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 Cranfield School of Management
Cranfield University
Bedfordshire
UK

Author for correspondence: David Parker, Cranfield School of Management, Cranfield University, Befordshire, MK43 0AL: Tel (0044) 1234 754378; email:david.parker@Cranfield.ac.uk

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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. 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 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 36 developing and transitional countries, over the period 1985 to 2003. The study identifies the impact of these reforms on generating capacity, electricity generated, labour productivity in the generating sector and capacity utilisation. The main conclusions are that on their own privatisation and regulation do not lead to obvious gains in economic performance, though there are some positive interaction effects. By contrast, introducing competition does seem to be effective in stimulating performance improvements.

1. Introduction[1]

In the last twenty years, a large number of developed and developing countries have introduced major electricity sector reforms which have altered significantly the sector's market structure and institutional framework. This increase in private participation in the electricity sector was accompanied by a change in thinking on how utilities should be organised and regulated (Newbery, 1999; Gomez-Ibanez, 2003).

Power sector reform has usually involved some combination of product market competition, privatisation and regulation. In developed countries, the process of reform in the electricity sector has been well documented and appears to have been reasonably successful (Pollitt, 1995; Newbery, 1999)   In developing countries, however, the path to reform has been more difficult. Developing countries can suffer from serious institutional weaknesses, meaning that planned reforms may not produce their intended benefits (Parker, 2002). In most developing countries the process of capacity building and establishing adequate regulatory institutions has been a slow and complex one, lagging behind the entry of private operators in the electricity sector (World Bank, 2003, pp. ix-x; Cubbin and Stern, 2006; Zhang, Parker and Kirkpatrick, 2005).

The motivation for this paper is to examine the separate effects of privatisation, competition and regulation as components of electricity sector reform on performance in developing countries. In doing so, we deploy a new and hitherto unused panel database, which provides separate measures of the level of privatisation, competition and regulation in the electricity sector in 36 developing and transitional economies over the period 1985 to 2003. The aim of the analysis is to improve our understanding of the determinants of performance improvements in electricity sectors in developing countries and thereby contribute to the design of better reform programmes.

 The paper is organised as follows. Section 2 discusses the impetus for electricity reform in developing countries, describes the typical components of reform and

provides a review of relevant empirical studies on the effects of competition, privatisation and regulation.   Section 3 generates a number of research hypotheses and Section 4 then addresses data issues and discusses the modelling used to test the hypotheses. The results are presented in section 5. The last part of the paper, section 6, provides a discussion of the results and summarises the main conclusions and policy implications.

2. Reform of the Electricity Sector in Developing Countries

The principal driving forces behind electricity reforms have been discussed in the literature (for example, Bacon, 1995; World Energy Council, 1998; Czamanski, 1999; APERC, 2000; Bacon and Besant-Jones, 2001). Following Jamasb, *et al.* (2004), we can distinguish between 'push' and 'pull' factors. The former category includes the poor performance of state-run electricity operators in terms of high costs, inadequate expansion of access to electricity services and unreliable supply; the inability of the state sector to meet the investment and maintenance costs of the electricity industry associated with the increasing demands for power resulting from economic development in other sectors of the economy; the need to remove electricity subsidies so as to release resources for other areas of public expenditure; and the desire to raise immediate revenue for the government through the sale of state assets. The 'pull' factors have included: the demonstration effects of the pioneering reforms of the power sectors in Chile, England and Wales and Norway in the 1980s and early 1990s; advocacy of reform by international financial organisations and donor agencies such as the IMF and World Bank, through their 'lending for institutional reform' programmes; and 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.

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

1. 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.
2. Privatisation of the unbundled generators, transmitters, distributors or suppliers.
3. Development of a new regulatory framework. 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 USA and UK (Spiller, 1996; Schmitz, 2001)

While the reform programmes for the electricity sector have been built around these three elements, the detail has varied to reflect local circumstances (Bacon and Besant-Jones, 2001; World Bank, 2004). For example, privatisation of power has occurred in the form of operating concessions and greenfield investments, as well as state asset sales, but has rarely involved complete transfer of the entire electricity supply chain to the private sector, as occurred in Britain. 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.

