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A Survey of Empirical Evidence on Determinants

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CMI Working Paper

Electricity Sector Reform in Developing Countries: A Survey of Empirical Evidence on Determinants and Performance

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5 July 2004

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Abstract

Vast amounts of financial resources and effort have - driven by ideology, economic reasoning, and early success stories - been spent on reforming infrastructure industries in developing countries. It is, therefore, important to examine whether evidence supports verifies the logic of reforms. This paper reviews the empirical evidence on electricity reform in developing countries. We find that country institutions and sector governance play an important role in success and failure of reform. Also, reforms also appear to have increased operating efficiency and expanded access to urban customers. However, they have to a lesser degree have passed on efficiency gains to customers, tackled distributional effects, or improved rural access. Moreover, some of the literature is not methodologically robust and on par with general development economics literature. Further, findings on some issues are limited and inconclusive while other important areas are yet to be addressed. Until we know more, implementation of reforms will be more based on ideology and economic theory rather than solid economic evidence.

1   Introduction

Since the early 1990s, a large number of developed, transition and developing countries around the world have embarked on electricity sector reform. The pace and the extent of the trend has been remarkable and, by the end of 1990s, the majority of OECD countries and over 70 developing and transition countries had taken some steps towards reforming their electricity sector (Bacon, 1999; Steiner, 2001). This has occurred under a broad paradigm shift from state ownership and centralised organisation of infrastructure industries to private ownership, public regulation and market-oriented structures (OECD, 2000). The technological progress and reform pioneered in some countries has encouraged others to follow suit.

This trend primarily reflects dissatisfaction with the performance of traditional forms of organisation and a desire to improve efficiency and reduce fiscal drain in the public sector. Added to this is a growing questioning of the theoretical and empirical justification for state owned enterprise, the development of models of competition within network utilities and theories of incentive regulation of private natural monopolies (see Newbery, 1999).

The model adopted for the electricity supply industry (ESI) since the Second World War resulted in the use of costly generation technologies, neglect of customer services and economic inefficiency. Combined with the interruption of demand growth after the oil crisis of the 1970s, the traditional approach to the industry resulted in excess capacity. In addition, the perverse incentives of cost-of-service regulation had received serious criticism (Averch and Johnson, 1962). However, measuring inefficiencies and the effect of regulation has proven to be very difficult (Joskow and Rose, 1989; Joskow and Noll, 1981). Later, much of the debate on problems of regulation of monopoly firms has been focused on the issues of information asymmetry and incentives (see e.g. Laffont and Tirole, 1993; Sappington and Stiglitz, 1987; Baron and Myerson, 1982).

The argument for integration of generation and transmission systems was further undermined by the emergence of new technologies: combined-cycle gas turbines reduced the importance of economies of scale, information technology significantly improved remote monitoring and control of electricity flows (e.g. dynamic thermal circuit ratings (DTCR) and the Wide Area Measurement System (WAMS)).

However, the driving forces behind electricity sector reform differ considerably between developed and developing countries. In developed countries the principle aim has been to improve the economic and financial performance of technically reliable systems. A conjunction of circumstances also contributed to increase the pressure for reform.

In developing and transition countries the burden of subsidies, low service quality, non-collection rates, high network losses and poor service coverage have meant that many governments are no longer willing or able to support the existing arrangements (Newbery, 2002a; Joskow, 1998). Macroeconomic conditions played a rather more

fundamental role in developing economies. For example, in Latin America the debt crisis of the 1980s interrupted capital flows into the region and it became increasingly difficult for the public sector to maintain the required financing for infrastructure investment. Private ownership imposes hard budget constraints, ensures that bills are collected and increases revenue. Governments should note that, to privatise successfully, regulation needs to be improved. The regulation needed to support privatisation should ensure that prices are set at cost-reflecting levels which should, in turn, solve the twin problems of financing investment and reducing fiscal drain. Privatisation proceeds can also be used to alleviate the fiscal crisis by amortising debt and restructuring public sector liabilities.

International finance and development agencies were advocates of market-oriented reform in developing and transition economies. This background explains the appeal of privatisation and market-oriented reform in developing economies which, at times, preceded other necessary reform measures. Thus privatisation in Central and Eastern Europe preceded the establishment of effective regulatory institutions, and privatisation in many Latin American countries clearly sacrificed competitive market structure to the need to raise extra privatisation revenue (e.g. in Chile).

While many OECD countries, transition economies and a significant number of developing economies have taken concrete steps towards liberalisation, reform is only in its early stages in the majority of developing countries. In South Asia and sub-Saharan Africa, less than 20% of countries have taken key reform steps (Bacon, 1999). China and India, in particular, are both in the early stages of their electricity reform.

There are differing views and a degree of theoretical ambiguity in the economic literature on the effectiveness of privatisation and competition in network industries on issues such as the relative efficiency of privately vs. publicly owned natural monopolies, and gains from competition vs. economies of co-ordination in vertically integrated systems. In practice, the benefits of each reform and restructuring must more than compensate for the increase in transaction costs of unbundling vertically integrate systems (Joskow, 2002). The pre-reform literature suggests that publicly owned and privately owned firms were equally efficient (see Pollitt, 1995) and that there were substantial vertical economies associated with electricity generation and downstream wires networks (e.g. Kaserman and Mayo, 1991). The legacy of this literature still colours the debate in spite of post-reform evidence to the contrary, most powerfully demonstrated in the experience of the UK, Argentina and Chile.

In many countries, reforms have encountered significant difficulties and policy makers have found the reform path considerably more complex than anticipated (World Bank, 2003a). This is partly because electricity markets are characterised by the need for real time balancing of supply and demand (due to a lack of storage) and hence are required to be better designed and regulated than most other deregulated sectors. It is also clear that reformers underestimated the political difficulty in moving tariffs to cost-recovering levels, and the problems of corruption, patronage, labour opposition to reducing waste, poor collection and other fiscal leakage. Simpler reforms, such as encouraging Independent Power Producers to enter into long-term Power Purchase Agreements with financially fragile counterparts, stored up difficulties that were revealed by devaluation

and other macro shocks. Serious reform of the price setting mechanism for residential tariffs, combined with economically rational regulation, both central for revenue adequacy, were delayed or not recognised as important, or were derailed by intransigent price regulation.

At the same time, countries interested in reform, as well as international development and finance organisations, have to evaluate their options and policies towards the electricity sector in the light of recent blackouts in leading reform-countries such as Italy 2003, California 2001, Auckland, New Zealand 1998, and Chile 1998-99. As shown by the case of California's electricity crisis, the financial and political costs of flawed reforms can be unacceptably high (Newbery, 2002b; Joskow, 2001).

Within this context and in the light of accumulated experience from countries around the world since the 1990s, the empirical literature on reform can make an important contribution to the debate and, more importantly, inform policy-making decisions.

Organisation of the study
In this study, we present a critical review of the empirical literature on the determinants and performance of electricity sector reform in developing and developed countries. More specifically, the aim is to establish the extent to which the literature has: (i) resolved the theoretical ambiguities involved in the reforms, (ii) enhanced our understanding of the determinants of reform, (iii) contributed to the design of better reform models, and (iv) measured reform performance. We outline a conceptual model of electricity reform for the review that is largely based on the established structure-conduct-performance paradigm of industrial organisation. The study reviews the main research questions and hypotheses tested in the studies, assesses the methodologies and performance measures used, and evaluates the robustness of the findings. We then identify some additional hypotheses and issues that need to be addressed in order to improve the theoretical and empirical basis of policy debates on electricity sector reform in developing countries.

The next section outlines a theoretical and conceptual framework for examining the empirical literature on electricity reform, Section 3 reviews the empirical literature on electricity reform and other related studies in designated subcategories, Section 4 summarises the results and tested hypotheses in the literature, Section 5 outlines a set of untested research questions and hypotheses of interest, Section 6 is the conclusion and summarises the direction for future work. Section 7 discusses importance of empirical evidence for policy advice.

2   Theoretical basis

In principle, a reform should be undertaken if it will have a positive welfare economic impact. However, governments do not necessarily perform social cost-benefit analysis prior to reform and instead they tend to rely on less formal types of assessment (UNESCAP, 2001).

One of the main policy objectives of reform in developed market economies was to promote efficiency. There are different theoretical arguments on why private ownership and market-oriented reforms might lead to greater efficiency. Pollitt (2002) classifies the main relevant theories as: (i) property rights theories, (ii) bureaucracy theories, (iii) influence theories, (iv) economic regulation theories, and (v) commitment theories. On balance these theories predict that reform will lead to improved economic efficiency. Hart, Shleifer and Vishny (1997) suggest that public ownership is superior to private ownership only in a narrow range of circumstances.

In developing countries, the main policy objective is more likely to be a rise in the rate of investment and a reduction in the cost to the public budget. Increases in efficiency that reduce costs certainly help, but if prices are not able to cover both running and capital costs, investment will be either curtailed or financed at the expense of increasing public deficits. Private ownership offers the prospect of imposing hard budget constraints and the need for sustainable (full) cost-reflective pricing. Seen in this light, successful privatisation is a test of public commitment to address these fundamental problems.

The counter argument is that such privatisation requires the government to create credible regulatory institutions and to restore prices to cost-reflective levels, and if it were able to do that, then the sector's problems would have been solved. Much, then, depends on whether public sector regulatory prudence is better sustained with private ownership, or whether any government sufficiently capable of successful restructuring, regulation and privatisation would also be able to manage a publicly owned electricity industry competently.

Certainly, a poorly designed regulatory framework and lack of government commitment may negate the expected benefits of reform. Galal et al. (1994) stresses that arguments such as those explored by property right theories or by public choice and bureaucracy theories, are not applicable to all market structures. Also, De Fraja (1993) shows that, within the framework of principal-agent theory, public enterprise performance evaluation and optimal contracts can be more efficient than the profit incentive of private firms. In addition, Pint (1991) suggests that regulated private companies and public enterprises exhibit higher inefficiencies, the former in the form of excessive use of capital and the latter in the use of labour, than the second-best efficient solution in the presence of natural monopoly. Furthermore, Megginson and Netter (2001) in their assessment of empirical studies on the privatisation experience worldwide suggest that there exists strong evidence that privatisation improves operating performance.

At the same time, while the perceived benefits of private ownership and competition have constituted a 'pull' factor in the adoption of reform, the widespread adoption cannot be entirely explained by theory-informed economic policies and ideas. Indeed, most of the reform measures being implemented have been known for some time and their recent spread can hardly be explained as a consequence of theoretical innovations alone. Instead the pressure to privatise has been underpinned by a combination of long running problems of underperformance in state owned enterprises and observation of the successful privatisations of leading reform countries such as the UK, Chile and Argentina. This has facilitated the paradigm shift in the relationship between the state

and infrastructure and network industries can also explain a 'push' element toward the reform trend.

Schneider and Jäger (2003) identify three types of theory for the withdrawal of the state from infrastructure industries. They classify them into three main categories: (i) dynamic theories of diffusion and contagion - emphasising the inter-relationships and co-evolution of economies, (ii) structuralist and functionalist theories - stressing the inevitability of the withdrawal of the state as a consequence of structural changes in the economy and technological evolution, and (iii) actor-centred and institutionalist theories of political scope of action - opposing the notion of inevitable convergence across the countries and emphasising the feasibility of multiple and country-specific paths and models.

Although the emergence of the liberalisation paradigm for infrastructure industries may be explained in terms of pull and push factors, its macroeconomic effects are yet to be established. As Chang (2003) points out, historically in all developed economies the state and interventionist policies played an active role. Chang also states that there is no theoretical reason that a more liberalised economy will achieve higher allocative efficiency, or that higher allocative efficiency will necessarily lead to higher economic growth.

As discussed, the predictive power of theory is limited with regard to the outcome of the reform of natural monopolies (such as the network businesses of the electricity sector), as this is dependent on how the sector is structured and regulated. Therefore, in order to enhance our understanding of the reforms, it is useful to examine and compare existing experience and evidence on the performance and determinants of reform (see e.g. Jamasb, 2002; Pollitt, 1997). In particular there is much work to be done on the detail of best reform policy. Empirical studies, especially those of the type reviewed in Megginson and Netter's survey, tend to focus on simple comparisons of pre- and post-reform situations using narrow measures of financial and operating performance. As both reform and performance are multi-dimensional, it is important to examine the details of how each reform impacted on variables of socio-economic. The ability to do this is restricted by over-identification and a shortage of degrees of freedom. This makes econometric analysis challenging.

2.1   Framework for the study of electricity sector reforms

Electricity sector reforms are multi-dimensional activities with interacting factors and a variety of impacts. The process generally involves a set of concrete steps or measures based on a specific model of reform. At one level, these measures involve structural and organisational changes to the industry, and at another level there is a requirement for appropriate institutional arrangements such as legislation and new agencies.

In addition, sector endowments and characteristics such as size, resource mix, historical development, define the initial market structure and starting point and can influence the reform path and outcome. Market structure is then influenced by various measures, such

as unbundling of vertically integrated enterprises, as well as institutional factors such as regulatory authorities and legislation.

The multi-faceted nature of electricity reform results in a variety of outcomes so effectiveness and impact can be measured through different performance indicators, e. g. operating efficiency or increased investment. There can also be linkages between sectoral performance and the driving forces that trigger reform. These forces can be internal (e.g. poor sector performance) or external (e.g. foreign debt).

Figure 1 illustrates a conceptual model of the main aspects of a reform and their inter-relationships. The model is broadly along the lines of the structure-conduct-performance paradigm of industrial organisation. The model outlines the most important issues and causal effects that are generally involved in the reform. It also helps to place individual studies reviewed in this study in the wider context of reform to facilitate identification of research areas and questions that have received less attention. It is noteworthy that each component of this sector-level model can be thought of as having a counterpart in a higher or country-level framework of an economy. The remainder of this section outlines these aspects of reform in some detail.
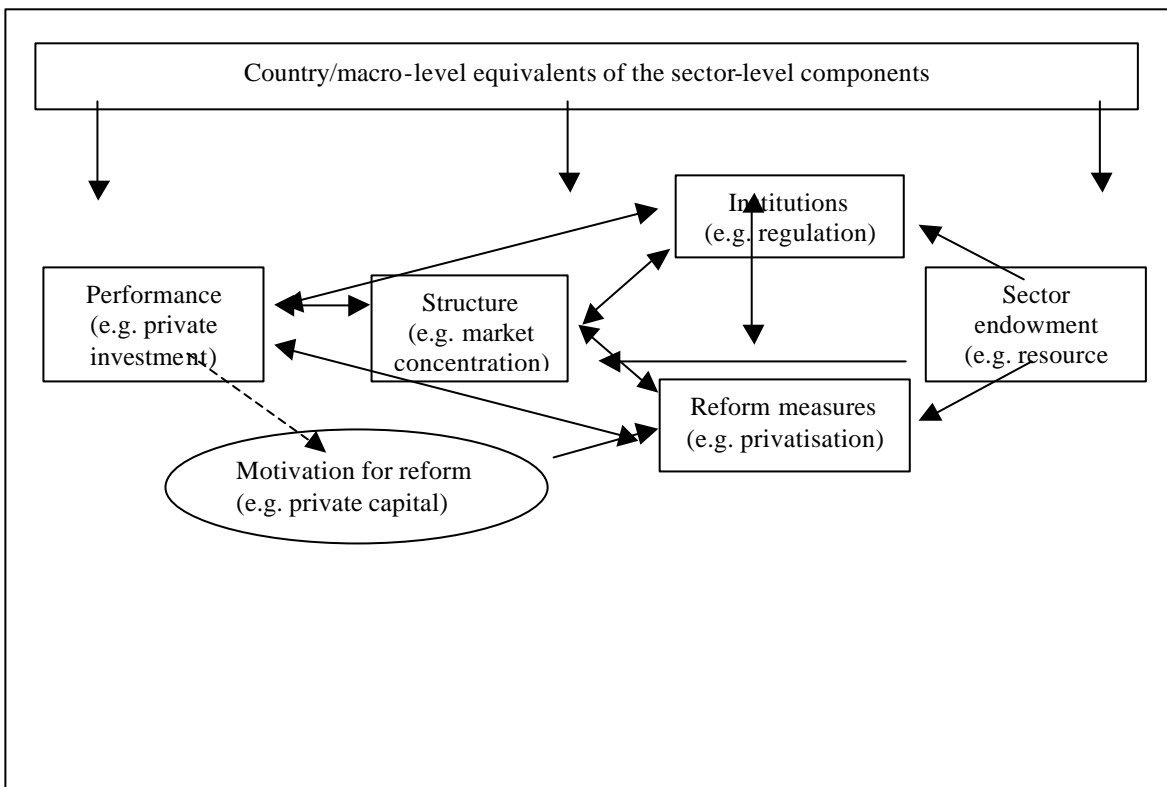
2.1.1 Motivation for reform

Actual reform steps, their sequence, and ultimately the reform performance, may be influenced by the motives (e.g. privatisation proceeds) behind the decision to reform. High electricity price levels may be an important driving force. Joskow (1998) points out that, in the US, states with the highest electricity prices were most likely to

implement reform. The main differences in reform issues, in both developing and developed countries, are often rooted in the determinants and driving forces behind reform.

In developing countries, the macroeconomic crisis of the 1980s created the need for a regime of fiscal responsibility. A combination of high levels of inflation, increasing debt burden and deterioration of the quality of public services, spurred political support for the liberalisation of infrastructure industries. Tariffs kept artificially low for anti-inflationary purposes meant that electricity utilities' self-financing capacity was increasingly eroded during the 1980s, affecting both investment and quality of service. Privatisation would improve not only the financial health of the sector, but would also increase revenue for state treasuries, so helping to reduce and restructuring public debt. In addition, new investment would be undertaken by the private sector.

The need to ensure expansion of capacity is of special importance to less developed countries where there are 1.7 billion people without access to electricity (WRI, 2002), and social and environmental considerations need to be integrated into reform design. The pressure for reform from donor agencies also reinforced the move towards liberalisation.

