India’s Electricity System: Power for the States

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by

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1 Introduction

1.1 Aims

The aim of this thesis is to explain the continuing challenge faced by India's states in developing their electricity systems and achieving electrification given:

- the choice of the state as spatial governing unit for the systems within the country;
- the policy framework selected;
- the economic and technical foundations common to all electricity systems;
- and critically, the unique institutional and physical characteristics of the individual states that have had responsibility for electricity system development.

Electricity systems have particular characteristics – the evolution of technologies for generation, transmission and distribution and the economies of scale available from exploitation of technologies in large markets. These interact with national electricity policy and the ability of individual states to implement those polices. The result has been considerable and persistent unevenness in the level of attainment of electricity system between the states and ultimately, large differences in the states' ability to deliver universal access to electricity to their populations. It is assumed that understanding and acceptance of state-level characteristics is therefore vital in policy formulation for electricity system growth and universal access as similar policies play out differently across the states according to the context of implementation – some more successfully than others. There are a number of specific objectives laid out in the order they are discussed:

Firstly, to explain that the decision to place implementation responsibility for the electricity system with the states (and accept the consequences of subsequent uneven electricity system expansion) was itself, a political and cultural decision based on history and the political context of independence. It is then possible to explore the ramifications of this decision with particular emphasis on how the sub-national state characteristics interact with the universal technical and economic realities of building electricity systems.

Secondly, to identify the key state-level institutional characteristics – born out of history, culture, politics and geography – that have been influential in the execution of electricity policy and whether the changing role of central government from central planning to economic liberalisation has amplified the influence of state differences in policy implementation. These are expected to include factors that result in some states failing to meet their electricity sector objectives. Particularly, attention is focused on the potential underlying and intractable causes of under-development that may require novel policy responses to eliminate - by the state, central government or the donor community.

A final objective is to examine the contemporary policy environment and, using the insights gained from the previous analyses, challenge the policy approach from two perspectives:

– Do sophisticated electricity system governance strategies, adopted with the liberalisation of the Indian electricity system, have unintended consequences due to the institutional incapacity of some states to manage those strategies effectively?

- Have lessons been learned and incorporated in the current policy regime from previous failed attempts to expand access to electricity that will ensure greater support for institutionally weak states and result in successful realisation of universal electricity access across all states?

1.2 Why does this matter?

Energy is important in the development process – having a profound impact on economic development as well as the social progress of communities and countries. The foundation for this thesis lies in the central importance of energy services in such progress. Following the signing of the Millennium Declaration in 2000 there has been increasing recognition amongst international development institutions that energy provision is a critical component of the development process. This position was first articulated at the Commission on Sustainable Development 9th session (CSD-9) that concluded that:

in order to halve the proportion of people living on less than one dollar per day by 2015, access to affordable energy services is a prerequisite (Commission on Sustainable Development 2001: Decision 9/1, Sec 22).

This statement was followed by calls for action at the World Summit on Sustainable Development in Johannesburg – amongst other things, specifically to:

Improve access to reliable, affordable, economically viable, socially acceptable and environmentally sound energy services.

Recognise that energy services have positive impacts on poverty eradication and the improvement of standards of living (WSSD 2002: 5, 6).

The World Bank has also highlighted the importance of increasing energy consumption in the achievement of the Millennium Development Goals. In the Investment Framework for Clean Energy and Development, the Bank states that:

> Although energy is not explicitly mentioned in the Millennium Declaration, the MDGs cannot be met without higher quality and larger quantities of energy services than currently available (World Bank 2006: 49).

Development theory from the human development tradition provides other channels for justifying the assertion that energy is critical for development. Sen's interpretation of development as an improvement in the level of freedom and capabilities rather than a narrow focus on growth in national income (Sen 1999) and Friedmann's definition of development as human flourishing (Friedmann 1992) provide a theoretical basis for links between energy and the MDGs on a basis other than economic growth as measured by national income. For example, there are numerous studies indicating improvements in health, gender equality and opportunity resulting from a switch from traditional biomass to cleaner and more efficient cooking solutions (Clancy et al. 2003, Cecelski 1987, Cecelski 2003, Smith et al. 2003).

Energy infrastructure affects growth through a number of channels (Agenor and Moreno-Dodson 2006). It delivers both direct and indirect impacts on the development process and most studies recognise that the effects of energy infrastructure on development indicators are positive (Briceño-Garmendia et al. 2004, Romp and De Haan 2007). Direct effects occur as energy infrastructure acts as an intermediate factor of production supporting commercial activities (Cabraal et al. 2005). Indirect influence occurs through a number of channels including facilitating the diffusion of ideas and technology and quality of life improvements that encourage the retention of higher skilled workers in a region – both factors that fit within the endogenous growth theories – encouraging the development of technology and human capital (Barnes and Floor 1996). However, studies are not able to reach definitive conclusions as to the magnitude of the effect of such infrastructure investment on development – an unsurprising finding given the different starting points, institutional settings and objectives of policy in different regions and jurisdictions – and this is particularly true of energy infrastructure (Estache and Fay 2007).

In developed societies, driven by concern over climate change, emphasis is increasingly being placed on reducing the energy intensity of economies through the more efficient conversion of energy into useful services balanced with a concern for energy security. Alongside this, there is increasing investment in delivering cleaner, lower carbon forms of energy. This includes a shift away from fuels such as coal to cleaner options such as natural gas. It also includes increasing investment in renewable energy sources. In the developing world – particularly those emerging economies that are seeing rapid growth – as well as these considerations there are additional challenges:

- Building an energy infrastructure
- Delivering affordable, modern forms of energy services to the entire population,
- Supporting increased economic activity that will raise national income.
- Dealing with the environmental challenges related to rapidly increasing energy consumption (a constraint not applied to developed country electricity infrastructures until the infrastructure was largely complete and universal access attained).

All energy infrastructure is complex. Electricity is a unique and particularly complex commodity (discussed in some detail in chapter 3). It is difficult to store and requires instantaneous matching of supply and demand over large geographical areas. It is characterised by a need for large capital investments and strong institutions to manage a large and pervasive infrastructure. Historically, electricity systems were often managed as large, centralised monopolies to ease the challenge of coordinating such a large and technically complex infrastructure. Given the criticality of electricity to both economic and social activity, this led, in many countries, to the politicisation of the delivery of electricity (Romp and De Haan 2007). It is therefore apparent that the provision of electricity cannot be analysed as a solely technical or even economic activity (Canning 1998).

1.3 India as a case study

India has been selected for research for a number of reasons:

- Its criticality globally – both from the perspective of making a sizeable development benefit through improving energy access to many millions of people and the potentially damaging effects of massive increases in carbon rich energy consumption as the economy grows.

- Its positioning in the maturity curve for electricity infrastructure make it relevant as a case for understanding future challenges in other developing economies notably in other parts of South Asia and Africa.

- Its political and institutional structure and its evolution over time support a comparative analysis both spatially and temporally.

It is over sixty years since India achieved independence from the UK in 1947. One of the political pillars of the newly independent India was to achieve equitable development for all. The stability of a country as large and diverse as India is in many ways predicated on ensuring a degree of social cohesiveness to mitigate recurring pressures for the nation to fragment. Since independence, considerable financial transfers have occurred from the Indian national government (the centre) to the states to achieve development objectives (under the auspices of the Planning Commission and the Finance Commission). A succession of programmes has endeavored to achieve greater equity in development opportunities across the nation. With the 60th anniversary of independence in 2007, the values of equality were restated by the incoming president Smt. Pratibha Devisingh Patil:

> Growth, when unevenly spread, dwarfs overall prosperity. Only through socially inclusive growth can there be sustained consistency in our growth rates. We have to ensure equitable growth for all. The fruits of economic development must necessarily touch, especially, the living and working conditions of our toiling masses and people below the poverty line (Patil 2007).

There is a presumption within the Indian polity that providing electricity access is a basic human right and a primary policy objective of the Indian government (Planning Commission, Government of India 2007b). However, there is, despite aspirational policy goals, little clarity over the country's ability to create a process to deliver on these goals. Access to modern energy sources is limited in India. Traditional biomass remains the most significant form of energy for 740 million Indians, 29% of the total reliant on traditional biomass globally (International Energy Agency 2006). Over 400 million Indians do not have access to electricity (International Energy Agency 2007). Per capita electricity consumption (all sectors) stands at only 594 KWh per annum. This contrasts with 1,440 KWh in China and 14,057 KWh in the U.S (UNDP 2006).

India is a federally structured country with much responsibility for electricity devolved to the individual states and therefore provides an intriguing natural experiment for research. States have considerable latitude in their development strategy and implementation. There is, by consequence, considerable unevenness in the level of success in electricity provision experienced by the states. However, India also has a strong central government and history of technocratic, data-driven central planning. It is therefore possible to undertake comparative studies across India that can identify differences in approach and results between the states.

Policy in the electricity sector has evolved over the sixty years since independence but has included policies to support industrial expansion, agricultural productivity (through irrigation schemes), universal access to electricity and energy security through the exploitation of indigenous energy sources. Under the Indian constitution, the provision of electricity is a shared responsibility between the federal government and the states. This division of responsibility provides an opportunity to analyse the relative effectiveness the states have achieved in delivering on their electricity sector obligations. The differences in the effectiveness of the electricity sector between the states over time have been quite stark. Per capita electricity consumption in 2004 / 05 was 908 KWh in Gujarat, 713 KWh in Tamil Nadu and 907 KWh in Punjab but only 202 KWh in Uttar Pradesh, 85 KWh in Assam and as little as 45 KWh in Bihar (Central Electricity Authority 2006). Indeed, as is explored in detail in the following chapters, there is a pattern of weak performance experienced by a number of states that is consistently apparent according to a variety of measures such as per capita electricity consumption and rural electrification. This weakness and its consistent manifestation in a small number of states forms the basis of the analyses presented.

This analysis is therefore primarily undertaken at the state level – the principle spatial unit for electricity system management. The objective of the analysis is to uncover and explain the causal factors leading to the development of the electricity system through comparative analysis of different states. The historic structure of the Indian electricity sector supports this analysis as for most of the period since independence the Indian electricity sector has been primarily managed at the state level (supported by a process of central planning). Further, from 1991 India has commenced a process of liberalising its electricity sector. This provides an opportunity to investigate the causal drivers of success of electricity sector development across both a centralised, planned period and a period of liberalisation and allows a critique of the liberalised approach to electricity sector development over the historically favoured approach.

India has a strong history of planning infrastructure development and forecasting future needs (TERI 2006b). Delivery on targets set however, has been more problematic. This thesis explores whether a deeper understanding of the institutional and geographical context within which electricity investment must take place would support a more nuanced and successful strategy for development of the sector. Further, recognising the different challenges facing India (and potentially other developing countries) will support a more critical evaluation of the processes of liberalisation that have largely been lifted wholesale from developed country settings – even to the extent of considering different measures of what constitutes success in the context of liberalisation. As stated, the Indian electricity sector has undergone a significant transformation in the last decade. With antecedents in the federal government decisions to liberalise electricity and other markets in 1991, major changes have occurred in the provision of electricity. However, it is proposed that, despite recent changes, many of the currently observed outcomes within the electricity sector may trace their causality back through the long history of the development of the sector. It is also considered whether there are fundamental contradictions between the over-arching political need for social inclusiveness in India and the mechanisms of liberalisation that are currently underway in the country. The pressures for social inclusiveness and equality translate into an ambition of universal affordable access to electricity – manifesting in diversion of resources to grid connect rural areas and subsidies for various classes of electricity consumer.

The electricity sector in its current form is now sixty years old and more than a decade has passed since the commencement of electricity reform in the states of India[1]. The Indian National Congress was elected in 2004 and re-elected in 2009 (with their coalition partners in the United Progressive Alliance) under a policy of delivering on the promise of a National Common Minimum. It is an appropriate time to question why some states have been so much more successful than others in delivering an effective electricity sector in terms of their ability to service their populations and economies.

1.4 Approach

The approach adopted is highly inter-disciplinary – cutting across the disciplines through which the electricity system is typically researched. This is a critical part of the research design - recognising the rich and complex nature of the influences on the electricity industry and endeavouring to integrate insights from the contributing disciplines. For instance, as discussed in chapters 3 and 4 below, an observed weakness in comparative development economics research on electricity systems is a lack of consideration for the particular technical and economic characteristics of

[1] Many of the key electricity sector institutions are, however, the same as those created at the time of independence (through the Electricity Act 1948) – namely the State Electricity Boards, the Ministry of Power and the Central Electricity Authority

electricity systems. For example, how has India's electricity system been influenced by technical advances elsewhere and by India's willingness and ability to absorb those innovations? Equivalently, political economy electricity system analyses have commonly given insufficient attention to the spatial and resource endowment influences on the system – focusing primarily on institutions and political interest groups. This thesis examines whether all of these influences have played a part and concentrating the focus on any one sub-discipline is likely to miss the key conclusions: history, culture, politics and geography all play an important role and need to be understood to devise the most appropriate policies for ensuring electricity system progress.

Further, the thesis takes a less conventional approach than many political economy analyses from a methodological perspective by undertaking quantitative analyses to attempt to identify the key causal trends in electricity sector development and also, importantly, taking a long term view of the analysis. The long historical perspective is designed to capture the influence of path dependent processes – processes that are resistant to change, that may prove to have durable effects on the evolution of the electricity sector in different states and be highly resistant to policy action from the central government. It is anticipated that the historical antecedents of the current institutional structure and energy endowments have a significant influence on current policy and investment outcomes. It is also examined whether the decision to liberalise the electricity sector – commencing in 1991 may be perceived as a true structural break in the long run trend in electricity sector development. Analysis will be undertaken to test the veracity of this claim and determine the degree to which previously powerful path dependencies may be continuing to operate.

1.5 Scope

The scope of the study has been defined to provide a rich dataset for quantitative analysis whilst ensuring that the data is internally consistent and appropriate for comparative analysis. Two scoping decisions were critical:

- selection of states to include
- length of time series

India today, is comprised of 28 states and 7 union territories. India's states have undergone several rounds of reorganisation since independence. The most material reorganisation occurred in 1956 with the States Reorganisation Act (Government of India 1956). This Act redrew state boundaries along more linguistic lines than was previously the case. The initial state boundaries agreed at the time of independence were largely influenced by the colonial and princely state structure. From a practical perspective, state level analyses prior to the 1956 Act are considerably more difficult due to the unavailability of granular (district level and below) data to reconstruct state level data for the states in their modern form. Also, and more importantly, analysis predicated on policy activity by the states can only be usefully undertaken if there is a consistent physical jurisdiction over which that policy action occurs.

For these reasons, the quantitative analysis has a starting point of 1961 – which is the first years for which reporting is provided for the new administrative units[2]. Other state reorganisations have taken place since 1956 and a variety of approaches has

[2] Qualitative evidence is called upon from earlier periods.

been taken to manage their impacts on the analysis. This is discussed at greater length in chapter 5.

