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REGULATORY EFFECTIVENESS: THE IMPACT OF GOOD REGULATORY GOVERNANCE ON ELECTRICITY INDUSTRY CAPACITY AND EFFICIENCY IN DEVELOPING COUNTRIES

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ABSTRACT

This paper assesses for 28 developing countries over the period 1980-2001 whether the existence of a regulatory law and higher quality regulatory governance are significantly associated with superior electricity outcomes. The analysis draws on theoretical and empirical work on the impact of independent central banks and of developing country telecommunications regulators. The empirical analysis concludes that, controlling for other relevant variables and allowing for country specific fixed effects, a regulatory law and higher quality governance is positively and significantly associated with higher per capita generation capacity levels and higher generation capacity utilisation rates. In addition, at least for three years or more, this positive regulatory impact appears to increase with experience.

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1. Introduction

Over the last 10-15 years, a very large amount of attention has been given to the role of institutions in economic growth. This has, in large part, been driven by economic policy priorities such as how to develop effectively functioning market economies in Central and Eastern Europe and the former Soviet Union post-1989; and how to foster economic growth in lagging world regions such as Sub-Saharan Africa. In parallel, and partly in response, there have been major explorations of the role of institutions in the functioning of market economies both by economists (e.g. the literature arising out of Williamson's transaction cost economics approach) and by economic historians (e.g. North (1990) and others).

In recent years, there has also been a substantial empirical literature on the relative roles of institutions, policy, geography and trade openness on growth performance across countries. This literature currently indicates that *institutional quality* is the dominant determinant of variations in long-term growth performance[1]. Good institutions embody a heritage of past good policy decisions and themselves generate a flow of superior policy decisions that support sustained investment and productivity growth[2]. In his recent survey on growth strategies, Rodrik (2003) argues that, although it is quite possible to achieve short-term growth accelerations (e.g. of 10 years or more) with very limited institutional change; the main requirement to ensure sustained growth and convergence with the living standards in advanced countries "… is the acquisition of high quality institutions". In particular, he argues that there is a requirement for a "… cumulative process of institution building to ensure that growth does not run out of steam and that the economy remains resilient to shocks" [3].

Infrastructure industries are not just a microcosm of the aggregate economy. The arguments above on aggregate growth apply with extra force to utility service industries. This is because not just are they highly capital intensive, but, in addition, because most of their assets are very long-lived and (in economic terms) sunk assets. Hence, an effective institutional framework is essential to sustain growth in output, efficiency and capacity for commercialised utility service industries such as electricity, telecommunications, water and similar - particularly if these industries have significant amounts of private investment (physical and/or financial).

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1 See Rodrik , Subramanian and Trebbi (2002) for a recent survey of the literature on studies of cross-country growth performance.

2 Rodrik et al (2002), pp 20-21.

3 Rodrik (2003), p.25

The standard institutional solution is to introduce an *independent regulatory agency*, operating within a clearly defined legal framework[4]. The regulatory agency is intended to provide the "high quality institution" which permits and fosters sustained growth in capacity and efficiency in the utility service industries – particularly the network elements. Hence, whether or not country X has a high or a low quality institution is determined primarily by the *quality of governance of the regulatory agency*. As with the aggregate economy, developing countries with high quality regulatory agencies (as measured by their regulatory governance) should attract more investment <u>on a sustained basis</u> into their utility service industries and at a lower cost of capital, as well as having higher efficiency levels and growth rates.

We would expect this outcome to arise because regulatory agencies with better governance should (a) make fewer mistakes and (b) have their mistakes identified and rectified better and more quickly so that (c) good regulatory practice is more readily established and maintained. It may well be possible to obtain a major short-to-medium term increase in investment without an effective regulatory framework, but the considerations outlined above suggest that this will not be sustained long-term. The collapse of the Asian IPP boom of the early 1990s and the late 1990s difficulties with many of the Latin American infrastructure reforms and concession contracts provide some evidence to support this conjecture.

The perspective outlined above is at the heart of the recent literature on regulatory governance for utility service industries, particularly the literature that focuses on developing and transition economies. This perspective is set out in Levy and Spiller (1994) – which draws explicitly on North (1990) – as well as in a number of subsequent papers[5]. However, until recently, there has been very little *systematic empirical testing* of the hypothesis that better regulatory governance (a) reduces unserved demand by encouraging investment or (b) increases efficiency. There have been many case studies – and these can be very illuminating but do not allow reliable generalisations – but, until the last 2-3 years, little formal econometric or other statistical testing.

This is now changing. More developing country utility regulators have been in place for 5 years or more and data is now becoming available on them that can be related to industry outcomes on a comparable basis, most obviously for telecoms. Hence, there have been a number of studies of the impact of a regulatory agency on capacity growth and efficiency in telecoms. All the major recent studies show that having a regulatory agency is significantly associated, either directly or indirectly, with higher mainline capacity per capita and higher labour productivity.

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4 An independent regulatory agency is not the only way of providing the necessary institutional support either in theory or in practice. In addition, an independent regulator may be combined with a high or a low degree of reliance on contracts and courts.
There is a major issue of whether or not low income developing countries have the human and other resources to sustain independent regulatory agencies, particularly regulatory agencies with a significant degree of discretion. Nevertheless, an independent regulatory agency has become the standard solution to the private investment problem for utilities in the same way as an independent central bank has become the standard solution to handle commitment and time inconsistency problems in monetary policy. See Section 2 below as well as the literature discussed in Stern and Cubbin (2003).

5 See, inter alia, Smith (1997), Stern and Holder (1999), Noll (2001).

In this paper, we carry out a similar exercise for electricity supply industries in developing countries. Specifically, we provide an econometric analysis of the relationship between the quality of regulatory governance and (a) the level of generation capacity per capita and (b) some efficiency measures for a sample of 28 Latin American, Caribbean, Asian and African countries over the period 1980-2001.

The plan of the paper is as follows. In Section 2, we discuss the underlying economic issues and the main institutional design considerations. This includes a summary review of recent relevant literature and its relevance for our analysis. In Section 3, we set out our modelling approach, including the modelling objectives, our econometric approach, data issues and potential econometric concerns. Section 4 presents the estimation results. Section 5 discusses the results and their implications as well as providing some short concluding comments.

2. Underlying Economic Issues, Institutional Design and Implications for Empirical Analysis

The main issue on which we focus is the inability of governments to make credible and binding commitments about utility pricing to sustain private investment while retaining decision-making powers over these issues.

The discussion of utility service regulation concentrates on *commercialised* utilities facing genuine budget constraints, particularly where private investment and/or private finance is important. The focus of the discussion (and of our empirical work) is on *regulatory governance* (e.g. autonomy, accountability, etc) rather than on *regulatory content* (e.g. methods of price, investment and related aspects of regulation)[6].

2.1 Time Inconsistency Problems for Monetary Policy and for Utility Service Industry Investment

The underlying economic issue for utility regulation – as for monetary policy – is that governments, particularly at certain times, have a strong incentive to behave in a shortsighted and populist manner that reduces welfare summed over a medium to long-term period. Hence, both in general but particularly at times of pressure, they place a very high weight on retail electricity prices over the next year relative to the medium to long term. In consequence, in the utilities industry context, authoritarian governments facing serious protests (and democratic governments facing difficulties in imminent elections) have a strong incentive to hold down electricity prices below economic cost even if this jeopardises future investment and consumption.

This is very similar to the well-known time inconsistency problem in monetary policy[7] under which:

(a) governments always have an incentive to have a short-term monetary expansion to boost economic growth and reduce unemployment just before an election leaving the next government to deal with the resulting inflation; and

(b) market participants *know* that Governments have such an incentive so that they are very likely to discount Government statements on the need for a stable anti-inflationary policy, however strongly made.

But, in the utilities area as well, private investors *know* that governments have such incentives and take this into account in their behaviour. In practice, that means attempting to negotiate binding contracts that prevent such strategic behaviour but which are highly sub-optimal in terms of technical and allocative efficiency. Typically, such contracts also incorporate a high cost of capital, highly front-end loaded returns or similar as a way of attempting to mitigate the risks. In practice, these techniques are often unsuccessful and the contracts are unsustainable and

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6 We looked, in passing, at methods of price/profits regulation in our empirical work but this issue was a subsidiary concern for this paper. See Section 4 for the results.

7 See Kydland and Prescott (1977), Barro and Gordon (1983).

collapse with a messy workout - as seen in electricity-related contracts in Asia after 1997 and Argentina since 2000.

Both for monetary policy and utility regulation, the critical issue is the weight given to the welfare of *future* consumers (and taxpayers) relative to *current* consumers. Thus, in the UK, the independent Monetary Policy Committee (MPC) is charged with setting interest rates to achieve a medium-term inflation target i.e. 2-3 years ahead. Similarly, the UK Utilities Act 2000 states that the protection of consumers is the prime objective of regulation, but explicitly defines consumers to include future consumers as well as current consumers[8].

However, not only is the underlying problem essentially the same in the monetary policy and utility regulation cases, but so is the standard recommended institutional remedy. In the monetary policy case, it is an *independent central bank* and in the utility regulation case it is an *independent regulatory agency*[9]. For utility service industries, the fall-back solution, where such contracts are unsustainable (and where credibility cannot be provided by a regulatory or other institutional solution) is that the utility is operated as a state-owned vertically integrated company (i.e. as a "nationalized industry"). This, of course, has many other disadvantages e.g. on incentives and efficiency levels.

Given the equivalence between the monetary policy and utility regulation commitment issues, we can learn a lot about the likely determinants of regulatory effectiveness from the sizeable empirical literature over the last 10-15 years on the effectiveness of independent central banks (ICBs) and its determinants. In particular, we can usefully learn from the studies of the impact of governance arrangements on ICB effectiveness.

2.1.1. Modelling Implications of ICB and Utility Regulation Equivalence

There are two particular reasons why the substantial empirical literature on ICB effectiveness is useful in considering how best to model the effectiveness of utility industry regulatory agencies. These are as follows:

(i) Few countries develop independent utility regulatory institutions that do not already have an independent central bank; and

(ii) Countries that have difficulties in sustaining an effective ICB also have difficulties in sustaining effective utility regulatory agencies (e.g. Argentina, Bulgaria).

These points demonstrate the relationship between the ICB and regulatory effectiveness issues with the wider question of the role of institutions in promoting and sustaining good policies and strong growth. In addition, they also raise the issue of what can reasonably be expected from regulatory agencies in difficult environments where the rule of law and civil society institutions are weak and corruption may be pervasive.

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8 See Section 9(6) and 10(6).

9 See Stern and Trillas (2003) for a verbal discussion of these issues and Levine, Stern and Trillas (2003) for a full formal exposition. See also Chapter 2 of Newbery (1999).

The recent survey article by Berger, de Haan and Eijffinger (2000) provides a good overview of the impact of ICB governance aspects on their performance. For this paper, the key results that emerge are:

1) ICBs are associated with lower average inflation rates (but not, in general, with higher growth rates or lower average unemployment rates). The inflation result is robust to measures of inflation aversion.

2) For OECD countries, the ICB governance indicator best associated with lower inflation is a measure of *formal legal* characteristics (e.g. an index). The relationship appears to be "quite robust"[10].

3) For developing countries (low and middle income) as a whole, legal ICB indicators have little or no explanatory power whereas *practice* is significant and correctly signed. The typical measure of ICB (and government) practice is the turnover rate of Central Bank governors (e.g. the probability that governors will be replaced within a short time of a change in government)[11].

The evidence strongly suggests (a) that ICBs do reduce the average rate of inflation; and (b) that the *quality* of their governance is important in their effectiveness. However, the relevant measure of governance quality seems to vary between OECD and developing countries. For OECD countries, the government and other parties involved appear to follow the "rules of the game" as set out in the relevant law and supporting regulations – there do not seem to be major differences in ICB performance cet par on the quality of the legal framework. But, for developing countries, particularly developing countries with political instability involving radical changes of government, the relevant measure of quality seems to be how far the law is observed in practice and in spirit – hence, the importance of turnover rates for ICB governors.

However, some recent work suggests that the effect of the turnover rate of CB governors on developing country inflation rates is only significant if high inflation countries are included. Sturm and De Haan (1999) find that excluding these observations leads to significance of coefficients on the legal indicators in developing countries.

In addition, recent work on ICB *information transparency* shows that greater and more effective transparency is associated with fewer surprises (i.e. less uncertainty) in financial markets and there is some evidence that it is associated with better macro-economic outcomes[12]. However, it seems to take longer for developing countries to achieve the benefits of transparency, presumably because it takes longer to establish the credibility that the transparency is reliable and will be maintained[13].

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10 See Berger et al, op cit, p.29.

11 This result, first established in Cukierman (1992) and discussed in detail in Cukierman and Webb (1995), has been replicated in a number of other studies.

12 See Geraats (2002).

13 See Fracasso, Genberg and Wyplosz (2003).

The importance of transparency and the time required for developing countries to establish their reputation and credibility are also important for utility service regulators as we will discuss below.

One final point is that the same indicators of governance quality have been found important both for ICBs and utility regulatory agencies e.g. clarity of objectives and assignment of functions between government and ICB, stable and depoliticised funding and appointment of governors/commissioners and, most importantly, fixed terms of office plus protection against dismissal except for proven and serious malfeasance. In politicised environments, this last condition is often failed. Even where it exists in the law, ways around the law are often found in practice in some (but by no means all) developing countries, viz the examples of Argentina and Bulgaria cited above.

(See Stern and Cubbin (2003) for a fuller discussion of the issues raised in this section and below.)

2.2 Governance Measures for Utility Regulatory Agencies

The previous section has outlined the underlying time inconsistency problem for which independent regulatory agencies are intended to provide a solution. For utility service industries, long-term contracts without a regulatory agency may be sufficient in some circumstances to provide the necessary institutional surety (e.g. for toll roads, water and sewage and similar). However, a regulatory agency may well help improve the sustainability of contracts even in those industries[14]. For electricity, although contracts may play a large part, they do not seem to be able to substitute for regulation in providing a sound basis for private investment in generation, let alone in transmission and distribution[15].

In consequence, we assume in what follows that an independent regulatory agency is the first-best method of ensuring that private investment in the electricity and similar industries can be sustained and at the lowest possible cost of capital. Similarly, an independent regulatory agency seems to be the best way of providing effective but reasonable incentives for efficiency and high productivity – and strong growth in these. The question then is what are the appropriate measures of governance to ensure the effectiveness of the regulatory agency in terms of these objectives.

There is considerable consensus on the criteria for good governance in regulatory agencies[16]. The key requirements are:

1.) *A strong legal framework where the rule of law is observed, contracts can be enforced and there are sound commercial and other courts which make their decisions in a timely manner.*

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14 See Guasch, J.L., Laffont, J.J. & Straub, S., (2003) for a discussion of renegotiation of water and transport concession contracts in Latin America.

15 See Stern (2003) for a discussion of these issues in the context of the development of the UK electricity industry pre-1940.

16 See among others Levy and Spiller (1994), Smith (1997), Stern and Holder (1999), Noll (2001). For a full discussion, see Stern and Cubbin (2003)

- Reliable and well-defined legal processes are crucial as are appeal provisions.
- Trying to develop effective regulatory institutions in the absence of an effective rule of law is, at best, extremely difficult and, at worst, impossible.

2.) *The formal legal attributes of regulation must be clearly articulated and preferably in a primary law*. This implies

- Clarity of roles and objectives between regulator, Government and regulated companies – coherence of the assignment of functions
- Autonomy of the regulatory agency e.g. in funding, staffing, appointments and dismissals
- Accountability of the regulator e.g. responsibilities to legislature, rights of appeals and redress

3.) *The regulatory agency must operate in practice in ways that encourage good practice and consistent, reliable decision-making – adequacy on informal attributes of regulation.* This implies

- Transparency e.g. publication of licenses, methodologies, decisions and the reasons for decisions
- Participation e.g. the involvement of major stakeholders in the regulatory process via consultations and published responses to consultations
- Predictability e.g. constraints on arbitrary changes of regulatory or regulated companies powers and duties, publication and use of regulatory principles, consistency of decision making

It is worth noting that regulatory governance becomes more important the more discretion that regulatory agencies have. Some regulatory discretion is inevitable even if regulatory laws are written to try to eliminate it (e.g. in Chile and some other Latin American countries). Levy and Spiller argued that it should be minimised and hence concentrated on the legal context in 1.) above. Subsequent commentators have placed much more emphasis on the governance aspects of the regulatory agency e.g. on the issues in 2.) and 3.) above[17].

