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Electricity Intensity and Unemployment in South Africa: A Quantile Regression Analysis

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ABSTRACT

Our study investigates the relationship between electricity intensity and unemployment in South Africa. Our mode of empirical investigation is the quantile regressions approach which has been applied to quarterly interpolated time series data collected between 2000:01 and 2014:04. As a further development to our study, we split our empirical data into two sub-samples, the first corresponding to the pre-financial crisis period and the other corresponding to the post-financial crisis period. Our empirical results point to electricity intensity being significantly and positively correlated with unemployment in periods before the crisis at all estimated quantiles, whereas this relationship turns significantly negative in periods subsequent to the crisis at all quantile levels. In other words, since the financial crisis, increased electricity intensity (i.e., lower electricity efficiency) appears to reduce domestic unemployment rates, a result which indicates that policymakers should be discouraged from implementing electricity conversation strategies and encouraged to rely on environmental friendly methods of supplying electricity.

Keywords: Electricity Intensity, Unemployment, South Africa, SSA, Quantile Regressions
JEL Classifications: C31, C51, E24, Q43

1. INTRODUCTION

The period of 2008-2009 stands out as a historical landmark as the world economy slumped into a global recession as triggered by the collapse of the US Banking system. The adverse effects of the global recession period ricochet throughout both industrialized and developing economies notably in the form of deteriorating gross domestic product (GDP) growth rates and drastic increases of unemployment rates. In terms of maintaining energy efficiency, the reduced GDP growth caused by the turmoil of the recession period, would have required a similar or proportionate decrease in energy consumption, since by definition energy efficiency is computed as a ratio of the two variables. Nonetheless, IEA (2013) reports that world energy consumption figures have been steadily rising since 2008, whereas, on the other hand, GDP growth rates have deteriorated and have not fully recovered since the global recession period. Inevitably, this would point to a declining trend in energy efficiency for periods subsequent to the global recession of 2009.

Concerning the South African economy, the global recession of 2008, coincided with the 2008 electricity crisis which eventually led to a nation-wide load shedding scheme manifested in the form of a series of periodic ‘blackouts’ in the country. The advent of this infamous electricity crisis has sparked an on-going debate surrounding the efficiency of non-renewable energy sources such as a coal-based power generating schemes more especially in terms of greenhouse emissions (Khobai and Le, 2017). It is particularly argued that a shift from non-renewable to renewable energies should result in improved energy efficiency which is empirically depicted by a decline in the ratio of energy usage to GDP levels. Moreover, improving energy efficiency is a strategic priority of

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the National Development Programme, which in turn, is assumed to be a catalyst for job creation and improved economic welfare. Notably such arguments have been re-iterated by the International Energy Agency (IEA, 2013) albeit for European economies, hence widening the scope of the importance of energy intensity on a global front.

In this present study, we examine the relationship between electricity intensity and unemployment for the South African economy and we particularly focus on electricity intensity since it arguably represents the most prominent component of energy efficiency. Methodologically, we rely on the quantile regression approach of Koenker and Bassett (1978) which allows us to examine the effects of covariates on the dependent variable on different points of distribution and hence present a more complete picture concerning the relationship between the dependent variable and it's covariates. We consider this empirical approach as been worthwhile or beneficial for the literature since such a study of this nature has not being previously conducted. To be more precise, former empirical studies on electricity intensity tend to strictly use a variety of linear estimation techniques.

Our study also adds value to the literature since previous empirical works on electricity intensity either focus on the determinants of electricity intensity (see Wang (2013), Kepplinger et al. (2013), Mulder et al. (2014), Filipovic et al. (2015) or on the convergence effects of electricity intensity (see Liddle (2009) and Herrerias and Liu (2014) and wholly ignore the effects of electricity intensity on the macroeconomy. Our study bridges this gap by examining the effects of electricity intensity on unemployment for the South African economy, which represents Africa's largest producer and user of electricity. As a further dissemination of our study, we examine the effects of electricity intensity on unemployment for periods prior to the 2008-2009 recession and also for periods subsequent to the recession. Conducting our empirical analysis in this manner will provide additional policy value since patterns in electricity intensity have changed in periods subsequent to the global recession.

Against this background, the remainder of the paper is organized as follows. The next section of the paper presents an overview of electricity intensity in South Africa. The third portion of the paper presents a review of the associated literature. The fourth section presents the econometric model whilst the fifth section presents the data and empirical results. The paper is concluded in the sixth section of the paper in the form of policy conclusions and remedies.