2.1.2 Elements of reform

The electricity industry is a network comprising separate but connected and closely co-ordinated, potentially competitive and natural monopoly activities. Also, historical development, institutional features and resources characteristics of power sectors can differ considerably across countries. Although there is a substantial variability in individual reforms, they generally involve a combination of the following key elements (see e.g. IADB, 2001; Joskow, 1998; Newbery, 2002a):

- Corporatisation of state-owned utilities;
- Enactment of an electricity reform law;
- Unbundling of vertically-integrated utilities into corporatised generation, transmission, distribution and supply activities, and where necessary horizontal separation of these;
- Provision of third party access to networks;
- Regulatory reform, including adoption of incentive regulation for the natural monopoly network activities;
- Establishment of an independent regulator;
- Establishment of a competitive wholesale generation market;
- Liberalisation of the retail supply market;
- Privatisation of electricity assets;
- Definition of rules concerning consumer protection, allocation of energy subsidies, and stranded costs.

A World Bank survey on the state of energy reform in developing countries focused on six key steps to electricity sector reforms: (i) corporatisation or commercialisation of the core utility; (ii) enactment of an 'Energy Law'; (iii) establishment of an independent

regulatory authority; (iv) restructuring of the core utility; (v) private investment in greenfield sites; and (vi) privatisation (Bacon, 1999). The survey suggests a sequence of key reform steps in which the most common component is corporatisation and commercialisation of publicly owned utility, and the least common step undertaken is privatisation.

It should be noted that not all the above reform elements will be appropriate in all countries. For example, a particular issue that arises is whether smaller systems require vertical separation and third-party-access. Studies such as those of Bacon do not attempt to evaluate reform effects but they do provide potentially important information on the extent of reforms which facilitates testing of the empirical impact of different stages of reform on performance.

2.1.3 Sector endowments

Specific reform measures and some features of market structure and institutional framework can generally be regarded as controllable. However, these, and ultimately the sector performance, are also influenced by such factors as size of the system, available resources for generation (in particular hydroelectric resources and availability of domestic sources of fuel,) interconnections, and geographical factors. While the sector-level endowments are given, they can exert considerable influence on the capabilities and options of individual electricity sectors.

2.1.4 Market structure

In our conceptual model of reform, the market structure component refers to the wider framework within which the interaction of supply of and demand for electricity takes place. At the time of reform this structure is the result of the sector's history, of resource endowment and of past policies. The initial structure defines the starting point of the reform and is a given factor. Important features of market structure are the composition of demand for electricity, degree of vertical integration, market concentration of generation capacity, production technologies and degree of market opening.

Reform measures change the market structure, and this has a direct impact on the behaviour of the market actors and consequently on the performance of the sector. Structural changes take time to implement and often generate opposition from vested interests. It is, therefore, important that the appropriate structure is envisaged from the start of the reform and where this does not happen, it can take some years to sort things out. For example: horizontal market power in the England and Wales electricity generation market resulting from the initial creation of a duopoly (Newbery and Pollitt, 1997); vertical market power arising from the joint ownership of the largest generation incumbent and the high voltage transmission monopoly in Chile (Basañes, Saavedra, and Soto, 1999). At the same time, shortcomings in the inadequate restructuring increases the need for future intervention and imposition of rules and regulation that can increase uncertainty and tend to be imperfect substitutes to proper structure and that increase uncertainty.

2.1.4 Institutional factors

Institutional factors refer to sector-level legal and regulatory framework that influence and support the continuity of the reform process. An electricity act or law is generally recognised as the starting point and prerequisite for implementation of reform. In addition, most market-oriented reforms involve establishing independent regulatory agencies to oversee the sector and to protect the rights of consumers. Effective regulatory practice requires clarity of the regulator's mandate and clarity of the rules defining her/his relationship with other bodies, such as competition commissions and relevant ministries. Regulators' power and independence is often interpreted as an indicator of the decision-makers' commitment to the reform process.

The main problem here is that it is very difficult to measure regulatory effectiveness as distinct from regulatory governance (see Domah, Pollitt and Stern, 2002). It is possible to develop a series of measures for the characteristics of the regulator, e. g. number of staff, age, pay scales, funding source and nominal independence, but these do not measure competence level or performance against regulatory objectives. Measures of regulatory effectiveness (or institutional quality) are extremely difficult to devise.

2.2   Empirical studies of reform

As noted above, the actual consequences of reform are a matter for empirical testing rather than theoretical debate. It is possible to point to spectacular reform failures. However, the main issue is whether evidence from a small number of reforming countries yields useful general lessons. What is needed is a comprehensive characterisation (including institutional, policy and market structure) of the nature of reform and its effects within the context of a well framed model structure.

The structure-conduct-performance paradigm of industrial organisation can be adopted to represent the main components of the conceptual reform model outlined in Section 2 and Figure 1, and their inter-relationships in the form of a stylised set of simultaneous equations in (1)-(4). Broadly, the model encompasses most types of research question and hypothesis associated with electricity sector reform though the lag structure may be more complicated than in the simple form represented here.

$$PI(t) = \quad f\,(REFT(t), MKST(t), INST(t), END(t)) \qquad (1)$$
$$REFT(t) = \quad g\,(PI(t-1), MKST(t), INST(t-1), END(t-1)) \qquad (2)$$
$$INST(t) = \quad h\,(PI(t-1), REFT(t-1), MKST(t-1), END(t-1)) \qquad (3)$$
$$MKST(t) = \quad k\,(PI(t-1), REFT(t-1), INST(t-1), END(t-1)) \qquad (4)$$

where:

$PI(t) =$	performance indicator in period t
$REFT(t-1) =$	reform type in previous period
$MKST(t) =$	market structure in period t
$INST(t) =$	institutional factors in period t

       END(t) =   endowments in period t

In practice, most empirical studies of electricity sector reform have addressed types of questions that fall under Equation (1), namely, the effects of reform steps such as competition, regulation, and privatisation on sector performance. Some studies have focused on how institutional and policy factors have influenced the extent of reform; using specifications such as in Equation (2). Such simple models raise issues of endogeneity, misspecification, and omitted variables bias.

In particular, the issue of endogeneity can be raised in nearly all of empirical studies of electricity reform reviewed in this paper. In the context of electricity reform, it is conceivable that just as reform steps can affect performance of the sector, performance can affect reform decision. Endogeneity can be addressed by using instrumental and lagged variables and dynamic modelling which in turn would require better data such as time-series tends to require. Gutiérrez (2003) in a study of telecommunications reform has explicitly addressed the issue of endogeneity. In fairness to the empirical studies of electricity reforms and as this paper points out, the general lack of good and suitable data is an obstacle to the conduct of better analysis.

The basic framework outlined above could be expanded to encompass more variables and more endogeneity. Poor specification or, indeed single equation analyses which do not attempt to address the issue of endogeneity, will give rise to indefensible empirical estimates and non-robust estimates. In analysing and undertaking empirical analysis we need to be aware of these difficulties and inference from empirical tests of complex inter-relationships.

Characteristics of the electricity supply industry and the multi-faceted nature of the reform give rise to a diverse range of important economic, policy, and institutional-related questions:

    ?   What are the elements of an effective reform (e. g. privatisation, competition, restructuring), their sequencing and interrelationships in different economic, political and institutional environments?

    ?   What is the appropriate design and institutional arrangement (e. g. oversight and regulatory authorities)?

    ?   Do some market designs perform better in certain countries and under some system characteristics than others (e.g. size and resource mix)?

    ?   What are the distributional implications?

    ?   What is the impact on quality of service?

    ?   What are the roles of "deep" and country-level factors such as the level of economic development, economic policies, and institutional?

Ideally, empirical analysis of electricity reform should address as many important aspects as possible, including an examination of simultaneity and the reverse causal effects of commonly tested hypotheses. The issue of simultaneity requires multiple equations to be specified. This gives rise to the well known trade-off between estimating a reasonably well understood single equation for which data is available but which takes no account of simultaneity, and estimating multiple simultaneous equations which may be less well specified and are more likely to suffer from omitted variables bias.

Many studies of electricity reform suffer from a lack of detailed data and many have used single equations. The attempt to gain a consistent picture of reform is complicated by a lack of comparability between different studies that use a wide variety of data and methods. Many studies use constructed indices to measure characteristics such as liberalisation, but particular care must be taken to avoid incorporating co-linearity with reform outcomes, or of imposing prior judgements of reform success which bias econometric results.

Data availability has considerable bearing on which questions may be asked, and even on how these can be addressed. A common difficulty is how to represent qualitative aspects of reform such as institutional factors or certain market structure characteristics. As these aspects are generally difficult to define and measure directly and objectively, a common approach has been to use proxies in the form of indices and categorical variables. In what follows we revisit and evaluate empirical studies of electricity sector reform in the light of the simultaneous equations model presented in this section.

3   Empirical studies of electricity sector reform

In this section we review the empirical literature on electricity sector reform. There is an extensive volume of literature on reforms but, in order to be useful for the purpose of our study, we have focused on studies that are primarily based on data analysis, or a logical framework or model for examining the evidence. There is an extensive literature that is merely opinion and discussion and so do not meet our requirement.

The literature reviewed here covers different methodologies and consists of cross-country econometric analyses of electricity reform, efficiency and productivity analyses of electricity companies and reform, general economic growth studies which have some relevance for electricity reform, and single-country case studies of electricity sector reform. We also add a brief review of some important case study literature from the UK where may be relevant for developing countries. The primary aim of this paper is to review and examine the extent of empirical evidence on electricity reform in developing countries and the level of detail in the review represents a balance between detailed analysis of individual papers and the need to cover all significant studies. The paper therefore aims to comprehensively assess the state of knowledge rather than to conduct a detailed review of the methodologies and technical merits of all the individual studies discussed here. It should be noted that many of the key papers and working papers subject to revision before final publication.

3.1   Econometric studies

In this subsection we discuss the empirical literature that uses econometric techniques to study electricity liberalisation assessment that uses econometric techniques. The reviewed literature can be broadly divided into two categories: the first focuses on the determinants of reform and the key steps taken, while the second examines the effect of various reform steps on performance indicators. We also review selected empirical

papers that do not directly address the impact of reform, but give insight into how to model and estimate the impact, and determinants, of reform.

Bacon and Besant-Jones (2001) test hypotheses on to the determinants of reform. First, that country policy and institutions are positively correlated with reform where reform is understood as a number of key steps, such as corporatisation of the core utility or enactment of legislation. Country-level policy and institutions are expected to be positively associated with reforms. This is to be expected because adequate macroeconomic management, policies and institutions should be conducive to more active reform. The country policy and institutional assessment variable is based on 20 indicators. However the indicators are not clearly identified – economic management and sustainability of reform are among those mentioned - and there is the risk that some may be co-linear with the reform indicator.

Second, that country risk is negatively correlated with reform; we would expect reform to occur with higher probability in countries with lower political and economic risk. Once again this variable is not clearly identified in the paper, though it is stated that it is made up of nine indices, of which political risk and economic performance account for 25% of the weighting. In the UK, political risk was reduced and economic performance was improved by privatisation rather than the other way round (see Pollitt, 2000), so the direction of causality is not always clear. These hypotheses are tested for a sample of 115 developing countries for 1998. Although formulated to address reforms in the electricity sector, they could refer to liberalising reforms in general, as both policy/ institutions and risk variables refer to overall management of the economy and of the public sector.[1] Therefore, it is implicit in the analysis that the relevant necessary conditions cannot be influenced by the decision-makers in the context of reform in the electricity sector. This is a strong assertion.

The results support both hypotheses: the coefficient on the policy indicator and the coefficient on the risk indicator are significant and have the expected signs. In addition, some regional effects are detected, suggesting that countries in Latin America and the Caribbean are more prone to reform while countries in the Middle East and Africa are more likely to have taken fewer reform steps.

Decisions concerning energy policy, such as choice of fuel for generation, are left out of the analysis, as is the size of the market. Other independent variables are in per capita terms. Similarly the key reform steps are assumed to be independent of the size and previous structure of the ESI. It would also be of interest to separate macroeconomic policy from institutions, i.e., to examine the extent to which macroeconomic policies matter after controlling for institutions. In addition, empirical studies of electricity sector reforms are often constrained by the availability and quality of data and the absence of dynamics in them. Bacon and Besant-Jones (2001) study is limited to cross-section regression analysis of data for 1998 but a temporal dimension could clearly strengthen the validity of the findings.

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[1] The only variable specific to the sector is the annual growth rate of energy use per capita (MWh per capita), which is an independent variable in the model.

In contrast to Bacon and Beasnt-Jones' ahistorical approach, taking into account the fact that reforms must be designed in the context of previous policy commitments, we can test the effect of energy endowment, dependency on fuel imports or environmental commitment. Drillisch and Riechmann (1998) test the correlation between energy dependency and the choice of liberalisation model, as well as between commitments concerning the environment and the choice of liberalisation model. The paper also incorporates the date in which reforms started – for each year of delay (relative to the 1990 benchmark) half a point is deducted from the liberalisation index. The study is limited to a cross-section analysis, and a time effect is not explicitly incorporated into the model. A temporal dimension is, however, incorporated into the model in the form of the impact of past decisions on energy and electricity dependency, or on environmental commitment.

Also, Drillisch and Riechmann (1998) do not see reform as a sequence of steps, but use two types of model: one for wholesale and one for retail market. There is no control for institutional conditions, macroeconomic policy, and level of development or market size. The only other factors included in the model are the level of prices (i.e. high prices induce liberalisation) and a cultural link to the United Kingdom. These are limitations that refer to the formulation of the model. Another drawback of the study is the very restricted dimensions of reform included in the liberalisation index. For instance, it does not take into account corporatisation, privatisation, restructuring, regulatory change and the introduction of an independent regulator. Further, Drillisch and Riechmann (1998) finds a positive link between import independence and liberalisation but, interestingly, the estimated overall energy independence index is more significant than the independency index of the electricity sector alone. The study fails to detect significant interdependence between environmental commitment and the choice of liberalisation model.

Ruffin (2003) reports an econometric study of the institutional determinants of competition, ownership and extent of reform (dependent variables) in electricity sector restructuring. The institutional determinants (explanatory variables) used are different measures of judicial independence, distributional conflict, and economic ideology. The study uses a cross-section OLS regression analysis of a set of models with observations of up to 75 developed and developing countries that undertook some steps toward electricity reform during the 1990s. The study finds that the relation between judicial independence on the one hand, and competition and ownership on the other, is ambiguous; i.e. the coefficients are often insignificant or, when significant, their sign shifts across models. The results also suggest that greater distributional conflict is significantly correlated with a higher degree of monopoly, while in ownership models, the coefficients are mostly not significant. Moreover, the results indicate that the relation between economic ideology favouring competition and private ownership is generally positive and significant. Control variables, such as parliamentary control over government or per capita income, do not add much to the results.

In addition, Ruffin (2003) uses institutional explanatory factors with the electricity reform scores (as the number of reform steps taken) reported in ESMAP (1999) which reflect the extent of reform, including competition and privatisation. In these models, judicial independence shows a positive, though not always significant, relationship with

reform scores. Further, distributional conflicts exhibit some positive (and significant) relation with the extent of reform, while economic ideology shows a positive and mostly significant relation with the reform score.

Most countries that have introduced competition have also undertaken privatisation, so obtaining similar tendencies in results from the models with competition and privatisation is only to be expected. A separate dependent regulation variable would also be a suitable complement to competition and privatisation variables. The dependent variables in the study aggregate relevant aspects of the sector, and do not separate the effect of the institutional factors on potentially competitive generation and regulated transmission and distribution networks. The relatively low R-square values (0.14 to 0.37) suggest that the examined institutional factors, although significant, explain a limited amount of the variation in the dependent variables.

The study shares some of the shortcomings seen in other analyses of electricity reform. An important issue is the definition and construction of variables that comprise different components. There is also a temporal problem: the dependent variables seem to be calculated for 1998, while the variables that are used for the computation of the independent and control variables are for different time periods. The study does not treat the endogeneity that this is likely to exist in this context. In addition, the study presents only R squares or p values for the regressions. For example, the Likelihood Ratio test could be used to examine the significance of the whole regression (where the null is specified so that all coefficients are zero and therefore the regression has no power in explaining the phenomenon).

While some studies examine the determinants of reforms, others focus on the effect of various aspects of reform (e.g. regulation, restructuring, and privatisation) on the performance of the sector. Steiner (2001) tests whether the regulatory environment, the degree of vertical integration and the degree of private ownership have an impact on efficiency and on prices. Efficiency is measured by capacity utilisation rate and reserve margin in electricity generation. Liberalising regulation, restructuring and private ownership are expected to lead to improved efficiency, and lower industrial electricity prices and industrial/residential price ratios. These hypotheses are tested for a panel dataset of 19 OECD countries for the period 1987-1996. There are controls for previous commitment to generation technology and the control for GDP serves as proxy for electricity market size. There are no controls for institutions or for macroeconomic policy.

Steiner (2001) finds that utilisation rate is positively and significantly correlated with both private ownership and unbundling of generation and transmission. The coefficient on third-party-access, however, is not significant. The results also confirm the hypothesis for the reserve margin, with the exception of third-party-access, which is again statistically insignificant. With respect to the impact on prices, the estimated coefficients on unbundling of generation and transmission, and on third party access are not significant. Contrary to expectations, the coefficient on ownership is positive and significant, which suggests that private ownership is not necessarily correlated with increased competition. The establishment of a spot market was found to lead to lower prices. The results of the price ratio indicate that the benefits of reform are

disproportionally realised by industrial customers. This is in line with efficient price rebalancing but this does raise the important political issue in many countries: that large customers are seen to disproportionately benefit from relative price changes following reform.

Hattori and Tsutsui (2003) argue that the precise definitions of the indicators are critical to this kind of empirical work. This paper reproduces Steiner's model for the same sample of countries, but for the period 1987-1999, changing slightly the definitions of regulatory reform indicators. In contrast to Steiner (2001), Hattori and Tsutsui (2003) find that the existence of a wholesale market is statistically significantly positive for prices. In addition, third party access is statistically significantly negative in Hattori and Tsutsui (2003) and statistically insignificant in Steiner (2001). Also, in contrast to Steiner's results, the sign of the private ownership coefficient is found to be significantly negative for prices. The sensitivity of results to subtle changes in the definitions of variables recommends caution in the specification of reform and performance variables. Therefore, as well as specifying the appropriate model to test relevant hypotheses, one should carefully consider how to define variables, especially how to represent the various dimensions of reform.