A number of studies have examined the effects of privatisation on economic performance in developing countries (Megginson and Netter, 2001; Parker and Kirkpatrick, 2005). The conclusions of these studies are broadly consistent in showing that ownership alone does not generate economic gains. 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) and that the success or failure of the privatisation of monopolies depends on the post-privatisation

regulatory framework, which in turn is affected by political and social norms (Levy and Spiller, 1996; Villalonga, 2000). Megginson and Netter's (2001) recent review of the privatisation literature 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 obvious. Studies by Wallsten (2001), Gutierrez and Berg (2000) and Bortolotti et al. (2002) of telecommunications across a number of countries report similarly that privatisation alone is associated with few performance improvements and that effective regulation and competition are important.

There is a limited literature that focuses on the impact on economic performance of reform in the electricity sector in developing countries (Jamasb, *et al*. 2004). The standard structure-conduct-performance model has been used to test the effect of market structure, institutional factors and reform measures, on economic performance. These three main types of determinants have been tested in a number of combinations and a wide range of variables has been used to represent market structure, institutional factors and sector reforms. Similarly, a number of different performance measures have been adopted. A particularly important study is that by Bortolotti *et al*. (1998), who use data on the privatisation of electricity generation in 38 countries (both developed and developing) between 1977 and 1997. They conclude that effective regulation is crucial to the success of privatisation (also see Pollitt, 1997). Steiner (2000) uses a panel data set for 19 OECD countries and dummy variables for market liberalisation, ownership and privatisation of generation, along with variables for vertical integration, the existence of an electricity market and consumer choice. She finds that market liberalisation led to lower prices and that capacity utilisation was higher under private ownership and vertical unbundling.

Turning to other relevant studies, Hawdon (1996), analysing the performance of power sectors supported by World Bank loans, found that those countries adopting 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). In a comparison of electricity production in 27

developing countries in 1987, and using DEA analysis,[2] 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. 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. Cubbin and Stern (2006) assessed for 28 developing countries over the period 1980-2001 whether the existence of a regulatory law and higher quality regulatory governance are significantly associated with superior electricity outcomes. Their empirical analysis concludes that a regulatory law and higher quality governance are positively and significantly associated with higher per capita generation capacity levels and that this positive effect increases over time as experience develops and regulatory reputation grows**.** Domah *et al* (2002) empirically estimated a translog cost function which specified a model of the determinants of staff numbers that reflect the complexity of the electricity system, and national economic and regulatory environments. They found that developing countries faced high fixed costs relative to market size in establishing independent regulatory agencies.

Overall, therefore, the available empirical evidence suggests that in assessing the results of electricity privatisation in developing countries the effects of competition and regulation also need to be taken into account. However, previous studies have tended to look at only one or maybe two of these three reforms without controlling for the others and considering possible interaction effects. For this study a data set was created that allowed for the measure of these separate effects and their possible interactions.

3 The Research Hypotheses
This section of the paper develops a number of hypotheses as to the effects of privatisation, competition and regulation in electricity generation, which are then tested empirically in the next section of the paper.

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[2] Data envelopment analysis: a form of frontier efficiency measurement using a non-stochastic method.

3.1 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 and Vishny, 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 and Vishny, 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. 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 pursuing privatisation is that it will lead to more capital invested.

From the above arguments the following two hypotheses are derived:

> Hypothesis P1: Privatisation will lead to higher labour productivity and higher capital utilisation.

Hypothesis P2: Privatisation will lead to more capacity and hence higher output, provided that the regulatory regime is supportive of investor confidence.

3.2 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 following two hypotheses are therefore relevant on the effects of competition:

Hypothesis C1: Competition will lead to higher labour productivity and higher capacity utilisation.

Hypothesis C2: Competition will lead to a larger capacity and a higher output in electricity generation.

It is, of course, possible that in large firms, prevalent in the electricity sector, managerial discretion and "x-inefficiency" may mean that competition does not have the expected results.

3.3 Hypotheses on regulation

Electricity generation is characterised by long-term sunk investments, which is why an effective regulatory system is crucial for both investor confidence and consumer protection. 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 and incentives to promote 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. Such expectations lead to the following two hypotheses:

> Hypothesis R1: Independent regulation in place of direct government department regulation will improve labour productivity and capacity utilisation.
> Hypothesis R2: Independent regulation will also raise investment in the industry leading to more capacity and more electricity generated.

