To what extent do infrastructure and financial sectors reforms interplay? - Evidence from panel data on the power sector in developing countries*

Lika BA
Ecole des Hautes Etudes en Sciences Sociales, Paris
ndlikaba@gmail.fr

and

Farid GASMI
Toulouse School of Economics (Arqade & Idei)
farid.gasmi@tse-fr.eu

Abstract

The main goal of this study is to demonstrate the existence of a significant empirical link between infrastructure and financial sectors reforms the effects of which are reflected in infrastructure sectors performance. This paper reports on the findings of an exploration of this issue for the case of the power sector in developing countries. We estimate the impact of the four main components of the power sector reform in these countries, namely, the creation of an independent regulatory agency, the unbundling of generation, transmission, and distribution, the introduction of competition and the implementation of privatization programs in the generation and distribution segments, on some of this sector's performance outcomes, and attempt to assess the contribution of the domestic financial systems' reforms to these outcomes. In a dataset on 42 developing countries covering the 1990-2005 period, we find that private participation in generation and distribution has significantly improved power supply as reflected in higher electricity generation per capita and technical and labor efficiency in the distribution segment. The unbundling of generation, transmission, and distribution has contributed to improving productive efficiency through a better use of the labor factor in the distribution segment. We find that the creation of a separate regulatory agency has boosted the generation segment in terms of both capacity and sales and has generated better incentives for a more efficient use of labor input in the distribution segment. We also find that regulatory experience has significantly contributed to improving access to electricity. The results suggest that while the power sector, in particular, its generation segment, has significantly benefited from the introduction of independent regulation, the beneficial effects of (good) regulatory practices have been exacerbated by the modernization of the financial systems. More specifically, improved financial systems have eased access to capital for operators allowing them to upgrade their networks and decrease power losses in distribution. The overall results obtained in this paper strongly recommend that along with reforming the power sector, policy makers in developing countries should implement the financial reforms that would deepen their domestic financial systems thus allowing them to recover the full benefits of these systems' positive externalities on the performance of the sector.

JEL codes: L2, L33, L94, L98, O16, C23

Key words: Developing countries, electricity industry performance, privatization, regulation, unbundling, competition, financial sector development.

November 2011

* We thank Luis Andres, Jon Stern, and Loïc Whitmore for having provided us with parts of the data used in this paper. We are indebted to Paul Noumba for insightful discussions we had on the topic of this paper. We also thank the Agence Française de Développement (AFD) for financial support. The views expressed in this paper and any remaining errors are ours only.

1. Introduction

As in most parts of the world, infrastructure services in developing countries were traditionally provided by stated-owned vertically integrated monopolies. However, this model has become plagued by poor performance due to various factors including political interference, inefficient management, and under-investment.[1] With limited resources, the public sector alone in these countries cannot ensure adequate funding together with the operational activities necessary to provide quality of service. This situation has led to a soaring need to upgrade networks and has made the financing of infrastructure projects even more challenging as demand for infrastructure services has substantially increased following population growth and large-scale urbanization.

In the late 80s and early 90s many developing countries conducted important structural reforms of their infrastructure sectors and gave high priority to the objectives of reducing the cost of the public budget by promoting foreign and domestic private investment in these sectors. In the power sector, although they varied across countries, the implemented reforms mainly consisted of a combination of four policies, namely, the unbundling of the generation, transmission, and distribution activities of the vertically integrated utilities, the privatization of the transmission and distribution segments of the industry, the introduction of competition in the generation segment, and the creation of an energy regulatory authority. In parallel to these sectoral reforms, large efforts were made to modernize the banking and financial system.

Privatization coupled with competition are meant to enhance efficiency, innovation, and customer responsiveness while independent regulation, as an alternative to centralized regulation by a government department, improves investors' confidence and consumers protection.[2] Indeed, degree of competition and ownership are known from basic theory (Vickers and Yarrow, 1988) to be key determinants of the levels of outputs, costs, and prices, and hence of the level of allocative and productive efficiency in the market. Therefore, provided they are properly designed and implemented, the electricity sector reforms conducted in developing countries were expected to enhance industry performance as reflected in higher access and usage demand and greater efficiency of supply.

In practice though, the power sector reform encountered great difficulties in many developing countries due to institutional weaknesses and lack of modern financial systems crucial to sustain the development of a sector that necessitates large capital investments. As a consequence, the establishment of appropriate regulatory bodies and the building of capacity have followed a

[1]The public good nature of infrastructure services, the existence of externalities, and the incompleteness of markets are the main market failures that have traditionally justified state intervention. However, these services are increasingly becoming rival and excludable goods therefore questioning the necessity of public intervention.

[2] See Jasmab et al. (2005) and Zhang et al. (2002) for a discussion of these points.

slow and complex process (Cubbin and Stern, 2006, Zhang et al., 2008). This led observers to question not only the efficiency of the sectoral and financial reforms themselves, but also their interaction and the timing of their introduction. This paper seeks to feed in the academic debate on these issues by exploring them in a panel dataset on the power and financial sectors in 42 developing countries from 1990 to 2005.

This paper is organized as follows. The next section reviews the relevant literature on the impact of the power sector and financial reforms on the electricity industry performance and extracts from the main findings of this literature a set of hypotheses to be tested empirically. Section 3 describes the data and presents the econometric approach used to analyze them. Section 4 reports the results of our empirical analysis. Section 5 discusses the empirical results in relation with the hypotheses and concludes. The appendix provides some complementary material.

2. Impact of sectoral and financial reforms on industry performance in electricity

The major part of the literature that has attempted to evaluate the performance of the infrastructure industries reforms has been concerned with developed countries and among those on developing countries only a few has examined the electricity sector.[3] This gap is partly due to the lack of consistent data on the sector that allow rigorous econometric analysis and partly to the difficulty in finding/constructing accurate indicators of the various energy reform policies implemented by developing countries. In this section, we briefly review some studies that are most related to our work as to their objectives and methodology and derive a number of testable hypotheses.

