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POWER SECTOR REFORM AND CORRUPTION: EVIDENCE FROM SUB-SAHARAN AFRICA

Mahmud I. Imam *Tooraj Jamasb* *Manuel Llorca*

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Keywords Panel data, dynamic GMM, electricity sector reform, corruption, Sub-Saharan Africa.

JEL Classification Q48, D02, K23, D73

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Abstract

In order to reduce the influence of corruption on electricity sector performance, most Sub-Saharan African countries have implemented sector reforms. However, after nearly two and half decades of reforms, there is no evidence whether these reforms have mitigated or exacerbated corruption. Neither is there evidence of performance improvements of reforms in terms of technical, economic or welfare impact. This paper aims to fill this gap. We use a dynamic panel estimator with a novel panel data set of 47 Sub-Saharan African countries from 2002 to 2013. We analyse the impact of corruption and two key aspects of electricity reform model – creations of independent regulatory agencies and private sector participation – on three performance indicators: technical efficiency, access to electricity and income. We find that corruption can significantly reduce technical efficiency of the sector and constrain the efforts to increase access to electricity and national income. However, these adverse effects are reduced where independent regulatory agencies are established and privatisation is implemented. Our results suggest that well-designed reforms not only boost economic performance of the sector directly, but also indirectly reduce the negative effects of macro level institutional deficiencies such as corruption on micro and macro indicators of performance.

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1. Introduction

Over the past two decades, a body of literature has emerged that establishes the various transmission channels through which corruption can constrain economic development. For example, corruption when defined as the "abuse of entrusted power for private gain"[1] is found to have corrosive effects on economic development through increasing transaction costs and uncertainty (Murphy et al., 1991), inefficient investments (Mauro, 1995; Shleifer and Vishny, 1993), reduced human capital development (Reinikka and Svensson, 2005) and misallocation of resources (Rose-Ackerman, 1999).

Recently, attention has shifted to another important but less explored micro-level channel, i.e. the operation and regulation of electricity systems particularly in developing countries (Wren-Lewis, 2015; Estache et al., 2009; Dal Bó, 2006; Bergara et al., 1998). The preponderance of evidence from this strand of literature suggests that, corruption can cripple economic development by inhibiting the performance of the electricity sector. For instance, corruption reduces labour productivity (Wren-Lewis, 2015; Dal Bó, 2006), increases transmission and distribution losses and constrains the efforts to increase access to electricity services (see Estache et al., 2009).

The impacts of corruption on electricity sector performance is particularly relevant in the Sub-Saharan Africa (SSA) context, where welfare improvements can intuitively be linked to corruption (Gyimah-Brempong and Camacho, 2006), which appears to be widespread. Despite the obvious difficulties of measuring corruption, the Corruption Perception Index (CPI) produced by Transparency International (TI, 2013) shows that, eight out of the twenty most corrupt countries in the world were SSA countries, and the only region with more than two countries in this group. Thus, in weak institutional environments, major undertakings such as the construction of large hydroelectric dams, government intervention in the operations of utilities, monopolistic characteristics of the sector, absence of competition and the substantial revenues from the sales of electricity can attract and make the sector vulnerable to corruption (Bosshard, 2005; World Bank, 2009; Reinikka and Svensson, 2005).

The above factors could be partly blamed for turning the electricity sectors in SSA countries into sources of corruption and cronyism (Patterson, 1999) and the concentration of electricity services to urban areas whilst rural areas remained unconnected or underserved (Byrne and Mun, 2003). This is referred to as 'electricity poverty' and is widespread in the region.[2] In order to improve efficiency and reduce corruption, many SSA countries implemented some form of Electricity Sector Reforms (ESR) (Eberhard et al., 2016). The reforms, also referred to as 'standard electricity sector reform model' and often prescribed to developing countries by multilateral development organisations, were first implemented in OECD countries such as Chile, Norway and the UK in the 1980s and 1990s.

[1] See Kaufmann and Siegelbaum (1997) for discussions on this definition.

[2] According to IEA (2014), the majority of the estimated 500 million people that lack access to clean and affordable electricity in the region are poor and rely on traditional biomass – wood, agriculture residues and dung – for cooking and heating.

The experiences of these pioneer countries supported the notion that effective implementation of ESRs would not only enhance technical efficiency of the sector, but would also translate the efficiency gains into social welfare and economic growth (Sen et al., 2016). Moreover, according to the World Bank (2000), as part of wider economic liberalisation, deregulation and de-monopolisation policies, ESR policies were further underpinned by anticorruption agendas. Thus, reformers not only promised improved efficiency and wider access to reliable and affordable services, they also promised to reduce corruption in the sector (Estache et al., 2009) and the wider economy (World Bank, 2000).

Despite the anticipated positive outcomes from implementation of the ESRs, there are widespread perceptions that reforms have hurt the poor through increased tariffs, stronger enforcement of bills collection (Scott and Seth, 2013) and unemployment, while benefitting the powerful and wealthy notably through corruption (Auriol and Blanc, 2009). As a result, the reforms often lacked social legitimacy, and this usually manifests through increases in electricity theft and vandalism (Williams and Ghanadan, 2006). Moreover, as Estache et al. (2009) have noted, large numbers of people believe that corruption remains a problem in the sector. However, despite the anecdotes that connect corruption to sector performance after the reform efforts, there is a lack of empirical evidence on whether the electricity sector reforms implemented in SSA region have mitigated or indeed exacerbated the effect of corruption in the electricity sector.

Previous empirical studies have shown the relevance of corruption as a driver of ESR in developing countries, but they either focus on labour efficiency in electricity distribution firms (e.g., Wren-Lewis, 2015; Dal Bó and Rossi, 2007) or on different sectors (e.g., Estache et al., 2009). Moreover, the former two studies focused on Latin American countries while the latter study also includes countries from different developing regions of the world. Therefore, to our knowledge, this is the first empirical study to assess the electricity reforms in SSA countries and among the few studies that examine the interactions between country level institutions and micro-level electricity reform steps (e.g., Wren-Lewis, 2015; Estache et al., 2009). Most studies of this strand of literature tend to focus on specific aspects of the textbook reform model or on specific countries without explicitly accounting for the role of institutions apart from those earlier mentioned.

The paper addresses the deficit in the literature and contributes to better understanding the institutional aspect of electricity reforms (e.g., Dorman, 2014; Chang and Berdiev, 2011; Nepal and Jamasb, 2012a; Cubbin and Stern, 2006; Erdogdu, 2013) and the political economy literature of regulatory agencies (e.g., Pitlik, 2007; Potrafle, 2010; Scott and Seth, 2013). The paper also indirectly contributes to the literature on obsolescing bargaining (Vernon, 1971) since political corruption entails government commitment to honour the terms of electricity reforms and particularly the privatisation of state assets, could be doubtful. Thus, the findings would give further insights into why investments in the SSA electricity markets tend to be more concentrated in the generation segment than in the distribution utilities since the former is more vulnerable to corruption.

The remainder of this paper is organised as follows. Section 2 reviews the nearly three decades of ESR implementations in SSA countries and discusses how each of the key steps of the reform model may mitigate the adverse effects of corruption on the performance of the electricity reforms. Section 3 presents three research hypotheses related to key performance aspects of the reforms to be tested. Section 4 presents the empirical methodology and the data used in the study. Section 5 presents and discusses the results. Section 6 concludes the paper.

2. Electricity Sector Reforms in Sub-Saharan Africa

Historically, the generation, supply and marketing of electricity in most SSA countries, as in many other countries in the world, were dominated by vertically integrated state-owned utilities (Clark et al., 2005). These arrangements were partly due to factors regarded as primary functions of the state, such as, the high fixed costs of large plants, the desire of governments to enhance welfare, national security concerns, social equity objectives (World Bank, 1993) and ideological reasons (Erdogdu, 2013). The state-ownership of utilities were further reinforced by the idea that permitting more than one firm to provide electricity would rather rise, than reduce, costs which resulted in historically higher investments by the state in public utilities relative to private investments (USAID, 2005). However, the 1980s and 1990s saw SSA countries, similar to other developing countries, becoming increasingly unable to sustain their investments in the sector. Decades of government investments had not produced the anticipated increase in performance, as services remained largely concentrated to urban areas, nor were there improvements in quality and reliability of services.

At the same time, macroeconomic conditions external to the sector, such as, the deteriorating international business climate, fiscal constraints faced by governments, structural adjustment programmes, which later became part of lending conditions of the IMF and World Bank (Jamasb, 2006) compelled SSA countries to undertake structural and institutional reforms of their electricity sectors. Moreover, many of the arguments that supported state ownership of electricity utilities disappeared by the 1980s as the economies of scale associated with vertically integrated electricity utilities had exhausted (Joskow, 2006; Gilbert et al., 1996), therefore state-ownership of the sector came to be seen as a major hindrance for the introduction of new technologies developed mostly by the private sector (Downing et al., 2006). The reform efforts in SSA were triggered by investment shortage and concerns that monopolisation of electricity generation and supply activities by state-owned utilities were wasteful and inefficient (Victor, 2005).