It has also been increasingly recognised that the effectiveness of regulatory agencies depends on adequate human resources – especially the number of qualified professionals[18]. This is particularly important for regulators operating with more discretion.

17 See Stern and Cubbin op cit for a full discussion.
18 See, for instance, Noll (2001) and Domah, Pollitt and Stern (2002).

2.3 Evidence on Quality of Regulatory Governance and Modelling Implications

There have been many case-studies of regulatory agencies and their performance both for OECD countries and for developing countries, but few systematic comparative studies.

For high income countries (e.g. North America, EU member states and similar), there have not been major concerns about the quality of governance of regulatory institutions for electricity or other infrastructure industries. Some countries (e.g. Germany, New Zealand) have tried – and failed – to do without regulatory agencies. In general, regulatory laws and the way that they have been applied in practice are undoubtedly less than perfect but there have not been any obvious major failures.

In general, in high income countries, independent regulatory agencies have grown in number and in scope and no country has reverted to regulation by government Ministry or just by contract and the courts. For electricity, the main problems have been in market design e.g. in the design and operation of generation markets and their interaction with transmission. In particular, OECD and other studies suggest that the quality of enforcement appears reasonably good and broadly comparable in quality across such countries.

This is not the case in developing and transitional economies (DTEs). Examination of electricity or energy laws shows considerable variations in quality and many countries do not have electricity or similar laws that establish regulatory powers and duties. In general, countries with independent regulatory agencies establish the agency by a primary law; but, in some cases, it is established by Decree which makes its legal basis significantly less secure.

Of course, many DTEs retain a Ministry regulator with or without a law establishing regulatory powers and duties. Also, many electricity laws that are ostensibly designed to establish independent regulatory agencies retain a governmental role or veto powers that seriously compromise the autonomy of the institution[19].

More importantly, the quality of implementation and enforcement of regulatory laws varies considerably across DTEs. Both case studies and the few systematic studies that have been done to evaluate the quality of regulatory frameworks show that regulatory practice is consistently *worse* than the formal legal provisions[20]. For instance, among regulatory agencies, requirements for publishing reasons for decisions – or even annual reports - are often just not observed. On the other side, regulated companies, often colluding with governments, outflank or ignore regulatory requirements that they dislike[21].

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19 See Kennedy (2003) for a recent survey of the quality of Central and East European and CIS electricity/energy laws.

20 See the Prayas Report (2003) for an excellent – and worrying - recent survey of the regulatory process of State Regulators in India. See Stern and Holder (1999) for an earlier survey across five Asian developing economies.

21 See the discussion in Stern and Cubbin op cit of the Prayas Report and Kennedy (2002).

This last point is important for the analysis of the effectiveness of regulatory institutions on outcomes. As yet, data on regulatory governance across DTEs is confined to some measures of a few *formal* governance properties, typically on the degree of formal independence. This is also true of our work reported in Section 4 below. There is, as yet, virtually no comparable data across DTEs on the informal, practical and process aspects of regulation or on the quality of regulatory decisions (if this last could be established).

The absence of data on the non-formal aspects is not only unfortunate but also implies a potentially serious errors-in-variables problem in econometric estimation of the impact of governance variables on industry outcomes. A very preliminary investigation of this last using the Stern-Holder data set suggested a downward bias on estimated coefficients of around 5-10%. However, the Stern-Holder data set contained relatively little data on non-formal governance aspects than on formal ones so that it was far from an ideal test-bed for testing the bias[22]. The true bias could be significantly larger and this should be borne in mind in considering the results of our study as well as of other studies of regulatory effectiveness.

2.4 Output Measures for Utility Regulatory Agencies

When estimating the effects of governance variables for ICBs, there is relatively little problem in deciding on relevant output measures either for developed or developing countries. For all countries, rich or poor, the same output measure apply - lower and less variable average inflation rates, lower and less variable unemployment rates and higher growth rates.

Unfortunately, the same does not apply to utility service industries. For all countries, rich and poor, a relevant output is higher levels of (and faster growing) technical and efficiency as well as quality of service. However, whereas virtually all developing countries need significant *increases* in capacity to meet demand – at least in electricity supply, the same is by no means always true for rich countries. One of the main drivers of the liberalisation plus privatisation plus independent regulation OECD electricity reform model has been the desire to *reduce* unnecessarily high capacity reserve margins as well as to reduce investment costs. Similarly, after 1989, the CEE and CIS post-Communist transition countries inherited a large surplus of generation and transmission capacity.

This issue is important since *significantly higher investment (and private investment)* was the single most important reason cited over the last 15 years by the World Bank and similar policy institutions for the promotion of independent regulatory agencies in electricity and similar utility service industries[23]. This view goes back to the underlying time-inconsistency problem and the question of how, given limited tax resources, developing countries can increase capacity and reduced unserved demand – particularly for countries with poor reputations as regards their treatment of private investment. Hence, an independent regulatory agency has been advocated as the way in which private investors can be assured that they will be able to earn a reasonable rate of return.

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22 See Stern and Cubbin op cit, p. 30-32 for a fuller account.

23 The World Bank's 1994 World Development Report "Infrastructure for Development" is a good example. See Chapter 3.

In consequence, on this hypothesis, it is to be expected that sizeable private investment flows (domestic and foreign) will arise in developing country electricity and similar industries following the establishment of an independent regulatory agency. It is, however, worth noting that the speed at which the regulatory credibility is established is very unclear. It is likely to take some time, so that one might well expect lags of some years between the establishment of the new regulatory agencies and any significant increase in investment.

The implications of the above are that, in estimating the impact of regulatory governance variables on outcomes, we concentrate on:

(i) Electricity capacity levels in developing countries, excluding transition economies as well as OECD countries; and

(ii) Efficiency measures in developing countries, insofar as they are available.

We discuss the precise statistical measures of these in the next section. However, the key point to note here is that we have chosen our sample so that it includes only countries where there is good reason to believe that there are significant amounts of unsatisfied electricity demand because of capacity constraints.

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2.4.1. Results from Studies of Regulation on Developing Country Telecommunications Outcomes

The approach outlined above is echoed in a rapidly growing literature on the impact of regulation on telecom outcomes. That literature has developed in recent years: (a) because there are more countries with independent regulatory agencies for telecoms which have 5 years or more of existence (at least of legal existence)[24]; and (b) because of the growing availability of high quality and comprehensive data on telecom reform in developing countries[25].

The main empirical papers in this area (e.g. Fink, Mattoo and Rathindran (2003), Wallsten (2002) and Gutierrez (2003)) estimate the effects of regulation on

(i) mainline penetration rates (a standard measure of capacity) and

(b) efficiency (e.g. mainlines per employee).

They typically estimate panel data models (primarily fixed effects models) with one or other of the outcome measures as the dependent variable, and include regulatory variables as independent variables along with competition and privatisation variables,

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[24] See Wallsten (2002), Table 1

[25] The key data set is the ITU-World Bank Database on telecommunications policy. There is also the data from the Stanford –World Bank database (for Latin America) and the World Bank African Telecommunications Research Project

as well as standard control variables. We follow this approach in estimating the impact of regulation on electricity industry outcomes.

The standard model estimated in these papers (e.g. by Gutierrez) is

$$Y_{it} = X_{it}\beta + D_{it}\delta + \alpha_i + \varepsilon_{it}, \quad i = 1, \ldots, N; \; j = 1, \ldots, T \qquad \text{(Equ 1)}$$

where X is a vector of exogenous variables,
D is a vector of dummy variables,
α_i is a country specific fixed effect and
$\varepsilon_{it,}$ is an error model.

The X vector includes both regulatory variables and standard control variables

The approach of Gutierrez (2003) is particularly relevant to this paper. He constructs a *regulatory governance index* for his sample of 22 Latin American and Caribbean countries. This 7-element index (derived from the Stern-Holder typology) is calculated from examination of each country's telecom laws and changes in the laws. In our model for electricity outcomes, we adopt a similar approach and use a 'snapshot' 4-element index for 2000. (See Section 4 below for further details of our index and the data.)

Fink et al (2003) and Wallsten (2002) find that the presence of a telecoms regulator has a statistically significant association both with mainline penetration rates and with efficiency, but only indirectly via enhancing the effects of competition and privatisation. However, in neither paper is the regulatory measure strong and in both it is difficult to separate the dating of changes in privatisation, competition and regulation.

Gutierrez (2003) is stronger on all these aspects and he finds statistically and positive direct effects of his regulatory index both on tele-density and on efficiency. This result occurs both in static and dynamic models and after testing for the endogeneity of regulation[26]. The estimated effect of a 1-point increase in the index on mainlines per 100 inhabitants varies somewhat depending on the precise model specification but is, in general, of the order of 20%.

The Gutierrez study and its estimates provide a useful benchmark for our modelling of the effects of regulation on developing country electricity industry outcomes[27].

2.4.2. Results from Studies of Regulation on Developing Country Electricity Industry Outcomes

As yet, there are only a very few and very preliminary empirical studies e.g. Zhang, Kirkpatrick and Parker (2002) and a part of Pargal (2003). For data availability reasons, the capacity variable for these studies is *generation capacity only*. Data on this is available on an annual basis from the US Department of Energy's EIA website

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[27] See Stern and Cubbin op cit, p. 38-43 for further details of these studies

for almost all countries from 1980. Unfortunately, there is nothing similar available for capacity in transmission or distribution[28].

These papers find only weak effects of regulation, if any, and there are major problems in disentangling the effects of regulation from those of liberalisation. However, the studies are much more preliminary than those for telecoms, particularly in data terms.

In this paper, we have had access to much better data on regulatory governance and its variation across countries. However, our estimation of models for capacity, like those of Zhang et al and Pargal, is also limited to generation capacity.

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28 Pargal uses the Calderon –Serven infrastructure investment data set for 9 Latin American countries 1980-98. This divides electricity investment into public and private but appears, again, only to cover generation. See Calderon and Serven (2002) for a description of these data.

3. Model Specification and Modelling Issues

Our modelling work is primarily concerned with whether better regulatory governance in developing countries:

(i) increases rated generation capacity per capita; and

(ii) increases efficiency e.g. by increasing capacity utilisation in generation and/or reducing transmission and distribution losses.

3.1 Underlying Economic Rationale

On capacity, we start from the basis that developing countries have serious capacity constraints which lead to significant unserved demand arising, among other reasons. from many years of low levels of investment. In developing countries, it has typically been the case that electricity supplies were inadequate and intermittent. Supply was insufficient to cope with the level of demand as a result of several interconnected factors including:

- Lack of investment in generation, transmission and distribution
- Social pricing policies which led to inadequate returns on investment
- Public ownership associated with policy goals unrelated to electricity production
- Various other factors.

Rectifying the issue of inadequate levels of capacity and investment has been a major policy objective and a justification for electricity sector reform shared by developing country governments and development agencies, national and international, including the World Bank and the international regional banks.

The World Bank and others have argued that the establishment of good regulatory governance (e.g. via the development of well-founded independent regulatory agencies) has been a key element in their reform strategy over the last 15 or more years. Hence, estimating whether regulatory agencies have significant impacts on electricity capacity levels over time is important for the effectiveness of the policy. This also provides a test of the theoretical case for the importance of time inconsistency arguments as a useful framework for considering investment in the electricity industry.

Of course, inadequate supply levels are not due just to inadequate investment. In many developing countries, rated capacity has been much higher than available capacity. However, the same factors (e.g. revenue shortages and inadequate returns) also lead to low levels of maintenance. This is a major reason for expecting that improvements in regulatory governance will increase efficiency and raise capacity utilisation rates.

3.1.1 Regulation and Capacity Levels

The effect of electricity reform and the introduction of explicit regulation is to focus the policy of the electricity industry on providing sufficient supplies. In some cases, this has been done by harnessing the forces of private ownership and/or competition. In others, it has to provide a workable financial framework within which the electricity industry could develop by loosening the ties with government – for example, by enacting an electricity law giving various powers and duties to a Ministry regulator thereby requiring publicly owned electricity companies to operate in a more commercial way.

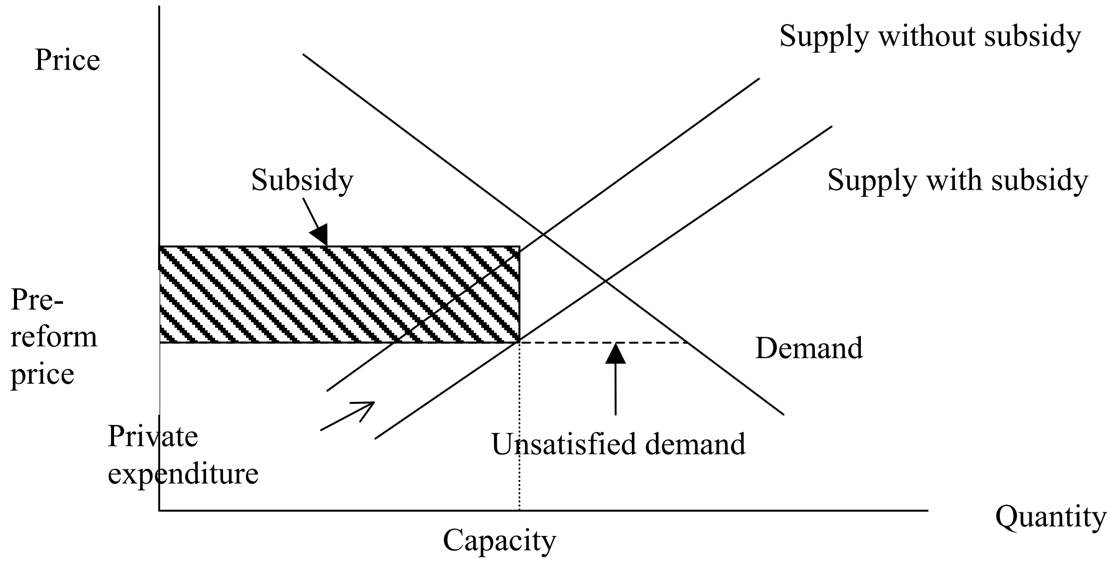
Investment is encouraged once effective regulation is available to support a workable financial framework. If the electricity industry is in private ownership the owners have the prospect of a return on their investment; if publicly owned, the industry can become independent of tax revenue or continually increasing loans. In addition, the existence of an effective regulatory framework can also encourage the growth of private investment and/or private finance within state systems, as has been happening in recent years in India and China.

These considerations suggest that the presence of an effective regulatory framework should, in general, lead to increased investment in the electricity sector, including the balanced development of generation, transmission, and distribution *ceteris paribus.* Unfortunately, comparable time-series capacity data across countries only exists for generation and it is on this aspect that the present study focuses.

In an unconstrained market economy, per capita generation capacity will adjust to the level of demand, which will depend upon the level of per capita income, the price of electricity, and environmental factors such as climate. The price of electricity will be determined in part by the efficiency of the sector. The latter may depend upon regulatory factors, but also availability of energy sources such as hydro, gas, oil, and coal. (This is most evident in cross-US comparisons of prices.) However, many developing countries with a traditional, vertically integrated and state-owned electricity sector will be constrained not so much by market demand but by the availability of continuing subsidy.

The capacity constraints arise because of either inadequate government revenues for electricity investment or subsidy payments and/or insufficient revenue flow to support viable private investment. A simple diagrammatic version of such a model is shown in Figure 1.

Figure 1 Chronic Supply Constrained Electricity Shortage (loss making public enterprise)



In this model, the level of capacity in the unreformed industry depends on the sum of private and public expenditure on investment in electricity which, in turn, will be determined primarily by the level of national income per capita. It is also well-established that the demand for electricity (and hence for electricity capacity) has an elasticity close to 1 with respect to GDP. Hence, we would expect equilibrium electricity demand and supply for electricity to be related to GDP growth.

For both these reasons, we include per capita GDP in our model, with an expected long-run elasticity not significantly different from 1.