Another problem is the absence of considerations over market power. We expect market power to have an impact on performance but this is not controlled for in these studies. In addition, due to unavailability of data the impact on quality of service is not incorporated. Given the importance of quality to electricity customers in terms of security and reliability, this is a serious drawback that can only be tackled by better cross-country data – in particular, on the number and duration of power outages per year. Finally, there are the problems of time span and choice of sample. Considering the timing of reforms and the time span of these studies, privatisation often has the largest impact. The expansion of the time span would probably be useful to identify the effects of privatisation, restructuring, deregulation and competition. It would also be interesting to see to what extent the results hold for developing countries.

With respect to model specification and estimation, both Steiner (2001) and Hattori and Tsutsui (2003) use the same basic framework: a model that explains each performance measure as a function of country-specific effects, a set of controls – i.e. independent variables that influence performance but are not directly related to reforms – and a set of regulatory reform indicators. While Steiner (2001) only presents the results for random effects models, Hattori and Tsutsui (2003) presents results for both random and fixed effects estimation. Econometric theory suggests that fixed-effects model is an appropriate specification if we are focusing on a specific set of individuals (in our case, countries), and our inference is restricted to the behaviour of this set of individuals (see Baltagi, 1995). In contrast, the random-effects specification is appropriate when drawing individuals randomly from a larger population. If we consider (as in Steiner, 2001) that the relevant sample of OECD countries is drawn from a much larger population of OECD and non-OECD countries, the random effects specification is preferred. This approach can be strengthened by performing a Hausman test.[2] For both studies, the test indicates that a random-effects model should be chosen.

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[2] A specification test for fixed vs. random effects used with fixed-effect models. A large test statistic value indicates that fixed-effect specification id preferable.

Both studies do not include time effects, which are more relevant the longer the time series used, and the analyses take place in a static framework. However, perhaps the most serious caveat in the specifications is common to much of the econometric literature on policy impacts: the problem of endogeneity of the right-hand "independent" variables. As emphasised in Section 3, sector performance is not only influenced by reforms (Equation 1) but it can also influence the reform decisions (Equation 2). The standard remedy for endogeneity in a single equation context is to use instrumental variables. However, the challenge for the empirical literature is to identify appropriate instruments in the context of electricity reforms or to provide more carefully specified models that address the endogeneity problem. The problem of endogeneity in a dynamic context in which policy decisions can be influenced by past performance is a relevant research issue.

While the previous studies examine the impact of reforms on OECD countries, Zhang, Parker and Kirkpatrick (2002) aim to identify the effects of particular aspects of reform in developing countries. This study tests whether privatisation leads to higher operating efficiency and capacity utilisation, and to higher residential and lower industrial prices. Competition, it is hypothesised, should lead to larger capacity, higher output and greater labour productivity, and to higher residential and lower industrial prices. The existence of an independent regulator is expected to improve productive efficiency and to lead to higher residential prices. Privatisation with supportive regulatory framework in the form of independent regulation and commitment should lead to higher output and capacity. There are no controls for institutions and only limited controls for country economic conditions (e.g. GDP per capita, urbanisation, economic freedom, and industrial output as a percentage of the GDP). The absence of controls for macroeconomic reforms is especially serious as sector liberalisation in developing countries has often been accompanied or even preceded by extensive macro reforms. Perhaps the most significant drawback of this study is the use of 1/0 dummies to represent key variables of reform. Such a representation of privatisation places a leading reform country like Argentina in the same category as lagging performer such as Bulgaria. It is also the case that simple measures of regulatory independence need to be better specified, as nominal independence of regulator without transfer of key powers, such as final authority in price setting, will be misleading as to the true nature of regulation. Better data can help alleviate this type of problem, as can detailed case studies which can suggest what were the crucial powers of the regulator and particular combination of circumstances which led to successful or unsuccessful reforms.

Concerning the model specification, Zhang, Parker and Kirkpatrick (2002) propose (based on the argument that the sample is large relative to the entire population, and supported by a Hausman test) a fixed-effects model to account for unobservable country characteristics. Besides the more usual static panel model specification, the study estimates an equation including the combined effects of regulation and competition, and of regulation and privatisation. Another point that differentiates the specification in this study from studies is the use of a semi-logarithmic functional form. Although the choice of functional form is not completely resolved in the literature (and it is influenced by the

desire to achieve a better fit), one can argue that for low levels of reforms the impact of strengthening reforms is higher (Gutiérrez, 2003). In addition, as pointed in the study, another advantage of using the log-linear transformation is that it enables one to compute directly the elasticity of the dependent variable with respect to the independent variable. As in Steiner (2001) and Hattori and Tsutsui (2003), time effects are not included – the time span is larger, and it is easier to identify the shocks that affected all developing countries during the period – and the problem of endogeneity remains untackled. This is a major problem because liberalisation takes time to have an impact and the impact may be cumulative. Countries which liberalised early are more likely to show an impact in this study than those that liberalised towards the end of the period considered.

The results of Zhang, Parker and Kirkpatrick (2002) suggest that, if ownership change is to significantly improve performance, privatisation should be accompanied by competition and independent regulation. It is somewhat difficult to interpret the results as the regulation variable is mostly insignificant in the reported regressions, and when it is significant, and counterintuitive, regulation and competition together reduce efficiency. It should be noted, however, that in this study, measures of performance are rather crude single factor efficiency measures (electricity generation per capita, electricity generation per employee and capacity per capita) rather than cost per unit of electricity. The study rejects the hypothesis that privatisation *per se* leads to higher operating efficiency in terms of labour productivity. However, capacity utilisation does improve under privatisation, independently of competition and regulation. Consistent with another hypothesis, results suggest that privatisation will lead to increased capacity and consequently higher output, provided that there is a supportive regulatory regime in place. With respect to the effect on prices, the estimated coefficients are not significant for privatisation, and there is only partial support for the hypothesis that competition will lower industrial prices. Moreover, the results support the hypothesis that competition leads to higher capacity, output and labour productivity. The direction of the effect of having an independent regulator on productive efficiency is ambiguous (in the absence of privatisation). In addition, the estimation does not support the hypothesis that regulation will raise prices to domestic consumers. Although this study gives some plausible results it clearly does not address issues of simultaneity and it uses some problematic measurements of the underlying variables of interest.

Wolak (1997) tests the impact of market rules and market structure on the properties of spot prices. The econometric analysis is carried out in the context of specific countries – England & Wales, Australia, Norway & Sweden, and New Zealand. The study proposes a time series framework (a VAR model) to capture price movements in each market. The objective is to examine the relationship between market rules and market structure, and the behaviour of prices. The approach shifts the focus to price volatility, an aspect particularly important for developing countries and one that is usually absent – in the literature there seems to be a consistent focus on levels rather than growth rates. The study suggests that market structure and market rules both exert strong influences on the behaviour of prices, but further research is required to disentangle the two factors. In order to arrive at a better understanding of how the interaction of market rules and market structure allow the exercise of market power, a larger time series would be useful, especially one with comparable pre- and post-reform data. Also, the sample is

small and limited to developed countries. However, in order to extend the analysis to a larger sample more controls would have to be included.

One of the main drivers of reform in developing countries is the need to transfer the investment burden to the private sector, so the impact reforms exert on investment is a relevant topic for empirical analysis. Holborn (2001), Zelner and Henisz (2000) and Bergara, Henisz and Spiller (1997) focus on how political conditions and institutions influence firm-level investment decisions.

Holborn (2001) tests whether the probability of an individual firm's entry to a specific market increases with the amount of its prior experience on the same type of market. The firm's decision is influenced by the risk of expropriation, which in turn, is affected by previous experience. In contrast to the above studies, the dependent variable here is firm-level: the firm's decision to enter a specific country in a given year. A standard probit model is estimated by maximum likelihood. Different model specifications are estimated in an attempt to capture both the isolated and combined impact of independent variables. If the study includes country, market and institutional conditions, it fails to include all relevant aspects of reform. Important aspects of reform such as the type of regulation, vertical or horizontal unbundling are not included. Neither does the study examine the exit of firms from markets, assuming that firms do not exit countries they had previously entered.

Holborn's results support the hypothesis tested, suggesting that experience has a substantial impact on the probability of entry, but firms tend to concentrate on one type of market environment (either a competitive market or a monopsony). Experience in one type of market does not seem to spill over into investments in the opposite type of market.

Another relevant hypothesis to be tested with respect to investment is whether well-defined and credible political institutions are positively correlated with investment. The rationale behind this hypothesis is that with such an institutional framework, the risk of political expropriation is low. Bergara, Henisz and Spiller (1997) test this hypothesis for a reasonable sample of developed and developing countries, but only for one year, 1987. The results support the hypothesis and are not sensitive to the specific definition of the political variable used. Unfortunately they do not include post-reform data when private investments would be more sensitive to political and institutional factors. Another drawback is the use of generation capacity as a proxy for investment. This is a potentially serious measurement problem especially as the composition of investment between generation, transmission and distribution is likely to vary significantly from country to country. Some questions require further research: how do institutional conditions shape investment decisions? Are there any other factors that matter for the investment decision? Importantly, to what extent do investments improve institutional quality and reverse the causal relationship assumed in this paper?

Zelner and Henisz (2000) test whether the level of interest group competition has any impact on how institutions constrain investment decisions. The ratio of industrial to total electricity consumption is defined as a proxy for interest group competition and used as an independent variable. Zelner and Henisz (2000) test two types of hypothesis:

first, when facing strong interest group competition a utility will invest more in the presence of higher political constraints, *ceteris paribus*; second, when operating in an environment with relatively low political constraints a utility will invest more in the presence of weak interest group competition, *ceteris paribus*. The results suggest a conclusion that departs from the traditional institutional literature – when industrial representation among consumers is low, utilities would rather have lower political constraints. Therefore, there is more than political constraints to take into account when deciding on where, or how much, to invest. Again caution should be exercised when analysing these results, especially because they are based on crude constructions of political and group competition variables.[3] Besides, although the time span of the study is relatively long (1970-1994), the study does not control for any aspect of electricity liberalisation.

The econometric specification in Zelner and Henisz (2000) is sophisticated in comparison to other studies discussed so far. The panel model includes both country and time effects, and the problem of endogeneity is addressed by the use of time lagged variables which function as instruments. This introduces some dynamics into the analysis. Since the goal is to measure the impact of the level of political constraints on investment, conditional on the level of interest group competition, as well as the impact of interest group competition on investment, conditional on the level of political constraints, the model includes multiplicative interaction terms. In order to deal with potential problems of country-wise serial correlation and heteroskedasticity in the error term, the study uses an estimator based on the one developed in Newey and West (1987) to ensure consistency. In short, the econometric framework proposed in Zelner and Henisz (2000) gives valuable insight on how to improve the specification and modelling of the impact of reform on performance.

Finally, there are hypotheses which examine the impact of market structure and regulation on privatisation itself. Siniscalco, Bortolotti and Fantini (2001) test whether vertical integration has a negative impact on the number of privatisations and on the aggregate proceeds of privatisation. In addition, it tests whether regulation has a positive impact on the number of privatisations, on the aggregate proceeds of privatisation and on the percentage of privatised stock. The findings support the hypotheses and suggest that vertical integration is significantly negatively correlated with the number of sales and with the aggregate proceeds of privatisation. The regulatory index is positively and significantly correlated with the number of sales and with privatisation proceeds.

Considering that one of the main objectives of privatisation in developing countries was to improve the finances of the public sector, the question addressed is a relevant one – how Siniscalco, Bortolotti and Fantini (2001) address it is what seems to be the problem. There is one model specification for each dependent variable – i.e. number of sales, sales proceeds, and percentage of privatised stock. The first two models are specified as Tobit models, and the latter is based on OLS regression. The static models

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[3] The political constraint variable is constructed from information on the number of independent branches of government, adjusted to take into account the extent of alignment across different branches and of preference heterogeneity within each legislative branch. The interest group competition variable is simply the ratio of industrial to total electricity consumption.

proposed are rather limited, there are no time or country effects, no controls for macroeconomic reform or the size of the stock market, and not much is said about the error structure. In addition, the main explanatory variables are dummies.[4]

At this stage we can draw some conclusions from this brief review of econometric studies. First, at the current state of reforms in the electricity sector one should be able to work with panel datasets rather than simple cross-section models, preferably containing pre- and post-reform data. As observed in Fink, Mattoo, and Rathindran (2002), estimating a model containing time-series cross-section data usually implies a complicated error structure. Problems such as serial and/or contemporaneous correlation and heteroskedasticity should be addressed in the estimation procedure. Ignoring presence of serial correlation results in consistent but inefficient estimators. Similarly, assuming homoskedastic disturbances when heteroskedasticity is present will still result in consistent estimators, but correction for heteroskedasticity makes the estimation far more efficient (Baltagi 1995). Dealing with contemporaneous correlation across panels is a more complicated matter, considering the availability of data. The appropriate estimation that incorporates contemporaneous correlation would require as many time series as there are panels (in order to satisfy matrix invertibility conditions), which is usually not possible. For example, a dataset with panel of thirty countries would also require data for thirty years.

Second, especially when dealing with a varied sample of (developed and developing) countries and a larger time series, country and time effects should be included in the model. These should be included in the form of fixed effects when we are focusing on a specific set of countries. When we are drawing individual countries randomly from a large population, the use of a random effects specification is appropriate. To strengthen our choice we should perform a specification test (Hausman's test).

Finally, further empirical research should concentrate efforts in targeting the problem of endogeneity. This has been attempted for the telecommunications sector (Gutiérrez (2003)), but not so much for the electricity supply industry (with the exception of Zelner and Henisz (2000) of the papers reviewed in this Subsection). As suggested by our conceptual reform model outlined in Section 3, performance is not only influenced by reforms but also itself influences reform decisions. Gutiérrez (2003) proposes a dynamic model that uses lagged variables as instruments and show that neglecting the effect of lagged dependent variables may distort or overestimate the effects of all variables, including reform variables. Dynamic panel data modelling and estimation is one way to tackle the problem; however the estimation itself is not so straightforward when the time span is limited (as is usually the case for policy analysis). However, this problem becomes more tractable over time as datasets become larger.

4.2 Efficiency studies

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[4] The proposed regulatory index is actually the result of the interaction of three dummy variables. In addition, there is a dummy for vertical integration.

A number of studies have attempted to analyse the effect of reform on productive efficiency. The methods used can be classified into three categories: econometric production or cost models, total factor productivity (TFP) indices and frontier methodologies. In general the first two methods provides measures of technical change or TFP, assuming all firms are technically efficient. In contrast, frontier methodologies do not assume that all firms are technically efficient and, by the construction of a cost or production frontier, measure efficiency as the distance to the frontier. Therefore, each individual firm is benchmarked against best practice. Frontier methodologies also make possible the distinction between technical change (frontier shift) and efficiency change (move towards the frontier).[5] There are two widely used methods of constructing a frontier: Data Envelopment Analysis (DEA) or Stochastic Frontier Approach (SFA). DEA uses linear programming to calculate the frontier and SFA uses econometric methods to estimate the best practice or frontier.

Plane (1999) evaluates the impact of the privatisation of Côte d'Ivorie Electricity Company (CIE) on efficiency and on the distribution of welfare. Privatisation in this case has taken the form of a ten-year lease contract. The study uses a stochastic production frontier model to measure efficiency change and, in order to assess the distributional impact, it uses the surplus accounts method. The basic production model expressed gross generation (GWh) as a function of the installed generation capacity (MW) and the number of permanent employees. Other tested models include the ratio of customers to the length of the distribution network, with a binary variable to indicate privatisation. Parametric and non-parametric tests cannot reject the hypothesis of a significant performance improvement in the post-privatisation period relative to the immediately previous period. However, technical efficiency measures have behaved irregularly since privatisation. In addition, they never reach the annual values of the 1970s when the company was under close government supervision and hard budget constraint. In terms of welfare distribution, the main beneficiaries were consumers through a substantial price decrease. At the same time quality was improved and the number of customers supplied was increased by over 16%. These results are even more striking when we consider that the private administration had a commitment to retain the existing workforce and the level of nominal wages.

Considering that there was no restructuring (the monopoly of CIE remained unchanged) and the only change in the electricity sector was the privatisation of management, it is important to investigate what the driving forces of these positive results were and whether the experience can be transferred to other low-income economies, in particular to other Sub-Saharan countries. The author argues that the benefits stem from organisation innovations, especially decentralisation, reduction of hierarchy layers and managerial incentives. However, we observe that most of the efficiency improvement occurred after 1993, when a realignment of the exchange rate permitted an economic recovery. In addition, Plane points out that the private contractor had an interest in promoting similar arrangements in other African countries. More importantly, taking into account the long-term performance of CIE, especially under close government operation, it is not clear that partial privatisation was a first best solution for the country.

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[5] See Coelli et al. (1998) for a more detailed analysis on efficiency measurement.

Therefore, extreme caution should be exercised in the generalisation of the Côte d'Ivorie model.

While Plane (1999) focuses on management change, other studies examine other aspects of reform. Arocena and Waddams-Price (1999) and Hattori (1999) analyse the impact of regulatory reform. Arocena and Waddams-Price (1999) evaluates the effect of change in regulatory schemes on thirty-three publicly and privately owned coal-fired electricity generation units in Spain between 1984 and 1997. The study develops a DEA model and uses Malmquist indices. The DEA model uses generation capacity (MW), number of employees and volume of fuel as inputs. Besides the usual output – production (MWh) – the study introduces declared availability (MWh declared available) and three undesirable outputs (pollutants). This innovation captures important features of the industry in the efficiency measure. Given that the number of private and public companies is somewhat limited for DEA, efficiency measures are calculated using the *whole sample* (all time periods) as well as the average plant for each sector and each year. The results suggest that public generators are on average more efficient under cost of service regulation, while private generators catch-up and overtake the public sector under price cap regulation. As the Spanish experience provides data of both public and private operation under cost of service and price cap regulation, it allows the impact of regulatory change on a stable ownership environment to be measured. In most cases of reform, regulatory change is accompanied by other aspects of reform – restructuring and privatisation, for example. However, in the above paper, the effect of the type of regulation on the form of ownership is examined independently of a reform-related privatisation as, during the period under study, the ownership of the generating units remained unchanged.

