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ELECTRICITY SECTOR REFORM IN DEVELOPING COUNTRIES: AN ECONOMETRIC ASSESSMENT OF THE EFFECTS OF PRIVATISATION, COMPETITION AND REGULATION

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ELECTRICITY SECTOR REFORM IN DEVELOPING COUNTRIES: AN ECONOMETRIC ASSESSMENT OF THE EFFECTS OF PRIVATISATION, COMPETITION AND REGULATION

Abstract

Over the last two decades electricity sectors in both developed and developing countries have been subject to restructuring to introduce private capital and increase competition. This has been accompanied by the introduction of new regulatory regimes. Although the effects of such reforms in a number of the developed economies are now well documented, apart from a few case studies, the experience of developing countries is much less well researched. This is important because privatisation, competition and the reform of state regulation are key themes in donor aid programmes, notably of the World Bank.

This paper provides an econometric assessment of the effects of privatisation, competition and regulation on the performance of the electricity generation industry using panel data for 51 developing countries, over the period 1985 to 2000. The study identifies the impact of these reforms on generating capacity, electricity generated, labour productivity in the generating sector, capacity utilisation and industrial and residential user prices. The paper concludes that competition appears to bring about favourable results for service penetration, capacity expansion, labour efficiency and prices to industrial users. The effect of privatisation and having an independent regulator, separately, is statistically insignificant except in the case of capacity utilisation and privatisation; while the co-existence of these two reforms does seem to be correlated with greater electricity availability, more generation capacity and higher labour productivity. The main policy conclusions are that on their own privatisation and regulation do not lead to obvious gains in economic performance. When privatising electricity under conditions of monopoly, emphasis should be placed on implementing an effective regulatory framework. By contrast, introducing competition does seem to be effective in stimulating performance improvements, irrespective of changes in ownership or regulation.

INTRODUCTION

In the last twenty years the electricity power sector in both developed and developing countries has been subject to restructuring. Although the approaches to reform have varied across countries, the main objective has been to improve the economic efficiency of the sector by introducing private capital, liberalising markets and introducing new regulatory institutions. In economic theory, ownership and the degree of competition are both important factors in determining output levels, costs of production and prices (Vickers and Yarrow, 1988). More formally, the capital market and the product market determine the levels of allocative and productive efficiency. Therefore, privatisation, competition and more effective state regulation of monopoly activities should lead to improved economic performance. This

depends, however, on the reforms being appropriately designed and implemented. Developing countries can suffer from serious institutional weaknesses, meaning that planned reforms may not produce their intended benefits. Therefore, the impact of privatisation, competition and regulation on the electricity sector in developing economies deserves to be assessed empirically.

More than 600 private electricity projects, accounting for investment of US $160bn reached financial closure in 70 developing economies in the 1990s (Izaguirre, 2000, p.5). These projects were implemented under schemes ranging from management contracts, to divestitures of state assets, to greenfield facilities under build-operate-own (BOO), build-operate-transfer (BOT) and build-operate-own-transfer (BOOT) schemes. However, while a number of studies have examined the effects of privatisation and market liberalisation on a range of industries, they have been mainly concerned with the experiences of developed economies (e.g. Ehrlich *et al*., 1994; Pollitt, 1995; Martin and Parker, 1997; Ros 1999; Villalonga 2000; Saal and Parker, 2000, 2001). Some studies have focused on the developing countries (World Bank, 1995) and a few on the electricity sector in developing countries (Baer, 1994; Spiller and Martorell, 1996). But there remains a paucity of econometric analysis of the effects of recent changes in ownership and competition in developing countries. There are even fewer studies that provide insights into the effects of regulatory changes. This gap exists partly because reforms in most of the developing countries are still recent, meaning that only now is enough data becoming available to permit econometric analysis; and partly because of the difficulty in accurately measuring the various reform policies adopted by different countries for econometric purposes.

Using an original panel dataset for the period 1985 to 2000, this paper provides an econometric analysis of the effects of regulation, competition and privatisation in the electricity generation sectors of 51 developing economies in Asia, Africa and Latin America. The paper is organised as follows. Section 2 briefly discusses the impetus for electricity reforms in developing countries and the typical components of reform. Section 3 provides a review of relevant empirical and theoretical studies on the effects of competition, privatisation and regulation, from which a number of research hypotheses are generated. Section 4 then address data issues and the modelling used to test the hypotheses. The results are presented in section 5 discussed in section 6. The last part of the paper, section 7, provides a summary the main conclusions and outlines their policy implications.

REFORM OF THE ELECTRICITY SECTOR

In most countries infrastructure activities such as electricity supply have been viewed as strategic activities with 'natural monopoly' characteristics. These monopoly characteristics result from the existence of economies of scale and scope. Hence, the view has been that supply is best provided by vertically integrated monopolies owned by government. However, over the last two decades, the notion of 'natural monopoly' has been rejected in electricity generation and supply and these parts of the supply chain have been opened up to competition; though transmission and distribution systems still retain important economies of scale that usually limit the scope for competition.

A number of studies and reports (for example, Bacon, 1995; World Energy Council, 1998; Czamanski, 1999; APERC, 2000; Bacon and Besant-Jones, 2001) have already described the principal driving forces behind electricity reforms. Although they may not be present in every country that is reforming its electricity sector, they can be summarised as: (1) the poor performance of state-run electricity operators in terms of high costs, inadequate expansion of access to electricity services and unreliable supply; (2) the inability of the state sector to meet the investment and maintenance costs of the electricity industry, in order to keep pace with the increasing demands for power resulting from economic development in other sectors of the economy; (3) rapid changes in technology in both the generation of electricity and in the computing systems used to meter and dispatch power, making new industrial structures possible; (4) the need to remove electricity subsidies so as to release resources for other areas of public expenditure; (5) the desire to raise immediate revenue for the government through the sale of state assets; (6) the demonstration effects of the pioneering reforms of the power sectors in Chile, England and Wales and Norway in the 1980s; and (7) pressure for reform from international financial organisations and donor agencies such as the IMF and World Bank, through their 'lending for institutional reform' programmes.

