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Power it up: Strengthening the electricity sector to improve efficiency and support economic activity☆

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ABSTRACT

Poor performance of the electricity sector remains a drag to economic efficiency and a bottleneck to economic activity in many low-income countries. This paper proposes a number of models that account for different equilibria (some better, some worse) of the electricity sector. They show how policy choices (affecting insolvency prospects or related to rules for electricity dispatching or tariff setting), stochastic generation costs, and initial conditions, affect investment in generation and electricity supply. They also show how credible (non-credible) promises of stronger enforcement to reduce theft result in larger (smaller) electricity supply, lower (higher) government subsidies, and lower (higher) tariffs and distribution losses, which in turn affect economic activity. To illustrate these findings, the paper reviews the experience of Haiti, a country stuck in a bad equilibrium of insufficient supply, high prices, and electricity theft; and that of Nicaragua, which is gradually transitioning to a better equilibrium.

1. Introduction

Reliable and low-cost electricity supply is an essential input for economic activity and to attract productive investment (Alam, 2006; Payne, 2010). Conversely, high electricity costs and electricity shortages act as a disincentive to investment, hamper competitiveness, and complicate efforts aimed at poverty reduction, all in all resulting in reduced efficiency and a bottleneck to economic activity. Inadequate management of the electricity sector usually brings about electricity rationing and costly subsidies, which are often exacerbated by fraud and nonpayment, or by weak enforcement. All these elements result in price distortions as well as direct and contingent fiscal costs (IMF, 2013; Di Bella et al., 2015). Unsurprisingly, several agencies (including the World Bank and the World Economic Forum) consider the electricity sector's performance as a critical input in evaluating how easy it is to do business. Moreover, there is evidence that structural reforms, including those aimed at strengthening the electricity sector's performance and infrastructure, increase total factor productivity (IMF, 2015a).

This paper proposes a number of theoretical models for the electricity sector and illustrates some of their implications by reviewing the experience of Haiti and Nicaragua. The models allow assessing how solvency prospects, dispatching rules, generation costs resulting from alternative technologies, as well as the existing composition of the generation matrix, affect long-term investment in the sector (both level and composition), and thus supply levels and average generation costs. The models also show how a credible promise of stronger regulation and enforcement to reduce electricity theft results in larger investment and electricity supply, in lower government subsidies, and in lower tariffs and theft ratios; and, conversely, how a non-credible promise fails to attract sufficiently high investment levels, which result in a sector characterized by low electricity supply, high electricity tariffs, high distribution losses, and high government subsidies.[1]

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[1] Distribution losses consist of technical and non-technical losses. Technical losses include power dissipation in electricity system components such as those arising from transmission line losses, power transformer losses, distribution line losses, and low-voltage transformer and distribution losses. These are often accompanied by non-technical losses, which are caused by actions external to the power system and consist mainly of electricity theft, delinquency, inadequate metering and billing, and errors in accounting and record keeping (World Bank, 2009a, 2009b).

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One relevant conclusion from the models presented is that depending on policy choices, there may be different long-term equilibria for the electricity sector, some better than others. A *better equilibrium* would be generally characterized by long-term public policy choices geared at low theft-ratios and delinquency, strong enforcement, low government subsidies, appropriate tariff setting and electricity dispatching rules, all of which would result in lower generation costs and a volume of investment that is large enough to guarantee electricity supply levels commensurate with peak demand. Alternatively, a *worse equilibrium* would be characterized by high theft-ratios and government subsidies, weak enforcement, inappropriate electricity tariff setting and dispatching rules, all of which would generally result in large generation costs, as well as investment in generation and distribution that result in insufficient electricity supply levels, thereby acting as a bottleneck to economic activity.

Better and worse long-term configurations are influenced by policy choices in the short-term, which also affect the sector's performance. In this regard, the paper describes how poor management will affect the sector's cash flow and solvency prospects, and how constrained financing will result in insufficient supply or rationing, both of which act as a drag on economic activity. Similarly, it shows how cross subsidies embedded in the tariff (or implicit in high distribution losses), can act as a constraint on economic activity, either through high electricity costs, rationing, or both. In particular, the paper emphasizes that investors in electricity generation and distribution usually form their expectation about future solvency prospects based on the sector's current parameters and policies. For instance, if electricity tariffs are lower than generation costs, or if electricity theft and government subsidies are high, the cash flow generated by electricity distribution will generally be insufficient to ensure the sector's solvency and the appropriate maintenance of distribution networks (Varangu and Trevor, 2002; Morgan, 2007; and World Bank, 2009a, 2009b). This will negatively affect investors' perceptions about future solvency, and thus, their current decisions on investing in electricity generation and distribution. All this can result in a given country getting stuck with a distribution network of a size that is not commensurate with demand growth, and with an electricity generation matrix characterized by high costs.[2] Alternatively, if the management of the sector in the short term supports good solvency prospects, investment in generation and distribution will be larger, and the composition and size of the generation matrix will gradually adjust to ensure competitive costs and sufficient supply.

