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Sector Reforms and Institutional Corruption:

Evidence from Electricity Industry in Sub-Saharan Africa

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Keywords electricity sector reform; corruption; Sub-Saharan Africa; panel data; dynamic GMM.

JEL Classification Q48, D02, K23, D73

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Abstract

We analyse the impact of corruption and two key aspects of electricity sector reforms, such as the creation of independent regulatory agencies and private sector participation, on several performance indicators in Sub-Saharan Africa. We find that corruption reduces technical efficiency of the sector and constrains the efforts to increase access to electricity and national income. However, some negative effects are offset where independent regulators are established and privatisation is implemented. Our findings suggest that well-designed reforms not only boost economic performance of the sector, but also reduce the negative effects of macro-level institutional deficiencies, such as corruption, on performance indicators.

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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 impact of corruption on electricity sector performance is particularly relevant in the Sub-Saharan Africa (SSA) context, where welfare improvements can be linked to widespread corruption (Gyimah-Brempong and de Camacho, 2006). Despite the obvious difficulties of measuring corruption, the Corruption Perception Index (CPI) produced by Transparency International (TI, 2013) shows that eight of the twenty most corrupt countries in the world are in SSA and it is the only region with more than two countries in this group. Thus, in weak institutional settings, major undertakings such as the construction of large hydroelectric dams, government intervention, monopolistic characteristics of the sector, absence of competition and substantial revenues from the sales of electricity 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 have implemented Electricity Sector Reforms (ESRs) (Eberhard et al., 2016). Such reforms, also referred to as the 'standard electricity 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] The majority of the estimated 500 million people who lack access to clean and affordable electricity in the region are poor and rely on traditional biomass – wood, agricultural residues and dung – for cooking and heating needs (IEA, 2014).

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 demonopolisation policies, ESR policies were further underpinned by anticorruption agendas. Thus, reforms not only promised improved efficiency and access to reliable and affordable services, they also promised reduction in corruption in the sector (Estache et al., 2009) and the wider economy (World Bank, 2000).

Despite the anticipated positive outcomes from implementation of the reforms, 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 still 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 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 utilities (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 includes countries from different developing regions. 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.

Our paper addresses the deficit in the literature and contributes to better understanding of the institutional aspect of electricity sector 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). This paper 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 provide 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 as follows. Section 2 reviews the nearly three decades of ESR 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 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 regions of 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 reinforced by the idea that permitting more than one firm to provide electricity would increase, rather than reduce, costs which resulted in historically high investments by the state in public utilities relative to private investments (USAID, 2005). However, the 1980s and 1990s saw SSA countries increasingly unable to sustain investments in the sector. Decades of government investments had not produced the anticipated improvement in performance, as services and subsidies remained concentrated in urban areas, nor were there improvements in quality and reliability of service.

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 utilities had been exhausted (Joskow, 2006; Gilbert et al., 1996), therefore state-ownership of the sector came to be seen as a hindrance to the introduction of new technologies developed mostly by the private sector (Downing et al., 2006). The reform efforts in SSA were triggered by investment shortfalls 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 took place in Chile in 1983, which later spread to 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 was later 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 enhancement of economic and

technical efficiency of utilities and the transfer of the efficiency gains to consumers in the form of 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 independent sector regulator would supervise and regulate the monopoly-prone parts of the sector (Victor and Heller, 2007). Table 1 summarises 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 in 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, under investments in the sector.	***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:* for example, 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 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 utilities, weak institutional setting, the inabilities of both utilities and governments to mobilise sufficient investments to provide access, 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 people (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; 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 efficient electricity sectors 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 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 economies, 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 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 the SSA countries studied here.

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 Seychelles Congo Dem. Rep. Guinea	Botswana Chad Madagascar Mauritius Liberia Guinea Bissau Comoros Congo, Rep.	Mauritania Niger Swaziland	Angola Burkina Faso Cape Verde Cameroon Côte d'Ivoire Ethiopia Gabon Gambia Malawi Mali Mozambique Namibia Lesotho Rwanda São Tomé & Príncipe 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.
*** Somalia and South Sudan are not included in our analysis. The former due to the lack of data and the latter gained independence from (North) Sudan in 2011 and our data covers until 2013.