An important dimension of the power sector reform is the unbundling of vertically-integrated electricity utilities into corporatized generation, transmission, and distribution usually coupled with a change of ownership and management in the generation and distribution segments and the introduction of competition in these two segments. The literature on the incentive effects of ownership structure (see, e.g., North, 1990, Levy and Spiller, 1996) and agency and public choice theories (see Niskanen, 1971, Boycko and Vishny, 1996, among others) provide useful insights on the impact of privatization on economic performance. Privatization is expected to improve economic efficiency by (i) changing the allocation of property rights resulting in different incentives for management; (ii) removing the budget constraint of taxpayer support and exposing firms to the discipline of the private capital market; (iii) setting more precise and measurable objectives, such as loss reduction, thereby decreasing transaction costs, in particular, those related to management monitoring by principals; (iv) removing political interference with management.

[3] Being historically at the forefront of the reform wave that has profoundly affected infrastructure sectors worldwide, the telecommunications industry reforms have been subject to far deeper empirical analysis. Among others, see Fink et al. (2003), Gasmi and Recuero Virto (2010), Gasmi et al. (2011), Ros (1999), and Walsteen (2001).

When applying these theoretical arguments to the electricity industry, however, needless to say that one should account for the specific characteristics of the sector. Indeed, electricity production is associated with large sunk investments, generally exhausted economies of scale, and non-storable and massively consumed output which may lead to government opportunistic behavior vis-à-vis private investors, and hence affect their incentives to invest in generation. Consequently, whether privation would necessarily lead to capacity expansion is not guaranteed. Nevertheless, it is safe to say that technical and operating efficiency may be expected following privatization and this is likely to result in efficient utilization of installed capacity, capital, and labor.

Competition is viewed as a reliable mechanism to improve allocative and productive or technical efficiency. Indeed, in a competitive market, prices reflect firms' costs and productive efficiency and hence by putting downward pressure on prices, competition can be expected to increase technical and operating efficiency as well as labor productivity. In turn, the improved technical efficiency may lead to lower prices, hence to higher demand which in turn is likely to increase capacity and supply (Leibenstein, 1966, Zhang et al., 2002).

The existing empirical studies on the impact of the reforms on performance in the developing countries' electricity industry have led to mixed results essentially due to the diversity of the econometric methodologies and the samples of countries analyzed. Gassner et al. (2009) investigate whether private sector participation in electricity distribution has improved economic performance in a panel of 71 developing and transition countries over the 1900-2002 period and report that labor productivity and operational efficiency have indeed increased. Zhang et al (2002) examine the impacts of privatization, competition, and regulation on the electricity sector's performance using a data set on 51 developing countries over the period 1985-2000. Their empirical results suggest that competition has positive effects on service penetration, capacity expansion, labor efficiency, and prices to industrial users. Taken separately, privatization and regulation have no significant effect on performance, but the authors find that their interaction leads to greater electricity availability, more generation capacity, and higher labor productivity.

Zhang et al (2005) study the impact of the sequencing of privatization, competition, and regulation on the electricity industry performance using data on 25 developing countries from 1985 to 2001. While they find that individual reform indicators have negative but not significant effect on performance, these authors emphasize that creating a separate regulatory authority and introducing competition before privatization is associated with higher electricity generation and higher generating capacity. They also find that the introduction of competition before privatization enhances capital utilization measured by the ratio of electricity generation to average capacity.

Zhang et al (2008) extend their 2002 study (Zhang et al., 2002) by using some new measures of privatization, competition, and regulation and examining the impact of the electricity industry reform in a sample of 36 developing countries from 1985 to 2003. They reach the same conclusions as in their previous study, namely, that competition fosters generation, generating capacity, and labor productivity while privatization and regulation do not. They however find evidence of some positive effects of the interactions of privatization with regulation and competition. In contrast, Sen and Jasmab (2010) find in a sample of 19 Indian States from 1991 to 2007 that unbundling, privatization in distribution, and regulation tend to worsen technical and operating efficiency and gross generation decreases with privatization. As to the effects of the reforms on electricity prices, regulation and unbundling have positive but not significant effects on average electricity price while the existence of an independent regulatory body is associated with a significant increase in the average industrial price.

Some studies have focused on the effects of regulation and governance on performance. Cubbin and Stern (2006) examine the impacts of the existence of a regulatory law and regulatory governance on performance in power generation segment controlling for privatization and competition. In a panel data set of 28 developing countries covering the period 1980-2001, they find that both regulatory law and quality of regulatory governance have positive and significant effects on per capita generation capacity. Moreover, these impacts increase with the regulatory agency's experience and reputation.

Andres et al. (2009) construct an index of quality of regulatory governance and investigate the effects of change in ownership and of various characteristics of the regulatory agency on the performance of 250 electricity utilities in Latin America and the Caribbean from 1995 to 2005. These authors' results indicate that, independently of ownership the mere existence of a regulatory institution significantly enhances performance. They also find that the coefficients associated with the ownership dummies in the performance regressions have the expected signs and are significant. The result found by Cubbin and Stern (2006), that experience in regulation and quality of governance have significant effects on performance, is also confirmed by this study.

The least one can say from the above overview of the empirical literature that seeks to evaluate the reforms of the electricity industry in developing countries is that the conveyed messages are somewhat mixed. In what follows, we structure the results discussed in this literature into a set of hypotheses that we will attempt to test in our data. We take the view that an explanation of the divergence of the results obtained might be that some important factors that affect the working of sectoral reforms and hence their impact on industry performance have been omitted in the studies. In this paper, we argue that financial reforms play a non-negligible role in the

determination of the outcomes of sectoral reforms. Hence, we incorporate in the analysis of the impact of sectoral reforms on industry performance their possible interaction with financial reforms.

