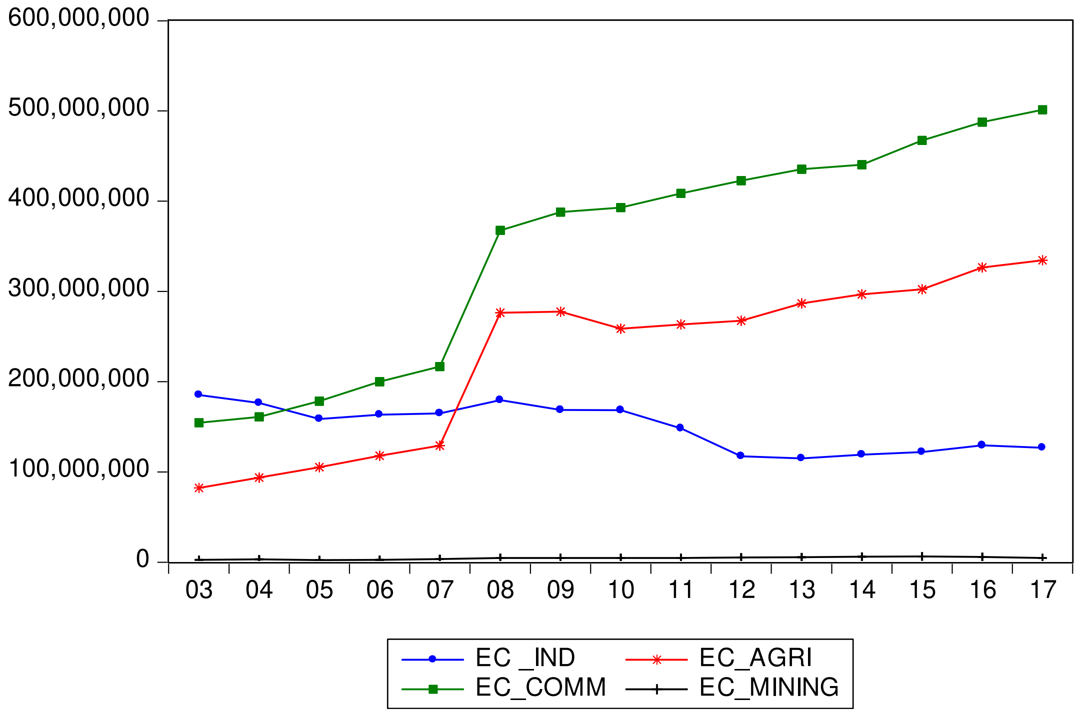
The Eastern Cape is one of the poorest provinces in South Africa and contributes the least of all provinces to the national GDP output. In retrospect, the economic structure of the Eastern Cape province is different from the national economy due to the absence of a local mining sector and significantly larger tertiary activity, accounted for mainly by the public sector. Economic growth in the province is driven by 4 major sectors namely; commercial sector, agricultural sector, industrial sector and minerals sector. Figure 1 provides time series plots of economic output in four economic sectors for commercial output (GDP_COMM), agricultural output (GDP_AGRI), industrial output (GDP_IND) and minerals output (GDP_MIN) between 2003 and 2017. As can be observed from Figure 1, economic output in the Eastern Cape has been primarily driven by the commercial and industrial sectors whilst the agricultural and the mining sectors contribute less towards economic activity.

Figure 1: Economic output per sector in the Eastern Cape province (2003-2017)



