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Does loadshedding affect the housing market in South Africa? Some empirical evidence

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Abstract

Purpose – The purpose of this study is to quantify the impact of electricity power outages on the local housing market in South Africa.

Design/methodology/approach – This study uses the autoregressive distributive lag (ARDL) and quantile autoregressive distributive lag (QARDL) models on annual time series data, for the period 1971–2014. The interest rate, real income and inflation were used as control variables to enable a multivariate framework.

Findings – The results from the ARDL model show that real income is the only factor influencing housing price over the long run, whereas other variables only have short-run effects. The estimates from the QARDL further reveal hidden cointegration relationship over the long run with higher quantile levels of distribution and transmission losses raising the residential price growth.

Research limitations/implications – Overall, the findings of this study imply that the South African housing market is more vulnerable to property devaluation caused by power outages over the short run and yet remains resilient to loadshedding over the long run. Other macro-economic factors, such as real income and inflation, are more influential factors towards long-run developments in the residential market.

Originality/value – To the best of the authors' knowledge, this is the first study to examine the empirical relationship between power outages and housing price growth.

Keywords Electricity distribution and transmission losses (EDTL), Power outages, Loadshedding, House prices, South Africa, Quantile autoregressive distributive lag (QARDL) model

Paper type Research paper

1. Introduction

The prevalence of loadshedding in South Africa poses as a threat to everyday economic life. Electricity outages are a major setback to a country's long-term growth perspectives and economic damages arising from loadshedding range from direct sales losses, to diverting scarce resources into mitigation systems such as generators, to decreases in consumer confidence (Timilsina and Steinbuks, 2021). Whilst the direct economic effects of loadshedding on economic activity are well known (Adams *et al.*, 2020), there is less knowledge on the effect of power outages on the property market. We consider the residential market of particular interest because this sector is one of the largest consumers of electricity (Blignaut *et al.*, 2015) and housing ownership is at the epitome of an individual's wealth status which, in turn, is used by governments to reduce inequality through social

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cohesion (Tita and Opperman, 2022). Moreover, the vulnerability of the housing sector to price fluctuations makes the housing markets susceptible to episodes of bubble “build-up and crash” which is of interest to investors, banks, regulators and monetary authorities (Ncube and Ndou, 2011; Peretti *et al.*, 2012; Inglesi-Lotz and Gupta, 2013; Simo-Kengne *et al.*, 2013; Chang *et al.*, 2014).

In this study, we examine the impact of loadshedding on house price growth in South Africa as a country with one of the most developed property and housing markets on the African continent (Phiri, 2018). Despite boasting the highest electricity generating capacity in the sub-Saharan Africa region (Akinbami *et al.*, 2021), South Africa has been experiencing loadshedding since the declaration of an energy crisis in 2009, and these “power blackouts” have been implemented as a last resort to preventing the entire collapse of the national electricity grid (Ting and Byrne, 2020). From Figure 1, it can be observed that South Africa’s electricity distribution and transmission losses (EDTL), which are a result of an aging local grid and inefficient infrastructure (Ouedraogo, 2017; Akpeji *et al.*, 2020), have been on a steady increase since 2003 and reached a peak in 2009 when the country first implemented loadshedding. At the same time, the housing market boomed between 2000 and 2006, which eventually crashed in 2007 and has experienced sluggish recovery afterwards. At face value, it is difficult to tell whether there is any meaningful relationship between EDTL and house price growth, an observation that warrants formal empirical investigation into the subject matter. To the best of our knowledge, there is no previous research conducted on this topic, and this highlights the novelty of our contribution to the literature.

This paper examines the effects of loadshedding on house price growth in South Africa between 1971 and 2014 using two empirical models. Firstly, we use the autoregressive distributive lag (ARDL) model of Pesaran *et al.* (2001) to investigate the long- and short-run cointegration relationship between EDTL and house price growth. Secondly, we extend the ARDL model within a quantile framework in the spirit of Cho *et al.* (2015). By using the quantile autoregressive distributive lag (QARDL), we can unveil “hidden” cointegration relationships which may exist at other quantiles of distribution different to median-based estimates. Moreover, in differing from the conventional quantile regression of Koenker and Bassett (1978), the ARDL model retains the advantages of the ARDL model such as being compatible with time series with different orders of integration and allowing for short-run dynamics in the cointegration sense.