4. Data and Modelling

The above hypotheses were tested using panel data for 36 developing and transitional economies over the period from 1985 to 2003.[3] 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, 2003, 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. Even so, not all data exist for all of the years for all 36 countries and therefore 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 table 2 below and vary between 644 and 347). Again for data availability reasons, we focus on electricity generation. However, given that privatisation has been concentrated in power generation, with three quarters of private investment in power generation plants (Izaguirre, 1998,p.4), this is not a serious limitation to the study.

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[3] The countries are: Albania, Algeria, Argentina, Armenia, Bangladesh, Bolivia, Brazil, Chile, China, Columbia, Costa Rica, Czech Rep., Dominican Rep., Ecuador, El Salvador, Gabon, Honduras, Hong Kong China, Hungary, Indonesia, Kenya, Latvia, Malaysia, Mexico, Morocco, Nepal, Nicaragua, Panama, Peru, Philippines, Poland, Singapore, South Africa, Sri Lanka, Tanzania, Zambia. Details of the dates of competition, regulation and privatisation can be obtained from the authors.

The performance indicators used in the study are net electricity generation per capita of the population, installed generation capacity per capita of the population, net electricity generation per employee in the industry and electricity generation to average capacity (capacity utilisation). These indicators capture the extent of electricity available to the economy, labour productivity and capacity utilisation in the generation of electricity. Another potentially useful measure of performance, quality of service, could not be estimated because of a lack of data. Similarly, we would like to have investigated the impact of reforms on the prices charged for electricity generated, but there is a lack of sufficient comparable data across our sample of countries to carry out such an analysis.[4] The indicators of generation, capacity and capital efficiency were calculated based on data from the Asia Pacific Energy Research Centre (APERC) 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.[5] 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), APERC publications and databases published by the World Bank.

The privatisation variable used in the study was constructed as the percentage of generating capacity owned by private investors. Data on total generation capacity were drawn from the World Bank Development Indicators. Data on privately owned generating capacity were calculated based on the database of Private Participation in

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[4] In an earlier stage of the research we used cruder proxies for privatisation, competition and regulation than used in this paper, in which a dummy variable simply indicated whether the economy had *any* private sector generation capacity;   the measure of competition was a dummy variable that equalled 1 either when there existed a wholesale market where generators competed to conclude supply contracts with distributors or where large users could negotiate contracts directly with generators; and 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. The use of these broader measures allowed for the inclusion of a larger data base (consisting of 51 countries rather than 36) and permitted an analysis of price effects in a sub-set of these countries. The findings suggested that competition was the main influence on prices but more especially for industrial users rather than domestic consumers. The earlier results can be obtained from the authors.

[5] For those countries where data on employment in the generation subsector were not available, the number of employees   was estimated   by applying the average ratio of generation employment to total sector employment to the available data on total electricity sector employment.

Infrastructure (PPI) published by the World Bank. It should be noted that data on investment in the PPI database include private and public sector contributions. However, detailed inspection of the PPI database indicated that at least 80% of the investment in the projects reported in the database came from the private sector (Kirkpatrick et al, 2006, forthcoming)

The measure of competition was constructed on the basis of the market share of the three largest generators in the sector. Data on the share for 20 of the 36 sample countries came from the Electricity Regulation Database published by the World Bank. Information for the other countries was mainly drawn from the Country Briefs of the US Energy Information Administration and the Latin American Energy Organisation (OLADE).[6] 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. In this study, we constructed a four-component index of regulatory governance in the electricity sector. The four elements are: (1) whether there is an electricity or energy law; (2) whether the regulator claims to be independent; (3) whether there is a fixed-term appointment for the head of the regulatory body, as fixed terms appointments may provide more independence from political manipulation; and (4) whether the finance of the regulator depends on licence fees and levies rather the government funding. The first three components are all represented by binary dummies in our model. The last element takes a value between 0 and 1, with 0 indicating that the regulator is financed completely by government budget and 1 meaning that it relies totally on levies. Data for constructing the index came from the Electricity Regulation Database, the International Directory of Utility

