

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

by

**Yin-Fang Zhang, David Parker\*and Colin Kirkpatrick**

**Centre on Regulation and Competition  
Institute for Development Policy and Management  
University of Manchester  
UK**

**\*and Aston Business School  
Aston University  
Birmingham  
UK**

**Author for correspondence: David Parker, Aston Business School, Aston  
University, Birmingham B4 7ET, UK: Tel (0044) 121 359 3611;  
email:d.parker1@Aston.ac.uk**

**ELECTRICITY SECTOR REFORM IN DEVELOPING  
COUNTRIES: AN ECONOMETRIC ASSESSMENT OF THE**

# EFFECTS OF PRIVATISATION, COMPETITION AND REGULATION

by

*Yin-Fang Zhang, David Parker\*and Colin Kirkpatrick*

## 1. Introduction<sup>[1]</sup>

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 and growth 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, in particular, can suffer from serious institutional weaknesses, meaning that planned reforms may not produce their intended benefits (Parker, 2002). 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; O'Mahony and Vecchi, 2001). Some studies have focused on the developing countries (World Bank, 1995; Boubakri and Cosset, 1998; Dewenter and Malatesta, 2000) and a few on the electricity sector in developing countries (Baer, 1994; Hawdon, 1996; Spiller and Martorell, 1996; Pollitt, 1997; Estache, Rossi and Ruzzier, 2002). 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 addresses data issues and the modelling used to test the hypotheses. The results are presented in section 5 and discussed in section 6. The last part of the paper, section 7, provides a summary of the main conclusions and outlines their policy implications.

## **2. 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 this part of the supply chain has 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 early 1990s; 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 retail suppliers of electricity.
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 under conditions of incomplete contracts (Spiller, 1996; Schmitz, 2001). 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.

### **3. Literature Review and Hypotheses**

#### *3.1 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. 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) discovered increased labour productivity in the privatised Bangladesh jute industry. 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. Ros and Banerjee (2000) found that privatisation had reduced unmet demand for telecommunications services in Latin America.

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). 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. However, causation was unclear: 'privatisation was adopted by those least in need of efficiency gains' (ibid., p.28). 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; although 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). Megginson and Netter's (2001) recent review of the literature also suggests that, on balance, in the utilities sector deregulation and market liberalisation are associated with

efficiency improvements but that the effect of privatisation by itself is less clear cut. Hernando and Gutierrez (2003) argue that competition, regulation and ownership all contributed to better performance in telecommunications in their sample of 22 Latin American countries. While Bortolotti et al. (2002) find similarly that competition and regulation impact on performance in international telecommunications independently of ownership changes.

Arguably, therefore, in appraising the performance of the electricity sector in developing countries it is important to take account of the effects of ownership *and* 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 success of the privatisation process was highly and positively correlated with the nature of the 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 (similarly findings for the telecommunications sector can be found in Gutierrez and Berg, 2000, and Bortolotti *et al.*, 2001). 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 suggest 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 variables. 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 often concentrated on Latin America, and especially Chile and Argentina (e.g. Lalor and Carcia, 1996; Chisari *et al.*, 1999). There is a lack of empirical study of the joint effects of privatisation, competition and regulation 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.

### *3.2 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 on economic performance 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 higher utilisation of the available capital stock. 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 and non-storable 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 renegeing 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 change of 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, 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 at prices that are not necessarily related to the marginal costs of supply, in order to reach as much of the population

as possible and because individual electricity users are also voters. In particular, 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 labour productivity 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 long-run marginal costs.**

### *3.3 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 the quantity of electricity supplied 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 into the industry 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.**

### *3.4 Hypotheses on regulation*

Electricity generation is characterised by long-term 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 (Jamash and Pollitt, 2000). However, it has been claimed that 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 government department regulation will improve productive efficiency.**

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

#### **4. 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 has taken both forms.

The starting date for the study, 1985, was dictated by data availability; although this is not a problem because little reform of the electricity sector occurred 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, again 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 (in real terms).