The reform programmes adopted by countries have tended to include the following four main elements:

1. Introduction of competition to the sector in order to improve efficiency, customer responsiveness and innovation.

2. Restructuring the industry in order to enable the introduction of competition. This means breaking up, or 'unbundling', the incumbent monopoly utilities possibly into separate generation, transmission, distribution and supply providers.
3. Privatisation of the unbundled generators and suppliers. It is expected that entities under dispersed ownership will facilitate competition and that private investors and operators will bring in financial resources and managerial expertise into production and supply, previously dominated by sleepy state-owned monopolies.
4. Development of a new regulatory framework. State regulation is still required especially of those areas of electricity supply that remain dominated by one or a very small number of operators, to prevent monopoly abuse. Instead of direct regulation by a government department, the establishment of 'independent' or quasi-independent regulatory bodies, in the forms of offices and commissions, has been favoured, drawing particular on the regulatory models of the US and UK. This form of arm's length regulation is expected to encourage private capital to invest in capacity in the face of a potential 'hold up' problem (Hart and Moore, 1988). Privatisation requires investors to sink funds into fixed assets in the electricity sector that may have little if any residual value if government should renege on power contracts, say in the form of failing to take supplies or preventing price increases when input costs rise. Energy supplies and prices are always of interest to politicians because supply failures and sharply higher prices can provoke social unrest. Some form of independent regulation can provide reassurance to investors that prices, outputs and inputs will not be politically manipulated. However, there is an extensive literature on the distorting effects of state regulation even when conducted by dedicated regulatory bodies (Armstrong *et al.*, 1994; Guasch and Hahn, 1999).

While the reform programmes for the electricity sector have been built around these four elements, the detail has varied to reflect local circumstances (Bacon and Besant-Jones, 2001). For example, in developing countries privatisation of power has occurred in the form of operating concessions and greenfield investments, as well as state asset sales, but is rarely complete. The result is electricity systems with private and public ownership co-existing. Also, the degree of competition permitted can vary depending on which restructuring model has been used, for example the single-buyer model, wholesale competition (which can itself take various forms), or retail competition (Lovei, 1996; Hunt and Shuttleworth, 1996).

Finally, regulation can take many shapes (Gilbert and Khan, 1996; Stern and Holder, 1999) and, as Crew and Kleindorfer note (1996, p.215), the need for workable solutions can lead to the design and implementation of regulatory systems that are not necessarily in line with economic theory.

LITERATURE REVIEW AND HYPOTHESES

Literature review

A number of studies have examined the effects of ownership and competition on industrial performance, though mainly for developed economies (for a recent review see Megginson and Netter, 2001). The main aspects of economic performance studied have been labour and total factor productivity, costs of production, profits and other financial ratios, and prices. The conclusions of these studies are not completely consistent, however (ibid.). This is true of those studies that have looked specifically or in part at the experiences of the developing economies. For instance, Ros (1999), using a panel-data set across 31 countries for the 1986-1995 period concluded that privatisation was positively related to network expansion and labour productivity in the telecommunications industry. Ramamurti (1997) reports a staggering 370 percent increase in labour productivity on the privatised Argentine railway. Hawdon (1996), analysing the performance of power sectors supported by World Bank loans, found that those countries using privatisation had significantly higher efficiency than the non-privatising group. Galal *et al.* (1994), using a panel of developed and developing economies, similarly discovered that privatisation had important economic benefits. Boubakri and Cosset (1998), Dewenter and Malatesta (2000), Delfino and Casarin (2001) and Tolero and Pasco-Font (2001) also find evidence of performance gains in privatised firms in developing economies. While Bhaskar and Kahn (1995) discover increased labour productivity in the privatised Bangladesh jute industry and Petrazzini and Clark (1996) report that deregulation and privatisation were both associated with significant improvements in telephone density in 26 developing countries, although there appeared to be no obvious impact on service quality.

By contrast, however, a number of studies have been much more cautious about the economic gains associated with privatisation in developing countries. For instance, Bortolotti *et al.* (1998), studying data on the privatisation of electricity generation in 38 countries (both developed and developing) between 1977 and 1997, concluded that effective regulation is crucial to the success of privatisation (also see Pollitt, 1997). Adhikari and Kirkpatrick (1990) report some evidence of poorer performance in state firms than privately-owned ones, but

suggest that the causes are more complex than ownership alone. Macedo (2000) and Saha and Parker (2002) report a worsening of asset and income distribution in Latin America, associated with privatisation to elites. In a comparison of electricity production in 27 developing countries in 1987, and using DEA analysis, Yunos and Hawdon (1997) found that public sector suppliers performed as well as private sector companies; though in none of the countries studied had effective competition been introduced. While Cook (1999) provides case studies of utility reform in developing economies to demonstrate that creating a competitive environment and effective regulation is a difficult and slow process even when firms are privatised.

Vickers and Yarrow (1988) argue that the mixed results from the empirical literature on the effects of privatisation are due to a focus on the ownership variable. Other factors that should be taken into account include the nature of market competition and the role of institutions, such as well-developed capital markets and private property rights (Vickers and Yarrow, 1988; Lee et al, 1999;Villalonga, 2000). This conclusion is supported by studies that have found that competition is associated with lower costs, lower prices and higher productive efficiency (Bouin and Michalet, 1991; Kwoka, 1996; Kleit and Terrell, 2001; Martin and Vansteenkiste, 2001) and that the success or failure of privatisation depends on the post-privatisation regulatory framework, which in turn is affected by political and social norms (Levy and Spiller, 1996; Torp and Rekve, 1998; Jamasb and Pollitt, 2000; Villalonga, 2000; Arocena and Price, 2002).

