Detection of multiple bubbles in South African electricity prices

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Abstract

This paper investigates the existence and dating of electricity price bubbles in South Africa from 1965 to 2013. In the literature, it is agreed that such a task is difficult due to the explosive nature of price bubbles and labeling their presence's occurrence. To overcome the predicament, we follow the methodological approach suggested by Phillips et al. (2013): a recursive right-tailed Generalized Sup Augmented Dickey-Fuller (GSADF). Two significant bubbles were detected in the output-adjusted nominal prices: the one was a long one from 1971 to 1998 and can be attributed to the monopolistic unregulated nature of the electricity market at the time; while the second one lasted for a shorted period of time (2008-2009) coinciding with the severe supply crisis of 2008, and the massive price hikes that followed it.

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Keywords: Bubbles; electricity prices; GSADF; South Africa

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Introduction

The detection of financial bubbles has been an attractive topic in the literature both from a theoretical and empirical point of view. Especially due to the recent global financial crisis, the literature focused on the bubble-like behavior not only of the prices of financial assets and housing market prices but also commodity and energy prices. The existence, duration and collapse of bubbles contribute to possible misallocation of resources and have negative economic consequences. As Phillips and Yu (2011) explain: "The most urgent ongoing questions relate to matters of fiscal, monetary and regulatory policies for securing financial stability and buttressing real economic activity".

Recently, South Africa has experienced sharp electricity tariff increases that has arguable affected not only the power sector but the economy in its entirety. In 2008, the first severe indications for a supply-side crisis were presented through power interruptions nationally with negative consequences. Since then, almost bi-annually, Eskom, the national electricity supplier, has applied continuously for price increases to the National Energy Regulator South Africa (NERSA) that have been in their majority accepted.

Although the effects of the electricity prices to the electricity consumption in South Africa are well documented (Ziramba, 2008; Inglesi, 2010; Inglesi-Lotz, 2011; Inglesi-Lotz and Blignaut, 2011; Inglesi-Lotz, 2014; Inglesi-Lotz and Pouris, forthcoming), the nature of the evolution of electricity prices in South Africa was never examined in the literature.

The main purpose of this paper is to fill this gap in the literature and investigate, for the first-time, the existence of the formation of bubbles in the electricity prices in South Africa from 1965 to 2013. In the literature, it is agreed that such a task is difficult due to the explosive nature of price bubbles and labeling their presence's occurrence. To overcome the predicament, we follow the methodological approach suggested by Phillips et al. (2013): a recursive right-tailed Generalized Sup Augmented Dickey-Fuller (GSADF). Bubbles are defined in this technique as periods of mildly explosive departures from a unit root Data Generating Process (DGP) followed by reversion back to a martingale process.

The paper is structured as follows. The second section presents the background of the South African electricity sector with particular emphasis to the pricing structures of the country as well as the specifics of the electricity market in South Africa. Next, the methodology will be explained and the data used will be described while consequently we will discuss the policy implications of the results. The final section concludes the paper.

Background on the electricity pricing in South Africa

The modern history of electricity pricing in South Africa started with establishment of the National Energy Regulator (NER) in 1995 and its close collaboration hereafter with Eskom in price-setting. In the 1990s, the priorities of the government differed to the current ones: providing access to energy was the primary focus. Hence, cost-reflecting tariffs and extending generational capacity were on hold for a few years. The high increases though in electricity demand as a result of the country's industrialization as well as the Free Basic Electricity initiative led to a serious mismatch of supply and demand in 2008. Eskom implemented rolling blackouts (load shedding) to stabilize demand and avoid total blackouts. (Thopil and Pouris, 2013).

The electricity pricing scheme used in South Africa is based on the multi-year determination (MYPD) and takes into account Eskom's cost recovery requirements with main aim the viability, profitability and sustainability of the national supplier. Although the first MYPD was formulated for the period from 2006 to 2009, Eskom applied for a review of the prices based on increasing energy costs in 2007. NERSA accepted an increase of approximately 14%. In 2008, a new application was submitted justified by fuel price volatility, fuel mix uncertainty, and excess energy demand and fuel burn rate efficiency uncertainty. The second MYPD specified an increase of 25% increase per annum until 2013 applicable to all electricity consumers.

The debate among various stakeholders, policy makers and researchers on the consequences of further increases in electricity prices has not stopped since the crisis of 2008, especially due to the new supply crisis of 2015 and the delays in the operation of the two new power plants (Kusile and Medupi).