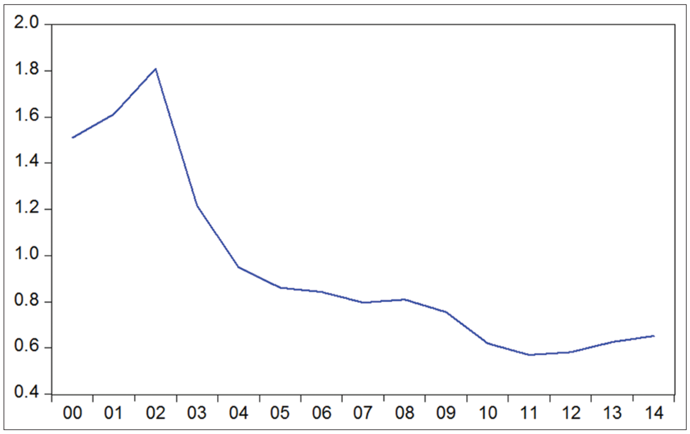
2. AN OVERVIEW OF ELECTRICITY INTENSITY IN SOUTH AFRICA

Within the South African economy, the electricity industry is dominated by the government owned national power utility, Eskom, which is not only responsible for supplying electricity domestically, but is also responsible for supplying electricity to more than two-thirds of the African continent, thus rendering the parastatal as the most prominent producer of electricity on the continent. Historically, Eskom was formed in 1992, 5 years subsequent to the release of the Electricity Act of 1987 which defined the structure, functions and responsibilities of the Electricity Control Board and assigned the sole right of electricity supply within municipal boundaries to local government (Winkler, 2007). Currently, Eskom's total installed capacity in South Africa is approximated to be over 42,000 MW, which is generated by 27 power stations across the country (Deloitte, 2009). In terms of electricity distribution, Eskom is responsible for approximately 94% of domestic electricity which is primarily distributed to different segments of the economy inclusive of industries, mining, commercial, agriculture, residential customers and redistributors. On the other hand, Eskom also exports approximately 45% of it's production to neighbouring countries such as Swaziland, Botswana, Mozambique, Lesotho, Zambia, Namibia and Zimbabwe and also imports its electricity supply from neighbouring countries like Mozambique, Zimbabwe, Zambia and the Democratic of Congo (Phiri and Nyoni, 2015).

Historically, both electricity usage and electricity intensity had been on a rising trend following the democratic elections of 1994 when the newly elected ANC government began to embark on a series of large-scale socioeconomic policies aimed at eradicating the inherited social injustices caused by the former Apartheid regime. Part and parcel of these development policies was the Integrated National Electrification Programme whose primary objective was to increase the scope of electricity access towards less fortunate communities which resulted in almost 80% of the population having gained access to electricity by 2000. Nevertheless, prior to the democratic elections of 1994, less than a third of South Africa's population had access to electricity particularly due to the repercussions of former apartheid policies which prioritized electricity supply towards the industrial sector and privileged white minority (Amusa et al., 2009). Declining electricity prices experienced in periods subsequent to the 1994 elections as primarily caused by cheap coal-prices resulted in electricity intensive sectors which has placed Eskom in a strong competitive position in international markets (Kohler, 2014). Nevertheless, the Department of Energy (DOE, 2012) has declared that even though the three broad sectors of the South African economy are all electricity intensive, it is the primary sector, constituting of mining and chemical industries, which is more electricity intensive compared to the secondary and tertiary sectors. Gradual increases in electricity intensity within these sectors has come at an environmental cost as South Africa's greenhouse emissions caused by heavy reliance on coal-based electricity production has been particularly problematic to the environmental economy (Khobai and Le, 2017). Currently Eskom is ranked as the second greatest emitter of carbon dioxide (CO_2) globally.

Figure 1 presents a plot of electricity intensity in South Africa from 2000 to 2014 and three main phases can be identified from the plot. The first phase can be approximated from 2000 to mid-2002 and describes a phase of increasing electricity intensity. During these periods, legislation had just being passed out which converted Eskom to a tax-paying public entity, fully owned by the state (Amusa et al., 2009). Furthermore, effective energy efficiency plans were not yet formally put into perspective and were hence not taken as a priority of policymakers. The second phase corresponds

Figure 1: Electricity intensity in South Africa (1990 to 2014)



to the period of 2003 to 2006 when there was a noticeable sharp decline in electricity intensity and corresponds to a period when Eskom embarked on a price restructuring programme (Inglesi-Lotz and Blignaut, 2012). It was during these periods that the Department of Minerals and Energy (DME) issued out the country's first energy efficiency strategy and electricity intensity in the country began to fall to levels lower in comparison to other emerging economies such as Brazil, India, Indonesian and China. The third and final phase identified, begins in 2008, a period when the economy faced countrywide blackouts as ESKOM struggled to provide sufficient electricity supply to an escalating electricity demand. These periods of constrained electricity supply seemingly caused further reductions in energy intensity and since then energy intensity has been slightly on a downward trend since 2008. In 2010, the Department of Energy (DOE) introduced the integrated resource plan (IRP) as part of national strategy concerned with policy issues such as nuclear options, emission constraints, import options as well as energy efficiency being highly prioritized. In terms of electricity efficiency, it is reported that the IRP sets to reduce the electricity intensity ratio as part of a long-term policy objective. Our current study is primarily concerned with evaluating whether or not such policy objectives are conducive towards unemployment reduction.

3. LITERATURE REVIEW

Due to the novelty of this current study, there exists no previous study, to the very best of our knowledge, which directly examines the effects of energy or electricity intensity on unemployment. Nevertheless, we identify a number of recent studies in the empirical literature which are closely related to our study, that is, literature which examines the relationship between energy intensity and other macroeconomic variables. Belonging to this cluster of studies are the works of Galli (1998), Yuxiang and Chen (2010), Zheng et al. (2011), Sadorsky (2013), Elliott et al. (2013); Liu and Xie (2013), Kepplinger et al. (2013), Adom and Kwakwa (2014), Ma (2015), Huang and Yu (2016), Sweidan and Alwaked (2016), Calcagnini et al. (2016), Bilgili et al. (2017) and Elliott et al. (2017). A summary of these studies has been conveniently provided for in Table 1 indicating the different countries or regions investigated in each study, the different methodologies employed. The different measures of energy intensity used as well as the various independent variables used and the results obtained.