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 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 countries 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 country claimed to have an electricity regulatory agency 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 environmental 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.<sup>[2]</sup> Other control variables included the percentage of industrial output as a share of GDP and a variable to measure a country's 'economic freedom'. 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 political and institutional factors associated with performance

improvement, independent of privatisation, competition and independent regulation. A number of studies have pointed to the separate importance of political and institutional factors in encouraging investment (e.g. Gutierrez and Berg, 2000; Hamilton, 2000; Henisz and Xelner, 2001). Admittedly, a finer grained analysis would be superior to test for the separate effects of different political and institutional factors. But the variable used here must suffice for our purposes because of, once again, data constraints and because our main concern is with the roles of competition, regulation and privatisation. 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).<sup>[3]</sup>

Table 1 lists the variables used in the study. Descriptive statistics and a correlation matrix for these variables is provided in the appendix to the paper.<sup>[4]</sup> The matrix confirms that there is no evidence of serious multicollinearity between the variables.

(Table 1 here.)

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 periods 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 logarithmic form:<sup>[5]</sup>

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

where  $y_{it}$  is each of 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  $\varepsilon_{it}$  is the remainder of the disturbance.

The control variables included in the model varied. 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 final regressions. 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.<sup>[6]</sup>

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

$$\ln y_{it} = \alpha_i + \beta_1(R_{it}) + \beta_2(C_{it}) + \beta_3(PC_{it}) + \beta_4(R_{it} * C_{it}) + \beta_5(R_{it} * PC_{it}) + \beta_6(C_{it} * PC_{it}) + \delta(\ln x_{it}) + \eta_i + \varepsilon_{it} \quad (2)$$

Equation (2) allows for the separate effects of the reform variables and of their interactions to be examined. Regressions including a time trend variable in equations (1) and (2) above were also run and the results were generally consistent. They are not therefore separately reported.<sup>[7]</sup>

## 5. Results

Equations (1) and (2) were estimated for each of the five dependent variables. The Prais-Winsten transformation was used to overcome the problem of autocorrelation in the initial estimations. Table 2 presents the regression results.

(Table 2 here.)

### *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 supply. But the result is possibly explained by the primary objective of private investors being 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 output 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 per capita in both of the estimations, while the effect of the interaction terms with regulation and privatisation are not significant. Hence, it seems that competition, on its own, is the 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 (columns 3 and 4) 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, although the interaction of competition and privatisation is not statistically significant. This privatisation with regulation 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, although 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*

Turning to columns 4 and 5 of Table 2, 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 an 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 (see Table 2 columns 7 and 8). 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<sup>[8]</sup>, that is consistent with the theory that regulation leads to over-expansion of the asset base (Averch and Johnson, 1962). Interestingly, the economic freedom variable appears to have the largest impact on electricity utilisation. The reasons for this are unclear, but the result may reflect a more conducive environment for the management of investment.

### *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 (Table 2 columns 9 to 12), 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.

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 both when competition alone is introduced and when it is combined with privatisation. 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 here.)

## **6. 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 labour productivity and higher capital utilisation.* 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 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 long-run marginal 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 alone does seem to lower industrial prices and when combined with privatisation, but the result is reversed when competition co-exists with regulation. This suggests that regulation may help to sustain cross-subsidies. 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; although when independent regulation and competition co-exist, industrial prices tend to be

higher. These results may reflect the particular crudity of the regulation measure used, in the absence of a superior alternative, as well as the potential distortionary effects of regulation on prices. Certainly the results for price effects deserve further investigation. 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) and Wallsten (2001). Steiner 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 results with our own. 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).

Turning to Wallsten's modelling of efficiency in telecommunications (Wallsten, 2001), Wallsten concluded that competition is beneficial for economic performance, but that privatisation is beneficial only when coupled with the existence of an independent regulator. Therefore, although he was studying a different sector – telecommunications rather than electricity – the results complement our own. Together Wallsten's study and our own suggest that privatisation is likely to disappoint in the absence of other reforms involving the introduction of competition or (more evident in Wallsten's study than our own) the creation of an independent regulator.

It could be argued that our results are affected by heterogeneous data, the data being derived from a wide range of developing countries. To assess whether a subset of the data might show differing trends, the regressions were re-run including data for Latin American countries only and then for African and Asian countries separately. The Latin America results are reported here because this is the continent in which much privatisation activity has occurred.

The results are provided in Table 4. The results for residential and industrial prices are excluded because they are almost identical to those in Table 2 (which is to be expected given that most of our price data relates to Latin America). The results in Table 4 are similar to our earlier findings with competition having a positive and statistically significant effect on electricity generation per capita, installed generation per capita, electricity generation per employee and electricity generation to average capacity (using equation 2). However, there is some suggestion that privatisation has had a more favourable impact on electricity generation per capita in Latin America than in Africa and Asia. Also, the competition-privatisation interaction dummy is now more statistically significant. Nevertheless, the results for Latin America alone are generally consistent with the earlier findings. [\[9\]](#)

(Table 4 here.)