One reason why equilibrium electricity demand and supply for electricity might grow faster or slower than GDP is if the share of industrial output in GDP were changing significantly. A rapidly growing share of industrial output (particularly in heavy industry such as aluminium smelting, iron and steel, etc) might be expected to increase the demand for electricity over and above what might be expected given GDP growth. In addition, in unreformed energy industries, retail industrial electricity prices are typically relatively high both compared to LRMC (long-run marginal cost) and to prices paid by households and small farmers. Hence, in unreformed systems, the extra revenue coming from a larger share of industrial consumers should increase electricity industry revenues and help ease investment financing problems.

For both these reasons, we include in our model the share of industrial value added as a percentage of GDP, with an expected positive coefficient.

The level of indebtedness is also highly likely, through the impact of borrowing constraints, to affect the ability of developing country governments to finance domestic public electricity investment, directly or by subsiding public enterprise losses. For private investment, particularly foreign private investment, high levels of government indebtedness are likely to be a significant risk factor discouraging investment (and one which effective regulatory institutions are intended to mitigate.)

For these reasons, we include in our model the share of government debt service as a proportion of gross national income. We would expect a negative coefficient on this variable.

The effect of an effective regulatory framework should be to reduce the constraint on the operation of the market, increasing supply and moving the outcome closer to the market equilibrium. The better the governance of the regulator, the greater the expected increase in capacity and increase in electricity supply.

We measure the quality of governance primarily by an *index of regulatory governance* which has 4 elements:

(i) Whether the country has an electricity or (energy) regulatory law;

(ii) Whether the country has an autonomous or a Ministry regulator for electricity;

(iii) Whether the country's electricity regulator is funded from licence fees (or equivalent) or out of the government budget; and

(iv) Whether the staff in the electricity regulator can be paid as appropriate given skill needs and labour markets or whether staff have to be paid on civil service pay scales.

These are all measured by 0/1 dummies. The highest governance ranking (a score of 4 on the index) is represented by having enacted an electricity regulatory law, plus an autonomous regulator, plus funding from licence fees and the staff not being confined to civil service pay scales. The dating of the switch from 0 to 1 on the appropriate variables (subsequently maintained at a constant level) is derived from the date of enactment of the law (except for cases where other information was available to provide a known, superior alternative). Hence, we can investigate the effect of *age* of the regulatory agency as well as its existence.

Given the economic arguments set out above and in Section 2, we would expect the coefficients on the index and on each of its components to be positive. We might also expect the effect of regulation to increase with the age of the regulator, particularly for the first few years.

In terms of the typology in Section 2.2, the regulatory variables in our index are all measures of *formal* attributes of regulation. Unfortunately, no comparable data is currently available on the *informal, practical* qualities of electricity regulation and the necessary omission of data on these characteristics must be borne in mind when considering the results, including potential biases to the estimates and to estimated standard errors. In addition, unlike Gutierrez (2003), we have no time dimension on changes in formal governance attributes subsequent to the enactment of the electricity/energy regulatory law.

In Section 2.2, we also refer to the background legal and related characteristics within which electricity regulators operate. We test for these using indicators for the rule of law and for corruption levels derived from the Kaufmann indices.

We would expect that a higher ranking on the rule of law would have a positive impact on generation capacity either directly or via an interaction term with our specific regulatory measures. A higher ranking on corruption might be expected to have a negative impact on generation capacity.

These considerations suggest a capacity model of the following form:

$$\text{Log(ELCAPPC)}_{it} = (a_0 + a_i) + a_1 \log(\text{GDPPC})_{it} + a_2 \text{Industry}_{it} + a_3 \text{Debt}_{it} + a_4 \text{RegIndex}_{it} + a_5 X_{it} + u_{it} \quad \text{(Equ. 2)}$$

Where Log ELCAPPC is the log of per capita electricity generation capacity in Gigawatts;

a_0 is a constant term;

a_i is a time-invariant country specific fixed effect

GDPPC is real per capita national income in $US 1995[29];

Industry is the log of industry value added as a percentage of GDP;

Debt is the share of government debt service as a percentage of gross national income;

RegIndex is our regulatory governance index (or individual components of it);

X is a vector of other potentially relevant variables (e.g. rule of law and corruption measures, age of regulatory agency, method of price regulation, etc); and

u_{it} is an error term

In all cases, the variables exist for i = 1, …, I countries over t = 1, …., T time periods.

The regulatory index takes the value of 0,1, 2, 3 or 4 where zero is ascribed to countries with a Ministry regulator, no electricity regulatory law, government budget funding and civil service pay scales.

29 Hence, GDP is on an exchange rate rather than a PPP basis.

The X vector for this equation might well include domestic fuel/hydro source availability and a variety of other country specific economic and/or institutional variables. However, these variables can be expected to stay fairly constant over the period of estimation.

Following the literature on the impact of telecom reform in developing countries, we also explore the role of (i) privatisation and (ii) competition on generation capacity growth. We investigate both direct and indirect effects (e.g. interactions between these variables and the regulatory index).

Although we start by estimating an OLS version of the model above, most of the results reported in Section 4 are for a fixed effects model[30]. Differencing the equation above eliminates the constant term and the country-specific fixed effects. If fixed effects are significant, the error term the equation above will not be normally distributed with zero mean when estimated by OLS. (See Section 3.2.2 below for a fuller discussion of econometric issues.)

The fixed effects are likely to include country variables with little or no time variation over the sample period including not just fuel source availability, but also many constant or slowly changing institutional variables. The eliminated fixed effects may therefore capture some of the aspects of the rule of law and corruption as country rankings on these indicators tend to be relatively stable over 10-20 year periods.

The theoretical basis for positive regulatory effects on investment applies to all commercialised electricity industries, public or private. However, they are likely to be stronger the greater the role of private investment. In consequence, we also estimate a variant of the capacity model above for a set of 9 Latin American countries for which generation data split by public/private is now available.

The equation above is a *static* representation of the model, which provide evidence on long-run equilibrium effects. We also consider *dynamic* variants e.g. incorporating a lagged dependent variable[31].

3.1.2 Regulation and Efficiency

As regards efficiency, we concentrated on the impact of regulation on two readily measurable characteristics of electricity supply industries for which comparable time-series data existed:

(i) Utilisation of generation capacity; and

(ii) Technical losses in transmission and distribution.

The first was measured as:

(Total Annual Generation in TWh)/(Generation Capacity in TW/365 * 24).

---

30 See Section 3.3.2 .1 below for a fuller discussion of heterogeneity issues.

31 See Section 3.3.2.3 below for a fuller discussion. Fink et al (2003), Appendix 4 has a discussion of estimation issues in panel data models in the context of the estimation of the impact of regulation and other policy variables on telecom industry outcomes.

This measure provides a good proxy for the *availability* of generation plant. Many developing countries have rated capacity levels that are considerably higher than available capacity and higher utilisation rates should closely reflect improvements in availability e.g. from the impact of better regulatory governance on maintenance expenditure.

Technical losses were measured as transmission and distribution losses as a percentage of total generation.

In both cases, we deliberately estimated a simple and parsimonious fixed effects model with the regulatory index as the main explanatory variable and real per capita GDP as a control variable. This was, not least, because there was no obvious well-defined theoretical model on which to base a more sophisticated approach.

We would very much have liked to estimate models for *quality of supply* (e.g. supply interruptions, coverage of system) and also for *commercial losses*. Empirical studies of electricity reform have shown that a major impact has been to improve quality and to reduce non-technical losses, particularly at the distribution level[32]. Unfortunately, no data currently exists for these variables that would allow the estimation of cross-country panel data models to test for the impact of improved regulation on quality.

We again estimated static and dynamic models for utilisation and technical losses.

3.2 Modelling Approach

The purpose of the investigation was:

a) to undertake a preliminary analysis for the electricity industry of the effect of independent regulators and aspects of their governance on improving the overall performance of the sector; and

b) to identify priority areas where enhanced data was required to allow a better analysis of these effects.

Under a), the key questions we have tried to answer are:

i) *Does the existence of an independent regulator appear to have any effects on measurable aspects of electricity industry performance (generation capacity, utilisation and technical losses)?*

ii) *If so, how big is the effect?*

iii) *By how much is the size of any effect influenced by measurable aspects of the governance of the regulatory institutions?*

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32 See, for instance, Bacon and Besant-Jones (2001)

iv) *What effects do private ownership and competition have in enhancing the aspects of performance we have measured, independently and in combination with regulation?*

On b), the quality and precision of the answers to these questions should help us to identify priorities for improvements on currently measured data. Consideration of the potential impact on the results of omitted variables and the resulting potential biases should help identify priorities for collecting data on variables for which data is not currently available.

3.2.1. Data

We have collected data on 28 developing countries over a 21 year period (1980-2001). Of the 28 countries in the sample, 15 were in Latin America, 6 in the Caribbean, 4 were in Asia and 5 were in Africa. The list of countries includes large countries (e.g. Brazil and India), small countries (e.g. Jamaica); middle income countries (e.g. Chile and Mexico) and poor countries (e.g. Ethiopia and Sudan). The full list of countries for which we have data is in the Appendix.

We also use a 9 country Latin American sample for an 18 year period (1980-1998) to exploe the effects of regulation on private investment in electricity generation.

Although much of the regulatory activity took place in the last half of the data set, the earlier period is important in effectively establishing benchmark levels of the dependent variables, and also in reducing some of the biases that can potentially arise in the use of short panels. In fact, 20.7% of the total number of country-sample years were years with an autonomous regulator and 31% with an electricity or energy regulatory law.

3.2.1.1 Data Sources

Data used in the results reported here were taken from the following sources:

- *World Total Generation Capacity, World Total Generation:* US Energy Information Agency - individual country data
- *Electric power transmission and distribution losses; Per capita GDP in $US1995; NPV of debt as a percentage of gross national income; industry value added as a percentage of GDP*: World Bank Development Indicators
- *Components for index of governance for electricity regulators and other data on electricity regulation and regulators; Electricity industry technical characteristics, competition and privatisation*: mainly based on a survey in 2001 by Preetum Domah, supplemented by authors' own research[33]

[33] See Domah, Pollitt, and Stern (2002) for full details. We are very grateful to Preetum Domah for permission to use the information from his survey in this paper.

- *Individual country goverance indicators for (a) rule of law and (b) corruption in 1996*[34]: Kaufmann, Kray, and Mastruzzi, World Bank (2003)
- *Private investment in electricity generation for 9 Latin American countries*: Data from Calderon and Serven (2002) as reported in Pargal (2003).[35]

This is the best data available in the absence of purpose-designed data-set(s) on which to estimate the effects of electricity reform of the kind that exist for telecoms. It is very suitable for a preliminary investigation but is far from ideal. In particular, it suffers from the following weaknesses:

1) The data on electricity market structure is poor and the data on privatisation very limited;
2) There is no data on the informal, practical aspects of regulation (e.g. security of tenure of regulatory agency heads or commissioners, etc);
3) The data on regulatory governance, competition and privatisation has no time dimension beyond a simple 0/1 dichotomy from a single year;
4) The data on the formal aspects of regulation only allows for a 4-element index rather than a larger index (e.g. 7-element telecom regulation index used by Gutierrez).

These weaknesses should be born in mind when considering the econometric results.

3.2.2. Econometric Issues

Panel data generally gives rise to some opportunities for carrying out investigations that are not possible with single-year cross sections or single-country time series, but these give rise to a number of issues which need taking into account for estimation. In our case, with data on 28 countries for 21 years, we have a large and long panel. Because of missing observations, it is an unbalanced panel.

The use of panel data provides many opportunities but also raises a number of potential econometric problems which we discuss below.

3.2.2.1 Coefficient Heterogeneity

If countries differ in their responses to the explanatory variables in ways that are related to the levels of the explanatory variables then misleading conclusions may be drawn. (See for example Hsiao pp 5-7, and figures 1.1 – 1.5 therein.) Such heterogeneity may be in the intercept, the slope coefficients, or both.

We have strong prior views that countries will differ consistently in their intercepts according to persistent unmeasured local factors such as the availability of indigenous fuel sources and seasonal low or high temperatures. For this reason our maintained

[34] The indicators exist for 1998, 2000 and 2002 but not for earlier years. In addition, rankings between countries on these countries change little and slowly.

[35] We are very grateful to Cesar Calderon and Luis Serven for permission to use their data.

hypothesis is that a fixed effects model is more appropriate than a random effects approach. In addition, the fixed effects static model avoids the potential biases which could arise in the random effects model owing to correlation between the included exogenous variables and omitted country attributes.

3.2.2.2 Dynamic structure

Static models, which assume that all adjustment to disequilibrium occur within the period defined by observation frequency may be inappropriate. In particular, investment in electricity is not usually completed in a year so we would expect that scope for some adjustment process would need to be incorporated into our model.

Such processes can be modelled generally by a combination of lags on the dependent variable (autoregressive) and on the explanatory variables (moving average).

However, the presence of a lagged dependent variable in a fixed-effects model can result in a biased estimates for the lagged dependent variable coefficient. The size of the bias will depend on the number of time series, *N*, the length of the time series, *T*, and the influence of other exogenous variables in the determination of the dependent variable (See Hsiao, op cit).

The problem is mainly significant in short panels. For T=21 we have estimated the asymptotic bias (as N increases) to be of the order of 3%. This is an upper limit given the presence of other major influences on the dependent variable.

3.2.2.3 Endogeneity

There has been much discussion of the need to take account of the endogeneity of regulatory agencies. This has been a major theme in the ICB literature where the introduction of an ICB (particularly the *early* introduction) may be interpreted as a signal of strong commitment to anti-inflation policies. Similarly, the introduction of an autonomous regulator (particularly the *early* introduction) may also be a signal of a strong commitment to commercialisation and the enforcement of property rights[36].

For telecom regulation, this issue was explored empirically in Gutierrez (2003). His coefficient estimates for the impact of regulatory governance were little affected by correcting for potential endogeneity. It is, however, difficult to find appropriate instruments.

In the results reported below, we do not explicitly model for the potential endogeneity of regulation. However, some of our main results are for equations with *lagged* values of the regulatory index. Hence, we would argue that comparisons of the estimates with lagged and unlagged values of the index should provide an indication of whether or not a potentially serious endogeneity problem exists.

[36] See Gual and Trillas (2002)

4. Results

In this section, we report the results of our empirical analysis. This is divided into two sections. Firstly, we set out some key descriptive statistics; and then, secondly, we report and discuss the results of our econometric analysis.

4.1 Descriptive Statistics

In the tables below, we present some key descriptive statistics relating to electricity regulation and our sample of developing countries.

4.1.1 Countries with Autonomous Electricity Regulators

Table 1 shows that by 1998 just under half the countries in our sample had an autonomous electricity regulator[37] – mainly in Latin America. However, in the following three years 3 African and 1 Caribbean country joined the set. Asia provides an exception to the spread of autonomous regulators with only 1 country (Philippines) having an autonomous regulator before 2001.

By 2001, a majority of countries had regulators classified (at least in legal terms) as autonomous.

Table 1: The Trend towards Autonomous Regulators (by Continent)

		1998		2001	
	Total	Ministry	Autonomous	Ministry	Autonomous
Africa	5	5	0	3	2
Asia	4	3	1	3	1
Carrib	6	3	3	2	4
Latin America	13	4	9	4	9
Total	28	15	13	11	17

Source: Domah 2001 survey, supplemented and updated by authors

4.1.2 Countries with Electricity Regulatory Laws

Even where there was no autonomous regulator, laws for the reform of the ESI Including regulatory reform were being passed. Table 2 shows the regional distribution of electricity reform laws for those states without autonomous regulation. According to the Domah data, all the countries with autonomous regulators had enacted an electricity regulatory law. By the end of our sample period only two countries in the sample (Barbados and Indonesia) did not have any electricity regulatory law in place.

These laws sometimes provided for IPPs or other elements of market reform, for commercialisation and sometimes for unbundling and competition in generation and supply. If the laws covered regulation, they typically specified the powers and duties

37 The Domah questionnaire used the term “autonomous” rather than “independent”, not least because it is more neutral. We treat the two terms as synonymous.

of the Ministry (or designated Ministry agency/department) in carrying out regulatory functions.