Arguably, therefore, in appraising the performance of the electricity sector in developing countries it is important to take account of the effects of ownership, competition *and* regulation, perhaps alongside other institutional factors. One of the practical difficulties, however, is how to measure such factors. Using 11 political variables, Bergara *et al*. (1997) composed two political indexes to examine the effect of institutions on electric utility investment. They found that well-defined and credible political institutions were positively and significantly correlated with global electricity generating capacity. Based on three aspects of regulation – entry conditions, access to the network and prices – Bortolotti *et al*. (1998) concluded that the smoothness of the privatisation process was highly and positively correlated with the extent of regulation. Taking regulation as a dummy variable, Wallsten (2001) reports that privatisation in the telecommunications sector, which alone was associated with few benefits in his study, showed positive correlations with performance

measures when combined with the existence of an independent regulator. Alongside Wallsten's work, the closest study to our own is that by Steiner (2000), who used a panel data set for 19 OECD countries and dummy variables for market liberalisation of electricity generation, ownership and privatisation of generation (partial or complete), along with variables for vertical integration, the existence of an electricity market and consumer choice. The results from this study are mixed. They are compared with our own in the discussion section of the paper, section 6, below.

Overall, the empirical evidence seems to suggests that, in assessing the results of electricity reforms, the effects of privatisation, competition and regulation should be taken into account, both separately and in some form of combined or interactive way. Most of the existing studies of electricity have dealt only with one or two of these factors. Another gap in the literature exists because the studies focusing on changes in the electricity sector have been mostly drawn from the developed economies, such as the UK, US and Scandinavian countries. Where developing countries have been examined, studies have usually concentrated on Latin America, and especially Chile and Argentina (Lalor and Carcia, 1996; Chisari *et al*., 1999). There is a lack of empirical study of the effects of privatisation, competition and regulation *together* for the electricity sector covering a number of developing countries. This paper undertakes such an analysis. The rest of this section of the paper develops hypotheses from economic theory as to the effects of privatisation, competition and regulation, which the empirical results reported later test.

Hypotheses on privatisation

The new institutional economics (North, 1990; Levy and Spiller, 1996) provides important insights into the incentive effects of different types of ownership structure. Other streams of thought that are relevant to forming a hypothesis of the impact of privatisation are agency and public choice theories (Niskanen, 1971; Zeckhauser and Horn, 1989; Boycko *et al.*, 1996). In brief, privatisation is expected to raise economic efficiency by (1) changing the allocation of property rights, which leads to a different structure of incentives for management and hence to changes in managerial behaviour; (2) removing the 'soft budget' constraint of taxpayer support and exposing enterprises to the disciplines of the private capital market (Alchian, 1965; De Alessi, 1980); (3) introducing more precise and measurable objectives, thus reducing transaction costs, especially associated with principals monitoring management

(agent) behaviour; and (4) removing political interference in the management of enterprises and capture by special interest groups (Boycko *et al*., 1996).

Most of the theoretical arguments for privatisation are concerned with the effects on productive efficiency. It is expected, for example, that privatisation will lead to higher labour productivity and more economic use of the capital stock (higher capacity utilisation). When applying the theoretical insights into aspects of economic performance in the electricity sector, however, specific features of that sector need to be taken into account. The electricity utility industry is characterised by large sunk investments, minimum economic scale, and non-storable and massively consumed outputs. These factors provide governments (either national or local) with the possibility of behaving opportunistically *vis-à-vis* the investing company, as already noted. Knowing that under some circumstances governments may not be able to refrain from reneging on explicit or implicit agreements and behaving opportunistically, private investors may be cautious about investing in capacity. As a result, the actual effect of privatisation on generation-capacity expansion and use is not clear, although one of the expectations of governments from privatisation is more capital invested in the electricity infrastructure.

Ownership change is usually accompanied by a shift of functional objectives (Martin and Parker, 1997, p.3). A common component in the objective function of state-owned electricity firms is to provide basic services to as many individuals as possible and at prices that may be below the incremental costs incurred, especially for residential ('voter') consumers. By contrast, when state-owned electricity firms are transferred into private hands, it is likely that the new owners will be reluctant to increase the amount of electricity generated unless it is profitable to do so.

Historically electricity is priced by governments in a manner that is allocatively inefficient (prices not related to marginal costs), in order to reach as much of the population as possible and because individual electricity users are also voters. Hence, residential consumers are often cross-subsidised by other categories of consumers, notably industrial users. Privatisation could lead, therefore, to higher prices to residential consumers and lower prices to industry, as prices are aligned with long-run supply costs and because profits, not votes, are the main concern of private investors.

From the above arguments the following three hypotheses are derived:

Hypothesis A1: Privatisation will lead to higher operating efficiency and higher capital utilisation.

Hypothesis A2: Privatisation will lead to more capacity and hence higher output, provided that the regulatory regime is supportive of investor confidence.

Hypothesis A3: Privatisation will lead to higher prices to residential consumers and lower prices to industrial users as prices are aligned with marginal costs.

Hypotheses on competition

In the economics literature competition is regarded as a reliable mechanism for stimulating both allocative and technical efficiency (Leibenstein, 1966). In a competitive market, prices and profits reveal important information about the costs of a firm and the efficiency of input use, thus providing the firm with incentives to improve internal efficiency (Hayek, 1945). As a result, it is to be expected that competition will lead to higher electricity generation per employee. Moreover, lower per-unit costs resulting from increased technical efficiency may be passed through in lower prices, thus increasing the quantity demanded. Therefore, competition is likely to have positive effects on both electricity supply and capacity expansion.

The introduction of competition may impact on electricity prices in different directions depending on the categories of customers. Competition undermines the feasibility of cross-subsidising one set of customers at the cost of another set because entrants target over-charged consumers. Given the cross-subsidies prevalent under state ownership in electricity, already referred to, competition is likely to lower industrial user prices. There might be an expectation of consequent higher pricing to (at least some) residential users, though this is by no means certain. Competition could result in lower production costs and therefore lower prices to residential users, even while cross-subsidies are being unwound.

The following two hypotheses are therefore put forward on the effects of competition:

Hypothesis B1: Competition will lead to a larger capacity, a higher output and greater labour productivity.

Hypothesis B2: Competition will lead to lower industrial user prices and could either raise or lower residential user prices.