## **7. 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 retail firms; privatising state-owned incumbents; introducing competition among operators, especially in the generation sector; and establishing new regulatory bodies. The main driving forces in electricity reform are 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. The results are broadly similar for Latin America alone.

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. The competition variable is significant with the expected sign except in the most politically sensitive area of residential prices and for capacity utilisation where liberalisation may lead to a decline in average capacity usage. 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 that facilitates market entry, rather than regulating it, and enhances competition more generally.<sup>[10]</sup> 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.

Apart from competition, the other variable having a consistent impact on performance is 'economic freedom'. Although the variable used is a broad estimator of the political and institutional environment, the result is consistent with other studies that have emphasised the role of institutions in successful economic reform.

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 true status of 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.<sup>[11]</sup> Finally, the paper has not explored in detail the social and long-term developmental effects of price and service changes in developing countries resulting from privatisation and market liberalisation in the electricity sector. Nor has the paper developed an analysis of the distributional effects of privatisation, other than looking at some broad price effects. These important issues for developing countries will be the subject of future research.

**Table 1: Description of the Variables**

<i>Dependent Variable</i>	<i>Description</i>
NG	Net electricity generation per capita (KW/person)
GCAPP	Generation capacity per capita (KW/person)
NGPE	Net electricity generation per employee (million KW/person)
RPRICE	Residential prices (1995 constant US\$)
NPRICE	Industrial prices (1995 constant US\$)
<i>Independent Variable</i>	<i>Description</i>
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 (%)

**Table 2: The Main Regression Results**

	Electricity generation per capita NG		Installed generation capacity per capita GCAPP		Net electricity generation per employee NGPE	
	(1)	(2)	(3)	(4)	(5)	(6)
	Equation 1	Equation 2	Equation 1	Equation 2	Equation 1	Equation 2
R	.011 (.557)	.046 (.652)	-.019 (1.037)	.014 (.504)	.022 (.223)	.143 (1.190)
C	.025 (1.722)***	.013 (2.173)**	.036 (1.657)***	.066 (2.492)**	.131 (2.254)**	.282 (2.399)**
PG	.019 (.438)	.0191 (.503)	.244 (1.465)	-.018 (.358)	.061 (1.158)	-.282 (1.387)
R*C		-.124 (1.171)		-.039 (.852)		-.168 (.521)
R*PG		.077 (1.881)***		.041 (2.329)**		.215 (2.112)**
PG*C		.031 (.305)		-.007 (.158)		-.056 (.204)
LGDPP#	.407 (7.096)*	.540 (23.654)*	.608 (14.489)*	.999 (13.813)*	.647 (3.658)*	.500 (2.857)*
LUB#	1.236 (17.662)*	.727 (13.556)*	.608 (6.493)*	.371 (4.641)*		
LIN#	.288 (3.909)*	.697 (12.451)*	-.050 (.679)	-.080 (1.171)		
LFDOM#	.302 (3.531)*	.565 (5.893)*	.145 (3.088)*	.349 (2.967)*	-.983 (5.950)*	-1.296 (5.162)*
Adjusted R-squared	.981	.982	.946	.955	.809	.809
F test	729.58	704.64	234.41	226.78	41.41	40.81
D-W test	1.712	1.692	1.690	.1789	1.689	1.766
Number of observations	782	782	782	782	357	357

For the key to the 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.

**(continued)**

(continued)

Electricity generation/average capacity		Residential prices RPRICE		Industrial prices NPRICE	
(7)	(8)	(9)	(10)	(11)	(12)
Equation 1	Equation 2	Equation 1	Equation 2	Equation 1	Equation 2
-.149 (2.416)**	-.035 (.480)	.069 (.351)	.010 (.183)	.036 (.848)	-.036 (.789)
-.125 (1.574)	.107 (1.292)	.049 (.229)	-.035 (.518)	-.061 (1.193)	-.239 (3.757)*
.079 (1.869)***	.136 (3.038)*	.025 (.142)	.107 (1.294)	-.0178 (.428)	-.065 (1.197)
	-.482 (2.709)*		.160 (1.375)		.366 (3.609)*
	-.005 (.052)		-.210 (.611)		.277 (2.791)*
	-.044 (.297)		-0.033 (.251)		-.340 (3.155)*
.098 (.578)	.100 (.599)	1.418 (2.502)**	.177 (1.364)	-.170 (.911)	-.234 (1.265)
		-4.099 (2.787)*	-1.092 (5.128)*		
				-.768 (11.038)*	-.755 (10.926)*
4.380 (34.544)*	4.368 (34.398)*	.7421 (1.355)	.965 (2.691)*	-.147 (.916)	-.108 (.660)
.827	.828	.727	.740	.797	.804
69.89	67.92	35.44	33.51	48.08	45.72
1.659	1.657	1.970	1.880	1.766	1.832
782	782	332	332	324	324