Despite the fact that the importance of financial systems for development has been emphasized in the literature and that the impact of sectoral reforms on performance has drawn much attention, to our knowledge, the combined effect of sectoral and financial reforms on sectoral performance remains relatively weakly explored.[4] This paper seeks to contribute to filling this void by empirically investigating how the level of development of domestic financial systems affects the impacts of sectoral reforms on the performance of the power sector in developing countries.

In a recent paper, Ba and Gasmi (2011) find a positive link between financial reforms and the level of development of financial systems in a dataset on 54 developing countries covering the 1973-2005 period. Using a 1990-2007 dataset on 56 developing countries, Ba et al. (2010) demonstrate that the level of financial development is a key determinant of the electricity sector attractiveness for private investors which, itself, is crucial for its growth. In this paper, we seek to test the hypothesis that financial development, resulting from financial reforms, enhances the impact of the power sector reforms on this sector's performance. Putting together the findings of Ba et al. (2010) and Ba and Gasmi (2011), an important policy implication of the empirical validity of this hypothesis would therefore be that infrastructure sectors' reforms can be expected to benefit from financial reforms in terms of enhancing both the infrastructure sectors' growth and performance.[5]

While our main objective is to perform an econometric test of the hypothesis that financial development improves the impact of electricity industry reforms on this industry's performance, we also seek to contribute to the empirical literature on the evaluation on the outcomes of these reforms. To this end, we organize the various findings reported in the literature, although somewhat divergent, into a set of hypotheses that reflect their main implications. Table 1 below, describes this set of hypotheses that we designate by H1 through H6. This table also presents our main hypothesis on the role of financial systems and for the purpose of simplifying our discussion, we will write $\bar{H}I$ to indicate the application of our hypothesis to the reform that HI, I=1, 2, … , 6 is concerned with. Hence, for example, saying that $\bar{H}6$ is not rejected by the data means that, all things equal, there is

[4] For empirical evidence on the relationship between financial development and economic growth, see Ang and McKibbin (2005), Ben Naceur et al. (2008), De Gregorio (1999), Huang (2006), Klein and Olivei (2001), and Levine (2001).

[5] The reader might wonder why we didn't use directly the indicators of the financial sector reforms in the empirical analysis (We thank E. Auriol for having raised this issue.). First, see Ba and Gasmi (2011), the number of those indicators is so large that incorporating them in our regressions would make the econometrics intractable. Instead, given the positive relationship found between these indicators and the indicator of financial development, we chose to use the latter as a way of synthesizing a large set of information on the financial reforms. Second, the option of using directly the indicators of financial reforms was not feasible for us anyway because of incompatibility of datasets.

enough empirical evidence in the data that financial development has made stronger the impact of competition on technical and operating efficiency.

Table 1 - Testable hypotheses

Hypothesis	Content
H1	Unbundling and privatization lead to higher capacity, generation, and access to electricity
H2	Unbundling and privatization lead to higher operating and technical efficiency
H3	Unbundling and privatization lead to higher labor efficiency
H4	Establishment of independent regulatory authority enhances "industry performance"
H5	Competition leads to higher capacity and output
H6	Competition leads to higher operating and technical efficiency
$\bar{H}I$, I=1,2,…,6	Financial development affects industry performance through its interaction with the sectoral reform concerned by hypothesis HI

3. Data and econometric models

To investigate the effects of sectoral reforms on the electricity industry performance accounting for the country's level of financial development, we collected data on 42 developing countries in Latin America and Caribbean (LAC), Asia, Middle East and North Africa (MENA), and Sub-Saharan Africa (SSA) over the period from 1990 to 2005. Table 2 below lists these countries and gives the World Bank income group each of these countries belongs to.[6] The period of the study was imposed to us by data availability. However, we should mention that little or no reform has occurred in developing countries before 1990 and that our panel is unbalanced as not all the data were available for all the years for all of the 42 countries.

Table 3 below exhibits the list of variables on which data have been collected.[7] The electricity performance measures, the dependent variables in this study, are those that are under the label "Electricity sector performance" in this table. These variables are net electricity generation per capita (*generationpc*), installed generation capacity per capita (*gencapacitypc*), sales per employee (*salesperemp*), electricity losses in the distribution network (*distlosses*), and the number of connections per 100 inhabitants (*connect*). These measures are meant to capture respectively the

[6] A country is considered as a lower middle income country when its 2008 GNI per capita is between $976 and $3,855, a higher middle income country when its 2008 GNI per capita is between $3,856 and $11,905, and a low income country when its 2008 GNI per capita is equal to $975 or less.

[7] More detailed information on these variables and some descriptive statistics are given in the appendix.

quantity of electricity supplied during a given year in a given country, labor efficiency, operating and technical efficiency in distribution, and the extent of access to electricity by the population.[8]