Hypotheses on regulation

Electricity production is characterised by scale economies and sunk investments. This is why an effective regulatory system is crucial for both investor confidence and consumer protection. At the same time, because electricity is viewed as an essential public service, local and central governments have incentives to intervene in price, output and investment. Public ownership becomes the default mode of organisation if it is not possible to create an efficient and credible system of private-sector regulation (Short, 1984). The primary purpose of a well-designed regulatory system is to protect consumers from monopoly abuse, while providing investors with protection from arbitrary political action alongside incentives for efficient operation and investment (Laffont and Tirole, 1993). Carefully designed regulation can be expected, therefore, to be a key component of a successful process of electricity privatisation.

Regulation can affect a firm's efficiency. Regulation that is too onerous will negatively affect a firm's input (Averch and Johnson, 1962) and output decisions and depress productivity. Private operators will be unwilling to invest and will produce less under risky regulatory conditions (Gupta and Sravat, 1998; Holburn, 2001). At the same time, clearly stated regulatory rules within a well-defined regulatory framework can be expected to reduce 'regulatory risk' and provide incentives for private investment and this is the main objective when 'independent' regulatory bodies are established.

The effects of regulation on electricity prices, or allocative efficiency, is more difficult to predict. Different regulatory policies could be adopted by different countries, producing divergent results (Jamasb and Pollitt, 2000). However, the first big task of new regulators in many developing countries is to reduce or even remove subsidies to domestic users and align residential prices with supply costs (Tenenbaum, 1995). For this reason we propose the following two hypotheses for the effects of regulation:

Hypothesis C1: Independent regulation in place of direct govemment department regulation will improve productive efficiency.

Hypothesis C2: Independent regulation will raise prices charged to domestic consumers as cross-subsidies are removed.

DATA AND MODELLING

The above hypotheses were tested using panel data for 51 countries in Africa, Latin America and the Caribbean and Asia, over the period from 1985 to 2000. East Asia and the Pacific and Latin America and the Caribbean have absorbed the lion's share of the investment in projects with private participation, accounting for more than 60 percent of the total capital invested (Izaguirre, 1998, p. 3). In Latin America private participation has occurred mainly in the context of wider reforms involving vertical separation of the electricity sector and the establishment of more liberalised markets and new regulatory structures. Most of the private electricity projects have involved divestitures by the state. In contrast, in Asia most private projects have involved greenfield investments, reflecting the acute power shortages in this region. Private participation in electricity in Africa is at a relatively early stage compared with Latin America and Asia and has so far taken both forms.

The starting date for the study, 1985, was dictated by data availability, though little reform of the electricity sector began before this date. The final date, 2000, represented the last year for which data were available at the time the research was conducted. The choice of the sample countries was based on access to data and especially information on privatisation, competition and regulation in each country. Even so, not all data exist for all years for all 51 countries and the sample size differs depending on the performance indicator used in a particular estimation (the sample sizes are given when the results are reported in tables 3 and 4 below and vary between 782 and 324). In addition, the study is mainly concerned with electricity generation, this again is for data availability reasons. However, this does not seem to be a major limitation. Of the privatisation projects in developing countries, 73 percent have involved the construction of power generation plants (Izaguirre, 1998, p.4).

The primary performance indicators used in the study include net electricity generation per capita, installed generation capacity per capita, net electricity generation per employee, electricity generation to average capacity (capacity utilisation) and residential and industrial user electricity prices. These indicators capture the extent of electricity available to the economy, labour and capital productivity in the generation of electricity, and the effects on consumers in terms of prices. Another useful measures of performance, quality of service, could not be estimated because of a lack of data. The first four indicators were calculated based on data from APERC's (Asia Pacific Energy Research Centre) database and the World

Development Indicators published by the World Bank. The employment data used to calculate labour efficiency were compiled from the *Industrial Statistics Yearbook* (various years) and the database of the International Labour Organisation. Data on electricity prices were not available for all of the countries and most of the countries involved in the regressions on prices are in Latin America. The relevant data came from the OLADE (Latin American Energy Organisation). The price data for countries in the other regions included in the regressions were drawn from OECD data.

The privatisation, competition and regulatory variables were constructed according to reports in *The Yearbook of Privatisation* (various years), Energy Information Administration (EIA) publications, World Energy Council (WEC) and APERC publications. The information on which the reform variables were constructed was then crosschecked for accuracy by development economists at the University of Manchester and economists and regulators from a sample of the countries who agreed to assist with our research.

Ideally privatisation in the generation sector would be measured as the percentage of electricity produced by private companies or as the percentage of generation capital owned by private investors. However, there was not sufficient, consistent information across the 51 sample firms to define privatisation in this way. Therefore, a dummy variable was used that indicates whether the economy has *any* private sector generation capacity. The limitation of this approach is, of course, that the dummy does not capture the *extent* of privatisation and it is to be expected that the extent of privatisation will impact on managerial incentives and performance. This should be borne in mind when interpreting the results. The measure of competition is also a dummy variable, which equals 1 either when there is a wholesale market where generators compete to conclude supply contracts with distributors or if large users can negotiate contracts directly with generators. Again, ideally some form of concentration ratio for the electricity sector in each country would also be used to measure competition but such data are not available.

Particular difficulties arise in measuring regulation for the purposes of empirical study. There is limited published information on the forms of regulation adopted in particular developing countries and, in any event, practice may be different to the published information. To simplify the regulatory measure, a dummy variable was employed to indicate whether a separate electricity regulatory agency existed not directly under the control of a ministry. As

pointed out by Wallsten (2001), who uses the same approach in his study of telecommunications reform, the effect of having a separate regulator in a regression analysis is best interpreted as indicating a country's propensity to undertake regulatory reform rather than being a precise indicator of the operation of a separate regulator.