While financial problems of electricity sectors that rely on non-renewable generation become apparent at times of high oil prices, the recent decline in oil prices brings about new challenges. Ceteris paribus, lower oil prices reduce generation costs from non-renewable sources, improve the cash flow of electricity distribution, result in a decline in energy subsidies, and provide an opportunity to clean balance sheets and repay cross arrears. However, despite a history of substantial volatility and large swings in oil prices, when the latter are low the incentive for structural reforms and investment in financially less attractive renewable sources is small. Therefore, plans to rebalance electricity generation between renewable and non-renewable sources become less urgent, as hedging properties of renewable sources and environmental costs of non-renewable may get neglected.

The cases of Haiti and Nicaragua are representative of two different equilibria of the electricity sector. Haiti's experience illustrates clearly how the electricity sector can act as a bottleneck to economic activity. Inadequate management and regulation has resulted in insufficient supply, high generation costs, poor service, and has forced the private sector to self-generation, which prevents taking advantage of economies of scale. Haiti's electricity sector is a drag to the budget and an important source of macroeconomic vulnerability and strong actions have to be taken to make the sector sustainable (IMF, 2015b). In contrast, Nicaragua's experience since 2007 illustrates the transition from a worse towards a better equilibrium for the electricity sector (IMF, 2012). Strengthened regulation has gradually resulted in increased supply and a more diversified energy matrix, lower generation costs, the elimination of blackouts, decreases in theft ratios and, despite room for further improvement, in a more sustainable electricity sector. Going forward, a rule-based tariff setting in the context of a clearly specified medium-term framework should help Nicaragua consolidate the gains to date.

The paper is organized as follows. Section 2 presents some theoretical models that illustrate how better and worse equilibria for the electricity sector may arise. Section 3 discusses the experiences in Haiti and Nicaragua, and in the case of the latter, it illustrates how the ongoing transition to a fully sustainable sector may proceed through a medium-term framework. Finally, Section 4 presents some concluding remarks.

2. Some models for the electricity sector

This section presents a number of theoretical models for the electricity sector. It first reviews some basic concepts, and then proposes a model of optimal long-term investment in electricity generation, identifying the parameters that will influence its level and composition among different generation technologies. The section then moves to discuss issues related to the distribution network, and analyzes the role that credible government commitments to strengthen enforcement and fight theft (which are frequently associated with improvements in the regulatory framework), have on the network's size, theft ratios, electricity supply and tariffs, and economic activity. The section ends by briefly describing a number of topics relevant to the sector including the conditions upon which electricity shortages, self-generation, and cross arrears and subsidies may arise.

2.1. Basic concepts

2.1.1. Electricity tariffs

Electricity tariffs are periodically set by the energy regulator to cover generation, capital and operational costs, and account for distribution losses:

$$P_t^S = L_t\left[P_t^G + AVD_t + OF_t\right] \tag{1}$$

where P_t^S denotes the average electricity tariff (in, e.g., US$/MWh) charged to consumers; $P_t^G = P_t^T + P_t^E$ is the average electricity cost, which is composed by a transmission fee, P_t^T, and the electricity price charged by generators, P_t^E; AVD_t corresponds to the aggregate value of distribution and is set so to cover the operational costs of electricity distribution, capital investment and infrastructure maintenance, financial costs and taxes, and a competitive profit; and OF_t corresponds to other factors defined by the regulator, including to compensate clients or the electricity distribution company depending on circumstances.[3]

2.1.2. Distribution losses

The "loss factor" $L_t \geq 1$ in Eq. (1) is defined as:

$$L_t \equiv \frac{1}{1-\lambda_t} \tag{2}$$

[2] If electricity distribution is insolvent, private investment in generation may only occur provided the state offers large (and costly) guarantees, including in the form of power-purchase agreements or subsidy transfers, which in the end are likely to translate in higher electricity tariffs.

[3] Tariffs are usually set as a weighted average of tariffs applied to different consumption blocks, so it involves an estimation of the composition of the client base. If, *ex post*, the composition was different than estimated, the regulator usually compensates either consumers or the distribution company, through the tariff.