In further classifying these reviewed studies, we can further segregate these empirical works into four groups relating energy intensity to four macroeconomic variables. The first strand of identifiable literature are those studies which include GDP or per capita income their analysis and we note that the works of Galli (1998), Bilgili et al. (2017) and Sadorsky (2013) advocating for a negative energy intensity-income relationship whilst the studies of Elliott et al. (2013), Kepplinger et al. (2013), Sweidan and Alwaked (2016) and Elliott et al. (2013) finding an positive correlation between the two variables. The second strand of studies identifiable from the literature more specifically highlights the relationship between energy intensity and FDI with Adom and Kwakwa (2014) and Adom (2015) finding a positive relationship between the two variables whilst Zheng et al. (2011), Elliott et al. (2013) and Huang and Yu (2016) establishing an inverse relationship. The third group of studies are those which indicate an energy intensity – trade relationship with Huang and Yu advocating for a positive relationship whilst Adom and Kwakwa (2014), Sweidan and Alwaked (2016) and Rafiq et al. (2016). The final group of studies identified examine the correlationship between government expenditure and energy intensity and the sole study of Yuxiang and Chen (2010), which falls in this category, depicts a positive energy intensity – government size relationship.

We also note that even though a majority of these reviewed studies employed total energy intensity as measure of energy intensity the studies of Ma (2015) and Elliott et al. (2017) specifically use electricity intensity as one of the measures of energy intensity in their respective studies and this emulates the intensity measure which this present study adopts. Moreover, with the exception of the study of Liu and Xie (2013), the remaining studies strictly employ linear estimation techniques, which is a limitation which our study overcomes.

4. METHODOLOGY

4.1. Empirical Specification

Our baseline empirical model assumes the following functional form:

$$y_t = x_t \beta_\tau + e_t \qquad \text{for i} = 1, 2, \ldots, n \tag{1}$$

Where y_t is the i^{th} observation of the dependent variable, the unemployment rate, x_t is the column vector that is the transpose of the i^{th} row the $x_{n\times k}$ matrix of dependent variables, comprising of energy intensity and other conditioning variables of the unemployment rate, β is K × 1 vector of coefficients and e_t is a well behaved disturbance term. Concerning the explanatory variables contained alongside the energy intensity variable of matrix, x_t, we base our choice of conditioning variables of the unemployment rate on the previous literature. For instance, we include the inflation rate (i.e., inf_t) as our first conditioning variable courtesy of the standard Phillips curve relationship which is a well-known policy model depicting a potential trade-off between inflation and unemployment.

Table 1: Summary of the reviewed literature

Author (s)	Countries/ region	Period	Method	Dependent variable	Independent variables	Results
Galli (1998)	10 Asian countries	1973-1990	RCM, FEM	EI, EIPC	YPC	EI/EIPC negatively related with YPC
Yuxiang and Chen (2010)	China	1996-2006	GMM	EI	GOV, TER/GDP, VA/POP, IO/POP, PPI.	Positive relationship between EI and GOV between 1997-2002 whilst relationship turns negative between 2001-2006. No significant relationship between EI and remaining variables in all periods
Zheng et al. (2011)	China: 20 industrial sub-sector	1999-2007	FGLS, PCSE, TAR	EI	EXP, FDI, INN, VA	EI positively related with EXP whilst negatively related with remaining variables.
Sadorsky (2013)	76 developing countries	1980-2010	MG, CCEMG, AMG	EI	YPC, URB, IND	EI negatively related with YPC whilst positively related with URB and IND.
Elliott et al. (2013)	China: 206 cities	1995-2012	FEM, REM	EI, IEI	FDI, YPC, IO	EI/EIE negatively related with FDI and IO whilst a positively related with YPC.
Liu and Xie (2013)	China – 3 countrywide regions	1978-2010	TVECM	EI	URB	
Kepplinger et al. (2013)	163 countries	1963-2009	MEM	EI	GDP, POP	EI negatively related with GDP whilst a positively related with POP.
Adom and Kwakwa (2014)	Ghana	1975-2011	FMOLS, DOLS	EI	TRADE, FDI, IO, URB	EI positively related with IO and FDI whilst negatively related with TRADE.
Adom 2015	South Africa	1970-2011	FMOLS	EI	OIL, IO, FDI, EcI	EI negatively related with OIL and EI whilst positively related with remaining variables.
Ma (2015)	China	1986-2011	CCEMG, AMG	EI, CEI, EEI	YPC, URB, IND	EI/CEI/EEI negatively related with YPC whilst positively related with URB and IND.
Huang and Yu (2016)	China: 27 provinces	2004-2013	PCSE, FGLS	EI	FDI, INV, URB, EXP, IMP, PPI, IO, R&D	EI negatively related with FDI, INV, R&D, PPI whilst positively related with IO, EXP whilst the impact of EI on both IMP and URBAN differ across regions.
Sweidan and Alwaked (2016)	Gulf Cooperation Council (GCC)	1995-2012	PCSE	EIWB	YPC, HEALTH, DEMO, EXP	EIWB positively related with YPC, HEALTH and DEMO whilst a negatively related with EXP.
Calcagnini et al. (2016)	Italy	1961-2010	SVAR	EI	CO2, POL	Supply shocks cause a persistent increase in EI, POL and CO2
Rafiq et al. (2016)	22 urbanized emerging economies	2001-2010	MG, CCEMG, AMG, PMG	EI	POP, AFL, REN, NRN, URB, TRADE	EI positively related with EI and POP, AFL, NRN whilst a negative related with TRADE, whilst insignificant related with remaining variables.
Bilgili et al. (2017)	10 Asian countries	1990-2014	AMG, PMG, Panel causality	EI	YPC, YPC.sq, URB, RUR, EXP, REN, NRN	EI negatively related with YPC, URB, EXP, REN whilst a positively related with RUR and NRN.
Elliott et al. (2017)	China: 30 provinces	1995-2012	OLS, FE, AMG	EI, CEI, EEI	YPC, IND, URB	EI/CEI/EEI negatively correlated with YPC and URB whilst positively related with IND.