Non-reform variables were included in the analysis as controls. In particular, both an increase in GDP per capita and of the share of the population living in urban areas can be expected to be associated with a higher demand for electricity, thus inducing higher investment by utilities. Other control variables included the percentage of industrial output as a share of GDP and a variable to measure the 'economic freedom' of a country. A large proportion of industrial customers implies a higher potential for co-generation and a more even demand for electricity. Holding other factors constant, there would, therefore, be a reduction in the need for generation capacity. The economic freedom variable can be interpreted as a proxy for wider institutional factors associated with the success of market liberalisation, other than privatisation, competition and independent regulation in electricity generation, such as lower taxation and fewer restrictions on foreign investment. Admittedly, a finer grained analysis would be superior to test for the effects of these and other institutional factors. But the one used has to suffice for our purposes because of, once again, data constraints. The macroeconomic and demographic variables came from the World Bank's World Development Indicators and the economic freedom variable was based on the 10-point indices published in *Economic Freedom of the World: 2002 Annual Report* (the higher the score the 'freer' an economy).

Table 1 lists the independent variables used in the study. The correlation matrix for these variables is provided in the appendix to the paper[1]. The matrix confirms that there is no evidence of serious multicollinearity between the variables.

Table 1: Description of the Independent Variables

Variable	Description
R	Regulation dummy
C	Competition dummy
PG	The Dummy of privatisation in the generation sector
GDPP	GDP per capita (1995 constant US$/person)
UB	Urban population as a share of the total (%)
IN	Industrial output as a share of GDP (%)
FDOM	The degree of economic freedom

The model employed in this study draws from those used in Ros (1999), Wallsten (2001) and Bergara *et al*. (1997). Log-linear functional specifications are adopted in the regression to transform a likely non-linear relationship between the performance indicators and the explanatory variables into a linear one. Also, the logarithmic transformation enables the elasticity of the dependent variable with respect to various independent ones to be directly obtained.

The variables proved to be stationary over the period studied, thus reducing the danger of spurious regressions. The unit root test for the panel structure of data proposed by Im *et al*. (1995) or the so-called IPS test was used. Countries with missing data were first singled out and balanced panel datasets were obtained. These were subsequently tested using the IPS

method. Because the period covered by the data for the countries with missing data are relative short, sometimes as little as three or four years, this meant that excluding these countries from the unit root test did not exert a significant effect on the general results. The results from the unit root tests are listed in the appendix.

In order to control for unobserved country-specific factors, a fixed-effects panel model was used, taking the form[2]:

$$\ln y_{it} = \alpha_i + \beta_1(R_{it}) + \beta_2(C_{it}) + \beta_3(PG_{it}) + \gamma(\ln x_{it}) + v_i + \varepsilon_{it} \quad (1)$$

where y_{it} is the electricity indicators discussed above; R_{it}, C_{it}, PG_{it} are regulation, competition and privatisation dummies respectively; x_{it} donates the control variables; v_i is the unit-specific residual that differs between units but remains constant for any particular unit, while ε_{it} is the remainder of the disturbance.

The control variables included in the model vary depending on the performance indicators regressed. For electricity generation per capita and generation capacity per capita, all the four exogenous variables were included as controls. For electricity generation per employee and capacity utilisation only GDP per capita (GDPP) and economic freedom (FDOM) were involved in the regression. Apart from GDPP and FDOM, urban population as a share of the total (UB) and industrial output as percentage of GDP (IN) were used as a control in the estimations of residential prices and industrial prices, respectively. The studies on which our model was based gave some guidance as to which control variables to use for the different performance indicators. The use of different controls was also justified using the Akaike Information Criteria.

As noted above, privatisation alone may not result in performance improvement. Competition and in its absence effective regulation may be required to capture any potential benefits privatisation might bring. To explore further the effects of regulation, equation (2) was estimated:

$$\ln y_{it} = \alpha_i + \beta_1(R_{it}) + \beta_2(C_{it}) + \beta_3(PG_{it}) + \beta_4(R_{it} * C_{it}) + \beta_5(R_{it} * PG_{it}) + \gamma(\ln x_{it}) + v_i + \varepsilon_{it} \quad (2)$$

Equation (2) allows for the separate effects of the reform variables and of their interactions to be examined.

RESULTS

Equations (1) and (2) were estimated for each of the five dependent variables. To overcome the problem of autocorrelation in the initial estimations, adjustments were made using the method described in Gujarati (1995, pp.430-433)[3]. Table 2 presents the regression results.

Table 2: The Main Regression Results

	Electricity generation per capita		Capacity per capita		Electricity generation per employee	
	Eq (1)	Eq (2)	Eq (1)	Eq (2)	Eq (1)	Eq (2)
R	.011 (.557)	.054 (.821)	-.019 (1.037)	.015 (.545)	.022 (.223)	.113 (1.113)
C	.025 (1.722)***	.013 (2.155)**	.036 (1.657)***	.065 (2.451)**	.131 (2.254)**	.277 (2.406)**
PG	.019 (.438)	.0184 (.487)	.244 (1.465)	-.022 (.655)	.061 (1.158)	-.293 (1.506)
R*C		-.104 (1.258)		-.042 (.970)		-.207 (.806)
R*PG		.075 (1.858)***		.041 (2.323)**		.213 (2.106)**
LGDPP#	.407 (7.096)*	.540 (23.667)*	.608 (14.489)*	.999 (13.830)*	.647 (3.658)*	.501 (2.867)*
LUB#	1.236 (17.662)*	.727 (13.575)*	.608 (6.493)*	.371 (4.637)*		
LIN#	.288 (3.909)*	.697 (12.470)*	-.050 (.679)	-.080 (1.163)		
LFDOM#	.302 (3.531)*	.564 (5.889)*	.145 (3.088)*	.349 (2.974)*	-.983 (5.950)*	-1.292 (5.171)*
Adjusted R-squared	.982	.982	.955	.946	.809	.809
D-W test	1.712	1.739	1.690	.1788	1.689	1.759
Number of observations	782	782	782	782	357	357

	(Electricity generation) /(average capacity)		Residential prices		Industrial prices	
	Eq (1)	Eq (2)	Eq (1)	Eq (2)	Eq (1)	Eq (2)
R	-0.149 (2.416)**	-0.032 (.446)	.069 (.351)	.010 (.186)	.036 (.848)	-.034 (.740)