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[6] In a competitive market, the percentage of the market supplied by the largest producers can be a good proxy of competition. However, in infrastructure industries like electricity, this proxy may exaggerate the extent of market competition. For example, the electricity sector in a country which has been unbundled may have several generators, not all of whom serve the same geographic market. In order to reduce this potential bias in the market share proxy for competition, the competition variable used in the study was transformed and rebased using logarithms and the square root of the market share. The results were consistent with those reported here; which are also consistent with the alternative competition proxy used in an earlier version of this paper. As mentioned already, this reflected the existence of a wholesale market where generators competed to conclude supply contracts with distributors or where large users could negotiate contracts directly with generators. None of the competition proxies used is perfect, but the use of different variables producing the same broad results gives confidence that we have not seriously misspecified the degree of competition.

Regulatory Institutions, and the Country Briefs of the US Energy Information Administration.

In the model a time-specific residual was included to capture the time effect.[7] Also, a number of variables were included in the model as environmental controls. In particular, both an increase in GDP per capita and 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.[8] Other control variables included the percentage of industrial output as a share of GDP and a variable to measure a country's 'economic risk'. A large proportion of industrial customers implies a higher potential for co-generation and a more even demand for electricity, and, *ceteris paribus*, a reduction in the need for generation capacity. The economic risk variable measures the quality of governance in five areas (the size of government, legal structure and security of property rights, access to sound money, freedom to trade internationally and regulation of credit, labour and business), and can be interpreted as a proxy for wider political and institutional factors associated with performance improvement, independent of privatisation, competition and independent regulation.[9] The openness of an economy, measured as the percentage of GDP accounted for by exports, was included as an additional control variable, and acts as a proxy for the economy's integration with rules-based international transactions. The macroeconomic and demographic variables came from the World Bank's World Development Indicators and the economic risk variable was based on the 10-point indices published by the Fraser Institute. Table 1 lists the independent variables used in the study.[10]

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[7] We also ran regressions with the time trend as an independent variable instead of as a composite error term and the results were similar. Ideally, we would have liked to have used leads and lags of the reform variables but were unable to do so given the number of observations and therefore the degrees of freedom.

[8] 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.

[9] A number of studies have confirmed the influence of such political and institutional factors on private investment in the utilities sector (Guitierrez and Berg,2000; Hamilton 2000; Henisz and Zelner, 2001; Kirkpatrick et al 2006).

[10] The correlation matrix for the independent variables is provided in the appendix table A1. The descriptive statistics for the variables used in the study are given in appendix table A2.

(Table 1 here.)

The model employed in this study draws from those used in Ros (1999) and Wallsten (2001) for telecommunications and Bergara *et al*. (1997) for electricity. All non-index and non-percentage variables used in the study took the log form. A fixed-effects panel model that controls for country effects and time effects was used.[11] The model is:

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

where y_{it} is each of the electricity indicators discussed above; R_{it}, C_{it}, P_{it} are the regulation, competition and privatisation variables, respectively; x_{it} denotes the control variables; v_i is the unit-specific residual that differs between countries but remains constant for any particular country; while u_t captures the time effect and therefore differs across years but is constant for all countries in a particular year; ε_{it} is the remainder of the disturbance.

As noted above, privatisation, competition and regulation may interact to result in performance improvements. To explore interaction effects, model (2) was also estimated:

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

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

The variables proved to be stationary over the period studied, thus reducing the danger of spurious regressions. The unit root test (IPS test) for the panel structure of

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[11] 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, the Hausman test showed that the fixed-

data proposed by Im *et al*. (1995) 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, 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 table A3.[12]

The variables for privatisation, competition and regulation may be endogenously determined. In other words, privatisation, competition and regulation may influence each other, as well as the performance of the electricity sector. For example, the poorly performing generators may be privatised first because governments are keen to get rid of them, while better performing generators are sold off more slowly leaving time to introduce prior changes to the regulatory and competitive environment. Our analysis deals to some extent with this potential problem by including country and year fixed effects. The country fixed effects control for country-specific propensities to reform and matters such as institutional quality, and year fixed effects control for any general trend in the reform of electricity generation.[13]

5. The Results

Models (1) and (2) were estimated for each of the dependent variables, namely, electricity generation per capita, installed generation per capita, electricity generation per employee, and electricity generation to average installed capacity. 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.)