For the key to the 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



**Table 3: Supplementary Regression Results**

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

**Table 4: The Results for Latin America**

	Electricity generation per capita		Installed generation capacity per capita		Electricity generation per employee	
	(1) Equation 1	(2) Equation 2	(3) Equation 1	(4) Equation 2	(5) Equation 1	(6) Equation 2
R	-.067 (1.567)	.025 (.482)	-.017 (.651)	.048 (.659)	.039 (.336)	-.072 (.544)
C	.080 (1.715)***	.185 (2.261)**	.063 (2.203)**	.093 (1.985)**	.084 (1.846)*	.554 (2.627)*
PG	.096 (2.463)**	.150 (2.578)**	.051 (1.619)	-.027 (.527)	-.047 (.517)	-.077 (.655)
R*C		-.131 (1.122)		-.003 (.032)		.079 (.342)
R*PG		.026 (0.254)		.204 (2.270)**		.378 (2.357)**
PG*C		.054 (1.833)***		.181 (1.974)**		-.157 (.954)
LGDPP#	.651 (5.635)*	.633 (5.333)*	.602 (7.161)*	.725 (6.847)*	.153 (.519)	-.356 (1.047)
LUB#	2.795 (5.053)*	2.679 (4.774)*	1.327 (5.615)*	2.117 (4.226)*		
LIN#	.102 (2.243)**	.108 (1.129)	.007 (.094)	-.077 (.901)		
LFDOM#	.141 (1.719)***	.126 (1.960)***	.099 (1.185)	-.055 (.753)	-.313 (1.441)	-.324 (1.449)
Adjusted R-squared	.978	.978	.955	.961	.840	.841
F test	353.19	330.96	192.26	226.78	45.31	39.98
D-W test	1.738	1.692	1.748	.1789	1.879	1.895
Number of observations	342	342	340	782	194	194

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.

(continued)

(continued)

	Electricity generation/ average capacity	
	(7)	(8)
	Equation 1	Equation 2
R	-.040 (1.135)	-.110 (1.036)
C	-.162 (1.511)	.224 (2.584)**
PG	.194 (3.518)*	.115 (1.888)***
R*C		.097 (.795)
R*PG		.201 (1.941)**
PG*C		.133 (.2.439)**
LGDP#	.117 (1.127)	-.055 (.538)
LUB#		
LIN#		
LFDOM#	.147 (2.050)**	.156 (1.893)**
Adjusted R-squared	.705	.706
F test	10.86	6.80
D-W test	1.602	1.616
Number of observations	368	368

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.