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

3. Literature on Corruption and Sector Reform

As argued in World Bank (2000), ESRs 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 treated as commercial enterprises and thus, expected to pay interest and taxes, and earn commercially competitive rates of return on

[3] See Appendix A for types, project names and status of management contracts in SSA countries of our sample.

equity capital. They can also plan and execute budgets, and initiate and implement borrowing procurement and employment conditions (Kapika and Eberhard, 2013).

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 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 their operations, 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 bill 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 private sector has proved to be complex and contentious in some countries. 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 government agencies to pay their bills, forbidding utilities from reducing the workforce or disconnecting delinquent consumers (Nellis, 2005).

Other stakeholders removed from management positions, and the employees laid off criticised such contracts especially where large fees were paid to management contractors (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 argued not to be commensurate with the modest improvements in the finances of utilities. This helped galvanise political backlash against such contracts in the region. Moreover, it was argued that, many regulators failed to capture the benefits of efficiency gains and competition from management contractors (Nellis, 2005). As a result, management contracts were viewed by policymakers in SSA as unsustainable, thus of 16 management contracts in the region, 4 were cancelled before their expiration dates, 12 were allowed to

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

expire after their initial terms, and only in Liberia and Lesotho there are contracts currently active. Eberhard and Gratwick (2011) state that of all the countries with management contracts, only those 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 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 energy from state-owned energy (e.g., oil and gas) companies (Nellis, 2005) even while lower cost alternatives exist. Thus, it became increasingly difficult to insulate corporatized utilities from corruption usually associated with state ownership of utilities, which has been among 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 impacts, reformers have advocated for the introduction of competitive electricity markets after the sector is unbundled vertically and horizontally. Thus, irrespective of ownership status, reformers anticipate that competition between the unbundled segments and among generating plants offers a reliable mechanism to reduce energy losses and increase capacity utilisation. These efficiency gains are expected to increase access rates, while 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 than the terms of service provided by state-owned monopolies. This freedom of choice means consumers can escape from corruption hitherto associated with government owned 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 UK, 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 prices (Lewis, 2014). Similarly, the idea that the market would discipline competing firms and thereby benefit consumers was tested by the California power crisis in 2001. Byrne and

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

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 their bidding strategies. Therefore, instead of lowering prices, the day-ahead, hour-ahead, and real-electricity markets 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 competitive retail or wholesale electricity 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 many 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 from financial 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 the performance of the sector through changing the incentive structure. The owners of privatised utilities are the residual claimants of revenue generated by service provision, incentivising them to close inefficiencies including those related to corruption (Olson, 2000). This differs from when services were provided by 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 the rents produced by privatised utilities. In other words, privatised firms become more productive and profitable relative to state-owned firms 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.

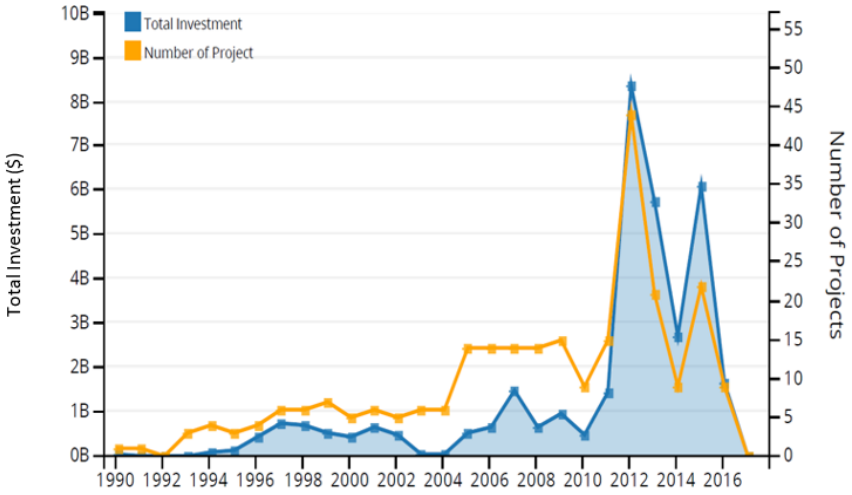

Figure 1: IPP Investments in SSA Countries, 1990-2016
Source: World Bank PPI Database