On the other hand, electricity is distributed to these economic sectors of the Eastern Cape province via the National grid. Electricity is transmitted, via the transmission grid to three major substations (i.e. Poseidon, Delphi and Vuyani substations) that mainly feed the Eastern Cape. Different municipalities within the province act as redistributors by purchasing electricity in bulk from Eskom and then redistribute it to various sectors of the economy. Figure 2 provides time series plots of electricity usage by the four growth sectors in the province, that is, electricity usage in commercial sector (ELE_COMM), electricity usage in agriculture sector (ELE_AGRI), electricity usage in industry sector (ELE_IND) and electricity usage in minerals sector (ELE_MIN). As can be observed, the structure of electricity usage has gone through changes over the period of 2003 and 2017. For instance, between 2003 and 2005, electricity consumption was dominated by the industrial sector followed by the commercial sector, the agriculture sector and then the minerals sector. However, subsequent to 2007, electricity usage has been dominated by the commercial sector followed by the agriculture sector, the industrial sector and the minerals sector. Henceforth, the cardinal ranking of electricity consumption in the different growth sectors in the Eastern Cape corresponds to the contribution of the various growth sectors to economic activity.

Figure 2: Electricity consumption per growth sector in the Eastern Cape province (2003-2017)



4 EMPIRICAL MODEL

4.1 Empirical growth function

In order to investigate the relationship between electricity consumption and growth in the Eastern Cape, we rely on a log-linearized dynamic growth model augmented with an energy sector and a government sector, which is estimated using the pooled mean group (PMG) panel estimation of Pesaran et al. (1999). Our baseline endogenous AK production function is specified as:

$$Y=f(K) \quad (1)$$

Where Y is provincial output production and K is the provincial capital input. As previously mentioned, we augment our production function with and energy sector which is responsible for providing for electricity consumed by economic units (i.e. E) and the provincial government sector which provides expenditure on public goods (i.e. G). The direct modelling of monetary policy into our dynamic provincial growth model is unfeasible since monetary policy in South Africa is conducted a national level. Instead, we further supplement our provincial dynamic growth model with provincial inflation variable (i.e. INF) as it would reflect the influence of the South African Reserve Bank's inflation targeting programme on aggregate price movement in the province. Altogether our augmented production function is represented as:

$$Y=f(K, E, G, INF) \quad (2)$$

Our econometric specification is obtained in two steps. Firstly, we log-linearize our augmented growth function (4) by specifying the following long-run estimation equation:

$$Y = \beta_0 + \beta_1 e + \beta_2 k + \beta_3 g + \beta_4 inf + e_t \quad (3)$$

Where β_0, β_i and et are the intercept, regression coefficients and disturbance terms, respectively. Note that the lower-case letters denote the natural logarithm transformation of the variables. Secondly, we specify regression (2) as a pooled mean group (PMG) regression of Pesaran et al. (1999) which is a generalized panel extension of the ARDL model of Peseran et al. (2001). In it's generalized form our empirical panel model can be specified as:

$$Y_{it} = \alpha_0 + \alpha\delta_{1i}X_{it} + \alpha_{2i}X_{i,t-1} + \psi_i Y_{i,t-1} + e_{it} \quad (4)$$

And the associated equilibrium error correction representation is given as:

$$\Delta Y_{it} = \alpha_0 + \delta_{1i}\Delta X_{it} + \phi_{1i} Y_{i,t-1} - \theta_{0i} - \theta_{1i}X_{i,t-1} + e_{it} \quad (5)$$

Where $\theta_{0i} = \frac{\alpha_i}{1-\psi_i}$, $\theta_{1i} = \frac{\delta_{0i}+\delta_{1i}}{1-\psi_i}$ and ϕ_i = (ψ_i- 1) and X_t=[e, k, g, inf]. The above described PMG cointegration framework is coupled with the panel cointegration test of Kao (1999). In outlining the Kao (1999) cointegration test, we assume the residual terms obtained from a panel regression, e_{it}, can be expressed as:

$$e_{it} = \rho\, e_{it} + \sum_{j=1}^{n} \Phi_j \Delta e_{it-j} + v_{itp} \quad (6)$$

And from equation (19) the null hypothesis of no cointegration is given as:

$$H_0: \rho = 1 \quad (7)$$

Kao (1999) suggests that the no cointegration null hypothesis can be tested using the following modified ADF-type test statistic:

$$t_{kao} = \frac{t_{adf} + \sqrt{6N}\sigma_v/(2\sigma_{ov})}{\sqrt{\sigma_{ov}^2/(2\sigma_v^2) + 3\sigma_v^2/(10\sigma_{ov}^2)}} \sim N(0,1) \quad (8)$$