Hattori (1999) assesses the impact of the 1995 regulatory reforms on the efficiency of Japanese electric utilities, focusing on fossil fuel generation. These reforms consist of the introduction of competitive tendering for new generation from IPPs, and of yardstick regulation which replaced the traditional rate-of-return regulation. The study estimates a parametric cost system by maximum likelihood. The approach models explicitly both technical and allocative inefficiency in the cost function, and estimates them together with technology parameters. The results fail to support the hypothesis of a positive impact of reforms on technical efficiency. However, these results should be taken with extreme caution. As is the case with much of the empirical literature on the impact of reform, Hattori (1999) draws its conclusions from the outcomes of the first years after reform. Actually only two years after 1995 are included. More precisely, our conclusion should be that regulatory reforms in Japan have not had short-term effects on efficiency.

Delmas et al. (2003) examine the short-term impact of supply deregulation on the productive efficiency of electricity utilities in the United States, and the relationship between the level of vertical integration and efficiency in a deregulated environment. The study uses DEA for the computation of efficiency scores and then develops a tobit model to test two hypotheses. The first is that, in the short-term, the greater the level of deregulation, the lower the level of technical efficiency of the utility. The second states that there is a U-shaped relationship between the level of vertical integration and efficiency. The rationale for this is that totally vertically-integrated firms are more

insulated from the uncertainty created by deregulation. At the other end of the spectrum, non-integrated utilities, by focusing on purchasing electricity in the wholesale market and selling it to consumers, will be able to adapt more quickly to the new deregulated environment. As input of the DEA model the study uses several variables to incorporate operating costs and capital costs, as well as the costs of electricity purchased. The volume of sales (MWh), discriminated by type of customer, is used as output. Deregulation, level of vertical integration, competition, economies of scale, mergers, generation technology and location are the independent variables that explain the behaviour of productive efficiency.[6] The results are supportive of both hypotheses. The limited time span of the paper is a drawback. Although its objective is to measure short-term effects, even this could be improved if it was possible to examine the long-term evolution of efficiency. Also, it is not clear whether changes in fuel prices may have affected the results. A further problem is the number of categorical variables used to represent the various aspects of reform while there are no controls for economic changes and for state characteristics, such as urbanisation or density.

It is not clear that Delmans et al.'s use of DEA is appropriate. DEA is generally most useful for comparison of similar activities and technologies such as distribution networks or specific type of power plants and suitability of the technique for mixed units such as vertically integrated firms is limited. Nearly 50 percent of the over 700 observations in Delmas et al. appear to be on the efficient frontier that is a rather high share while a fair number of firms get very low scores. Moreover, second stage Tobit regression on DEA scores is generally performed for the purpose of adjusting efficiency scores for factors that are beyond the control of the management of the companies. Furthermore, statistical significance can be different from sizeable impact on measured relative efficiency. Finally, a lower efficiency score for a given firm in one period relative to an earlier period indicates a decline in relative efficiency but does not necessarily represent an absolute decline in the efficiency of that firm.

Similarly, Pardina and Rossi (2000) study technical change in a sample of electricity distribution companies in South America. The technique used is the estimation of a stochastic frontier production function. The objective is not to study the impact of reforms, but to aid the setting of the X factor in a price cap regime. Nevertheless, the production function includes a dummy to indicate whether the firm belongs to a country which has already reformed its ESI. The dependent variable is the number of customers. Distribution network length, number of employees, service area, transformer capacity, the proportion of sales to residential customers, total sales, and an interaction variable between time and a reform dummy are the regressors. The model also includes a time trend. A sample of 36 distribution companies from ten South American countries should provide a comprehensive outline of the industry in the continent, but the data is not available for all years (1994-1997) for each company, and as a consequence the time-series cross-section data is unbalanced. The results fail to reject the hypothesis of no change in inefficiency effects over the period 1994-1997. In addition, there is only partial evidence of correlation between reforms and performance. Only when more interaction variables are included are the coefficients significant. There are not many

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[6] Deregulation here includes not only regulatory change but also the enforcement of restructuring or divestiture.

efficiency studies on the Latin America electricity sector, and Pardina and Rossi (2000) introduce data from a reasonable number of distribution companies. However, there is room for improvement, especially in the formulation of the reform variable and of the production function, and in the organisation of a more balanced dataset.

Whiteman (1999) evaluates the macroeconomic impact of microeconomic reform of the Australian ESI. This study supplements macro considerations to the usual efficiency analysis. The paper uses Data Envelopment Analysis and Stochastic Frontier Analysis techniques to measure inefficiency. Then it introduces the calculated potential increase in total factor productivity (TFP) into a computable general equilibrium model (CGE). Besides the problems of parameterisation, one of the common criticisms to the use of CGE models is that they cannot incorporate all the important details of the reforms. By preceding the CGE experiment by efficiency analysis the problem is at least partially addressed. However, the paper benchmarks the performance of Australian utilities with an international sample and this might overestimate the potential increase. The results rely upon the sample used for benchmarking. The study estimates a 0.22% increase in GDP in the long run as a result of the reform, which is less than the direct benefit. This result relies on the assumption that there is no increase in aggregate employment stemming from microeconomic reforms. As a consequence, the benefits of the reform are reflected in terms of rise in real wages rather than an increase in employment. The increase in real wages adversely affects the terms of trade, which in its turn has a negative impact particularly in industries that rely heavily in exports. Hence the final impact is less than the direct benefit of the reform.

3.3   Determinants of economic growth

The electricity sector operates within the wider economic system. It is, therefore, plausible to expect that the sector is susceptible to influence from high-level country-specific factors that influence the overall economic framework. Indeed, the components of the electricity reform model outlined in Figure 1 can be thought of as having economy-level counterparts. For example, reform measures can be likened to macroeconomic policies while reform performance can be compared to economic indicators such as income per capita. Also, institutional aspects of the sector such as legal basis and regulatory regime, have high-level parallels such as rule of law and property rights. Similarly, sector endowments such as energy resource independence is comparable to the countries' geographical and resource advantage and so forth.

In order to improve reform design, it is important to identify the main factors affecting the reforms and their performance. More specifically, it is important to enhance our understanding of whether or to what extent these factors (i) are sector-level or economy-level variables, (ii) exert a direct or indirect influence, and (iii) are given or controllable factors? Some recent studies of determinants of economic growth have addressed these types of questions and can guide the design of similar studies of electricity sector reform. The findings of these studies emphasise imply the need to examine the importance of sector-level and country-level institutional factors and their interactions with endowments and policies. This section is not a review of the literature on economic

growth but merely highlights the relevance for electricity sector reform of some studies on general economic development.

For example, Easterly and Levine (2002) examine the effect of quality of institutions, endowments, and policies on economic development, in terms of GDP per capita for a large sample of countries. The study suggests that quality of institutions has significant influence on economic development. The findings indicate that country endowments do not exhibit independent influence over economic development, rather, they have an indirect effect through their influence on the quality of institutions. Similarly, macroeconomic policies of the countries, after controlling for the effect of endowments on development through institutions, do not show significant effect on economic development. The study highlights the need to include appropriate institutional variables in the analysis of sector-level performance.

Rodrik et al. (2002) examine the importance of institutions, geography and trade on income levels in a large sample of countries, and suggest relatively similar results for the role of institutions. The study finds that the main influence of geography on income level is through its effect on the quality of institutions. Also, trade does not show a significant independent effect on incomes, although it has a positive impact on institutions. The paper also points out a difference between the nature of institutional and policy variables when studying income levels. It argues that institutions can be regarded as stock variables that also represent the accumulated influence of policies through time as flow variables. The paper suggests that it is more appropriate to estimate the impact of policy variables on income growth instead of income level.

In another paper, Acemoglu, Johnson and Robinson (2001) examine the effect of the colonial past of a sample of developing countries on the quality of institutions and ultimately on their level of economic development. The study finds evidence that in countries where the mortality rate among the European settlers were high, the institutions established by them were of extractive nature, that is, mainly intended to repatriate the profits back to their home countries. The study suggests that institutions have important effect on income levels and, when the effect of institutions is controlled for, the income levels in countries with low-quality and high-quality institutions is not very different.

However, other studies have argued that assuming an exclusive influence from and through institutions on economic development, exaggerates their importance. McArthur and Sachs (2001) and Sachs (2003) find that geography and related variables, such as malaria and life expectancy at birth, can also exert independent influence on economic development beyond their impact through affecting the quality of institutions. Rodrik (2003) also offers a complementary view of policy and institutions. This view holds that while policies are important in order to initiate reforms, appropriate institutions are needed to sustain continuity and the dynamic of the reform process.

In a different type of study, Cohen and Soto (2002) show that the combined effect of modest relative deficiencies in some key variables of economic development can produce considerable cross-country differences in income level. The paper uses a sample of developing countries where physical capital, human capital, and factor

productivity are approximately 70% of those of rich countries. The paper however suggests that the combined effect of the disadvantages in these factors result in a per capita income that is approximately 30% of that of rich countries.

Almeida and Ferreira (2002) examine an interesting issue in the context of general economic performance. The study finds evidence that centralised countries have a more volatile economic performance than less centralised countries. Such a hypothesis has not been tested for sector level performance (pre-reform as well as post-reform). However, if this result does apply to sector level performance, then, as volatility in the electricity sector has considerable political, social and business implications, it need to be considered in the reform design.

As we saw, while there is some evidence in support of the importance of institutions on economic development, the main sources of this influence are less certain. In the context of electricity, it is useful to determine what factors have an impact on the institutions and whether they exert an independent or indirect influence on the performance of reform.

The aforementioned studies of the electricity sector in Bacon and Besant-Jones (2001) and Drillisch and Reichmann (1998) examine aspects of the role of institutions, policies, and endowments as determinants of reform. There is however considerable scope for improved modelling of institutional and country development variables in sector specific studies. This is important because reforms need to be appropriate for the general economic circumstance of the country.

3.4   Country case studies

Cross-country econometric and productivity analysis can be useful for addressing well-defined questions associated with reform. These questions are addressed using a limited number of variables that are similar in measurement units and are comparable in what they represent. However, the issues associated with model specification and accuracy of variables in representing the relevant aspect of reform pose limitations on these types of studies.

The multi-faceted nature of reforms and the varied characteristics of the sector across countries, mean that case studies can address issues that do not easily lend themselves to rigorous quantitative analysis, or could not be addressed due to lack of data. Further, results suggesting that, on average, there is a statistically significant correlation between a dependent variable and certain independent variables, have limited relevance to decision-makers concerned with individual sectors. Further, in electricity reform, dynamics, such as the implementation process, and qualitative aspects, such as regulation and conflict resolution are crucial and, at the same time, inherently difficult to capture through statistical methods.

Case studies can play a complementary role in understanding complex questions and multi-dimensional activities such as electricity reform. A statement in Rodrik (2003) made in the context of general economic development is also valid in the case of

electricity sector reform: *"Ideally, case studies can generate novel hypotheses that in turn suggest new cross-national tests. A claim based on case studies that does not find support from cross-country regressions requires close scrutiny. By the same token, any cross-national empirical regularity that cannot be meaningfully verified on the basis of country studies should be regarded as suspect"* (pp. 10*).*

The main performance tests of a reform are whether: (i) restructuring, privatisation, regulation, and competition result in efficiency improvement, (ii) the benefits exceed the associated costs, and (iii) the gains are passed on to customers. This section reviews the case studies of electricity sector reform. As reforms in different regions of the world share some common traits, the structure of this section is based on a regional divide.

3.4.1 Latin America

An intriguing aspect of electricity sector reform is that the first such reform was introduced in Chile in the 1980s; a developing country with a small system, weak rule of law and weak democracy. Generally, these qualifications are regarded as major obstacles to market-oriented reform with private sector participation. However, electricity reform in Chile appears to have fared relatively better than most other developing countries that reformed later despite having the benefit of experience from other countries. The relative success and length of the Chilean reform experience can provide insight on long-term performance of reform generally.

Galal, Jones, Tandon, and Vogelsang (1994), in one of the first and most comprehensive studies of reform analyses the welfare implications of privatisation of state-owned enterprises. The study is among the first to emphasis that privatisation of natural monopolies, when combined with proper regulatory framework, can be welfare-enhancing. The majority of the cases examined in the study were taken from developing countries which included the privatised Chilean electricity companies ENERSIS (an electricity distribution company) and CHILGENER (a power generation company). The study finds that privatisation of the two Chilean firms produced significant new welfare improvements. However, the gains were achieved at a fiscal loss to the government and (expectedly) a welfare reduction for non-payee customers.

In Chile, following the reform, operating efficiency of the electricity sector has shown significant improvement. For example, labour productivity in generation has increased and energy losses have declined (Figures 2 and 3). At the same time, there has been a considerable decrease in electricity prices (Figure 4). In Argentina, the installed generation capacity has increased and operating performance in terms of plant availability and labour productivity has improved (Figures 5 and 6).
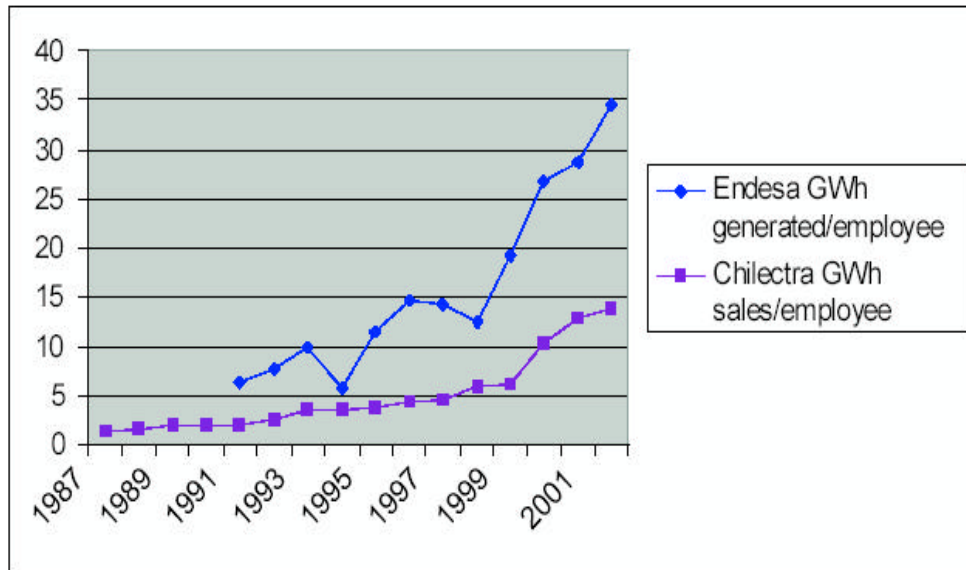
Figure 2: Labour productivity since privatisation in leading Chilean electricity companies
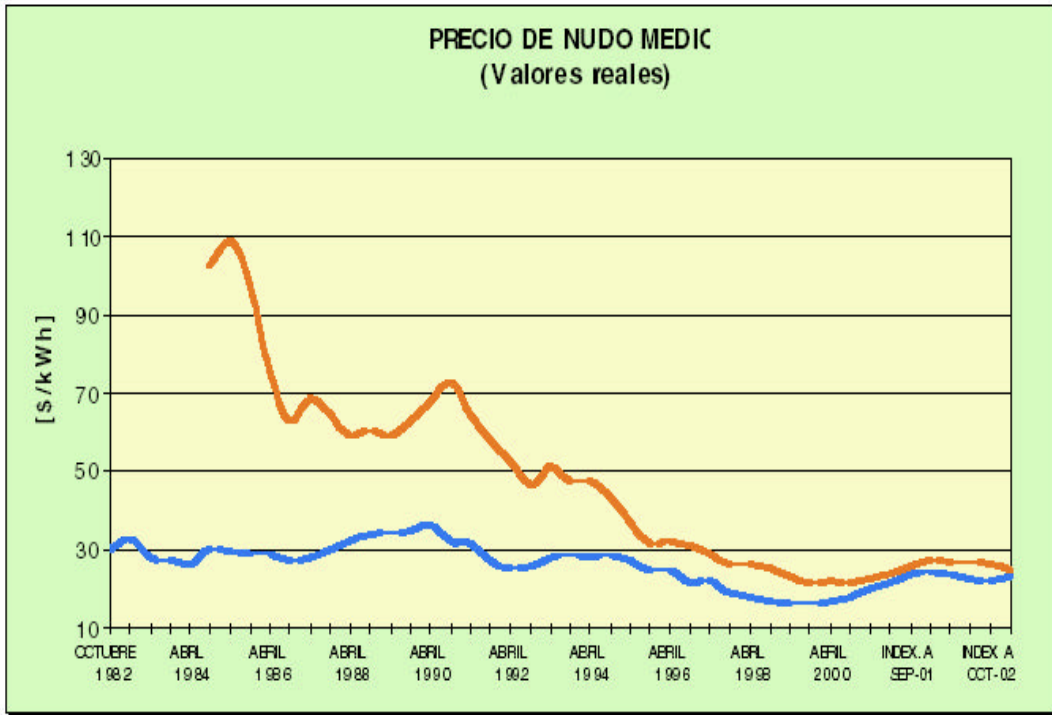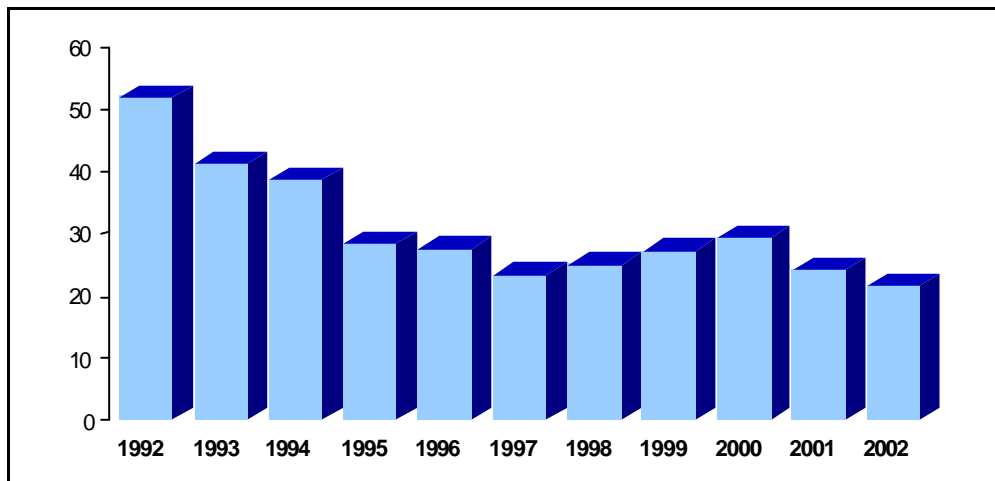**Source: Fischer, Gutierrez and Serra (2003, p.42-43) and annual reports**
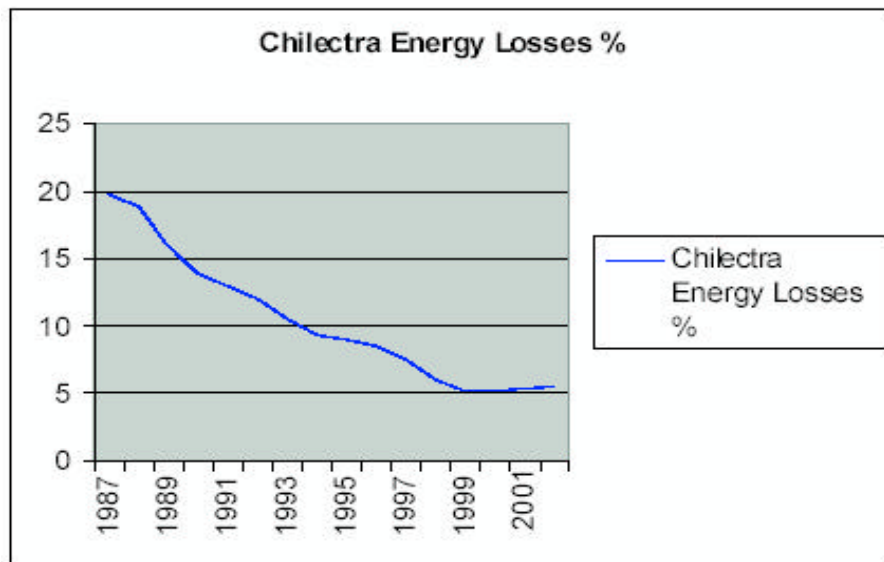
Figure 3: Energy Losses (Technical and Non-Technical)
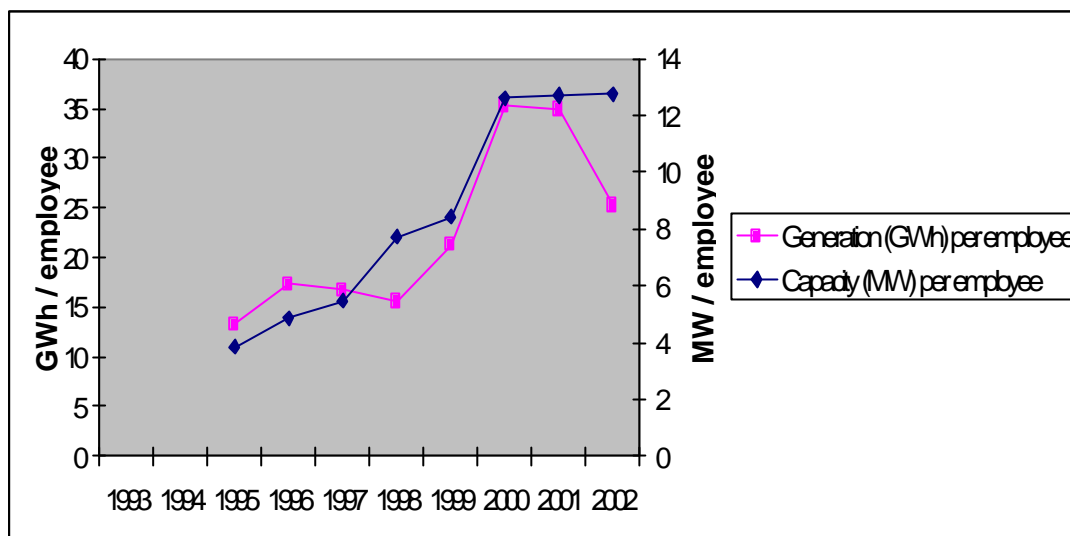**Source: Fischer, Gutierrez and Serra (2003, p.42) Chilectra Annual Report 2002**