The first electricity sector reform was first introduced in Chile, which later spread to other OECD countries such as, Norway and United Kingdom. From the experiences of these countries, emerged the theory and practice of the 'standard textbook reform model' that later became widely prescribed to developing countries by the IMF and World Bank. It was believed that reforms would reduce the dominance of the state in the sector through creation of Independent Regulatory Agencies (IRAs) and private sector participation in electricity markets (Jamasb et al., 2016). The expected outcome of these efforts are the enhancements of economic and technical efficiency of utilities and the transfer of the efficiency gains to consumers in the form improved access to affordable and reliable electricity services (Nepal and Jamasb, 2012b; Estache et al., 2009).

The standard reform model advocated for the unbundling of state-owned electricity utilities vertically (generation, transmission, distribution and retailing) and horizontally (generation and retailing). The unbundled parts amenable to competition would then be sold to the private sector and an IRA created by the state would then supervise and regulate the monopoly-prone parts of the sector (Victor and Heller, 2007). Table 1 summarizes the factors that motivated ESR in developed and developing countries. The Table shows that, the electricity sector specific and external factors (factor outside the sector) that triggered ESR varied differed between developed and developing countries.

Electricity Sector Drivers	**External Drivers**
Developed countries: Excess capacity, use of costly generation technologies, economic inefficiencies, growing consumer demand for cheap energy.	***Developed countries:*** Lack of *political and economic ideologies:* faith in the market, competition and privatisation. *OECD energy deregulation:* creation of new energy multinationals looking for new investments opportunities. *Technological innovation:* for instance, the development of Combined Cycle Gas Turbine (CCGT) plants.
Developing countries: Lack of public investment to meet growing demand, institutional inefficiencies, burden of price subsidies, high electricity losses, poor quality of service and coverage, capacity shortages, poor electricity sector investments.	***Developing countries:*** *Macroeconomic factors:* such as the post-Soviet economic transition (1989), Latin American debt crisis (1980s), Asian financial crisis (1997-1998). *Lending policies of donors:* such as those of the IMF and World Bank with strings attached. *National economic reform context:* as the result of economic crisis and structural adjustment programmes.

Table 1: Drivers of Electricity Reforms in Developed and Developing Countries
Source: Jamasb et al. (2016)

However, as pointed out in Nepal (2013), the extent and outcome of electricity reforms have differed between developed and developing countries. The reforms in developed countries were undertaken in the context of excess capacity and relatively stable institutions aimed at improving economic and financial performance of technically reliable systems, encourage interregional trade, transfer investment risks to the private sector, offer consumers alternative choices, and reduce overinvestment in the sector (Jamasb et al., 2014; Erdogdu, 2013). Conversely, ESR in the developing countries were implemented within a context of poor technical and financial performances of state-owned electricity utilities, weak institutional setting, the inabilities of both utilities and governments to mobilise sufficient investments to expand electricity services, low tariffs and poor service quality (Jamasb et al., 2005).

However, the appropriateness of the standard ESR model for developing countries has been questioned as its implementations usually resulted in higher prices, loss of employment, unreliable services, and concentration of services to profitable areas since the private firms did not have incentives to extend the service to poor areas (Transnational Institute, 2002; Victor, 2005). Thus, in the unprofitable segments of the market there has been almost total absence of service provision (Auriol and Picard, 2006). The poor access rates in SSA relative to other developing regions may be partly attributed to this lack of incentives. For example, although between 2000 and 2014, there was some progress in increasing access to electricity in all developing regions of the world; electricity access deficit is overwhelmingly concentrated in SSA region, as progress has fallen consistently short of population growth. The poor outcomes have led the reform critics to argue that since costly electricity infrastructures needed to extend services to rural and poor areas are considered risky and unprofitable by the private sector, the state should undertake such investments since it enjoys a monopoly on capital and investments (Victor, 2005).

Moreover, the experiences of ESR around the world have shown the difficulty of creating an economically efficient electricity sector underpinned by genuine competitive markets that show significant potentials to benefit consumers through reliable service, low tariffs, and choice of alternative sources (IEA, 2014). As a result, the reform experience in SSA countries has lagged behind the anticipated outcomes of the standard reform model and thus has led to extensive political backlash against reforms. Higher electricity prices have been an obvious source of political resistance in many countries, especially for groups that have become accustomed to paying near nothing for electricity services (Victor, 2005) and this resistance was further reinforced by the awareness that elections can be won or lost because of electricity prices (UNDP and World Bank, 2005).

However, despite the difficulties of ESR in developing countries, they have not deterred SSA countries from implementing some aspects of the textbook reform model. Twenty four countries in the region have enacted ESR law, three-quarter have attracted private participation, nearly all have corporatized their electricity utilities, two-thirds have set-up regulatory bodies, and more than a third have Independent Power Producers (IPPs) in place (Eberhard et al., 2016). Table 2 summarises the reform efforts in some SSA countries.

No ESR Initiated	Vertically integrated w. priv.[*]	Vertically integrated w. IRA only	Vertically integrated w. IRA and priv.	Unbundled w. IRA and priv.	Unbundled w. IRA only
Benin Burundi Central African Rep. Djibouti Equatorial Guinea Eritrea Somalia Seychelles Congo Dem. Rep. Guinea	Botswana Chad Madagascar Mauritius Liberia Guinea Bissau Comoros Congo, Rep	Mauritania Niger Swaziland	Angola Burkina Faso Cape Verde Cameroon Cote d'Ivoire Ethiopia Gabon Gambia Malawi Mali Mozambique Namibia Lesotho Rwanda Sao Tome and Principe Senegal South Africa Tanzania Togo Zambia	Ghana Kenya[**] Nigeria Uganda Zimbabwe[**]	Sudan

[*]All forms of private participation excluding management contracts, lease contracts and concession.
[**]Kenya and Zimbabwe have only undertaken partial unbundling unlike the other three countries that have fully unbundled.

Table 2: Implementations of Electricity Sector Reforms in SSA countries
Sources: Eberhard et al. (2016) and World Bank Infrastructure Database (2017)

3. The Literature on Corruption and Reform

As argued by the World Bank (2000), electricity sector reforms have the potential not only to improve technical efficiency of the sector but also to reduce the corruption associated with state-ownership. This section reviews the relevant literature on how each key aspect of the reforms can mitigate the adverse effects of corruption.

3.1. Corruption and Corporatization/Commercialization

The most pervasive aspect of the reform model implemented in SSA was the transformations of incumbent state-owned utilities into separate legal entities through corporatization or commercialization.[3] Although, the corporatized utilities were distinct from government ministries or energy departments, they are however, treated as a commercial enterprise and thus, expected to pay interest and taxes, and earn commercially competitive rates of return on equity capital. They can also plan and execute budgets, and initiate and implement borrowing procurement and employment conditions (Kapika and Eberhard, 2013).

[3] See Appendix A for the types, names of projects and status of management contracts in some SSA countries.

Although independent and incorporated under the same laws governing private corporations, the state retains ownership of corporatized utilities and in some cases runs them through appointed independent board of directors. However, in countries such as Cameroon, Côte d'Ivoire, Tanzania, Namibia, Madagascar and Ghana their business decisions were contracted out to private managers[4] (Ghanadan and Eberhard, 2007). Whether managed by an appointed board of directors or private contractors, corporatizations of utilities were mainly aimed at reducing the inefficiencies induced by government interference in the operations of utilities, facilitate the entry of private capital and move utilities toward cost-recovery in pricing through improved metering, billing and collection (Eberhard and Gratwick, 2011).

Corporatized utilities have achieved modest performance improvements especially those operated by management contractors. In Tanzania, a management contractor used a poverty tariff for consumers using 50 kilowatt hour (kWh) a month or less and nearly doubled the revenues of the corporatized utility (TANESCO) by reducing costs by 30%, rising collection rates from 67 to 93%, reducing system energy losses by 5%, and connecting 30,000 new customers (Ghanadan and Eberhard, 2007). Similarly, a management contractor in Namibia between 1996 and 2002 succeeded in doubling the electricity consumers, and increasing labour productivity without laying-off employees (Clark et al., 2005).

These positive outcomes and others such as improvements in bills collections and reductions in system losses in almost all SSA with management contractors, made international aid agencies such as the IMF and World Bank involved in almost all management contracts, to regard them as a first step towards comprehensive reforms of the sector. However, contracting out operations of utilities to the private sector has proved to be complex and contentious in some countries of the region. For example, most governments were unwilling to honour their financial obligations needed to expand capacities, reject tariff hikes (e.g., in Senegal), unwilling to compel other government agencies to pay their bills, forbidding utilities from reducing the size of the workforce or disconnecting delinquent consumers (Nellis, 2005).