Table 2 - Sample countries

Country	World Bank region	World Bank income group
Argentina	Latin America & Caribbean	Upper middle income
Bangladesh	South Asia	Low income
Belize	Latin America & Caribbean	Upper middle income
Bolivia	Latin America & Caribbean	Lower middle income
Brazil	Latin America & Caribbean	Upper middle income
Chile	Latin America & Caribbean	Upper middle income
China	East Asia & Pacific	Lower middle income
Colombia	Latin America & Caribbean	Lower middle income
Costa Rica	Latin America & Caribbean	Upper middle income
Cote d'Ivoire	Sub-Saharan Africa	Low income
Dominica	Latin America & Caribbean	Upper middle income
Dominican Republic	Latin America & Caribbean	Lower middle income
Ecuador	Latin America & Caribbean	Lower middle income
Egypt	Middle East & North Africa	Lower middle income
El Salvador	Latin America & Caribbean	Lower middle income
Grenada	Latin America & Caribbean	Upper middle income
Guatemala	Latin America & Caribbean	Lower middle income
Honduras	Latin America & Caribbean	Lower middle income
India	South Asia	Lower middle income
Indonesia	East Asia & Pacific	Lower middle income
Jamaica	Latin America & Caribbean	Upper middle income
Malaysia	East Asia and Pacific	Upper middle income
Mexico	Latin America & Caribbean	Upper middle income
Morocco	Middle East & North Africa	Lower middle income
Nicaragua	Latin America & Caribbean	Lower middle income
Nigeria	Sub-Saharan Africa	Low income
Panama	Latin America & Caribbean	Upper middle income
Paraguay	Latin America & Caribbean	Lower middle income
Peru	Latin America & Caribbean	Lower middle income
Philippines	East Asia and Pacific	Lower middle income
South Africa	Sub-Saharan Africa	Upper middle income
Sri Lanka	South Asia	Lower middle income
St Kitts and Nevis	Latin America & Caribbean	Upper middle income
St Lucia	Latin America & Caribbean	Upper middle income
St Vincent and the Grenadines	Latin America & Caribbean	Upper middle income
Thailand	East Asia and Pacific	Lower middle income
Tunisia	Middle East & North Africa	Lower middle income
Turkey	Europe & Central Asia	Upper middle income
Uruguay	Latin America & Caribbean	Upper middle income
Venezuela	Latin America & Caribbean	Upper middle income
Zambia	Sub-Saharan Africa	Low income
Zimbabwe	Sub-Saharan Africa	Low income

The independent variables on which we will focus are grouped under the labels "Electricity sector reforms" and "Financial development." The sectoral reform variables comprise indicators of privatization in generation, privatization in distribution, unbundling, competition, and existence of a regulatory body independent from the ministry of energy. Ideally, privatization in generation would

[8] The measures of net generation, generation capacity, and electricity distribution losses were available only for LAC countries.

be measured by the percentage of electricity produced by private companies or by the percentage of generation capital owned by private investors. Similarly, competition would be best measured by some sort of concentration ratio for each country's electricity sector and some information on the quality of regulatory governance in each country would have been suitable for the analysis. Unfortunately, such (quantitative) data were not consistently available for all the countries in the sample and so far only limited information on the design of regulatory institutions in developing countries is available.

Table 3 - Variables and designation

Variable	Designation
Electricity sector performance	
generationpc	Net generation per capita
gencapacitypc	Installed generation capacity per capita
salesperemp	Sales per employee
distlosses	Distribution losses
connect	Connections per 100 inhabitants
Electricity sector reforms	
ppgen	Privatization in generation
ppdist	Privatization in distribution
sepreg	Separated regulator
expreg	Experience of regulator
unbundling	Unbundling of generation, transmission, & distribution
competition	Wholesale market
Financial development	
findev	Overall financial development
Institutional quality and risk	
countryrisk	Country risk
govtstability	Government stability
Economic development and population distribution	
gdp	GDP per capita
urbanization	Urban population

To circumvent these difficulties, we constructed dichotomous dummy variables indicating whether the electricity sector has been "unbundled" into its three segments (*unbundling*), whether there exists a wholesale market where generators can compete to conclude supply contracts with distributors or large users (*competition*), whether private participation exists in the generation segment (*ppgen*), and whether a separate regulatory authority not directly under the control of the Ministry of energy has been created (*sepreg*).[9] We also use a variable that indicates the number of

[9] These dummy variables were constructed on the basis of information collected from various regulatory reports and websites which are listed in the references. We should mention that a wholesale market in generation is typically created when this segment is unbundled from transmission and distribution. Hence, the variables *unbundling* and *competition* should be highly correlated and, indeed, it is the case in our data where a correlation of 0.87 between them has been found. This led us to interpret and actually use these two variables in the regression analysis as substitutes for indicating that the power sector has experience (some) openness to competition. Finally, we should mention that the issue of whether or not the regulatory agency is truly independent from the political power is not addressed in this paper.

years since the regulatory agency has been created (*expreg*). Private participation in distribution (*ppdist*) is measured by the percentage of the total number of connections supplied by the private sector.

To measure the level of financial development, our proxy for financial reforms, we use the variable *findev* which we calculate as the first principal component of financial variables that capture the development level of the banking sector and stock markets. For the banking sector we use the variables *CBA*, *DMBA*, and *CBPC*. Expressed as fractions of GDP, these indicators represent, respectively, total assets held by the Central Bank, total assets held by domestic financial institutions (to capture the depth of the banking sector), and total loans granted by commercial banks to the private sector. For the capital markets, we use the variables *SMC*, *TVT*, and *SMT*. The variables *SMC* and *TVT* are also expressed as ratios of GDP and represent, respectively, stock market capitalization and total value of shares traded on the stock market. These variables are meant to measure size and liquidity of the capital market respectively. The variable *SMT* is the domestic capital market turnover. Meant to assess the efficiency of the stock market, for a given year, it is calculated as the ratio of the total value of shares traded to the average market capitalization.

In addition to variables of performance, sectoral reforms, and financial development, we use an indicator of the quality of a country's institutions and a measure of this country's level of risk as control variables. Presented under the label "Institutional quality and risk" in Table 3, these variables represent the country's level of political and economic risk (*countryrisk*) and the ability of the government to commit to its announced economic program (*govtstability*). To account for economic growth and urbanization effects that have been discussed in the literature (see, e.g., Zhang et al., 2002), we use GDP per capita (*gdp*) and the share of the country's total population which lives in urban areas (*urbanization*). These two variables are under the label "Economic development and population distribution."

