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Aggregate demand for electricity in South Africa: An analysis using the bounds testing approach to cointegration ☆

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ABSTRACT

Electricity demand in South Africa has grown at a very rapid rate over the past decade. As part of reform initiatives to enhance long-term sustainability of the country's electricity industry, South Africa's authorities have in recent years sought to develop an electricity pricing framework that is cost reflective and forms the cornerstone of demand management schemes meant to foster changes in consumption behaviour and enhance efficiency in resource use. The effects of any pricing policy on aggregate electricity consumption will depend on a useful understanding of the factors that influence electricity demand, and the magnitude to which electricity demand responds to changes in such factors. In this context, this paper applies the bounds testing approach to cointegration within an autoregressive distributed lag framework to examine the aggregate demand for electricity in South Africa during the period 1960–2007. The results indicate that in the long run, income is the main determinant of electricity demand. With electricity prices having an insignificant effect on aggregate electricity demand, future pricing policies will need to ensure that electricity prices are cost reflective and enhance efficiency of electricity supply and use.

1. Introduction

Owing to the utilisation of its vast coal resources and extensive public sector investment in generation and transmission, electricity prices in South Africa are ranked as one of the lowest in the world. Since 1994, government's desire to ensure universal access to electricity and buoyant economic growth has seen South Africa's aggregate electricity demand grow at a rate of 4% per annum. However, the scaling down of investments in new generation and transmission infrastructure between the late 1990s and 2004 has resulted in a shortfall in available electricity capacity and a drastic reduction in the gap between electricity supply and demand. By 2007, South Africa's electricity reserve margin – the difference between generation and demand – had declined from 25% in 2001 to between 8% and 10%.[1] The net effect of demand outstripping supply is a growing power crisis that threatens to negatively affect South Africa's stated objective of growing the economy at 6% per annum between 2010 and 2014. In mid-January 2008, nationwide power outages occurred and lasted approximately four weeks, with the economic costs of the outages estimated at between $253 million and $282 million. Approximately half of this amount represented losses in the country's key mining and manufacturing sectors (EIA, 2008). With demand management schemes[2] expected to curtail investment related expansion plans in the country's critical mining and industrial sectors, the power crisis is expected to act as further constraints to set growth targets.

To address the inadequate electricity capacity, Eskom[3] plans to spend 343 billion Rands (or an estimated $44billion) between 2008 and 2013. With current strategies aimed at boosting economic growth expected to increase electricity demand by 4% per annum, an extra 1.3 trillion Rands will be required until 2025 to ensure that Eskom's generating capacity is expanded to meet the anticipated increase in demand. While much of this spending will be funded via borrowing and government transfers, there is a growing understanding that going into the future, electricity

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[1] To ensure security of electricity supply, the global benchmark figure is set at 15%.

[2] Most notably a proposed power conservation programme targeting mandatory savings from the country's top 300 energy intensive businesses.

[3] Eskom, South Africa's major electricity supplier, is wholly owned by the South African government through the Department of Public Enterprises.

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prices will have to rise to fund some of the investments in new generating capacity. Given that consumers in South Africa have enjoyed some of the world's lowest electricity prices and against the backdrop of historical inequities and a burgeoning welfare state, the policy debate has centered on two key issues: (i) determining an efficient price level and (ii) the extent to which electricity prices should increase. In this regard, the design of appropriate government policy on these two vital issues will have to be informed by studies that provide a rigorous analysis of the determinants of electricity demand in South Africa. Reliable estimates of price and income elasticity demand are vital in informing government as it seeks to implement an electricity pricing policy that ensures cost-reflective tariffs and protects the poor.