Other stakeholders removed from management positions, and the thousands of employees laid off criticised such contracts especially where large contract fees were paid to management contractors (e.g., Tanzania and aid agencies paid for the 56 months' contract period, \$8.5 million in fixed fees and \$8.9 million in performance based fees) (Eberhard and Gratwick, 2011). The large payouts were further argued not to be in commensurate with the modest improvements in finances of utilities and this helped galvanised political backlash against management contracts in the region. Moreover, it was argued that, many regulators failed to capture the benefits from the efficiency gains and competition produced by management contractors (Nellis, 2005). As a result, management contracts were viewed by policymakers in SSA as unsustainable, thus 16 of management contracts engaged in the region, 4 were cancelled before their expiration dates, 12 were allowed to expire after their initial terms, and only in Liberia and Lesotho there are management contracts currently

[4] Some SSA countries contracted out the operation and management of their corporatized utilities to management contractors.

active. According to Eberhard and Gratwick (2011), of all the countries with management contracts, only those engaged in Gabon and Mali have led to further reforms.

The eventual disengagement of management contractors from most SSA countries shows that state-owned utilities managed by government appointees are once again becoming the most dominant players in the sector. Under state-ownership, there are temptations on part of some governments to force utilities to charge electricity prices below the costs of generation and supply, dictate the choice of plants locations or mandate utilities to purchase their primary energy from state-owned national energy (e.g., oil and gas) companies (Nellis, 2005) even while lower cost alternatives exist. Thus, it became increasing difficult to insulate corporatized utilities from corruption usually associated with state ownership of utilities, which has been one of the key motivators of the reforms in the region.

3.2. Corruption, Unbundling and Competition

In order to target the sources of inefficiency such as corruption and reduce their performance impacts, reformers advocated for the introduction of competitive electricity markets after the sector has been unbundled both vertically and horizontally. Thus, irrespective of ownership status, reformers anticipate that competition between the unbundled segments and among generating plants offer a reliable mechanism to reduce network energy losses and induce full capacity usage. These efficiency gains are then expected to increase access rates, while at the same time reducing the cost of service to pre-existing consumers (Zhang et al., 2008). More importantly, the unbundling and the subsequent competition entails consumers to have more freedom of choice compared to when services were provided by a state-owned monopolist with incentives to withhold capacity or determine areas to concentrate services. This freedom of choice therefore means consumers can escape from corruption hitherto associated with government ownership of utilities.

Although, countries such as Ghana, Zambia, South Africa, Tanzania and Zimbabwe have indicated their intention to introduce market competition, this has not materialised. As a result, only Nigeria has taken steps towards wholesale competition after unbundling and privatising its generation and distribution segments (Gratwick et al., 2006).[5] Although, the lack of competition in electricity markets of SSA countries can partly be linked to the difficulties of reforming small systems, the absence of private participation in countries such as Sudan,[6] indicates that governance issues are still at the core of the electricity reform efforts in many countries.

Despite the governance enhancing virtues of competition, experience reveals the difficulties of creating genuine competitive electricity markets even in developed countries which are usually associated with strong institutions. In Britain, the 15 electricity utilities that emerged from the reforms of the 1990s re-integrated and consolidated to just six utilities after 5 years. This has led to the perception that the utilities tacitly collude to charge consumers higher

[5] Nigeria established a Transitional Electricity Market (TEM) on February 1, 2015.
[6] Sudan has successfully unbundled its electricity market both vertically and horizontally, and has also established an IRA.

prices (Lewis, 2014). Similarly, the idea that the market would discipline competing electricity firms and thereby benefit consumers was tested by the California power crisis. Byrne and Mun (2003) reported that various participants in California electricity market succeeded in gaming the system to maximise short-term profits by creating artificial scarcity through adjusting their bidding strategies. Therefore, rather than to lower prices, the day-ahead, hour-ahead, and real-electricity markets actually led to increases in prices.

In the SSA context, the emergence of hybrid electricity markets and the absence of robust anti-competitive laws may explain the absence of competitive electricity markets apart from the TEM in Nigeria and the predominance of private sector participation largely in the form of IPPs. This is because implementation of retail or wholesale competitive markets requires sophisticated institutional and financial infrastructures, which are inadequate in SSA (Eberhard et al., 2016). In order to mitigate investment risk in weak institutional environments, private sector participants such as IPPs usually enter into power purchase agreements with the incumbent off-takers by requiring measures such as government guarantees, and the inclusion of international arbitration clauses.

3.3. Corruption and Private Sector Participation

In order to attract investments reformers advocated total privatisation of state-owned utilities to complement other forms of private sector participation. The withdrawal of the state from the sector would not only attract the needed extra private sector investments, but would also reduce the burden of subsidies on the government to cover finance overruns of state-owned utilities. Therefore, privatisation has the potential to reduce political interference or bureaucratic rigidities in the operations and management of utilities since control rights over these factors would no longer be under the direct control of politicians or civil servants.

This suggests that privatisation can improve electricity sector governance through changing the incentive structure in the sector. For example, since the new owners of privatised utilities are now the residual claimants of revenue generated by service provision, it would incentivise them to close all types of inefficiencies including those related to corruption (Olson, 2000). This differs considerably from when services were provided by the previously state-owned utilities without clear residual claimants, and thus no incentives to reduce inefficiencies especially those related to corruption. This argument was highlighted by the theoretical works of Shapiro and Willig (1990), Shleifer and Vishny (1993) and Boycko et al. (1996) who argued that privatisation makes it difficult for corrupt politicians and bureaucrats to control rents produced by privatised utilities. In other words, privatised firms become more productive and profitable relative to state-owned by closing the sources of inefficiencies including those related to government corruption.

Despite the increase in private sector participation after the financial crisis of 2008 in SSA electricity markets (Figure 1), there remains a funding gap for connecting the estimated 500 million people without access to electricity services in the SSA region (IEA, 2014). The African Development Bank (ADB, 2010) notes that social welfare improvements and productivity in the region, continues to be constrained by the inadequate generation capacity, large technical and commercial losses, limited electrification rates, unreliable services, and high electricity tariffs.

For example, in terms of generation capacity, the entire installed generation capacity of 48 SSA countries was 83 gigawatts (GW) in 2012, and when South Africa is excluded, the figure drops to 36 GW, and just 13 of the remaining countries have power systems larger than 1 GW (Eberhard et al., 2016). Moreover, one-quarter of that capacity is unavailable due to aging plants and poor maintenance (Eberhard et al., 2008). The investments required to close this gap are large. It was estimated that, in order to keep pace with projected economic growth, to meet suppressed demand and provide additional capacity to achieve universal access, up to 7 GW in new generation capacity were required annually between 2005 and 2015 (Eberhard and Gratwick, 2011). The authors estimated that, it would cost about US$15 billion to add new generation capacities and a further US$5 billion annually for the operation and maintenance of existing generation plants and transmission networks. If the current trend continues, less than 40% of the SSA countries will be able to achieve universal access by 2050 (IEA, 2016).

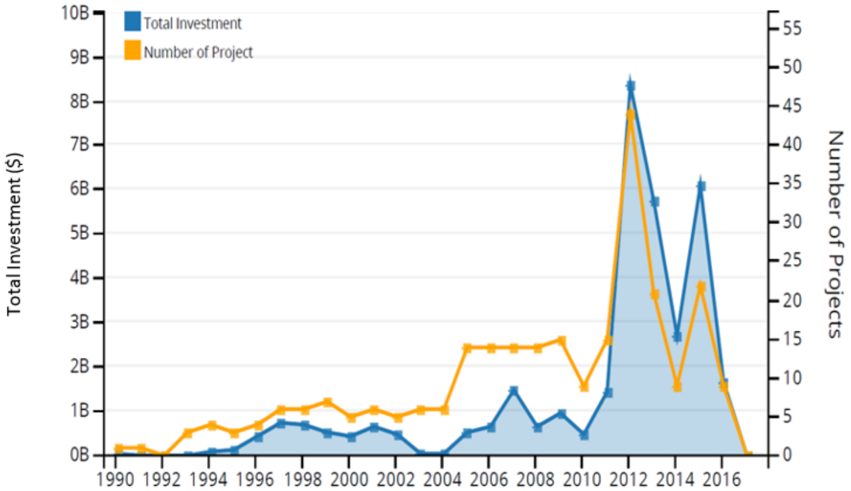

Figure 1: IPP Investments in SSA Countries, 1990-2016
Source: World Bank PPI Database

3.4. Corruption and Independent Regulatory Agencies

Previous studies have linked huge energy shortages and investment gap to historical, financial, social, technical, and economic factors (e.g., Jamasb et al., 2016; Dornan, 2014; Eberhard and Gratwick, 2011). Recently other studies have attempted to link the poor outcomes to the failure of IRAs to improve the institutional conditions of the sector as private investors largely depend on their credibility and independence when investing in countries with weak institutions. Moreover, the emergence of hybrid electricity markets which does not entail total withdrawal of the state from the electricity sector (Eberhard et al., 2016),[7] have

[7] This is one of the key factors often suggested for the vulnerability of the electricity sector to corruption.

made the IRAs to struggle to balance the interests of private utilities and the dominant state-owned utilities.