All states that have made data available for the entire period under analysis have been included. The spatial scope of the project encompasses over 97% of the population in up to 20 states (per 2001 census). A number of smaller states have been excluded. These are largely in the north east of the country and have a set of specific challenges that are less representative of the entire country. Goa is also excluded due both to data availability reasons and the fact that it is highly unrepresentative of the rest of the country. However, Union Territories have been explicitly excluded from the analysis for two reasons:

- Being under direct control of the national government, a key hypothesis of state politic conflict cannot be considered.
- There is considerable heterogeneity between the union territories as a group and the states as a group due to size, urban / rural distribution and often wealth.

Other scope limitations have been taken to facilitate focus. Despite being of importance at the margin from a development perspective, off-grid electricity provision has been excluded from the analysis. This has been done for two principal reasons:

- Indian policy is explicitly to deliver grid-connected electricity unless there is a clear economic barrier (due to remoteness) for doing so;
- The policy environment and technologies deployed in off-grid electrification efforts are very different to those employed in developing grid connected

electricity (driven by the Ministry of New and Renewable energy rather than the Ministry of Power).

Centrally owned generation of electricity has been explicitly excluded from the historical quantitative analysis in chapter 5. This has been done for two reasons:

– The focus of the research is action at the state level – driven by state institutions and the inclusion of centrally owned and managed generating utilities dilutes the evidence for the quality of state level activity.
– For pragmatic reasons, as central utility generation is difficult to allocate across the states – particularly in the earlier periods under study.

The influence of central generation is, however, discussed in the context of the qualitative history of the sector, introduction of technology, electricity trading and rural electrification efforts discussed in chapters 4, 6 and 7.

1.6 Definitions

1.6.1 Economic liberalisation and electricity reform

It is instructive to define what is meant by the terms liberalisation and electricity reform in the specific context of India and this research project. In the context of this analysis in India, liberalisation has two inter-related facets:

– The broad liberalisation trends within the economy as a whole;
– The specific reforms that have taken place within the electricity industry.

Economy-wide liberalisation is commonly cited as beginning in 1991 in India (although early steps in creating more freedom in the economy can be traced as far back as the late 1970s). Liberalisation in India is an on-going process and is visible in a number of ways. At the macro-economic level, there has been a shifting in the weight of development planning towards ‘indicative’ planning with a greater expectation that the private sector would play an increasing role in business investment. At the micro-level, there has been a steady erosion of the ‘license raj’ – the need to attain government permits to undertake many forms of industrial and commercial activity.

Within this context, there has been a specific effort to reform the electricity industry. In India, because electricity reform has taken place in a landscape of economy-wide liberalisation, the term liberalisation is commonly applied to the process of electricity reform. The definition of electricity liberalisation or reform in India is best presented through a brief discussion of the reform actions undertaken within the country. In different countries, reform of electricity industries has involved one or more of the following actions (Energy Sector Management Assistance Programme 1999). ESMAP suggested that these steps should optimally be followed in sequence (although the scorecard results indicated that this was rarely the case in reality):

- Corporatisation
- Restructuring / unbundling
- Legal frameworks
- Regulation
- Introduction of independent power producers
- Privatisation of generation / transmission

Per ESMAP's scorecard of 1999, India scored a perfect six for its reform efforts – indicating the inherent weakness in the approach. Any evidence of any of the reform steps being taken anywhere in the country ensured a positive score for that measure. In India, at that date:

- corporatisation had theoretically commenced but only one or two utilities were able to function without considerable public support;
- restructuring had only taken place in a few states (e.g. Orissa);
- electricity reform laws were minimal (solely focused on enabling legislation for independent regulators – discussed in detail in chapters 4 and 7);
- regulation had barely commenced and was certainly not fully functional in most states (discussed in the context of rural electrification in chapter 7)
- a few instances of IPP investment were evident but they were clustered in a few states and privatisation was minimal (and still is).
- Privatisation had taken place only in Orissa and was under consideration in Delhi.

The electricity reform process in India is therefore characterised as a hybrid reform process rather than the 'standard' prescription of unbundling, privatisation and competition (Gratwick and Eberhard 2008b)[3]. The reform process began from a position of state-level monopoly with state electricity boards in each state, directly accountable to and usually controlled by state government. There was no independent regulation and competition was explicitly disallowed. The commencement of liberalisation was signaled in 1991 with the amendment to the Electricity (Supply) Act that allowed independent power producers to operate in the country (Reddy 2001).

[3] Delhi and particularly Orissa's reform process – heavily informed by UK consultants are closer to the 'standard' model.

This coincided with a broad push towards the attraction of private capital into electricity in developing economies across the world e.g. Africa (Gratwick and Eberhard 2008a). In most cases there was little progress until the creation of state electricity regulators beginning in 1998, (Orissa is the exception, undergoing its reform programme in the mid 1990s).

In the Indian context, there has been very limited transfer of ownership into private hands (again, only Orissa and Delhi have undertaken privatisation). Restructuring, in the form of vertical unbundling of monolithic state electricity boards into generators, transmission companies and distribution companies has been undertaken in many but not all states. An element of competition has been introduced by the creation of multiple distribution companies in some states and support for independent and merchant electricity producers together with central generators has increased competition in generation – although only a few states such as Gujarat are perceived to be attractive by the private sector (Jain 2009b). Transmission, common with most electricity systems largely remains a regulated monopoly. Independent regulators have been set up per electricity legislation in all states but the degree to which the regulators are independent of political influence is debatable. The state regulators are set up by the state governments and the role of the state remains considerable, particularly in the creation of additional capacity through the need for support for land purchases and environmental clearances (Srivastava 2009). All state electricity companies are expected to run as commercial operations – many state electricity companies are now corporate entities but wholly owned by the state - and the tariff setting processes of the state regulators (including the increasing use of multi-year tariffs) is slowly encouraging the unbundled electricity utilities to run their operations as commercial businesses. This process of commercialization cannot be assumed complete. Some state electricity companies (e.g. Chhattisgarh) continue to balance social and political objectives with commercial ones (Verma 2009). Financial loss levels in the Indian electricity sector, particularly in the distribution sector (Mohan 2009a), demonstrate how far this process still needs to run and this issue is explored in the context of rural electrification in chapter 7. Few Indian state electricity companies could operate without public sector financial support.

1.6.2 Path dependence

An important hypothesis of the analysis presented is that the impact of the causal influences on development difference may be long-lived irrespective as to whether the causal factor is still relevant. This may particularly be the case for historical sources of uneven development. This path dependence, first formalised by Arthur and David is explained by David as follows (Arthur 1989, David 1985, David 1993):

> …why particular sequences of events in the past are capable of exerting persisting effects upon current conditions; of how adventitious, seemingly transient actions may be become so magnified as to exercise a controlling (and sometimes pernicious) influence over matters of far greater economic and social significance (David 1993: 29).

Dosi puts it more succinctly:

> the explanation to why something exists intimately rests on how it became what it is (Dosi 1997: 1531).

Path dependence is less a theory than an analytical construct to aid the understanding of historical processes that may have lasting effects. Discussed in more detail in chapter 2, it is important to clarify that path dependence in no way proscribes the possible outcomes for a given situation – rather it suggests a probabilistic likelihood of particular outcomes being more or less likely. Equally, path dependency is not a static concept – it is presumed that policy action, appropriately designed, may influence the likelihood of desired outcomes being achieved. Indeed, the potential for path dependent processes to be influenced by policy provides a principal rationale for undertaking this research project.

1.6.3 Institutions

In the literature, there is continuing debate about the exact nature of institutions in the context of social sciences: their role, how they form, evolve and precisely what they comprise. Institutional economics provides a number of valuable perspectives on which elements of this project are based. Gagliardi reviewed the literature and suggests three theoretical approaches to the study of institutions (Gagliardi 2008):

- A historical perspective as championed by North;
- A comparative institutional approach provided by Aoki;
- An imperfect information theory exemplified by Bhardan.

Of these, the historical approach is theoretically and methodologically suited to this analysis. North's definition of an institution is an appropriate place to begin:

> Institutions are the rules of the game in society, or, more formally, are the humanly devised constraints that shape human interaction…Conceptually, what must be clearly differentiated are the rules from the players. The purpose of the rules is to define the way the game is played. But the objective of the team within that set of rules is to win the game (North 1990: 3).

In chapter 2, North's definition of institutions is examined in detail – particularly, the potential conflation of institutions with organisations and the relative importance of organisations as opposed to individual agents in influencing events. Phelps argues that, in fact, institutions are themselves a product of the economic culture in which they have evolved and that "a country's economic institutions are *proxies* to some unknown extent for the prevailing culture" (Phelps 2006: 3). He goes on to suggest that institutions may therefore be unalterable if the underlying economic culture is unchanged. Although Phelps did not explicitly make the link, it is the underlying economic culture that provides a pathway by which institutions manifest path dependent properties.

1.7 Structure

The thesis is structured as a case study of aspects of India's electricity system. It incorporates quantitative and qualitative chapters focusing on specific aspects of the evolution of the system. Each of these is developed within an overall framework directed by the methodological approach and theory discussed in chapter 2 and a brief definition of the particular characteristics of electricity systems outlined in chapter 3.

Firstly, to understand the current condition of the electricity systems of India's states it is argued that the context and decisions that formed the structure of the system must be explored and explained. Examining the historical record, chapter 4 presents and gives answers to three questions that together provide some understanding of why and how India's electricity system has developed in the uneven manner visible today:

- Why was the implementation of electricity system devolved to the state?
- What have been some of the ramifications of state-led implementation?
- Given this institutional structure, how was technology innovation embraced and what effects did this have?

The aim of chapter 5, given the critical role of the states, is to uncover quantitative evidence for the level and distribution of unevenness in the development of the states' electricity systems together with explanations for that unevenness – based in the institutional qualities of the states and their geographical characteristics. This is achieved by interrogating a panel data set of electricity consumption data and a selection of candidate explanatory variables covering each of the large Indian states from 1961 to 2000. The liberalisation of the Indian economy that accelerated in the 1990s also provides an opportunity to investigate whether a liberalised economy is more likely to encourage uneven electricity systems due to state specific characteristics than was previously experienced under central planning.

Chapters 6 and 7 select two current policies (inter-state electricity trading and rural electrification) for a detailed examination of the continuing influence of state-level characteristics on the on-going development of the country's electricity system. These two contemporary cases demonstrate the continuing influence of underlying characteristics in the states' execution of electricity policy and provide evidence of a continuing, persistent challenge in delivering electricity to the entire population to support social progress.

Chapter 6 focuses on the some of the effects of the policy of grid integration and regional electricity trading on the state's electricity system performance. The aim is to explore some of the consequences of implementing a sophisticated national policy framework, supported by considerable technology advances, on a diverse and, in places, institutionally challenged electricity sector. One of the mechanisms in place is the unscheduled interchange mechanism. Designed to improve grid discipline in the withdrawal by states of centrally generated electricity, the mechanism also allows the effective sale of rights by a state to its central generation allocations. The extent to which the states use the UI mechanism varies considerably. It is argued that, despite the improvements in overall electricity system performance supported by grid integration and application of the unscheduled interchange mechanism, the institutional weakness of some states has resulted in unintended consequences that have reinforced existing weakness. This chapter interrogates financial data relating to unscheduled interchange payments to provide insight into decision-making processes of the states' electricity industries.

Chapter 7 examines the continuing challenge of rural electrification in India – one of the primary pillars of Bharat Nirman - the country's rural development programme – and recognised as one of the most challenging[4]. Of all the challenges facing India's electricity systems, progress in rural electrification has the greatest potential to improve the lives of hundreds of millions of rural Indians. In 2005, the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) programme, a major initiative to deliver universal access to electricity by the end of the 11th five-year plan in 2012, was announced. The legislative, regulatory and planning background of the rural electrification effort since independence is detailed together with a presentation of achievement to date. It is made clear that a number of states in the north and east of the country have struggled over time to meet rural electrification expectations and continue to be challenged. The current policy efforts under RGGVY are critically analysed to determine whether the institutional weakness of some states has been

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[4] Bharat Nirman was launched in 2005 and is a key focus of development planning as stated by Prime Minister, Manmohan Singh at the 52nd National Development Council Meeting:
"The Bharat Nirman Programme focuses on rural infrastructure, such as irrigation, rural roads, drinking water, rural electrification, housing and rural telecom connectivity. We have established monitorable targets for each state that are further disaggregated into targets for districts. The component that is the most challenging is rural electrification and we need to make special effort in this area" (National Development Council 2006).

sufficiently recognised and supported by policy action or whether the latest efforts at bringing electricity to India's village households will fail for the weak states as have previous efforts.

A concluding chapter reflects on the importance of the early decision to place implementation responsibility for electricity system development with the individual states. The impacts of the innate geographical characteristics and institutional weakness that some states exhibit are reviewed and the importance of recognising state-level characteristics in policy formulation is re-emphasised. The opportunity to generalise from the Indian experience, along with pitfalls in doing so, is explored. Finally, recommendations are made for additional research to strengthen the conclusions drawn from the evidence presented. This focuses on the value of understanding the historical context within which other regions are developing their own electricity infrastructures, the importance of case-level research on those Indian states that demonstrate continuing institutional weakness and the evolving experience with the policy instruments currently underpinning electricity system liberalisation and progress towards universal electricity access currently underway in India. However, before beginning the analysis, it is necessary to set out the theoretical and methodological foundations for the research project.

2 Theoretical foundations, literature and research design

What can economic and physical geography and economic theories tell us about the potential influences on the development of the Indian electricity sector? Specifically, what are the factors that affect the size and quality of the sector? How might these factors have had different impacts in different parts of India to result in the level of unevenness observed over time and still existing today?

This thesis is a contribution to the economic geography and infrastructure literature as it relates to a process of development. It is focused, however, on a small part of the development process – the provision of energy services in the form of grid-delivered electricity in India. The extent to which institutions, the forces of agglomeration and increasing returns result in increasing spatial concentration of economic activity is examined using the available empirical evidence (that convergence of economic performance across regions is not observed) - and that these may be driven by path dependent processes. As Gagliardi puts it:

> …economic growth models predict that less developed countries should catch up with their richer counterparts, while the evidence shows that this has not happened, thus giving support to the path dependence conjecture (Gagliardi 2008: 422).

Jamasb et al, in a review paper of electricity sector reform in developing countries, recognised the potential value of the broader development literature – both theoretically and methodologically – and argued for the need to consider broader economic and institutional issues in attempting to understand how one sector, the electricity sector, has evolved:

> Some recent studies of determinants of economic growth have addressed these types of questions [institutional qualities, geographical and resource endowments] and can guide the design of similar studies of electricity sector reform. The findings of these studies imply the need to examine the importance of sector level and country-level

institutional factors and their interactions with endowments and policies (Jamasb et al. 2004: 24).