We use the ARDL and QARDL models to investigate three aspects of the EDTL–growth relationship. Firstly, we are interested in the sign of the relationship, that is, does EDTL increase or decrease house prices. On one hand, a negative relationship implies that

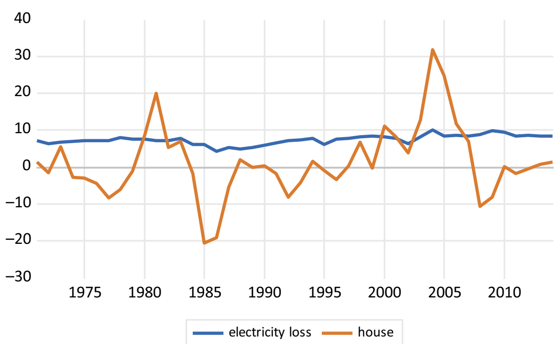

Figure 1.
Time series plots of housing price growth (house) and EDTL (electricity_loss)

loadshedding decreases the value of the housing market as it disrupts disposable household income and hampers investor confidence (Adams *et al.*, 2020), which can have adverse demand-side shocks into the housing markets. On the other hand, a positive relationship implies that loadshedding can push up house prices due to increased supply-side costs such as those incurred in the construction sector (Timilsina and Steinbuks, 2021). Secondly, we are interested in determining whether the observed relationships are long-run or short-run. Whereas potential homebuyers would be interested in short-run adjustment effects of loadshedding on house prices, homeowners and policymakers would be more interested in the long-run effects. Lastly, we are interested in determining whether the observed relationships are asymmetric. For instance, EDTL could only affect house prices at higher levels of distribution and transmission losses, but not at mild or low levels. This is important since loadshedding has been getting more severe over time and it is possible that its effect on the residential markets may be more prominent at higher quantiles of distribution.

Despite our study being conducted over the period 1971–2014, due to data constraints, it is important to note that power outages in South Africa have been increasingly worsening since 2018. In response to the recent severity of power shortages, the National Energy Regulator South Africa released a code of practices for real-time emergencies (i.e. NRS 048-9:2019) which makes provision for continuous time-based interruption of supply to customers on a rotational basis. Since then, the country has been subjected close to 4,000 rotational hours of loadshedding (i.e. equivalent to 166 "blackout days") between 2019 and 2022 (so far) and with no immediate end in sight to the ongoing planned power outages. Our findings can shed light on the expected impact of loadshedding on South Africa's housing market over both the short and long run. Also considering that there no previous empirical studies, to the best of our knowledge, which have examined the impact of power outages on the housing market, our study makes a novel contribution to the burgeoning literature on housing market dynamics.

Against this background, the rest of this paper is structured as follows. Section 2 presents the literature review, whereas Section 3 outlines the empirical methods used in the study. The data and empirical results are presented in Section 4, and the study is concluded in Section 5.

2. Literature review

Whilst there are no previous studies which have investigated the impact of loadshedding on the housing market, our study relates to previous studies which have directly or indirectly estimated the impact of loadshedding on economic activity in South Africa. We categorize these studies into three strands of empirical works.

Firstly, there are studies which have indirectly investigated the impact of loadshedding on economic growth in South Africa by examining the electricity–growth relationship using country-specific data (Wolde-Rufael, 2005; Ziramba, 2008; Odhiambo, 2009; Dlamini *et al.*, 2015; Phiri and Nyoni, 2016; Bah and Azam, 2017; Nyoni and Phiri, 2018). Notably, these studies produce an array of conflicting empirical evidence, with the studies of Ziramba (2008), Odhiambo (2009), Phiri and Nyoni (2016) and Nyoni and Phiri (2018) finding an adverse effect of decreased electricity consumption/production on growth, whereas the studies of Wolde-Rufael (2005), Dlamini *et al.* (2015) and Bah and Azam (2017) find no impact of electricity consumption/production on growth.

Secondly, there are studies which have used computerized general equilibrium (CGE) models to calibrate the direct impact of loadshedding on economic growth in South Africa. Punt (2008) uses the social accounting matrix and CGE models to stimulate the impact of a decrease in productivity caused by loadshedding and find that blackouts are likely to decrease imports, exports, employment and household income whilst increase the inflation rate. Volkwyn and Kleynhans (2014) also use a CGE model to stimulate scenarios of electricity price increases and electricity supply disruptions and find that the costs associated with an increase in the price of electricity would be a more preferable to those from electricity reduction through power cuts. Olasoji *et al.* (2018) present an economy-wide assessment of the impact of electricity disruptions in South Africa by using a hypothetical extraction method which removes the interactions of the electricity sector with the rest of the economy. The authors find that the annual supply-side losses (R297,607m) are more severe than the annual demand-side losses (R238,920). More recently, Akpeji *et al.* (2020) measure the cost of power interruptions using survey data which is applied to a dynamic inoperability input-output model and estimated an economy loss of R54,536m for 24 hours of loadshedding which is equivalent to 27 days of continuous stage 1 loadshedding.