Variable notations: EI: Energy intensity; IEI: Industrial energy intensity; CEI: Coal energy intensity; EEI: Electricity energy intensity; REI: Relative energy intensity; EIWB: Energy intensity of human well-being; GOV: Government spending; TER/GDP: Ratio of tertiary to GDP; VA: Value added; VA/GDP: Value added per capita; IO: Industrial output, PPI: Purchasing price index; GDP: Economic growth; YPC: Per capita GDP; YPC.sq: Square of per capita GDP; POL: Pollution; POP: Population; URB: Urbanization, IND: Industrialization, RUR: Ruralisation, EXP: Exports; IMP: Imports; FDI: Foreign direct investment, INV: Domestic investment; R&D: Research and development; Health: Health expenditure; DEMO: Democratization; INT: Interest rate; CO2: Carbon emissions; AFL: Affluence; REN: Renewable energy; NRN: Non-renewable energy; TRADE: Trade openness; INN: Innovation; EcI: Economic integration; OIL: Crude oil. MODEL NOTATIONS: TVECM: threshold vector error correction model; PMG: Pooled mean group estimators; FGLS: Feasible generalized least squares; PCSE: Panel-corrected standard errors; SVAR: Structural vector autoregressive; AMG: Augmented mean group; CCEMG: Common correlated effects mean group; FMOLS: Fully modified ordinary least squares; DOLS: Dynamic ordinary least squares; GMM: Generalized method of moments; RCM: Random coefficient model; FEM: Fixed effect model; REM: Random effects model; TAR: Threshold autoregressive; MEM: Mixed effects model

Our second conditioning variables is the domestic investment variable (inv_t) which has long been popularly assumed to reduce unemployment following the seminal theoretical model of Khan (1931). The third conditioning variable is the government expenditure variable (gov_t) which for the case of South Africa, is a prominent policy tool which is currently being used by fiscal authorities in reducing long-term unemployment rates. Theoretically, the literature tends to offer a variety of views concerning the government size-unemployment relationship with Gali et al. (2012) advocating for a positive relationship whilst Yaun and Li (2000) argues for an inverse correlation. Our last conditioning variable is terms of trade (*tot*) which has been conventionally assumed to be negatively correlated with unemployment following the early theoretical contribution of Young (1991) whose theoretical argument is more relevant towards a small, open economy like South Africa.

4.2. Quantile Regressions Estimator

As previously mentioned, the paper relies on the quantile regression approach of Koenker and Bassett (1978), to bring our empirical problem/investigations to hand. From our empirical regression (1), the traditional OLS estimates are obtained by finding the vector β that minimizes the sum of squares residual (SSR) i.e.,

$$\min_{\beta^k}[\sum_{i\{i:y_i x_i \beta\}} y_i - x_i^{'}\beta y_i - x_i^{'}\beta] \tag{2}$$

On the other hand, the quantile regression estimators minimize a weight sum of the absolute value of the residuals i.e.,

$$\min_{\beta^k}[\sum_{i\{i:y_i x_i \beta\}} y_i - x_i^{'}\beta + \sum_{i\{i:y_i x_i \beta\}} (1-) y_i - x_i^{'}\beta] \tag{3}$$

Where τ represents the τ^{th} quantile. By employing different values of τ bound between 0 and 1 (i.e., $\tau \in (0,1)$, we can estimate a unique vector of B for each given value of τ, hence yielding the regression quantiles for varying distributions of y given x. A special case exists when $\tau = 0.5$, since the minimization problem depicted in equation (3), reduces to

$$\min_{\beta^k}[\sum_{i\{i:y_i x_i \beta\}} y_i - x_i^{'}\beta y_i - x_i^{'}\beta] \tag{4}$$

Of which equation (4) is the last deviation estimator of regression (1). For the remaining quantiles, that is for the lower (i.e., $\tau < 0.5$) and upper (i.e., $\tau > 0.5$) quantiles, the obtained estimators represent the marginal change in the dependent variable associated with a marginal change in the independent variable(s) at the bottom half and the top half of the conditional distribution of the dependent variable, respectively.