To place the research in a theoretical context (given the relative paucity of theoretical contributions focused specifically on electricity systems), a discussion of the theoretical approaches adopted in the literature to understand regional development and the comparative unevenness of development is presented focusing on the concept of path dependence. It is felt that non-electricity or energy-specific literature is applicable to this study (and may not be for many other industrial sectors) because electricity systems are economy-wide, deeply entwined with the politics of the country, material from a macro-economic perspective and, fundamentally, heavily influenced by the quality of institutions - similar to national economies. Methodologically, the techniques explored at the macroeconomic level may, as Jamasb suggests, provide an alternative robust, quantitative approach to the comparative study of different electricity systems that may generate insights that may be lost by case based qualitative study discussed in more detail in section 2.3.2. The following literatures are explored:

- The role of institutions
- The role of physical and economic geography
- Path dependence as a dynamic process

The various concepts that have been set out are explicitly linked to the aims of this research project and ontological differences in context between some of the literature cited and the current study are discussed and evaluated for materiality.

Following the theoretical context setting, the research design and methodological choices are discussed with particular focus given to two key decisions – the selection of the comparative method and the use of statistical techniques where possible. Given the emphasis placed on quantitative methods and the developing country context and long time series, consideration is given to data quality and consistency.

2.1 Path dependence as an analytical tool

There has recently been much theoretical and empirical effort applied to incorporating path dependence concepts into existing frameworks for understanding economic activity across space. Substantial analysis has been focused on single industries and often, individual industries in specific locations (Kenney and von Burg 2001, Rigby and Essletzbichler 1997). Martin and Sunley suggest that, to date, less attention has been given to how 'a regional economy as a whole evolves through time' (Martin and Sunley 2006: 411). The initial event that 'locks in' a particular path is often considered as a given or chance act (Boschma and Lambooy 1999). The subsequent mechanisms of concentration and agglomeration are emphasised rather than the initial seeding action. Economic historians, however, have given considerable focus to what the case by case historical factors might be that have created opportunity for positive feedback, increasing returns and hence path dependence. Political scientists are also increasingly recognising the importance of path dependent processes in policy formulation and execution. As Pierson puts it:

> In searching for explanation, we need to think about causes and effects that are often separated in time, rather than focus exclusively on synchronic explanations (Pierson 2000: 253).

Path dependence can be created through multiple channels. Martin and Sunley suggest a number of possible sources of regional path dependence (Martin and Sunley 2006):

1. Natural resource based
2. Sunk costs of local assets and infrastructure
3. Local external economies of industrial specialisation
4. Regional technological lock-in
5. Economies of agglomeration
6. Regional specific institutions, social forms and cultural traditions
7. Inter-regional linkages and interdependencies

Technology choices have a significant potential to lock in economic and service outcomes in the electricity sector over significant periods due to the high capital cost and long expected life of generation and transmission infrastructure. Have the technology choices made in the first thirty years of independent India locked in performance characteristics of the electricity sector today? Technological lock-in occurs where two or more technologies with increasing returns compete for a market (sources 2 and 4 in Martin and Sunley's categorisation). Seemingly insignificant events may influence the adoption of one technology over another that then are reinforced as market share grows and experience with using and enhancing a particular technology beds in (Arthur 1989). Interestingly and importantly, there is no guarantee that the selected technology will prove, over the long term, to be the most efficient (David 1985).

A second channel for the creation of path dependence lies not in the selection of technology but in the political, economic and social institutional endowment that may result in preferences for particular policy making approaches; human capacities adapted to particular forms of economic activity and the erection of unanticipated barriers to adopting welfare optimising political and economic practices. It is through this channel that institution formation during the colonial era could continue to influence economic development today (source 6 in Martin and Sunley's categorisation).

A third channel for the creation of path dependence ties in more directly to environmental and economic geographic explanations of uneven development – that is, initial advantage and opportunity gained through natural endowment – be it location, topography or natural resources – that seeds on-going and self-reinforcing agglomeration economies (sources 1, 3, 5 and 7 in Martin and Sunley's categorisation).

Page has developed an alternative framework and taxonomy for classifying and verifying the ways in which history can matter (Page 2006). He also suggests that the lack of such a framework is surprising. He has endeavoured to deconstruct the concept of path dependence to support a more nuanced understanding of the processes that may operate in any given empirical situation. Three types of historical dependence are proposed – in increasing order of restrictiveness:

- State dependence – current period events are predicated on the previous period event. A suggested example is an election in a two party system where the party in power will lose and the other party will take its turn;
- Phat dependence – current events are predicated on a series of previous events but the order of those previous events is irrelevant (hence the re-ordering of the letters in the word 'path');

- Path dependence – current events are predicated on a series of previous events and the order of those previous events matters.

He goes on to unpack the concept further. Firstly, he identifies four potential causes of path dependence:

- Increasing returns – the more a particular choice is made, the greater is its value;
- Self reinforcement – a particular choice creates forces (potentially other than increasing value) to reinforce the continuing selection of that choice;
- Positive feedback – a particular choice by one individual makes that choice more attractive to other individuals;
- Lock-in – a particular choice becomes preferred simply because others have selected it.

He also differentiates between situations in which history influences the current period and instances in which the long run equilibrium position is influenced. Both are considered path dependence. The former being labeled outcome dependence and the latter being labeled equilibrium path dependence. The distinction is important. The fact that historical events may influence the current period but have no effect on long run outcomes is a much weaker statement than that in which historical events influence the long run. A final clarification is between what Page calls early path dependence as opposed to sensitivity to initial conditions. Sensitivity to initial conditions implies a deterministic process that pre-ordains the destination depending on the starting point. Early path dependence, on the other hand, suggests "early random outcomes shape the probability distribution over future histories" (Page 2006: 91). Early path dependence is, therefore, of greater interest from a policy perspective as it is, by definition, possible to influence outcomes as they are not fixed – merely influenced by early events.

To explore the potential of path dependence concepts to assist in the study and understanding of India's electricity system it is necessary to explore in detail some of the mechanisms by which path dependence can be manifested. Institutions, the forces of agglomeration and natural resource endowments are candidate channels of influence. It is therefore possible to consider the form of path dependence that may have manifested in India per Page's taxonomy. It is, suggested, however, that a thorough understanding of the detailed actual channels through which path dependence may have manifested in individual Indian states may only be effectively analysed by case-based research of particular situations and the institutions and actors that engaged in them – which is outside the research design and scope of this study. It is also instructive to examine a particular shock to the status quo that is occurring in India – the process of economic liberalisation.

2.1.1 The role of institutions

2.1.1.1 Theoretical background

The various development economics approaches to explaining uneven development have originated from many disciplines. One area of increasing commonality in this seeming confusion of unconnected theoretical pathways is the centrality of institutions to development. As Williamson stated, "institutional economics has been invited to join the area [of development economics]" (Williamson 1994) quoted in (Picciotto 1995: 17). Indeed, it is reasonable to suggest that the current state of knowledge would place institutional quality at the centre of the development problem. As Rodrik states in the opening of his paper 'Getting Institutions Right':

> There is now widespread agreement among economists studying economic growth that institutional quality holds the key to prevailing patterns of prosperity around the world (Rodrik 2004: 1).

However, citing institutional quality as a key determinant of development is of only limited value. It immediately raises the question of what causes the type and quality of institutions. In India the institutional structure of the electricity system, prior to the liberalisation period comprises the organisations working in the sector. These were notably, the state electricity boards, private electricity utilities, central public sector undertakings such as the NTPC, NHPC and DVC together with the relevant government agencies notably the Ministry of Power and the Central Electricity Authority (all either owned by or heavily influenced by the activities of the national and state governments). To clarify, the activities of individual actors within these organisations are, in large part, hidden by an approach of analytical abstraction discussed in some detail in section 2.2.1 below[5]. However, and importantly, these organisations are embedded in or wrapped by a broader set of cultural, economic and political institutions that provide the context in which the electricity sector institutions work. These include physical organisations such as the planning commission, the INC and the state governments (the apparatus of the state) but also a set of norms, the 'rules of the game' that influence the approaches that the institutional actors adopt in working within the system. Examples include legal or policy structures such as the planning system itself and the formulae guiding central plan transfers but also non-legal norms such as the use of electricity institutions to deliver political results or the

[5] It should be further added, that this abstraction must be aligned with the methodology chosen. A detailed case study of the progress of individual state systems would be well served by greater weight being placed on the role of individual actors.

lack of adherence by state electricity boards to grid withdrawal agreements and illegal norms such as the prevalence and tacit acceptance of electricity theft. The following chapters research the manner in which electricity sector institutions adapt to these norms and how this has had a material influence both on outcomes in the current period but also, given the potentially strong path dependence reinforced through these institutions, the likely equilibrium position reached by the state electricity institutions. Such path dependent processes would be defined by Page as early path dependence in that the outcome is not pre-determined by the starting point (sensitivity to initial conditions) – rather, the initial conditions or early characteristics have a probabilistic effect on future outcomes. The next section briefly explores the empirical literature that focuses on the effects of such initial institutional conditions.

2.1.1.2 Empirical studies

Colonial history has provided abundant opportunities for researchers to try to associate the current state of the post-colonial economies with decisions and actions taken by the ruling authorities in colonial times. Acemoglu et al attempted to empirically explore the hypothesis that colonies that were settled by Europeans fared better than those where resource extraction was the primary focus (Acemoglu et al. 2001). Lange has examined the type of colonial rule – recognising two governing strategies used by the British colonial powers: direct and indirect rule. He found that indirect rule was correlated with poorer long-term development of political institutions with subsequent impacts on economic development (Lange 2004). This insight is valuable in the Indian context as both direct and indirect rule were employed in different parts of India (Banerjee and Iyer 2005). Other scholars have suggested that the approach towards land tenure has had long-term ramifications on development. Sokoloff and Engerman observed (across North and South America) that initial land tenure regime had a long-term effect on development prospects through the evolution of institutions. They linked the initial land tenure regime to a geographical source (see the next section) driven by the suitability of land to plantations as opposed to small-scale farms (Sokoloff and Engerman 2000). Banerjee and Iyer have found evidence in India to correlate improved growth prospects with property rights institutions – providing land rights to cultivators rather than large landowners (Banerjee and Iyer 2005).

Dutt takes up the debate on the effects of British economic and trade policy on India's long-term development prospects (Dutt 1992). Drawing on Krugman's model of north – south trade (Krugman 1981), he suggests that the relative capital stock imbalance between Britain and India would result in Indian de-industrialisation. Indeed, this was seen to be the case for the Indian textile industry (Chaudhuri 1982) and suggests that under-development may be evident today in those areas that underwent drastic de-industrialisation under colonial rule.

Over-riding political philosophy and polity – (e.g. democratic, free market, openness, more or less interventionist) is often cited and analysed as a determinant of development differences in cross-country studies (Alesina et al. 1996, Dollar 1992). Alesina and Perotti note that the empirical evidence for this effect is, however, weak suggesting that studies have struggled to differentiate in a fine-grained way between dictatorships and different democratic forms – i.e. there is little homogeneity about different forms of dictatorship (Alesina and Perotti 1994). This is of limited relevance in the Indian context as the foundational political philosophy is defined at the national level. There are, however, significant practical political differences between states and there have certainly been differences in the vigour with which policies have been pursued at the state level (particularly the aggressiveness of the adoption of recent liberal reforms) and these will be analysed in the section on centre-state political misalignment.

A lack of political stability has been frequently cited as a rationale for development ineffectiveness. Alesina categorised political instability studies into two forms – those based on indices of sociopolitical instability (SPI) (e.g. Easterly and Rebelo 1993, Ozler and Tabellini 1991, Barro 1991) and those focused on the frequency of legal executive change (Edwards and Tabellini 1991). Econometric analyses of this effect, however, have struggled to infer causality. Has political instability led to reduced growth or, conversely, has improved economic growth increased political stability (Londregan and Poole 1990) – or is there joint endogeneity whereby the causality runs both ways (Alesina et al. 1996)? Further, and importantly in the context of India, it was argued by Alesina that uncertainty increases the greater the degree of polarisation that exists in the political landscape. A similar position was taken by, for example, Ozler and Tabellini (1991). The theoretical rationale here is that government change in an environment where policies are unlikely to be significantly different does not result in material changes in the behaviour of economic agents.

Annett has analysed the impact of social fractionalisation on political instability – based on the premise that a society consisting of significant, separate social groups is going to be less likely to be able to deliver long-term political stability (Annett 2001). Alesina develops the theoretical underpinnings of this possible channel of influence in a 2005 review paper. A number of potential channels are identified:

- The direct effect on preferences suggested by social identity theory whereby individuals gain or lose utility from positive actions towards members of their own group;
- A strategic approach to deal with market imperfections whereby cooperative strategies are more easily accommodated by transacting with members of one's own group;
- Production function efficiencies gained by avoiding group members and instead engaging with diverse a diverse group made up of many group members.

An identified result is the under-provision of public goods in ethnically diverse societies as suggested by the first two channels. However, the positive production efficiencies benefits of diversity were less clear.

Thus, in development economics studies (commonly but not always focused on national income growth) there are a number of channels identified in the literature whereby institutional quality may affect outcomes. Given the propensity for institutions to self-perpetuate (discussed in section 2.1.3), the need for exploring the role of the formative influences on institutional strength on ultimate outcomes in the electricity sector, are considerable.

2.1.2 The role of economic geography

2.1.2.1 Theoretical background

The earliest efforts at formally analysing firm location came with the work of Weber (Weber 1947). Weber fundamentally looked to transport costs as the key determinant of location – proposing that rational firm location was driven by the efforts to minimise the transport costs of inputs and final products. Losch expanded the analysis with the key recognition that both agglomerating and dispersing forces exist (centripetal and centrifugal forces in the modern vernacular). He identified scale economies and specialisation as agglomerating forces with transport costs as dispersing forces (Losch 1954). Hotelling gave particular focus to market area and the importance of price competition with market area driving agglomeration and price competition acting in the opposite direction (Hotelling 1929). Commencing in the 1950s, theoretical rigour and much empirical work were provided to support the role of agglomeration economies in influencing regional development (Myrdal 1957, Hirschman 1958).

Myrdal's contribution to the theoretical understanding of uneven development is drawn from his analysis of the problem of explaining the existence and persistence of economic inequality between developed and under-developed countries – as perceived at the time of writing in the mid-1950s. He attempted to uncover the causal mechanisms that gave rise to such inequality.

In brief, Myrdal argues that a set of economic and social forces have the tendency to reinforce the upward or downward progression of existing economic conditions – fundamentally, that a set of positive feedback mechanisms exist that drive increasing inequality rather than converging economic conditions[6]. He recognised that such mechanisms existed at a variety of scales, both within national boundaries and internationally (between the developed and the developing world). Myrdal felt that

[6] Convergence was an expected theoretical result from neoclassical growth models (Barro and Sala-i-Martin 1992) prior to the development of endogenous growth models (Lucas 1988, Romer 1990) that found little empirical support (Darity Jr., Davis 2005).

there were potentially many mechanisms driving the positive feedback but these can be broadly defined as a set of external economies. He cited, for instance, the potential for differential tax rates in vibrant versus stagnant economies, selectivity in migration choices, the effects of wealth on fertility rates and differing abilities to invest in infrastructure and other physical and human capital. Importantly, Myrdal provides support for central planning in a developing economy. He argues for the criticality of the role of government in moving the economy onto a path of positive cumulative causation – an early expression of the recognition of the importance of institutional quality.