Lastly, and more closely related to our study, is the recent work of Adams *et al.* (2020) which examines the direct impact of EDTL on economic growth in South Africa over the period 1971–2014 using both linear ARDL and nonlinear autoregressive distributive lag (NARDL) model. The linear model reveals a negative short- and long-run effect of EDTL on economic growth whilst the NARDL model further shows that magnitude of the harm caused increasing rates of EDTL on economic growth outweigh the magnitude of economic growth gains obtained from decreasing rates of EDTL.

Our study contributes to this line of literature by examining the impact of EDTL on house price growth in South Africa as a means of evaluating the impact of loadshedding on the housing market. On one hand, we hypothesize that loadshedding can adversely impact the housing market through demand factors as demonstrated in Punt (2008), Olasoji *et al.* (2018) and Akpeji *et al.* (2020). On the other hand, we hypothesize that loadshedding could have more dominant supply-side effects as reflected through higher electricity tariffs and production costs, and this argument has been previously put forth by Volkwyn and Kleynhans (2014). We outline the methodological framework used to test these hypothesizes in the following section.

3. Methodology

3.1 Baseline autoregressive distributive lag model

Theoretically, the life-cycle hypothesis (LCH) of Modigliani (1966), which describes the preferred distribution of consumption and saving/investments patterns over a person lifetime, is crucial to understanding why loadshedding may lead to imbalances in the housing market. Several studies have used LCH to model consumption patterns of housing assets over an individual's life cycle and mutually conclude that institutional and borrowing constraints hinder individuals from accumulating housing assets in their early life, whilst transaction costs generate the slow downsizing of the housing assets later in their life (Artle and Varaiya, 1978; Li and Yao, 2007; Yang, 2009). Moreover, Fakih *et al.* (2020) consider power outages a disruption cost which diverts resources from their productive use leading to lower company profits, job losses and stagnant economic growth. These factors, in turn, can adversely affect the demand for housing assets for individuals in both their earlier stage (Attanasio *et al.*, 2012) and late stage (Green and Lee, 2016) of their life cycles. To test the formulated hypothesis of whether loadshedding affects house market, the study explores the empirical relationship between EPTL and house price growth where EPTL approximates how much was forfeited in electric energy as a result of loadshedding. Our baseline empirical specification is given as:

$$\text{House}_t = \psi_0 + \psi_1 \text{EDTL}_t + \psi_2 \text{GDP}_t + \psi_3 \text{inflation}_t + \psi_4 \text{interest}_t + \psi_4 \text{FDI}_t + \varepsilon_t \quad (1)$$

where α is an intercept and ψ's are the regression coefficients. Real gross domestic product (GDP), inflation, real interest rates and foreign direct investments (FDI) are added to the model as control variables as dictated by literature. For instance, GDP is considered the main driver of housing market growth because it directly reflects the real disposable income generated by individuals, firms and government available to purchase and/or build properties and thus drive up market demand and supply in the housing market (Simo-Kengne *et al.*, 2012; Chang *et al.*, 2014; Tita and Opperman, 2022). Also, an increase (decrease) in interest rates can adversely affect the housing market through user increased (decreased) cost of capital, higher (lower) expectations of future housing prices and lower (higher) housing supply and further exert indirect effects on wealth accumulation, consumer spending and access to credit (Mishkin, 2007). Henceforth, a negative relationship is expected between interest rates and the property market (Ncube and Ndou, 2011; Peretti *et al.*, 2012). Moreover, inflation is considered as a suitable determinant of housing market although the literature is divided on their relationship, with Inglesi-Lotz and Gupta (2013) advocating for a positive relationship via the Tobin (1965) effect, whereas Akca (2022) finds a negative yet insignificant relationship implying long-run "superneutrality" of money supply (Sidrauski, 1967). We lastly include FDI as determinant of housing price growth because foreign buyers in local emerging markets has considerably increased over the last few decades and have contributed to the growth of housing markets (Kim and Lee, 2022).

To estimate the empirical regression (1), we make use of the ARDL model of Pesaran *et al.* (2001) and model the short- and long-run cointegration relationships between the time series. The ARDL framework is preferred because of its well-known empirical advantages, such as its flexibility in accommodating a mixture of I(0) and I(1) variables; its suitability for small sample sizes; and produces unbiased estimates of the long-run coefficients even if some of the regressors are endogenous (Pesaran *et al.*, 2001). We specify our baseline ARDL model as:

$$\begin{aligned}\text{house}_t = {} & \alpha_0 + \sum_{i=0}^{p} \beta_1 \text{house}_{t-i} + \sum_{i=0}^{q} \beta_2 \text{EDTL}_{t-i} + \sum_{i=0}^{r} \beta_3 \text{GDP}_{t-i} \\ & + \sum_{i=0}^{s} \beta_4 \text{inflation}_{t-i} + \sum_{i=0}^{t} \beta_5 \text{interest}_{t-i} + \sum_{i=0}^{t} \beta_6 \text{FDI}_{t-i} \\ & + \gamma_1 \text{house}_{t-1} + \gamma_2 \text{EDTL}_{t-1} + \gamma_3 \text{GDP}_{t-1} + \gamma_4 \text{inflation}_{t-1} \\ & + \gamma_5 \mathit{interest}_{t-1} + \gamma_6 \mathit{FDI}_{t-i} + \end{aligned} \quad (2)$$