The main objective of this paper is to provide, by means of an econometric model, estimates of income and price elasticities of aggregate electricity demand in South Africa. Despite the policy importance of identifying factors affecting electricity demand and quantifying their effects, there is still a paucity of research analysing electricity demand in developing countries. Of the scarce studies that exist, the focus has been on countries in Asia (see for example Ishiguro and Akiyama, 1995) and the Middle East (Al-Faris, 2002) leaving a glaring gap for sub-Saharan Africa and South Africa in particular. A notable number of studies have attempted to fill this gap. In the case of sub-Saharan Africa, De Vita et al. (2006) as part of a comprehensive quantitative analysis of energy demand in Namibia examined the determinants of electricity demand. While there are a few case studies specific to South Africa, the predominant focus has been on analysing electricity demand at the residential/household level (Louw et al., 2008; Ziramba, 2008). The only study of which we are aware, which estimates *aggregate* electricity demand in South Africa, is by Pouris (1987). With respect to the study by Pouris (1987), our paper is novel in two important respects. First, the study by Pouris (1987) does not take into account recent advances in econometric modelling. By failing to test for evidence of unit roots and cointegration amongst variables of the estimated model, the findings from Pouris (1987) study are potentially spurious. To address this issue, we draw on recent energy demand modelling literature and taking cognizance of the time-series properties of model variables, examine aggregate demand for electricity in South Africa within an autoregressive distributed lag (ARDL) framework (Pesaran et al., 2001). Second, we make use of the error correction framework inherent in the ARDL approach to quantify both long- and short-run elasticities of the determinants of aggregate electricity demand in South Africa. We note further that without compelling evidence indicating that factors influencing electricity demand/consumption remain unchanged over time, there is a need to test if parameter estimates are stable over time. Thus, we augment estimations of the long- and short-run elasticities by testing for parameter stability of the aggregate electricity demand model. The value added of the work carried out in this paper lies in the modelling of the determinants of aggregate electricity demand in South Africa through the use of an econometric framework that takes account of time-series properties of chosen variables. In this manner, reliable estimates of both long- and short-run elasticities useful for the formulation of appropriate electricity pricing policies are provided.

The rest of the paper is structured as follows. Section 2 gives an overview of the electricity industry in South Africa. Section 3 provides a review of the existing literature on the estimation of energy demand. Section 4 explains the empirical model specification utilised in this study and relevant data issues. Section 5 describes the econometric methodology and discusses the empirical results. Finally, Section 6 concludes the paper by giving a summary of the study's main findings and their policy implications.

2. The electricity sector in South Africa

2.1. Evolution of South Africa's electricity industry

The development of South Africa's electricity sector has closely tracked the country's socioeconomic and political development. Electricity was first introduced to South Africa around 1882 and expanded quite rapidly to support the development of extensive gold mining activities in the interior of the country. For most of this period and the first decade following the formation of the Union of South Africa in 1910, electricity systems were developed by a mixture of municipal and private utilities that employed different technical standards and were governed by a variety of provincial and municipal by laws. By 1920, authorities began to consider the concept of a coordinated electricity system that could deliver cheap and abundant electricity to support the country's industrialization. This culminated in legislation that established the Electricity Supply Commission (ESCOM) in 1922. By 1948, the consolidation of electricity generating and transmission infrastructure resulted in ESCOM's monopoly over most of the country's power stations and high voltage transmission lines. The completion of the interconnected national transmission grid in the early 1970s established the long-term institutional and technical pattern of South Africa's electricity industry. This pattern had three key features, namely (i) assigning responsibility for production and transmission (including ownership of related infrastructure and systems) to the state utility—ESCOM; (ii) that the development of distribution systems was the function of local government authorities; and (iii) allowing major operators in the mining and heavy industrial sector to source their electricity needs directly from ESCOM.

The oil shocks of the 1970s coupled with a raft of economic and political sanctions against the apartheid government gave impetus to policy imperatives that promoted self-sufficiency. For the electricity sector, this manifested itself in the form of extensive capacity expansions that were funded through commercial debt and government guaranteed bonds issued in both domestic and international capital markets. Concerns over ESCOM's management and pricing policies led to a government appointed commission of enquiry in 1983. The Commission's recommendations led to a name change (to Eskom), and more importantly, the enactment of the Electricity Act of 1987 that resulted in Eskom abandonment of its principle of operating at "neither a profit nor a loss". Instead, Eskom was required to supply electricity in a cost-effective manner subject to resource constraints and the need to enhance the national interest. By the beginning of the 1990s, South Africa had a relatively well-developed electricity generation and distribution system. However, apartheid policies biased electricity supply in favour of the industrial sector and a privileged white minority. Under the doctrine of 'separate development', electricity supply excluded most parts of rural South Africa while fostering massive backlogs in electricity connections to black households. By 1991, only a third of South Africa's population had access to electricity (Ziramba, 2008).

The country's democratic transition of 1994 ushered in a wave of political and institutional reforms. For the electricity sector, the initial set of reforms targeted the consolidation of electricity distribution for purposes of improving financial viability and performance, and addressing previous inequities. Notably, in 1994, the post-democratic government rolled out the Integrated National Electrification Programme (INEP), an aggressive electrification program aimed at ensuring universal access to basic electricity. In the first phase of the program (1994–1999), an estimated 2.8 million households (or 66% of total households) were electrified. In the second phase (which began in 2000) it is