Inglesi-Lotz (2011) showed the importance of higher electricity prices: the higher the prices (for example in the 1980s) the higher the sensitivity of consumers to price fluctuations. Thus, further increases of the electricity prices may lead to changes in the behavior of electricity consumers, focusing their efforts on improving their efficiency levels by introducing demand-side management techniques or even turning to other sources of – cheaper – energy. It is hence important to examine the nature of electricity prices through the years and identify possible bubbles, link them with the policies in the specific periods and see the consequences of their collapse.

Methodology and Data

A battery of tests was developed by Phillips, Wu and Yu (2011), Phillips and Yu (2011), Phillips, Shi and Yu (2012) and Phillips, Shi and Yu (2013) to identify an exact bubble in a series as well as its origination and collapse dates. To do so, these studies considered an Augmented Dickey and Fuller (1979, ADF) -type regression in a rolling window. In this paper an ADF regression for a rolling interval beginning with a fraction r_1 and ending with an r_2 fraction of the total number of observations, and hence, the size of the window is $r_w=r_2-r_1$.

Phillips, Wu and Yu (2011) suggested the following equation as the main econometric model, representing the middly-integrated root as specified in Phillips and Magdalinos (2007) and denoting a right-sided test:

$$y_t = m + \lambda y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-1} + \epsilon_t, \quad \epsilon_t \sim iid\ N(0, \sigma^2),\ \ t = 1, \dots \dots T \tag{1}$$

The null hypothesis H_0: $\lambda=1$ is tested in comparison to the alternative of H_1: $\lambda>1$ as suggested by Phillips et al (2012). The ADF statistic corresponding to (1) is noted $ADF_{r_1}^{r_2}$ and the number of observations taken into account is $T_w=[r_wT]$ where [.] is the integer part.

The conventional unit root tests have limited power in detecting bubbles due to their nature of collapsing periodically. Phillips et al. (2012) and Phillips et al. (2013) make use of a recursive sequence of right-tailed ADF-type tests based on a forward expanding sample, and then, consider the supremum (sup) of these.

The method and test proposed by Phillips et al. (2011) estimates consistently the start date of the first bubble in any sample but in the case of two bubble alternatives, the second bubble might not be detected if the first bubble is the dominant one. The answer to this problem was suggested by Phillips et al. (2013) that formulated a backward sup ADF test with two main differences: a) the endpoint of the subsample is fixed at a fraction r_2 of the whole sample and b) the window size is expanded from an initial fraction r_0 to r_2. This sup ADF test is as follows:

$$SADF_{r_2}(r_0) = sup_{r_1 \epsilon [0, r_2 - r_0]} ADF_{r_1}^{r_2} \tag{2}$$

Next, by repeating the SADF test procedure for each r2 $\in$ [r0, 1], the generalized sup ADF (GSADF) is constructed:

$$GSADF(r_0) = sup_{r_2 \in [r_0,1]} SADF_{r_2}(r_0) \tag{3}$$

The data used involves the electricity prices (Rand cents per kWh) and electricity production (kWhs), and are derived from the South African Energy Statistics of the National Energy Council (NEC, 1990) for the period 1965 to 1989 and the Energy price Report 2013 (DME, 2013) for the rest of the sample. Since bubbles imply deviation from fundamentals, following Phillips and Yu (2011), our metric for testing multiple bubbles in the electricity market is the ratio of electricity prices to production (output- adjusted prices). Note that we work with natural logarithmic values of the data.

