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The long-run price sensitivity dynamics of industrial and residential electricity demand: The impact of deregulating electricity prices

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ABSTRACT

This study examines the demand-side of Ghana's electricity sector. We test two important related hypotheses: (1) deregulation of electricity price does not promote energy conservation, and (2) demand-price relationship is not an inverted U-shaped. The Stock and Watson dynamic OLS is used to address the so-called second-order bias. The result showed that, deregulation of electricity price in Ghana has induced behaviours that are more consistent with energy conservation improvements. The demand-price relationship is an inverted U, which suggests that there is a price range that end-users can tolerate further price rise and still increase their consumption of electricity. However, the degree of price tolerability is higher for residential consumers than industrial consumers. The simulation results showed that, further economic growth is likely to compromise energy conservation but more in the industrial sector than the residential sector. On the other hand, future crude oil price is likely to deteriorate energy conservation in the initial years after 2016, but this trend is likely to reverse after the year 2020. Pricing mechanisms are potent to induce energy conservation but inadequate. The results suggest that they should be complemented with other stringent policies such as a mandatory energy reduction policy, investment in renewables, and personalization of energy efficiency programs.

1. Introduction

The electricity sector in Ghana remains a very important sector for the country's long-term sustainable development. Nonetheless, investment commitments in the sector have been very sluggish and poor. The consequences are that, transmission and distribution losses are increasing. On the other hand, demand is growing at a much faster pace (about 10–15% per annum) due to increased demand for technology, demographic changes, and behavioural changes among end-users of electricity. Altogether, this has contributed to widening the demand-supply gap in the sector. The lack of significant infrastructural development in the sector subjects the power grid to future vulnerability and possible future increases in the frequency of power outages in the country. Given that, on one hand, infrastructural development is likely to progress slowly in the sector, and on another hand, electricity demand is likely to increase in the future, energy access is likely to be a problem in the future, which could threaten the country's long-term sustainable development. Goldemberg (2000) has established a positive correlation between access to electricity and development. Though electricity may not be the direct panacea for economic development (see Bhattacharyya, 2006), achieving a modest electricity access is crucial to improving the welfare of the poor (see World Bank, 2008).

Against this background, both capacity expansion and demand-side management are critical policy options for the country to pursue aggressively. In terms of cost efficiency, however, demand-side management policies may be the most best preferred option to secure the energy system. It is no surprise that, energy efficiency policies have become an integral part of the global economic and climate change policies. A recent report by the International Energy Agency reveals that, globally, in 2015, energy efficiency investment was more than two-thirds larger than investment in conventional electric power generation, excluding renewable energy. The US, France, China, and Germany accounted for a larger share of this investment. Interestingly, however, demand-side management policies have received very little attention from previous and recent governments in Ghana. This motivates the current study to investigate the demand-side of the electricity sector in Ghana with the intent to offer further insights into demand-side management policies. Specifically, we test two important related hypotheses. First, deregulation of electricity price does not promote energy conservation in the electricity sector. Second, there is a price threshold that promotes energy conservation, which suggests that, demand-price relation is an inverted U-shaped.

The case of Ghana is interesting for two reasons. First, the benefits of energy savings in Ghana are likely to cut across borders to Benin, Burkina Faso and Togo. For example, during periods of severe energy shortages in 2006/2007, 2012, and 2015/2016, measures were taken

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by the Ghana government to reduce power supply to these economies. Second, Ghana's electricity price shows a unique feature that is very interesting to study both from international and domestic perspectives. For a very long time in the history of the country, electricity price was regulated by the government. Combined with the high hydro concentration, this produced a low stable electricity price (see Appendix A). Between 1970 and 1994, the average end-user tariff of electricity averaged GH¢0.0033/KWh. The real intent of the government regulation was to make electricity affordable and accessible to the poor. However, it worked against production incentives since producers of electricity could not recover the marginal cost of production and made losses in the process. This adversely affected the financial position of the sector and made it a less attractive sector for Independent Power Producers (IPPs). Motivated by this, the government established the Public Utility Regulatory Commission (PURC) in 1994 to ensure efficient pricing using an automatic adjustment formula. Soon after the coming in of PURC, prices began to adjust upward but slowly; since the change always came with a public opposition, and politicians in order to maximize their votes still subsidized prices. Between 1994 and 2000, electricity price averaged GH¢0.0182/KWh, which is about six (6) times that achieved during 1970 and 1994. The year 2000 saw a significant rise in electricity prices. Prices during 2000 and 2014 averaged GH¢0.1509/KWh, which is about eight (8) times the average for the period between 1994 and 2004 and approximately forty-six (46) times the average for the period 1970 and 1994. Consequently, in 2000, Ghana had the first Independent Power Producer (IPP), which is the Takoradi International Company (TICO). Since then, the average end-user tariff has adjusted upwards, and the number of IPPs has consequently increased. Currently, there are three (3) IPPs and fifty-five (55) more have received provisional licences to produce power via thermal and renewable sources. The price dynamics raise the concern that, the deregulation of electricity prices may have changed consumers' sensitivity to price changes in a manner that promotes energy conservation. If this assertion is true, does it then imply, in the case of Ghana, there is a certain price threshold that promotes energy conservation? We address these concerns in this study.