For example, the entire installed generation capacity of 48 SSA countries in 2012 was 83 gigawatts (GW), 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 new generation capacity was required annually between 2005 and 2015 (Eberhard and Gratwick, 2011). The study 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).

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

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

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 the latter group of countries, governments have full regulatory discretion in determining monitoring and enforcing maximum tariffs and minimum service standards. Some argue 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, 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.

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

[8] Only 26 of the 47 SSA countries studied here have established independent energy regulatory agencies.

sectors about 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 this body of literature to identify three potential indicators of electricity sector performance to assess the corruption reducing potential of ESR policies. The variables 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 can be 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 unelectrified 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 privatisation, 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. We extend the performance impacts of corruption and ESR, to the wider economy and 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:

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

where *i* and *t* index a country and year, *Y* is the performance output reflecting either of the three performance indicators: technical efficiency (T&D energy losses; *losses*), 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 two dummies that reflect the existence of an independent regulatory agency (*ira*) and privatisation (*priv*), a proxy for all forms of private sector participation in electricity sectors. 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*), structure (*struc*) and size (*urban*) of the electricity sector.

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. 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. 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 the methodological concerns, we transform (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 (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} denotes the lagged value of performance, whilst φ is the parameter associated with that variable. 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. This 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. The estimator 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

Our econometric analysis is 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 focus of the paper is on the influence of IRAs and privatisation on corruption, the limited reforms implemented so far in the region would not permit us to assess the impacts of ESR and corruption before 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 the years and countries. Therefore, as we analyse different performance indicators the sample size also changes.[9] Table 2 shows the countries included in our analysis.

As noted, the three performance indicators (technical, welfare and economic impacts) are measured by T&D losses (*losses*) as a percentage of total electricity production, per capita electricity consumption (*access*)[10] and GDP per capita (*gdpper*). Data on *access* (relabelled as *comper* to use as a control variable in the economic impact model) is obtained from the U.S. Energy Information Administration (EIA) database, while data on *losses* and *gdpper* are 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.[11] Data on *priv* was obtained from the World Bank Infrastructure Database. Table 3 summarises summary statistics of the variables used.

The data for the control variables *urban* and *genper* were obtained from the World Bank Development Indicators and the U.S. EIA respectively. Data for *struc* was obtained from World Bank Development Indicators Database and updated with data from African Development Bank Energy Utilities Database, included in the Africa Infrastructure Knowledge Program. Using these data, we follow Jamasb et al. (2004) to create an index of binary numbers 1 and 0 to indicate whether a country has unbundled its electricity sector. *urban* is a proxy for the size of electricity markets and is measured as the percentage of total population that resides in urban areas. In addition, the data on total household electricity

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

[10] See Appendix B for a discussion of this measure as a proxy for access to relative to alternative indicators. The variable has been averaged by total population data from the World Bank Development Indicators database.