Thus, in the context of weak institutional environments such as those of SSA countries, political expediency tied to the state-owned utilities tends to undermine the independence of the IRAs (Eberhard, 2007). For example, in some SSA countries where IRAs have attempted to exert their independence there has been a high turnover among the board members and management (Kapika and Eberhard, 2013). As a result, the regulatory frameworks in these countries are often viewed as compromised. This in turn leads many consumers to assume that the utilities are in collusion with the IRAs and make excessive profits since the regulatory framework has become prone to political capture or a tool for corrupt government officials (Stiglitz, 1998).

Moreover, despite the importance of IRAs in providing right institutional environment for investors to thrive and give consumers the necessary protection, the reform efforts in the region shows that not all countries have set up IRAs. For example, according to Eberhard et al. (2016) as of 2014, only 26 of the SSA countries have set up IRAs, while in the remaining countries, energy ministries or departments have assumed regulatory responsibilities with the aim of achieving specific social and economic objectives. Thus, in this later group of countries, governments have full regulatory discretion in determining monitoring and enforcing maximum tariffs and minimum service standards.

Some have argued that self-regulation usually allows corruption to be pervasive in the operations of utilities as most positions in IRAs are usually staffed with friends, family, or political and financial allies of politicians (Estache and Wren-Lewis, 2010). Similarly, even in countries that have set up independent regulatory agencies, it has often been difficult for these new bodies to escape from political interference and pressure and various forms of corruption (Spiller, 1990).[8]

The preceding paragraphs suggest that the strategic nature of electricity to the economies of SSA countries implies that the wider fragmented socio-political and economic environments may largely influence guidelines on electricity generation, and transmission and distribution. Thus, in such weak institutional environments, the efficient operation of electricity networks could be influenced by the private agendas of regulators/government energy departments or government corruption. Despite these links between weak institutions and performance of the utilities, the issue of how corruption and weak governance might influence the electricity sector performance post reforms in SSA has been neglected in both the electricity sector reforms literature and the current policy approaches pursued by SSA governments. In order to fill this gap, we analyse whether the implementations of ESR have offset or exacerbated the negative influence of corruption on performance.

[8] Only 26 of a total of 47 SSA countries included in our study have established independent energy regulatory agencies.

3.5. Hypotheses

As noted in the introduction section, the main objective of ESR in SSA countries was to improve technical efficiency and translating this gain into increase access rates and keep up with the projected economic growth. In order to develop a set of hypotheses to test whether these objectives have been achieved, we rely on the literature on corruption in regulated sectors that on how a well-designed regulatory framework may insulate firms from corruption (e.g., Levy and Spiller, 1994; Laffont and Tirole, 1986; Estache and Wren-Lewis, 2009).

We are further guided by the economic development literature that shows how economic performance could be affected indirectly through the impact of corruption on private investment (e.g., Wei, 2000). Thus, we draw on these varied set of literature to identify three potential indicators of electricity sector performance to assess the corruption reducing potentials of ESR policies. The variables in included in our dataset are placed into three categories each reflecting three different dimensions of performance – i.e. technical efficiency, access rates and economic performance. The first hypothesis focuses on the technical efficiency of electricity sector proxy by Transmission and Distribution (T&D) losses per capita, and expressed as follows:

- *H1: Electricity sector reforms in SSA countries, by offsetting or overcoming the adverse effects of corruption, have improved technical efficiency.*

Theoretically, T&D energy losses is a suitable proxy for the technical efficiency of the sector because the higher these losses, the higher the probability that firms are not only undertaking needed investments to upgrade and maintain supply networks, but it would also indicate firms having operational challenges. More importantly, vandalism, illegal connections and bribes to utilities' workers to avoid full payment of electricity bills would also contribute to higher losses as utilities become constrained financially to undertake further investments. These factors all combine and adversely affect the overall sustainability and productivity of the electricity sector. Therefore, we expect the reforms to enhance investor confidence to undertake further investments, improve their operations and close all sources of inefficiencies thereby leading to efficiency gains.

We extend the assessment of impacts of ESR and corruption beyond the sector since one motivation of the reforms in SSA countries was to expand affordable and reliable electricity services to the un-electrified majority. Therefore, our second hypothesis traces the impacts of reforms beyond the sector to analyse the impact of reforms on access to electricity services. Previous research has suggested how corruption and clientelistic practices (e.g., Min, 2010) can undermine government efforts to extend electricity services to the poor. Therefore, we expect the loosening of the ties between the government and utilities, through the creations of IRAs and privatization, to reduce corruption usually related to direct government operations and regulation of utilities. Moreover, we expect technical efficiency gains from ESR to translate into expansion of electricity to those who lack access to the service. Thus, our second hypothesis is as follows:

- *H2: implementation of ESR by reducing the negative association between corruption and technical efficiency has increased access rates in SSA countries.*

According to the International Energy Agency (IEA, 2014), ESR implementations will boost the economic performance of SSA region by 30% in 2040, not only through new private sector investments but also through governance improvements inside and outside the energy sector. Moreover, World Bank (2000) notes that ESR as part of wider economic liberalisation policies has further anticorruption potentials to reduce the negative association between corruption and economic performance. Therefore, due to the positive association between the economy and electricity use on the one hand, and the negative association between corruption and economic performance, we expect the reforms to boost income levels in two ways. We extend the performance impacts of corruption and ESR, to the wider economy and thus postulate that:

- *H3: implementations ESR policies in SSA countries have enhanced economic performance of SSA countries by reducing negative association between corruption and economic growth.*

4. Methodology and Data

4.1. Electricity Sector Performance Equation

The setup and analysis of the performance equation is influenced by the awareness that ESR in developing countries, as in other sectoral reforms, is not an isolated undertaking but is closely interlinked with the legal and institutional environments of reforming countries. Therefore, in its simplest form, we postulate that electricity sector performance (*Y*) depends not only on the vector of reform policies (*REF*) implemented by SSA countries but also on corruption (*cor*) which measures the institutional quality of the countries, and a set of vector of control variables (*X*). Thus, our performance output equation can be expressed as:

$$Y_{it} = \alpha_i + \sum_{p=1}^{2} \beta_{1p} REF_{pit} + \beta_2 cor_{it} + \sum_{p=1}^{2} \beta_{3p} \left(REF_{pit} \cdot cor_{it}\right) +$$

$$\beta_4 ira_{it} priv_{it} + \sum_{q=1}^{Q} \beta_{5q} X_{it} + \beta_6 time + \varepsilon_{it} \tag{1}$$

where *i* and *t* indexes a country and year, *Y* is performance output reflecting either of the three performance indicators: technical efficiency (T&D energy losses; *losper*), access rate (per capita electricity consumption; *access*), and economic performance (GDP per capita; *gdpper*). βs are the parameters to be estimated, the term *time* represents a linear time-trend, which takes into account technological progress. α_i are country-specific effects, included to control for time-invariant unobservables and $\varepsilon_{it} \sim N(0, \sigma^2)$, is the stochastic error term. The vector of reform policies (*REF*) consists of independent regulatory agency (*ira*) and privatisation (*priv*), a proxy for all forms of private sector participation in electricity markets. These two reform policies entail whether country *i* at time *t* has succeeded in establishing an independent regulatory agency and opened its doors for private participation. The vector of Q control variables (X) depends on which of the three performance indicators is used. It captures the demand side of the market and consists of GDP per capita (*gdpper*), total gross electricity generation (*genper*) and, structure (*struc*) and size (*urban*) of electricity markets.

In order to capture the corruption reducing effects of ESR on performance, we follow Estache et al. (2009) and Wren-Lewis (2015) and use interaction terms between corruption and the two reform policies (*iraXcor* and *privXcor*). The coefficients of these two interaction terms measure the corruption reducing potential of reforms. We also include an interaction term between the two the reform policies (*iraXpriv*) to assess whether IRAs have constrained or improved the performance of privatised utilities or if private utilities have constraint or reinforced regulatory activity. This is important because, private investors in electricity sectors of developing countries mostly require credible and transparent IRAs to safeguard their investments from expropriation by the state.

Similarly, as noted in the literature on regulatory capture, there is a tendency for regulatory capture in regulated electricity markets due to economic incentives that may push regulators to cater for the interest of the regulated (e.g., Olson, 1965; Dal Bó and Di Tella, 2003; Leaver, 2009). These incentives may arise due to reliance of the regulators on the regulated entity for information they need to do their duties and the desire to hold future well-paid jobs with the regulated since human capital in the sector tends to be industry-specific. Hence, this is our motivation for the inclusion of the third interaction term.

4.2. Estimation method

In panel data regressions, the choice of an estimator mostly lies between the Random Effects (RE) or Fixed Effects (FE) estimators to deal with the bias of unobserved heterogeneity. However, both estimators address the bias at the expense of a strong exogeneity assumption. For instance, Equation (1) includes not only country-specific effects that can be correlated with other regressors, but also other theoretically established endogenous regressors (e.g., per capita GDP), thus the orthogonality condition is not likely to be met for a RE or FE estimator to produce consistent estimates. Moreover, Jamasb et al. (2005) note that most ESR researchers tend to ignore (implicitly or explicitly) another sources of endogeneity which arises from the possibility of current values of ESR variables and past performance being a function of past condition or performance. Therefore, the RE and FE estimators do not produce consistent coefficient estimates in the presence of endogenous regressors and dynamics, and thus it is not possible to make inferences based on their estimates.