To estimate the effects of sectoral reforms and the level of financial development on the performance of the electricity industry, we run a set of single-equation regressions with the performance indicators as dependent variables. Part from the independent variables of main interest, namely, sectoral reforms and financial development indicators, the set of right-hand variables of these regressions comprises variables that capture some important features of the countries' institutional and regulatory environment and level of economic development. Thus, these regressions provide us with an empirical framework that can be used to test the hypotheses on the impact of sectoral reforms discussed in the previous section (see Table 2) while controlling for these other features of a country's economy.

Given that our data are in a pooled time-series cross-sectional form, we consider both fixed (FE) and random effects (RE) models and discriminate between these two specifications by means of a Hausman test. Note that the RE model assumes that the regressors are not correlated with the unobserved country effects. However, factors such as those related to the quality of governance and institutions are very likely to affect sectoral reforms measures and hence, when omitted, their impacts are included in the unobserved country effects leading to a correlation between the regressors and the country effects. Moreover, countries included in the sample analyzed are clearly not drawn randomly but are developing countries for which relevant data were available. Finally, we must indicate that we have performed a Fisher test that confirmed the presence of country fixed effects in all the specified models.[10] These reasons led us to use fixed-effects panel models that control for country-specific unobserved effects.[11]

Our empirical strategy consists of a stepwise procedure motivated by two main objectives. A first objective is to examine whether sectoral reforms have the expected effects on the electricity sector's performance, i.e., to test hypotheses H1 through H6 discussed in the previous section. A second objective is to analyse the interaction between the financial and sectoral reforms. Thus, this second objective encompasses the testing of our main conjecture on the incremental effect of financial sector reform on performance, or equivalently, hypotheses $\overline{\text{H}}1$ through $\overline{\text{H}}6$.

The first objective is tackled by means of regressions of the following general form which we refer to as Model (1):

$$perf_{it} = \alpha_0 + \mu_i + \alpha_1 pp_{it} + \alpha_2 reg_{it} + \alpha_3 open_{it} + \sum_{j=4}^{7} \alpha_j X_{jit} + \varepsilon_{it} \qquad (1)$$

Where $i = 1,...,42$ and $t = 1,...,16$ are indices that refer to the country and the year respectively, *perf* is a variable of industry performance, *pp* is either *ppgen* or *ppdist* depending on the industry performance variable used, *reg* is either *sepreg* or *expreg* depending on goodness-of-fit, *open* is either *unbundling* or *competition* also depending on goodness-of-fit, the *X*s are the control variables under the labels "Institutional quality and risk" and "Economic development and population distribution" in Table 3 above, the αs are unknown parameters, μ_i is a fixed country effect term, and ε_{it} is an error term.

To achieve the second objective, which is to investigate the contribution of financial reforms to the impact of sectoral reforms on performance, we proceed in two steps. We first examine the

[10] The results of the Fisher test of the presence of country fixed effects are available from the authors upon request.
[11] We nevertheless realize that, even if the FE estimator is always consistent, the RE estimator, where applicable, is more efficient (Sen and Jasmab, 2010).

effect of sectoral reforms and financial development on performance through their interactions. This is achieved by estimating regressions of the following generic form referred to as Model (2):

$$perf_{it} = \alpha_0 + \mu_i + \alpha_1 pp.findev_{it} + \alpha_2 reg.findev_{it} + \alpha_3 open.findev_{it} + \sum_{j=4}^{7} \alpha_j X_{jit} + \varepsilon_{it} \qquad (2)$$

Where *findev* is the (principal component) index of financial development discussed earlier and the other variables are as defined above. The cross-terms in this specification are meant to capture the interactions between sectoral reforms and financial development.

Finally, to investigate whether the different dimensions of the power sector reform affect directly industry performance or through their interaction with financial reforms or both, we run regressions of the following form referred to as Model (3):[12]

$$\begin{aligned} perf_{it} = {} & \alpha_0 + \mu_i + \alpha_1 pp_{it} + \alpha_2 reg_{it} + \alpha_3 open_{it} + \alpha_4 findev_{it} + \alpha_5 pp.findev_{it} + \alpha_6 reg.findev_{it} \\ & + \alpha_7 open.findev_{it} + \sum_{j=8}^{11} \alpha_j X_{jit} + \varepsilon_{it} \end{aligned} \qquad (3)$$

Models (1) through (3) are estimated for each of the performance measures and some control variables are included depending on the performance variable used.[13] Moreover, as sectoral reform indicators may influence each other and can also be determined by the performance of the electricity sector, endogeneity might be an issue and we account for it when appropriate in each regression. The next section presents the estimation results produced with Stata 11.

4. Empirical results

This section reports the estimation results of our econometric analysis. As indicated in the previous section, this analysis is organized around two main objectives. We first estimate Model (1) to examine the effect of the various dimensions of the electricity sector reform on the industry performance.[14] A regression is run for each of the performance measures described in Table 3 of the previous section. Then, to investigate the influence of financial development on these effects of the indicators of sectoral reform on performance, we proceed in two steps. First, we investigate the combined effect of sectoral reform and financial development on performance through their interactions by estimating Model (2). Second, we examine the robustness of these individual and/or combined effects in the larger model by regressing each of the performance measures on the sectoral reform indicators, the financial development index, and the cross-term that captures their interaction as specified in Model (3).

[12] Note that Models (1) and (2) are non-nested whereas both of these models are nested in Model (3).
[13] To alleviate multicollinearity problems due to high correlation, the independent variables were mean-centered.
[14] The dependent variable has been re-scaled by taking the logarithm.