The delta sign Δ represents the differences operator, α is the intercept, β's and γ's are the short- and long-run model coefficients, respectively, and ε is the error term. The modelling process begins with performing the bounds test for cointegration by testing the following null hypothesis:

$$\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0 \quad (3)$$

Against the alternative:

$$\gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq \gamma_5 \neq 0 \quad (4)$$

The above hypotheses are tested using a F-statistics against lower- and upper-bound critical values provided by Pesaran *et al.* (2001). The decision rule is that cointegration effects exist if the estimated F-statistics is larger than the upper-bound critical statistics whereas if it lies below the lower bound, then cointegration is rejected, and if it lies in between the lower and upper bound, the test is inconclusive. Once cointegration effects are verified, then we proceed to estimating the long-run regression found in equation (1) with the long-run coefficients being computed as $\psi_1 = \gamma_2/\gamma_1$; $\psi_2 = \gamma_3/\gamma_1$; $\psi_3 = \gamma_4/\gamma_1$ and $\psi_4 = \gamma_5/\gamma_1$. Finally, the short-run and error correction form by firstly extracting the error term from equation long-run regression and creating the following error correction model:

$$\begin{aligned}\text{house}_t = \ & \alpha_0 + \sum_{i=0}^{p} \beta_1 \Delta\text{house}_{t-i} + \sum_{i=0}^{q} \beta_2 \Delta\text{EDTL}_{t-i} + \sum_{i=0}^{r} \beta_3 \Delta\text{GDP}_{t-i} \\ & + \sum_{i=0}^{s} \beta_4 \Delta\text{inflation}_{t-i} + \sum_{i=0}^{t} \beta_5 \Delta\text{interest}_{t-i} + \sum_{i=0}^{t} \beta_6 \Delta\text{FDI}_{t-i} \\ & + \Psi ECT_{t-1} + \varepsilon_i \end{aligned} \quad (5)$$

where the term ECT is the error correction term which measures the speed of reversion back to equilibrium following a shock to the system and is assumed to be negative and statistically significant. Note that Pesaran *et al.* (2001) treat the t-statistics of the ECT as an additional test for cointegration in the ARDL model.

3.2 Quantile autoregressive distributive lag model

Whereas the ARDL model is virtuous in being a flexible framework which can model the long- and short-run cointegration relations amongst the time series, one notable disadvantage is that the model fails to incorporate nonlinear dynamics. To this end, we consider the QARDL model of Cho *et al.* (2015) which is an extension of the conventional ARDL model with the quantile regression process proposed by Koenker and Bassett (1978). By converting equation (2) into a quantile format, we obtain our baseline QARDL model specified as:

$$\text{Y}_t = \ \alpha_0(\tau) + \sum_{i=0}^{p} \phi_i(\tau)\text{Y}_{t-i} + \sum_{i=0}^{p} {}^{*} \phi_i(\tau)\text{X}_{t-i} + U_t(\tau) \quad (6)$$

where Y_{it} is the dependent variable, house and X_{it} is the compact set of distributive lag covariates. For analytical purposes, equation (7) can be respecified as:

$$\text{Y}_t = \ \alpha_0(\tau) + \sum_{i=0}^{q-1} W'_{t-i} \ \delta_j(\tau) + X'_t\gamma(\tau) + \sum_{i=0}^{q} \phi_i(\tau)\text{Y}_{t-i} + U_t(\tau) \quad (7)$$

where $\gamma(\tau) = \sum_{i=0}^{q-1} W'_{t-j}\theta_j(\tau)$, $\text{W}_\text{t} = \Delta\text{X}_\text{t}$ and $\delta_j(\tau) = -\sum_{i=0}^{p} {}^{*} \phi_i(\tau)\text{X}_{t-i}$. In following Koenker and Bassett (1978), the conditional mean function of Y on X can be expressed as:

$$\min_\beta \left[\theta \sum |Y_t - X_t\beta| + (1+\theta) \sum |Y_t - X_t\beta|\right] \{t : FS_t \geq X_t\beta\}\{t : \ FS_t < \ X_t\beta\} \quad (8)$$

where, $\{Y, t = 1,2 \ldots, T\}$ is a random sample on the regression process. $Y = \alpha_t + X_t\beta$, with conditional distribution function of $F_{\frac{Y}{X}}(y) = F(Y_t \leq house) = F(Y_t - X_t\beta)$ and $\{X_t, t = 1,2 \ldots, T\}$ is the sequences of (row) k-vectors of a known design matrix. The θth regression quantile, $Q_{\frac{Y}{X}}(\theta),\ 0<\theta<1$ is any solution to minimize problems, β_θ denotes the solution from which the θth conditional quantile $Q_{\frac{Y}{X}}(\theta)=x\beta_\theta$. Once the estimates from the baseline QARDL regression are obtained, then the long-run estimator is given as:

$$\beta(\tau)=\gamma\ (\tau)\left(1-\sum\nolimits_{i=0}^{p}{}^{*}\,\phi_i(\tau)\right)^{-1} \tag{9}$$