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effect model was superior for the purposes of our study. The Hausman test results can be obtained from the authors.

[12] We also ran Seemingly Unrelated Regressions, as proposed by a referee. The results were similar to those reported in Table 2. The SUR results can be obtained from the authors on request.

[13] We are grateful to a referee for raising the issue of endogeneity. Instrumental variables have been used in the literature to correct for this potential bias, however, as Jamasb et al. (2004) point out, the major challenge is identifying appropriate instrumental variables and collecting data on them.

Electricity generation per capita

The first two columns of Table 2 show the results for the regressions using the log form of electricity generation per capita. In both of the equations the regulation variable (R) and the privatisation variable (P) are statistically insignificant. This suggests that regulatory reform or private investment, *on their own*, is not sufficient to increase the availability of electricity in our sample of developing and transitional countries. Indeed, both variables have an unexpected negative sign suggesting that these reforms on their own may actually reduce electricity output. The negative coefficient for the privatisation variable may be explained by the fact that the primary objective of private investors is to make profits. In contrast, under state ownership the objective may be to provide electricity to as many individuals as possible, sometimes at prices well below costs. Possibly privatisation would then lead to lower output, at least in the short term. The result for regulation is less easy to explain, but may indicate that imposing an independent regulator where state ownership persists is ineffective. However, in both cases the coefficient values are statistically insignificant and therefore not too much should be read into these results.

When the interaction variable between regulation and privatisation (PR) is considered, there appears to be a positive correlation, significant at the 10% level. In other words, although not significant when considered separately, private involvement in electricity generation together with regulatory reforms *is* associated with an increase in electricity generation per capita. 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 (C) is found to be positively associated with electricity generation per capita in both of the estimations, i.e. with or without the inclusion of interaction effects, and has the largest coefficient of any of the reforms. Hence, it seems that competition is an effective driver of increased electricity production. However, the interaction terms between privatisation and competition (PC) and regulation and competition (RC) are not statistically significant and in the case of regulation and competition the coefficient has an unexpected negative sign. These results suggest that it is competition on its

own rather than competition and ownership change or competition and the establishment of an effective regulatory framework that is critical in explaining increased electricity output in our sample.

As expected, GDP per capita is positively correlated with electricity generation as is the degree of openness of the economy, as reflected in the exports variable. Also as expected, the larger the degree of industrialisation in a country the higher the average amount of electricity generation available to each citizen. The urbanisation variable was not statistically significant and nor was the economic risk variable.

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, the competition variable (C) seems to have a significant, positive effect on capacity expansion, while the coefficient for the effect of regulatory reforms with an independent regulator, (R) is once again statistically insignificant and negative, and the privatisation variable (P) also has a negative sign.

The interaction results confirm that performance improvement following private participation is dependent on the deepening of regulatory reforms if there is a lack of competition. The PR variable is positive and statistically significant at the 1% level, a result that is consistent with the argument 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 of the sector. They are therefore more willing to invest in capacity building. Privatisation on its own, however, has seemingly a negative effect on installed generating capacity, underlining the importance of competition and regulation. Private participation in a more competitive industrial structure (PC) has a positive effect on installed capacity.   The results for the interaction of regulation and competition (RC) are also consistent with those for electricity generation per capita in finding a negative effect, in this case reducing installed generating capacity. This time the coefficient is statistically significant (at the 10% level), implying that regulation can actually impair the positive effects of competition. This may be explained by inefficiencies in the operation of regulation in developing countries, for example the existence of regulatory regimes that protect

existing suppliers from competition. Recent research by the World Bank has stressed the damaging effects that poor regulation can have on economic growth (World Bank, 2005).

The effects of GDP per capita and urbanisation on capacity expansion are significant and positive, as is the coefficient for industrialisation in one of the results. These results are in line with expectation, as are the results for both the economic risk and the export orientation variables. Countries with lower economic risk and with economies more open to exporting seem to be associated with higher installed generating capacity. This confirms that economies with better protected property rights, smaller government, access to sound money and greater freedom to trade internationally are more conducive to private investment in electricity generation.