The foundations laid by Hirschman and Myrdal have been developed by both economists and economic geographers. New economic geography (or geographical economics) follows in a similar theoretical tradition to Weber, Losch, Myrdal and Hirschman's work but endeavours to deliver a more precise mathematical understanding of the mechanisms underlying spatial concentration of economic activity (Barnes 2003). New economic geography (NEG) was developed initially by Fujita, Krugman and Venables as a means of re-establishing spatial considerations into the economic analysis of development unevenness (Fujita 1988, Krugman 1991, Venables 1996).

Krugman traces the genealogy of these ideas right back to Marshall who argued that there were three primary drivers of industrial concentration (Marshall 1961):

- A pooled market of appropriately-skilled workers;
- Support for the production of non-tradable specialised inputs;
- Informational spillovers.

Although accepting these spillover effects from agglomeration, Krugman argues that two other effects are, in fact critical:

- pecuniary externalities i.e. effects of increasing demand and supply have a positive reinforcement on a local market;
- Economies of scale i.e. increasing returns to scale exist.

Given these assumptions, Krugman developed a relatively simple model that, assuming imperfect competition, will result in industrial activity tending to concentrate spatially. Krugman does acknowledge that his model is sensitive to the starting position of the economy under analysis. An economy dominated by agricultural production and suffering from high transport costs – such as is the case in some Indian states (particularly in the north east) is unlikely to see industrial concentration in the same manner as would be seen in an economy with a large manufacturing and services sector with lower transport costs.

From an economic perspective, Krugman has delivered increased realism to his model of economic activity with respect to the neoclassical approach through two key innovations:

- Recognising that economic agents do not act in a perfectly competitive environment, instead Krugman models firms under principles of monopolistic competition.
- Recognising that constant or increasing returns to scale are a common feature of economic activity (the neoclassical approach assumes decreasing returns to scale).

Krugman's work has been extended to try to enrich the NEG model without losing the model consistency considered critical. For instance, Baldwin and Forslid have added knowledge spillovers into the analysis of agglomeration (Baldwin and Forslid 2000). Brakman and Garretsen have incorporated additional centrifugal forces into the model (i.e. forces that would tend to drive greater dispersion of economic activity), with a particular focus on congestion costs (Brakman and Garretsen 2006).

Taking the categorisation provided by Ottaviano and Thisse, three distinct approaches towards NEG have been identified (Ottaviano and Thisse 2004):

- Home market effect (HME)
- Core-periphery structure
- Vertical linkage framework

Of these, Venables' work on vertical linkages provides the most valuable insights into the Indian electricity sector development. The HME model can also be mapped onto an electricity sector case. The centripetal forces lie in market access with transport costs determining the ability to compete in any given market. In the context of electricity, transmission costs (including capital cost and operational losses) can be viewed as equivalent to transport costs for physical goods[7]. Transmission costs dictate the distance from markets that an electricity generating plant can be located. The centripetal force is manifested in market crowding (losing market to competitors working in the same space). In the electricity context, this is equivalent to plant having to be run at reduced capacity due to insufficient demand. The core-periphery

[7] Interestingly, electricity transportation costs are one of the few goods that actually fit the iceberg model of transport costs used in many NEG models whereby transport costs are modeled as a proportion of the product lost or 'melted away' in the activity of transportation.

model is based on assumptions of capital immobility and labour mobility that fits less well with the Indian electricity sector case (where capital has definitely been mobile nationally and labour mobility is not a key factor in location decisions). However, it also looks to the pecuniary externalities that arise from co-locating industries in the same supply chain. This is directly relevant to the electricity sector where industrial consumption is the single most important component of electricity demand and electricity is a key input to many industrial processes.

Each of the theoretical approaches assumes monopolistic competition. This is certainly not an appropriate assumption for the Indian electricity sector where monopoly (in some cases oligopoly) better describes the facts on the ground.

A primary channel of enquiry for economic geography is the spatial unevenness of economic activity. Since the establishment of NEG by Paul Krugman, there has been much debate over its usefulness by geographers. The crux of the debate centres on both methodological concerns with the use of formalised economic models and the reduction in complexity required to render those models tractable. As Perrons stated:

> it is precisely the issues considered intangible by NEG I [Krugman] that for the basis of the substance of NEG II [Amin, Thrift, Storper and Scott], where soft factors – that is relational, social and contextual aspects of economic behaviour – are emphasised (Perrons 2001: 209).

Geographers see NEG analysis as essentially isolated from the broader social and political context within which economic decisions are made. Methodologically, formal models are seen as inadequate to the job of representing sufficient complexity. A further distinction within the theoretical perspectives on agglomeration lies in motive. Myrdal, Krugman and others assume a politically neutral set of fundamentally economic processes of increasing returns to scale to be the drivers of the concentration of wealth and resources. This perspective is challenged by a group of more critical academics that seek a behavioural rationale for the identified concentration phenomena in terms of Marxist political economy (Scott 2004). The theories of unequal exchange proposed by Frank and others reflect this philosophy in the context of developing countries (Frank 1967). Harvey has also eloquently articulated a position on unevenness of development (Harvey 1973, Harvey 2006). Such theoretical constructs provide one potential theoretical base for the political and social influences on the development process (through capture of the political process by elite groups and through class conflict).

Economic geography provides other theoretical contributions that may have explanatory power in the analysis of India's electricity systems. The concept of the resource curse, whereby resource rich economies fail to grow as successfully as countries without such abundance, can be traced back to analyses in the early 1990s studying the effects of commodity price volatility on economic growth (Auty 1993)[8]. However, many studies trace the genesis of the concept back to Sachs and Warner's 1995 paper on natural resource abundance and economic growth (Sachs and Warner 1995). A number of pathways through which resource abundance might influence development achievement have been proposed. Kolstad and Wiig propose three general channels (Kolstad and Wiig 2009)[9]:

[8] Although the effects of resource abundance were also part of the analytical framework for the work of structuralists in the 1950s (Prebisch 1950)
[9] Other channels have been suggested such as the lack of investment in human capital (Gylfason 2001).

- Dutch disease models that focus on the crowding out of alternate productive activities through exchange rate movements and terms of trade effects (Sachs and Warner 1995);
- Centralised political economy models that focus on government behaviour and patronage (Collier and Goderis 2007);
- Decentralised political economy models that focus on the rent seeking behaviours of individual entrepreneurs (Mehlum et al. 2006).

Almost all resource curse studies are focused at the national level – either case study-based or comparative. Van der Ploeg has provided a recent review of studies (van der Ploeg 2006). In the last few years, the resource curse literature has evolved, recognising the empirical challenges thrown up by the relative success of some resource rich countries such as Australia, Canada, Norway and Botswana (van der Ploeg 2006, Torvik 2009). It is increasingly clear that resource abundance does not, per se, imply weak economic performance. Other factors must be considered. As suggested by Kolstad and Wiig:

> Empirical results suggest that this resource curse is conditional on the level of institutions of countries, where countries with bad institutions of democratic accountability and the rule of law suffer a negative impact of resources, whereas countries with good institutions do not (Kolstad and Wiig 2009: 5317).

Not all research supports the role of institutions on resource abundant regions. A thoughtful study by Brunnschweiler and Bulte challenges some of the evolving conventional wisdom about the resource curse. Firstly, they clarify the specification of the dependent variables in many studies arguing that resource abundance is not what is actually being used (commonly the ratio of resource exports to GDP). Rather, this indicator measures resource dependence and they suggest that a stock indicator such as overall resource reserves may be more appropriate. They further argue that use of such an indicator that explicitly includes the size of the overall economy potentially renders the indicator endogenous to the model and questions results of previous studies on the direction of causality. Indeed, they conclude their study with this result:

> The empirically significant relationship between institutional quality and resource dependence reflects that countries with poor institutions are unlikely to develop non-primary production sectors to reduce their dependence on resource exports. If so, the causality would be from institutions to dependence, and not the other way around (Brunnschweiler and Bulte 2008: 261).

In the context of India and the potential for the resource curse to manifest at a regional level the economic 'Dutch Disease' mechanism has much of its strength eliminated through the presence of a single exchange rate regime across the entire country and free flow of financial and human capital between regions. However, both a centralised and decentralised political economy model has the potential to be effective at the regional level. The principle resource in India pertinent to the development of the electricity sector is, of course, coal[10]. There is therefore a theoretical possibility that those coal rich states, through both centralised and decentralised attempts at rent seeking, may have underperformed other states.

2.1.2.2 Empirical studies

Geographical or environmental theories of unevenness probably have the longest tradition. Easterly and Levine trace environmental theories of development back at least to Montesquieu in 1748 and also find evidence in the work of Machiavelli in 1519 (Easterly and Levine 2003). More recently, Diamond and Landes have again

[10] Hydropower potential may also be considered a resource but due to, until recently, the inability to transmit electricity very long distances it is argued that hydropower could not be considered tradable.

popularised theories of environmental endowment on development. Diamond considered the uneven distribution of cultivable plants and domesticable animals (Diamond 1997). Landes drew attention to climate – particularly the effects of tropical climates (Landes 1998). Diamond's theories have limited value for understanding uneven development in the Indian context – all regions of India having been integrated and having shared plant and animal endowments for thousands of years. Landes' perspective, however, retains merit given the latitudinal breadth and topographical variety of the country.

Fundamentally, environmental theories of unevenness can be categorised under a small number of headings:

- Climate / tropics
- Connectedness
- Physical resource endowment

Easterly and Levine briefly review the literature and identify two causal pathways for environment to influence development (Easterly and Levine 2003). Firstly, a direct pathway in that environmental endowment may directly affect land, labour and production technologies. These are exemplified by Diamond's work on crop yields (Diamond 1997) and Sachs and Warner's recognition of the impediments to development caused by tropical location and by landlockedness (Sachs and Warner 1997). Secondly, an indirect pathway in which endowment may have a long lasting and deep-seated effect on institutions that, in turn, influence the form and pace of development (for instance, the work of Engerman and Sokoloff referenced in the previous section on the colonial origins of unevenness). The direct relevance of geographical factors in development has also been challenged. For instance, the primacy of institutions as an explanation of development progress is argued by Rodrik with geographical factors only having an subordinate effect through the development of institutions (Rodrik et al. 2004).

The climate factor has been extensively evaluated empirically and a tropics variable is a common component of development regression models (Sachs and Warner 1995, Easterly and Levine 2003, Hall and Jones 1996, Kenny 1999).

Connectedness has received somewhat less attention. This concept is grounded in the increased transportation costs associated with remoteness, difficult terrain or lack of a coastline for seaborne trade. Mainstream economic analyses of development have given significant attention to economic openness – recognising the development benefits to be gained from trade through comparative advantage and technology sharing. The institutional inducements or barriers to openness such as tariff levels, exchange rate management and capital flow restrictions have undergone much analysis (Dollar 1992, Bailey and Driffield 2002, Barro et al. 1995). However, physical characteristics are also recognised as being of importance. Simple measures of landlockedness have been built into a number of analyses (Auty 2001). Frankel and Romer devised the concept of natural openness using a gravity model (Frankel and Romer 1999). They theorised that openness and level of international trade is the crucial factor in explaining development progress. They argued that physical geography played a subordinate role in that the propensity for trade is dependent, other things being equal, on the size of the local economy and the distance to other economies (measured in physical, time or cost terms). Within India, this form of analysis has elegance as it provides for opportunities to capture both transportation challenges to individual states – particularly relevant in the mountainous north and physically remote north east of the country. It also supports consideration of the importance of existing Indian growth poles – lack of proximity to which may be causing on-going challenges for the more remote regions.

Physical resource endowment has received considerable research attention as a general theme for underdevelopment taking the hypothesis of the resource curse and has been investigated both through case study (Auty 2001) and cross country analyses (Sachs and Warner 1995, Collier and Goderis 2007, Auty 2001, Gylfason 2001, Isham et al. 2005, Mehlum et al. 2006). Other studies (e.g. Deaton and Miller 1995, Raddatz 2005) suggest that the resource curse, particularly the form of the curse driven by commodity prices, is not supported by robust analyses. Collier and Goderis argue that, indeed, cross-sectional analyses of the resource curse are not robust but that appropriately specified panel data tests demonstrate a strongly significant resource curse effect (Collier and Goderis 2007). The role of institutions in the manifestation of the resource curse has also been debated. In the context of the development of the Indian electricity sector, natural resources may have been influential in two ways: both through the endowment effect provided by the availability of resources[11] and the potential resource curse effect of having an economy skewed in favour of primary resource exploitation.

[11] For instance, the siting strategy of centrally-owned electricity generating plant under the DVC, NTPC and NHPC were in large part driven by primary energy sources – both coal and hydro potential.

2.1.3 Path dependency and institutional change

A commonly recognised weakness in the path dependency framework, identified in a variety of academic disciplines, is the perception that it is overly deterministic (Martin and Sunley 2006, Page 2006, Crouch and Farrell 2004, Thelen 1999, Kay 2005). For path dependence to be a useful concept in understanding potential policy outcomes and therefore policy design there has to be primarily a belief that path dependency is, in fact, only a probabilistic influence on the possible set of outcomes. Subsequent to that, the mechanisms by which path dependent processes can be influenced need to be understood. Martin and Sunley argue for the need for a:

> path as process approach, wherein the process of economic evolution must be understood as an ongoing, never-ending interplay of path dependence, path creation and path destruction that occurs as actors in different arenas reproduce, mindfully deviate from, and transform existing socio-economic-technological structures, socio-economic practices and development paths (Martin and Sunley 2006: 408).

Crouch and Farrell have endeavoured to extend the theoretical framework of path dependence to account for path change. Their contribution to the literature is to develop a framework for understanding how "path dependent development trajectories interact with exogenously changing environments" (Crouch and Farrell 2004: 6). This extension to the theoretical framework of path dependence is critical in that it enables a rigorous analysis of how path dependent trajectories may change or evolve in response to shocks from outside the institutional context in which the path dependence is acting. This allows an analysis of major policy actions and their potential impact.

Martin and Sunley argue that economic path dependence bears similarities to the biological notion of punctuated equilibrium in which periods of stability are punctuated by junctures – major shocks to the system that result in 'system-wrenching change' (Martin and Sunley 2006). Krasner described punctuated equilibrium as "an imagery that expects short bursts of rapid institutional change followed by long period of stasis" (Krasner 1984: 242). North argues that the breaking away from a path is typically driven by a change in polity (North 1990). Duit, however, argues that the empirical evidence does not wholly support the thesis that institutional change is primarily driven by major endogenous or exogenous shocks to the status quo (Duit 2007).

The theory of institutional change being a fundamentally incremental process is explored by Thelen (1999). She views institutional change as much more of an evolutionary phenomenon as institutions react and adapt to incremental exogenous and endogenous changes in their environment. The form that the evolution takes depends crucially on the reproductive processes in place that sustain those institutions and therefore these reproductive mechanisms must be influenced to effect change. Thelen also identifies the potential resilience of institutions (broadly defined) as carriers of path dependency as conceived by institutional sociologists arguing that:

> Specific organisations come and go, but emergent institutional forms will be 'isomorphic' with (i.e. compatible with, resembling and similar in logic to) existing ones because political actors extract causal designations from the world around them and these cause-and-effect understandings inform their approaches to new problems (Thelen 1999: 386).