Whilst the short-run and error correction models are estimated as:

$$\Delta Y_t = \alpha_0(\tau)+\zeta_*(\tau)\left(Y_{t-i}-\beta(\tau)'X_{t-i}\right)+\sum\nolimits_{i=0}^{p-1}\phi_i(\tau)\Delta Y_{t-i}$$
$$+\sum\nolimits_{i=0}^{p}{}^{*}\,\phi_i(\tau)\Delta X_{t-i}+U_t(\tau) \tag{10}$$

where $(Y_{t-i}-\beta(\tau)'X_{t-i})$ is the quantile error correction term.

4. Empirical results

4.1 Data description, summary statistics and correlation matrix

Annual data was obtained from the World Bank and the Federal Reserve Economic Data (FRED) database by the Federal Reserve Bank of St. Louis. The EDTL, GDP, real interest rate (interest) and consumer price inflation (inflation) data was obtained from the World Bank database. The national house-price growth data was obtained from FRED. Our sample covers the period from 1971 to 2014 and is determined by data availability. The variables definitions and their sources are detailed further more in the Appendix.

Table 1 summarizes the descriptive statistics of the time series which presents some interesting stylized facts. For instance, the summary statistics indicate that whilst house price growth has averaged 1.32 over the sample period, the series has been very volatile as evident from the reported standard deviation of 9.64. Conversely, the EDTL has averaged 7.45% of GDP and is not very volatile. Also note that the interest rate on average been larger than inflation implying an averaged positive real interest rate for the country whereas GDP has averaged 2.54% which reflects the low-growth trajectory the country has had since the 1970s.

Table 2 presents the correlation matrix of the time series variables from which we observe some preliminary relationships of interest. In particular, we have positive (negative) correlation between house price growth and EDTL, GDP, FDI, inflation and interest rates.

Lastly, Table 3 presents the unit root tests of the time series variables. Whilst we note that the ARDL framework is compatible with a mixture of stationary and first-differenced stationary series, we need to be ensured that none of our variables is second-differenced

Summary statistics	House	EDTL	GDP	Inflation	Interest	FDI
Mean	1.32	7.45	2.54	9.53	10.12	0.72
SD	9.64	1.25	2.25	4.38	4.31	1.12
Skew	0.73	−0.34	−0.39	−0.02	0.43	1.94
Kurtosis	4.93	3.07	2.39	2.29	2.08	8.02
Jarque–Bera	10.69	0.88	2.39	2.29	2.08	73.80
p-value	0.00	0.64	0.41	0.63	0.23	0.00
Observations	44	44	44	44	44	44

Table 1. Summary statistics

stationary or of higher integration. The results of the ADF and DF-GLS tests performed with either an intercept or an intercept and a trend confirm that all series are either I(0) or I(1) and none are I(2). Moreover, the findings from the Lee and Strazicich (2013) (L-S hereafter) unit root test with an endogenous determined structural break reveals similar findings to the conventional tests albeit identifying a number of structural beak in the time series. We treat this evidence of structural break behaviour in the variables as motivation to account for location asymmetries in our analysis.

4.2 Autoregressive distributive lag results

We begin by estimating the linear ARDL model of our empirical regression and we have reported the empirical findings in Table 4 below. Panel A of Table 4 presents the long-run regression estimates and as can be observed the coefficient on EDTL, inflation, interest rates and FDI are insignificantly related with house price growth over the steady state whereas a positive and significant relationship is only found for GDP. In turning to the short-run coefficients reported in Panel B, we now observe negative and statistically significant estimates for EDTL, inflation and FDI whereas that for GDP remains positive. The results for inflation are mixed, with negative (positive) and significant estimates found at lower (higher) coefficient lags. The significance of the error correction term and the F-statistic (Panel C) indicate significant cointegration effects in which the short-run dynamics gradually converge towards the long, with dis-equilibrium been corrected after 1.67 years after the initial shock.