Where $t_{adf} = \frac{(\rho-1)[\sum_{i=1}^{N}(e_i' Q_i e_i)]^{\frac{1}{2}}}{s_v}$. (9)

5.4 Panel Homogenous Non Causality (HNC) tests

To examine the causal relationship between electricity consumption and growth we rely on the panel causality test of Dumitrescu-Hurlin (2012) who suggest the following regression:

$$y_{it} = c_i + \sum_{i=1}^{n} \alpha_i y_{i,t-j} + \sum_{i=1}^{n} \beta_i \Delta x_{i,t-j} + e_{i,t} \quad (10)$$

Where $\beta_i=(\beta_i^{(1)}, \ldots, \beta_i^{(k)})'$. Dumitrescu-Hurlin (2012) propose a Homogenous Non Causality (HNC) hypothesis defined as:

$$H_0: \beta_i = 0, \forall i=1,\ldots, N. \quad (11)$$

Where $\beta_i=(\beta_i^{(1)}, \ldots, \beta_i^{(k)})$. Under the alternative hypotheses we assume the existence of $N_1<N$ individual processes with no causality from x to y, whilst the remaining process $N_2=N-N_1$ process have causality i.e.

$$H_1: \beta_i = 0 \ \forall i = 1,\ldots,N_1 \quad (12)$$

$$\beta_i \neq 0 \ \forall i = N_1+1, N_1+2\ldots,N$$

Dumitrescu-Hurlin (2012) propose the use of the following average individual Wald statistic to test the HNC null hypothesis

$$W_{N,T}^{Hnc} = \frac{1}{N}\sum_{i=1}^{N} W_{i,T} \quad (13)$$

Where $W_{i,T}$ denotes the individual Wald statistic for the i^{th} cross section unit corresponding to the individual causality hypothesis H_0: $\beta_i = 0$. Dumitrescu-Hurlin (2012) note that the individual Wald statistics provide undesirable distribution properties in small samples hence the authors propose the following approximated standardized statistics:

$$Z_{N,T}^{Hnc} = \sqrt{\frac{N}{2N}}(W_{N,T}^{Hnc} - K) \quad (14)$$

$$\hat{Z}_{N}^{Hnc} = \frac{\sqrt{N}[W_{N,T}^{Hnc} - E(\widehat{W}_{i,T})}{\sqrt{Var(\widehat{W}_{i,T})}} \quad (15)$$

Where the second order moments of the individual Wald statistics, $W_{i,T}$, only exist if the condition T > 5 + 2K holds. In our study, we limit the lag length to K=5, given that our sample size consists of T=16 observations.

5 EMPIRICAL ANALYSIS

5.1 Data description

Our empirical data used in our study is sourced from Quantec online statistical database as well as from Eskom Eastern Cape. The time series variables employed can be classified into three groups. The first group consists of sectoral GDP at market prices for the agricultural sector, the commercial sector, the industrial sector and mining sector. The second data group consists of sectoral electricity consumption at market prices for the agricultural sector, the commercial sector, the industrial sector and mining sector. The third data group consists of control variables inclusive of provincial inflation, provincial investment and provincial government expenditure. All our time series is collected in annual intervals between 2003 and 2017 and they have transformed into their natural logarithms for empirical purposes.

5.2 Panel unit root test results

Prior to carrying out our main empirical analysis, it is imperative that we conduct unit root tests on the time series variables to ensure their order of integration. Table 2 reports the findings from the Levin et al. (2002) (hereafter LLC) and Im et al. (2002) (hereafter IPS) panel unit root testing procedures for panel time series data. As can be observed, all variables fail to reject the unit root null hypothesis in their levels whilst rejecting the unit root null at all critical levels once the variables are transformed into their firs differences. Against this evidence of all the time series variables being integrated of order I(1), we proceed to carry out our main empirical analysis.