[11] 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/; and São Tomé and Príncipe Autoridade Geral de Regulação: http://www.ager-stp.org/index.php/pt/.

consumption (*hols*) was obtained from the United Nation's Energy Statistics Database. The countries included in our sample are listed in Table 2.[12]

Variables Names	Labels	Unit	Obs.	Mean	Std. Dev.	Min.	Max.
Electricity Gen., Per Capita	*genper*	kWh per capita	562	435	880	8	5,306
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	628	1,467	7	10,566
Household Elect. Consumption	*hols*	Million kWh	528	1,755	5,806	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
T&D Losses	*losses*	%	271	20.52	14.36	2.93	86.75
GDP, Per Capita	*gdpper*	2010 US$	562	2,138	3,250	194	20,172
Population Density	*popden*	Inhab./km^2	562	86.63	112.45	2.38	620
Structure	*struc*	Dummy	564	0.09	0.29	0	1

Note: *genper*, *access*, *hols*, *gdpper* and *popden* were log-transformed prior to estimation
* Equatorial Guinea is a notable exception with exports being larger than GDP

Table 3: Summary Statistics

5. Results

This section presents the results of the three performance dimensions of electricity (technical, welfare and economic impacts) using a dynamic panel Sys-GMM estimator. We first discusses the estimates of the T&D energy losses equation, then electricity consumption per capita, and finally the estimates of the GDP per capita equation. The results in Tables 4-6 indicate that they fit the data well. The AR(1) and AR(2) test statistics indicate that there is first order serial correlation, but not at the second order, which suggests the inconsistency of OLS and appropriateness of a GMM estimator in our context (Arellano and Bond, 1991). In addition, 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 that use static models to analyse the impacts of ESR on performance (Zhang et al., 2008; Estache et al., 2009; Wren-Lewis, 2015).

[12] In order to test the robustness of our results we included three additional explanatory variables - share of industrial output (*ind*), trade openness (*export*) and population density (*popden*) - in the reform performance equations in alternative estimations. The data for these variables were obtained from the World Bank Development Indicators Database. The results of these models do not show significant changes relative to those presented in this paper. The parameter estimates of these models are available from authors upon request.

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 negative and highly significant, suggesting that an increase in the corruption index (i.e., the country is cleaner in terms of corruption) is associated with reduction in energy losses. Thus, corruption can be considered here as a major source of inefficiency in SSA countries. Therefore, adopting measures to reduce corruption can have positive impact on technical efficiency. This result is similar to those obtained by other studies that have found a positive relationship between corruption and inefficiency in the sector (Dal Bó, 2006; Estache and Trujillo, 2009; Dal Bó and Rossi, 2007; and Wren-Lewis, 2015).

The coefficient of *ira* is significant and positive suggesting that, the creation of IRAs have led to a statistical increase in energy losses. A similar result was obtained by Nagayama (2010) who finds the establishments of IRA led to an increase in T&D losses in Latin American and some former Soviet Union countries. Similarly, Smith (2004) and Zhang et al. (2008) find reform policies such as the creations of IRAs are associated with deterioration in energy losses. The coefficient of *priv* is not significant indicating that, private sector participation has no impact on the technical efficiency of the sectors during the period of our study. This result contrasts with Clark et al. (2005) who find the introduction of private sector participation in countries such as Namibia, Nigeria, Uganda and Mali is associated with efficiency improvements. This also contradicts earlier studies that find private participation in the electricity sector is associated with technical efficiency improvements (e.g., Andres et al., 2008; Nagayama, 2007; Balza et al., 2013).

The failure of independent regulators and private sector participation in SSA countries to reduce the energy losses can in part be explained by the need of the reforms to initially direct their efforts to improve the conditions of the generation segment of the sector. This, however, in practice, often tends to come at the expense of delays in the regulatory reform of the transmission and distribution network utilities where most of the energy losses occur. Indeed economic regulation of network utilities has proven to be a rather difficult task in developed as well as in developing countries.

Do electricity reforms reduce the negative influence of corruption on technical efficiency of the sector? This can be examined through the two interaction terms *iraXcor* and *privXcor*. The coefficient of *iraXcor* is positive and significant suggesting that creations of IRAs have a statistical impact on the relation between corruption and technical efficiency. Conversely, the coefficient estimate suggests that creation of IRAs have reinforced the negative influence of corruption on technical efficiency. This finding has been highlighted by Smith (2004) that argues that reform policies such as the creation of IRAs were not effective in reducing energy losses and especially electricity theft in developing countries such as in SSA. The study attributed this finding to weak quality of governance such as, ineffective accountability and political stability.