Table 2: Non-Autonomous Regulators: Existence of Law

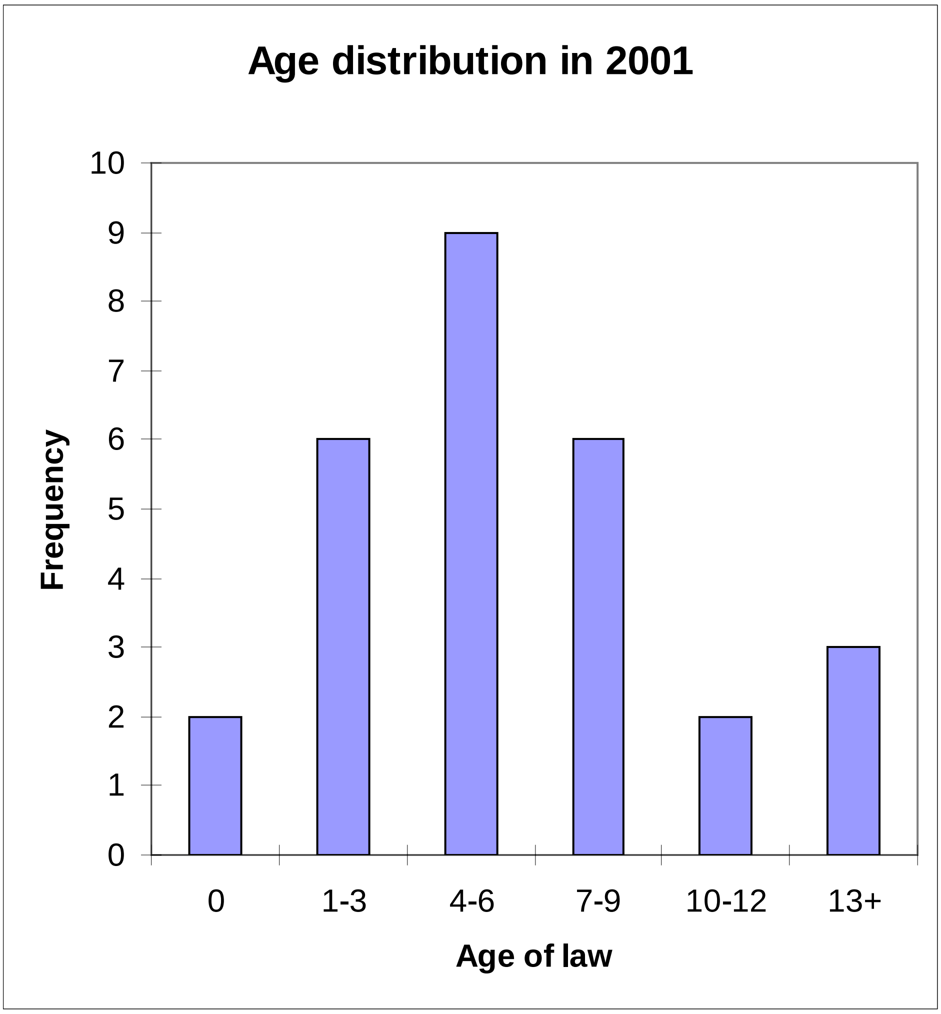
		1998		2001	
	Total	Law	No Law	Law	No Law
Africa	5	0	5	3	0
Asia	4	1	2	2	1
Carrib	6	1	2	1	1
Latin America	13	3	1	4	0
Total	28	5	9	10	2

Source: Domah 2001 survey, supplemented and updated by authors

4.1.3 Age Distribution of Autonomous Regulatory Agencies

Many, but by no means all, of the autonomous regulators in the sample had been put in place after 1995. This is shown in Figure 2 below.

Figure 2: Age Distribution Of Autonomous Electricity Regulators



Source: Domah 2001 survey, supplemented and updated by authors

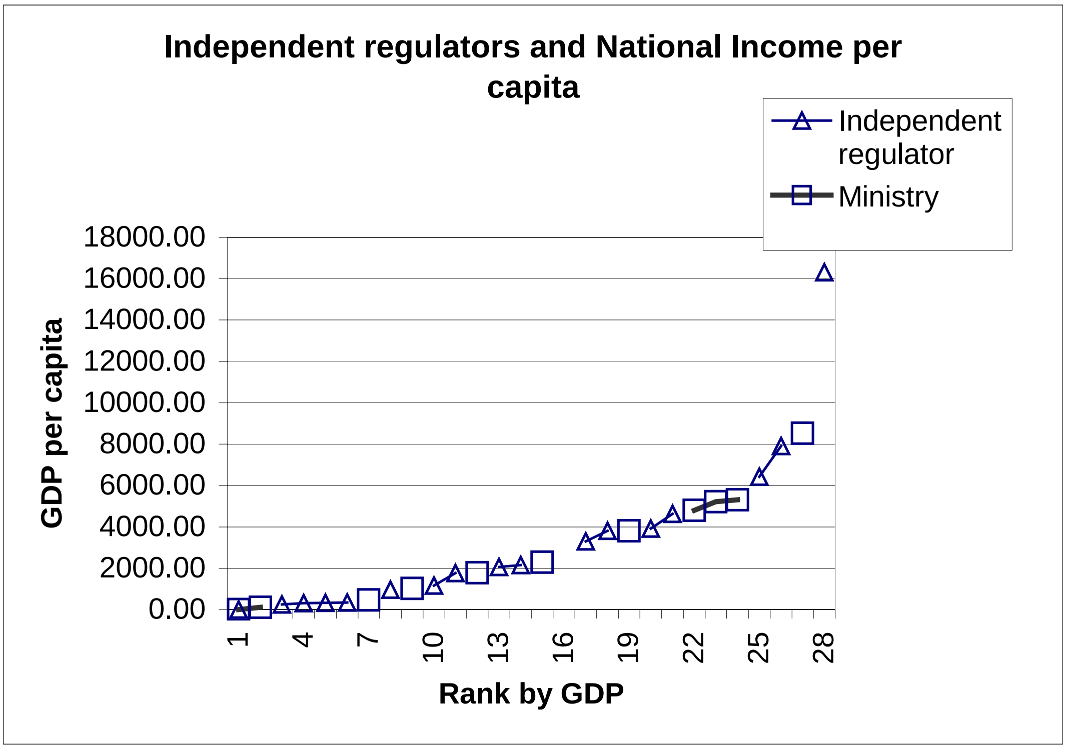
Figure 2 shows clearly how many of the DTE regulatory agencies in our sample were very recently established. 8 (47%) were under 3-years old in 2001, including all the African electricity regulators. The median age was just under 5 years. However, 5 (29%) were 10 years old or more and accounts for 42% of the total number of sample years with an autonomous regulator. The over 13 year-old group of autonomous electricity regulatory agencies comprises Costa Rica, Philippines and Trinidad and Tobago.

4.1.4 Ministry or Autonomous Regulator and Per Capita GDP

Figure 3 shows, very interestingly, that – at least within this sample - there is little relationship between the existence of an autonomous regulator and per capita GDP. Both autonomous and Ministry regulators are scattered through the income range.

The mean income for countries with an autonomous electricity regulator was $3,500. For those with a ministry regulator it was $3,300. The difference was not significant. However, low income countries with an autonomous regulator have younger regulators e.g.. the two Sub-Saharan African regulators established since 1998 (Kenya and Uganda).

Figure 3: Type of Regulator and Per Capita Income (in Real $ 1995)

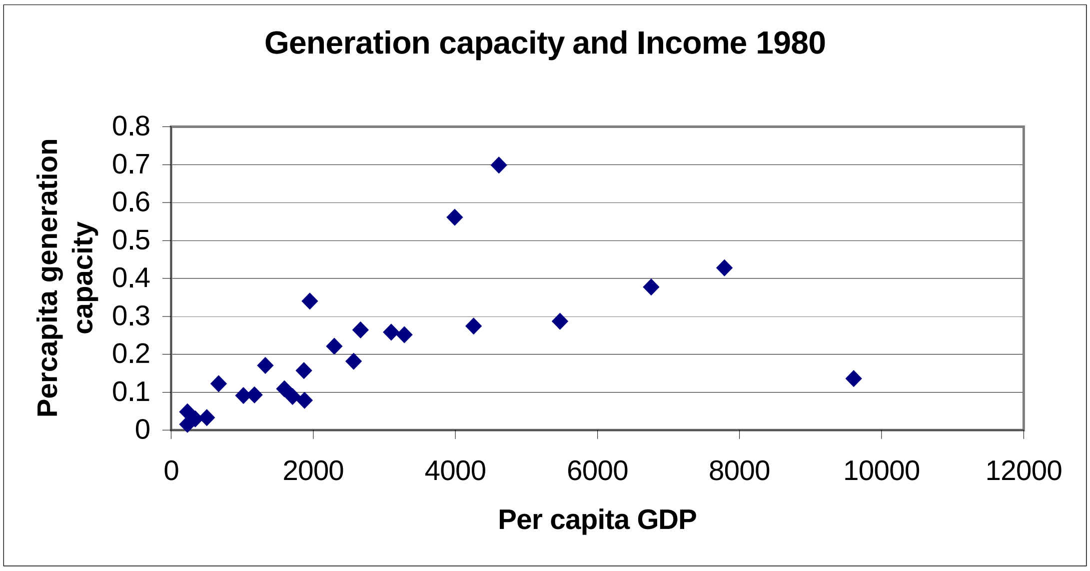


Source: Domah 2001 survey, supplemented and updated by authors

4.1.5 Generation Capacity and per Capita Income

Figures 4 and 5 plot generation capacity by real GDP for our 28 country panel at the start and end of the period. The plots show an upward sloping but by no means either uniform or linear relationship.

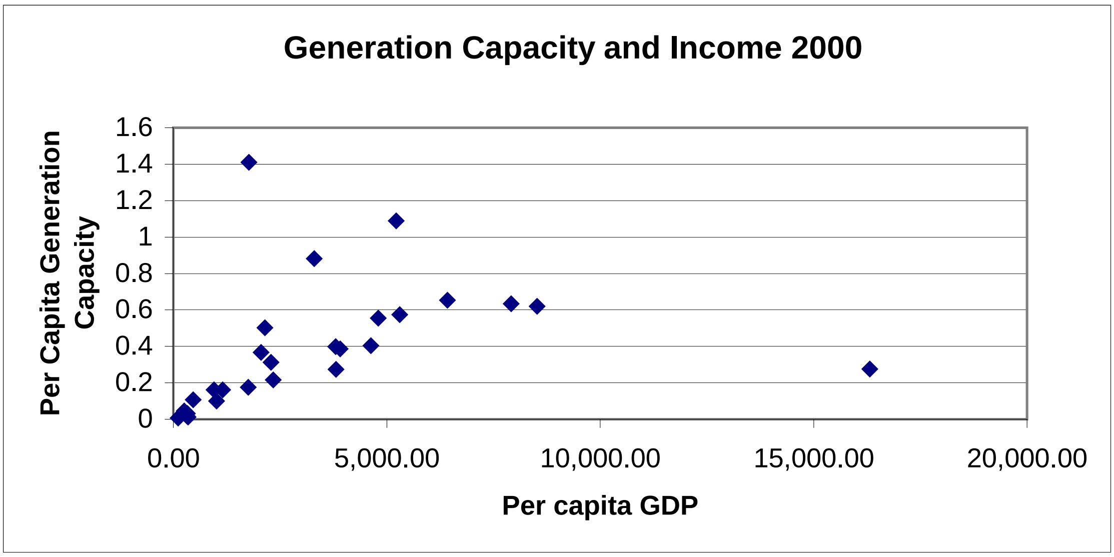
Figure 4: Generation Capacity and Income 1980



Source: US Energy Information Agency and World Bank Development Indicators

The outlier in the bottom right is Ecuador- as it was again in 2001. In 2001, only 55% of the population had access to mains electricity, even though the country is Latin America's largest oil exporter.

Figure 5: Generation Capacity and Income in 2000



Source: US Energy Information Agency and World Bank Development Indicators

The country at the top left of Figure 5 is Paraguay. It is a major exporter of hydro-power, and meets 25% and 40% respectively of Brazil and Argentia's electricity demands.[38] Interestingly, Ecuador has a (relatively young) autonomous regulator but Paraguay has a Ministry regulator.

For the pooled sample, the elasticity of generation capacity with respect to real per capita GDP was 0.89 (with a standard error of 0.02). The cross-section elasticities for selected years were as follows:

Table 3: Generation Capacity Real Income Elasticities

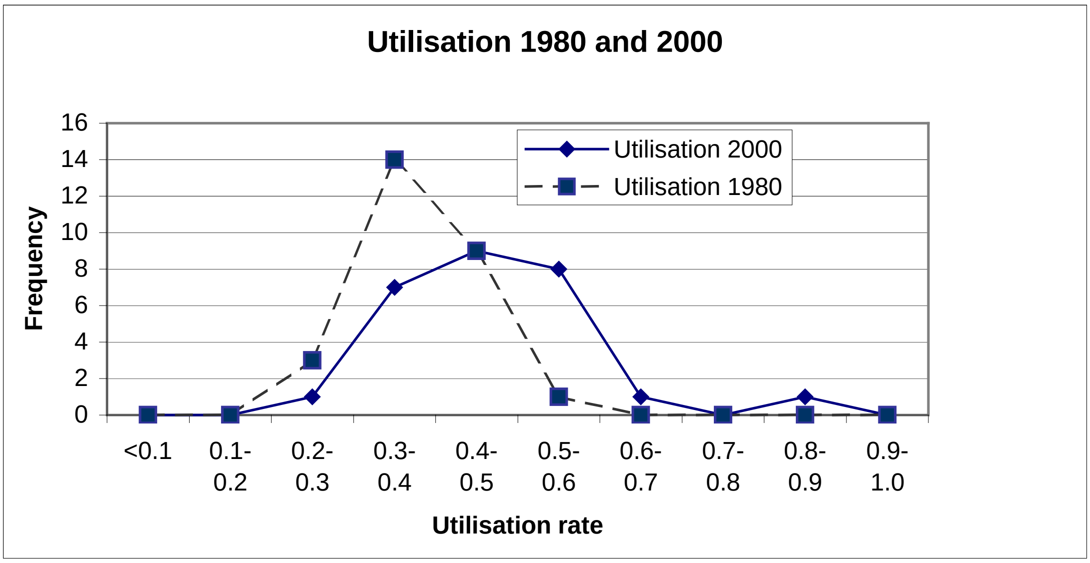
Year	Estimated Generation Capacity/ Real GDP Elasticities (Standard error in parentheses)
1980	0.78 (0.09)
1990	0.90 (0.11)
2000	0.94 (0.11)

Table 4 shows a trend towards the simple elasticity rising towards unity i.e. faster growth in generation capacity than in real income over the period. It remains to be seen whether this is in any way related to the spread of electricity regulatory reform.

4.1.6 Generation Capacity Utilisation 1980 and 2000

Beginning and end-of-period generation capacity utilisation rates are shown in Figure 6 below. In general, there has been a noticeable increase in capacity utilisation, but there are country exceptions (e.g. Colombia).

Figure 6: Utilisation of Generation Capacity 1980 and 2000



Source: US Energy Information Agency

[38] See IEA country analysis brief :Paraguay at www.eia.doe.gov

4.1.7 Correlation between Indicators of Regulatory Governance

As discussed above, our regulatory index includes 4 indicators. These are classified positively for: (i) the enactment of an electricity regulatory law; (ii) the existence of an independent/autonomous regulator; (iii) funding from licence fees (or equivalent) and (v) staff salaries not necessarily confined to civil service pay scales.

Although the majority of our results are based on the index, we also try to estimate their separate effects. However, the degree to which we are able to do so depends on the levels to which they are correlated with one another. Not surprisingly, they are highly inter-correlated as shown in Table 4 below.

Table 4: Correlation Matrix between Regulatory Governance Variables

	ElAct	*Funding*	*Orgtype*	*Cserv*
ElAct	1			
Funding	0.848968	1		
Orgtype	0.783066	0.703489	1	
Cserv	0.783066	0.551221	0.442631	1

The correlations are highest within the law/funding/autonomy grouping.