Figure 4: Average node prices - SING (top) and SIC (below) systems (2002 prices)
Source: www.cne.cl

Figure 5: Thermal plant unavailability (% of capacity unavailable)
Source: ENRE

Figure 6: Labour productivity in Endesa Argentina generation
Source: Endesa Annual Report 1999 and 2002

Since Chile, several Latin American countries have embarked on extensive economic reform programmes with privatisation playing a central role. A review of the privatisation experience in Latin America suggests that ownership change, although competition and effective regulation has not always been present, has improved the financial and operating indicators of the sectors (see ESCAP, 2001).

Fisher, Gutierrez, and Serra (2003) addresses the effect of the privatising several sectors of the economy in Chile on efficiency of firms and social welfare. Although privatisation of the electricity sector was part of a larger reform program between 1985 and 1989, the proceeds from the sale of the assets in this sector accounted for about half of the total proceeds in this period. Between 1988 and 2000, the installed capacity of the system has grown from a small size of 4,016 MW to a medium size of 10,045 MW.

The study finds that since privatisation investments have risen, unit costs of declined, energy losses have fallen, labour productivity has increased and end-user prices have declined (although mostly due to lower fuel prices). However, it is noted that prior to privatisation, while the firms were making large losses around 1974, by the time of privatisation they had become profitable. The study finds a moderate profit increase in generating firms. The profits in the distribution firms, where regulation has been relatively weak, appear to have been stronger. The study concludes that regulators have been unable to pass all the benefits to customers.

The study shares a common shortcoming of multi-sector case studies. While it is useful to view the reform aspects in specific sectors in a larger context of economic reforms, there tends to be a trade-off in the form of limited in-depth analysis of individual sectors. The paper compares the before and after performance of the major electricity firms using t statistics. However, a counterfactual for the post privatisation period is not considered, and there is no formal analytical linkage between the performance improvements on the one hand, and the impact of price reductions on consumer welfare

and distributional effects on the other. Also, there is a lack of clarity on the extent to which some general statements on regulated and non-regulated firms apply to the electricity companies.

Paredes (2001) discusses the efficiency and welfare aspects of privatisation process and regulation of telecommunications, electricity and water industries in Chile. The study indicates that electricity privatisation has led to reduced energy losses, higher profits, and increased access for low-income groups. Also, prices appear to have fallen following privatisation, although establishing the causal effect is complicated by hydrological conditions. It should, however, be noted that the price impact might be due more to the targeted subsidies and electrification policies than privatisation per se. The paper argues that opposition to privatisation came from better-off consumers and workers and was due to uncertainty. There was little opposition from the poorest groups due to their limited ability to mobilise political resources. The paper also argues that privatisation gains have overwhelmed the losses from weak regulation. Although the study does not contradict the main findings of Fisher et al. (2003), it shares the same shortcomings of the study in terms of depth and linkage between performance and welfare impacts.

Di Tella and Dyck (2002) examine the procedure for determining the distribution tariffs and occurrence of strategic behaviour associated with price-cap regulation of electricity distribution utilities in Chile. The findings indicate that the firms' costs were on a downward trend, but one year in four they were about 1.4% above trend. These cost reversals occurred in the year preceding a price review. The observed cost increase appears to lead to higher returns in stock prices of the firms. Di Tella and Dyck suggest that this reflects perverse incentives in the system of regulation, whereby higher costs in the year of price determination lead to higher prices in the following control period.

Many of the problems encountered in electricity sector reform have been attributed to failure to establish an appropriate regulatory framework that ensure well functioning of the restructured sectors. Although there is an extensive literature on the importance and proper characteristics of regulatory frameworks, the theoretical foundations of the subject are less well developed. Heller and McCubbins (1996) is a systematic approach to the analysis of political factors influencing regulatory governance. It proposes a theory and model of regulatory commitment and credibility designed to promote private sector participation.

The proposed theory is applied to a comparative qualitative study of electricity regulation in Chile and Argentina though the framework of the study is applicable in other contexts. The study examines two hypotheses: (i) assignment of agenda control over regulatory policy changes, the definition of revisionary regulatory policy, and the number of veto gates are determinants of regulatory predictability, and (ii) unity of purpose among policy makers and separation of powers are determinants of regulatory regime stability. The paper argues that both countries have arrived at relative regulatory stability over time. It also suggests that, while the development in Chile has been steady over time, the process has been more erratic in Argentina. However, the study does not discuss the importance of political and institutional endowments as important determinants of predictability and stability of regulatory regime. Moreover, the study

dates back to 1996 and, therefore, precedes the macroeconomic crisis that eroded much of the achievements of the regulatory regime in Argentina.

In Argentina, the majority of state-owned firms were privatised between 1989 and 1993, with privatisation proceeds from the electricity sector amounted to about 25% of the total. Delfino and Casarin (2001) examine the welfare impacts of the program in the Gran Buenos Aires area of Argentina, using a family expenditure survey of about 5,000 households. Between the time of privatisation and the end of 1999, expenditure on electricity in real terms for a representative small consumer (average monthly maximum consumption <150 KWh) increased by about 20%, while an average large user (>150 KWh) enjoyed a tariff reduction of about 23%. The paper shows that nearly all income groups among the existing customers increased their consumer welfare after privatisation, with the exception of the lowest income group. The results indicate that higher income groups have, in absolute terms, benefited more than low-income groups, although in percentage terms, the benefits are more similar. It also finds that losses to the poor are lower than the reduction in variable charges to high consumption customers. Also, new customers enjoy higher welfare measured as the difference between the cost of provision of access and consumer surplus.

Ennis and Pinto (2002) examine the effect of privatisation on income distribution and the welfare of the poor. Argentina's macroeconomic performance in the 1990s as measured by inflation control, growth and budget deficit was positive, but weak on unemployment and inequality. Privatisation of the electricity industry resulted in increased collection rates and improved quality of service. Cross-subsidies were eliminated and the government financed some of the subsidies. Household survey data shows that between 1985/6 and 1996/7, the budget share of water and electricity rise sharply for the lower deciles. In real terms electricity prices for residential users, inclusive of taxes, remained stable, while pre-tax prices are 12% higher. At the same time, prices for industrial users decreased by about 7%. Prices were still low by international standards. Access to service for the poorest groups rose sharply: residential service in Buenos Aires area increased from 65% in 1985/6 to 99% in 1996/7. The estimated change in consumer surplus between 1985/86 and 1996/97 show substantial welfare gains, especially for lower income deciles due to increased access and lower prices.

The paper, however, points out that the results can be sensitive to the choice of years. The collective fiscal effect of privatisation of electricity and other industries was also significant. The privatisation proceeds amounted to about one-third of the government bonds outstanding in 1990. The sale of assets allowed the government to repurchase some bonds and, thereby, reduce interest payments. The falling public debt and reduced expenditures on utilities was accompanied by increased social expenditures. At the same time, between 1992 and 1999 the dividends paid by the privatised firms amounted to an average of 38.5% (increasing from 12% ($US 159 mill.) in 1992 to 64.1% ($US 1,670 mill.) in 1999) of the all dividends paid. However, it is argued that the distributional impact of all dividends has been limited as some individual and employees owned part of the issues shares.

The performance of the reform in Peru is somewhat more mixed. Torero and Pascó-Font (2003) show that privatisation and reform of the electricity sector between 1994 and 1997 has brought about significant improvements in access to services, labour productivity, quality of service, and energy loss reduction. At the same time, from 1991 to 1994 and in 1997, there was a significant decline in consumption for all income quintiles. This is evidently the effect of the upward price adjustments that started prior to privatisation. Price increases have resulted in a reduction in consumer surplus, although the decline has been greater for the high-income quintiles. However, it is noteworthy that the pre-reform tariff levels were below average operational costs of the sector, and the coverage ratios and resulting losses accrued to the sector in 1989, 1990 and 1991 amounted to 39% ($US 426 mill.), 74% ($US 302 mill.), and 92% ($US 38 mill.) respectively.

The main considerations when designing wholesale electricity markets are efficient pricing, control of market power, and correct signals for new entry and investments. In Argentina and other countries such as Chile, Bolivia and Peru wholesale markets are structured around cost-based bidding arrangements combined with capacity payments. At the same time, the relatively high degree of market concentration in Latin American sectors has been a source of market power that can distort both short-term prices and long-term investments. Ferreira (2002) examines the effectiveness of the Argentinean market in avoiding market power and providing signals for efficient capacity expansion by analysing cost, price and operational data for the year. A model of optimum capacity expansion developed in Chao (1983) is used with data for the 1992-2001 period to examine the social desirability of the sector's capacity expansion pattern. The study suggests that the price volatility in the last months of 2000 cannot be attributed to the exercise of market power. Moreover, the results indicate that the market design has offered proper signals for optimum technology mix and capacity.

A cost-based market for bidding deviates from both the theoretical models and from arrangements established in developed countries. However, in the light of political and social sensitivities, and high economic costs of design failure, they may be a workable middle way. The main advantages for developing countries, are their relative ease of implementation and lower likelihood of extreme price fluctuations. Despite the findings of the study, the overall experience in several Latin American countries has not been free from problems. Contract renegotiations and conflicts have been common-place as a result of rent-seeking behaviour, complexities arising from resource-mix, and flaws in market design (Benavides and Fainboim, 1999; Abdala, 2001; Basañes, Saavedra and, Soto, 1999).

Depending on market design, a degree of volatility or variability may be necessary in order to allow firms to cover their fixed capital costs and to encourage system expansion. Benavides (2003) argues that, if intervention removes quasi-rents from high-price periods in which firms recover their capital costs firms will seek or require other arrangements, such as capacity payments, to finance these costs.

Recent theoretical developments in regulatory economics have not been able to resolve the increasing demand for sustainable regulatory design and process (Crew and Kleindorfer, 2002). At the same time, the importance of having an appropriate

regulatory framework for effective competition and privatisation on the one hand, and transference of efficiency gains to customers on the other, is increasingly recognised and stressed in the reform literature (Brown, 2002). This emphasis on the importance of regulatory reform is also in line with the findings of the econometric studies reviewed in this paper.

Chisari, Estache, and Romero (1997) use a fixed-price, general equilibrium model and data from 1990/91, 1993, and 1995 to quantify the importance of effective regulation when Argentina deregulated its infrastructure industries. The findings suggest that between 1993 and 1995 the savings from operational gains for all utilities sectors combined amounted to 41% of household expenditure on utility services (i.e. US$ 2.3 billion or 0.9% of the GDP). Using a flexible-price model, the gains from efficient regulation are estimated at about 16% or US$ 0.9 billion. The results also suggest that while the operational gains (in term of percentage of household expenditures on utilities services) to the high-income groups were larger, gains from effective regulation also benefited low-income groups. Moreover, between 1993 and 1995, the gains from electricity generation with fixed-price and flexible-price models amounted to 0.05% and 0.1% of the GDP, while the gains for electricity distribution amounted to 0.17% and 0.21% respectively.

Mota (2003) also stresses the importance of regulation on welfare distribution. The paper presents a social cost-benefit analysis of privatisation of electricity distribution utilities in Brazil between 1993 and 2000. The paper found significant efficiency gains from cost savings and increased labour productivity. The estimated efficiency gains amount to about $US 12 billion. of which approximately $US 2.2 billion accrued to consumers (at 12% discount rate). The results indicate that, although consumer surplus showed signs of growth, companies were allowed to retain most of the achieved gains. These findings are in line with a shortcoming of the reform design: tariff restructuring and privatisation occurred before a regulatory agency was established.

Estache, Guasch, and Trujillo (2003) argue that price-cap regulation in privatised sectors in Latin America has generally not been very successful. The paper argues that firms have improved efficiency under price cap regime, but price-caps have tended to increase the cost of capital, and hence, tariffs. At the same time, due to regulatory weakness and lack of government commitment, as is the case of electricity distribution utilities in Argentina, much of the gains have either remained with companies or have been captured by the government.

Low rates of public approval for reform may be linked to an inequitable distribution and low level of customer gain. Lora and Panizza (2002) refer to surveys of public opinion in 17 countries in the region that show a growing disapproval of the reforms, in particular among the middle classes. Without visible benefits and strong support from public opinion the sustainability of the reform process can easily be undermined. At the same time, it may be argued that some mistakes and problems are inevitable during the early years of reform.

For example, with regard to incentive regulation of distribution networks, the initial price-caps appear to have underestimated the cost saving potential of the utilities and/or

tended to focus on ensuring the viability of the new regime, rather than focusing on distributional aspect. This has even been the case in the first distribution price control in the UK which led to windfall profits for privatised companies and the subsequent introduction of windfall taxes. Therefore, the source of much of the problems may be lack of experience and implementation of regulation rather than the failure of the regulation models per se.

Easterly and Servén (2003a) in a set of studies examine aspects of privatization and changes in the stock of infrastructure assets in Latin America during the 1980s and 1990s. Calderón, Easterly, and Servén (2003a) argue that, during this period, the stabilisation programmes adopted in Latin America resulted in disproportionate investment cutbacks in, and maintenance of, infrastructure assets. Consequently, the gap in the stock of infrastructure assets (including electricity) between LAC and those of Asian and OECD economies widened significantly. As the economic return on infrastructure assets in LDCs is considerably higher than their borrowing cost, the spending cuts have had a negative effect on inter-temporal public budgets and long-term prospects of economic growth. The paper suggests that, overall, electricity generation capacity per worker in Latin America has been lower, while network losses have been higher, than in the Asian economies. Also, most countries witnessed a decline in their total and public investment in the sector. Although private investment rose in nearly all countries, the per capita investment did not reach the pre-reform levels of public investment.