In order to overcome these methodological concerns, we first transform Equation (1) into a dynamic panel specification where lagged values of the three indicators of performance, i.e. the alternative dependent variables (technical efficiency, access rates and per capita GDP) are included as additional regressors. The dynamic performance equation can be expressed as in equation (2):

$$Y_{it} = \varphi Y_{it-1} + \alpha_i + \sum_{p=1}^{2} \beta_{1p} REF_{pit} + \beta_2 cor_{it} + \sum_{p=1}^{2} \beta_{3p} \left(REF_{pit} \cdot cor_{it}\right) + \beta_4 ira_{it} priv_{it} + \sum_{q=1}^{Q} \beta_{5q} X_{it} + \beta_6 time + \varepsilon_{it} \quad (2)$$

where Y_{it-1} presents the lagged value of performance, whilst φ is the parameter estimate of lagged performance. All other variables and coefficients are defined as before. As noted, neither the pooled OLS, FE nor RE estimates of φ are consistent in dynamic models when the time span is small (Nickell, 1981). We could consider using the dynamic panel General Method of Moments (GMM) estimator proposed by Arellano and Bond (1991). This estimator has the potential to produce consistent estimates in the presence of endogeneity of regressors, unobserved country fixed effects and dynamics. The estimator first eliminates the country-specific effects α_i by differencing the model and instrumenting the lagged dependent variable (Y_{it-1}) with lagged levels of this variable (Arellano and Bond, 1991). However, differencing the data removes all time-invariant variables of interest during the estimation. Moreover, the Difference GMM (Diff-GMM) is noted to perform poorly in the presence of persistent processes since the lagged levels may convey little information on future changes, thus implying the problem of weak instruments and biased estimates (Roodman, 2008).

Arellano and Bover (1995) and Blundell and Bond (1998) developed a System GMM (Sys-GMM) estimator to improve the efficiency of the Diff-GMM estimator. The Sys-GMM estimator solves the endogeneity problem by treating the model as a system of equations in first difference and in levels. The endogenous regressors in the first difference equation are instrumented with lags of their levels, whilst the endogenous regressors in the level equation are instrumented with the lags of their first differences. The consistency of the Sys-GMM estimator depends on the assumption of no serial autocorrelation in the errors and existence of an array of exogenous regressors. An important aspect of the estimator is that it relies on internal instruments contained within the panel itself and therefore eliminates the need for external instruments and it also avoids full specification of the serial correlation and heteroscedasticity properties of the stochastic error term, or any other distributional assumption.

Despite its advantages, the Sys-GMM estimator has limitations especially as it relies on using the lags of both the dependent and independent variables for identification. This would potentially give rise to a problem of weak instruments, which is usually magnified as the number of instrumental variables increases. Although, increasing the instruments' lag length could make them more exogenous, it may also make them weaker. Furthermore, when using panel data estimators such as the Sys-GMM, the bias resulting from errors in regressors may also be magnified (Griliches and Hausman, 1986). In order to reduce the influence of these and other limitations of the estimator on our results, we avoid the instruments counts exceeding the number of countries in the sample or overfitting of the instrumented regressors. Thus, we collapse the instrument set as recommended by Roodman (2009) and report the instrument count for each of the estimations.

Obtaining consistent, efficient and unbiased results using the Sys-GMM estimator is contingent on two specification tests; Hansen test for over-identification restrictions and the Arellano and Bond (1991) test for serial correlation (AR) of the disturbances up to the second order. The Hansen test of over-identification restrictions is a joint test of model specification and appropriateness of the instrument vector. Failure to reject the null hypothesis of the test would indicate that the instruments used in estimation are valid and the model has been well specified. The appropriate check of the Arellano and Bond (1991) test for serial correlation (AR) relates only to the absence of second-order serial correlation (AR2) since the first differencing induces first serial correlation in the transformed errors.

4.3. Data

The econometric analyses are based on annual country-specific observations from 47 SSA countries over the period 2002-2013. Our selection of countries and time period are largely determined by data availability. Moreover, since the main aim of paper relates to the influence of IRAs and privatization on corruption, the little reforms implemented so far in the region would not permit us to assess the impacts of ESR and corruption prior 2002. Similarly, the final year 2013, represents the last year for which data are available on electricity consumption per capita and T&D losses at the time we conducted the analyses. Also, we do not have complete data for all years on the 47 countries especially as we change the performance indicators and the sample size changes depending on the performance indicator being analysed.[9] Table 3 summarises summary statistics of the variables used.

As noted, the three performance indicators (technical, welfare and economic impacts) are measured by per capita T&D losses (*losper*)[10], per capita electricity consumption (*access*)[11], GDP per capita (*gdpper*). Data on *losper* and *access* (relabelled as *comper*) and used as a control variable in the economic impact regression) are obtained from the United States Energy Information Agency database, while data on *gdpper* is from the World Bank Development Indicator Database. Data on corruption is from Kaufmann et al. (2010) included in World Bank’s Governance Indicator Database, which includes annual country-level data. The corruption index, which measures corruption in both public and private sectors, ranges from -2.5 (highly corrupt) to 2.5 (highly clean). Data on *ira* was obtained from Eberhard et al. (2016) and updated with data from Burundi, Cape Verde, Madagascar, Seychelles and São Tomé and Príncipe electricity regulatory agencies’ websites.[12] Data on *priv* was obtained from the World Bank Infrastructure Database.

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[9] The different sample sizes were reported at the bottom of three estimation results tables in the next section.

[10] The losses and access variables have been averaged by total population data from the World Bank’s development indicators database to obtain a per capita measure before estimations.

[11] See Appendix B for using this measure as a proxy for access to electricity relative to alternative indicators.

[12] See Burundi’s Drinking Water and Electricity Sector Control and Regulation Agency (ACR): https://www.ppbdi.com/index.php/extras/economie-sciences-education-formation/3397-ministere-de-l-energie-et-des-mines-regulation-du-secteur-de-l-eau-potable-et-de-l-electricite, Cape Verde Agência de Regulação Económica: http://www.are.cv/index.php, Madagascar office de régulation de l'electricité: http://www.ore.mg/, The Seychelles Energy Commission (SEC): http://www.sec.sc/, São Tomé and Príncipe Autoridade Geral de Regulação: http://www.ager-stp.org/index.php/pt/.

Variables Names	Labels	Unit	Obs.	Mean	Std. Dev.	Min.	Max.
Electricity Gen., Per Capita	*genper*	KWh per capita	562	440	0.88	10	5310
Regulator	*ira*	Dummy	564	0.49	0.50	0	1
Privatisation	*priv*	Dummy	564	0.58	0.49	0	1
Corruption	*cor*	Index	564	-0.60	0.58	-1.71	1.25
Urbanisation	*urban*	%	562	38.49	16.27	8.68	86.66
Elect. Consumption, Per Capita	*access*	KWh per capita	562	630	1.47	10	10,570
Household Elect. Consumption	*hols*	KWh per HH	528	1,743	5,804	4	41,173
Export	*export*	%	528	35.11	22.38	4.43	122.26*
Industrialization	*ind*	%	522	26.24	14.30	3.33	84.28
Population	*pop*	Millions Inhab.	562	17.13	26.15	0.08	170
Trans./Dist. Losses, Per Capita	*losper*	KWh/Mill. Inhab.	521	68.56	91.96	0.19	485.60
GDP, Per Capita	*gdpper*	2010 US$/Inhab.	562	2,138	3,250	194	20,172
Population Density	*popden*	Inhab./km^2	562	86.63	112.45	2.38	620.03
Structure	*struc*	Dummy	564	0.09	0.29	0	1

Table 3: Summary statistics of data
Note: We have log transformed the variables *losper, genper, access, hols* and *gdpper* prior to the estimations
***Equatorial Guinea is a notable exception with exports being larger than the GDP**

Data for the control variables *urban* and *genper* were obtained from the World Bank's Development Indicators and the United States Energy Information Agency respectively. Data for *struc* was obtained from World Bank's Development Indicators Database and updated with data from African Development Bank's Energy Utilities Database, included in the Africa Infrastructure Knowledge Program. In addition, the data on *hols* was obtained from the United Nation's Energy Statistics Database. The countries included in our sample are listed in Appendix C.

Finally, in order to check the robustness of our main results, we have added three explanatory variables - share of industrial output (*ind*), trade openness (*export*) and population density (*popden*) - to the three electricity reform performance equations to be analysed in alternative estimations. [13] The data for these variables were obtained from the World Bank's Development Indicators Database.

[13] The results of the robustness checks are presented and discussed in Appendix D.

5. Results

In this section, we present and discuss the estimation results of the performance equations along the three dimensions of performance (technical, welfare and economic impacts) using dynamic panel Sys-GMM estimator.[14] The first subsection discusses the estimates of the T&D energy losses equation, the second subsection estimates energy consumption per capita access, whilst the third subsection discuss the estimates of GDP per capita equation.