4.2 Econometric Results

In what follows, we report various results. In Table 5 below, we report the core results for our static model of per capita generation capacity. Tables 6 and 7 report the results from variants on the static model. Table 8 reports some results of dynamic models of generation capacity and (for 9 Latin American countries) private investment in generation. Table 10 reports some results for generation capacity utilisation and technical losses.

4.2.1 Econometric Results for Models of Generation Capacity and Investment

We start by reporting the results of an OLS equation as a baseline. All subsequent equations are modelled using a fixed effects estimator. Given the nature of the underlying model, we would expect a fixed effects model to be more appropriate than a random effects model. For some of the equations, we tested this assumption using the Hausman test and the random effects model was consistently rejected in favour of a fixed effects model.

4.2.1.1 Basic Static Generation Capacity Model Results

The key results from Table 5 below are:

- The fixed effects model clearly dominates the OLS model as shown in the standard error of estimate for the regressions.

- The estimated coefficient on the regulatory index is significantly different from zero at the 1% level in Equations 1 and 2. The implications of Equation 2 (our basic fixed effects model) is that, in the long-run, each unit increase in the regulatory governance index increases per capita generation capacity by 4.3 % so that a country with best regulatory governance practice and an index score of 4 could expect to have 17.2% higher generation capacity per capita.

- Equations 3 and 4 include *age of regulator* variables as well as the regulatory index. (The age of regulator variables - dummy and continuous - refer to all regulatory agencies, Ministry and autonomous, covered by a regulatory law. The estimated coefficient on the regulatory index is no longer statistically significantly different from zero even at the 10% level.

- The impact of regulation clearly increases with age of regulator. Equation 3 suggests a long-run effect of regulators aged over 3 years of 35% on per capita generation capacity. Equation 4, which assumes a quadratic effect of age of regulator, the impact of having a regulator peaks at 15 years[39]

- The coefficient estimates for log(real GDP) are 0.7 - 0.8, with t-values of 8 or more.

- The estimated coefficient on the debt variable is both very small and has a very high standard error. Only in the OLS equation is the estimated coefficient on the GDP share of industry value-added significant at the 5% level or better.

- The equations all have very low Durbin-Watson statistics which suggest that t-values may be upward biased.

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[39] The implicit decline in effectiveness after 15 years is not well-founded as only one of our regulatory agencies (Costa Rica) has a regulator in place for more than 15 years

Table 5: Static Models for Generation Capacity

Dependent Variable = Log(Electricity Generation capacity per capita)	**OLS model**	**Basic FE model**	**Age-of - regulator dummies**	**Quadratic in age of regulator**
Explanatory variables	**1**	**2**	**3**	**4**
Constant	-8.286			
	(-52.162)			
Real GDP per capita (log)	0.772	0.805	0.697	0.699
	(31.071)	(9.970)	(8.343)	(8.522)
Debt payments as a proportion of national income	4.14E-12	2.49E-12	-4.65E-13	1.07E-12
	(0.838)	(0.556)	(-0.104)	(0.244)
Industry value added as proportion of GDP	0.024	-0.002	0.000	0.001
	(7.981)	(-0.607)	(-0.003)	(0.232)
Index of regulatory governance 0-4	0.056	0.043	-0.026	-0.011
	(2.982)	(3.444)	(-1.067)	(-0.638)
Regulator under 1 year			0.090	
			(1.465)	
Regulator 1-3 years			0.187	
			(2.398)	
Regulator aged over 3 years			0.353	
			(4.370)	
Age of regulator				0.055
				(4.132)
(Age of regulator)^2				-0.002
				(-2.635)
Estimation method	OLS	Fixed effects	Fixed effects	Fixed effects
Adjusted R-squared	0.764	0.952	0.954	0.954
S.E. of regression	0.605	0.272	0.267	0.266
F-statistic	465.943	372.079	352.169	365.770
Durbin-Watson	0.043	0.161	0.163	0.153
No of observations	577	577	577	

Note: t statistics in parentheses

4.2.1.2 Impact of Individual Governance Index Components in Static Generation Capacity Model

Table 6 reports the results taking sequentially each component of the index in counterpart equations to Equation 2. The main features to note are:

- The largest regulatory effect – 18% (and the highest t-value) - is from having an electricity law; but, given the high level of collinearity with the other regulatory index measures shown in Table 4, this is almost certainly an upwardly biased estimate.

- The negative sign on non-mandatory civil service pay scales (significant at the 1% level) is the opposite of that predicted by regulatory governance theory.

Table 6: Static Models for Generation Capacity: Variants 1

Dependent Variable = Log(Electricity Generation capacity per capita)				
	Electricity Law	**Type of regulator**	**Funding**	**Staffing pay**
Explanatory variables	**5**	**6**	**7**	**8**
Real GDP per capita (log)	0.722	0.848	0.818	0.747
	(8.755)	(10.667)	(10.363)	(8.825)
Debt payments as a proportion of national income	9.38E-14	1.74E-12	4.99E-12	-1.62E-13
	0.021	0.378	1.124	-0.0350
Industry value added as proportion of GDP	(-0.001)	(-0.003)	(-0.002)	(-0.002)
	(-0.249)	(-0.920)	(-0.645)	(-0.599)
Index of regulatory governance 0-4				
Electricity Law	0.180			
	(5.130)			
Autonomous regulator		0.100		
		(2.343)		
Licence funding of regulator			0.135	
			(3.419)	
Civil service pay scales non-mandatory				-0.180
				(-4.010)
Estimation method	Fixed effects	Fixed effects	Fixed effects	Fixed effects
Adjusted R-squared	0.953	0.952	0.953	0.953
S.E. of regression	0.271	0.273	0.271	0.271
F-statistic	385.888	367.622	382.725	375.033
Durbin-Watson	0.165	0.156	0.161	0.162
No of observations	585	577	583	577
Note: t statistics in parentheses				

4.2.1.3 Variants on the Static Generation Capacity Model

Table 7 reports the results of equations where we estimate the effects of including independent variables measuring the rule of law as well as equations including privatisation and competition variables. The rule of law measure is the Kaufmann index for 1996.

Table 7: Static Models for Generation Capacity: Variants 2

Dependent Variable = Log(Electricity Generation capacity per capita)			
	Rule of Law	**Privatisation and Competition 1**	**Privatisation and Competition 2**
Explanatory variables	**9**	**10**	**11**
Real GDP per capita (log)	0.685	0.783	0.863
	(8.228)	(10.457)	(12.052)
Debt payments as a proportion of national income	1.55E-12		
	(0.351)		
Industry value added as proportion of GDP	0.002		
	(0.534)		
Index of regulatory governance 0-4	0.040	0.059	
	(2.269)	(3.399)	
Privatisation x Autonomous regulator dummy		0.021	0.186
		(0.268)	(2.961)
Competition x Autonomous regulator dummy		(-0.146)	-0.100
		(-1.600)	(-1.098)
Age of regulator	0.021		
	(4.096)		
Kaufmann Rule of Law Index x Index of Regulatory Governance	0.061		
	(1.902)		
Estimation method	Fixed effects	Fixed effects	Fixed effects
Adjusted R-squared	0.954	0.955	0.954
S.E. of regression	0.267	0.266	0.269
F-statistic	363.457	408.369	413.946
Durbin-Watson	0.157	0.166	0.160
No of observations	577	602	602
Note: t statistics in parentheses			

Both privatisation and competition are included as 0/1 dummies with the switch to 1 ascribed to the years following enactment of the electricity law. Privatisation is measured by a 50% or more private shareholding in one or more of generation, distribution and supply. A competition dummy of 1 was given to countries classified as having more than 8 companies operating in the electricity industry.

The data for the construction of these dummies were taken from the Domah 2001 survey and represent the privatisation and competition picture in 2001. However, the actual dummies were constructed by the authors. Neither of these dummies is very satisfactory for our purposes although they represent the best that can be done with currently available data. The privatisation dummy is deficient on dating and the competition dummy is a weak proxy as well as poor on dating. Improving data on these variables beyond what is currently available for electricity (i.e. to provide information comparable to telecoms) should be a high priority.

The main points of interest from Table 7 are:

- Equation 9 is the best fitting equation including the Kaufmann governance measures. The coefficient on the Kaufmann rule of law index is positive and significantly different from zero at the 10% level when interacted with the regulatory index. Coefficient estimates on rule of law never approached statistical significance when included directly nor was it consistently significant as an interacted variable in other equations.

  Coefficients on the Kaufmann corruption index were never statistically different from zero at the 10% level when include either directly or indirectly (i.e. as an interactive term).

- The coefficient on our competition proxy variable was consistently negative but not significantly different from zero. The coefficient on the privatisation variable was only significant at the 10% level or better when interacted with the regulatory dummy and the regulatory index was excluded, as in equation 11. For the reasons given above, the results on the privatisation and competition variables probably reflect the deficiencies in the measures as much as any genuine economic impact.

The failure to find any statistically significant coefficients on these variables does not necessarily mean that the legal and socio-economic context is irrelevant nor that our equations imply a zero effect. We strongly suspect that these variables (and similar others) are captured to a considerable extent in the estimated pattern of fixed effects[40].

4.2.1.4 Simple Dynamic Models of Generation Capacity

In Table 8 below, we report our estimates of some relatively simple dynamic models Equations 12 and 13 report the results of the model for per capita generation capacity, but adding a lagged dependent variable. Equation 14 estimates a dynamic model similar to that in Pargal (2003) for private investment in generation capacity in 9 Latin American countries using data from the Calderon-Serven data set.

The main features of Table 8 are:

- The estimated long run coefficients on the regulatory variables in Equations 12 and 13 are comparable to their equivalents in the static equations. However,

[40] We will explore this conjecture in subsequent estimation.

the coefficient on the regulatory index in Equation 12 is only statistically significant at the 10% level.

- The implicit long-run coefficient on the regulatory governance index in Equation 12 is 6.1 per unit on the index, implying a long-run effect of 24% on per capita generation capacity for a maximum score on the index. The implicit long-run effect in Equation 13 on per capita generation capacity from a regulatory agency with at least 3 years of existence is 26%.

- The elasticity of per capita generation capacity wrt. real GDP is very close to 1 in both Equations 12 and 13.

- For private electricity generation investment, in Latin America 1980-98, the regulatory variables never approached significance in any of the equations estimated. Equation 14 is a typical example. The share of industry value added was, however, consistently positive and significant.

Table 8: Dynamic Models for Generation Capacity and Investment

Dependent Variable	Log(Electricity Generation capacity per capita)	Log(Electricity Generation capacity per capita)		Log(private investment in generation in 9 Latin American countries)
Explanatory variables	**12**	**13**		**14**
Lagged dependent variable	0.885	0.879		0.540
	(66.186)	(66.0940		(6.805)
Real GDP per capita (log)	0.119	0.121		1.805
	(4.558)	(4.610)		(3.223)
Debt payments as a proportion of national income				2.05E-10
				(0.363)
Industry value added as proportion of GDP				0.078
				(3.454)
Index of regulatory governance 0-4	0.007			-0.075
	(1.835)			(-0.663)
Regulator aged 1-3 years		0.010		
		(0.893)		
Regulator aged over 3 years		0.032		
		(2.247)		
Age of regulator				-0.003
				(-0.036)
Public investment in electricity generation (log)				0.137
				(1.585)
Implied long run multiplier 1/(1-lamda)	8.732	8.249		
Estimation method	Fixed effects	Fixed effects		Fixed effects

Adjusted R-squared	0.996	0.996		0.857
S.E. of regression	0.083	0.083		0.683
F-statistic	4366.527	4399.462		43.037
Durbin-Watson	1.850	1.834		1.911
No of observations	576	584		99
Note: t statistics in parentheses				

4.2.1.5 Tests of the Generation Capacity Model for Spurious Correlation

In all the main generation capacity equations reported above, the R^2 statistics are high – around 0.95 in the static fixed effects models and over 0.99 in the dynamic model. This clearly raises questions as to whether the empirical results are dominated by the purely statistical relationship of one highly trended variable (per capita generation capacity) with another (real per capita GDP).

In fact, as shown in the country graphs reproduced in Appendix 2, neither the per capita generation series nor the real per capita GDP series are dominated by an obvious trend and the capacity per unit of GDP graph shows considerable variation over time within and between countries. However, the issue is also worth more formal investigation and we report some preliminary regression results in Table 9.

Table 9: Generation Capacity – Tests for Spurious Correlation

Dependent Variable	Log(Electricity Generation capacity per capita)		Log(Electricity Generation capacity per capita)
Explanatory variables	**15**		**16**
Time Trend	0.017		-0.0001
	(7.695)		(-0.071)
(Lagged Dependent Variable) $_{t-1}$			0.821
			(49.429)
Real GDP per capita (log)	0.441		0.179
	(5.683)		(5.500)
(Index of regulatory governance 1-4) $_{t-3}$	0.022		0.013
	(1.803)		(2.511)
Estimation method	Fixed Effects		Fixed Effects
Adjusted R-squared	0.977		0.996
S.E. of regression	0.195		0.081
F-statistic	741.539		4289.469
Durbin-Watson	0.255		1.896

No of observations	529		529

Note: t statistics in parentheses

Key features arising are:

- The time trend is significant at the 1% level in Equation 15 but not in Equation 17, where the estimated coefficient is both negative and very small in magnitude as well as having an extremely low t-value. The estimated trend coefficient in Equation 15 is relatively small at 1.7% per year.

- The estimated coefficient of the regulatory dummy in equation 16 is statistically significant at the 1% level and the magnitude of the long-run coefficient is very similar in magnitude to its equation 12 counterpart. However, the magnitude of the estimated regulatory coefficient in 15 is about half the magnitude of its equation 2 counterpart and only significant at the 10% level.

  (Note that lagging the regulatory variable by 3 years implies that all regulators established after 1997 will be excluded.)

These results are not conclusive in resolving the econometric modelling concerns and there are clearly unresolved issues in terms of the appropriate dynamic structure. We will explore these issues more fully in further work. However, the results reported in Table 9 provide evidence that our results reflect underlying economic relationships and are not just time-dominated statistical artifacts.

4.2.2 Econometric Results for Models of Generating Capacity Utilisation and Technical Losses

Table 10 presents some results relating to the impact of regulatory governance on efficiency. For the reasons set out above, we deliberately estimated simple models. The results were reasonably positive for capacity utilisation in generation but we never found any positive or significant effect of any regulatory variable for transmission and distribution losses

Table 10: Utilisation and Technical Losses

Dependent Variable	**Utilisation of generation capacity***		**Technical losses in transmission and distribution (%)**
Explanatory variables	**17**		**18**
Real GDP per capita (log)	0.729		-0.841
	(2.279)		(-0.441)
Index of regulatory governance 0-4	0.079		0.219
	(2.330)		(1.016)
AR(1)	0.713		0.648
	(23.365)		(17.786)
Estimation method	FE + Prais – Winsten		FE + Prais – Winsten
Adjusted R-squared	0.743		0.840
S.E. of regression	0.449		2.697
F-statistic	56.196		92.624
Durbin-Watson	2.138		2.032
No of observations	574		472

Note: t statistics in parentheses

Utilisation = generation/(capacityx24x365)

The positive effect in the utilisation equation of the regulatory index (significantly different from zero at the 1% level) was found in some but not all other equations estimated. In the equation reported, a 1 point increase in the regulatory index is associated with a 0.8% increase in utilisation so that utilisation with the maximum index score of 4 implies a 3.2% increase relative to countries with an index score of zero.

Generation capacity utilisation rates also appear to be positively (and significantly) associated with higher GDP within and between countries.

5. Discussion of Results and Concluding Comments

5.1 Discussion of Results

The results of this study seem to provide a broadly consistent picture that the existence of a regulatory agency with good governance characteristics not only can in principle improve regulatory outcomes *but actually does so in practice*. For electricity supply industries in 28 developing countries in the 1980-2001 period, we find that an index of regulatory governance is a consistently positive and statistically determinant of per capita generation. Our results, using fixed effects estimation methods, are similar to those found in for telecoms in developing countries (e.g. Gutierrez, 2003).

The main positive findings are that

1) Averaging over developing country regulatory agencies, the estimated long-run impact on per capita generation capacity of a maximum regulatory governance index score of 4 is of the order of 15-25% cet par.