Technical Impact (*losses*)		
Variable	**Est.**	**t-stat.**
losses(t-1)	0.429***	4.42
cor	-16.431**	-2.19
ira	8.626**	2.24
priv	12.703	1.59
struc	1.081	0.67
iraXcor	9.749***	4.94
privXcor	9.342	1.18
iraXpriv	-2.105	-0.58
ln *hols*	-3.677***	-3.15
urban	0.015	0.21
time	0.228***	2.86
intercept	18.547***	3.80
No of obs.		231
No of countries		223
Instruments		22
AR(1) test (p value)		-2.26(0.024)
AR(2) test (p value)		0.71(0.475)
Hansen test (p value)		13.60(0.192)

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

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

The coefficient of the *privXcor* interaction term is positive but not significant suggesting that, the SSA countries that have opened their electricity sectors to private participation have not been able to offset the negative influence of corruption on efficiency. Similarly, the coefficient of the interaction term *iraXpriv* is positive but not significant indicating that regularised privatised networks have no effect on technical efficiency. It appears that even though IRAs on their own increase energy losses privatization has no effect on technical efficiency. Nagayama (2010) obtained a similar finding in the former Soviet Union, Eastern European and Latin American countries.

Regarding the control variables, the negative and significant coefficient of *hols* suggests that an increase in household demand for electricity has led to reduced T&D losses, likely due to a positive size effect. The coefficient of *struc* and *urban* are not significant and suggest that unbundling and urbanisation have not have an effect on technical efficiency during the period of our study. The coefficient of the time trend is positive and significant thus indicating that there has been an increase in the electricity losses of the countries over our sample period. It should be noted that this and the subsequent results should be interpreted with some caution since the dummies used are nominal values and thus may 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.

5.2. Welfare Impact – Per Capita Electricity Consumption

The main aim of electricity sector 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 positive and significant, suggesting that, an increase in corruption (i.e., a decline in *cor*) decreases access to electricity services. This result is consistent with the findings by other studies 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 increased access to electricity. This result contrasts with those obtained by Estache et al. (2009) who associated the creation of IRAs with 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 reform steps (e.g., privatisation) have led to a decline in access 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 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.

Regardless of the impacts of individual reform policies, the coefficient of *iraXpriv* suggests that together they exert a significant decreasing effect on access to electricity. In other words, although the creation of IRAs has led to increase in access rates while privatisation has no effect, their interaction have led to reductions in access rates. This may be attributed to the conflicting objectives of independent regulators and private utilities. Independent regulation may be keen to extend the often-subsidised service to mostly unelectrified poorer areas. However, private firms have shown little interest to extend the service to new low-income and low-usage consumer groups.

The coefficients of *gdpper*, *urban* and *struc* are all not significant suggesting that income level, the size, and the structure of electricity markets have no impact 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 indicating that there has been no improvement in the electricity access of the region over time.

Welfare Impact (ln *access*)		
Variable	**Est.**	**t-stat.**
ln *access*(t-1)	0.871***	23.46
cor	0.093*	1.74
ira	0.270***	2.86
priv	-0.051	-1.00
struc	0.032	1.09
iraXcor	0.157**	2.06
privXcor	-0.106	-1.60
iraXpriv	-0.209***	-2.97
ln *genper*	0.092**	2.17
ln *gdpper*	0.018	0.41
urban	0.001	0.92
time	0.001	1.13
intercept	-0.167	-0.62
No of obs.		515
No of countries		47
Instruments		37
AR(1) test (p value)		-4.04 (0.000)
AR(2) test (p value)		-1.55 (0.120)
Hansen test (p value)		31.74 (0.134)

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

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

5.3. Economic Impact – GDP Per Capita

The earlier results indicated that the implementation of electricity reforms in SSA countries can reduce the negative influence of corruption on the performance of the sector. Similarly, the implementation of reforms in developing countries was noted to have anticorruption potentials to reduce the effects of corruption on economic development (World Bank, 2000). Therefore, we expect the electricity reforms in SSA to enhance economic performance at two levels. First, by enhancing the performance of the sector by improving technical efficiency and extending the service to those without access. Second, as part of wider economic reforms, often underpinned by an anticorruption strategy, the reforms can reduce the effect of corruption on economic performance.