Empirical results and Discussion

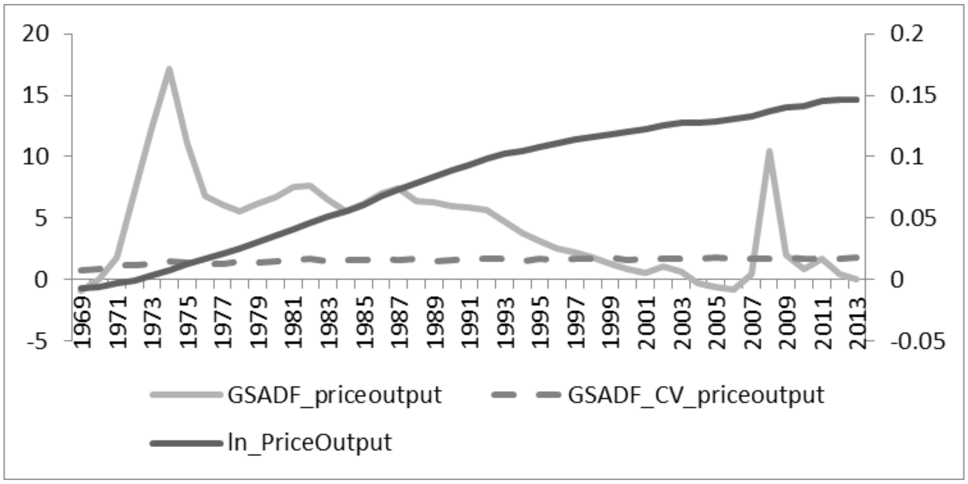
The results of the ADF, SADF and GSADF tests are summarized in Table 1. Here, we present on the output-adjusted nominal price series. From the Table, we can observe that based on the ADF test, the ratio of electricity prices to output not only has a unit root, but has exhibited an explosive behavior, as indicated by the SADF and GSADF. As per Phillips, Shi and Yu (2013), the results by GSADF outperform those of SADF in a case of possible multiple bubbles in the series since GSADF covers more subsamples of data.

Table 1: Tests for explosive behavior in output-adjusted nominal price series

	Price-output ratio		
	ADF	SADF	GSADF
	-1.6823***	17.137***	7.654***
CV 1%	-3.5777	7.2077	2.5466
CV 5%	-2.9252	3.8500	1.7989
CV 10%	-2.6007	2.9555	1.4673

Notes: *** Indicates the significance level at 1%. Critical values are obtained from Monte Carlo simulations with 1000 replications for the ADF, SADF and GSADF tests.

Figure 1: GSADF statistics of output-adjusted nominal price series



Notes: ln_priceoutput (dark grey) shows the series of Nominal electricity prices in its natural logarithm; GSADF_priceoutput (light grey) is the corresponding sequence of GSADF statistics; GSADF_CV_priceoutput (dotted grey) represents the 5% GSADF critical values. The initial window size is set at 10 percent of observations, i.e., 1965-1969 (5 observations).

To identify specific date points for the development and collapse of a bubble, we used the recursively estimated version of the GSADF on the output-adjusted nominal electricity prices, with the initial estimation based on 10 percent of the observations (Phillips, Shi and Yu, 2013), which implies we lose the period of 1965-1969. Figure 1 presents the series of the output-adjusted prices as well as the GSADF statistics and the critical values of the test over the period 1970-2013.

The first and most persistent bubble of the series was developed in 1971 only to collapse in 1998. The electricity market in South Africa during that period was characterized as an unregulated monopoly of Eskom. NER was only established in 1995, exactly three years prior to when the bubble in our estimation collapsed. The second bubble identified was smaller in duration and lasted from 2008 to 2009. The first MYPD was approved with massive increases in electricity prices for the period 2006 to 2009 in comparison with the past tariffs that were kept relatively lower for political reasons.[1] As depicted in the Appendix of the paper, the results of the electricity bubbles obtained from the output-adjusted nominal electricity prices, are, understandably, driven by electricity prices on their own.[2] The only difference is that the first bubble is now shown to last one additional year, i.e., till 1999, starting again in 1971.

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[1] If we used a 10 percent critical value, instead of the 5 percent, results were similar, except now a third bubble was detected for the year 2011, both under the case of the output-adjusted nominal electricity prices and nominal electricity prices. We also tested the robustness of our results based on an alternative size of the initial window, also suggested in Phillips, Shi and Yu (2013), based on the following formula: $(0.01+1.8/ (T)^{1/2})*T$, with T being the sample size. Now 13 observations were lost for the initial estimation. For the case of the output-adjusted nominal electricity prices, as well as, nominal electricity prices only one major bubble is detected. For the output-adjusted nominal electricity prices the bubble originated in 1977 and collapsed in 1998 or 1999 depending on whether we used the 5 percent or 10 percent critical value. For nominal electricity prices, irrespective of whether we use a 5 percent or 10 percent critical value, the bubble started in 1977 and collapsed in 2000. However, as in Phillips, Shi and Yu (2013), our preferred initial window of estimation is 10 percent of the observations, because the results obtained under this case, especially in terms of the second bubble, is in line with the history and events related to the South African electricity market. All the results discussed in this footnote are available upon request from the authors.