5. DATA AND EMPIRICAL RESULTS

5.1. Data Description

The empirical data used in our study has been collected from three main sources. Firstly, we collect our unemployment data (*unemp*) from the FRED online database. Secondly, we collect our GDP levels (*gdp*), CPI inflation (*inf*), gross domestic investment (*inv*), total government expenditure (*gov*) and terms of trade (*tot*) variables are collected from the South African Reserve Bank (SARB) online database. Lastly, total electricity consumption (*ec*) time series is collected from the World Bank online database. Since the World Bank publishes it's electricity consumption statistics as annual data limited until 2014, we interpolate the time series into quarterly data and create a new dataset corresponding to a quarterly period of 2000:Q1 to 2014:Q4. Moreover, in line with Ma (2015) and Choi et al. (2017) we form our electricity intensity (i.e., int) variable as:

$$int_t = \frac{ec_t}{gdp_t} \tag{5}$$

The descriptive statistics for the utilized time series variables and the associated correlation matrix are presented in Table 2. In referring to the top panel of Table 2, our descriptive statistics point out some stylized facts such as a relatively high rate of unemployment of 24%, which is not a surprising statistic as South Africa is well-known for her menacing unemployment especially amongst the youth (Phiri, 2015). Also note that the average electricity ratio over the period of our study is 0.98, a figure which is well below the reported historic figure of 1.5. This difference in statistics exits since our data covers a period in which policymakers were successful in improving levels of electricity efficiency. Note that, the average rate of inflation over the study period is 5.87, a figure which falls within the SARB's current inflation target range of 3-6%, and this generally reflects the general success of the Reserve Bank in keeping inflation within it's designated target. Moreover, our descriptive statistics further indicate that each of the time series do not contain much volatility, with the exception of the terms of trade, and the variables are normally distributed, as shown by the standard deviation and the JArque-Bera statistics, respectively.

Table 2: Descriptive statistics and correlation matrix for the time series variables

Time series	unemp	int	inf	inv	gov	tot
Descriptive statistics						
Mean±Std.dev.	24.07±1.53	0.95±0.40	5.87±2.35	12.84±1.31	19.29±0.93	90.32±9.18
Skewness	−0.28	1.06	0.63	0.76	0.04	−0.02
Kurtosis	2.45	2.75	4.00	3.09	1.73	1.17
JB p-value	0.38 (0.83)	2.85 (0.24)	1.62 (0.45)	1.44 (0.49)	1.02 (0.60)	1.04 (0.59)
Correlation matrix						
unemp	1.00					
int	0.35	1.00				
inf	0.04	0.17	1.00			
inv	−0.67	−0.59	0.44	1.00		
gov	0.47	−0.58	−0.20	−0.08	1.00	
tot	−0.02	−0.90	−0.04	0.43	0.70	1.00

On the other hand, our correlation matrix reported in the lower panel of Table 2, depicts unemployment is found to be positively correlated with electricity intensity, inflation and government expenditure whereas both domestic investment and terms of trade are negatively correlated with unemployment. Note that with the exception of inflation, the reported correlation coefficient signs produced between unemployment and the other control variables, more or less concurs with those predictions inferred by the literature. However, as previously mentioned, it is possible that these correlations vary at different quantile distributions, a phenomenon which we shall explore in the next section of the paper.

5.2. Quantile Regression Results

Having provided the descriptive statistics of and the correlation matrix between the time series variables, we proceed to conduct our quantile regression empirical estimates. Table 3 presents the empirical results for the pre-crisis period whereas Figure 2 presents the associated quantile process estimates plots. The quantile regression estimates have been performed for the 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th and 90th quantiles. Our regression estimates indicate that for periods prior to the recession, the coefficient estimates on electricity intensity are positive across all quantiles. Note that these coefficients are significant at all critical levels. The coefficient on electricity intensity gradually declines from the

Figure 2: Quantile process estimates (post-recession period)