Labour productivity

Turning to columns 5 and 6 of Table 2, the competition variable (C) in the estimations is shown to have a positive impact on electricity generation per employee. However, private participation alone does not seem to lead to higher productivity and indeed the negative sign on P suggests the alternative, although it is statistically insignificant. The regulation variable is also statistically insignificant except when the interaction terms are introduced. With the interaction terms the results suggest that a more independent regulator is associated with higher labour productivity except where competition is also strong. In this case, the regulatory reforms may be reversing some of the productivity gains introduced by competition, perhaps by restricting the extent to which competition removes overmanning. Regulators may be given an objective by government of reducing unemployment or may introduce regulations that lead to increased manning. In contrast, regulation and private participation together (PR) do seem to lead to increased labour productivity. The overmanning may therefore be centred on regulated state-owned generators.

Perhaps surprisingly the variable for the interaction between competition and privatisation (PC), while having the expected positive sign, is statistically insignificant. But considered alongside the positive competition (C) variable and negative privatisation variable (P), the result is consistent with the view that labour productivity is most likely to rise when generators are privatised into a competitive

environment. Once again the GDP and export variables are significant and have the expected sign. The degree of industrialisation and urbanisation and the economic risk variables, however, do not appear to have a significant effect on labour productivity.

Capacity utilisation

In a capital-intensive industry like electricity generation, a labour productivity measure needs to be supplemented by a measurement of capital productivity. The results for the ratio of electricity generated to generating capacity are reported in Table 2 columns 7 and 8. They confirm, once again, that private investment and independent regulation on their own have little obvious effects on performance and that competition is the most important variable. In these results the interaction effect between privatisation and regulation (PR) is also once again statistically significant, confirming that in the absence of competition performance improvements following the involvement of the private sector may be heavily dependent upon having in place effective regulation. Indeed, for this set of results competition and the interaction of privatisation and regulation dominate in terms of explaining improved capacity utilisation.

To add further detail, Table 3 provides estimates of the quantitative effects of the individual reform variables calculated on the basis of the results in Table 2.[14] As some of the coefficients of the reform variables are not statistically significant, the calculation was based on the significant ones only.

(Table 3 here)

6. Discussion

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. This study is based on a data base especially created from a range of international sources to measure the effects of privatisation, regulation and competition on performance in electricity

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[14] We thank a referee for suggesting this extension to the reporting of our results.

generation in developing countries. Data were collected for 36 countries covering the period 1985 to 2003. The empirical results presented show consistently that competition in electricity generation is more important than privatisation or the establishment of independent regulation in bringing about performance improvements.

Reviewing our findings in more detail and in relation to the research hypotheses, we did not find that privatisation leads to improved labour productivity or to higher capital utilisation (Hypothesis P1) or to more generating capacity and higher output (Hypothesis P2), except where it is coupled with the existence of an independent regulator. But regulation on its own also seemed to have little significant effect on the performance variables (Hypotheses R1 and R2). In other words, when competition is weak, performance improvements from private participation seem to be dependent upon having an effective regulatory regime in place to stimulate management to improve performance. In contrast, independent regulation without privatisation, in effect regulation of state-owned enterprises, seems to be ineffective. This result is not surprising when we bear in mind that where government is the operator of enterprises, the existence of independent regulation may lack credibility. Regulatory decisions are subject to being overridden where they impact adversely on state industries and budgets. Independent regulation may then become little more than a sham.

In contrast to the results for regulation and privatisation, our findings do confirm strongly the overwhelming importance of increasing competition to promote improved performance, in terms of greater electricity generation, generating capacity and improved labour productivity and capital utilisation in developing countries (Hypotheses C1 and C2). In our results competition dominated as the explanation of performance in electricity generation. Although it is possible that managerial discretion and "x-inefficiency" could reduce the beneficial effects of competition on performance, our results are consistent with the view that competition is very beneficial.
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Our results complement earlier research into electricity generation. Like Bortolotti *et al*. (1998) and Pollitt (1997) we conclude that in the absence of competition, effective regulation is crucial to the success of privatisation. In our results, as in Cubbin and

Stern (2006), regulation is associated with higher per capita generation capacity levels, but only when private operators exist. Like Yunos and Hawdon (1997) our results are consistent with state-owned suppliers performing as well as private sector companies in the absence of complementary reforms. However, unlike Bergara *et al*. (1997) our measures of the institutional conditions in different countries (economic risk and export orientation) were less consistently associated with performance. This may be because in our study the reform variables, especially competition, were capturing some of the effect of the institutional conditions researched by Yunos and Hawdon, or it could be a reflection of using different institutional measures. This deserves further investigation given the current emphasis in the development literature on the importance of institutions.