2) The estimated impact of regulation increases with experience – at least for the first 3-5 years or more. The cet par impact on per capita generation capacity of a regulator (autonomous and/or Ministry) established at least 3 years is of the order of 25-35%.

3) The effects on per generation capacity are robust not just to the inclusion of a lagged dependent variable but also to the inclusion of a time trend and 3-year lags on the regulatory variables.

4) The effects of the enactment of (a) a regulatory law, (b) of having an autonomous regulator and (c) licence fee funding of the regulatory agency were each positive and statistically significant at the 1% level.

5) There is some evidence that better regulatory governance is a statistically significant determinant of generation capacity utilisation (a good proxy for availability).

6) There is some evidence, albeit weak, that the better the rule of law, the stronger the regulatory effect

There are, however, some negative findings. These include the following

1) A limited investigation showed no significant, positive effect of any of our regulatory governance measures on private electricity generation investment in nine Latin American countries.

2) There was no evidence of any significant, positive effect of any of our regulatory governance measures on transmission and distribution losses.

3) There was no reliable evidence in this data set that competition or privatisation were significant determinants of generation capacity either individually or

when interacted with regulatory governance. However, the data set we used was much stronger on regulatory variables than on competition and privatisation variables.

On the whole, we were surprised at the strength and robustness of the positive results. The data set we used has a number of major weaknesses in spite of being the best currently available. Among the main weaknesses of the data set are:

- ❖ The absence of any data on regulatory practice, including government (and/or electricity company) malpractice towards supposedly independent regulatory agencies (e.g. high within-term turnover rates of regulatory office heads/commissioners).

- ❖ The absence of any reliable cross-country data on ESI efficiency and productivity or on service quality and revenue collection

- ❖ The limited time dimension to the regulatory data – and the extremely limited time dimension to data on privatisation and competition.

- ❖ Potential omitted variable biases from the inability to test for the inclusion of many potentially significant variables.

- ❖ The limited and possibly unrepresentative sample of countries.

It is to be hoped that some of the major data weaknesses can be remedied e.g. by systematic data collection exercises of the sort that have been carried out for telecom reform.

5.2 Concluding Comments

In this paper we have presented evidence which suggests that good regulatory governance does have a positive and statistically significant effect on some electricity industry outcomes in developing countries – notably per capita generation capacity levels - but we have not examined *why* this is so.

To examine *why and how* regulation operates to improve outcomes is not a task that obviously recommends itself to econometric analysis. We suggest that, at least at this stage, it is better pursued by case studies with econometric work being concentrated on whether or not the results reported in this paper are confirmed in subsequent analysis e.g. with superior data, particularly on regulatory practice, privatisation and competition variables.

Nevertheless, we are confident that the results reported here are entirely consistent with the literature on the role of institutions in economic growth. The key point is that regulatory agencies with better governance are:

- Less likely to make mistakes

- More likely to correct mistakes speedily

- Less likely to repeat mistakes

- More likely to develop procedures and methodologies that involve participants and develop good practice.

All of these reduce uncertainties for commercially operating companies – particularly private and foreign companies. This is especially important to sustain and encourage long-lived, sunk investments in highly capital-intensive industries at a reasonable cost of capital. As such, regulatory agencies, which have and maintain good governance, provide an effective underpinning for the operation of contracts as well as sound regulation of monopoly elements.

The utility service industries like electricity supply may be considered as a microcosm for considering the role of institutions in sustaining investment, efficiency and growth. But, in fact, they are a touchstone. Given their role in supporting growth as well as their technical characteristics, electricity and similar industries are among those most in need of strong and effective regulatory frameworks. Hence, we suggest that our positive results on the role of good governance support and enhance the lessons of similar studies for independent central banks and telecom reform as well as supporting the general arguments of North, Rodrik and others on the role of effective and evolving institutions for sustained growth.

It remains to be seen whether the results reported in this paper survive in the light of further analysis and can be replicated with better data.

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APPENDIX: LIST OF COUNTRIES IN SAMPLE

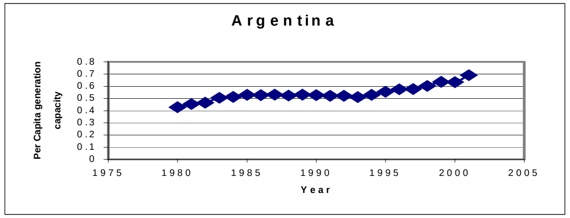
(i) Main sample

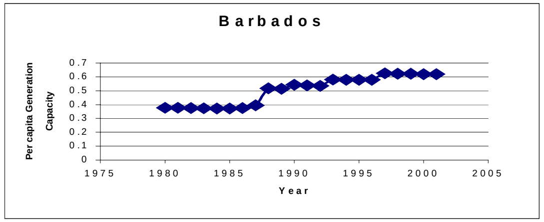
Argentina
Barbados
Bolivia
Brazil
Chile
Colombia
Costa Rica
Dominican Republic
Ecuador
El Salvador
Ethiopia
Grenada
India
Indonesia
Jamaica
Kenya
Malaysia
Mexico
Nicaragua
Nigeria
Paraguay
Peru
Philippines
Sudan
Trinidad
Uganda
Uruguay
Venezuela

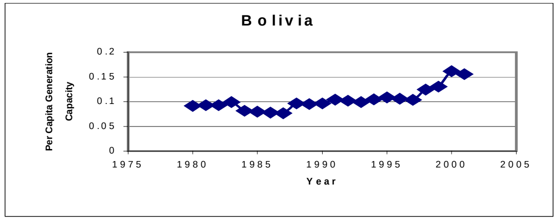
(i) Latin American (Calderon-Serven Sample)

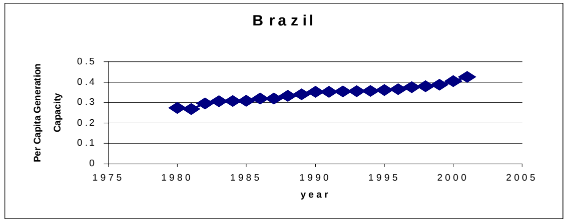
Argentina
Bolivia
Chile
Colombia
Ecuador
Mexico
Peru
Venezuela

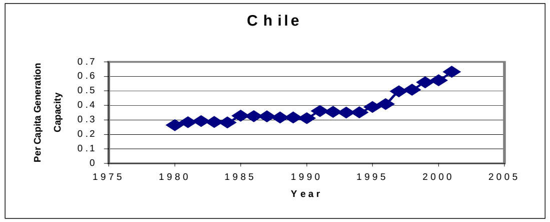
Data Appendix: Graphs 1 - Installed Generation Capacity Per Capita 1980-2001

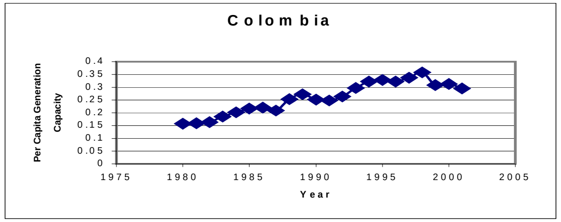


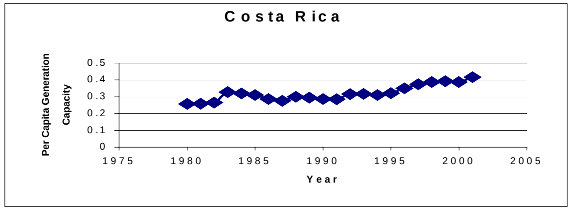


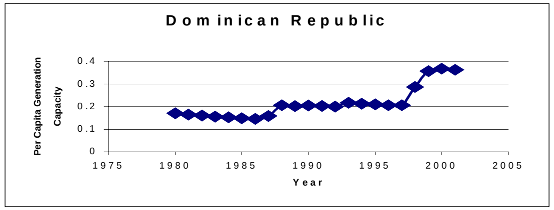


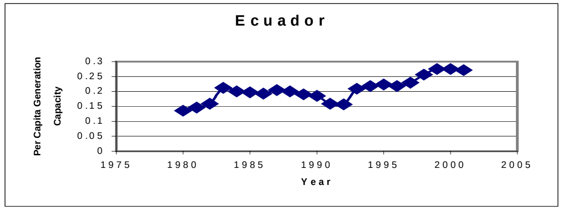




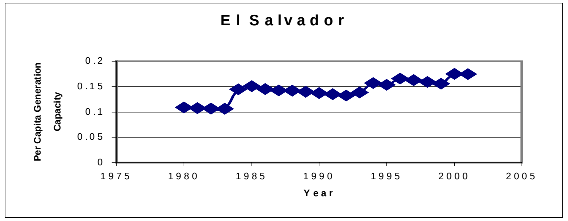


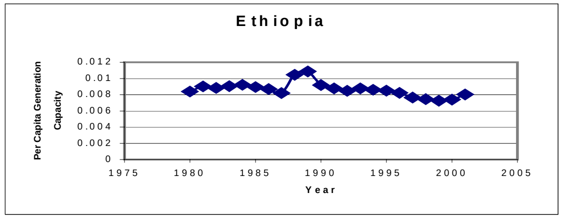


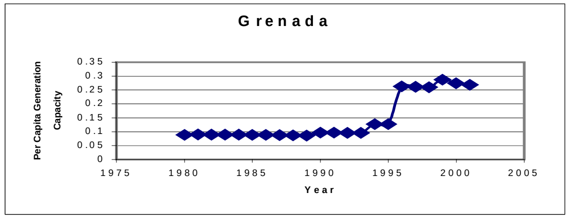


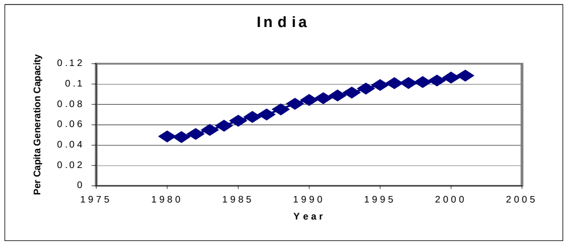


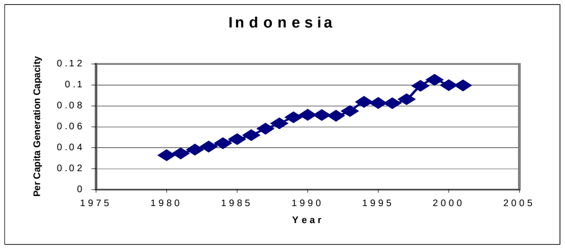
Source: Installed Capacity (GW) Data from US EIA Database

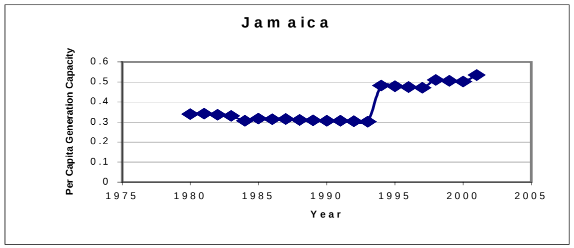


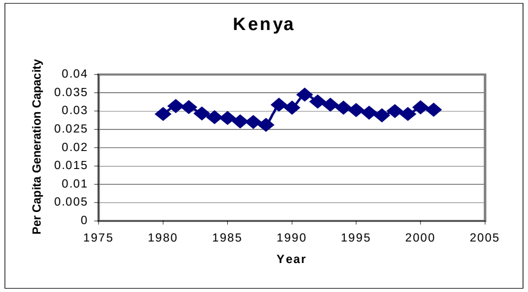
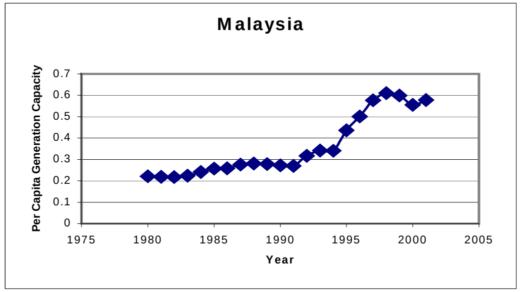
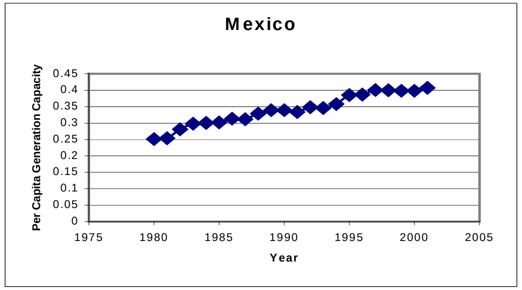
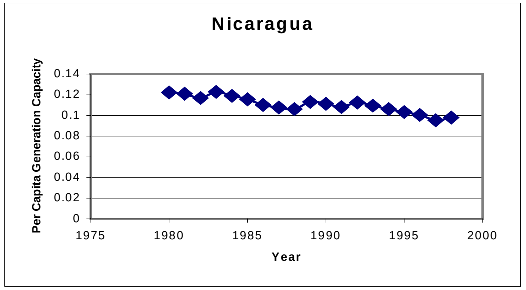
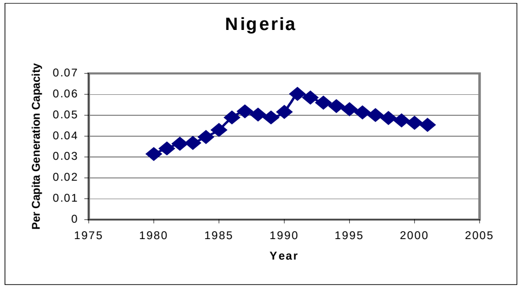
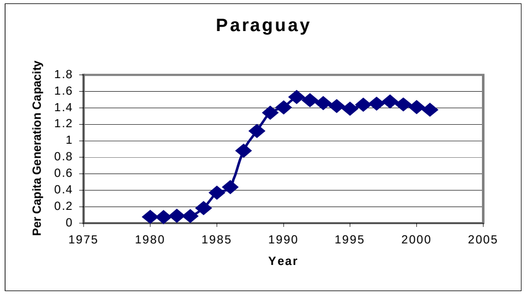
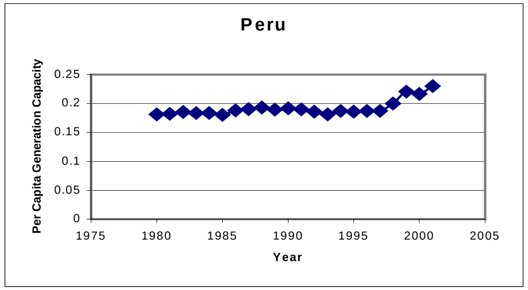
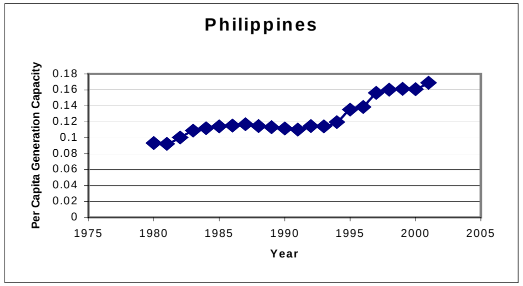
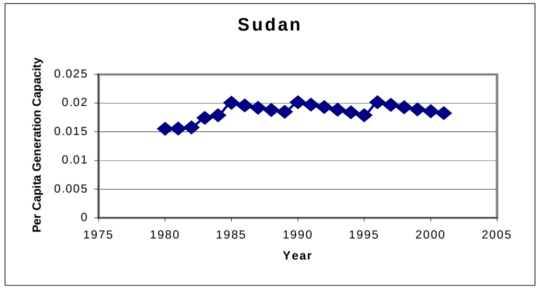
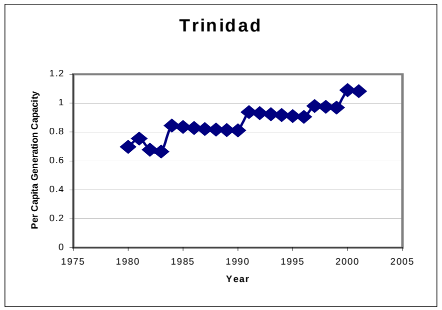
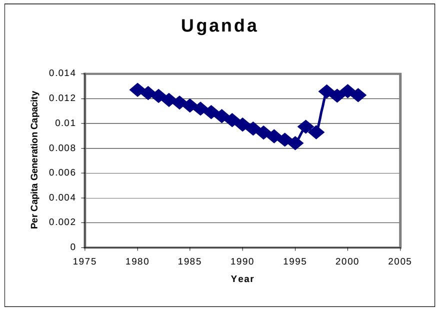
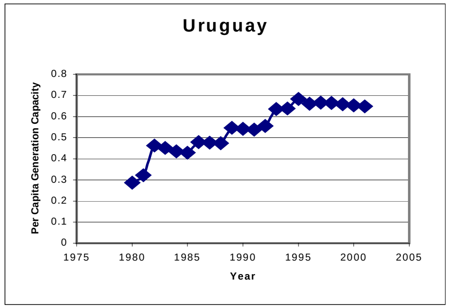
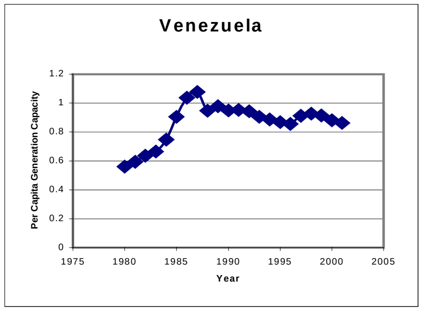