Table 2. Correlation matrix

Correlation matrix	House	EDTL	GDP	Inflation	Interest	FDI
House	1					
EDTL	0.41	1				
GDP	0.50	0.15	1			
Inflation	−0.53	−0.75	−0.37	1		
Interest	−0.18	−0.36	−0.40	0.38	1	
FDI	0.14	0.39	0.17	−0.47	−0.16	1

Table 3. Unit root tests

Unit root tests	House	EDTL	GDP	Inflation	Interest	FDI
Panel A: Levels						
ADF: int.	−2.19*	−2.21	−4.67***	−1.81	−2.76*	−4.56***
ADF: int. + trend	−3.59**	−2.93	−4.63***	−3.64**	−2.71	−5.93***
DF-GLS: int.	−2.95***	−2.21**	−4.41***	−1.69*	−1.81*	−4.50***
DF-GLS: int. + trend	−3.65**	−2.89*	−4.57***	−2.30*	−2.60	−5.53***
L–S	−4.33*	−5.07***	−5.59***	−4.09	−6.67	−5.38
	[1998]	[1995]	[1984]	[1997]	[1983]	[1995]
Panel B: First difference						
ADF: int.	−5.90***	−8.08***	−6.69***	−5.56***	−5.61***	−7.96***
ADF: int. + trend	−5.83***	−7.98***	−6.61***	−6.38***	−5.49***	−7.93***
DF-GLS: int.	−5.87***	−6.99***	−6.70***	−6.32***	−5.69***	−9.61***
DF-GLS: int. + trend	−5.93***	−7.84***	−6.31***	−6.54***	−5.86***	−7.64***
L-S	−5.82***	−8.34***	−7.28***	−7.24***	−6.87***	−7.13***
	[1979]	[1983]	[2007]	[1993]	[1982]	[2008]

Notes: ***, ** and * denote 1, 5 and 10% significance levels, respectively. Breakpoint years for the L-S test are reported in brackets

Variables	Coefficient	p-value
Panel A: Long-run		
EDTL	3.61	0.15
GDP	5.49	0.00***
Inflation	1.52	0.05*
Interest	0.21	0.63
FDI	1.83	0.51
Constant	−57.53	0.02*
Panel B: Short-run		
Δhouse(−1)	0.29	0.01**
Δhouse(−2)	0.34	0.00***
Δhouse(−3)	0.45	0.00***
ΔEDTL	1.41	0.17
ΔEDTL(−1)	0.02	0.98
ΔEDTL(−2)	−2.78	0.00***
ΔEDTL(−3)	−1.55	0.06*
ΔGDP	0.72	0.07*
Δinflation	−1.33	0.00***
Δinflation(−1)	−1.20	0.00***
Δinterest	−1.00	0.00***
Δinterest(−1)	−1.78	0.00***
Δinterest(−2)	0.63	0.09*
ΔFDI	−1.26	0.02**
ECT(−1)	−0.61	0.00***
Panel C: Diagnostics		
F-stat	6.89***	
JB	1.02	0.59
BGsc	1.42	0.28
ARCH	1.53	0.18
FF	0.31	0.75

Note: ***, ** and * denote 1, 5 and 10% significance levels, respectively

Table 4. ARDL results

Moreover, the results of the diagnostic tests reported in Panel D indicate an absence of non-normality, serial correlation, heteroscedasticity in the regression error terms, and further advocate for correct functional form implying that higher order terms do not need to be included in the regression. Finally, the CUSUM and CUSUM square tests indicate that the estimated regression is stable at a 5% critical level (see Figures 2 and 3).

4.3 Quantile autoregressive distributive lag results

We now present the findings from the QARDL model which we report in Table 5. Overall, we observe that the findings from the QARDL model uncover hidden cointegration relationships existing at different distributional quantiles which could not be captured by the mean-based estimations of the conventional ARDL model.

From Panel A, the reported long-run coefficients show that all variables contain significant estimates albeit at different quantiles of distribution. For instance, EDTL produces a positive and significant estimate on the house price growth at the 90th quantile whilst showing insignificant estimates at other quantiles. Similarly, interest shows a positive coefficient at the 80th quantile whilst being insignificant at the remaining quantiles. Notably, GDP (inflation) produces a positive (negative) and significant long-run impact on