The results on the relative roles of privatisation, regulation and competition are also very similar to those found by Wallsten (2001), Gutierrez and Berg (2000) and Bortolotti *et al.*, 2002) for the telecommunications sector. For example, Wallsten concludes that competition is beneficial for economic performance, but that privatisation is beneficial only when coupled with the existence of an independent regulator. Our results do differ from those of Steiner (2000), who was concerned with electricity generation in 19 OECD countries and found that capacity utilisation was higher under private ownership. However, this is not entirely unexpected as differences are likely between developed and developing economies. 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. It is also the case that reforming the electricity sector can be expected to be more complex than reforming telecommunications because of the differing technologies involved and the greater difficulties of introducing effective competition. In telecommunications wireless technology has helped to circumvent the incumbent's ownership of the fixed line network. However, in electricity new market entrants must obtain access to the existing transmission and distribution systems.

The results have policy implications for electricity reformers in developing countries. They suggest that in developing countries performance improvements in electricity generation are more assured when competition is promoted or, failing that, independent regulation is instituted. 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. It is also the case that it might be difficult to introduce and maintain competition in the absence of privatisation because of the incentive for government to protect its own assets from depreciation. Nevertheless, our results suggest that privatisation *without* competition is likely to disappoint.

The research does, however, have a number of limitations, which we acknowledge. To begin with, the sample is composed of developing countries (including five emerging transitional economies) for which we could obtain data on regulation, competition and privatisation to create our variables. There will be sample selection bias if the countries making this data available have differing results for the dependent variables than those which do not make data available. We have no reason to believe that this should be the case, but cannot of course rule it out. Secondly, while we have endeavoured to produce satisfactory measures of competition, regulation and privatisation, more work would be valuable at an international level to obtain superior measures especially on the effectiveness of regulation.

Finally, the paper has not explored the 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 poverty and income distribution effects of privatisation. These are important issues for developing countries, particularly in the context of the Millennium Development Goals, and remain the subject of future research.

Table 1: DESCRIPTION OF THE INDEPENDENT VARIABLES

Variable	Description	Source
R	Four-component regulatory index	*The Yearbook of Privatisation*, Energy Information Administration, World Energy Council, APERC and the World Bank.
C	Square root of (100 – the market share of the three largest generators)	*The Yearbook of Privatisation*, Energy Information Administration, World Energy Council, APERC, the World Bank and OLADE.
P	Share of privately-owned capacities (%)	*The Yearbook of Privatisation*, Energy Information Administration, World Energy Council, APERC and the World Bank.
GDP	GDP per capita (1995 constant US$/person)	World Bank Development Indicators
Urbanisation	Urban population as a share of the total (%)	World Bank Development Indicators
Industrialisation	Industrial output as a percentage of GDP (%)	World Bank Development Indicators
Exports	Export of goods and services as a percentage of GDP (%)	World Bank Development Indicators
RISK	The degree of economic risk	The Fraser Institute