Regression statistics of the three estimations (Tables 4-6) indicate that all models fit the data well. The test statistics indicates that there is first order serial correlation AR (1) but not at the second order AR (2), while the Hansen test of model specification and over-identifying restrictions indicates that all three models are correctly specified with appropriate instruments. Our estimation strategy differs from earlier studies who use static models to analyse the impacts of ESR on performance (Zhang et al., 2008; Estache et al., 2009; Wren-Lewis, 2015).

5.1. Technical Impact – T&D losses

The immediate impacts of ESR are the technical improvements on the sector. The estimates of the Sys-GMM estimation in Table 4 shows that, the coefficient of *cor* is positive and highly significant, suggesting that an increase in the corruption index is associated with reductions in efficiency particularly in countries without private sector participation. Thus, corruption can be considered here as a major source of inefficiency in SSA countries and therefore, decreasing it could have enormous positive impact on technical efficiency. This result is similar to the results obtained by other researchers who find a positive relationship between corruption and inefficiency (Dal Bó, 2006; Estache and Trujillo, 2009; Dal Bó and Rossi, 2007; and Wren-Lewis, 2015).

The coefficient of *ira* is not significant suggesting that, creation of IRAs has no statistical effect on technical efficiency. The negative coefficient for *priv* indicates that, countries with private sector participation are associated with a statistically significant improvement in technical efficiency during the study period. Evidence of this cuts across the whole of SSA where for example, introduction of private sector participation in countries such as Namibia, Nigeria, Uganda and Mali, which have greatly improved efficiency (Clark et al., 2005). Moreover, this result is consistent with earlier studies that find private sector participation in electricity markets is associated with technical efficiency improvements (e.g., Andres et al., 2008; Nagayama, 2007; Balza et al., 2013). However, Smith (2004) and Zhang et al. (2008) find that certain electricity reform policies such as regulation and privatisation are associated with the deterioration of efficiency.

Do implementations of ESR reduce the negative influence of corruption on technical efficiency? The answer depends on the coefficient estimates of the two interaction terms *iraXcor* and *privXcor* included in Equation (2). The coefficient of *iraXcor* is not significant

[14] Although, we estimate our model with the Sys-GMM estimator, however for completeness, we present pooled OLS regressions results in Appendix E.

suggesting that creations of IRAs have no any statistical influence on relation between corruption and technical efficiency. Conversely, the coefficient estimate also suggests that corruption has not interfered with regulatory activities. The coefficient of the *privXcor* interaction term is negative and significant suggesting that, SSA countries that have opened their electricity markets to private sector participation have greatly offset the negative influence of corruption on efficiency. The coefficient of the interaction term *iraXpriv* is not significant indicating that regulation of the privatised networks has had no effect on the efficiency of the utilities and owners have not interfered with regulatory activities.

Regarding the control variables included in the estimation, the negative and significant coefficients of *struc* and *urban* suggest that, countries that have unbundled sectors and increased the size of their electricity markets have improved technical efficiency. On the contrary, the coefficient of *hols* suggests that increased electricity consumption by households have led to efficiency deterioration during the period covered by our study. The coefficient of the time trend is not significant. It should be noted that this and the subsequent results should be interpreted with some caution since the dummies used as proxies are nominal values and thus will not capture the intensity of reform policies among countries in the sample. Moreover, the measure of corruption used is at best the perception of corruption, which could be different from reality.

Technical Impact (*losper*)		
Variables	**Est.**	**t-stat.**
Ln losper(t-1)	0.857***	19.02
cor	1.035***	4.30
ira	0.174	0.96
priv	-0.533***	-3.10
iraXcor	0.003	0.03
privXcor	-0.955***	-4.51
iraXpriv	-0.125	-0.86
Ln hols	0.065**	2.26
struc	-0.551***	-3.76
urban	0.004*	1.87
time	0.003	1.16
No of obs.		444
Countries		41
Instruments		36
AR(1) test (p value)		-2.28 (0.023)
AR(2) test (p value)		0.09 (0.925)
Hansen test (p value)		23.59 (0.485)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Two-Step GMM Estimates of T&D Losses Equation

5.2. Welfare Impact (access) - Per Capita Electricity Consumption

The main and ultimate aim of electricity reforms in developing countries has been to improve the socio-economic welfare of the population. The parameter estimates of the performance equation (*access*) are presented in Table 5. The estimated coefficient of *cor* is negative and significant, suggesting that, an increase in corruption decreases access to electricity services. This is consistent with similar findings obtained by other researchers on how corruption reduces the quality and quantity of publicly consumed services (e.g., Fredriksson et al., 2004; Estache et al., 2009).

The coefficient of the IRA dummy is positive and significant, indicating that for the period covered by our study, countries that have created IRAs have boosted access to electricity services. This result contrasts with the result obtained by Estache et al. (2009) who associated the creations of an IRAs with a statistically significant reduction in access rates. The coefficient of *priv* is not significant indicating that the privatisation policies have no significant effect on the access rates. The estimate also contrasts with the findings of earlier studies such as Sihag et al. (2007) and Bhattacharyya (2006) who find that reforms policies (e.g., privatization) have led to a decline in access the rates in the State of Orissa in India.

The coefficient of the interaction term *iraXcor* is positive and significant indicating that, creations of IRAs have offset the negative influence of corruption on access rates. The coefficient estimate of the interaction *privXcor*, is not significant suggesting that private sector participation has not been effective in addressing the negative influence of corruption. It may also suggest that corruption has not constrained the efforts of privatised utilities to increase access to electricity services.

Regardless of the impacts of individual reform policies, the coefficient of the interaction term *iraXpriv* suggests that together they exert a statistically significant decreasing effect on access to electricity. In other words, although the creation of IRAs have led to increase in access rates while privatisation has no effect, their interaction have led to reductions in access rates in SSA countries. This may be attributed to the conflicting objectives between independent regulators and private utilities. For example, independent regulation may be keen to extend electricity services to the mostly un-electrified poor areas, while private firms may be motivated by profit motive and thus have no incentives to extend the electricity service to new low-income and low-usage consumers.

The coefficients of *gdpper*, *urban* and *struc* are all not significant suggesting that income level, the size of/and structure electricity markets have no impacts on electrification rates. The electricity generation per capita variable (*genper*) is positive and highly significant indicating that further increases in electricity generation leads to increase in access rates. The time trend is not significant.

Welfare Impact (*access*)		
Variables	**Est.**	**t-stat.**
Ln access(t-1)	0.846***	23.13
cor	-0.147*	-1.91
ira	0.281***	4.04
priv	0.124	1.37
iraXcor	0.231***	4.63
privXcor	0.042	0.50
iraXpriv	-0.146***	-2.63
Ln genper	0.178***	5.03
Ln gdpper	-0.058	-1.45
struc	0.003	0.16
urban	0.001	1.20
time	0.002	1.48
No of obs.		515
Countries		47
Instruments		41
AR(1) test (p value)		-4.17 (0.000)
AR(2) test (p value)		-1.62 (0.106)
Hansen test (p value)		26.69 (0.535)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table 5: Two-step GMM Estimates of Per Capita Energy Consumption

5.3. Economic Impact - GDP Per Capita

The results indicate that the implementation of electricity reforms in SSA countries have the potential to reduce the negative influence of corruption on electricity sector performance. The implementations of reforms in developing countries are noted to have anticorruption potentials to reduce the effects of corruption on economic development (World Bank, 2000). Therefore, we expect the implementation of reforms in SSA to enhance economic performance through two channels. First, by enhancing the overall performance of the sector (i.e., by improving technical efficiency and extending services to those without access). Second, as part of wider economic reforms, often underpinned by an anticorruption strategy, the reforms can also reduce the effects of corruption on economic performance. The coefficient estimates of *privXcor* and *iraXcor* are shown in Tables 4 and 5.

In Table 6, where *gdpper* is a dependent variable in the performance equation, the coefficient of *cor* is negative and significant. This is consistent with other well established findings on the relationship between these two variables (e.g., Barreto, 2000; Rose-Ackerman 1999; Shleifer and Vishny 1993). Thus, an increase in the control of corruption index in a country is associated with a decrease in per capita GDP. The coefficient of *ira* is positive and not significant, suggesting that creation of IRAs hass not had impact on the level of income.

The coefficient of *priv* is also positive and significant indicating that private sector investments have boosted economic performance of SSA reforming countries. A similar result was also obtain by Chisari et al. (1999) who find privatization of electricity generation and distribution assets led to positive economic performance in Argentina. Similarly, the estimate of *priv* confirms the argument by the IMF that ESR policies such as privatization has the potential to free up government energy subsidies and thereby boost economic performance over the long run (IMF, 2013).