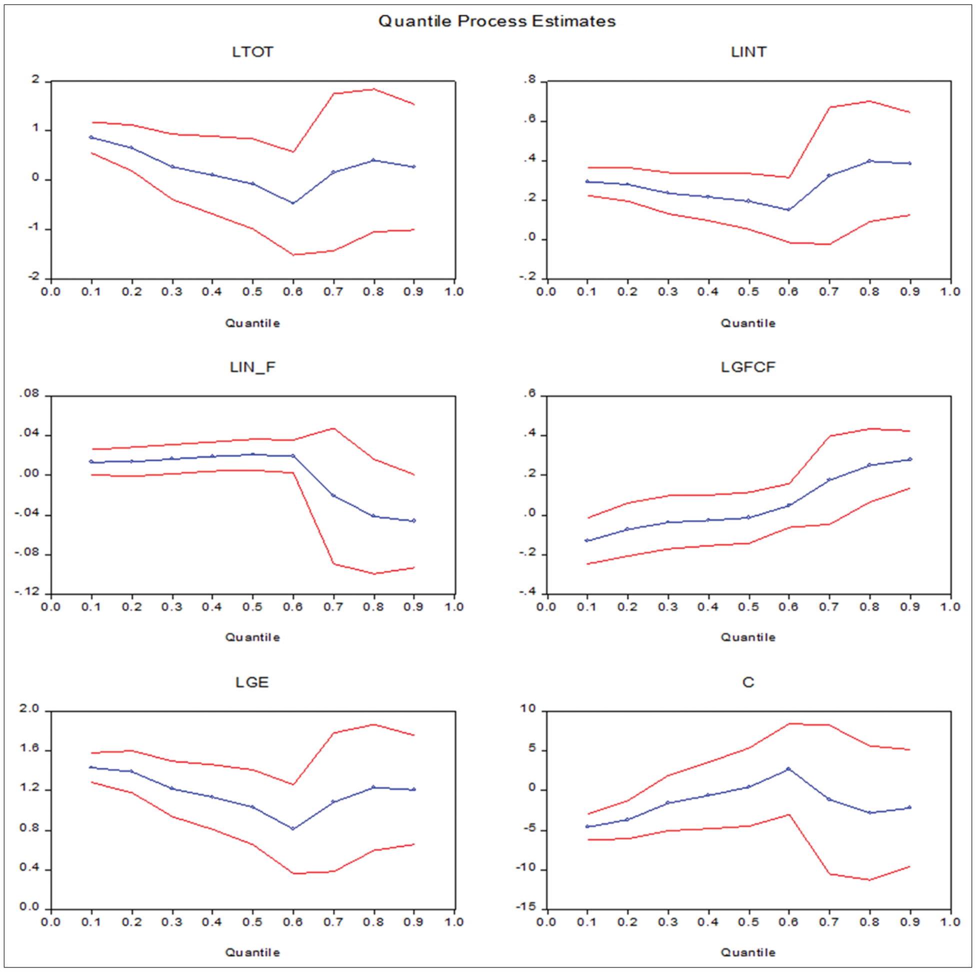


Table 3: Quantile estimate for pre-crisis periods

Quantiles	c	int	inf	inv	gov	tot
OLS						
0.1	−4.592 (0.00)***	0.293 (0.00)***	0.013 (0.04)**	−0.131 (0.03)**	1.431 (0.00)***	0.866 (0.00)***
0.2	−3.676 (0.00)***	0.279 (0.00)***	0.014 (0.06)*	−0.072 (0.29)	1.390 (0.00)***	0.653 (0.00)***
0.3	−1.576 (0.38)	0.234 (0.00)***	0.016 (0.03)**	−0.036 (0.60)	1.218 (0.00)***	0.273 (0.42)
0.4	−0.615 (0.78)	0.216 (0.00)***	0.019 (0.01)**	−0.026 (0.68)	1.136 (0.00)***	0.106 (0.79)
0.5	0.452 (0.86)	0.194 (0.00)***	0.021 (0.01)**	−0.013 (0.84)	1.031 (0.00)***	−0.073(0.88)
0.6	2.704 (0.36)	0.150 (0.07)*	0.019 (0.02)**	0.049 (0.39)	0.811 (0.00)***	−0.468 (0.38)
0.7	−1.152 (0.81)	0.323 (0.07)*	−0.021 (0.56)	0.176 (0.12)	1.082 (0.00)***	0.162 (0.88)
0.8	−2.815 (0.52)	0.396 (0.01)**	−0.041 (0.16)	0.251 (0.00)***	1.232 (0.00)***	0.402 (0.59)
0.9	−2.208 (0.56)	0.384 (0.00)***	−0.046 (0.06)*	0.281 (0.00)***	1.206 (0.00)***	0.268 (0.68)

P-values reported in parentheses. ***significant at 1% level, **significant at 5% level, *significant at 10% level

10th through to the 60th quantiles and thereafter sharply increases from the 70th to the 90th quantiles. Collectively, these results imply that prior to the recession period, increased energy efficiency policies were beneficial in terms of unemployment reduction.

The remainder of the regression quantile estimates on the other control variables produce a variety of mixed results. For instance, we find the coefficient on the inflation variables at the 10th quantile through to the 50th quantile to be positive and statistical significant at ta 5% level, inflation then turns negative and insignificant at the 70th and 80th quantile whilst at the 90th quantile inflation produces a negative coefficient which is significant at a 10% level. We thus deduce a nonlinear relationship between inflation and unemployment which is reminiscent of a nonlinear Phillips curve relationship as has been previously advocated for in the works of Nell (2006) and Phiri (2016). These particular results imply that during the pre-recession period, extremely low inflation levels would have created a conducive environment for unemployment reduction whereas at extremely high inflation levels monetary authorities were offered a Phillips curve type-of trade-off.

Similarly, for the investment variable, we note asymmetric tendencies as the associated coefficient estimate is negative and statistically significant at all critical levels for the 10th quantile, turns insignificant at the 20th quantile through to the 80th quantile, and then becomes positive and significant at all critical levels at the 90th quantile. We particularly note that the negative relationship between domestic investment and unemployment, as common depicted in the theoretical literature (see Khan (1931), Smith and Zoega (2009) and Guerrazzi, (2015), only exists at very low domestic investment levels. On the other hand, government expenditure is positive and significant at all critical levels across all quantiles. The theoretical underpinnings as presented by Aiyagari et al. (1992), and Yuan and Li (2000) argue that public expenditure positively affects unemployment due to it's crowding out effects on consumption which adversely affects wealth effects and ultimately reduces working hours. Moreover, our obtained empirical adheres to that obtained in the empirical study of Domenech and Garcia (2008) which supports the positive government spending-unemployment relationship whereas on the contrary, our presented results are contradictory to those presented in Young and Pedregal (1999) who find a negative public-spending –unemployment relationship.