This suggests that institutional resilience runs deeper than specific institutions and that institutional change requires something more than the creation of new physical institutions or re-allocating responsibilities between organisations. In the context of the Indian economic system, it is argued that the commencement of broad economic liberalisation has acted as a critical juncture – or punctuation in the equilibrium position of strong central planning, industrial licensing and public sector orientation.

Following Crouch and Farrell, it is therefore proposed that the institutional setting in which individual actors work is not inviolate. Exogenous shocks can occur that require adaptation by the institutional actors involved as those institutions recognise that the 'rules of the game' have evolved and institutions at the national level and state level begin to adapt to those rules. Evidence for the manifestation of this concept is considered in chapters 4 and 5 and the implications for policy analysis are explored in chapters 6 and 7. Before concluding a discussion of theoretical contributions, it is necessary to reflect on the particular circumstances of the India case being considered and to challenge the applicability of the literature discussed given those specific circumstances.

2.2 Caution with application of theory to this project

A broad literature has been leveraged to build a theoretical basis for this analysis. Much of this literature differs from this thesis in two regards, which will be discussed in turn:

– They address somewhat different questions

– They assume different ontological contexts.

Firstly, the analyses of the theoretical underpinnings of the development process that have been discussed in the introduction are primarily focused on providing explanations for differences in income. Income is treated as the dependent variable in the analysis. This thesis focuses instead on a proximate indicator of development: the provision of electricity infrastructure and electricity services. Further, analogous to the selection of broader measures of development such as the human development index instead of simple economic measures of development such as GDP, this thesis examines questions of electricity sector effectiveness based on social policy measures as well as measures of economic efficiency. It is argued that analyses based on income remain relevant when considering the theoretical influences on electricity sector development and should therefore be examined in some detail. It will also be noted in the following chapters that there are opportunities to leverage the methodological approaches taken in the broader development literature.

2.2.1 Assumptions about agency and rationality

It is necessary to consider an appropriate model for the behaviour of individuals within the governing institutions. As already discussed, a broad but rigorous comparative study such as this, requires a pragmatic determination of the appropriate unit of analysis. Given the geographical and chronological breadth of this study, the actors for analysis are assumed, as a convenient abstraction, to be the physical organisations engaged in the governance of the electricity system. Only limited consideration has been given to the most influential individual actors (e.g. Nehru, Mahalanobis, Manmohan Singh). From an institutional analysis perspective, this is considered warranted and is supported by a further assumption of bounded rationality of individual actors. This is driven by the social embeddedness of organisational actors in the institutions in which they belong. As Simon puts it:

> …there are practical limits to human rationality, and that these limits are not static, but depend upon the organizational environment in which the individual's decision takes place (Simon 1976: 240-241).

North identifies institutions as the rules of the game, not the actors working inside the structure. In this regard, North's proposal is similar to the reconciliation of the structure-agency debate in Giddens' theory of structuration (Giddens 1984). Institutions are not, therefore, physical entities in the lay sense of the word. North goes on to differentiate institutions from organisations:

> It is the interaction between institutions and organisations that shapes the institutional evolution of an economy. If institutions are the rules of the game, organisations and their entrepreneurs are the players (North 1993: Sec 3).

Hodgson has commented on North's suggestion that organisations are the players or actors. He argues that definitionally assuming an organisation to be, itself, an actor in an institutional context may lead to "an unwarranted conflation of individual agency and organisation" and that "the treatment of an organisation as a social actor should not ignore the potential conflict within the organisation". Discussion with North resulted in agreement that it can be appropriate for organisations to be treated as both institutions and actors in an analysis as an analytical abstraction "for the purposes of analysis of the socio-economic system as a whole" (Hodgson 2006: 10).

Hodgson, in his examination of institutions also differentiates between agent-sensitive and agent-insensitive institutions. He argues that some institutions have hard constraints associated with them such as strict budget constraints that 'push the agents into position and offer them few alternatives' but that these are something of a special case (Hodgson 2006: 16). Constraints may also operate through incentive, disincentive or legal penalties – again reducing the opportunities for individual agents to act outside the institutional norms. In the context of the Indian electricity sector, it is argued that individual actors in the governing institutions face hard constraints – financial constraints as well as clear disincentives to act against, for instance, the demands of political masters and potentially the incentive of personal enrichment from the engagement in corrupt practices.

Many of the studies discussed above (particularly the economic analyses), that this research leverages both theoretically and methodologically, assume rational decisions based on principles of profit maximisation – i.e. a standard neoclassical economic ontological context. However, the development of the Indian electricity sector is an explicitly and directly political process with a relatively small number of organisational actors. The directness of the political influence on the electricity sector is critical. Political processes can be an integral part of most forms of economic development in developing countries, where the state plays a much larger and more active role in economic decision-making – this can be particularly true with respect to infrastructure development (Ayogu 2007). In the context of Indian electricity sector development, the central government five year planning process has been integral to decision making and the ultimate path of the electricity sector in each state. Investment decisions have been directly taken by government entities (at the national and the state level). Only since the early 1990s, has there been any meaningful reduction in the role of the state as the electricity sector has gradually been opened up to the private sector. However, government institutions remain the key decision makers in the electricity sector. This provides support for the research focus on the unevenness of development at a national scale. Territorial boundaries (both national and state) are still of importance[12]. This stands in contrast to the areas of increasing activity in economic geography that are increasingly interested in regional and global distribution of economic activity as national boundaries become more porous with the processes of globalisation (Clark et al. 2000)[13].

[12] Notwithstanding increasing regional integration of electricity grids and a small number of regional linkages in the Indian electricity infrastructure (with, for instance Bangladesh with respect to gas imports, imports of LNG from the Middle East and electricity imports from hydro facilities in Bhutan).
[13] Globalisation, however, does have a role to play in this analysis. Industrial location has a two-way relationship with the development of the electricity sector. The demand of new industry encourages increases in the quantity and quality of electricity supply and conversely, inadequacies in the electricity infrastructure can discourage other industries from locating in particular locations

2.2.2 Application to a centrally planned economy

Myrdal provides support for central planning in a developing economy. He argues for the criticality of the role of government in moving the economy onto a path of positive cumulative causation – reinforcing the position taken by many developing countries including India – but with a prescription based on the need to emphasise the spread effects of economic policy i.e. those that promote increasing equality. However, this was not necessarily adopted policy. As Chakravarty notes:

> In the case of India, it is certainly true that deficiencies of the market mechanism in promoting what plan documents called balanced regional growth were implicitly or explicitly recognised from the mid-fifties onwards…..However, it is not clear whether the type of planning that India adopted has in fact succeeded in avoiding the dangers of polarised growth. Quite a few would maintain that it has not. (Chakravarty 1987: 46).

Indeed, India has been independent for sixty years and there is evidence that development unevenness has increased since independence (Bagchi and Kurian 2005). This raises the question as to whether decisions or outcomes from the planning process (that, to recall, was explicitly intended to reduce inequalities over time) have actually tended to reinforce development unevenness. Chakravarty enumerated three reasons why he felt development results could be polarised in a large country such as India:

1. Transportation costs were (and are) significant in India and explicit efforts to attempt to minimise the resources expended on transportation could result in increasing concentration of development.
2. The existence of strong external effects in space
3. The relative mobility of capital compared to labour results in the concentration of capital investment in higher yielding locations.

These factors bear a clear resemblance to the causal factors for economic agglomeration proposed by economic geographers. Indeed, Chakravarty references both Hirschmann and Myrdal) (Chakravarty 1987).

It is therefore necessary to demonstrate a theoretical link between the drivers of development identified in the selected economic development and economic geography literatures with those of central planners[14]. The former tend to be based on a free-market foundation and driven by the profit seeking decisions of rational economic agents whilst the latter are also driven by optimising decision processes but based on different information inputs and broader objectives than profit maximisation (or even cost minimisation). Decision-making primarily occurred at institutions within national and state government and therefore arguably influenced as much by political as economic factors – hence the over-arching need for a political economy rather than neoclassical approach to the economic aspects of the analysis.

2.3 Overall research design

2.3.1 Epistemological position: naturalism

The underlying approach to this project is naturalism - as opposed to anti-naturalism, critical social science and pluralism (Schwandt 2007)[15]. Moses and Knutsen describe the characteristics of naturalistic research (Moses and Knutsen 2007):

– There exist regularities or patterns in nature that can be observed and described;

[14] It should be noted that the development literature is very broad and includes many examples that are not based within a neoclassical economic context. However, much of the selected literature which this thesis seeks to advance and challenge, theoretically and methodologically, does indeed have a neoclassical economic ontological context.

[15] Schwandt's is only one taxonomy. For instance, Moses (Moses and Knutsen 2007) suggests two competing methodologies – naturalism and constructivism although naturalism is defined similarly by both authors.

- Statements based on these regularities can be tested empirically according to a falsification principle and a correspondence theory of truth
- It is possible to distinguish between value-laden and factual statements (and facts are, in principle, theoretically independent)
- The scientific project should be aimed at the general (nomothetic) at the expense of the particular (ideographic)
- Human knowledge is both singular and cumulative

This project is primarily theoretically led in that the starting point is a desire to understand the role of path dependent forces in the evolution of a major critical infrastructure – electricity systems. However, there is a recognised interplay between theory and the empirical data through a process of hypothesis refinement. As Ragin states:

> The interplay between concept formation and data analysis leads to progressively more refined concepts and hypotheses. Preliminary ideas may continue to serve as guides, but they are often refined or altered, sometimes fundamentally, in the course of data analysis (Ragin 1987: 164-165).

Naturalist social scientists recognise a hierarchy of available methods (Lijphart 1975) - the experimental method, the statistical method, the comparative method and the case-study method. There is an implied declining strength of those methods as one moves from experiment to case study. This project therefore uses the statistical method where possible and the comparative method where this is deemed inappropriate due to a reliance on qualitative data. The term 'comparative method' has, subsequent to Lijphart, been redefined by many scholars to embrace the statistical method in what macro-sociologists and political scientists term variable-oriented research (Engelstad and Mjoset 1997). Thus, both statistical analyses – typically various forms of multivariate analyses - and multiple case-based qualitative studies are comparative. The comparative method has both strengths and weaknesses as a methodological approach. These are discussed below.

2.3.2 Use of the comparative method

Comparative studies have a number of weaknesses that require acknowledgement and mitigation. Goldthorpe recognises three common key challenges with the comparative method (Goldthorpe 1997)[16]:

- The small-N problem whereby the number of available entities to study is limited and this is compounded by potentially large numbers of explanatory variables resulting in serious degrees of freedom challenges;
- Galton's problem[17] that recognises the likely lack of independence between studied entities;
- The black-box problem that recognises the challenge of explaining why a particular phenomenon has occurred.

The small-N problem is a very real concern for this project. Given the focus on the spatial scale in India at which electricity system development decisions are made, the population of potential units of analysis is limited to 28 states and 7 union territories for contemporary India. It is not possible to expand the population beyond these limits. The reorganisation of states has increased the number of states over time that places further downward pressure on the population for historical analysis spanning the period prior to reorganisation. Recognising this weakness, two approaches have been

[16] Macro-sociology, being focused on explaining patterns in national-level economic and social phenomena often through the analysis of the historical and cultural underpinnings of societies, provides useful insights into the methodological challenges faced by this study.
[17] Named for the nineteenth century academic, Francis Galton (Goldthorpe 1997).

adopted in the quantitative chapters. In chapter 4, a panel data set has been developed that provides additional data variety over time in contrast to the limited variety available for a cross-section study (Jamasb et al. 2004). This does not fully mitigate the concerns over small-N as some explanatory variables are time invariant. There is therefore also an attempt to be parsimonious in the selection of explanatory variables to ensure sufficient degrees of freedom and only a subset of the initial candidate variables is ultimately used. In chapter 6, the population is slightly larger at 20 cases due to the inclusion of the states newly formed in 2001. However, a cross-section analysis has to be performed due to the limited history with the policy being analysed. It is therefore necessary to be particularly strict with the selection of explanatory variables and pre-filtering of variables is performed to exclude those with no discernible explanatory power.

The ‘Galton’ problem is a feature of all non-experimental quantitative analyses. Goldthorpe argues that it is equally true of qualitative comparative analyses. In the context of this project, focused on states within India rather than nation states, it is clear that there is not independence between the units of the analysis. Indeed, the partial homogeneity of the units of analysis (culturally, in terms of polity and history as well as national government policy and the planning regime) allows for focus on those state characteristics that do vary – and reduce the risk of omitted variable bias.

The black-box problem is handled in two ways. There is acceptance of the limit to which a quantitative analysis can deliver detailed causal explanation. However, this is mitigated by ensuring that the hypotheses tested are based in theory and that theory is therefore able to provide a degree of explanatory power. Goldthorpe describes the approach as follows:

> theory must be sought that is general in that it permits the specification of causal processes which, if operative, would be capable of producing the regularities in question and would have a range of further implications of at least a potentially observable kind (Goldthorpe 1997: 16).

Moses identifies two key issues with qualitative comparative methods: selection bias and over-determination (Moses and Knutsen 2007). Over-determination is equivalent to Goldthorpe's small-N problem and is discussed above although the importance of parsimony in the selection of explanatory variables is given more weight by Moses. The importance of theory in ensuring this parsimony is also emphasised. Selection bias is likely to occur using comparative methods as the units of analysis are explicitly selected for some reason – generally because of some characteristic of interest. In this project, the choice of India as a case study is of itself a biased decision based on expectations regarding the likelihood of a fit with the theoretical position taken – i.e. that the relative attainment of the states' electricity systems can be demonstrated to be influenced by path dependent characteristics of the states. However, it is debatable whether there is anything unique in India's likelihood to conform to this theoretical position. Rather, India is selected both because of its developmental importance in terms numbers of still unelectrified people and because the federal structure supports an analysis of this type at the intra-country level which is an appropriate unit of analysis given the governance of electricity systems in India. Selection bias within the case study is further minimised in two ways. The choice of states to be included in the multivariate regression analyses performed in chapters 5 and 6 is driven, not by any evaluation of the dependent variables concerned but by a desire to maximise the number of cases under analysis. Exclusions have taken place but for theoretically informed reasons. Union territories have been excluded because the governance structure for their electricity systems is different from the states (electricity departments within the state government as opposed to theoretically autonomous state electricity boards). The union territories are also, all at least an order of magnitude smaller than the states with the exception of Delhi. Delhi is excluded, as it is also a primarily urban state heavily reliant on electricity imports from the states in its hinterland. The small states in the northeast of the country are excluded as their electricity systems are at a different phase of development to the rest of the country and they are considerably smaller in terms of population than the states in the rest of the country. Goa is the final state excluded .It is also a small state, heavily reliant on larger neighbours for its electricity provision. The categorisation of cases to analyse the rural electrification policy in chapter 7 is driven by the degree of success of the states in achieving rural electrification to date. However, this evaluation has been undertaken over a long time-period and under different definitions of rural electrification attainment. The successful and unsuccessful states are consistently categorised over time. In this way, categorisation of the states for purposes of policy evaluation is based on consistent historical fact rather than the potential for the categorisation approach to reinforce a particular theoretical position.