Do implementations reform policies reduce the negative association between corruption and economic growth? The coefficient of *iraXcor* is not significant suggesting, that, for the period of this study, countries that established IRAs have not exerted beneficial effects on the negative association between corruption and per capita GDP nor has corruption affected the relation between regulation and economic performance. This is inconsistent with Jalilian et al. (2007) who stressed the importance of credible and independent regulation on economic growth. The coefficient of *privXcor* is positive and significant indicating that, countries that open their doors to private sector investments have reduce the negative association between corruption and per capita GDP and thus they have succeeded in boosting their income levels. The coefficient of *iraXpriv* is not significant suggesting that the interaction of the regulator and privatisation does not exert an influence on the economic performance.

Economic Impact (gdpper)		
Variables	**Est.**	**t-stat.**
Ln gd*pper(t-1)*	0.984**	64.15
cor	-0.092***	-2.60
ira	0.016	0.57
priv	0.107***	2.86
iraXcor	0.026	0.92
privXcor	0.071*	1.68
iraXpriv	-0.032	-1.18
Ln *comper*	0.014*	1.72
struc	-0.004	-1.41
urban	-0.000	-0.79
time	-0.001**	-2.53
No of obs.		515
Countries		47
Instruments		36
AR(1) test (p value)		-2.90 (0.004)
AR(2) test (p value)		-1.29 (0.196)
Hansen test (p value)		22.46 (0.552)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table 6: Two-step GMM Estimates of Income Growth Equation

Of the three control variables included in the model, only the coefficient of per capita electricity consumption (*comper*) is positive and significant. This suggests that an increase in energy consumption impacts positively on per capita GDP, while the structure (*struc*) and size (*urban*) of electricity markets have no effects on level of income after controlling for the effect of corruption. However, the time trend is significant and negative, which may indicate the adverse effect of decreasing technical progress on the region's economic performance over the period covered by our study.

6. Conclusions

Sub-Saharan African countries are noted to be among the most corrupt countries of the world. As a result, various studies have investigated how corruption have continued to constrain the economic development of these countries through some transmission channels. However, one important transmission channel not yet investigated is the operation and regulation of electricity networks. Studies that investigated this channel using data on other developing regions find evidence that corruption can increase system losses, restrict electricity services to urban areas and reduce income levels.

In order to reduce the influence of corruption in the electricity sector, reformers advocated for unbundling of state-owned electric utilities vertically (generation, transmission, distribution and retailing) and horizontally (generation and retailing). The unbundled parts that are amenable to competition would be sold to the private sector and an independent regulatory agency created by the state would then supervise and regulate the natural monopoly-prone parts of the sector.

After more than two decades of reforms in SSA countries, we investigate whether these reforms have reduced the influence of corruption on technical efficiency of utilities and if efficiency gains have been translated into increase in access rates and income growth. The paper uses panel data and a dynamic panel estimator to investigate the effects of corruption on electricity sector performance. Using World Bank's control of corruption perception index, the paper shows that corruption has an adverse and statistically significant effect on the three indicators of electricity sector performance - technical efficiency, access rates and economic performance. This finding adds to the body of evidence that stress the detrimental impacts of corruption on economic development and electricity sector performance.

We find that creation of independent regulation and private sector participation, not only have the potential to enhance the utilities' performance but have also wider economic benefits. Specifically, we find that independent regulation has the potential to increase social welfare directly and indirectly by reducing the association between corruption and electricity access rates. We also show that private sector participation is associated with improved technical efficiency and increased economic performance, while we find privatization policies have no statistically significant impact on access rates.

More importantly, we analyse the way corruption interacts with the two reform policies and how these interactions impact on the three indicators of performance. The creations of independent regulators has substantially reduced the adverse association between corruption and access rates, while they have not mitigated the often-cited negative association between corruption and income level and nor the association between corruption and technical efficiency. However, private sector participation has offset the adverse effects of corruption on technical efficiency and income, while they have no impact on the association between corruption and access rates.

These results are robust after controlling for other variables that also have impacts on the performance of the electricity sector. Thus, our results suggest that implementation of well-designed micro level electricity reforms have the potential not only to boost the firms' economic performance directly, they would also indirectly reduce the negative effects of macro-level institutional deficiencies such as corruption on micro and macro levels indicators of performance. Therefore, implementation of electricity reforms in developing countries can not only enhance the performance of the electricity sector, but would also boost economic performance, since improvements in technical efficiency can be translated into increased access rates and income growth.

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Appendix A

Country	Year of financial closure	Name of Project	Subtype of PPI	Project status	Segment
Chad	2000	Societe Tchadienne d'Eau et d'Electricite (STEE)	Management contract	Cancelled	G*, T** & D***
Gabon	1993	Societe Africaine de Gestion et d'Investissement (SAGI)	Management contract	Concluded	G, T & D
Gambia, The	1993	Management Service Gambia (MSG)	Lease contract	Cancelled	G, T & D
Gambia, The	2006	National Water and Electricity Company Management Contract	Management contract	Concluded	G
Ghana	1994	Electricity Corporation of Ghana	Management contract	Concluded	D
Guinea-Bissau	1991	Electricidade e Aguas de Guinea-Bissau	Management contract	Concluded	G, T & D
Kenya	2006	Kenya Power and Lighting Company Management Contract	Management contract	Concluded	T & D
Lesotho	2002	Lesotho Electricity Corporation (LEC)	Management contract	Active	G, T & D
Liberia	2010	Liberia Electricity Corporation Management Contract	Management contract	Active	T & D
Madagascar	2005	Jiro syRano Malagasy (Jirama)	Management contract	Concluded	G, T & D
Malawi	2001	Electricity Supply Corporation of Malawi Ltd (ESCOM)	Management contract	Concluded	G, T & D
Mali	1994	Electricite et Eau du Mali (Management)	Management contract	Concluded	G, T & D
Namibia	1996	Northern Electricity	Lease contract	Concluded	D
Namibia	2000	Reho-Electricity	Lease contract	Active	D
Rwanda	2003	Electrogaz	Management contract	Cancelled	G, T & D
Rwanda	2003	Electrogaz	Management contract	Cancelled	G, T & D
São Tomé & Principe	1993	Empresa de Agua e Electricidade	Management contract	Concluded	G, T & D
Tanzania	2002	Tanzania Electricity Supply Company (TANESCO)	Management contract	Concluded	G, T & D
Togo	1997	Companie Energie Electrique du Togo	Management contract	Concluded	G & D
*Generation, **Transmission and ***Distribution					

Table A1. Types of management contracts in SSA
Source: World Bank PPI database

Appendix B: Electricity Consumption Per Capita as a Proxy for Access Rates

To assess the impacts of corruption and ESR on access rates, we use per capita electricity consumption as dependent variable in Equation (1). Although this choice of dependent variable may have some limitations, there are several reasons why it is a better proxy than other two alternative measures commonly used by other scholars: IEA data on electricity access rates and night-time satellite imagery data captured by the US Defence Meteorological Satellite Program's Operational Linescan System (DMSP-OLS).[a]

The IEA data, which was first compiled in the "World Energy Outlook, 2002", was based on various sources such as countries' self-assessed reports (World Bank and IEA, 2015), which magnifies the sources of errors and thus leads to overestimation of access rates (Min, 2010). Another drawback of the IEA data is that, it only indicates the extent of electricity infrastructure provision, and therefore is silent on quality, reliability and whether services has been consumed or not (World Bank and IEA, 2015; Ahlborg et al., 2015).[b]

Similarly, night-time satellite imagery has some serious drawbacks. For example, the measure includes people without access to electricity services residing in electrified towns (Doll and Pachauri, 2010). As a result, its reliability as an indicator of access rate is weak since it only measures stable outdoor lights, which can be a major problem in SSA countries where there are high incidences of load shedding (World Bank, 2009).[c]

Therefore, using consumption per capita other than connection rates or satellite imagery as dependent variable has the advantage of assessing how consumers were able to translate access to real use, rather than just the physical extension of electricity infrastructures. As result, if there are significant changes in service reliability, we expect that consumption to be adversely affected. Moreover, as Ahlborg et al. (2015) have noted, using a per capita measure rather measuring average consumption among the electrified minority has the advantage of comparing development patterns across SSA countries of different population sizes. Furthermore, the per capita measure allows for the assessment of whether consumption levels have kept pace with population growth in each country. Thus, the proxy is a good indicator of whether ESR policies have improved quality, increase access to hitherto derived areas, and/or whether the population of those already connected have increased over time.

[a] The data is being archived and provided to researchers by the National Oceanic and Atmospheric Administration (NOAA) at its National Geophysical Data Centre.
[b] For further discussion, see Ahlborg et al. (2015).
[c] For further shortcomings of this data, see Doll and Pachauri (2010).

Appendix C

Angola	Gabon	Niger
Benin	The Gambia	Nigeria
Botswana	Ghana	Rwanda
Burkina Faso	Guinea	Sao Tome and Principe
Burundi	Guinea-Bissau	Senegal
Cape Verde	Kenya	Seychelles
Cameroon	Lesotho	Sierra Leone
Central Africa Republic	Liberia	South Africa
Comoros	Madagascar	Sudan
Congo Democratic Republic	Malawi	Swaziland
Congo Republic	Mali	Tanzania
Djibouti	Mauritania	Togo
Equatorial Guinea	Mauritius	Uganda
Eritrea	Mozambique	Zambia
Ethiopia	Namibia	Zimbabwe
Chad	Cote d'Ivoire	

Table B1. SSA countries included in the analysis

Appendix D: Robustness Analyses

It is possible that the coefficient estimates in Tables 4, 5 and 6 may suffer from omitted-variable bias. Here we check the robustness of our results by adding additional explanatory variables in the model, one at a time to both the performance and growth equations to see if this would significantly affect the results.