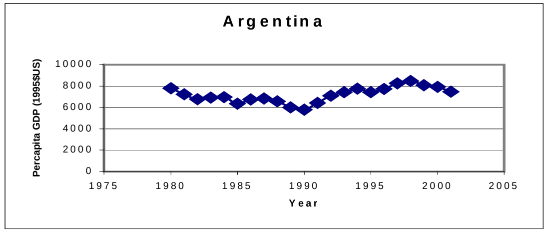


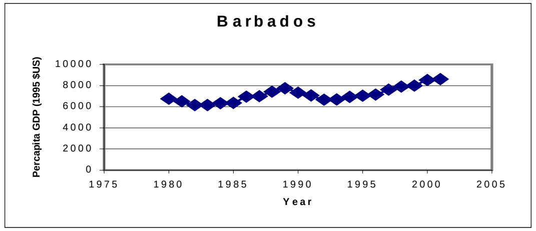


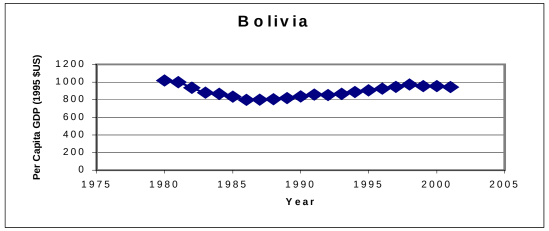


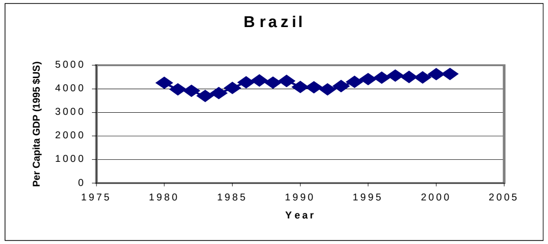

Kenya
Per Capita Generation Capacity
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1975 1980 1985 1990 1995 2000 2005
Year

Malaysia
Per Capita Generation Capacity
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1975 1980 1985 1990 1995 2000 2005
Year

Mexico
Per Capita Generation Capacity
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1975 1980 1985 1990 1995 2000 2005
Year

Nicaragua
Per Capita Generation Capacity
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000
Year

Nigeria
Per Capita Generation Capacity
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1975 1980 1985 1990 1995 2000 2005
Year

Paraguay
Per Capita Generation Capacity
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1975 1980 1985 1990 1995 2000 2005
Year

Peru
Per Capita Generation Capacity
0.25
0.2
0.15
0.1
0.05
0
1975 1980 1985 1990 1995 2000 2005
Year

Philippines
Per Capita Generation Capacity
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000 2005
Year

Sudan
Per Capita Generation Capacity
0.025
0.02
0.015
0.01
0.005
0
1975 1980 1985 1990 1995 2000 2005
Year

Trinidad
Per Capita Generation Capacity
1.2
1
0.8
0.6
0.4
0.2
0
1975 1980 1985 1990 1995 2000 2005
Year

Uganda
Per Capita Generation Capacity
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
1975 1980 1985 1990 1995 2000 2005
Year

Uruguay
Per Capita Generation Capacity
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1975 1980 1985 1990 1995 2000 2005
Year

Venezuela
Per Capita Generation Capacity
1.2
1
0.8
0.6
0.4
0.2
0
1975 1980 1985 1990 1995 2000 2005
Year

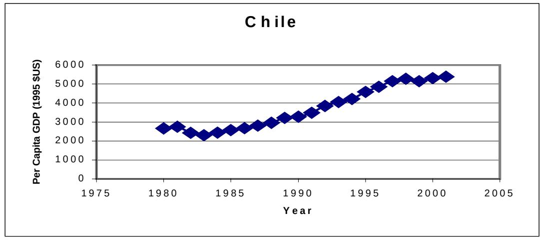
Data Appendix: Graphs 2 - Real GDP Per Capita (in US $, 1995 Prices) 1980-2001

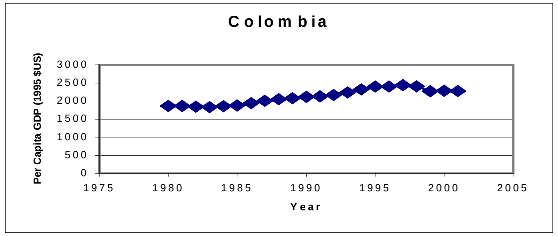


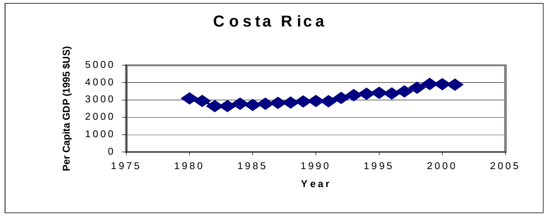


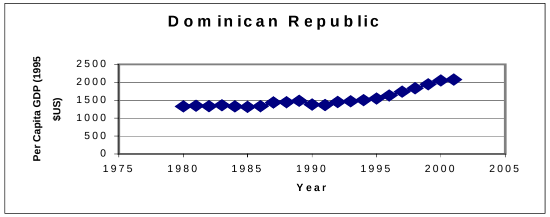


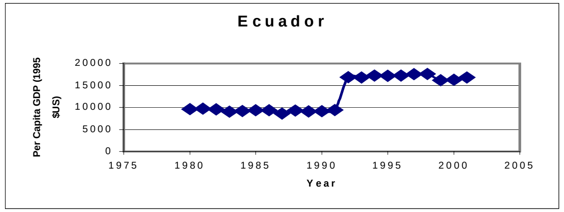




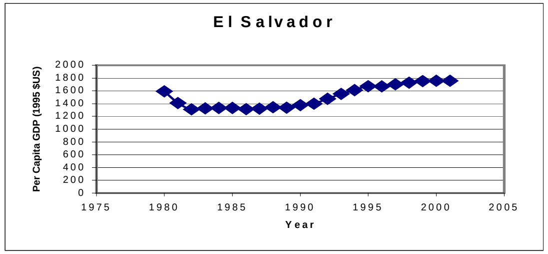


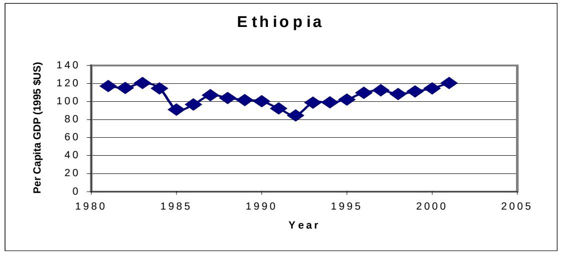


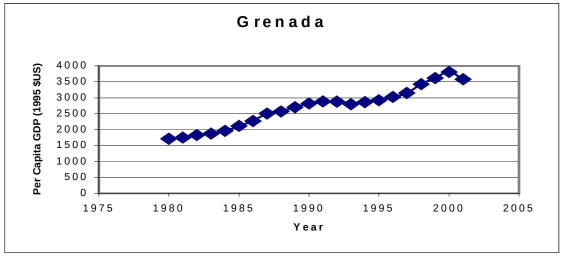


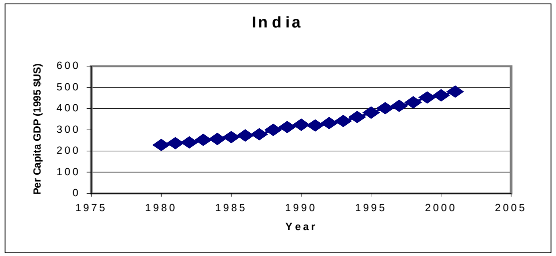


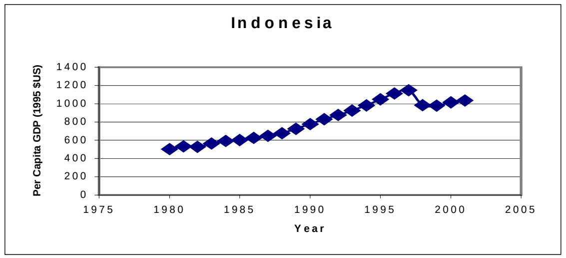
Source: World Bank Development Indicators

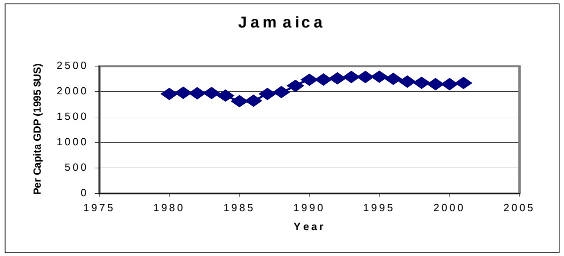


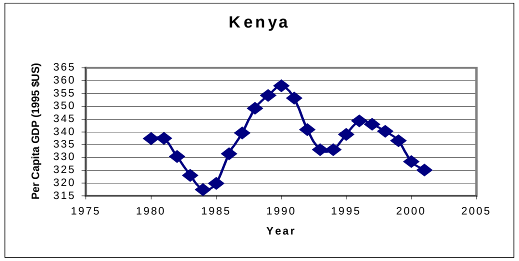


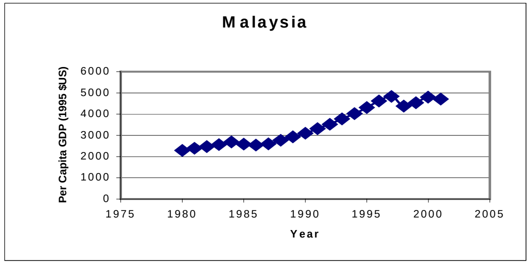


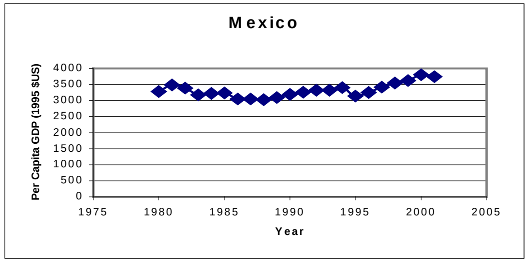


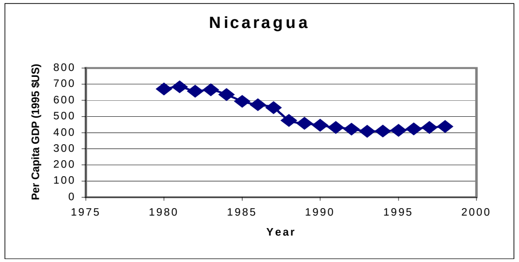


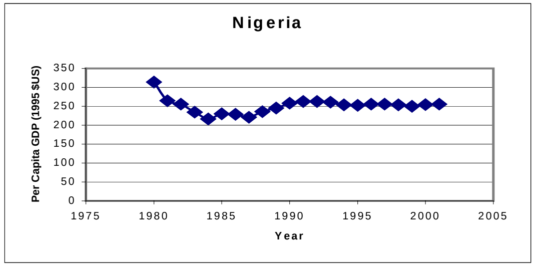


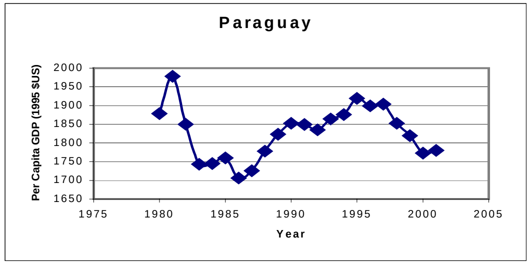

Kenya
Per Capita GDP (1995 $US)
365
360
355
350
345
340
335
330
325
320
315
1975
1980
1985
1990
1995
2000
2005
Year

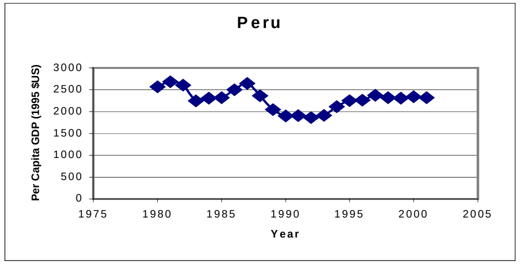

Malaysia
Per Capita GDP (1995 $US)
6000
5000
4000
3000
2000
1000
0
1975
1980
1985
1990
1995
2000
2005
Year

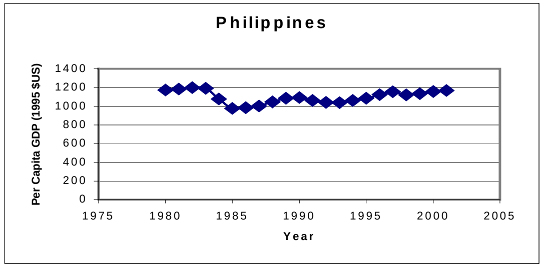

Mexico
Per Capita GDP (1995 $US)
4000
3500
3000
2500
2000
1500
1000
500
0
1975
1980
1985
1990
1995
2000
2005
Year

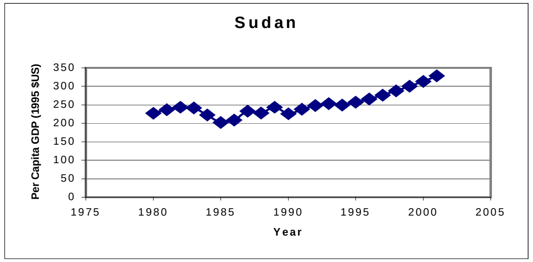

Nicaragua
Per Capita GDP (1995 $US)
800
700
600
500
400
300
200
100
0
1975
1980
1985
1990
1995
2000
Year

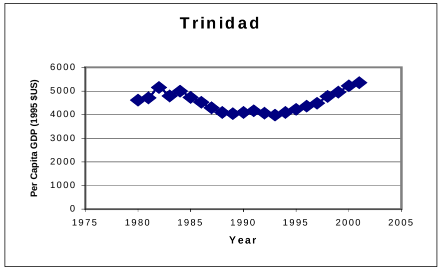

Nigeria
Per Capita GDP (1995 $US)
350
300
250
200
150
100
50
0
1975
1980
1985
1990
1995
2000
2005
Year

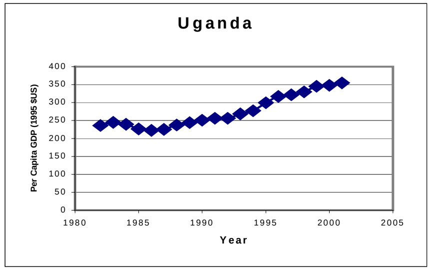

Paraguay
Per Capita GDP (1995 $US)
2000
1950
1900
1850
1800
1750
1700
1650
1975
1980
1985
1990
1995
2000
2005
Year