2.3.3 Selection of statistical or case-oriented comparative methods

Statistical and case-oriented comparative methods both have relative strengths and weaknesses. Ragin identifies four favourable characteristics of the case-oriented method:

- The ability to handle combinatorial causation i.e. recognising that causal factors may only work in combination. There are limited means for handling this in statistical analysis through, for instance, creation of variables to model interactions but creation of numerous such variables will quickly consume valuable degrees of freedom;

- All instances of a phenomenon will be directly analysed. This is in contrast to statistical analyses where the volume of data may result in individual instances being inadequately accounted for;
- The boundaries of the population under analysis are explicitly set by the researcher rather than a statistical approach that may arbitrarily include cases of limited relevance;
- The researcher is forced to become intimately acquainted with each of the cases as a whole and be able to directly compare each with the others (Ragin 1987).
-

These strengths suggest that case-oriented comparative studies should take precedence. However, statistical approaches have their own strengths:

- They can support analysis of a larger number of subjects than a case-oriented study. Case oriented studies suggest comparison of each case with each of the others. Therefore, the number of comparisons required exponentially rises as cases are added;
- They provide probabilistic rather than deterministic conclusions that, it may be argued, better reflects ground reality.
- The need for parsimony in variable selection forces the researcher to consider theoretical arguments and explicitly focus on what are perceived to be the most relevant variables.

In reality, of course, the choice of methodology is driven by the goals of the research project - particularly, the desire to uncover general conclusions or the desire to resolve complexity to the greatest degree possible. Ragin suggests that the choice of a primarily quantitative or qualitative methodology should consider the goals of the project. He argues that:

the goal of most comparative social science is to produce explanations of macrosocial phenomena that are general but also show an appreciation of complexity (Ragin 1987: 54).

He goes on to acknowledge the tension between these two goals:

An appreciation of complexity sacrifices generality; an emphasis on generality encourages a neglect of complexity. It is difficult to have both (Ragin 1987: 54).

He concludes with the observation that qualitative case studies tend to emphasise complexity over generality whereas quantitative studies emphasise the goal of generality. Selection of methodological approach should therefore reflect the overall objectives of the study. This research project recognises, in the development of India's electricity system at the state-level, a natural experiment that provides an opportunity to illuminate and explain key processes underlying the development of complex infrastructure sectors such as electricity. The specific characteristics peculiar to the India system are, of course, of considerable interest. However, the opportunity to develop general conclusions from an understanding of India's progress is a primary objective. Comparative inter-state analyses using both quantitative econometric models and qualitative historical and policy analyses are an appropriate way to uncover insights into the causal influences on India's electricity system.

The decision to adopt an inter-state comparative approach with considerable reliance on statistical methods rather than a qualitative case study approach is not uncontroversial. There has been much debate between economic geographers and economists over the most appropriate tools to employ to generate insights into the processes of place and time-specific development. Many economic geographers therefore recommend that analysis of uneven development requires more grounded, deeply empirical local research done with recognition of the contingency and non-linearity of the subject. As Clark suggests:

> a fine-grained substantive appreciation of diversity, combined with empirical methods of analysis like case studies are the proper methods of economic geography (Clark 1998: 75).

This is echoed by Barnes who argues that all knowledge is local and that locational analysis in geography must be based in the context of identified and specific contextual settings (Barnes 2003). The 'cultural turn' suggested by Amin and Thrift – in essence downplaying the 'economic' in economic geography – provides further weight to the debate within economic geography that deep sensitivity to the local is critical to understand regional development (Amin and Thrift 2000).

It should also be noted that some geographers question the validity or worth of using quantitative techniques to infer explanation and causality in processes as complex as development reinforcing the argument that detailed case analyses are the most viable way of understanding the nuanced and inter-related causes of uneven development (Harvey 2006). This position suggests that the appropriate research design for understanding the unevenness of the Indian electricity sector is deep case study analysis of individual states based on historical research and close dialogue with decision-makers. Indeed, such studies are warranted and a number of cases – all taking a political economy approach, focused on the current time period, have been attempted (Hansen and Bower 2003, Kale 2007, Kannan and Pillai 2002).

There is, however, some reaction in economic geography to this position. Traditional economic geography has provided a rich set of explanatory channels but, it may be argued has struggled to generalise (or even consider the value of generalising) their theories. As Scott puts it:

> …the geographers' critique [of new economic geography] has tended to veer too enthusiastically in favor of the virtues of the empirical and the particular and too forcefully against theoretical systematisation and formal analysis (Scott 2004: 485).

Plummer and Sheppard have tried to dispel the "current dualism between a quantitative, logical empiricist geographical economics, and a qualitative, post-positivist economic geography". They recognise challenges in employing quantitative (and therefore implicitly comparative) techniques but "notwithstanding the richness of qualitative economic geography, it remains possible to productively pursue a quantitative approach" (Plummer and Sheppard 2006: 634).

As discussed above, many economic geographers have not given much focus to quantitative analyses but development economists have. The majority of the work of development economists is aspatial but they have also given considerable attention to the characteristics that influence the political, social and cultural context within which economic decisions have played out. Further, development economists have applied econometric techniques to the data and presented many interesting empirical results.

Another development in the literature has been the renewed focus on intra-country inequality as opposed to regional or global inter-country comparisons. It is argued that, particularly if large countries are studied, they may provide richer insights into the causes of unequal development. This is due to the challenge of parameter heterogeneity. Temple notes that it is unlikely that countries with differing social, political and institutional characteristics will fall on a common surface for modeling purposes (Temple 1999). From a methodological perspective, this is an important argument for performing quantitative regional studies within a single country such as India where the parameter heterogeneity is unlikely to be so extreme. There is a greater possibility to control for external factors e.g. single national government and polity, legal structure and potentially greater cultural homogeneity (Durlauf 2001). Studies of income inequality for example, have been undertaken within both China and India (Bajpai and Sachs 1996, Shaoguang and Angang 1999).

In the context of electricity system analysis, Jamasb et al. attempt to defuse the debate between the supremacy of case studies over qualitative and quantitative comparative analyses.

> Cross-country econometric and productivity analysis can be useful for addressing well-defined questions associated with reform….Case studies can play a complementary role in understanding complex questions and multi-dimensional activities such as electricity reform (Jamasb et al. 2004: 26).

Of course, within the context of an entire study the presumed dichotomous choice between a quantitative, statistical study and a qualitative case comparison is a false one. Elements of both methodological approaches may be combined to offset the potential weaknesses of each. Mixed methods approaches recognise this opportunity. Johnson and Onwuegbuzie define mixed methods as:

> the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study (Johnson and Onwuegbuzie 2006: 36).

Greene suggests five reasons for choosing to conduct social science research using mixed methods (Greene et al. 1989):

- Triangulation

- Complementarity (seeking elaboration, enhancement, illustration and clarification)
- Initiation (discovering paradoxes and contradictions that lead to a re-framing of the research question)
- Development (using the lessons from one method to inform the other)
- Expansion (seeking to expand the breadth and range of research by using different methods for different enquiry components)

Each of these rationales for the use of mixed methods has merit. This study makes particular use of the triangulation, complementarity, development and expansion benefits of mixed methods. For instance, in chapter 6, the statistical results are recognised as somewhat weak due to the small-N problem discussed above. Qualitative evidence for public recognition of the perceived problem (profiting from the under-drawal of electricity) is presented as reinforcement to the identified statistical correlation. The policy analysis in chapter 7 develops and extends the conclusions generated in chapters 5 and 6 regarding the institutional influences on electricity system development but a comparative case study approach is more pertinent to allow a critical evaluation of the likely outcomes of the most recent rural electrification programme for states identified as strong and weak performers. Limited statistical analyses are also performed in this chapter as an elaboration tool.

2.3.4 Data considerations

Data is a major challenge in undertaking this type of research project. The weakness or outright absence of adequate quality data is a recognised concern in the study of infrastructure and electricity systems – particularly in developing countries and where a historical dimension is considered (Romp and De Haan 2007, Estache and Fay 2007, Canning 1998, Jamasb et al. 2004, World Bank 1995). Relatively good availability of data in India is a strong argument in favour of selecting India as a case study. Official data are the primary source of quantitative evidence – principally the Planning Commission and the Central Electricity Authority (along with other central government ministries). This does not suggest, however, that reliance on official data is without risk. However, in comparison with cross-country studies where there should be no assumption of commonality between different methodologies for calculating a given data series between countries, within India there is, at least, a strategic intent for the same data to mean the same thing across the Indian states. This consistency requirement is discussed next followed by a brief discussion of the approach taken to ensure data accuracy. Further details of the approach taken with data selection and verification are provided in the respective chapters as appropriate.

2.3.4.1 Consistency

Consistency of data in comparative studies has been long perceived as a weakness of the approach (Hudson 1973). In some respects, the selection of an intra-country study mitigates some of the concerns regarding data consistency across the units of analysis. Data reported at central government level are used in almost all instances. This is done for both reasons of maximising the potential for data consistency across states and for pragmatic reasons of efficiency in data collection and compilation. However, particularly in the case of state electricity data as reported by the CEA, the data is ultimately sourced within the state electricity boards themselves. There therefore remains the potential for differing interpretations of the data submission requirements at the state level. However, the standard approach for data acquisition by the CEA is the issue of pro forma data collection forms that provide a relatively detailed definition of the data requirement. An example of this approach and remaining weaknesses are briefly discussed in chapter 6 in which differing levels of detail of data submitted by the regional load dispatch centres limits the comparative data available in the country as a whole.

Regarding the panel dataset developed for chapter 5, although consolidated electronic data reports did exist for some of the later years in the selected time series, to ensure consistency, all data was sourced for the same statistical data series - the India Statistical Abstract (the India Statistical Abstract consolidates data from across the Indian economy). The CEA is the source of electricity system data in the abstract. However, the original CEA documents have not been consistently accessible – particularly for the earlier years in the study period. The primary source was used in all cases rather than placing any reliance on more convenient secondary sources that were available for more recent years.

Statistical data has consistently been recorded as at the end of the financial year unless specified otherwise. Throughout, the year label assigned to data relates to the end of the financial year (the financial year running from April to March). This has been unproblematic in most instances. However, in a very few cases, reliance has been placed on information provided in response to parliamentary questions (in both the lower and upper house of the national government) that is commonly reported as the latest available data rather than at year end.

2.3.4.2 Accuracy

Data accuracy has been a particular concern in the creation of the panel data set developed for the analysis in chapter 5. Electricity sector data for the states has been compiled into an electronic database format from physical statistical reports dating back to 1960. This data was transcribed by hand. To reduce the potential for data entry errors, sectoral electricity capacity, generation and consumption data were captured along with cross-sector totals. This allowed the crosschecking of sectoral totals against the totals provided in the official record. In a very small number of instances, this crosschecking procedure highlighted transposed character errors in the original physical dataset that were resolved. To attempt to identify other data errors in the primary sources, key data series were graphed to highlight single year spikes in key indicators. First differencing was also undertaken to identify trend reversals that may indicate data error rather than trend.

Qualitative data has almost exclusively been drawn from the official record. Exceptions to this rule are expert interview insights and media analyses that have been used for methodological and data triangulation purposes i.e. corroborating evidence rather than initial empirical evidence used to guide the direction of study. The historical record of official proceedings of the constitutional debates provides a verbose account of the evolution of the arguments resulting in the initial institutional setup of independent India. Analysis of the debates was facilitated by an electronic search engine of the original documents (Vivek 2007) [18]. Equally, national development council meetings are available and searchable electronically. Electronic searchability has considerably reduced the risk of oversight of relevant discussion in these lengthy documents.

State electricity regulatory documents are exceptional in that no central repository of these documents exists. It has therefore been necessary to analyse the records from

[18] Although a small number of key documents (especially volume 6 part 2) were missing from the search engine and were therefore interrogated manually.

each of the twenty states regulators under study individually. Again, documents are made available electronically – and indeed, must be under freedom of information legislation and norms of transparency for utility regulators. However, not all information is in the public domain. Minutes of meetings are generally not available nor are working documents. However, full details of public consultations are generally available and provide a valuable insight into the public perception of electricity system performance (as well as some of the lobbying activities of vested interests. The structure, format and depth of regulatory orders (e.g. tariff orders) are remarkably consistent across the states, easing the process of comparative analysis of these documents[19].

2.4 Conclusions

This research project is an institutional and geographical analysis of the development of a large country electricity system through independence a period of central planning and subsequent economic liberalisation. India has been selected as the case study used to help explore the influences on electricity system development. The project is interdisciplinary, drawing both theoretically and methodologically from development economics, political science, economic geography and practitioner-oriented literature focused specifically on electricity systems.

Within this context, the principle methodological approach is a rigorous inter-state comparison. However, the approaches taken to perform this inter-state comparison differ for each of the four principle research chapters. Chapter 4 is a historical analysis of the initial choices of India's government regarding the management of the

[19] One explanation for this consistency was suggested to be the engagement of a small group of consulting firms in the setup of many of the state electricity regulators (Kumar 2009).

electricity system at the time of independence. As such, the historical method is selected to ensure a suitable level of rigour is applied in the use of historical literature and archive materials. Chapter 5 leverages a panel data based econometric model to uncover the institutional and geographical influences on subsequent electricity sector attainment at the state level. Chapter 6 also uses an econometric model, this time a cross section analysis of the states at a point in time, to provide explanatory insights into the approaches taken by the states in interacting with a selected element of the electricity reform policy infrastructure. Chapter 7 is a policy analysis of another selected policy objective – rural electrification – with the objective being to determine the degree to which the policy suite being implemented is able to overcome the institutional barriers to electricity system attainment under the reform programme, identified in the earlier chapters. Further elucidation of theory, positioning within relevant literatures and methodological details are presented in each research chapter as deemed appropriate. To begin, and to guard against the project being too abstract and theoretical, the nature of electricity systems is set out.

3 The quiddity of electricity systems

3.1 Introduction

Analysis of electricity systems can be narrowly focused on the economics of the industry – regulatory structure, marginal cost pricing, return on capital employed - or the technical complexities of building, running and optimising electricity systems. However, although both these sets of aspects of managing an electricity system are vitally important other influences on the industry have a major role to play in decision-making and therefore results. Further, it is argued that the economic and technical possibilities for running a system are relatively universal. The physical characteristics of generating, transmitting and distributing electricity do not vary by place. In addition, irrespective of the form of governance in place, the fundamental economic characteristics of an electricity system such as economies of scale, long asset life and demand widely dispersed through the economy requiring complex distribution systems demonstrate considerable consistency.