## References

- Adhikari, R. and Kirkpatrick, C. (1990) 'Public Enterprise in Less Developed Countries: An Empirical Review', in J. Heath (ed.) *Public Enterprise at the Crossroads*, London: Routledge.
- Alchian, A.A. (1965), 'Some Economics of Property Rights', *Il Politico*, 30, 816-29.
- APERC (2000), *Electricity Sector Deregulation in the APEC Region*, Asia Pacific Energy Research Centre, Institute of Energy Economics, Japan.
- Armstrong, M., Cowan, S. and Vickers, J. (1994) *Regulatory Reform: Economic Analysis and British experience*, Cambridge, Mass.: MIT Press.
- Arocena, P. and Price, C.W. (2002), 'Generating Efficiency: Economic and Environmental Regulation of Public and Private Electricity Generators in Spain', *International Journal of Industrial Organization*, 20, 41-69.
- Asia Pacific Energy Research Centre, [www.ieej.or.jp/aperc](http://www.ieej.or.jp/aperc).
- Averch, H. and Johnson, L.L. (1962) 'Behavior of the Firm under Regulatory Constraint', *American Economic Review*, vol.52, pp.1052-69.
- Bacon, R.W. (1995), 'Privatization and Reform in the Global Electricity Supply Industry', *Annual Reviews Energy & the Environment*, 20, 119-43.
- Bacon, R.W. and Besant-Jones, J. (2001), 'Global Electric Power Reform, Privatization and Liberalization of the Electric Power Industry in Developing Countries', *Annual Reviews Energy & the Environment*, 26, 331-59.
- Baer, W. (1994) 'Privatization in Latin America', *World Economy*, 17 (4), 509-528.
- Bergara, M, Henisz, W.J. and Spiller, P.T. (1997), 'Political Institutions and Electric Utility Investment: a Cross-nation Analysis', Working Paper, University of California Energy Institute.
- Bhaskar, V. and Khan, M. (1995) 'Privatization and Employment: A Study of the Jute Industry in Bangladesh', *American Economic Review*, 85(1), 267-273.
- Bortolotti, B., D'Souza, J., Fantini, M. and Megginson, W.L. (2002) 'Privatization and the Sources of Performance Improvement in the Global Telecommunications Industry', *Telecommunications Policy*, 26, 243-268.
- Boubakri, N. and Cosset, J.-C. (1998) 'The Financial and Operating Performance of Newly Privatized Firms: Evidence from Developing Countries' *Journal of Finance*, 53(3), 1081-1110.

Bortolotti, B., Fantini, M. and Siniscalco, D. (1998), 'Regulation and Privatisation: the Case of Electricity', Working Paper, Department of Economics and Finance, University of Turin.

Bortolotti, B., D'Souza, B., Fantini, M. and Megginson, W.L. (2001) 'Sources of Performance Improvements in Privatized Firms: A Clinical Study of Global Telecommunications', mimeo, University of Oklahoma.

Bös, D. (2001) 'Bureaucrats and Public Procurement', *Finanzarchiv*, 58, 103-120.

Bouin, O. and Michalet, C.A. (1991), *Rebalancing the Public and Private Sectors: Developing Country Experience*, OECD, Paris.

Boycko, A.S. and Vishny, R. (1996), 'A Theory of Privatization', *Economic Journal*, 106, 309-319.

Chisari, O., Estache, A. and Ronlero, C. (1999), 'Winners and Losers from Utility Privatisation in Argentina: Lessons from a General Equilibrium Model', Working Paper, Washington D.C.: World Bank.

Cook, P. (1999) 'Privatization and Utility Regulation in Developing Countries: The Lessons So Far', *Annals of Public and Cooperative Economics*, 70 (4), 549-587.

Crew, M.A. and Kleindorfer, P.R. (1996) 'Incentive regulation in the United Kingdom and the United States: Some lessons', *Journal of Regulatory Economics*, 9, 211-225.

Czamanski, D. (1999) *Privatization and Restructuring of Electricity Provision*, Westport, Conn.: Praeger.

De Alessi, L. (1980), 'The Economics of Property Rights: a Review of the Evidence', *Research in Law and Economics*, 2, 1-47.

Delfino, J.A. and Casarin, A.A. (2001) 'The Reform of the Utilities Sector in Argentina', United Nations University World Institute for Development Economics Research Discussion Paper No. 2001/74, June.

Dewenter, K.L. and Malatesta, P.H. (2001), 'State-Owned and Privately-Owned Firms: An Empirical Analysis of Profitability, Leverage, and Labor Intensity,' *American Economic Review*, 91 (1), 320-335.

Ehrlich, I., Gallais-Hamonno, G., Liu, Z. and Lutter, R. (1994), 'Productivity Growth and Firm Ownership: an Analytical and Empirical Investigation', *Journal of Political Economy*, 102 (5), 1006-1038.

*Economic Freedom of the World: 2002 Annual Report*, [www.freetheworld.com/release.html](http://www.freetheworld.com/release.html)

Energy Information Administration (EIA), [www.eia.doe.gov](http://www.eia.doe.gov)