[2] Note that we work with natural logarithmic values of the nominal electricity prices.

Conclusion

In this paper, we aimed at examining the nature and dynamics of the nominal electricity prices in South Africa for the period of 1970 to 2013. We employed the methodology suggested by Phillips et al. (2013): a recursive right-tailed Generalized Sup Augmented Dickey-Fuller (GSADF). Bubbles are defined in this technique as periods of mildly explosive departures from a unit root Data Generating Process (DGP) followed by reversion back to a martingale process.

Two significant bubbles were detected in the output-adjusted nominal prices: the one was a long one from 1971 to 1998 and can be attributed to the monopolistic unregulated nature of the electricity market at the time; while the second one lasted for a shorted period of time (2008-2009). It was in the beginning of the period that South Africa experienced a major supply crisis with severe consequences to the country's economic activity. Identifying a bubble for this period in retrospect can support the characterization of the overall period as one of the most unstable for the South African electricity market.

Recently, NERSA has approved an average price increase of approximately 13% for the year 2015-16 (8% of which had already been approved through the original MYPD3). A potential erratic behavior of price might lead to another bubble in the electricity pricing in South Africa, especially in the light of the 2015 supply crisis and the private-public partnerships in the renewable electricity market of the country.

From a policy perspective, not dealing with certain types of bubbles before they aggravate can have intense consequences. Especially, since electricity plays such a vital role in all developing countries, its tariff and potential explosive behaviors can affect the economy in its entirety and not only the energy sector. The impact on the economy from a future electricity bubble will primarily be derived from the altering of their energy consumption and energy efficiency habits in response to the different price signals. When prices exhibit a bubble-like behavior, the supplier may respond by increasing its investment in capital than they would otherwise. If bubbles lead to damaging effects to the economy, then there is an incentive to policy makers to stop the bubbles before they even start. However, policy makers should be cautious before they take drastic measures to deflate bubbles. A policy should meet three requirements: the bubbles should be accurately identified; the policy should improve macroeconomic stability and finally, the policy should be tested with results in effective deflation of bubbles (Rudebusch, 2005).

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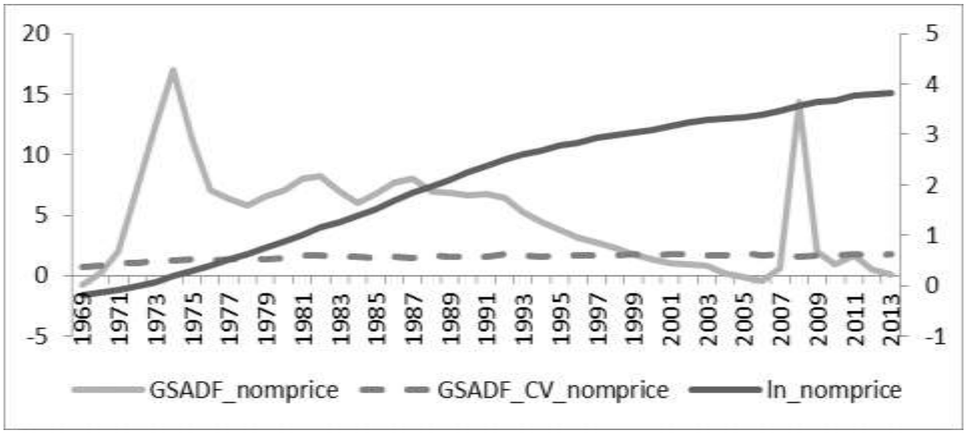
Appendix

Table A1: Tests for explosive behavior in nominal price series

	Nominal price		
	ADF	SADF	GSADF
	-1.5938***	17.043***	8.185***
CV 1%	-3.5777	6.8372	2.5466
CV 5%	-2.9252	3.8085	1.7989
CV 10%	-2.6007	2.9086	1.4673

Notes: *** Indicates the significance level at 1%. Critical values are obtained from Monte Carlo simulations with 1000 replications for the ADF, SADF and GSADF tests.

Figure A1: GSADF statistics of nominal price



Notes: ln_nominal price (dark grey) shows the series of Nominal electricity prices in its natural logarithm; GSADF_nomprice (light grey) is the corresponding sequence of GSADF statistics; GSADF_CV_nomprice (dotted grey) represents the 5% GSADF critical values. The initial window size is set at 10 percent of observations, i.e., 1965-1969 (5 observations).