Within these broad technical and economic characteristics lies a range of candidate options for structuring the electricity system and for selecting technologies. The extent to which individual regions have adopted these innovations is dependent on a set of factors that are very much a consequence of place. The manner in which these factors interact can have a measurable effect on the level of attainment reached by a region's electricity system. These factors are:

– Geography – both physical (resource availability, rainfall, topography) and economic (agglomeration processes, jurisdictional boundaries)

- History and culture – acting through the development of institutions – physical institutions as well as norms of behaviour
- Politics – the structure of political systems, form of polity, checks and balances.

The chapter proceeds by examining and enumerating the economic and technical characteristics of electricity systems identified in the literature – the near universal rules that shape the broad direction and shape of electricity system development. This is followed by a brief discussion of the channels through which physical and economic geography, history and culture, and politics can act on the decision-making processes for an electricity system. The analysis provides a rationale for the place-based analysis undertaken in subsequent chapters and for an inter-disciplinary breadth of understanding of the influences on electricity system development that differentiate this research from many other examples in the literature.

3.2 Some universal characteristics of electricity systems

What is it about electricity systems that drive investment decisions? It is informative to reflect on the unique characteristics of electricity and its relationship to the political economy as identified in the literature. There was a burst of academic research on such questions motivated by the electricity sector liberalisation that began in the 1980s. This has taken place in both the developed and the developing world with the World Bank taking a prominent role in the debate.[20] The following sections discuss the economic and technical characteristics of electricity systems. Both the underlying 'economic laws' of electricity systems are discussed as well as the innovations that have been developed that have increased the choices available to the stakeholders in

[20] The fact that research interest in this field has recently waned is unfortunate as the importance of the topic is as important as ever (Estache and Fay 2007).

electricity systems. This categorisation is somewhat artificial as the technical characteristics of electricity systems are a major driver of the economic characteristics of the systems and vice versa. However, such a categorisation provides a useful ordering and organising of the universal characteristics of electricity system development.

3.2.1 Economic characteristics of electricity

From an economic perspective, infrastructure is often characterised as a public good – non-exclusive and non-rival in consumption and therefore under-provided by a market system (Kaul 2003). However, most infrastructure does not conform to this characterisation. Roads come close to meeting this definition but increasing congestion argues against non-rivalness. Electricity in particular, is definitely rival in consumption in that two consumers cannot use the same kilowatt of generated electricity and it is excludable (within reason and assuming relatively robust management institutions)[21]. Infrastructure, however, does have some characteristics in common with pure public goods. Particularly, the presence of considerable positive externalities is a point of connection with public goods analysis. Joskow argues that a principle reason for the appearance of vertically integrated generation and transmission utilities was the ability to manage "the potential public goods and externality problems that arise as a consequence of the physical attributes of electric power networks through internal management control rather than through markets" (Joskow 1998: 27). This effect has remained particularly pertinent in the context of developing economies. The state has historically had a strong incentive to increase the availability of infrastructure such as electricity to gain the benefit of the public good

[21] Although certain elements of electricity supply are public goods in most current markets – for instance the provision of stable voltage and frequency.

effects (related to broad social and economic development) beyond what private actors would be prepared to pay for individually. Considering also, the sizeable economies of scale available from centralising resources and the high capital cost of infrastructure, there has been a pre-disposition for placing electricity system investment in the public sector (Romp and De Haan 2007).

Transmission systems are more characteristic of public goods than generation or distribution systems. As Hirst and Kirby note (Hirst and Kirby 2001), transmission is inherently uncontrollable which means that it is challenging to structure a market in which transmission operators cannot compete for business. Regulatory control of a single grid operator is therefore the norm. As expected from basic public good theory there has been under-investment in transmission in many jurisdictions as a 2003 OECD report states:

A fundamental and still largely unresolved question is how to induce efficient and timely expansions and augmentations to the transmission network (OECD 2003: 10).

Transmission systems are long-lived (30-50 years per Hirst and Kirby) and the need for additional investment is only readily signaled by the emergence of congestion costs (costs associated with the inability to move electricity from one part of the grid to another due to transmission system bottlenecks). Congestion costs have been poorly understood and approaches for the reflection of congestion costs in the prices faced by end-users for transmission system access are unresolved. Insufficient regulatory oversight coupled with incumbent interest in maintaining a status quo situation in which the generator can benefit from congestion[22] have also resulted in

[22] The benefit may come through artificial segmentation of the market that reduces competition. A Danish analysis indentified a price-cost mark-up difference of 3-4% to 40-43% compared to the rest of the Nord Pool grid to which it is a part due to transmission congestion (OECD 2003).

transmission investment failing to keep pace with generation and distribution investment (Woolf 2003).

In economic terms, electricity systems have been characterised as follows:

- natural monopolies with often high degree of supplier control over pricing due to price inelasticity i.e. demand for electricity is resistant to price changes in the short term and the limited number of substitutions for electricity extend this insensitivity to the long run (Stern 1998).
- high capital investment needs and considerable economies of scale (TERI 2006a). Considerable econometric analysis of the economies of scale of plant size has been undertaken (most commonly in the U.S.). The consensus conclusion is that scale economies are clear with growth from small to medium sized plants but evidence for continuing scale economies moving from medium sized to the largest, most efficient plant is less clear – due to perceived issues with reliability of the largest plant[23] – both sub-critical and super-critical technologies (Cowing and Smith 1978, Joskow and Rose 1985)
- long development lead times of between 4 and 10 years (Iwayemi 1978) depending on the technology with gas fired turbines being more rapid and coal, nuclear and hydro generation being more protracted.
- relatively high distribution costs making urban supply much more economic than rural supply due to the greater density of customers (Barnes 2007).
- substantial externalities (both positive and negative) (Israel 1992). Negative externalities include various forms of pollution on the local (NO_2) through

[23] Recent studies suggest that the stasis that was identified in innovation in coal fired generation technology has been followed by a period of reinvigoration (Yeh and Rubin 2007). However, the loss of a coal generation efficiency dividend was widely accepted through the 1980s and into the 1990s.

regional (SO_2 / acid rain) to global scale (CO_2). Positive externalities include the development benefit through improved education and health of access to electricity infrastructure that may increase long term earning potential.

- Lumpy investments with high up front costs and asset specificity presenting the risk of being left with stranded assets (Dailami and Leipziger 1998). Once built, there are few options to substitute generating plant to other activities. Equally, the type of plant invested in may lock in the fuel used and maintenance costs to ensure continued running (Cowing and Smith 1978).
- Long gestation period of infrastructure capital investment programmes and long social and economic pay back periods, generate considerable incentives for public expenditure on infrastructure to be curtailed when budget constraints are present (Ayogu 2007).
- Significant sunk costs (meaning once the investment is made, the owner has an incentive to continue production even if long run average costs are not met as the asset cannot readily be used for other purposes) (Bergara et al. 1997).
- The demand for electricity is a derived demand and is widely consumed (Bergara et al. 1997). People do not want electricity or roads or telephones for their own intrinsic value – they want to light their homes, get their crops to market and be able to talk to friends and family (Reddy 2001). Insufficient stocks of infrastructure result in an insufficient flow of these associated services that affect economic activity and social well-being in many ways.
- Critical for economic development. The infrastructure bottleneck has been widely perceived as a major constraint on economic growth (Bardhan 1998) and electricity has been highlighted as the most important constraint facing Indian businesses (Carter 2004).

Given these underlying economic characteristics, a number of approaches have been adopted over time for managing this complex challenge and are discussed below.

3.2.2 Technical characteristics of electricity systems

Electricity has some technical characteristics that influence the way in which systems have evolved and continue to dictate the possible approaches for investing in and managing the system. As Joskow stated:

The structure of the electric power sectors that emerged historically around the world have been driven heavily by the operating and investment complementarities between generation and transmission and technological advances that have expanded the geographic expanse over which integrated AC networks can be controlled reliably to exploit opportunities to tradeoff low operating cost generation to displace high operating cost generation and to reduce the cost of reliability (Joskow 1998: 26).

Electricity cannot currently be stored at any material scale[24]. Therefore, electricity provision requires almost instantaneous matching of supply and demand. This task is complex in the short and long run – particularly given the economic reality of high capital cost and long investment lead times. The challenge is particularly acute for rapidly developing economies where the forecasting of demand is difficult and conditions of chronic under-supply are the norm (Balachandra and Chandru 2003, Balachandra and Chandru 2002, Modarres 1990, Sanghvi 1991).

An inability to match supply with demand can lead to frequent loss of service and considerable economic cost (Balachandra and Chandru 2002). Unlike supply shortage

[24] Pumped storage of water for hydro generation is feasible and implemented in many locations but the number of potential locations for such facilities is limited. India's latest hydropower potential survey completed in 1987 identified 56 potential sites for pumped storage with total potential capacity of 94,000 MW (equal to about two thirds of identified hydropower potential). There is currently considerable R&D effort underway to yield further economic mechanisms for electricity storage – compressed air, flywheels, massive-scale batteries for instance.

in most economic sectors, it is not possible to always control who is impacted by a loss of supply as failures in the electricity system can hit customers randomly because of the technical characteristics of the transmission and distribution system (Anderson and Taylor 1986). A demand mismatch with supply also leads to deterioration in the quality of electricity supply manifested in frequency and voltage fluctuations. Such fluctuations can impose economic costs through increased maintenance costs for electrical appliances such as information technology and electric motors used in industry and irrigation pumps.

The generation technologies employed in the early stages of electricity system evolution – notably thermal generation using coal and hydro generation, were particularly sensitive to scale economics. Maximum generating unit size grew from 10MW in 1910, to 35MW in 1920 and 1275MW in 1930 (Ling 1964). Increasing scale brought lower prices and a larger market potential. Hannah reproduced cost of electricity figures from 1919 suggesting that a 25 MW facility could generate electricity at half the cost of a 1 MW plant (Hannah, L. 1979). Of the more recently introduced technologies, only nuclear comes close to exhibiting the scale economies seen with coal and large hydro generation. Gas fired generation using CCGT technology for instance, demonstrates economic viability with smaller scale. The EIA has detailed 2008 base costs for the development of new 400 MW convention CCGT plant at $907 / KW as compared to $1,923 / KW for a new 600 MW coal-fired plant (Energy Information Administration 2009a).

The physical characteristics of electricity transmission technology have constrained electricity system development. Transmission technologies have evolved markedly, resulting in increased capacity and feasible distance of transmission and therefore potential size of control area. Three-phase alternating current transmission is the global norm. The selection of alternating current for transmission mandates the synchronisation of frequency across the grid. Synchronisation implies a strong institutional structure to manage the synchronisation and dispatch of electricity into the grid throughout its jurisdiction. Direct current connectors can be employed with inverters and rectifiers to bridge between two unsynchronised AC grids and high voltage direct current (HVDC) transmission technologies at 800 or 1200 KV are increasingly being used for long distance transmission. However, electricity system development has been historically constrained by transmission technology evolution with early systems having limited capacity and unable to transmit over long distances – requiring generation to be located in close proximity to load centres (Hughes 1983). The need to synchronise frequencies acted as a disincentive to increase the size of the grid. This was countered by the load balancing benefits of servicing a diverse range of customers across a broad network.

Distribution technologies also share common features. A key technical requirement of a distribution system is the cost-effective stepping down of voltage to appropriate levels for local distribution. The decision to build generating plant at remote locations and use high voltage transmission lines to deliver electricity to load centres has mandated the need for electricity systems to have a series of step-down transformers placed in substations at the neighbourhood and even residence level. This standard prescription for distribution technology has implied relatively high costs for distribution to low consumption density rural communities. The need for expensive three-phase distribution lines has begun to be challenged by innovations such as single-wire earth return technologies together with supporting technologies like single phase motors that can be used for rural irrigation and other purposes (Bekker et al. 2008).

The nature of the demand for electricity has also evolved over time. Electricity consuming devices have grown in sophistication (particularly the increasing prevalence of electronic devices as opposed to simpler electro-mechanical devices). This has resulted in the need for higher quality electricity supply – high availability, reliability and cleanliness (voltage and frequency stability) – and has created pressure for greater investment in the electricity infrastructure (Dunkerley 1995).

These economic and technical characteristics have had a strong influence on the approach taken to govern increasingly complex electricity systems. Governance structures continue to evolve as technologies and hence the economics of electricity system development continues to develop. The next section explores the influence of technology and economics on electricity system governance.

3.2.3 The global evolution of electricity infrastructure

Electricity systems, driven by their economic and technical characteristics, demonstrate some common themes in their development trajectories around the world. With the risk of generalising, very early electricity systems tended to be privately owned utilities serving concentrated urban customer bases (Dunkerley 1995). Technical and economic factors encouraged the concentration of the industry. Advances in transmission and distribution technology meant a generator could service a larger area[25]. The load balancing opportunities of large-scale distribution delivered lower cost operations and higher service quality[26]. The need for synchronisation of AC grids being fed by multiple generators was eased by single ownership of a vertically integrated operator (owning generation, transmission and distribution). Economies of scale in generation and distribution were also available as steam based thermal generation technology improved (as discussed in the previous section). The first business model adopted was therefore one of large vertically integrated organisations that were able to capitalise on economies of scale in generation, manage large distributed networks and benefit from the smoothing of electricity loads gained from supplying to a broader and more differentiated set of customers (Stern 2009).

The agglomeration process drew increasing attention to the fact that electricity provision was a natural monopoly. Gilbert et al quote Farrer's definition of a natural monopoly as an industry with:

- Capital intensity and economy of scale
- Non-storability and fluctuating demand
- Locational specificity generating locational rents
- A necessary product, essential for the community
- Involving direct connections to customers (Gilbert et al. 1996)

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[25] As early as 1891 long distance transmission had been demonstrated in Frankfort, Germany with a 175 km, 25 kV installation at the World's Fair (Hughes 1983).

[26] Average peak load can be reduced as a proportion of base load thus reducing the reserve requirement. This can result in a need for less generating capacity or less load shedding in a capacity-constrained situation (Gilbert et al. 1996).

As technology supported larger scale generation and development of broad transmission and distribution networks, the electricity industry in most industrialised countries took on these characteristics of natural monopoly. The challenges of managing increasingly large natural monopoly businesses, coupled with the recognition of the criticality of electricity to economic performance, led to many electricity industries being brought under national ownership by the middle of the twentieth century (Patterson 1999). However, this is not to suggest that the economic form and ownership structure of electricity systems has been identical around the world. Two fundamentally different approaches (and a mixed hybrid of the two) have been adopted in an attempt to manage the complexities derived from the economic and technical realities of building and running electricity systems. For instance, American generation has always been organised regionally and held primarily in private ownership[27]. The Japanese system has also been primarily privately owned (apart from a short period of national ownership from 1939-1951 (Kikkawa 2006) and ten regional privately owned regional monopolies continue to dominate the industry (Federation of Electric Power Companies of Japan 2009). Many European electricity supply industries on the other hand evolved into centralised, publicly owned utilities (e.g. the CEGB in the UK prior to privatisation, EDF in France and Enel in Italy) (Gilbert et al. 1996). Other countries such as Belgium, Germany and Spain evolved highly mixed system with both public and private sector companies – and control at the municipal level although Spain had a dominant national utility in Endesa and

[27] Investor owned utilities currently comprise 37.6% of capacity. Non-utilities e.g. independent electricity producers hold 41.4%. The remainder is owned by publically owned utilities (9.8%), federal electricity agencies (6.8%) and cooperatives (4.4%) (American Public Power Association 2009).

transmission and distribution is spatially fragmented. This organisational structure remained in place until the wave of liberalisation that commenced in the 1980s.