- Estache, A., Rossi, M.A. and Ruzzier, C.A. (2002) 'The Case for International Coordination of Electricity Regulation: Evidence from the Measurement of Efficiency in South America', mimeo, Washington, DC: World Bank.
- Galal, A., Jones, L., Tandon, P. and Vogelsang, I. (1994) *Welfare Consequences of Selling Public Enterprises – An Empirical Analysis*, Oxford: Oxford University Press.
- Gilbert, R.J. and Khan, E.P. (1996) *International Comparisons of Electricity Regulation*, Cambridge: Cambridge University Press.
- Guasch, J.L. and Hahn, R.W. (1999) 'The Costs and Benefits of Regulation: Implications for Developing Countries', *The World Bank Research Observer*, 14 (1), 137-158.
- Gupta, J.P. and Sravat, A.K. (1998) 'Development and Project Financing of Private Power Projects in Developing Countries: a case study of India', *International Journal of Project Management*, 16 (2), 99-105.
- Gutierrez, L.H. and Berg, S. (2000) 'Telecommunications Liberalization and Regulatory Governance: Lessons from Latin America', *Telecommunications Policy*, 24, 865-884.
- Hawdon, D. (1996) *Performance of Power Sectors in Developing Countries – A Study of Efficiency and World Bank Policy using Data Envelopment Analysis*, Surrey Energy Economics Centre Discussion Paper 88, University of Surrey.
- Hayek, F.A. (1945), 'The Use of Knowledge in Society', *American Economic Review*, 35, 519-530.
- Hamilton, J. (2001) 'Institutions, Competition and the Performance of Telecommunications Infrastructure in Africa', *Working Paper*, Florida: Department of Economics, University of Florida.
- Henisz, W. and Zelner, B.A. (2001) 'The Institutional Environment for Telecommunications Investment', *Journal of Economics and Management Strategy*, 10, 123-147.
- Hernando, L. and Gutierrez, R. (2003) 'The Effect of Endogeneous Regulation on Telecommunications Expansion and Efficiency in Latin America', *Journal of Regulatory Economics* (forthcoming).
- Holburn, G.F. (2001) 'Political Risk, Political Capabilities and International Investment Strategy: Evidence from the Power Generation Industry', mimeo, paper presented at the the 5<sup>th</sup> Annual EUNIP Conference, Vienna, 29 November-1 December 2001.

- Hunt, S. and Shuttleworth, G. (1996) *Competition and Choice in Electricity*, Chichester: Wiley.
- Im, L.S.; Pesaran, M.H. and Shin, Y. (1995), 'Testing for Unit Roots in Dynamic Heterogeneous Panels', Working Paper, Department of Applied Economics, University of Cambridge.
- Izaguirre, A.K. (1998), 'Private Participation in the Electricity Sector – Recent Trends', Note 154, the World Bank, Private Participation in Infrastructure Group, Washington, D.C..
- Izaguirre, A. K. (2000), 'Private Participation in Energy', Note 208, the World Bank, Private Participation in infrastructure Group, Washington, D.C..
- Jamasb, T. and Pollitt M. (2000), 'Benchmarking and Regulation of Electricity Transmission and Distribution Utilities: Lessons from International Experience', Working Paper, University of Cambridge.
- Kennedy, P. (1992), *A Guide to Econometrics*, Cambridge, Mass.: MIT Press.
- Kleit, A.K. and Terrell, D. (2001), 'Measuring Potential Efficiency Gains from Deregulation of Electricity Generation: a Bayesian Approach', *Review of Economics and Statistics*, 83(3), 523-530.
- Kwoka, J.E. (1996), *Power Structure, Ownership, Integration and Competition in the US Electricity Industry*, Boston: Kluwer.
- Laffont, J.J. and Tirole, J. (1993), *The Theory of Procurement and Regulation*, Cambridge, Mass.: MIT Press
- Lalor, R.P. and Garcia, H. (1996), 'Reshaping Power Markets: Lessons from South America', *The Electricity Journal*, March 1996, 63-71.
- Lee, J.D., Park, S. and Kim T. (1999), 'Profit, Productivity, and Price Differential: an International Performance Comparison of the Nature Gas Transportation Industry', *Energy Policy*, 27, 679-89.
- Leibenstein, H. (1966), 'Allocative Efficiency versus X-Efficiency', *American Economic Review*, 56, 392-415.
- Levy, B. and Spiller, P.T. (1996), *Regulations, Institutions, and Commitment: Comparative Studies of Telecommunications*, Cambridge: Cambridge University Press.
- Lovei, L. (1996), 'The Single-buyer Model: a Dangerous Path toward Competitive Electricity Markets', *Electricity Journal*, 19(2), 21-27.