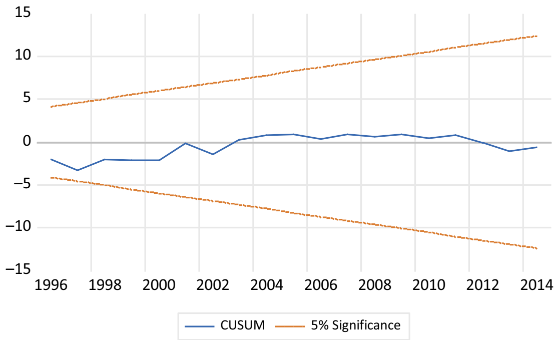

Figure 2.
CUSUM plot

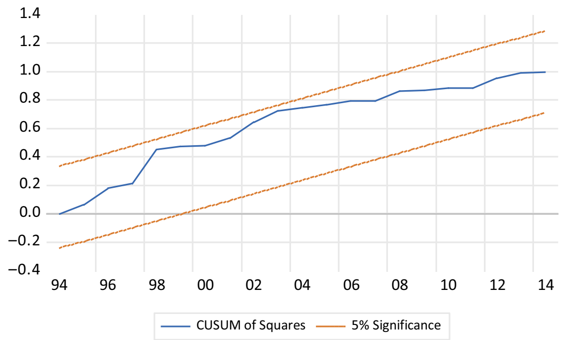

Figure 3.
CUSUM.SQ plot

housing growth at all quantiles except for the 30th and 70th (40th) quantiles. Lastly, FDI produces a negative long-run effect on housing growth across all quantiles.

Similarly, in Panel B for the short-run coefficients, we observe significant estimates for all variables at different quantiles except for interest rates and FDI in which the coefficient estimates are insignificant at all quantiles. For EDTL and inflation, negative coefficients are observed at all quantiles except the 40th–60th quantiles for the former and 10th–30th quantiles for the latter. For GDP, positive coefficients are observed at the 10th–30th quantiles and are insignificant otherwise. Lastly, the error correction terms provide the expected negative and positive coefficient estimate which we treat as evidence of significant QARDL effects of the estimated model. Moreover, the error correction terms inform us that disequilibrium in the system are corrected quicker at lower quantiles and slower at higher quantiles.

4.4 Further discussion of the results

In this section, we provide a further discussion of our empirical results. We firstly discuss the implications of the linear ARDL estimates followed by the implications for QARDL estimates.

From the linear ARDL estimates, we find that GDP is the only significant factor affecting house price growth over the long run and this effect is positive. This finding correlates with those previous found in the studies of Simo-Kengne *et al.* (2012) for South Africa provincial data and implies that long-run growth in the housing market can be fuelled by better

Quantile	EDTL	GDP	Inflation	Interest	FDI
0.1	0.07 (0.91)	1.94 (0.02)**	−0.85 (0.04)*	−0.28 (0.47)	−1.47 (0.55)
0.2	0.23 (0.69)	1.83 (0.02)**	−1.12 (0.00)***	0.07 (0.86)	−1.63 (0.44)
0.3	0.28 (0.67)	1.36 (0.11)	−1.01 (0.02)**	0.16 (0.67)	−1.17 (0.65)
0.4	−0.30 (0.64)	1.96 (0.02)**	−0.52 (0.33)	0.05 (0.90)	0.53 (0.76)
0.5	0.11 (0.87)	1.67 (0.04)*	−0.86 (0.08)*	0.47 (0.26)	−0.96 (0.69)
0.6	0.30 (0.67)	1.54 (0.07)*	−0.89 (0.06)*	0.46 (0.28)	−0.28 (0.86)
0.7	0.71 (0.43)	1.50 (0.13)	−0.99 (0.04)*	0.43 (0.35)	0.02 (0.99)
0.8	0.56 (0.55)	2.23 (0.02)**	−1.15 (0.04)*	0.79 (0.09)*	−0.62 (0.66)
0.9	2.14 (0.07)*	1.11 (0.37)	−1.32 (0.00)***	0.65 (0.35)	−1.93 (0.19)
	ΔEDTL	ΔGDP	ΔInflation	ΔInterest	ΔFDI
0.1	−0.77 (0.70)	0.12 (0.81)	−2.83 (0.00)***	0.17 (0.80)	1.18 (0.36)
0.2	−0.01 (0.99)	0.70 (0.10)	−1.29 (0.18)	0.01 (0.98)	−0.32 (0.87)
0.3	0.99 (0.61)	0.71 (0.18)	−0.99 (0.33)	0.04 (0.94)	0.72 (0.57)
0.4	2.18 (0.29)	1.04 (0.08)*	−1.28 (0.19)	−0.06 (0.92)	0.43 (0.75)
0.5	2.42 (0.23)	0.79 (0.18)	−1.33 (0.15)	−0.14 (0.83)	0.21 (0.86)
0.6	2.56 (0.21)	1.28 (0.09)*	−0.73 (0.36)	−0.31 (0.69)	−0.29 (0.74)
0.7	2.22 (0.25)	1.44 (0.05)*	−0.79 (0.31)	−0.41 (0.56)	−0.37 (0.63)
0.8	2.91 (0.08)*	1.06 (0.22)	−1.15 (0.08)*	−0.61 (0.37)	−0.40 (0.52)
0.9	2.01 (0.36)	1.70 (0.02)**	−1.50 (0.09)*	0.45 (0.53)	−0.92 (0.26)
	ECT(−1)				
0.1	−0.43 (0.06)*				
0.2	−0.49 (0.03)*				
0.3	−0.59 (0.02)**				
0.4	−0.49 (0.05)*				
0.5	−0.48 (0.05)*				
0.6	−0.21 (0.08)*				
0.7	−0.33 (0.07)*				
0.8	−0.32 (0.05)*				
0.9	−0.29 (0.09)*				