Though there are a number of studies that have analysed electricity demand at various levels in the literature (see Pourazarm and Cooray, 2013; Hamdi et al., 2014; Zaman et al., 2012; Bernstein and Madlener, 2015; Blazquez et al., 2013; Hung and Huang, 2015; Krishnamurthy and Kristrom, 2015; Arisoy and Ozturk, 2014 inter alia), the unique nature of the price dynamics in Ghana offers new insights into the demand-price relationship. This study offers a positive contribution to the recent discussions on deregulating the electricity sector in Ghana and energy efficiency improvements in the world. In the case of Ghana, there are few studies that have attempted to estimate electricity demand, but at the aggregate level (see Adom et al., 2012; Adom and Bekoe, 2012; Adom and Bekoe, 2013; Adom, 2013; Mensah et al., 2016). Also, these studies did not include price information. Therefore, the unique feature of the price dynamics in the electricity sector and its implications for demand-side management policies was not treated and discussed in these studies. Moreover, since these studies focused on aggregated demand, it is difficult to argue, in these studies, for sector specific demand-side management policies. The current study fills these gaps in the literature on Ghana's electricity demand.

The rest of the study is organized as follows. Section 2 reviews the literature on electricity demand. Section 3 describes the electricity sector in Ghana. Section 4 presents the method and data. Section 5 discusses the results of the study, and Section 6 concludes with some policy recommendations.

2. Literature review

This section reviews the empirical literature on aggregate and sectoral electricity demand with specific focus on the estimate of long-run price and income elasticities. Due to page limitation, we present the most recent estimates, which is expected to reflect the general position of the literature.

2.1. Aggregate electricity demand

Inglesi-lotz (2010) estimates long-run aggregate electricity demand for South Africa. She estimates the long-run price and income elasticities as −0.564 and 0.8196, respectively. Inglesi-Lotz (2011) confirms this result in another study in which she applied a time varying technique based on the Kalman filter to estimate electricity demand in South Africa. The results show that income elasticity decreased during the 1980s, reached almost zero during 1986–1990 and almost unit beginning of 1990s. Overall, long-run income elasticity is 0.794. Further, the results show that, price elasticity was close to unit elastic during 1980s and beginning of 1990s but decreased from −1.077 in 1986 to −0.045 in 2005. The overall price elasticity is −0.075. In contrast to Inglesi-Lotz (2010) and Inglesi-Lotz (2011), Amusa et al. (2009) find that, in the long-run, aggregate electricity demand is driven significantly by income and not the price of electricity in South Africa. The authors estimate the long-run income elasticity as 1.6734. Gam and Rejeb (2012) estimate aggregate electricity demand for Tunisia. They find both long-run price (−0.24) and income (0.86) effects to be inelastic.

In related studies on Ghana that excluded information on electricity prices, Adom et al. (2012), Adom and Bekoe (2012), Adom and Bekoe (2013), Adom (2013) and Mensah et al. (2016) find a more elastic long-run income effect for aggregate electricity demand. Adom et al. (2012) estimate the long-run income elasticity as 1.591, while Adom and Bekoe (2012) estimate the long-run income elasticity to range from 1.6974 (based on the autoregressive distributed lag method) to 2.6904 (based on the partial adjustment method). Based on the partial adjustment approach, Mensah et al. (2016) also estimate the long-run income elasticity as 2.710. Adom and Bekoe (2013), without taking into account the role of structural changes, rather find the long-run income elasticity as 0.8134. However, they find the long-run income elasticity remained unstable when the model accounts for structural changes. Electricity demand is more income elastic post-ERP (1.954) and inelastic pre-ERP (0.222). Adom (2013) confirms the elastic and shifting nature of income elasticity in a study that employs the Fully Modified-Phillip Hansen (FMPH) and Rolling Regression technique (RRT). Estimates based on the FMPH show a more elastic income (2.115) effect in the long-run. However, the RRT shows this elasticity increased from 1980 to 1988; remained stable between 1988 and 1992; decreased from 1992 to 2003, and increased after 2003.

Fan and Hyndman (2011) in South Australia and Zaman et al. (2012) in Pakistan have also confirmed the inelastic nature of the price and income effects, respectively. Fan and Hyndman (2011) estimate the long-run price elasticity to range from −0.363 to −0.428, while Zaman et al. (2012) estimate the long-run income elasticity as 0.973. Contrary to Zaman et al. (2012), Jamil and Ahmad (2010) find a more elastic income effect for Pakistan. They estimate the long-run income elasticity as 1.70. However, the price effect is inelastic. They estimate the long-run price elasticity as −0.83. Jamil and Ahmad (2011) confirm the elastic nature of the income effect but found the price effect to be elastic contrary to the popular stand in the literature. They provide a long-run income and price elasticities of 1.56 and −1.22, respectively.

2.2. Industry electricity demand

There are still disagreements on whether the industrial sector remains responsive or unresponsive to changes in the price of electricity and income. Jamil and Ahmad (2010), Dilaver and Hunt (2011), Inglesi-Lotz and Blignaut (2011), and Arisoy and Ozturk (2014) are among some of the studies that find that, the industrial sector is less responsive to changes in price and income. Jamil and Ahmad (2010) estimate the long-run income and price elasticities for the manufacturing sector in Pakistan. They find that, the manufacturing sector is less