- Macedo, R. (2000) 'Privatization and the Distribution of Assets in Brazil', Washington, DC.: Inter-American Development Bank Research Department, March.
- Martin, R. and Vansteenkiste, I. (2001), 'EU Telecommunications and Electricity Markets – Heading Towards Price Convergence?' *Intereconomics*, May/June, 131-41.
- Martin, S. and Parker, D. (1997) *The Impact of Privatisation: Ownership and Corporate Performance in the UK*, London: Routledge.
- Meggison, W.L. and Netter, J.M. (2001) 'From State to Market: A Survey of Empirical Studies on Privatization', *Journal of Economic Literature*, 39, 321-389.
- Niskanen., W.A.Jr. (1971) *Bureaucracy and Representative Government*, Chicago: Aldine.
- North, D. C. (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge University Press.
- O'Mahony, M. and Vecchi, M. (2001) 'The Electricity Supply Industry: A Study of an Industry in Transition', *National Institute Economic Review*, no.177, July, pp.85-99.
- Parker, D. (2002), 'Economic Regulation: A Review of Issues', *Annals of Public and Cooperative Economics*, 73 (4).
- Petrazzini, B. and Clark, T.H.K. (1996), 'Costs and Benefits of Telecommunications Liberalization in Developing Countries', *Institute for International Economics Conference on Liberalizing Telecommunications Services*, Washington, D.C.
- Pollitt (1995) *Ownership and Performance in Electric Utilities*, Oxford: Oxford University Press.
- Pollitt, M.G. (1997) 'The Impact of Liberalization on the Performance of the Electricity Supply Industry: An International Survey', *The Journal of Energy Literature*, 3 (2), 3-31.
- Ramamurti, R. (1997), 'Testing the Limits of Privatization-Argentine Railroads', *World Development*, 25 (12), 1973-93'
- Ros, A. J. (1999), 'Does Ownership or Competition Matter? The Effects of Telecommunications Reform on Network Expansion and Efficiency', *Journal of Regulatory Economics*, 15, 65-92.
- Ros, A.J. and Banerjee, A. (2000) 'Telecommunications privatization and tariff rebalancing: evidence from Latin America' *Telecommunications Policy*, 24, 233-252.

Saal, D.S. and Parker, D. (2000), 'The Impact of Privatization and Regulation on the Water and Sewerage Industry in England and Wales: a Translog Cost Function Model', *Managerial and Decision Economics*, 21, 253-68.

Saal, D.S. and Parker, D. (2001), 'Productivity and Price Performance in the Privatized Water and Sewerage Companies of England and Wales', *Journal of Regulatory Economics*, 20(1), 61-90.

Saha, S. and Parker, D. (eds.) (2002) *Globalisation and Sustainable Development in Latin America: Perspectives on the New Economic Order*, Cheltenham: Edward Elgar.

Schmitz, P.W. (2001) 'The Hold-Up Problem and Incomplete Contracts: A Survey of Recent Topics in Contract Theory', *Bulletin of Economic Research*, 53 (1), 1-17.

Short, R. (1984), 'The Role of Public Enterprises: an International Statistical Comparison', in Floyd, R.; Gary, C. and Short, R. (eds.), *Public Enterprises in Mixed Economies: Some Macroeconomic Aspects*, IMF, Washington, D.C..

Spiller, P. (1996) 'Institutions and Commitment', *Industrial and Corporate Change*, vol.5, no.2, pp. 421-452.

Spiller, P.T. and Martorell, L.V. (1996) 'How Should It Be Done? Electricity Regulation in Argentina, Brazil, Uruguay, and Chile', in R.J. Gilbert and E.P. Kahm (eds.), *International Comparisons of Electricity Regulation*, Cambridge: Cambridge University Press.

Steiner, F. (2000) 'Regulation, Industry Structure and Performance in the Electricity Supply Industry', *Economics Department Working Papers No.238*, Paris: OECD.

Stern, J. and Holder, S. (1999) 'Regulatory Governance: Criteria for Assessing the Performance of Regulatory Systems: An application to Infrastructure Industries in the Developing Countries of Asia', *Utilities Policy*, 8, 33-50.

Tenenbaum, B. (1995), 'The Real World of Power Sector Regulation', Note No. 50, Washington, D.C.: World Bank.

Torp, J.E. and Rekve, P. (1998) 'Privatisation in Developing Countries: Lessons to be Learnt from the Mozambican Case', *Transformation*, no.36, pp.73-92.