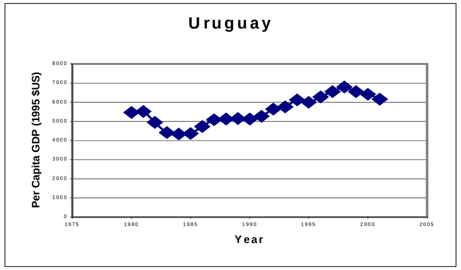

Peru
Per Capita GDP (1995 $US)
3000
2500
2000
1500
1000
500
0
1975
1980
1985
1990
1995
2000
2005
Year

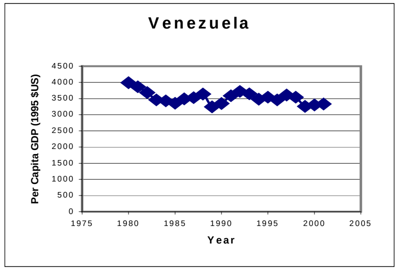

Philippines
Per Capita GDP (1995 $US)
1400
1200
1000
800
600
400
200
0
1975
1980
1985
1990
1995
2000
2005
Year


Sudan
Per Capita GDP (1995 $US)
350
300
250
200
150
100
50
0
1975
1980
1985
1990
1995
2000
2005
Year

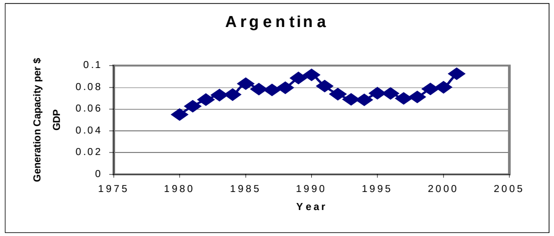

Trinidad
Per Capita GDP (1995 $US)
6000
5000
4000
3000
2000
1000
0
1975
1980
1985
1990
1995
2000
2005
Year

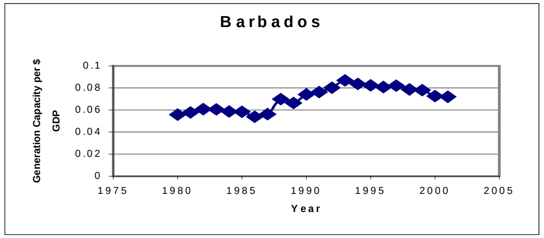

Uganda
Per Capita GDP (1995 $US)
400
350
300
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
Year

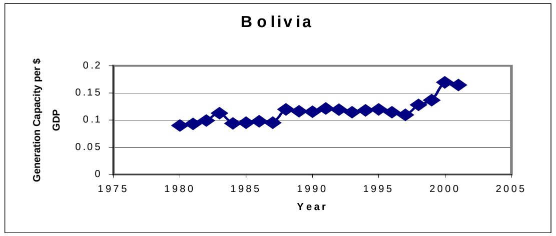

Uruguay
Per Capita GDP (1995 $US)
Year

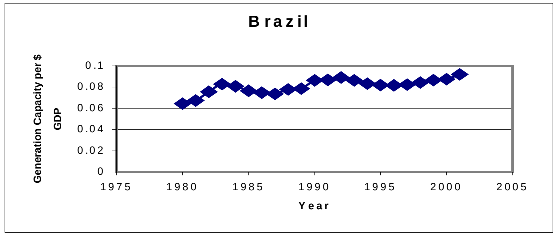

Venezuela
Per Capita GDP (1995 $US)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1975
1980
1985
1990
1995
2000
2005
Year

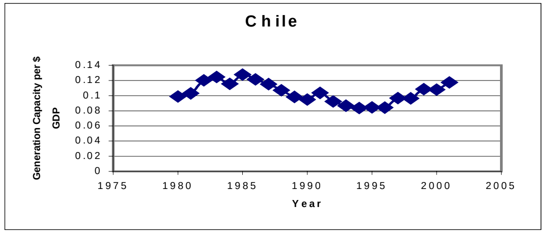
Data Appendix: Graphs 3 - Generation Capacity / GDP

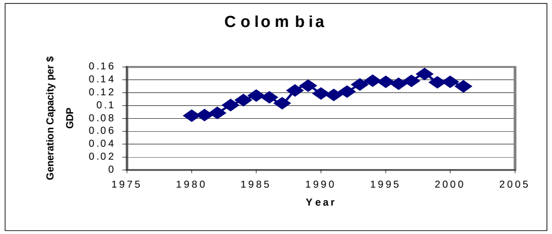


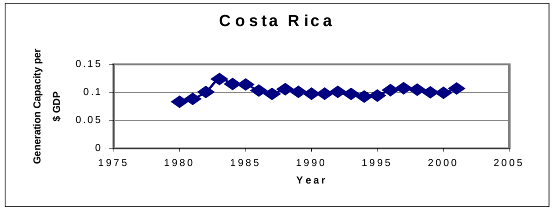


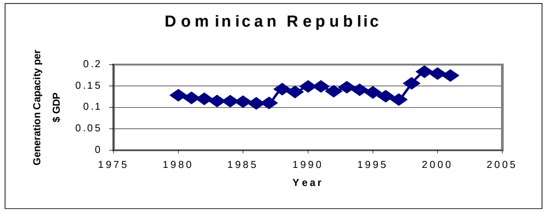


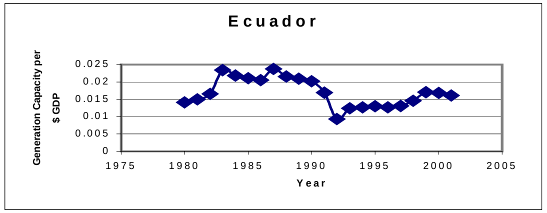




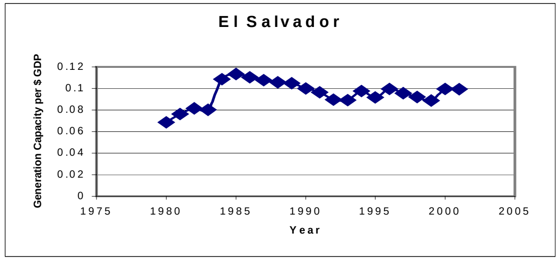


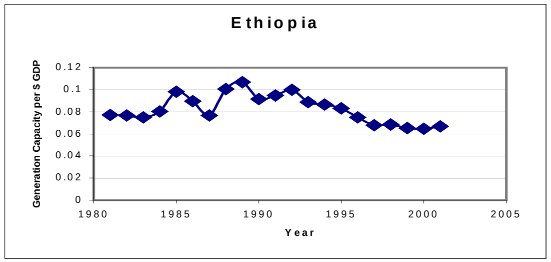


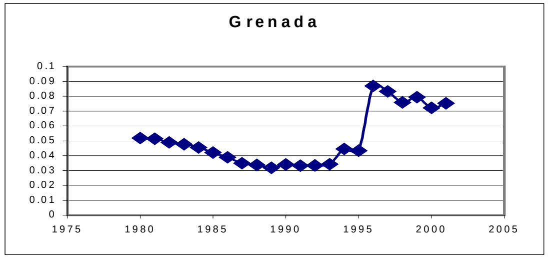


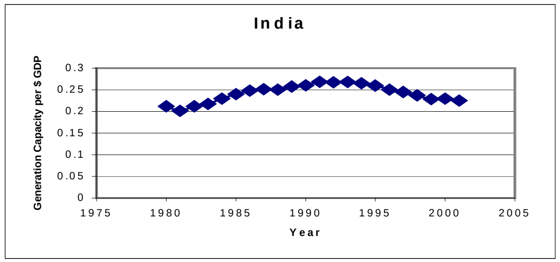


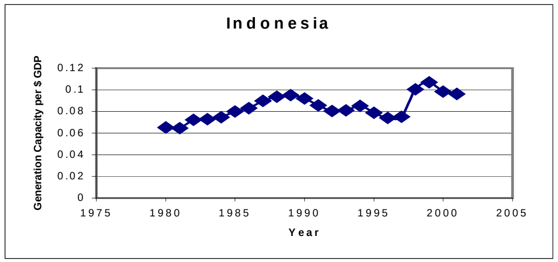
Source: Author's Calculations from Data in Previous Graphs

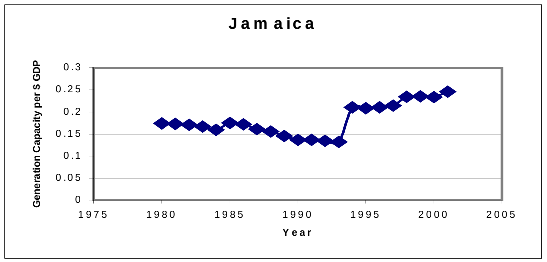


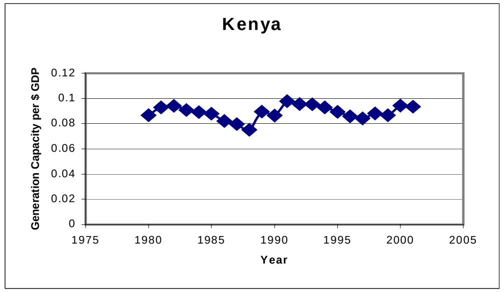


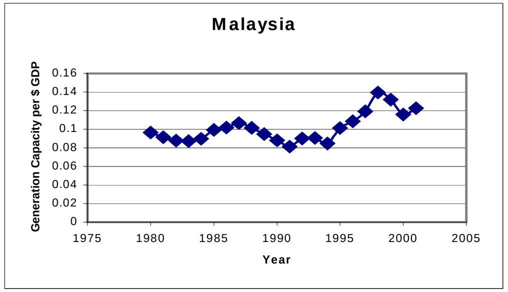


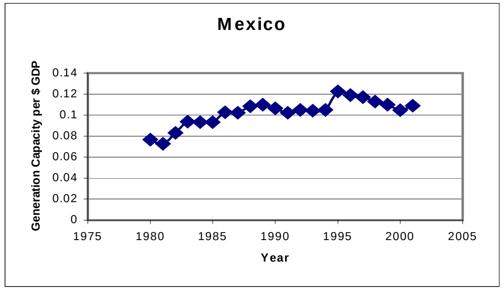


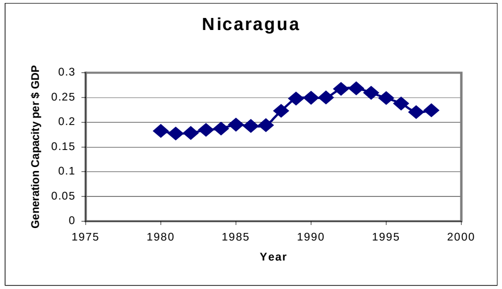


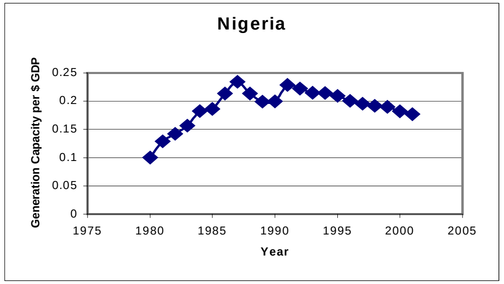


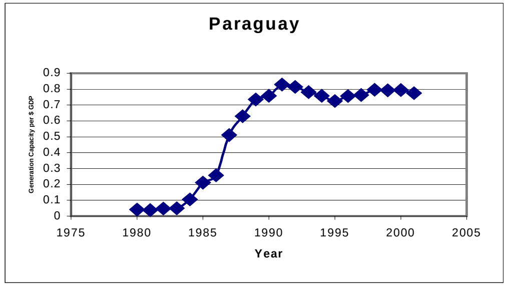

Kenya
Generation Capacity per $ GDP
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000 2005
Year

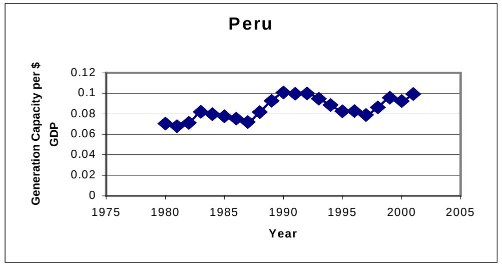

Malaysia
Generation Capacity per $ GDP
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000 2005
Year

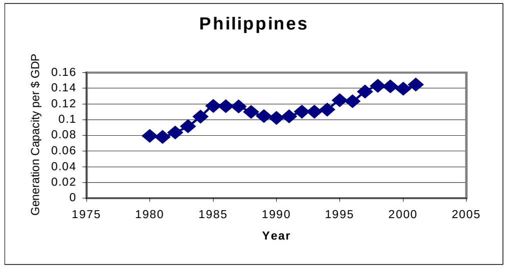

Mexico
Generation Capacity per $ GDP
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000 2005
Year

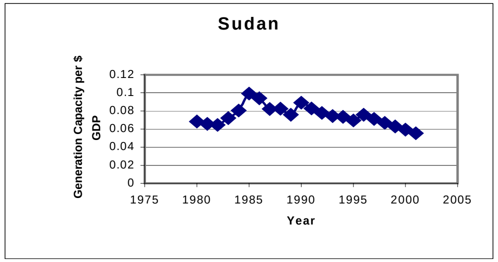

Nicaragua
Generation Capacity per $ GDP
0.3
0.25
0.2
0.15
0.1
0.05
0
1975 1980 1985 1990 1995 2000
Year

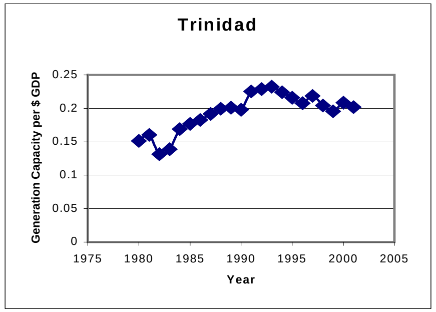

Nigeria
Generation Capacity per $ GDP
0.25
0.2
0.15
0.1
0.05
0
1975 1980 1985 1990 1995 2000 2005
Year

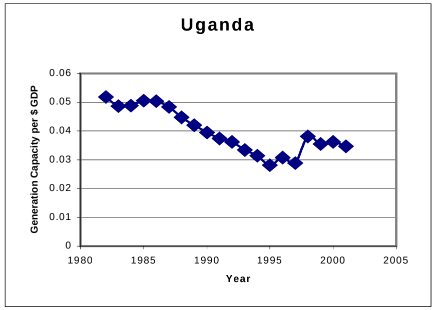

Paraguay
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1975 1980 1985 1990 1995 2000 2005
Year

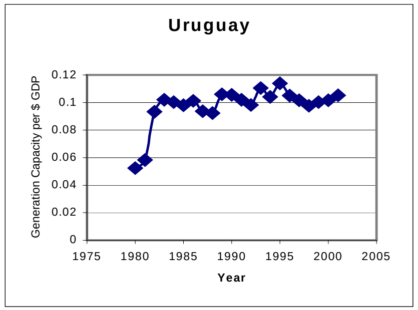

Peru
Generation Capacity per $ GDP
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000 2005
Year

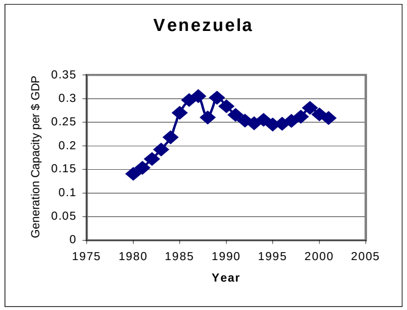

Philippines
Generation Capacity per $ GDP
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000 2005
Year


Sudan
Generation Capacity per $ GDP
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000 2005
Year


Trinidad
Generation Capacity per $ GDP
0.25
0.2
0.15
0.1
0.05
0
1975 1980 1985 1990 1995 2000 2005
Year


Uganda
Generation Capacity per $ GDP
0.06
0.05
0.04
0.03
0.02
0.01
0
1980 1985 1990 1995 2000 2005
Year


Uruguay
Generation Capacity per $ GDP
0.12
0.1
0.08
0.06
0.04
0.02
0
1975 1980 1985 1990 1995 2000 2005
Year


Venezuela
Generation Capacity per $ GDP
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1975 1980 1985 1990 1995 2000 2005
Year