The study also reports rather counterintuitive results from regression of energy losses as a percentage of output (as proxy for the quality of electricity assets) on the share of private expenditure on electricity. The negative coefficient signs suggest that higher private expenditure are correlated with higher losses. Recognising this unexpected result, the paper suggests that this may be a consequence of heterogeneity among public and private projects, or that governments have tended to privatise the least efficient firms. A more plausible explanation is, however, a possible disconnection between the losses and private share of expenditure. Most energy losses occur in the transmission and distribution networks, whereas most private expenditure in the sector has been in the generation business. Furthermore, energy losses are not good proxy for quality, but rather reflect network technical and non-technical efficiency. A subsequent regression using 10-year averages of the same variables found a weak tendency toward quality improvement.

Calderón and Servén (2003) estimate the output cost (in terms of GDP per worker) of the widened gap in infrastructure assets in the 1980s and 1990s in Latin America. The paper employs different econometric techniques and model specifications in regressions of electricity generation capacity, telecommunications (main phone lines) and transport (roads) assets, as well as measures of human and physical capital as instruments. The simpler OLS regressions do not produce strong results. However, the results from the generalised method of moments (GMM) technique show that infrastructure assets are significantly correlated with GDP per worker. The paper then estimates that about 30 percent of the output cost incurred in Latin America is associated with the gap in infrastructure assets, and that about 50 percent of this can be attributed to electricity generation assets.

Calderón, Easterly, and Servén (2003b) estimate the effects of the cuts in infrastructure expenditure on public sector solvency. The findings suggest that the cutbacks have a significant effect on growth and future public revenues and, therefore, should be carefully weighted against alternative spending reductions. The estimates suggest that a permanent cut in electricity generation spending, amounting to 1 percent of GDP, impacts the annualised public net worth between 1 and 0.17 percent (for public debt/GDP ratios ranging from 0 to 0.7).

3.4.2 The UK electricity reform

Few reforms have experienced such scrutiny as that in the UK. While the UK is not a developing country, the timing and characteristics of electricity sector restructuring and privatisation in the UK has provided insights into some important aspects of reform. For example, that the process of restructuring and regulation may face initial problems but, nevertheless, can continue to evolve into a workable market-oriented system (see e.g. Newbery, 1999).

In particular, the UK experience with restructuring of generation and mitigating possible market power has demonstrated the complexity and challenges involved in introducing competition into the sector. Green and Newbery (1992) show that the initial structure based on only two unequal competing generators was inefficient and that five equal competing firms would be more effective. Wolfram (1999) shows that although prices under oligopoly appear to have been above marginal costs, regulatory constraints, threat of new entry, and financial contracts may have produced lower prices than theory would suggest. At the same time, Sweeting (2001) shows that, between 1995 and 2000, generation asset divestitures and new entry did not result in lower prices.

Newbery and Pollitt (1997) estimate the costs and benefits of restructuring the state-owned Central Electricity Generation Board (CEGB), the enterprise in charge of electricity transmission and generation in England and Wales that was privatised in 1990. The study uses data for the 1989/90-1995/96 period and compares the post-privatisation performance of the CEGB relative to a counterfactual scenario without restructuring. There has been considerable improvement in labour productivity in the post-restructuring period, and the authors suggest that most of the efficiency gains came from non-fuel costs. They estimate future net efficiency gains from restructuring and privatisation of the CEGB at £9.6 billion (6% discount rate) or £5.2 billion (10% discount rate) after taking into account restructuring costs at £2.8 billion (6% discount rate) or £3.2 billion (10% discount rate).[7] In comparison, the proceeds from the sale of CEGB's assets amounted to about £9.7 billion. Also, the net welfare effect of restructuring and privatisation are then estimated at £4.8 billion (6% discount rate) or £4.3 billion (10% discount rate), after accounting for consumer losses of £1.3 billion (6% discount rate) or £2.2 billion (10% discount rate) which resulted from subsequent price increases.

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[7] The estimates are for the more probable counter-factual scenario under which CEGB would have continued to behave as in the past.

Reform in the rest of the UK also offers an insight into the possible effects of structure and market design on the performance of reform. Pollitt (1997, 1999) applies a similar social cost-benefit analysis methodology, similar to that in Newbery and Pollitt (1997), to the Scottish and the Northern Ireland systems. The Scottish system consisted of two vertically integrated companies that were privatised without restructuring, and a state-owned nuclear power company that was sold as part of the state-owned British energy in 1996. Pollitt (1999) estimates that the efficiency gains from privatisation in the Scottish system, under the more probable counterfactual scenario, were relatively small at about 10% of turnover (compared to 50% in England and Wales). Moreover, the costs of restructuring were almost equal to the efficiency gains.

An alternative "pro-public" scenario based on the assumption that the same firms were under public ownership but had initiated similar measures (such as closure of inefficient nuclear plants and expansion of the interconnection capacity to the south), found the total efficiency gains were almost zero and the discounted loss amounted to 74% of turnover. The distribution effect of the reform was more uneven than that in England and Wales. The estimated loss to consumers amounted to approximately £1.5 billion or 80% of turnover (compared to 8% in England and Wales). Proceeds from the sale of the assets were £3.6 billion, while the estimated loss of revenue stream amounted to £5.2 billion (excluding the subsequent windfall tax). The estimated profit stream to the new owners was £6.7, compared to the £3.6 billion price that was paid for the assets.

Reform in Northern Ireland followed a different path. The power generation units were sold through trade sale as three separate companies, each having long-term power purchase agreements with the transmission and distribution utility. The generating companies achieved significant efficiency improvements, although the power purchase agreements meant that the savings could not be passed to consumers. Pollitt (1999) estimates the gains in the generation companies at approximately £1 billion or 195% of turnover (compared with 55% in England and Wales), but restructuring costs were high and amounted to £0.1 billion.

The distributional impacts of reform were again uneven, but consumers benefited to the tune of £1 billion after intervention through a price review resulted in significant price reductions. Government proceeds from the sale of assets were £0.9 billion compared to future foregone revenue streams of £0.1 billion. At the same time, the new owners of the companies incurred a loss of £0.4 billion as a result of the price review.

Domah and Pollitt (2001) focus on the impact of reform on the distribution networks. The study presents a social cost benefit study of privatisation and regulatory reform of the regional electricity distribution companies in England and Wales at the end of 1990. It uses the actual data for the 1985/86-1997/98 period and cost predictions into 2005. The paper also points out that, in the first few years following the reform, both costs, prices, and profits rose. In subsequent years, costs began to fall. However, the distribution of efficiency gains was initially uneven; benefits remained with the companies, generating large profits, which eventually led to the imposition of special windfall taxes. It was not until around 2000 that consumers began to benefit from efficiency gains. The paper estimates that the benefits to customers were equivalent to

3% price reductions, while the government gained about £5 billion in privatisation proceeds and taxes.

4   Summary of tested hypothesis and variables

4.1   Econometric studies

In relation to the generic model of electricity sector reform analysis outlined in Section 2, the existing empirical econometric studies have at best partially addressed the performance and determinants aspects of reform. Broadly, the findings of this literature may however be summarised as follows:

- Institutional determinants of reform: Higher country policy and institutional quality is positively correlated with extent of reform (Bacon and Besant-Jones, 2002). The effect of judicial independence on competition level and ownership type is ambiguous and/or sensitive to model specification. Market-oriented economic ideology is positively correlated with higher competition and private ownership. Distributional conflict is positively correlated with higher level of monopoly, and ambiguous in relation to ownership type. Judicial independence, economic ideology, and distributional conflict are positively correlated with the overall reform score (Ruffin, 2003).
- Privatisation and efficiency: In developed countries, privatisation has improved operating efficiency and capital utilisation (Steiner, 2001). In developing countries, privatisation has improved efficiency when accompanied by independent regulation (Zhang et al., 2002).
- Privatisation and prices: In developed countries, the cost-reflective-pricing effect of privatisation (i.e. lower industrial prices and industrial/residential price ratios) has been mixed and sensitive to time factor and variable definition (Steiner, 2001; Hattori and Tsutsui, 2003); the effect in developing countries is not significant (Zhang, et al., 2002).
- Competition and efficiency: In developing countries, competition has resulted in improved operating and capital efficiency (Zhang et al., 2002).
- Competition and prices: The evidence of the effect of competition on cost reflective pricing (i.e. lower industrial tariffs and higher residential tariffs) in developing countries is weak (Zhang, et al. 2002). The price effect of competition in developed countries is mixed and sensitive to time factor and variable definition (Steiner, 2001; Hattori and Tsutsui, 2003).
- Regulation and efficiency: Independent regulation alone has not led to efficiency improvement in developing or developed countries (Zhang, 2002; Steiner, 2001).
- Regulation and prices: In developing countries, the effect of independent regulation on cost reflective pricing is insignificant (Zhang et al, 2002).
- Market opening, access, and prices: In developed countries, TPA and retail access tend to result in lower industrial prices and ratios to residential users (Steiner, 2001; Hattori, 2003).
- Investments and institutions: Private investment in the sector is positively correlated with credible institutional factors such as protection of property

rights, judicial and regulatory independence and country political risk (Bergara et al. 1997; Holborn, 2001; Zelner and Hensiz, 2000).

- Vertical integration and privatisation: Vertical integration has a negative effect on the number of, and proceeds from, privatisation while regulation tends to increase the number of, proceeds from and level of, privatisation (Siniscalco, et al. 2001).
- Market design and price volatility: Systems with large private participation have more price volatility but lower mean prices. Also, in electricity systems with mandatory participation in the wholesale market, spot price volatility is higher (Wolak, 1997).

It should be noted that that there has been limited cross-testing of most of the hypotheses across the studies, so further analysis is necessary to increase confidence in the results. There is also reason to question the robustness of some of the empirical findings as the comparability of the studies is constrained by variations in data and model specifications.

Even where there is a rather high degree of comparability, sensitivity of the findings to the choice and definition of variables and model specification, casts considerable uncertainty over the policy relevance of the existing body of knowledge. It is remarkable that, after so long, there is still very little systematic analysis and evidence on electricity reform.

4.2   Efficiency and productivity studies

The full potential of productivity analysis techniques for examining the performance of reform is yet to be recognised. Findings from the limited number of existing reform-related studies present a mixed picture of performance. Results of the reviewed studies can be summarised as follows:

- A sample of Latin American distribution companies suggests only partial evidence of correlation between reform and performance (Pardina and Rossi, 2000).
- In Cote d'Ivore, privatisation has resulted in efficiency improvement. However, performance remains below the 1970's level when the electricity sector was under close government supervision and subject to hard budget constraints (Plane, 1999).
- In the US, deregulation has resulted in a short-term decline in productive efficiency. Also, the vertically integrated utilities and companies that rely on the market for their electricity supplies are more efficient than those with hybrid structures (Delmas and Tokat, 2003).
- In Spain, public electricity generators are, on average, more efficient under cost of service regulation, while private generators catch-up and overtake the public firms under price cap regulation (Arocena and Waddams-Price, 1999).
- In Japan, the results do not support the hypothesis of increased technical efficiency among fossil fuel generators from the 1995 regulatory reform (Hattori, 1999).

- In Australia, the long-term macroeconomic gain from electricity reform is estimated at 0.22% of GDP (Whiteman, 1999).
- In Brazil, privatisation of distribution utilities lead to considerable efficiency gains which were, due to ineffective regulation, mainly retained by the companies (Mota, 2003).

4.3   Case studies

The main lessons from the single country and cross-country case studies can be summarised as follows:

- Efficiency gain: In Chile, privatisation resulted in higher investment, lower unit costs, lower energy losses and higher labour productivity (Paredes, 2001; Fisher et al., 2003). In Peru, significant improvements were achieved in loss reduction, quality of service, labour productivity and access. Tariff re-balancing meant higher prices, lower consumption and welfare surplus to consumers which benefited high-income users most (Torero and Pasco-Font, 2003).
- Distributional effect: In Chile, privatisation produced significant welfare improvements. However, there was a fiscal loss to the government and welfare reduction for non-payee customers (Galal, 1994).
- Low-income groups: The evidence is not conclusive on whether the poorest income groups have been better or worse off (Delfino and Casarin, 2001; .Ennis and Pinto, 2002; Chisari et al. 1997).
- Improved access: Policies aimed at improving access to service can be effective and combined with privatisation (Ennis and Pinto, 2002; Delfino and Casarin, 2001).
- Weak regulation: In Chile, weak regulation of network utilities resulted in distribution firms earning higher profits than generation firms (Fisher et al., 2003). In Brazil, most of the benefits remained in the companies (Mota, 2003). This may explain the increasing decline of public approval for privatisation in Latin America (Lora and Panizza, 2002). In the UK, customers began to benefit after further regulatory action (Newbery and Pollitt, 1997; Domah and Pollitt, 2000; Pollitt, 1997; Pollitt 1999).
- Credibility and commitment: Regulatory credibility and political commitment are important, as shown in Chile and Argentina (Heller et al., 1996). However, in both countries the majority of customers (with the possible exception of the poorest groups) enjoyed lower (or little changed) tariffs or welfare gain following privatisation. Sustainable regulatory commitment in countries where tariffs should increase will be much harder to achieve.
- Wholesale market design: Cost-based wholesale markets may be relatively effective in reducing price volatility and market power, as shown by Ferreira (2002) in Argentina.
- Incentive regulation: Price-caps may be effective but, with weak regulation, may lead to strategic behaviour by regulated distribution firms gaming the model (Di Tella and Dyck, 2002; Estache et al., 2003).
- Financial markets: Privatisation can increase the size of the stock markets as in the case of Argentina (Ennis and Pinto, 2002).

- Economic significance of electricity assets: In Latin America, despite private investment in the sector, total investment declined and the gap in the stock of electricity assets relative to Asian and OECD countries widened (Calderón et al., 2003a). About 15 percent of the output cost incurred in Latin America can be attributed to a decline in electricity generation assets (Calderón and Servén, 2003). Cutbacks in spending on electricity assets have significant negative effect on long-term growth and future public revenues (Calderón et al., 2003b).

5. Summary of untested hypothesis on reforms

The review of the literature revealed that all the studies have focused on rather narrow aspects of reform. Ideally, and where possible, it is preferable to employ systems of simultaneous equations. The main obstacles here would be data availability and model specification problems that may prove to be prohibitive. A second best but more feasible approach, is to separately test a set of coherent hypotheses that, collectively, can shed light on aspects of reform.

In this section, we propose a number of possible hypotheses focussing on Equations (1) and (2) from section 3 that address a wide range of issues arising in connection with electricity sector reform in developing countries. Appendix 2 summarises the identified untested hypotheses and types of variable required.

5.1 Performance indicators

5.1.1 Investment

Private investment in the sector is barely addressed in the studies reviewed. For developing countries, private investment is a top priority and is, perhaps, a more reliable measure of success or failure of price reform. At best, investment is represented by a proxy, e.g. generating capacity expansion as in Bergara, Henisz, and Spiller (1997). The relationship between private investment in (green-field projects and privatisation) may be examined in relation to various aspects of reform, institutional quality, market structure, endowments and private sector investment in other reformed infrastructure industries. Some of the untested hypotheses include:

H.1.0: *Higher economic growth and electricity demand growth lead to higher shares of private investment, ceteris paribus.*
H.1.1: *Lower levels of activity by international finance institutions are associated with lower levels of domestic investment and lower shares of private involvement in that investment in many, but not all, developing countries.*
H.1.2: *Foreign private investment is a function of effective electricity tariff reform (the extent to which extra investment is self-financing).*

Hypothesis H.1.0 reflects the observation from the telecommunications industry that rapid growth can reduce the demand for firm regulatory contracts. Hypothesis H.1.1 suggests that, particularly in poorer countries, international finance organisations may

have a role in supporting private investment that otherwise would not have taken place. Hypothesis H.1.2 links private investment to the prospects of a pricing system that supports self-sustained investment without dependence on, or recourse, to public funds.

5.1.2 Network regulation and privatisation

The review has revealed a tendency to ignore transmission and distribution activities. In effect, the network parts of the sector are treated as black boxes, although there are considerable cross-countries differences. In LDCs in particular, many of the underlying problems such as system losses, non-payment, network access, electrification, are related to networks (especially distribution) and, in the light of unresolved problems and declining international investor interest, it is useful to test whether guaranteed revenues have facilitated distribution privatisation.

H.2.0:   *Regulatory independence and credible arrangements have a positive effect on performance of T&D in terms of investment, and cost reflective prices*
H.2.1:   *Price/Revenue cap regulation is superior to cost-of-service regulation for T+D networks in terms of cost efficiency and loss minimisation.*
H.2.2:   *The introduction of price or revenue caps is a function of the degree of independence of the regulator.*
H.2.3:   *The presence of incentive regulation has a positive impact on investment in transmission and distribution (ceteris paribus).*
H.2.4:   *Privatisation of distribution networks improves efficiency when combined with incentive regulation.*

Hypothesis H.2.0 reflects the role of regulatory independence in promoting reform by reducing uncertainty and introducing price reforms. Hypotheses H.2.1-2 examine the origin and effectiveness of price cap regulation. Hypothesis H.2.3 addresses the particular issue of regulating investment in networks, as opposed to investments in generation, which has received relatively little attention. Hypothesis H.2.4 reflects the need to examine the effect of regulation on efficiency in distribution networks.

5.1.3 System losses and quality of service

Transmission and distribution losses are a major source of inefficiency in developing countries, but this is another network-related issue that has been under-investigated. In competitive markets there is a potential trade-off between profitability and quality of service and it would be worth testing the effect of reform on quality attributes such as reliability, voltage, etc.