Table 2: Panel unit root test results

	LLC		IPS	
	Stat	p-value	Stat	p-value
Panel A: Levels				
Log(gdp)	1.15	0.87	3.38	0.91
Log(ele)	1.11	0.87	1.93	0.98
Log(inv)	1.01	0.84	1.75	0.98
Log(gov)	2.93	0.99	0.41	0.99
Log(inf)	1.45	0.93	1.29	0.99
Panel B: First differences				
Log(gdp)	-3.16	0.00***	17.52	0.02**
Log(ele)	-3.96	0.00***	22.58	0.00***
Log(inv)	-4.65	0.00***	27.38	0.00***
Log(gov)	-3.86	0.00***	21.63	0.00***
Log(inf)	-3.87	0.00***	21.39	0.00***

Notes: "***", "**", "*" denote 1%, 5% and 10% critical levels, respectively.

5.3 PMG estimates

Having validated panel cointegration effects for our selected panel of time series, we proceed to provide PMG estimates for electricity-growth dynamic panel regression previously outline in our methodology section. The findings from our empirical exercise are presented in Table 3. The long-run regression estimates reported in Panel A of Table 3 produce insignificant estimates for all time series which particularly provide evidence of the absence of a long-run relationship between electricity consumption and economic growth in the Eastern Cape province. Notably these findings differ from those found in previous nationwide studies of Odhiambo (2009), Menyah and Wolde-Rufael (2010), Bildirici et al. (2012), Nyoni and Phiori (2016), Bah and Azam (2017), Khobai et al. (2017) and Nyoni and Phiri (2018) yet sharing a common finding with the more recent study of Dlamini et al. (2015). We treat our obtained results as an indicator of the absence of adequate long-term planning and implementation by local provincial government in using available resources such as government expenditure and electricity usage in achieving desirable long-term economic growth.

In turning our attention to the short-run estimates presented in Panel B of Table 3, we observe much more optimistic results. For starters, we take note of the positive coefficient estimate of 0.09 on the electricity consumption variable which is statistically significant at a 5 percent critical level. This estimate interprets to approximately a 10 percent increase in electricity consumption being required to increase provincial economic growth by 1 percent over the short-run. Clearly, our empirical results highlight the adverse effects of short-term load-shedding strategies as our findings directly imply that a percentage decrease in electricity consumption is associated with a 0.09 decrease in short-term provincial output. We note that our obtained coefficient estimate is much smaller in comparison to that of 3.94 and 0.21 obtained in the works of Khobai et al. (2017) and Phiri and Nyoni (2018), respectively, for nationally aggregated data. This would imply that relevance of electricity consumption in promoting economic growth for the Eastern Cape province is undermined in comparison to the country as a whole.

The remaining regressors estimated in the dynamic growth equation also produce significant estimates for the short-run. All regressors produce their expected coefficient signs, (i.e. positive for investment variable and negative for the inflation variable), with the exception of the coefficient on government sign which produces an unconventional negative estimate. This latter finding highlights the inefficiency of local government in diverting their spending resources towards productive growth sectors, albeit our finding holding for the short-run. Finally, our error correction terms produces its correct negative and statistically significant estimate of -0.02 which interprets to approximately 2 percent of deviations corrected per annum subsequent to a shock to the system.

Table 4: Empirical regression results

	Coefficient/estimate	Standard error	t-statistic	p-value
Panel A: Long-run estimates				
Log(ele)	2.724654	8.523801	0.319652	0.7516
Log(inv)	-55.43456	169.7771	-0.326514	0.7465
Log(gov)	8.812400	26.64845	0.330691	0.7433
Log(inf)	14.00939	43.30485	0.323506	0.7487
Panel B: Short-run estimates				
Ect(-1)	-0.021979	0.008915	-2.465478	0.0201**
Log(ele)	0.087514	0.050850	1.721017	0.0963*
Log(inv)	0.821712	0.211700	3.881488	0.00006***
Log(gov)	-0.288999	0.111859	-2.583593	0.0153**
Log(inf)	-0.019937	0.009100	-2.190791	0.0370*

Notes: "***", "**", "*" denote 1%, 5% and 10% critical levels, respectively.