Torero, M. and Pasco-Font, A. (2001) 'The Social Impact of Privatization and Regulation of Utilities in Peru', United Nations University, World Institute for Development Economics Research, Discussion Paper No.2001/17.

Vickers, J. and Yarrow, G. (1988), *Privatization: An Economic Analysis*, London-Cambridge MA, The MIT Press.

Villalonga, B. (2000), 'Privatization and Efficiency: Differentiating Ownership Effects from Political, Organizational, and Dynamic Effects', *Journal of Economic Behaviour & Organization*, 42, 43-74.

Wallsten, S.J. (2001), 'An Econometric Analysis of Telecom Competition, Privatization, and Regulation in Africa and Latin America', *The Journal of Industrial Economics*, 49(1), 1-19.

World Bank (1995) *Bureaucrats in Business: The Economics and Politics of Government Ownership*, Oxford and Washington, DC: Oxford University Press and World Bank.

World Bank (2003) *Global Economic Prospects and the Developing Countries*, Washington, DC: World Bank.

World Energy Council (WEC), [www.worldenergy.org/wec-geis](http://www.worldenergy.org/wec-geis).

World Energy Council (1998), *The Benefits and Deficiencies of Energy Sector Liberalisation*, Vol.1, World Energy Council, London.

*Yearbook of Privatisation* (various issues), London: Privatisation International.

Yunos, J.M. and Hawdon, D. (1997), 'The Efficiency of the National Electricity Board in Malaysia: an Intercountry comparison using DEA', *Energy Economics*, 19 (2), 255-69.

Zeckhauser, R.J. and Horn, M. (1989) 'The Control and Performance of State-owned Enterprises', in P.W.MacAvoy, W.T. Stanbury, G.Yarrow and R.J. Zeckhauser (eds.) *Privatization and State-owned Enterprises: Lessons from the United States, Great Britain and Canada*, Boston: Kluwer.

## Appendix

**Table A1: Descriptive Statistics of Dependent and Control Variables**

Variable	Mean	Std. Dev.	Minimum	Maximum
NG	1698.187	2210.344	1.085	15729.453
GCAPP	0.417	0.506	0.003	2.823
NGPE	1.518	1.883	0.055	16.875
CAPE	3850.490	964.764	380.511	9569.786
RPRICE	0.077	0.041	0.006	0.182
IPRICE	0.069	0.033	0.012	0.190
GDPP	3.370	4.991	0.163	28.230
UB	53.350	23.380	7.800	100.000
IN	31.599	11.265	10.280	71.810
FDOM	5.544	1.165	1.700	9.030

**Table A2: Correlation Matrix for the Dependent Variables**

	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	
LDFOM	.27	.28	.37	.23	.22	.24	-.004	.49	1.00

**Table A3: Results for the Panel Unit Root Tests**

<i>Dependent Variable</i>	<i>LNG</i>	<i>LGCAPP</i>	<i>LNGPE</i>	<i>LRPRICE</i>	<i>LIPRICE</i>
t-bar statistics	-3.7877	-4.4003	-2.7260	-7.2513	5.3362
<i>Independent Variable</i>	<i>LGDPP</i>	<i>LUB</i>	<i>LIN</i>		
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)			-2.1235		
		-6.18985			

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.

---

[1] We would like to thank Tony Boardman, Dieter Bös, Monica Giuiletti, Graeme Hodge, Michael Crew, Bill Megginson, Jon Stern, David Saal and attendees at a DFID workshop on 29 November 2002 for helpful comments on an earlier version of this paper. The usual disclaimer applies.

[2] Admittedly, over the long run there could be a causation problem here: GDP per capita and urbanisation may result from increased electricity generated because of the economic gains from electrification. However, the study deals with a relatively short period in which these long-run causation effects are unlikely to seriously bias the results.

[3] Ideally, when studying electricity price movements some fuel input price variable would be included. Although some data exist, notably on oil prices, in the absence of detailed knowledge of fuels used in generation and actual prices paid for inputs in each country, it was not possible to model using a fuel input price series.

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

[5] 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.

[6] These results can be obtained from the authors.

[7] They can be obtained from the authors.

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

[9] The results for Africa and Asia only also show competition to be a positive influence on performance. In this case, however, privatisation has a statistically significant positive effect on installed generation per capita but on none of the other dependent variables.

[10] For similar policy conclusions for the utilities sector in general, see World Bank, 2003, chapter 3.

[11] 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.