The estimation results are presented in Tables 4 through 8 below.[15] Part from parameter estimates of the regressions based on Models (1), (2), and (3) presented respectively in the 2nd, 3rd, and 4th column, these tables report the number of observations actually used to estimate each model, Obs., the Fisher statistic to test the joint significance of the independent variables, F(.,.), and the adjusted R^2 of the model, $\bar{R}^2$. When a right-hand-side variable, *x* say, turns out to be endogenous, that variable is instrumented by means of its lags and this is indicated in the tables by *x_*.

Table 4 below presents the parameter estimates of the three models when the industry performance variable used is net electricity generation per capita. We see from the results on Model (1) that the creation of a separate regulator and privatization of the generation segment have a positive (marginal) effect on electricity generation per capita while the existence of a wholesale market has a negative effect. When using Model (2) in order to capture the interaction between the power sector and the financial sector reforms, we see that financial development strengthens the marginal effects of privatization and competition but not that of the creation of a separate regulatory agency. When merging these two models into Model (3), the cross-effect of privatization with financial development is no longer significant while the variables of the creation of a separate regulatory instance and competition are significant both individually and when crossed with financial development. As to the control variables, *gdp*, *urbanization*, and *govstability* are all significant and have the expected sign.

Table 4 - Electricity generation per capita regression parameter estimates

Variable	Model (1)	Model (2)	Model (3)
intercept	3.93****	3.87****	3.86****
ppgen			0.14****
*ppgen_*	0.02*		
sepreg	0.09****		0.07***
competition	-0.08****		-0.24****
findev			0.01
ppgen.findev		0.03***	0.01
sepreg.findev		0.04	0.08***
competition.findev		-0.07**	-0.13****
gdp	0.00****	0.00****	0.00****
urbanization	0.03****	0.03****	0.03****
govtstability	0.01	0.02****	0.01****
Obs.	380	288	288
Fisher	F(33, 346) = 540.73****	F(27, 260) = 571.86****	F(31, 256) = 597.21****
$\bar{R}^2$	0.98	0.98	0.98

Table 5 below shows the estimation results obtained when installed electricity generation capacity per capita is the variable used to measure industry performance. When Model (1) is used to estimate the individual sectoral reforms' impact, we find that only the variable that captures the

[15] In these tables, we indicate by *, **, ***, and **** significance at the 20%, 10%, 5%, and 1% level respectively.

existence of a separate regulatory agency is significant. When investigating the existence of cross-effects with financial development, none of the sectoral reforms' variables is significant. When Model (3), the nesting model, is estimated we find that the sectoral reforms' variables that are individually significant are *sepreg* and *competition* which respectively indicate that a separate regulator has been created and wholesale market exists. The regression results show no evidence that financial development strengthens these reforms' individual effects. The coefficients associated with the control variables *gdp* and *urbanization* are significant.

Table 5 - Installed generation capacity per capita regression parameter estimates

Variable	Model (1)	Model (2)	Model (3)
intercept	-2.81****	-2.98****	-2.37****
*ppgen_*	0.01		0.00
sepreg	0.04*		0.05*
*competition_*	-0.01		-0.10****
*findev_*			0.00
*ppgen.findev_*		0.01	-0.01
sepreg.findev		0.01	0.08
*competition.findev_*		0.02	
competition.findev			-0.07
gdp	0.00****	0.00****	0.00****
urbanization	0.02****	0.02****	0.01***
Obs.	409	200	150
Fisher	F(39, 369) = 371.21****	F(28, 171) = 340.86****	F(27, 122) = 373.35****
$\overline{R}^2$	0.97	0.98	0.99

Table 6 - Electricity sales per employee regression parameter estimates

Variable	Model (1)	Model (2)	Model (3)
intercept	6.85****	5.95****	5.03****
*ppdist_*	0.00*		0.01*
*sepreg_*	1.01***		1.17**
unbundling	-1.54*		1.03**
*findev_*			-0.51
ppdist.findev		0.00	0.01
*sepreg.findev_*		-0.06	0.43
unbundling.findev		0.25	0.52
gdp	0.00	0.00**	0.00
Obs.	133	121	91
Fisher	F(23, 109) = 3.49****	F(18, 102) = 2.61****	F(20, 70) = 2.12***
$\overline{R}^2$	0.30	0.19	0.20

When industry performance is measured by sales per employee in the distribution segment, a variable that is meant to capture labor productivity in that segment, see Table 6 above, Model (1) yields significant effects for the three sectoral reforms that indicate private participation, the existence of a separate regulator, and the unbundling of the three segments of the power sector, namely generation, transmission, and distribution. The estimated results obtained with Model (2) reveal no cross-effects between sectoral reforms and financial development and Model (3) confirms

these preliminary findings although in this latter model the sign of the variable *unbundling* becomes, as can be expected, positive. None of the control variables turns out to be significant.

When the variable that measures the power losses in the distribution network is the dependent variable, the regression results obtained with Model (1), which are displayed in Table 7 below, show a negative and significant coefficient for the variable that says that private participation in this segment exits and a positive and significant coefficient for the variable that indicates the existence of competition. When Model (2) is used to capture any cross-effects of these sectoral variables with financial development, the only variable that is significant is the one that indicates that some degree of competition exists. Merging these investigations of individual and cross-effects (Model (3)), we find that private participation is the only sectoral reform which has a significant individual effect on distribution losses and competition is the only one that has a significant cross-effect with financial development. As to the controls, we note the positive and negative significant effects of respectively *gdp* and *urbanization*.