In Table 6, where *gdpper* is a dependent variable in the performance equation, the coefficient of *cor* is positive and significant indicating that a decrease in corruption augments national income. 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 corruption control index is associated with an increase in per capita GDP. The coefficient of *ira* is not significant; suggesting that creation of IRAs has not had impact on the level of income.

Economic Impact (ln *gdpper*)		
Variable	**Est.**	**t-stat.**
ln *gdpper*(t-1)	0.596***	14.38
cor	0.130***	4.90
ira	0.013	0.29
priv	0.140***	2.69
struc	0.120***	2.96
iraXcor	-0.006	-0.14
privXcor	0.164***	3.76
iraXpriv	0.014	0.30
ln *comper*	0.100***	6.04
urban	0.008***	6.48
time	-0.001	- 0.81
intercept	2.706***	9.01
No of obs.		515
No of countries		47
Instruments		48
AR(1) test (p value)		-2.76 (0.006)
AR(2) test (p value)		-0.89 (0.374)
Hansen test (p value)		38.10 (0.374)

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

Table 6: Two-step GMM Estimates of Per Capita Income Equation

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 obtained by Chisari et al. (1999) who find privatisation 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 privatisation has the potential to free up energy subsidies and thereby boost economic performance over the long run (IMF, 2013).

Do the electricity reforms 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 electricity sectors to private investments have reduced the negative association between corruption and per capita GDP and thus have succeeded in boosting 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.

The three control variables in the model are all positive and significant. This suggests that an increase in energy consumption (*comper*), unbundling (*struc*) and size of electricity markets (*urban*) impacted positively on per capita GDP, after controlling for the effect of corruption. The time trend variable is not significant which may indicate that there has been no technical progress over the period covered by our study.

6. Conclusions

Sub-Saharan African countries are noted to be among the most corrupt in the world. As a result, various studies have investigated how corruption has continued to constrain the economic development of these countries through different transmission channels. However, one important transmission channel not yet investigated is the organisation and regulation of electricity sectors. Studies that investigated this channel in other developing regions have found evidence that corruption can reduce technical efficiency, restrict electricity services to urban areas and reduce income levels.

In order to mitigate the influence of corruption in the electricity sector, reformers advocated the use 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 then sold to the private sector and an independent regulatory agency created by the state would then supervise and regulate the natural monopoly-prone networks of the sector.

After more than two decades of electricity sector reforms in SSA countries, we can now investigate whether these reforms have reduced the influence of corruption on technical efficiency of the sector and whether the efficiency gains have resulted in higher access rates and incomes. 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 the electricity sector performance – i.e. 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 the creation of independent regulators 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 although it can also reduce technical efficiency. In addition, we show that private sector participation is associated with improved economic performance, while we find that privatisation policies have no statistically significant impact on access rates and technical efficiency.

We also analyse how corruption interacts with the two reform policies and how these interactions impacted on the three indicators of reform performance. The creation of independent regulators has substantially reduced the adverse association between corruption and access rates, while they have reinforced the negative association between corruption and technical efficiency. We also find that creations of independent regulators have not mitigated the often-cited negative association between corruption and income level. Private sector participation has offset the adverse effects of corruption on income, while they have no impact on the association between corruption and access rates and technical efficiency.

These results are robust after controlling for other variables that impact 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 national income.

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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	1993	Management Service Gambia (MSG)	Lease contract	Cancelled	G, T & D
Gambia	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 and 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

In order 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).[14]

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).[15]

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).[16]

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) note, 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.

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