Lastly, concerning the terms of trade variable, we note a positive and statistical significant coefficients at all critical levels for the first two quantiles (i.e., 10th and 20th quantiles) and thereafter the coefficient on terms of trade turns insignificant at other quantile levels. Notably this particular piece of empirical evidence is contradictory to the conventional finding of the negative relationship between terms of trade and unemployment as theoretical depicted in the model presented by Young (1991) as well as in the empirical works of Gaston and Rajaguru (2013).

In turning to our empirical estimates for the time series data corresponding to the post-recessionary period, as reported in Table 4 and depicted in Figure 3, we firstly note a change in coefficient signs from positive in the pre-recession period and now turning negative and significant at all critical levels in the post-recession period. This finding implies that intense energy efficiency programmes will prove to be detrimental in terms of unemployment reduction and that unemployment can be reduced via increased electricity usage which will directly increase electricity intensity. Moreover, since the negative effect is amplified as one moves up the quantiles this implies that the more electricity intensive the sectors are, the lower unemployment will be. Another interesting finding concerns the coefficient estimates on the inflation variables which are now negative and all significance levels across all quantiles. This particular results points to a traditional Philips curve trade-off in which a more expansionary policy stance adopted by a Central Bank would result in less unemployment. And further seeing that the negative correlation exists at all quantiles levels, this particular result encourages the Reserve Bank to keep in pursuit of their current inflation targeting regime which will produce a conducive environment for unemployment reduction.

Also in similarity to the pre-recession periods, very low investment levels (i.e., 10th quantile) in the post-recession period produces a negative and 10% significant effect on unemployment whereas at relatively higher levels (i.e., 70th, 80th and 90th quantiles) investment exerts an increasingly positive and significant effect on unemployment. In the remaining quantiles (i.e., 20th, 30th, 40th, 50th and 60th quantiles), investment insignificantly affects unemployment. Furthermore, concerning the government expenditure variable, the coefficient estimates in the post-recession period are the same as those obtained for the pre-recession period in the sense of being positive and statistically significant at all critical levels across all the quantiles. Finally, for the terms of trade variable, the signs on the coefficient estimates change from being primarily positive in the pre-recession period to being negative in the post-recession at all significance levels for the 10th through to the 50th quntile, at a 10% critical level for the 60th quantile and 1% critical level for the 70th quntile whereas in the remaining quantile the reported coefficient estimates are statistically insignificant. Note that the negative terms of trade - unemployment relationship now adheres to that advocated for by Keynesian economists.

6. CONCLUSION

The objective of this study has been to investigate the impact of electricity intensity and other control variables on unemployment for the South African economy using interpolated quarterly data collected between 2000:01 and 2014:04. Our mode of empirical investigation was the quantile regression method which presents the advantage of enabling us to analyse the effect of electricity on unemployment across several distribution points. Moreover, our empirical analysis was conducted over two-sub sample periods, one corresponding to the pre-2008 electricity crisis period and the other corresponding to the post-electricity crisis period. Indeed our empirical results indicate a changing relationship between electricity intensity and unemployment as one moves from the pre-crisis period to the post-crisis period. In particular, we find that prior to the electricity crisis, electricity intensity was positively and significantly correlated with unemployment

Figure 3: Quantile process estimates (post-recession period)