Table 2: THE MAIN RESULTS USING FIXED EFFECTS PANEL DATA ANALYSIS

	Electricity generation per capita		Installed generation capacity per capita		Electricity generation per employee		Generation / average capacity	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Equation 1	Equation 2	Equation 1	Equation 2	Equation 1	Equation 2	Equation 1	Equation 2
R	-0.008 (1.364)	-0.007 (0.752)	-0.009 (1.413)	-0.011 (1.522)	-0.016 (0.815)	0.052 (2.050)**	0.004 (0.523)	-0.002 (0.173)
P	-0.0001 (0.353)	-0.001 (1.381)	-0.00008 (0.178)	-0.003 (4.027)***	-0.0002 (0.195)	-0.002 (0.590)	0.00001 (0.026)	-0.002 (1.545)
C	0.017 (1.748)*	0.019 (1.818)*	0.034 (3.567)*	0.028 (1.875)*	0.030 (2.929)***	0.021 (2.070)**	0.046 (1.709)*	0.094 (2.856)***
RC		-0.005 (1.404)		-0.006 (1.733)*		-0.02 (3.903)***		-0.002 (1.237)
PC		0.000001 (0.004)		0.0006 (3.824)***		0.0001 (0.291)		-0.0005 (1.233)
PR		0.0005 (1.781)*		0.0006 (2.580)***		0.001 (1.993)**		0.0006 (3.863)***
LGDP	0.573 (13.753)***	0.575 (13.752)***	0.527 (12.707)***	0.496 (11.78)***	0.527 (2.906)***	0.311 (2.256)**	0.046 (0.965)	0.068 (1.427)
Industrialisation	0.006 (5.353)***	0.007 (5.476)***	0.002 (1.897)*	0.003 (2.677)	0.007 (1.225)	0.005 (1.161)	0.007 (5.201)***	0.006 (4.694)***
Urbanisation	-0.0008 (0.353)	0.00007 (0.027)	0.008 (3.467)***	0.013 (4.889)***	-0.012 (1.039)	-0.003 (0.385)	-0.012 (4.346)***	-0.016 (5.522)***
Export (%of GDP)	0.003 (4.192)***	0.003 (4.038)***	0.002 (2.713)***	0.002 (3.075)***	0.005 (2.582)**	0.003 (1.933)*	0.0007 (0.383)	-0.0009 (1.140)
Freedom	-0.047 (0.906)	-0.037 (0.711)	0.068 (5.690)***	0.024 (4.614)***	0.044 (0.501)	-0.034 (0.502)	-0.017 (0.579)	-0.011 (0.379)
Adjusted R-squared	0.99	0.99	0.99	0.99	0.89	0.93	0.69	0.70
D-W test	1.74	1.73	1.79	1.79	1.81	1.83	1.74	1.73
Number of obs	638	638	644	644	347	347	638	638

Table 3: THE QUANTITATIVE EFFECTS OF THE INDIVIDUAL REFORM VARIABLES

	Electricity generation per capita	Installed generation capacity per capita	Electricity generation per employee	Generation / average capacity
R One unit change in the regulatory index is associated with	0.05% increase in electricity generation per capita	0.54% decrease in installed capacity per capita	3.30% increase in electricity generation per employee	0.06% increased in generation/average capacity
P When the proportion of generation capacity owned by private investors increase one percent, there will be	0.05% increase in electricity generation per capita	0.18% decrease in installed capacity per capita	0.1% increase in electricity generation per employee	0.06% increased in generation/average capacity
C when there is one unit change in the measurement of the competition variable, there will be	1.90% increase in electricity generation per capita	2.26% increase in installed capacity per capita	0.1% increase in electricity generation per employee	9.4% increased in generation/average capacity

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Appendix

Table A1: Correlation Matrix for the Independent Variables

	R	C	P	LGDPP	UB	IN	EX	RISK
R	1.00							
C	.57	1.00						
P	.33	.45	1.00					
LGDPP	.18	.26	.37	1.00				
UB	.27	.43	.43	.65	1.00			
IN	-.15	.03	-.17	.26	.19	1.00		
EX	-.07	-.13	.31	.58	.48	.08	1.00	
RISK	.36	.22	.57	.50	.38	-.22	.62	1.00

Table A2 Descriptive Statistics for the Variables

Variable	Mean	Std.Dev.	Minimum	Maximum
LNGP	6.692	1.200	3.069	8.987
LCAP	-1.512	1.175	-4.581	0.609
LGPE	-0.075	0.792	-2.907	1.883
LCAPEFF	8.204	0.232	7.283	8.841
R	0.970	1.489	0.000	4.000
P	14.617	25.244	0.000	100.000
C	1.549	2.382	0.000	9.967
LGDP	0.507	1.1589	-1.812	3.340
UB	56.257	21.317	7.800	100.000
IN	31.974	9.925	12.774	66.530
EX	36.400	33.603	6.250	206.930
RISK	5.636	1.277	1.700	9.030

Table A3: Results for the Panel Unit Root Tests

Dependent Variable	LNG	LCAP	LGPE	LCAPEFF	LGDP
t-bar statistics	-2.1.783	-2.9400	-2.3728	-2.9635	-7.8654

The critical value at the 1% confidence level is –1.96.

L indicates logged values.