C	-0.125 (1.574)	0.104 (1.246)	.049 (.229)	-.035 (.520)	-.061 (1.193)	-.241 (3.836)*
PG	0.079 (1.869)***	0.135 (3.015)*	.025 (.142)	.106 (1.288)	-.0178 (.428)	-.071 (1.311)
R*C		-0.501 (3.246)		.152 (1.363)		.286 (2.886)*
R*PG		-0.269 (.333)		-.215 (.644)		.038 (.478)
LGDPP#	0.098 (.578)	0.101 (.604)	1.418 (2.502)**	.201 (2.044)**	-.170 (.911)	-.183 (.980)
LUB#			-4.099 (2.787)*	-1.093 (5.172)*		
LIN#					-.768 (11.038)*	-.759 (10.845)*
LFDOM#	4.380 (34.544)*	4.367 (34.511)*	.7421 (1.355)	.963 (2.668)*	-.147 (.916)	-.147 (.902)
Adjusted R-squared	.827	0.829	.727	.740	.797	.801
D-W test	1.659	1.656	1.970	1.880	1.766	1.788
Number of observations	782	782	332	332	324	324

For the key to the independent variables, see Table 1.
the prefix L indicates a logged variable; t-statistics in parentheses.
*, ** and *** indicate that the coefficient is significant at the 1%, 5% and 10% levels respectively.

Electricity generation per capita

The first two columns of Table 2 show the results of the regressions using the log form of electricity generation per capita. In both of the equations the regulation dummy is insignificant. So is the privatisation variable. This suggests that having a separate regulator or privatisation, *on their own*, was not sufficient to increase the availability of electricity. That there is no evidence of increased electricity generation accompanying privatisation may at first appear to be surprising, given that privatisation is promoted as a means of increasing electricity investment. But the result is possibly explained by the primary objective of private investors to make profits, instead of, as under state ownership, providing electricity to as many individuals as possible, sometimes at prices well below costs. When the interaction variable between regulation and privatisation is considered, there appears to be a positive correlation, significant at the 10% level. In other words, there is a positive correlation

between electricity generation per capita and the existence of *both* privatisation and regulation, though not for either separately. This finding is consistent with the view that privatisation of electricity generation increases generating capacity where independent regulation exists to reduce the threat of 'hold up'.

Turning to the effects of competition, competition among generators is found to be positively associated with electricity generation in both of the estimations, while the effect of the interaction term is not significant. Hence, it seems that competition, on its own, is an effective driver of electricity production.

As expected, GDP per capita is positively correlated with electricity penetration. It seems that the larger the share of the urban population in a country, the higher the demand for electricity. The degree of industrialisation in the developing countries is also positively associated with the average amount of electricity generation available to each citizen. Both of these results are as expected and lend support to the conclusion that the regressions are appropriately specified. Finally, the results suggest that electricity penetration is likely to be greater in countries with more economic freedom – a finding quite consistent with the positive relationship between competition and generation per capita.

Installed generation capacity per capita

The regression results on installed capacity per capita in Table 2 are similar to those for electricity generation per capita. Again, competition seems to have a significant, positive effect on capacity expansion, both with and without privatisation and regulation. The coefficients for the effects of an independent regulator or privatisation, by themselves, are statistically insignificant. However, privatisation with an independent regulatory body appears to bring about favourable effects in terms of installed capacity. This result is consistent with the argument, rehearsed earlier, that private generators will feel their investment is less likely to be devalued or expropriated where there is an independent regulator instead of direct government control. They are therefore more willing to invest in capacity building. The effects of income per capita and urbanisation on capacity expansion, like those on electricity generation, are significant and positive. The coefficient for industrialisation, however, is insignificant, though the negative sign is not surprising. A larger proportion of industrial customers implies a higher potential for co-generation and a more

even demand for electricity, hence reducing the need for generation capacity. Once again, the economic freedom variable is positive and significant.

Labour productivity and capacity utilisation

In line with conventional economic theory on the benefits of competition, the competition dummy in the estimations is shown to have a positive impact on electricity generation per employee, but the existence of independent regulator appears to have no effect. Also, privatisation alone is seemingly not connected to higher labour productivity. This is perhaps because, in the absence of competition or effective regulation, private electricity generators are able to exert monopoly power and face insufficient incentives to improve internal efficiency. This suggestion is supported by the significant, positive coefficient for the interaction term between regulation and privatisation.

It can be argued, however, that in a capital-intensive industry like electricity generation, a labour productivity measure needs to be supplemented by a measurement of capital productivity. To address this, the ratio of electricity generated to generating capacity was introduced as a further dependent variable in equations 1 and 2 above. The results excluding the industrialisation and urbanisation variables proved the most satisfactory. They confirmed that privatisation is associated with higher capacity utilisation. However, interestingly regulation may lead to lower utilisation (see the results for equation 1 in Table 2), a finding, albeit tentative[4], that is consistent with the theory that regulation leads to over-expansion of the asset base (Averch and Johnson, 1962).

Electricity prices

Electricity prices can be set by governments with little or no regards to actual costs of supplying particular customer groups. The political sensitivity of electricity pricing means that charges tend to be one of the least liberalised areas of the electricity sector, even when other reform measures have been introduced (Spiller and Martorell, 1996). In particular, residential user prices may still be subsidised and charged below cost. This experience is reflected in the lower R-squared values of the regressions, especially for residential prices, suggesting that pricing is affected by considerations other than those reflected in the explanatory variables used. None of the reform measures – privatisation, competition or regulation - by itself nor the interaction terms seem to have a statistically significant effect on residential prices. The fact that competition does not seem to impact on prices charged to

domestic users is possibly because competition often involves some unwinding of subsidies and cross-subsidies on the one hand, but may result in lower unit-costs on the other. Interestingly, the results show that residential prices are lower the higher the degree of urbanisation - this probably reflects economies of scale in supplying urbanised areas. The economic freedom variable is also positively correlated with residential prices in the results using equation 2, possibly because the 'freer' the economy the more likely that subsidies to domestic users are reduced and in some cases even removed. The positive correlation with GDP per capita can be explained by the possibility that the 'richer' are average residential users, the less residential prices are held down by government controls.