5.4 Panel causality analysis

Whilst our findings indicate a positive relationship between electricity consumption and economic growth in the Eastern Cape province over the short-run, we are yet to determine the direction of causality between the variables, that is, does electricity consumption cause economic growth or vice versa? This is important to determine since the finding of unidirectional causality running from electricity consumption to economic growth would validate our fears that load-shedding certainly suppress economic growth in the Eastern Cape province. Conversely, the finding of no causality between existing between the time series would imply that electricity-conservation policies would not directly impact economic growth and that Eastern Cape provincial government does not need to be too concerned with load-shedding affecting provincial growth. As mentioned before, we apply the Dumitrescu-Hurlin (2012) non-causality panel test to check for causality effects between electricity consumption and economic growth in the Eastern Cape. Bearing in mind that all our utilized time series are integrated of order I(1), we perform the causality tests on the first differences of the time series to ensure compatibility with the causality tests. The findings from the Dumitrescu-Hurlin (2012) panel causality tests are reported in Table 5 below and indicate uni-directional causality from electricity consumption to economic growth for our data. These results provide evidence of the growth-led hypothesis for the Eastern Cape province of South Africa and are in accordance with the former study of Menyah and Wolde-Rufael (2010) and yet differ from those of Odhiambo (2009), Bildirici et al. (2012), Dlamini et al. (2015), Dlamini et al. (2015), Khobai et al. (2017) and Molele and Ncanywa (2018), Phiri and Nyoni (2016, 2018) and Bah and Azam (2017).

Table 5: Paiwise Dumitrescu Hurlin Panel Causality tests

Null hypothesis	W-stat	Zbar Stat	p-value
Log(gdp) does not cause log(ele)	9.92	3.33	0.00***
Log(gdp) does not cause log(ele)	0.99	-0.84	0.40

Notes: “***”, “**”, “*” denote 1%, 5% and 10% critical levels, respectively.

6 CONCLUSION

Provoked by the lack of provincial analysis between the electricity-growth relationship existing in the literature, our study sought to fill this empirical hiatus with an application to the Eastern Cape province of South Africa. Apart from the lack of provincial analysis on the subject matter in the literature, we consider our study important as the Eastern Cape province presents a unique economic structure in comparison to other South African provinces. The rationale is that the aggregated findings established in previous studies for the South African economy, as a whole, do not necessarily apply to individual provinces. Besides, electricity consumption planning and economic growth objectives are usually undertaken at a provincial level hence amplifying/magnifying the importance/usefulness of our study.

Using sectoral data (i.e. Agricultural, Commercial, Industrial and Minerals sectors) on electricity consumption, economic growth and other growth determinants such as investment, inflation and government expenditure collected annually between 2003 and 2017, we provided a panel cointegration analysis on the electricity-growth relationship for the Eastern Cape province. In differing from previous country-level South African studies, our empirical findings point to an insignificant effect of electricity consumption on economic growth over the long-run whereas a positive and significant effect is uncovered over the short-term. Moreover, our panel causality tests provide evidence in favour of the 'growth hypothesis' for the Eastern Cape province.

Based on our findings, we recommend that policies supporting building electricity infrastructure in the Eastern Cape to enable Eskom to proactively meet the electricity demanded by all the development initiatives as mapped out in the provincial industrial development strategy (PIDS), where government has committed to investing in infrastructure for the next 15 years from 2015. As endorsed by the National Development Plan (NDP), more attention must be given on alternative renewable energy, and other sources of energy especially for the not so "progressive" electricity sectors in the province, such as the traction, industrial and agricultural sectors. An example would be to employ solar energy for railway infrastructure for the traction sector and wind energy for agricultural sector, as these sectors form a smaller portion of overall consumption.

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