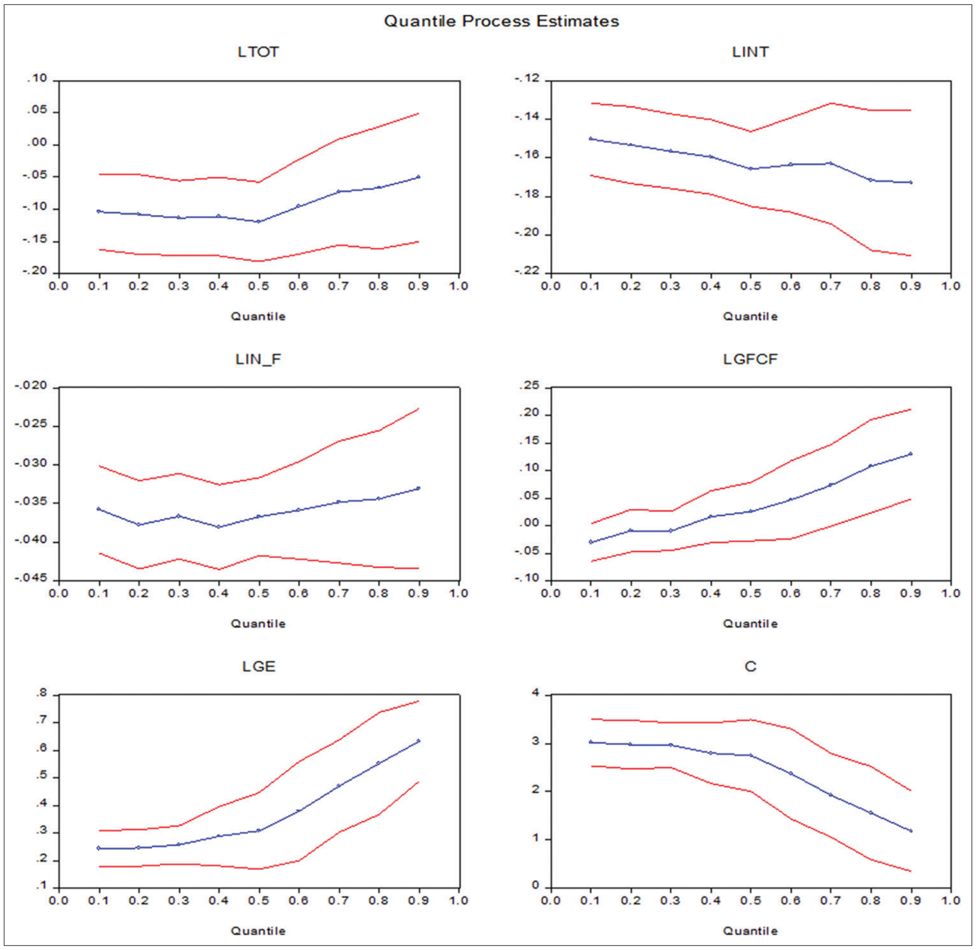


Table 4: Quantile estimate for post-crisis periods

Quantiles	c	int	inf	inv	gov	tot
OLS						
0.1	3.017 (0.00)***	−0.150 (0.00)***	−0.035 (0.00)***	−0.030 (0.08)*	0.243 (0.00)***	−0.104(0.00)***
0.2	2.976 (0.00)***	−0.153 (0.00)***	−0.037 (0.00)***	−0.009 (0.65)	0.246 (0.00)***	−0.108 (0.00)***
0.3	2.964 (0.00)***	−0.157 (0.00)***	−0.036 (0.00)***	−0.010 (0.60)	0.258 (0.00)***	−0.114 (0.00)***
0.4	2.979 (0.00)***	−0.159 (0.00)***	−0.038 (0.00)***	0.016 (0.50)	0.289 (0.00)***	−0.112 (0.00)***
0.5	2.749 (0.00)***	−0.166 (0.00)***	−0.037 (0.00)***	0.026 (0.35)	0.308 (0.00)***	−0.119 (0.00)***
0.6	2.369 (0.00)***	−0.164 (0.00)***	−0.036 (0.00)***	0.047 (0.19)	0.379 (0.00)***	−0.096 (0.01)**
0.7	1.925 (0.00)***	−0.163 (0.00)***	−0.035 (0.00)***	0.073 (0.06)*	0.470 (0.00)***	−0.073 (0.08)*
0.8	1.556 (0.00)***	−0.172 (0.00)***	−0.034 (0.00)***	0.108 (0.01)**	0.553 (0.00)***	−0.067 (0.17)
0.9	1.182 (0.00)***	−0.173 (0.00)***	−0.033 (0.00)***	0.129 (0.00)***	0.633 (0.00)***	−0.051 (0.32)

P-values reported in parentheses. ***significant at 1% level, **significant at 5% level, *significant at 10% level

at all quantiles hence implying that in the periods prior to the recession, improved electricity efficiency as indicated by a decreasing electricity intensive coefficient, would have resulted in a lowering of the unemployment rate. On the other hand, the relationship turns negative and significant in the post-recession period thus indicating improved electricity efficiency would cause more unemployment.

From a policy perspective our empirical results bears important implications. For instance, the asymmetric trend in the relationship between electricity intensity and unemployment signifies a decoupling effect as caused by the electricity crisis of 2008 in conjunction with the global recession period. Prior to these periods, when the policymakers began to engage in electricity efficiency programmes which resulted in a lowering of the electricity intensity or electricity usage per unit of output, resulted in desirable effects in terms of creating and environment conducive for unemployment reduction. However, following the crisis, which coincides with the global recession period, pursuing such policies would prove to hamper employment creation and thus increase current unemployment rates. Part of the reason for this finding could be that the economy has not fully recovered from the adverse effects of the recessionary period and hence increased electricity usage (i.e., lower electricity intensity) across all economic sectors may be pivotal in producing a conducive environment for reducing unemployment rates.

In collectively summarizing the findings of our study, the pre-crisis period of 2001 to 2008 represents an era of a positive unemployment-electricity intensity relationship whereas during the post-crisis period the relationship turns inverse. Therefore, our study particularly discourages policymakers from implementing aggressive electricity conservation policies and rather encourage policymakers to follow in pursuit in the use of alternatives forms of producing electricity without compromising the continual use of electricity by economic units within the country. The most notable of these alternatives are renewable energy sources which provide an additional environmental benefit, in terms of greenhouse emissions, and yet our study cautions policymakers to view these alternative measures as supplement rather than replacement sources for increased electricity usage. Taking into account the positive policy values derived from our study, possible avenues for future research would be to carry similar research for other economies or cluster of countries more specifically towards developing economies where the issue of electricity usage is particularly problematic.

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