Table 7 - Distribution losses regression parameter estimates

Variable	Model (1)	Model (2)	Model (3)
intercept	-3.07***	-2.67****	-3.32****
ppdist	-0.00****		-0.00*
sepreg	-0.002		-0.02
competition	0.13*		0.10
findev			0.08
ppdist.findev		0.00	-0.00
sepreg.findev		0.11	0.06
competition.findev		-0.23****	-0.18*
gdp	-0.00	-0.00***	-0.00***
urbanization	0.02	0.02**	0.02**
govtstability	0.01	-0.00	-0.00
Obs.	178	129	129
Fisher	F(22, 155) = 25.65****	F(19, 109) = 48.68****	F(23, 105) = 41.01****
$\bar{R}^2$	0.75	0.88	0.88

When the number of connections per 100 inhabitants is used as the measure of industry performance, the estimation of Model (1) yields a coefficient associated with the variable that represents regulatory experience, *expreg*, which is positive and significant (see Table 8 below). Moreover, when regulatory experience is crossed with financial development, the latter seems to increase the individual marginal effect of the former on population access to electricity as can be seen from the estimation of Model (2). However, when jointly estimating individual and cross effects by fitting in the data to Model (3), we see that this cross effect of regulatory experience with financial development is no longer significant suggesting that most of the access benefits are the results of favorable decisions made by experienced regulators.

Table 8 - Connections per 100 inhabitants regression parameter estimates

Variable	Model (1)	Model (2)	Model (3)
intercept	5.53*	9.96***	11.12***
ppdist	-0.00		0.00
expreg	0.04**		0.12*
competition	-0.14		-0.13
findev			0.22
ppdist.findev		-0.00	0.00
expreg.findev		0.02**	-0.02
competition.findev		0.04	-0.18
gdp	-0.00*	-0.00	-0.00**
urbanization	-0.02	-0.07*	-0.07
Obs.	178	129	129
Fisher	F(21, 156) = 8.94****	F(18, 110) = 5.36****	F(22, 106) = 4.45****
$\overline{R}^2$	0.49	0.38	0.37

What can we conclude from this analysis of the impact of the sectoral reforms on industry performance and the way they interact with the level of financial development? As discussed earlier, one way to tackle this question is to examine whether some empirical evidence can be extracted from the analysis on the validity of the various hypotheses stated in Table 1. Table 9 below summarizes our findings. This table gives the outcome of the test of each of the twelve hypotheses HI, $\overline{H}I$, I=1,2,…,6. Its second column indicates whether or not each of these hypotheses has not been rejected in the data with a "Yes" or a "No" and, in the case where it has not been rejected, gives the variables involved in the relationship(s) that allowed us to conclude on the non-rejection.[16]

Examining the validity of the hypotheses concerning the sectoral reforms' individual effects on performance, we see that the only hypotheses which are not validated in our data are H5 and H6. Indeed, unexpectedly, we find that competition has decreased generation both in terms of capacity and actual output (see Tables 4 and 5) and no significant empirical evidence that competition on its own has led to higher operating and technical efficiency when power losses in the distribution network are used to proxy efficiency (see Table 7). However, when looking at the cross-effects of sectoral reforms with financial reforms, we see that the interaction between competition and financial development has made competition significantly improve technical efficiency (see Table 7), i.e., $\overline{H}6$ is not rejected as indicated in Table 9.[17] Since financial development has significantly enhanced the marginal effect of the creation of a separate regulator on power generation per capita, as can be seen from Table 4, we conclude that $\overline{H}4$ is not rejected as indicated in Table 9.

[16] The sign of the relationship(s) is given in parentheses.

[17] Note also that interpreting the variables *competition* and *unbundling* as substitutes for representing market openness allows us to conclude that $\overline{H}2$ is not rejected from Tables 7 as indicated in Table 9.

Table 9 - Hypotheses testing outcomes

Hypothesis	Test outcome
H1	Yes *ppgen* → *generationpc* (+)
$\bar{H}1$	No
H2	Yes *ppdist* → *distlosses* (-)
$\bar{H}2$	Yes *competition* → *distlosses* (-)
H3	Yes *unbundling* → *salesperemp* (+) *ppdist* → *salesperemp* (+)
$\bar{H}3$	No
H4	Yes *sepreg* → *generationpc* (+) *sepreg* → *gencapacitypc* (+) *sepreg* → *salesperemp* (+) *expreg* → *connect* (+)
$\bar{H}4$	Yes *sepreg* → *generationpc* (+)
H5	No
$\bar{H}5$	No
H6	No
$\bar{H}6$	Yes *competition* → *distlosses* (-)

5. Conclusion

The main motivation of this paper was to demonstrate the existence of a significant empirical link between infrastructure and financial sectors reforms the effects the effects of which are reflected in infrastructure sectors performance. This paper has reported on the findings of an exploration of this issue for the case of the power sector in developing countries. We have focused on the four main components of the power sector reform in these countries, namely, unbundling, competition, privatization, and regulation and examined their impact on some of this sector's performance outcomes both on their own and via their interaction with financial reforms.

The logic of the empirical strategy used relied on results found in some of our previous work in the area (Ba et al., 2010 and Ba et Gasmi, 2011). On the one hand, Ba and Gasmi (2011) find a significant positive link between financial reforms and the level of development of financial systems in a dataset on 54 developing countries covering the 1973-2005 period. On the other hand, using a dataset on 56 developing countries that covers the 1990-2007 period, Ba et al. (2010) provide empirical evidence on the importance of financial development for fostering private

investment in electricity projects and hence crucial to the growth and performance of the power sector. The empirical analysis conducted in the present paper allowed us to test whether financial development strengthens the impact of the power sector reforms on this sector's performance. Putting together these findings, a conclusive test would then suggest that financial reforms have significant positive "externalities" on the power sector reforms.