Cubbin and Stern (2006) argue that a rapid growing share of industrial output (e.g., in heavy industry such as petrochemicals, aluminium, manufacturing) is expected to increase the demand for electricity. Similarly, Kaldor (1970) and Cornwall (1977) argue that expansion of the industrial sector is a driving force for economic development. Thus, excluding this variable (*ind*) from both the performance and growth equations could, potentially, lead to biased estimates of the effects of ESR and corruption on the three indicators of performance. We therefore include the share of industrial value added as a percentage of GDP as an additional regressor in three equations. Several authors also find the degree of openness of an economy to influence electricity sector performance (e.g., Zhang et al., 2008). We also include exports (*export*) as percentage of GDP as an additional regressor in the performance equation. The data for *export* is obtained from the World Bank governance indicators database.

Furthermore, several studies include a variable measuring population density to assess the ability of both public and private utilities to extend cheap and affordable electricity to populations spread over vast areas (e.g., Ahlborg et al., 2015; Estache et al., 2009; Min, 2010). The data is from the World Bank development indicators database.

Results of this exercise are presented in Tables D1, D2 and D3. Columns 1, 3 and 5 of each table presents the parameter estimates of the models when *ind*, *export* and *popden* are added, one at time, as an additional regressors to the three performance regressions. The coefficients of *cor*, *ira*, *priv* remained significant/not significant depending on the performance indicator with the expected signs regardless of the additional regressors added to the three equations. Similarly, the two interactions of interest (*iraXcor* and *priXcor*) remain significant/not significant regardless of extra additions to the three regressions.

Therefore, the additional inclusions do not significantly alter the estimates of the coefficients for *cor*, *ira* and *priv*. More importantly, the structure of the two interaction terms (*iraXcor* and *privXcor*) estimates remain remarkably stable regardless of which of the variables is added to the performance estimations. These results seem to indicate that the estimates presented in Tables 4, 5 and 6 are not suffering from omitted-variable bias.

	Technical Impact					
	ind		***ind + export***		***ind + export + popden***	
Variables	**(1) estimates**	**(2) t-statistic**	**(3) estimates**	**(4) t-statistic**	**(5) estimates**	**(6) t-statistic**
Ln losper(t-1)	0.794***	16.01	0.827***	22.17	0.825***	23.34
Cor	1.005***	3.85	1.047***	4.84	1.051***	4.95
Ira	0.142	0.81	0.105	0.42	0.180	0.67
Priv	-0.471***	-2.66	-0.540***	-3.73	-0.552***	-3.80
iraXcor	-0.196	-1.60	-0.131	-0.87	-0.090	-0.58
privXcor	-0.776***	-4.01	-0.812***	-6.71	-0.840***	-6.85
iraXpriv	-0.197	-1.44	-0.195	-1.09	-0.232	-1.25
Ln hols	0.064**	2.11	0.074**	2.38	0.062*	1.76
Struc	-0.604***	-3.62	-0.637***	-3.84	-0.572***	-3.09
Urban	0.005	1.41	0.004	1.49	0.005*	1.82
Ind	0.008***	3.07	0.015***	4.17	0.016***	4.01
Export			-0.009***	-3.53	-0.010***	-3.38
Ln popden					-0.0247	-1.06
Time	0.001	0.07	0.006	1.68	0.007*	1.84
Observations		424		398		398
Number of countries		40		39		39
Instruments		34		38		39
AR(1) test (p value)		-2.30(0.022)		-2.22(0.026)		-2.22(0.026)
AR(2) test (p value)		0.02(0.987)		0.03(0.975)		0.04(0.968)
Hansen test (p value)		17.18(0.700)		26.43(0.332)		26.05(0.351)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table D1: Two-step GMM estimates of T&D losses equation

Welfare Impact						
	ind		*ind + export*		*ind + export + popden*	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
Ln access(t-1)	0.912***	30.64	0.936***	33.68	0.854***	13.52
cor	-0.300***	-4.16	-0.208***	-2.83	-0.195**	-2.01
1ra	0182***	3.40	0.130**	2.19	0.299***	3.51
Priv	0.109	1.28	-0.006	-0.15	0.188	1.40
iraXcor	0.210***	3.18	0.222***	3.86	0.198**	2.42
privXcor	0.128	1.41	0.020	0.59	0.126	1.07
iraXpriv	-0.022	-0.27	0.047	0.78	-0.142	-1.40
Ln genper	0.123***	3.93	0.050***	2.33	0.173***	6.04
Ln gdpper	0.001	0.03	0.071*	1.91	0.034	0.50
struc	-0441	-1.21	-0.053	-0.70	-0.005	-0.03
urban	0.001	0.38	-0.001	-1.30	0.001	0.43
ind	-0.013***	-4.28	-0.004**	-2.47	-0.006***	-2.89
export			0.002**	2.22	0.002**	2.49
Ln popden					0.029	0.41
time	-0.000	-0.27	0.000	0.41	-0.002	-0.56
Observations		480		454		452
Number of countries		45		44		44
Instruments		62		63		72
AR(1) test (p value)		-4.12(0.000)		-4.12(0.000)		-3.91(0.000)
AR(2) test (p value)		-1.49(0.137)		--1.43(0.153)		-1.36(0.174)
Hansen test (p value)		32.96(0.952)		31.45(0.969)		31.37(0.997)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table D2: Two-step GMM estimates of per capita energy consumption equation

Economic impact						
	Ind		***ind + export***		***ind + export + popden***	
Variables	**(1) Est.**	**(2) t-stat.**	**(3) Est.**	**(4) t-stat.**	**(5) Est.**	**(6) t-stat.**
Ln gdpper(t-1)	0.947***	71.26	0.860***	25.70	0.934***	30.57
cor	-0.087**	-2.20	-0.086**	-2.17	-0.137***	-3.57
ira	0.018	0.84	0.030	1.02	0.054	1.32
priv	0.158***	4.50	0.213***	6.35	0.169***	5.65
iraXcor	-0.041	-1.38	-0.059	-1.08	-0.007	-0.24
privXcor	0.167***	4.64	0.223***	7.48	0.155***	3.69
iraXpriv	-0.050***	-2.62	-0.046	-1.31	-0.035	-1.14
Ln comper	0.014*	1.93	0.009	1.02	0.007	0.56
struc	0.015	1.49	0.063***	3.29	0.020	0.69
urban	0.000	0.50	0.003***	3.23	0.000	0.03
ind	0.001	1.27	-0.001**	-2.21	-0.001*	-1.80
export			0.004***	8.80	0.004***	10.11
Ln popden					-0.014	-0.76
time	-0.001***	-3.42	-0.002***	-3.07	-0.003***	-5.57
Observations		480		458		452
Number of countries		45		44		44
Instruments		41		62		71
AR(1) test (p value)		-3.09(0.002)		-2.97(0.003)		-3.04(0.002)
AR(2) test (p value)		-1.58(0.113)		-1.55(0.121)		-1.44(0.149)
Hansen test (p value)		21.72(0.794)		28.60(0.988)		33.73(0.992)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table D3. Two-step GMM Estimates of Income Growth Equation

Appendix E: OLS Estimates of the Performance Equation

(Energy Losses, Access Rates and Income)

These estimates, although inconsistent due uncontrolled unobserved heterogeneity and simultaneity, show the potential of some ESR policies to reduce the adverse relationship between corruption and performance of reforms.

	Technical Impact		**Welfare Impact**		**Economic Impact**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
cor	1.651***	6.80	0.320***	3.01	0.702***	5.79
ira	0.099	0.37	0.437***	3.95	-0.323**	-2.26
priv	-0.770***	-3.08	-0.181**	-1.98	0.191	1.35
iraXcor	-0.320*	-1.93	0.304**	2.25	-0.518***	-4.11
privXcor	-0.931***	-3.44	0.286***	2.59	-0.228	-1.61
iraXpriv	-0.103	-0.41	-0.107	-1.04	-0.196	-1.36
struc	0.442***	3.06	0.443***	3.40	0.226***	3.28
urban	0.046***	18.36	0.001	0.54	0.027***	14.12
Ln hols	0.261***	8.03				
Ln comper					0.218***	5.20
Ln gdpper			0.582***	10.69		
Ln genper			0.539***	13.31		
time	-0.004	-0.29	0.007	0.78	0.006	0.74
constant	-12.761***	-48.69	-4.725***	-10.70	6.031***	41.48
No. of countries	41		47		47	
No. Obs.	485		562		526	
Adj. R^2	0.534		0.796		0.566	

Significance code: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table E1: Estimates of the pooled OLS regression