H.3.0:   *Privatisation is associated with lower bill arrears and reduced technical and non-technical losses.*
H.3.1:   *Reforms that provide financial incentives for loss reduction and legal enforcement of bill payment reduce measured losses.*
H.3.2:   *Privatisation is associated with increased installation of meters and increased pre-payment charging.*

H.3.3:   *High numbers of meters/pre-payment is associated with lower levels of arrears and non-technical losses.*

H.3.4:   *Incentive regulation without clear incentives for network companies to maintain quality will reduce quality.*

Hypothesis H.3.0 examines the effect of privatisation on revenue collection at a distribution level that is crucial for the financial health of the whole, and on energy losses. Hypotheses H.3.1-3 examine whether financial incentives improve measurement, billing and loss reduction. Hypotheses H.3.4 examines the extent to which quality regulation is required to ensure that service does not deteriorate as a result of reform.

5.1.4 Market structure

Market power arises from ineffective competition and industry structure. The effect of vertical integration and horizontal concentration on the performance of reform is crucial.

H.4.0:   *HHI of less than 2500 is required for effective, unregulated competition in the generation market.*

H.4.1:   *Joint ownership of generation and transmission/distribution reduces efficiency, increases prices, and may deter entry.*

H.4.2:   *Cost-based bidding mitigates market power and price fluctuations in generation markets.*

Hypothesis H.4.0-1 are standard industrial organisation hypotheses applied to electricity reform to examine the effect of market structure on behaviour and performance, although regulations (i.e. cost-based bidding or mandated contracting) may be able to adequately mitigate market power even in concentrated markets (hypothesis H.4.2).

5.1.5 Threshold effects

Many developing countries have electricity systems that are smaller than 1,000 MW. Surprisingly, there has been no attempt in the empirical literature to identify a size threshold below which certain types of reform are unlikely to be effective. This is extremely important in the context of small developing countries.

H.5.0:   *There is a threshold size (which may depend on endowments) below which vertical separation is technically difficult, or not worthwhile, due to the transaction costs involved.*

This hypothesis examines whether effective competition can be achieved in small systems and whether the potential benefits exceed the increased transaction costs associated with vertical separation of the system.

5.1.6 Distribution of benefits

The distributional impact of reform, especially between industrial and residential customers on the one hand and between consumers and firms on the other, is a relevant issue that most studies do not address. A straightforward way to incorporate this dimension would be the use of price ratios but quality measures, including some indicator(s) of customer service and access to service, could also be used. It is, however, noteworthy that the losses of publicly-owned ESIs tend to be financed by the general budget.

H.6.0: *Reforms in developing countries bring improved access for residential consumers, but at higher prices.*

H.6.1: *Reforms in developing countries bring prices closer to costs (which may be lower) for industrial consumers, as well as better quality and more efficient input price signals.*

H.6.2: *Reform brings different welfare and distributional effects at different levels of income and electrification.*

H.6.3: *Inadequate competition and ineffective regulation prevent the benefits being passed on to consumers.*

Hypotheses H.6.0-1 examine price re-balancing and reduced cross-subsidy, as observed in the case of Argentina and, to a lesser extent, in Chile. Hypothesis H.6.2 reflects the notion that the general benefits of reform may be lower in countries with high electrification rates (e.g. CES countries) but increased access might offset price rises for poor residential consumers. Hypothesis H.6.3 examines the widespread observation in the UK, Chile, and Argentina that, at least initially, regulators are slow to pass the gains onto customers in the form of lower prices.

5.1.7 Asset prices

The effect of reform characteristics and electricity tariffs on the price and proceeds from asset sales is another area that could be better investigated. Although maximising proceeds is desirable, it can also lead to price increases.

H.7.0: *Non-cost-reflective tariff structures have a negative impact on proceeds from sales of distribution and generation assets.*

This hypothesis addresses the issue of whether a reform that establishes tariffs at unsustainable levels (or levels that assume ongoing government subsidies) is likely to lead to problems such as expropriation by investors.

5.1.8 Vertical and horizontal separation

Competition and privatisation are expected to lead to external and internal efficiency. However, unbundling of the system tends to increase transaction costs and loss of economies of co-ordination. The net effect is uncertain in the absence of independent

regulatory oversight. The effectiveness of competition and incentive regulation will determine whether the benefits of reform will exceed the higher transaction costs in order to produce net performance improvements. The issue has been researched in the context of the UK power sector.

H.8.0: *Transaction costs are significant for developing countries and are non-linear with sector size. Below a certain size, some types of restructuring have prohibitive transaction costs.*

H.8.1: *There is a threshold size below which wholesale market competition in generation is not worthwhile, and power purchase agreements (PPAs) may be preferable.*

Hypothesis H.8.0 examines the relationship between the system size and the increase in transaction costs resulting from restructuring of the sector. It suggests a cut-off point below which the increased transaction costs begin to exceed the benefits of unbundling of the industry. Hypothesis H.8.1 examines the effect of system size on choice of market design.

5.1.9 Sector endowment

There is an ongoing debate on the extent to which successful liberalisation depends on resource endowment.

H.9.0: *A diverse mix of generation mix facilitates introduction of competition in the sector.*

H.9.1: *The availability of natural gas facilitates introduction of competition in the sector.*

H.9.2: *Energy and fuel independence are positively correlated with introduction of market-oriented reform in developing countries.*

Hypothesis H.9.0 reflects the issue of whether limitations on the available technology, or the dominance of hydroelectric capacity, limits the scope for free entry in power generation. Hypothesis H.9.1 reflects the potential of gas-fired generation which is efficient at small scale, has a low capital cost and fast build-time to enable new entrants to enter at lower risk than with other fuels. Hypothesis H.9.2 is based on the idea that countries (e.g. Chile, UK, Argentina, Norway) which have access to own primary energy resources such as hydroelectricity or natural gas seem to have been more likely to liberalise their energy sectors.

6   Conclusions and policy implications

Although electricity sector reform has evolved over a number of years, it has largely remained a work in progress. There is a need to learn from the accumulated experience, as many developing countries are either contemplating to implement reform, or are at some intermediate stage. Our review of cross-country studies has revealed that there is

considerable scope for learning from the lessons around the world, but there is a need for more up-to-date analysis.

A notable aspect of the existing studies is that the number of countries included in the samples used are rather limited, with the notable exception of Bacon and Besant-Jones (2001) who includes 115 countries. In general, the samples used only a small number of reforming countries. A consequence of this is that much useful information embodied in lesser known reforms (or even non-reforming countries) representing counter-factual alternatives, is not utilised.

We have also identified a varied, but still representative, set of new hypothesis that can be used to test various aspects of reforms. Appendix 3 presents a more detailed list of variables required to test the new hypothesis.

A general conclusion of our review is that the existing body of evidence from rigorous analysis is rather limited, given the wide range of issues and the many questions that arise in connection with the success or failure of reform. In addition, the existing evidence that we review points to a number of data and methodological improvements that need to be addressed in future studies:
? no known attempts to use simultaneous equations
? missing performance indicators
? missing market structure variables
? missing endowment variables e.g. threshold effect.
? missing institutional variables e.g. types of legal systems
? variables used for reform measure are crude
? no studies use panel data
? interaction terms among variables generally missing.

The fact that reform experience in the sector does not go back further than the early 1990s has meant that most studies have been constrained by observations from a limited number of years. At the same time, in the light of the time lag between data availability and its analysis, the relevance of most of the existing studies is quickly diminishing. It is also important that new analyses are wider in terms of scale and scope, i.e. a larger number of jurisdictions and a wider range of issues need to be addressed within a longer time frame.

Our review of the analysis of electricity sector reform suggests that there is a great need for comprehensive, high quality data. For example, despite the significant resources and efforts spent on electricity reform and other infrastructure industries, there is yet no coherent set of indicators that are defined and regularly measured to assess, monitor, and compare reforms. In a companion paper we have proposed a set of core and other useful indicators for electricity reform (see Jamasb, Newbery, Pollitt, 2004). The existing state of data sets clear limits for the quantity and quality of empirical research useful for policy advice.

The usefulness of the existing evidence from empirical studies for policy advice is rather limited. The real world reform issues and debates have tended to move faster than the literature can catch up with and analyse them. For example, the private investment

in the sector has declined significantly in recent years. There is a considerable need for innovative financial and investment solutions. Also, there is an emerging realisation in the World Bank and elsewhere about the ability and capacity of some developing countries to implement and sustain a workable reform. Many electricity sectors are and may remain in a prolonged state of partial reform. For example, the implications of this for long-term operation and governance of mixed public-private and semi-competitive sectors are unclear. Finally, public perception and acceptance of reform is on the decline. However, the existing empirical evidence is of little help in providing guidance on how to best tackle these issues.

Appendix 1 - The Hypotheses tested in econometric studies

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
Zhang et al. (2002)	*H0: Privatisation leads to higher operating efficiency and asset utilisation.*	-operating efficiency: net electricity generation (MWh) per employee (#) (PI) -asset utilisation: electricity generation (MWh) / average capacity (MW) (PI)	-privatisation: existence of private generation (dummy) (MS/RM) *Result: insignificant*	-GDP per capita (US$ 95) (CL) *Result: significant at the 1% level* -urban population as % of total (CL) *Result: significant at the 1% level* -industrial output as % of GDP (CL) *Result: significance varies across models* -degree of economic freedom (based on 10-point indices in 'Economic Freedom of the World: 2002 Annual Report') (CL) *Result: significant at the 1% level*	51 LDCs from 1985-2000. Generation and capacity data: APERC database and World Dev. Indicators. Labor: Industrial Statistics Yearbook, International Labour Organisation. Privatisation, regulation, and competition: The Yearbook of Privatisation, EIA, WEC, and APERC.
	H1: Privatisation with supportive regulation leads to higher output and capacity.	-output: net generation (MWh) per capita (PI) -capacity: generation capacity (MW) per capita (PI)	-privatisation: existence of private generation (dummy) (MS/RM) -regulation: existence of independent regulatory agency (dummy) (I) *Result: taken together, the variables are significant (on*		

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
			generation at 10% level, on capacity at 5% level)		
	H2: Privatisation leads to higher residential and lower industrial prices.	-residential prices: user price (PI) -industrial price: user price (PI)	-privatisation: existence of private generation (dummy) (MS/RM) *Result: insignificant*		Price: OLADE , OECD.
	H3: Competition leads to larger capacity, higher output, and greater labour productivity.	-output: net generation (MWh) per capita (PI) -capacity: generation capacity (MW) per capita (PI) -labour productivity: net electricity generation (MWh) per employee (#) (PI)	-competition: existence of wholesale market (dummy) (RM) *Result: significant (the levels of significance vary across different models and equations – either 5 or 10%)*		
	H4: Competition leads to higher residential and lower industrial prices.	-residential prices: user price (US$) (PI) -industrial price: user price (PI)	-competition: existence of wholesale market (dummy) (RM) *Result: this is significant for industrial prices for only one of the specified equations (at 1% level of significance)*		
	H5: Independent regulation will improve productive efficiency.	-output: net generation (MWh) per capita (PI) -capacity: generation capacity (MW) per capita (PI)	-regulation: existence of independent regulatory agency (dummy) (I) *Result: insignificant*		
	H6: Regulation leads to higher residential prices.	-residential prices: user price (US$) (PI)	-regulation: existence of independent regulatory agency (dummy) (I) *Result: insignificant*		

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
Bacon and Besant-Jones (2001)	*H0: Country policy and institutional indicator are positively correlated with reform score.* *H1: Country risk is negatively associated with occurrence of reform score.*	-reform scores: number of reform steps t aken by each country in ESMAP (1999): corporatisation, restructuring, law, regulator, IPP entry, divestiture (RM)	-country policy and institutional indicator: based on 20 indicators, which focus on macro management and sustainability of reforms, policies for sustainable and equitable growth, policies for reducing inequalities, and public sector management (CL) *Result: significant (at 5% level of significance)* -country risk indicator : based on a weighted average of 9 indices, of which political risk and economic performance each account for 25% of the weighting (CL) *Result: significant (at 10% level of significance)* -GDP per capita (US$ per capita) (CL) *Result: insignificant* -aid/GDP ratio (CL) *Result: insignificant* -commercial energy use per capita (MWh per capita) (SE) -annual growth rate of commercial energy use per capita (SE)	-regional dummies for Latin America, Africa, Asia, etc. (CL) *Result: very significant*	Cross-section data on the 115 developing countries surveyed in ESMAP (1999). The dependent variable is from the study. The source of other data (policy, risk, and energy use data) is not specified.
Drillisch and Riechmann (1998)	*H0: There is a correlation between energy dependency and choice of liberalisation model.*	-liberalisation index, (RM) composed by the following elements:	-prices (US$), (PI) *Result: insignificant*	-"UK/ commonwealth" dummy (CL) *Result: insignificant*	Data on countries: Australia, Germany, Denmark, Spain, France, Japan, Norway, Netherlands, New

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
	H1: There is a correlation between environmental commitment and liberalisation	wholesale reform -reform model (pool, wholesale wheeling, competitive bidding) -timing (reform in 1990, 0.5 points deducted for each year of delay) retail reform -reform model (regulated TPA, negotiated TPA) -timing (reform in 1990, 0.5 points deducted for each year of delay)	-energy independence index (computed from total primary energy supply of each different fuel, total exports of each fuel, indigenous production of each fuel, share of each fuel in total electricity production) (SE) *Result: for the restricted model the coefficient is significant at the 1% level* -environmental index (constructed from information on Kyoto target increase, renewable energy R&D expenditure/ GNP, implementation of energy/ carbon tax, energy related carbon-dioxide emissions, renewable energy capacity excluding hydro, renewable energy capacity including hydro) (SE) *Result: insignificant*		Zealand, Sweden, Finland, UK, USA. Domestic primary fuel production and domestic primary fuel used, hard coal production, fuel imports and exports, fuel shares in total electricity production (required for all the countries in the sample for 1995 – for the calculation of the energy independence indices); prices discriminated by types of customer; qualitative data on the timing and model of the reform (both at wholesale and retail levels, required to construct the liberalisation index); qualitative and quantitative data on national commitment to protect the environment (such as Kyoto protocol targets, renewable energy R&D expenditure/ GNP, etc.). Data: mostly IEA for quantitative data, but various sources for qualitative data. Periods: 01 - mostly works with 1995 data. Number of observations: 13 countries.
Ruffin (2003)	*H0: Judicial independence, economic ideology, and distributional conflict influences competition.*	- competition score (composite variable) (RM)	-judicial independence (composite indicators/indices) (CL). *Results: mostly positively, but not significantly correlated with competition.*	-real per capita income (CL) -average percentage of foreign investment in country total investment	Up to 75 countries for different model specifications. Data: mostly for 1990s from a diverse set of sources.

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
			-economic ideology (composite indicators/indices) (CL). *Results: economic orthodoxy mostly positively, and significant, correlated with the degree of competition.* -distributional conflict (composite indicators/indices) (CL). *Results: level of conflict negatively, and mostly significant, correlated with degree of competition.*	(CL) -political regime (CL) -political instability (CL) *Results: Generally, control variables are insignificant and/or exhibit changing signs.*	
	H1: Judicial independence, economic ideology, and distributional conflict influences private ownership.	- ownership score (composite variable) (RM)	-judicial independence (composite indicators/indices). *Result: mostly not significant with changing signs.* -economic ideology (composite indicators/indices). *Results: economic orthodoxy is mostly positively, and significant, correlated with private ownership.* -distributional conflict (composite indicators/indices). *Results: higher level of conflict mostly positively, and insignificant, correlated with private ownership.*		
	H2: Judicial independence, economic ideology, and distributional conflict	- overall reform score (composite variable) (RM)	- judicial independence (composite indicators/indices) *Result: mostly positively, thought*		

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
	influences the extent of reform.		*not always significant, correlated with extent of reform.* - economic ideology (composite indicators/indices) *Result: economic orthodoxy positively, and mostly significant, correlated with reform.* -distributional conflict (composite indicators/indices) *Results: mostly negatively, though not always significant, correlated with reform score.*		
Bergara, Henisz and Spiller (1997)	*H0: Well-defined and credible political institutions are positively correlated with investment in the electricity sector.*	-log of public & private generation capacity per 1000 population (PI)	-political index (CL) based on the following elements: -*judicial independence with* index of law & order, -*formal constraints on executive discretion* (federalist state dummy, dual executive/legislature dummy, bicameral legislatures dummy, index of legislators' effectiveness, index of military role in government, index of gov. particip. by org. religion, degree of developm. of pol. parties), -*informal constraints on executive discretion* (index of quality of bureaucracy, index of corruption in gov., index of racial/nationalist tensions). -political index (2) - as above but index of law & order replaced with the 'tenure of high/supreme	-GDP per capita (log) (CL) -industry share in GDP (log) (CL) -urbanisation % (log) (CL) -energy share of hydro (log) (SE)	The analysis uses data from a total of 91 developed and developing countries for 1987. The size of the actual samples used in different models are 38 and 87 or 86 countries depending on data availability for variables.