Our empirical investigation through panel data regressions yields results that allow us to conclude that the power sector reforms have indeed reached some success in improving some aspects of the development of this sector. More specifically, we find that private participation in generation and distribution has significantly improved power supply, as gauged by higher electricity generation per capita, and technical and labor efficiency in the distribution segment, as reflected in less power losses in the network and higher volume sold per employee of this segment. The unbundling of the generation, transmission, and distribution segments, a policy that paved the way for further liberalization reforms (competition and privatization), is found to enhance labor efficiency in the distribution segment.

The creation of a separate regulatory agency was found to have created a better dynamic in the generation market by boosting both generation capacity and sales and by giving incentives for more efficient use of labor input in the distribution segment. As to regulatory experience, we found that it has significantly contributed to improving access to electricity. While the power sector, in particular, its generation segment, has significantly benefited from the introduction of independent regulation, the beneficial effects of (good) regulatory practices have been exacerbated by the modernization of the financial systems. More specifically, improved financial systems have eased access to capital for operators allowing them to upgrade their networks and decrease power losses in distribution.

While the econometric analysis conducted in this study will clearly gain from improving the dataset, a task which is on our current research agenda, the overall results obtained in this paper strongly recommend that along with reforming the power sector, policy makers in developing countries should implement the financial reforms that would deepen their domestic financial systems thus allowing them to recover the full benefits of these systems' positive externalities on the performance of the sector.

Appendix

Table A1 - Content of variables and data sources

Variable	Content	Source
generationpc	Electricity net generation per capita (billion Kwh).	Energy Information Agency (EIA)
gencapacitypc	Installed electricity generation capacity per capita (million Kw).	Idem.
salesperemp	Electricity sold per employee (MWh).	Electricity Benchmarking database, WB 2007
distlosses	Annual electricity distribution losses as a % of net generation.	Energy Information Agency (EIA)
ppgen	Privatization in generation indicator: dummy variable that takes the value 1 if there is any private participation in electricity generation and 0 otherwise.	ESMAP Study, January 19, 2007; various reports and websites (see references).
ppdist	Private participation in distribution indicator: private sector participation as a share of the number of connections.	Idem.
regsep	Dummy variable that takes on the value 1 if there exists a regulatory agency that regulates energy and is separated from the energy ministry and 0 otherwise.	Cubbin and Stern (2006); Electricity Regulation database, The World Bank and various websites (see references).
regexp	Regulatory authority's experience indicator calculated as the number of years since its creation.	Idem.
unbundling	Dummy variable that takes the value 1 when generation, transmission and distribution segments are separated and 0 otherwise.	ESMAP Study, January 19, 2007; various reports and websites (see references).
competition	Dummy variable that takes the value 1 when a wholesale market where generators can compete to conclude supply contracts with distributors or large users exists and 0 otherwise.	ESMAP Study, January 19, 2007; Zhang et al, 2005; various reports and websites (see references).
CBA	Total assets held by the central bank expressed as a percentage of GDP.	The World Bank Financial Development and Structure database (2007).
DMBA	Total assets held by the financial institutions expressed as a percentage of GDP.	Idem.
CBPC	Credit granted by commercial banks to the private sector expressed as a percentage of GDP.	Idem.
SMC	Value of stock market capitalization expressed as a percentage of GDP.	Idem.
TVT	Total value of stocks traded expressed as a percentage of GDP.	Idem.
SMT	Stock market turnover ratio calculated as the ratio of value of shares traded during a period to average market capitalization.	Idem.
findev	First principal component of *CBA*,*DMBA*, *CBPC*, *SMC*, *TVT*, and *SMT*.	Computed.
countryrisk	Composite country risk rating reflecting political, financial, and economic risk ranging from 0 to 100 (the higher the rating the lower the risk).	International Country Risk Guide database (year).
govtstability	Indicator of the government's ability to stay in office and carry out its declared economic program ranging from 0 to 12 (the higher the rating, the more stability there is).	Idem.
gdp	GDP per capita in 2005 USD.	ERS International Macroeconomic dataset (2008).
urbanization	Population living in urban areas as a share of the total population.	World Bank's World Development Indicators
population	Total population.	World Bank's World Development Indicators

Table A2 - Summary statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Median
generationpc	672	1335.81	1458.65	65.88	10039.84	861.04
gencapacitypc	672	16.84	44.62	0.01	442.89	2.56
salesperemp	209	2057.83	1459.61	101	9248	1846
distlosses	672	0.15	0.08	0.00	0.47	0.13
ppgen	512	0.50	0.50	0.00	1.00	0.00
ppdist	227	49.68	45.55	0.00	100	45.91
sepreg	624	0.37	0.48	0.00	1.00	0.00
*expreg**	624	2.23	4.44	0	25	0
unbundling	576	0.28	0.45	0.00	1.00	0.00
competition	448	0.29	0.45	0.00	1.00	0.00
findev	419	-0.00	1.77	-2.61	8.85	-0.53
gdp	672	2740.59	1928.06	35.75	11082.43	2484.97
urbanization	672	52.82	18.72	15.10	92.30	52.70
govtstability	576	7.76	2.04	1.00	12.00	8.00
countryrisk	576	64.69	8.68	35.00	82.00	66.00

*The maximum value of this variable corresponds to Costa Rica which has created a multi-sector regulatory agency (ARESEP) in 1980.

Table A3 - Correlation coefficients between the sectoral reforms and performance variables

	ppgen	*ppdist*	*sepreg*	*expreg*	*unbundling*	*competition*	*findev*
generationpc	0.14	-0.24	0.08	0.14	-0.09	0.11	0.22
gencapacitypc	0.14	-0.22	0.14	0.19	-0.04	0.16	0.21
salesperemp	0.33	0.23	0.41	0.55	0.41	0.24	0.52
distlosses	-0.16	-0.29	0.08	-0.10	0.15	0.08	-0.33
connect	-0.18	0.01	0.05	0.245	-0.24	-0.10	0.16

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