Turning to industrial user prices, the effects of regulation are inconclusive, while competition seems to lower them. This result is consistent with the view that state electricity monopolies tend to charge more to industrial users (above their marginal costs) to cross-subsidise domestic customers. The introduction of competition unwinds the cross-subsidies. However, the interaction between competition and regulation is found to have a positive effect on industrial prices. This is a particularly difficult finding to rationalise. Perhaps, where regulation exists after competition is introduced, firms are restricted in the extent to which they can remove cross-subsidies in favour of industrial users. This would be consistent with regulatory actions in the UK utilities sectors aimed at slowing down tariff rebalancing. However, there is also the possibility that simplifying the measurement of regulation into whether there is an independent regulator or not, does not capture the effects the various forms of regulation may take and therefore the true impact on pricing.

Electricity prices to end users are determined not only by generation costs but by the costs incurred in transmission, distribution and supply. Therefore, prices were also regressed on variables for privatisation of the whole electricity sector (generation, transmission, distribution and supply). The figures in Table 3 show that the results are not significantly different from those where the generation dummy was used.

Table 3: Supplementary Regression Results

	Residential prices		Industrial prices	
	Eq (1)	Eq (2)	Eq (1)	Eq (2)
R	.041	.019	.054	-.002
	(.200)	(.352)	(1.235)	(.036)
C	.036	-.032	-.053	-.242
	(.172)	(.477)	(1.075)	(3.860)*
PA	.099	.109	-.062	-.073
	(.541)	(1.335)	(1.615)	(1.359)
R*C		.123		.313
		(1.119)		(3.503)*
R*PA		-.198		-.037
		(.603)		(.508)
LGDPP#	1.420	.181	-.168	-.184
	(2.526)**	(1.740)**	(.901)	(.984)
LUB#	-4.081	-1.09		
	(2.815)*	(5.177)*		
LIN#			-.773	-.764
			(11.038)*	(10.866)*
LFDOM#	.759	.974	-.130	-.131
	(1.306)	(2.703)*	(.797)	(.802)
Adjusted R-squared	.727	.739	.798	.802
D-W test	1.972	1.878	1.783	1.800
Number of observations	332	332	324	324

PA refers to privatisation in the whole electricity sector.

DISCUSSION

The empirical results presented in this study seem consistent with the findings of a number of the studies reviewed earlier, that point to the importance of competition and/or effective independent regulation if economic performance is to improve following privatisation. Reviewing our findings in relation to the hypotheses generated from the literature, in detail:

> *Hypothesis A1: Privatisation will lead to higher operating efficiency*. This hypothesis was rejected for labour productivity when privatisation occurred independently of competition or where privatisation was not associated with regulatory reform. The result is consistent with the emphasis in the economics literature on competition rather than ownership as the key to performance improvements. Ownership change, *per se*, is not decisive but needs to be coupled with other institutional reforms, notably the introduction of either competition or independent regulation. However, capacity utilisation does seem to improve under privatisation, independently of competition

and regulation, a result consistent with the idea that the private sector is a more effective manager of capital stock use than the public sector.

Hypothesis A2: Privatisation will lead to more capacity and hence higher output, provided that the regulatory regime is supportive of investor confidence. Like regulation, privatisation on its own did not seem to generate many benefits. However, the interaction term between privatisation and regulation did show a positive impact on electricity penetration, capacity expansion and labour efficiency. The results underline the importance of regulatory reform along with privatisation. The results are therefore consistent with the hypothesis.

Hypothesis A3: Privatisation will lead to higher prices to residential consumers as prices are more aligned with supply costs. The results suggested that privatisation, even when linked with competition or regulation, does not have a statistically significant effect on residential prices. The results are the same for industrial user prices.

Hypothesis B1: Competition will lead to a larger capacity, a higher output and greater labour productivity. The findings from the research are consistent with the notion that competition does lead to a higher generating capacity per capita and a higher output per capita. It also leads to higher labour productivity.

Hypothesis B2: Competition will lead to lower industrial user prices and to either higher or lower residential user prices. The effect on prices was ambiguous. Competition does seem to lower industrial prices, but the result is reversed when competition co-exists with regulation. The hypothesis is therefore only partially supported. Also, competition does not necessarily lead to more efficiency in capacity utilisation – this is possibly because the entry of competitors expands generating capacity leading to a fall in average utilisation, at least for a time (this has happened in the liberalised British electricity market).

Hypothesis C1: Independent regulation in place of direct government department regulation will improve productive efficiency. The results suggest that while competition has a beneficial effect on labour productivity in electricity generation, the

direction of the effect of having an independent regulator is unclear. This suggests that regulation may well diminish efficiency incentives, as some of the economics of regulation literature suggests (Parker, 2002). Privatisation alone does not lead to improved labour productivity, but there is a significant, positive effect from having both privatisation and independent regulation.

Hypothesis C2: Independent regulation will raise prices charged to domestic consumers as cross-subsidies are removed. The research found that regulation, even when associated with privatisation or competition, does not appear to have a statistically significant effect on residential user prices. This finding is contrary to expectation. Independent regulation also seems to have no reliable impact on industrial user prices, though when independent regulation and competition co-exist, surprisingly, industrial prices are found to be higher. These results may reflect the particular crudity of the regulation measure used, in the absence of a superior alternative. Nevertheless, on the basis of our regression results the hypothesis has to be rejected.

In summary, the research findings suggest that only the competition variable had the full results expected. Privatisation and regulation, especially on their own, appear to have disappointing effects on electricity output, labour productivity and prices.