Notes: ***, ** and * denote 1, 5 and 10% significance levels, respectively. *p*-values reported in parentheses

Table 5. QARDL results

economic performance and more disposable income available to households. Concerning the short-run, we find that all factors impact house prices, with GDP still maintaining its positive effect whilst EDTL and inflation are dominantly negative and interest rates have negative effects in the first few lags and positive effects thereafter. Notably, the negative impact of consumer inflation on house price growth is not surprising as this implies that inflation erodes disposable income available for families to purchase new residential homes (Demary, 2010). Moreover, the initial positive effect of interest rates and electricity losses on house price growth implies that movements in these variables initially affect the supply-side factors such as costs which increases the value of the residential property, however, as time passes, the negative demand side effects such as loss in consumer confidence and loss of disposable income begin to appear. Also, the insignificant impact of FDI on housing growth implies that the financing structure of foreign investments is not conducive for the housing market (Nguyen, 2011; Tsai, 2018).

The QARDL estimates provide additional information on the relationship of the variables with house price growth at different quantiles of distribution. This is important as we would expect the effects of loadshedding to be better captured at higher quantiles because these power blackouts are associated with "above-normal" distribution and transmission losses in electricity provision. Indeed, our results show a significant and positive effect of EDTL on housing growth exists only at the highest distributional quantiles implying that loadshedding may have more supply side shocks over the long-run which may increase the value of residential property. The short-run effects remain negative although they are only significant at the bottom and top end of the quantile distributions. On the other hand, GDP (inflation) produces expected positive (negative) long-run effect at most quantiles, and this result is an improvement over the results obtained from the ARDL where these effects are only found in the short run. We further note that interest rates only produce a positive and significant effect at higher levels of distribution, and this finding implies that monetary policy can only affect the housing market at very high interest rates. Similar findings and insinuations are found in the study of Simo-Kengne *et al.* (2013). The observed insignificant effect of interest rates on housing market over the short run was similarly found by Phiri (2018) and further demonstrates resilience that the housing market has to short-run movements in monetary policy.

5. Conclusions

Our study examines the impact of EDTL on house price inflation as a means of quantifying the impact of loadshedding on the property market. To investigate this relationship, we used the ARDL and QARDL cointegration models applied to time series data collected over the period 1971–2013. The ARDL estimates provide little evidence of a significant long-run impact of EDTL on housing whilst the short-run effects are adverse. Conversely, the QARDL estimates show that "hidden" long-run relationships between EDTL and housing price growth exist at extreme quantiles whereas negative short-run relations are also found to be significant quantiles outside the median.

Overall, our findings show that loadshedding, as reflected at higher quantiles of distribution and transmission losses, initially depress housing prices in the short run due to demand-side factors such as decreased consumer confidence and lower disposable income, however, over the long-run supply-side factors take over and increase the value of property. Moreover, our findings indicate that other macro-economic factors such as disposable income and long-run interest rates are important for increasing residential property value whilst inflation hampers housing price growth. Therefore, we conclude that the housing market appears to be resilient to loadshedding over the long run and other macro-economic and monetary factors such as economic growth, interest rates and inflation, have more significant influence over long-run developments in the South African housing market.

Nevertheless, our results show that loadshedding is a concern for housing market over the short run and hence intervention is required to stabilize the housing markets. Furthermore, considering that our empirical analysis was performed over a period in which power outages were not so severe, the observed short-run adverse impact of loadshedding on housing markets could have intensified over time. Therefore, to ensure both short- and long-run stability in the housing market, the South African government needs to upscale its renewable energy sources through independent power producers and consequentially accelerate its transition away from coal-based energy supply sources which are responsible for the re-occurring blackouts.

Because our paper is a premier study investigating the effects of power outages on housing markets, we suggest at least three broad extensions to our current work. Firstly, researchers can consider using alternative measures of loadshedding since the current time series measuring EDTL from the World Bank only until 2013. Secondly, our analysis can be extended to include disaggregated sectors of the housing markets as loadshedding may have different effects across different housing categories, i.e. luxury, middle segment and affordable. Lastly, the analysis could be conducted for other countries and/or using more powerful estimation techniques.

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Appendix

Table A1.
Data sources

Name	Symbol	Source
Electricity power transmissions and distribution losses (% of output)	EDTL	World Bank development indicators
GDP growth (annual %)	GDP	World Bank development indicators
Inflation, consumer prices (annual %)	Inflation	World Bank development indicators
Real interest rate (%)	Interest	World Bank development indicators
Foreign direct investment, net inflows (% of GDP)	FDI	World Bank development indicators