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
			court justices' in the index; tenure of justices as separate variable. -alternative political variables: -sum of 'law & order', 'bureaucracy' and 'corruption' variables plus 'index of likelihood of contract modification w. foreign business' and 'index of likelihood of confiscation nationalisation', -index of inst. constraints on chief executive decision by accountability groups, -index of institutionalised democracy, -gastil index of political and civil liberties. *Result: significant*		
Holborn (2001)	*H0: The probability that an individual IPP will enter a country with monopsony market is increasing in the amount of the firm's prior monopsony market experience.* *H1: The probability that an individual IPP will enter a country with a competitive generation market is increasing in the amount of the firm's competitive market experience.* *H2: The probability that an IPP will enter a country is*	-the firm's decision to enter a country in a given year – takes the value of 1 if expected profits net of cost of capital are non-negative; otherwise takes the value of 0 (PI)	**-country-level variables**: GDP growth (CL) *Result: significant at the 0.1% level* GDP (US$) (CL) *Result: significant at the 0.1% level* a dummy variable to indicate if a country has implemented a competitive or a monopsony market (RM) *Results vary according to model* a measure of political risk (higher for stronger political constraints) (CL) *Result: significant (either at 5 or at 0.1%, depending on the model)*	-first year firms were able to enter a country (where hard to observe when liberalisation started, assumes this year to be the year of the first IPP entry) (RM)	

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
	decreasing in the risk of direct and indirect political expropriation. *H3: The effect of the risk of direct or indirect political expropriation on the probability of entry is lower for competitive generation markets than for monopsony generation markets.* *H4: The probability that an individual IPP will enter a country with a relatively high level of political risk is increasing in the amount of prior generation experience.* *H5: The effect of prior experience on the probability of entering higher political risk countries is greater for experience gained in monopsony than in competitive markets.*		a variable which is the product of the dummy of competitive market by the measure of political risk (RMxCL) a dummy variable to indicate privatisation programmes (RM) *Result: either significant at 0.1% or insignificant, depending on the model* **-relationship variables**: geographic distance between the firm's home country and the potential host country (CL), *Result: significant at the 0.1% level* dummy variables to indicate whether the two countries share a common language or a colonial history (CL) *Result: significant at the 0.1% level* **-firm-level variables**: value of a firm's net assets in each year (PI) *Result: significant at the 5% level* a variable to indicate the joint effect of firm size and political risk on the probability of entry (the product of the value of assets by the measure of political risk) (PIxCL) *Result: insignificant* cumulative number of projects in competitive markets (PI) *Result: significant at the 0.1% level when combined with competitive dummy* cumulative number of projects in monopsony markets (PI) *Result: significant at the 0.1%*		

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
			level either alone or combined with competitive dummy The variables are used to create a number of individual and interaction terms.		
Zelner and Henisz (2000)	*H0: the effect of political constraints on investment:* *-when facing strong interest group competition, a utility will invest more (less) in the presence of higher (lower) political constraints, ceteris paribus.* *-as the level of interest group competition declines, the positive (negative) effect of political constraints on investment becomes smaller and may become negative (positive), ceteris paribus.* *H1: the effect of interest group competition on investment:* *-when operating in an environment with relatively low political constraints, a utility will invest more (less) in the presence of weak (strong) interest group competition, ceteris paribus.* *-as political constraints increase, the positive*	-each country's annual growth rate of megawatts of generation capacity per capita (this is the measure of investment used) (PI)	**-political constraints variable** (CL) – constructed from information on the number of independent branches of government, adjusted to take into account the extent of alignment across different branches and of preference heterogeneity within each legislative branch *Result: mostly significant at the 5% level* **-interest group competition variable** – simply the ratio of industrial to total electricity consumption (SE) *Result: mostly significant at the 5% level* **-existing penetration level variable** – megawatts of generation capacity per capita in the previous period (PI) *Result: mostly significant at the 10% level* **-government's capital investment budget** (CL) – measured as real annual gross US dollar public investment on capital spending per capita; *Result: insignificant*	n.a.	Country-level panel data of 78 developed and developing countries over the period 1970-1994. The countries of the sample are grouped in three categories: countries facing high political constraints, countries facing low political constraints and weak interest group competition, and countries facing low political constraints and strong interest group competition.

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
	(negative) effect of weak (strong) interest group competition on investment becomes smaller, ceteris paribus. *-the effect of increasing interest group competition on investment is non-positive.*		**-demand growth** (CL) – GDP per capita real growth *The coefficients of the interaction terms are also significant. The results are consistent with the hypotheses*		
Siniscalco, Bortolotti and Fantini (2001)	*H0: vertical integration has a negative impact on the number of privatisations.*	-total number of sales in electricity generation in a given country (PI)	-a dummy for vertical integration (MS) *Results: significant at the 5% level for both number of privatisations and proceeds from privatisation*	-average annual electricity consumption (kWh) (SE) *Result: insignificant* a dummy for the political orientation of a county's privatisation (CL) *Result: significant and positive at the 10% level for number of privatisations* an institutional credibility index (CL) *Result: significant at the 5% level for the percentage of privatised stock* and financial market liquidity indicators (CL) *Result: significant at the 10% level for privatisation proceeds*	Privatisation data on 48 power generation companies from 19 developed and developing countries for the 1977-1997 period. Source: Privatisation International (1997) and original documents for some countries not included in this source.
	H1: vertical integration has a negative impact on aggregate proceeds of privatisation.	-the per country aggregate proceeds from total sales (PI) (US$ 96)			
	H2: a more regulated environment is conducive to privatisation; therefore, regulation has a positive impact on the number of privatisations.	-total number of sales in electricity generation in a given country (PI)	-a regulatory index (which takes the maximum value when a country's regulatory setting entails: regulated TPA, a regulated wholesale market and an independent regulatory		

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
			agency) (RM, I) *Results: significant at the 5% level for both number of privatisations and proceeds from privatisation. Significant at the 10% level for the percentage of privatised stock.*		
	H3: regulation has a positive impact on aggregate proceeds of privatisation.	-the per country aggregate proceeds from total sales (US$ 96) (PI)			
	H4: regulation has a positive impact on the percentage of privatised stock.	-the stake privatised at firm level (PI)			
Steiner (2001)	*H0: Regulation and restructuring leads to improved utilisation rate and reserve margin in electricity generation.* *H1: Regulation and restructuring leads to lower industrial electricity prices and industrial/residential price ratio.*	-industrial end-user price in PPPs (PI) -ratio of industrial to residential prices in PPPs (PI) -utilisation rate: energy production/total average capacity (PI) -distance of actual from optimal reserve margin (PI)	-time to liberalisation (years) (RM) *Results: significantly positive for prices* -time to privatisation (years) (RM) *Results: insignificant for prices* -unbundling of generation from transmission (multi-level indicator) (RM) *Results: insignificant for prices, significantly positive for utilisation rate.* -private ownership (multi-level indicator) (RM) *Results: significantly positive for prices and for utilisation rate.* -third party access (dummy) (RM) *Results: insignificant for prices*	-GDP (US$) (CL) *Result: insignificant* -hydro share in generation (SE) *Result: significant for prices* -nuclear share in generation (SE) -state preference against nuclear technology (SE) -state preference in favour of coal technology (SE) -urbanisation (CL)	Panel data from International Energy Agency and other sources covering 19 OECD countries. Number of periods (1986-1996): 11 $\Rightarrow$ number of observations: 209

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables	Notes: # of countries, times period, data source
			and for efficiency measures -wholesale pool (dummy) (RM) *Results: significantly negative for prices* -choice threshold (RM) -T price regulation (not used) (RM)		
Hattori and Tsutsui (2003)	*H0: Unbundling of generation from transmission, third party access, the existence of a wholesale market, and privatisation leads to lower industrial electricity prices and industrial/residential price ratios. As the start of liberalisation and privatisation approaches prices decrease.*	-industrial end-user price in PPPs (PI) -ratio of industrial to residential prices in PPPs (PI)	-wholesale pool (dummy) (RM) *Results: significantly positive for prices* -third party access (dummy) (RM) *Results: significantly negative for prices* -private ownership (multi-level indicator) (RM) *Results: significantly negative for prices* -time to privatisation (years) (RM) *Results: statistically insignificant*	-GDP (US$ PPP) (CL) *Results: statistically significantly negative for prices* -share of hydro capacity (SE) *Results: statistically insignificant* -share of nuclear capacity (SE) *Results: statistically insignificant*	Panel dataset of 19 OECD countries for the period 1987-1999 (number of observations: 232).
Wolak (1997)	*H0: Market structure and market rules influence price average and price volatility.*	-half-hourly or hourly spot prices (PI)	-lagged half-hourly or hourly spot prices (PI) *Results: the cross-country analysis suggests that market rules and market structure exert strong influence on the behaviour of prices.*		Hourly or half-hourly spot prices of electricity in the England & Wales Pool, Nord Pool, Victoria Power Exchange, New Zealand North Island, New Zealand South Island, from 1990 until 1997.

Notes: RM – reform measures I – (sector-level) institutions PI – performance indicator MS – market structure SE – sector endowments CL – country-level variables

Appendix 2 - New hypotheses proposed

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables
Investment Hypotheses	*H.1.0: Economic growth and electricity demand growth lead to higher private investment.*	-private investment in G,T,D	-GDP growth rate, unit sales (annual)	
	H.1.1: Lower levels of IFI investment are associated with lower levels of private and domestic investment in many, but not all developing countries.	-private investment in G,T, D.	-IFI investment in G,TD.	
	H.1.2: Foreign private investment is a function of effective tariff reform (the extent to which extra investment is self-financing).	-private investment in G,T, D.	-ratio of residential to industrial prices, ratio of electricity price to price of marginal fuel.	
Network regulation	*H.2.1: Regulatory independence and credible arrangements have a positive effect on performance in terms of investments, and cost reflective prices*	-investment levels -indust./resid. price ratios -reduce cross subsidy	-degree of regulatory independence	
	H.2.2: Price/Revenue cap regulation is superior to cost of service regulation for T+D networks in terms of cost efficiency and loss minimisation.	-no. of cust/units distributed per employee, no.of cust/units distributed per unit of capital (D), km of transmission wire per employee.	-dummy for price cap/cost of service regulation.	
	H.2.3: The introduction of price or revenue caps is a function of the degree of independence of the regulator.	-dummy for Price cap/cost of service regulation.	-regulatory independence variable: autonomous, government, semi-autonomous.	
	H.2.4: The presence of incentive regulation increases investment (ceteris paribus).	-private investment.	-dummy for price cap/PBR regulation.	
	H.2.5: Privatisation of distribution networks improves efficiency when combined with incentive regulation.	-operating efficiency and capital utilisation measures	-interaction variable e.g. price-cap/privatisation	

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables
System losses & quality of service	*H.3.0: Privatisation is associated with lower bill arrears and less technical and non-technical losses*	-non technical losses, arrears	-privatisation dummy	
	H.3.1: Reforms which provide financial incentives for loss reduction and also legal enforcement of bill payment reduce measured losses.	-losses	-dummy for presence of loss reduction incentive payment, incentive regulation, strength of judiciary index.	
	H.3.2: Privatisation is associated with increased numbers of meters and increased pre-payment charging.	-no. of prepayment meters, total numbers of meters.	-privatisation Dummy	
	H.3.3: Increased numbers of meters/pre-payment is associated with lower levels of arrears and non-technical losses.	-non-payment variable	-no. of prepayment meters, total numbers of meters.	
	H.3.4: Incentive regulation without clear incentives for network companies to supply quality will reduce quality.	-losses -number and duration of power outages	-type of regulation, explicit incentives for quality, e.g. customer penalties	
Market structure	*H.4.0: HHI of less than 2500 is required for effective competition in the generation market.*	-price/marginal fuel cost	-HHI in generation	
	H.4.1: Joint ownership of generation and transmission/distribution reduces efficiency and increases prices and may deter entry.	-price of electricity	-vertical integration dummies	
	H.4.2: Cost based bidding mitigates market power and price fluctuations in generation markets.	-price, of generated power/marginal fuel cost, max-min range of price of generated power/marginal fuel cost	-dummy for cost based bidding	
Threshold Effects	*H.5.0: There is a threshold size (which may depend on endowments) below which vertical separation (or competition) is technically difficult or not worthwhile due to the transaction costs involved.*	-price/marginal fuel cost	-degree of vertical separation	

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables
Distribution of benefits	*H.6.0: Reforms in developing countries bring higher prices for residential consumers, but improved access.*	-ratio residential/non residential price, outages, electricity rate.	-reform variables	
	H.6.1: Reforms in developing countries bring lower prices for industrial consumers but better quality and more Efficient input price signals.	-ratio, industrial/non-industrial price, outages, price/marginal fuel cost.		
	H.6.2: Reforms bring different overall benefits at different levels of income and electrification.	-change in price – industrial, residential.	-income per capita, electrification rate	
	H.6.3: Ineffective reform design (competition / regulation) prevents the benefits to be passed to consumers.			
Asset prices	*H.7.0: Non-cost- reflective tariff structures have a negative impact on proceeds from sales of distribution and generation assets.*	-asset sales revenue	-ratio of electricity price to marginal generation cost.	
Vertical and horizontal separation	*H.8.0: Transaction costs are significant for developing countries and are non-linear in size. Below a certain sector size certain types of reform have prohibitive transaction costs.*	-costs of power pool, SBM, power exchange	-size of the sector. -type of reform enacted.	
	H.8.1: There is a threshold size below which wholesale market competition in generation is not worthwhile and power purchase agreements (PPAs) may be preferable.			

Study	Hypothesis	Dependent Variable(s)	Independent Variable(s)	Control Variables
Sector endowment	*H.9.0: A diverse mix of generation mix facilitates introduction of competition in the sector.*	-competition index	-number of technologies in the generation mix with share higher than 10%.	-income per capita - political and institutional indices
	H.9.1: The availability of natural gas facilitates introduction of competition in the sector.	-competition index	-natural gas production and proven reserves in relation to the size of the electricity sector.	
	H.9.2: Energy and fuel independence are positively correlated with introduction of market-oriented reforms in developing countries.	-reform score/index	-share of domestic energy and fuel of total used.	

Appendix 3 – Extended list of variables for future studies and hypothesis

	Economy level	Sector level	Generation	Distribution	Transmission
1. Performance Indicators	-total private investments (US$) (foreign, domestic) -total public investments (US$) -IFI investments in total and in power sector	-private investments (US$) (foreign, domestic) -public investments (US$) -wholesale price (US$/ MWh) -residential price (US$/ MWh) -industrial price (US$/ MWh) -residential / industrial price ratio -marginal fuel cost (oil, gas, coal as appropriate) -sector profitability -arrears of revenue	-public and private (domestic, foreign) investments (US$): • greenfield • privatisation -capacity utilisation -labour productivity -plant availability factor -profitability -arrears of revenue	-public and private (domestic, foreign) investments (US$): • privatisation • network improvement expansion -profitability -arrears of revenue -network losses (technical and non-technical) (%) -electrification (%) -quality of service (no. of interruptions and no. of minutes lost per 100 customers)	-private investments (US$) (foreign, domestic) -total public investments (US$) -profitability (if separated) -arrears of revenue (if relevant).
2. Reform measures – unbundling, markets, concentration, & competition		-inter-connections (capacity, share of tot. market) -% share of vertically integrated supplied electricity -retail competition -% share of eligible customers -% share of 1st,2nd, 3rd suppliers -suppliers w. share >x%	-vertical separation (accounting, legal, ownership) -pool -organised contract market -SBM -share of volumes traded in spot & contract markets -type of bidding in power market (cost, price?) -share of x largest generation firms -no. of generators w. market share larger than z%. -HHI -annual max and min prices in power pool	-vertical separation (accounting, legal, ownership) - degree of market opening - % of customer class switched from incumbent	- vertical separation form G and D

	Economy level	Sector level	Generation	Distribution	Transmission
2. Reform measures - Privatisation		-date of privatisation -asset sales revenue split by function	-share of private (domestic, foreign), local, government in G (MW, MWh) -no. of private, local, government firms	-share of private, local, government in delivered energy (MWh) -no. of private, local, government firms	-network ownership (private, public, local) -TSO (public, private, …)
3. Reform measures - Regulation and Policy		-see Item (B)[8] *See also survey for the WB: -who sets tariffs -% share of taxes in prices -date of law, regulation and effective dates	-network access (rTPA, nTPA) -entry with authorisation or free	-PCAP, ROR	
4. Market structure		-system size - ownership structure	-resource mix		
5. Institutions, Endowments and control variables	-Item (A)[9] -GDP (US$) -GDP per capita (US$ per capita) -GDP growth rate (%) -country credit rating -debt payment /export ratio -domestic interest rate -inflation rate	-demand growth rate (% p.a.) -total profits after tax (US$) -total assets (US$) -no of employees	-generation assets (US$) -generation resource mix -no of employees -cost of pool or SBM or power exchange.	-distribution assets (US$) -distribution network length (overhead, underground) (km) -no. of customers (residential, non-residential, industrial, total) -energy delivered (MWh) (residential, non-residential, industrial, total) -transformers (capacity (MVA), number) -meters (number) (of which residential and pre-payment?) -maximum demand (MW) -no of employees	-transmission assets (US$) -no of employees -km of transmission wires (split by voltage level if possible)

[8] The information requirements for the construction of an Item (B) indicator are specified after the table.

[9] The information requirements for the construction of an Item (A) indicator are specified after the table.

(A) - Qualitative information required to construct institutional indicators:

- system of government (Parliamentary/ Presidential system)
- number of independent branches of government (executive, lower and upper legislative chamber, judiciary. etc.) with veto power over policy change
- party composition of each branch (in order to assess alignment)
- information on electoral rules:
  - non-simultaneous elections of different branches of government
  - proportional or district representation
- effective number of parties
- tenure of elected officials
- corruption indices
- reliability of judiciary
- type of judicial system
- other variables on general institutional environment

(B) – Qualitative information required to construct a regulatory indicators:

- independence of regulator (independent/government dept/semi-autonomous)
- price regulation/cost of service
- quality regulation (y/n)
- existence of financial guarantees for foreign investment
- responsibilities of regulator
- date of creation of regulator
- multi-sector regulator? If yes, which are the other sectors?
- financing of regulator
- total number of employees (discriminated in number of technicians, engineers, accountants, economists, lawyers, other)
- who appoints head/ commission, parliamentary approval for appointment
- Fixed-term appointment
- length of term (in years)

- re-appointment
- authority to fire commission, and reasons for firing
- how many heads have been removed so far
- who can veto regulator's decisions
- who issues policy guidelines for regulator
- publicly available policy guidelines?
- verbal instructions by minister/ president?
- decentralisation: have regional regulator been created?
- regulator compels financial/ performance information?
- standardised reporting format?
- how and by whom performance is audited?
- consultation process prior to decisions of regulator, type of consultation process
- who participates in regulatory proceedings?
- do utilities have the right to appeal regulatory decisions?
- where can utilities appeal to at 1st, 2nd and 3rd instance
- can other parties appeal?
- what other parties can appeal?
- are meetings actually open to public?
- are meetings required by law to be open?
- are regulator's decisions publicly available?
- are regulator's decisions required to be published?
- where decisions are published
- regulator's decisions actually published?
- where explanations of decisions are required to be published
- where explanations of decisions are actually published
- what does the legislation require from the regulator with respect to dealing with consumer's complaints?
- how does the regulator actually deals with consumer's complaints?
- number of consumers' complaints received p.a.
- is there any assessment of consumer's satisfaction with the way the regulator deals with complaints?

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