As mentioned earlier, our study has some similarities to that of Steiner (2000), though she was concerned with 19 OECD countries and not developing economies and used some different explanatory variables, including vertical unbundling, on which we were unable to obtain data. Nonetheless, it is interesting to compare the two sets of results. Steiner found that industrial prices were higher under private than public ownership (something she attributes, possibly, to governments raising prices to make the enterprises more attractive to investors), that market liberalisation led to lower prices, and that capacity utilisation was higher under private ownership and vertical unbundling. Hence her findings have some differences to our own, especially on the importance of privatisation. This is not entirely unexpected, however. Differences in the results may reflect a superior management of the privatisation process in OECD economies, with their more developed governmental and capital market institutions. Moreover, we would expect independent regulation to be more fully developed (and credible) in the OECD countries. This conclusion needs further investigation, but is intuitively

appealing given knowledge of widespread institutional weaknesses in developing countries (Parker, 2002).

CONCLUSIONS

More and more developing countries are thinking of or have already undertaken reforms in their electricity industry, with the objectives of increasing private capital, promoting competition and introducing new regulatory structures. In more detail the reform measures implemented usually involve unbundling existing utilities, possibly into separate generation, transmission, distribution and supply providers; privatising state-owned incumbents; introducing competition among operators, especially in the generation sector; and establishing new regulatory bodies to regulate the remaining monopoly infrastructure. The main purposes of electricity reform include improving the efficiency of the electric power sector, expanding private investment in infrastructure building and relieving government from ever-increasing budgetary pressures.

Using a panel data set covering 51 developing countries, for the period 1985 to 2000, this paper has examined the effects of privatisation, competition and regulation in the electricity sector. The performance indicators estimated were net electricity generation per capita, installed generation capacity per capita, net electricity generation per employee, capacity utilisation and electricity prices. It was found that competition appears to bring about favourable effects in terms of service penetration, capacity expansion, labour efficiency and prices charged to industrial users. The effects of privatisation or having an independent regulator, by themselves, were, however, inconclusive, except for capacity utilisation, which appears to be improved by privatisation. By contrast, the co-existence of the two reform measures did seem to be correlated with greater electricity availability, more generation capacity and higher labour efficiency.

These empirical results have policy implications for electricity reformers in developing countries. Like Pollitt (1997) the study finds that competition is the most reliable driver of economic benefits. In the light of the benefits associated with competition, reformers should introduce measures conducive to promoting liberalised electricity markets. When privatising industries where significant monopoly powers remain, emphasis should also focus on designing and implementing an effective regulatory framework. The competition variable is significant with the expected sign throughout, except on the most politically sensitive issue of

residential prices and for capacity utilisation, where liberalisation may lead to a decline in average capacity usage. Because competition is confirmed as the most reliable means of improving performance, this suggests that the use in a number of developing countries of exclusivity periods granted to new generators and long-term purchase contracts for IPPs, arranged so as to stimulate investment, may be unwise. Such measures may dim efficiency incentives and reduce economic performance by removing the incentive of competition.

This paper represents an attempt at econometric analysis of electricity reform in developing countries. However, it has limitations associated with data availability and data accuracy. In particular, the measures of the reform components used are simplified because of the difficulty of obtaining detailed information on the *degree* of privatisation and competition in developing countries and of gauging the *effectiveness* of independent regulatory structures. More specifically, the competition and privatisation dummies used do not capture the intensity of competition pressure faced by incumbents and the share of private capital in the generation sector, respectively, leading, potentially, to an omitted variables problem. Also, the regulation variable is particularly crude and cannot reflect the effectiveness of the various forms of regulation countries have adopted. Future research efforts need, therefore, to focus on developing more robust measures of electricity reforms in developing economies[5].

Appendix: Table 1
Correlation Matrix for the Dependent Variables

	R	C	PG	LUB	LIN	LGDPP	LFDOM
R	1.00						
C	.50	1.00					
PG	.49	.41	1.00				
LUB	.19	.24	.22	1.00			
LIN	-.13	-.02	-.08	.34	1.00		
LGDPP	.23	.17	.33	.76	.39	1.00	
LFDOM	.27	.28	.37	.24	-.004	.49	1.00

	R	C	PG	RC	RPG	LUB	LIN	LGDPP	LDFOM
R	1.00								
C	.50	1.00							
PG	.49	.41	1.00						
RC	.62	.84	.49	1.00					
RPG	.74	.58	.71	.70	1.00				
LUB	.19	.24	.22	.21	.17	1.00			
LIN	-.13	-.03	-.08	-.07	-.15	.34	1.00		
LGDPP	.23	.17	.33	.14	.21	.76	.39	1.00	
LFDOM	.27	.28	.37	.23	.22	.24	-.004	.49	1.00

Appendix: Table 2

Results from the Panel Unit Root Tests

Dependent Variable	*LNG*	*LGCAPP*	*LNGPE*	*LRPRICE*	*LIPRICE*
t-bar statistics	-3.7877	-4.4003	-2.7260	-7.2513	5.3362
Independent Variable	*LGDPP*	*LUB*	*LIN*		
t-bar statistics (when the dependent variables are LNG and LGCAPP)	-9.1617	-3.4125	-5.7579		
t-bar statistics (when the dependent variable is LNGPE)	-6.00257				
t-bar statistics (when the dependent variable is LRPRICE)	-6.18985	-2.1235			
t-bar statistics (when the dependent variable is LIPRICE)	-6.06698		-5.21262		

The critical value at the 1% confidence level is –1.96.
L indicates logged values.

Notes

[1] The variables in the correlation matrix are in logged form.

[2] According to Kennedy (1992), the use of the fixed-effects model is reasonable when the sample data are large relative to the entire population, as in our case. Also, an Hausman test showed that the fixed-effect model was superior for the purposes of our study. The Hausman test results can be obtained from the authors.

[3] The original data are transformed into $\ln y_{it} * ? \ln y_{it} ? ? \ln y_{it?1}$ and $\ln x_{it} * ? \ln x_{it} ? ? \ln x_{it?1}$. The first observations are transformed into $\sqrt{1 ? ?^2} \ln y_{i1}$ and $\sqrt{1 ? ?^2} \ln x_{i1}$.

[4] The result did not hold once the regulation-competition and regulation-privatisation interactive variables were included; see results for equation 2.

[5] The authors are involved in such work in the Centre on Regulation and Competition, in the IDPM, University of Manchester. They welcome interest in the research and assistance and advice.

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