For most developing countries prior to the 1990s, driven by the long term economics of investment and the positive social and economic benefits, conventional wisdom assumed that infrastructure sectors were a public sector responsibility and governments looked inward for the means to improve their quality and quantity (Estache and Fay 2007). Bond and Carter identified two key reasons why developing countries chose to keep electricity systems in the public domain throughout most of the second half of the twentieth century (Bond and Carter 1995):

- perceived strategic importance to the economy
- large investment costs and long gestation periods usually associated with such projects were thought to have constituted serious disincentives to private investors when coupled with the perceived higher risks of investing in developing economies.

In the 1970s there was a growing sense that the economic model under which the electricity system of industrialised countries operated was breaking down. Since the birth of the industry, there had been an ongoing process of increasing scale and thermal efficiency and consequently reducing cost – driven by technological innovation primarily in the coal fired generation sector. The efficiency dividend coming from this technological innovation meant that electricity generators were able to deliver declining real electricity prices to customers in many jurisdictions. A sizeable literature developed through the 1970s and 1980s (primarily focused on the U.S. electricity supply industry) suggested that plant economy of scale limits had indeed been reached (Christensen and Greene 1976, Joskow and Schmalensee 1987). Generators no longer had access to relatively easy efficiency gains and this created an opportunity for government owners and regulators to seek out cost efficiencies through economic and institutional restructuring of the industry (Jamasb et al. 2004).

Since the mid 1990s, however, more than 30 countries have embarked on a variety of liberalisation policies to alter the way electricity is financed and managed (Besant-Jones and Tenenbaum 2001a). The motivations for liberalisation have been particular to the context of each country but have occurred in a global ideological context that has emphasised market mechanisms over other governance structures. McGovern and Hicks have suggested a set of observed drivers for liberalisation (McGovern and Hicks 2004):

- technological developments - particularly the improved efficiency of gas turbines
- the need for increased investment - especially in developing countries
- a perception of high electricity prices
- recognition that electricity supply may not be a natural monopoly

The technical drivers of liberalisation have not received as much attention as the economic drivers. As McGovern notes, the introduction of new gas turbine technology (specifically CCGT technology[28]) offered the potential for an attractive investment opportunity for new entrants into the electricity generation market. Lead times and risks were considerably lower than for traditional coal fired of hydro powered generation. Capital costs were lower as CCGT plant is typically a smaller

[28] More recently, incentives to develop renewable energy sources – particularly wind have provided additional opportunities for private investment in the generation sector.

unit size than traditional coal fired plant - 400-600MW maximum size as opposed to over 1000MW (Hansen 1998). Thus, a technical innovation delivered an opportunity to open up the generation market to competition with an attractive offering for private capital and indeed, there is some evidence for this in India.

These drivers demonstrate a confluence of technical, economic and political philosophy factors that provide evidence for the need for a thorough understanding of the context in which an electricity system develops to gain insights into the historical path taken and the possible future trajectory of the industry. The following section discusses those contextual, place-specific characteristics.

3.3 Place-specific characteristics of electricity

To understand how a given region's electricity system has developed and is likely to evolve in the future requires more than consideration of the universal economic and technical characteristics of the system. Given the prevalence of electricity system engineering and economics in energy modeling studies, this is important to appreciate. The universal economic and technical characteristics of electricity systems only provide a set of parameters within which an electricity system is likely to evolve. Actual system development is going to depend on other, place specific factors. This is echoed on a 2004 World Bank infrastructure policy report:

It can be argued that the performance of state-owned network industries reflects a variety of country characteristics both observable and unobservable, including institutional capacity, business culture, nature of organised interest groups, patterns of social conflict, and codes of conduct (Kessides 2004: 7).

The literature on the historical evolution of electricity systems in specific locations is surprisingly limited. A small number of studies have focused on the U.S. and Western European industries (Hughes 1983, Hirsh 1989, Hannah 1979). Two historical studies with a non-western perspective have been identified in the literature – focused on the USSR and South Africa (Coopersmith 1992, Renfrew 1979) but:

"Non-Western electrification (still largely incomplete) is also recent and unfortunately is nearly absent from the electrification literature" (Morton 2002: 62).

The following three sections explore the theoretical channels through which these place specific factors – physical and economic geography, history and politics - can influence the development of a country or region's electricity system.

3.3.1 Institutional roles in electricity system development

The roles of history and politics in electricity system development are clearly related – the politics is borne out of historical and cultural context and institutions reflect both historical ancestry and current political reality. The differentiator from an analytical perspective is that historical influences on the sector may no longer be apparent but may continue to act on the electricity system through path dependent channels based on initial endowments, long-lasting capital investment decisions and institutional inertia.

The channels through which a region's history and culture influence electricity system development can be subtle and primarily are driven by the effects of history on institutions – both 'hard' institutions such as ministries, regulators, public sector undertakings etc as well as 'soft' institutions such as cultural mores, values and beliefs (North 1991). Potential channels that have been identified in the broader development literature include:

– Influences for electricity sector regulation: as discussed above, a number of approaches to electricity system structure, ownership and regulation have been practised around the world. The selection of approach for any given jurisdiction is determined by the institutional and cultural legacy of that jurisdiction (Levy and Spiller 1994). However, external influence is also common (for instance the modeling of the post-war Japanese electricity system on the American system). Appropriateness or otherwise of the influences selected can have a considerable impact on the future development of a region's electricity system (Jamasb et al. 2006).

- Polity: the degree of democracy can influence the allocation of resources between different interest groups in society and hence the cost and availability of access to electricity (Brown and Mobarak 2009).
- The constitutional structure as measured by the degree of federalism or central government control has the potential to influence the choices for institutional structure of the electricity industry (Bergara et al. 1997).
- Longevity of self-governance: for industries with long lead times such as electricity, investment uncertainty can destabilise their development. Government immaturity (and instability) can inhibit both public and private sector investment in the industry (Alesina et al. 1996, Heller and McCubbins 1996)
- Development strategy: different approaches to development present opportunities and barriers to the development of the electricity system. Development based on import substitution and internally generated growth present different challenges to export led development strategies (Heller and McCubbins 1996). The degree to which development is explicitly planned (along the lines of Soviet, Chinese and Indian five year plans) also has the potential to influence electricity system development.

Electricity provision is an inherently political activity. The literature has identified a number of reasons why political influence in the electricity sector appears to be the norm. From a political perspective, electricity systems have certain characteristics that influence decisions on how and how much to invest. Infrastructure (and specifically electricity) is:

- A basic and critical industry that may encourage a strategic desire for self-sufficiency that may not be defensible for a narrow economic perspective (Surrey 1987)
- It has a high potential social and political cost of failure to deliver and failure to deliver is readily apparent (Anderson and Taylor 1986)
- It is used as an indicator of reducing poverty and is therefore directly of interest to policy makers intent on improving poverty figures (Planning Commission, Government of India 2001, Ayogu 2007).
- It is often a material fraction of the discretionary spending of public authorities with resulting political interference and opportunism. Infrastructure spending can be used as a means of rewarding political constituencies (Ahluwalia 1994)
- The amount of spending on infrastructure makes it vulnerable to undue influence from interest groups e.g. generators (Henisz and Zelner 2006).
- It is institutionally complex to manage and therefore opportunities for politicisation increase as the strength of the institutional environment supporting it declines (Bergara et al. 1997).

Whatever the institutional and ownership structure of the industry there is a channel for:

- Explicit influence over investment decisions in a traditional public ownership utility model;
- Indirect influence over corporatised public bodies through political appointment of senior management;
- Political influence over regulatory bodies that define the structure for public and privately owned utilities through appointment of key personnel.

What are the implications of the politicisation of electricity system development? Firstly, it should not be presumed that political influence over electricity system development is negative per se and indeed, may be considered a necessity in the case of basic goods. Political influence is necessary to ensure a balance of, for example, social and environmental objectives with objectives of economic efficiency. Political involvement can result in inappropriate structure, poor management and inadequate or misdirected investment through short-term interference. Political involvement can also result in outcomes that are optimised for special interests rather than all the stakeholders in the electricity system. Examples of the impact of politics on electricity system development are found in country studies. Bergara et al identified a significant relationship between a measure of credible political institutions and per capita generating capacity (Bergara et al. 1997). The study particularly identified the importance of checks and balances on executive power – particularly through a robust and independent judiciary and regulatory structure. Henisz and Zelner confirmed this finding (Henisz and Zelner 2006). However, the implications of the politicisation of electricity system development are arguably most apparent in a comparative analysis within a country as will be demonstrated in the context of India in the next chapter.

3.3.2 Economic and physical geography's role in electricity system development

If there are a set of universal technical characteristics of electricity system development that define the parameters within which that development has occurred, there are equally a set of geographical, space-specific factors that further refine the potential scope and type of development of electricity systems within a region. Economic and physical geography influences both what is possible (e.g. limited hydropower generation in flat, arid regions) and what is probable (e.g. electricity systems develop first in well connected areas of existing economic activity). Both physical geography and economic geography may contribute – both acting in their own right and in relationship to the previously defined universal characteristics of electricity systems defined. Geographical characteristics to be considered are[29]:

- Availability of fossil fuel sources
    - Type (coal, oil, gas)
    - Quality: particularly relevant to coal, the quality of coal influences the cost of generation and distance over which the fuel can be economically transported (due to the energy density of the fuel). It also influences the technologies that can effectively be adopted – a recurring theme in the context of India.
    - Ease of extraction: influencing practicality and cost of extraction. As the principle variable cost input to electricity generation, cost of generation is highly sensitive to delivery cost of primary fuels.

[29] Select characteristics are considered here. As other energy sources reach critical mass such as wind, marine resources and biofuels their geography will also impact future development potential. However, from a historical perspective their materiality has been limited

  - Proximity to load centres (or potential load centres): transportation costs of fossil fuels can be a major component of primary fuel cost and therefore cost of generation.
- Availability of hydropower potential
  - Absolute potential: the theoretical amount of hydropower that could be generated if all technically or economically feasible opportunities were implemented.
  - Seasonality, rainfall intensity: heavily seasonal rainfall requires either sizeable water storage facilities (i.e. dams and reservoirs) or backup generating plant to be used in dry periods.
  - Availability / forms of water storage
  - Proximity to load centres (or potential load centres): hydropower potential is often located in hilly environments, far from load centres. Investment in transmission and acceptance of transmission losses (raising the cost of electricity at the point of consumption) are therefore necessary. Absolute hydro potential may therefore remain unexploited (or exploited last) due to the additional costs associated with remoteness from load centres.
- Agglomeration economies
  - Pre-existing generating capabilities: existing infrastructure (for both delivery of primary energy and transmission of generated electricity), planning decisions and skilled workforce can also enhance the attractiveness and reduce the costs of existing generating locations.

  - Centre of industrial activity: the existence of large loads local to a generating location provide a stable market and reduce transmission costs and losses.
- Position of region with respect to markets
  - Landlocked or not: high transport costs are associated with landlocked sites particularly if there is a reliance on, for instance, imported coal or liquid fuels.
  - Neighbouring large load centres: a region may be economically weak but neighbouring a strong region. Improvements in transmission capabilities have made it possible for regions to benefit from sale of commodities (including electricity) to richer neighbours.
- Topography: transportation costs and therefore economic competitiveness can be materially affected by topography – particularly in hilly environments.
  - Transportation costs of primary fuels
  - Transmission costs of surplus electricity

3.4 Conclusion

The above discussion highlights the underlying economic and technical realities that underpin any electricity system's development. It demonstrates how technology has evolved over time (in response to economic pressure to reduce cost, improve the stability and quality of service and exploit new energy sources). Economic and institutional tools have also adapted over time – in large part to the technology changes that have occurred[30]. It has been shown that a given country's approach to

[30] This is not to suggest that moving the technology and economic / institutional frontier necessarily represents progress in any absolute sense. In the case of some innovations such as improved transmission, more efficient and cleaner generating technologies, there is a clear opportunity for benefit

developing its electricity system is primarily influenced by location specific characteristics based on the institutional qualities and physical and economic geography of that region. To understand the developmental potential of a region's electricity system it is critical to understand these location specific characteristics. The evidence presented provides a structured approach for the comparative examination of the characteristics of a region and supports the development of a richer contextual understanding of how a country's electricity system has developed. The remainder of the analysis therefore focuses on the development of the electricity system in one country: India.

to accrue from embracing these innovations. The potential is less certain (and ideologically influenced) with other innovations such as nuclear power, short term electricity trading and private ownership and competition in electricity supply.

4 India's electricity governance: empowered states

4.1 Introduction

The literature on the history of the Indian electricity sector is limited. There are many studies of the contemporary performance of the sector – particularly in light of the reform programme that is underway (Bhattacharyya 2007, Dubash and Rajan 2001, Khaparde 2004, Sharma et al. 2005, Singh 2006, Dubash and Rao 2008). There have been a number of political economy analyses of the sector – including a number of state-level case studies (Hansen and Bower 2003, Kale 2007, Reddy and Sumithra 1997, Das and Mishra 2006). There have also been some national level qualitative analyses (Dubash and Rajan 2001, Morris 1996, Lal 2006, Kodwani 2006, Tongia 2007) including at least one that dates back to the 1960s and focuses, even at that time, on the inefficient management of the state electricity boards (Hone 1968). The majority of studies are very much focused on contemporary issues – particularly the legislative and institutional structure created with the reform programme and the financial viability of the sector. These are important questions but much of the literature has failed to place analysis of reforms into the context of how the electricity sector got to be where it is. Kale provides a detailed account of the historical context within which the electricity system has evolved. She adopts a "macro perspective in order to illuminate the underlying forces that have shaped changes in Indian electricity, with a focus on the intertwining of interest group politics and global ideology" (Kale 2004: 468) but provides little insight into either the geographical influences or the specifics of electricity systems that have influenced sector development. Rao, in his book 'Governing Power' discusses the progress of the sector from a political economy perspective (Rao 2004). He provides some insights into the pre-independence state of the sector but primarily from a legislative perspective. Surrey provides a detailed historical and political economy account of the development of India's indigenous electricity equipment supply industry and briefly discusses the development of the electricity sector up to the late 1980s and recognises the role of spatial concentration, fuel sources and technology innovation on the pattern of system development. However, he does not develop these themes further. (Surrey 1987). Explicit consideration of both technical electricity system specifics and intra-state comparison are largely absent from the analysis. Kannan and Pillai have endeavoured to examine the historical health of the state electricity boards from a physical efficiency and financial perspective (Kannan and Pillai 2002). Their analysis is one of a very few that considers the economic and technical characteristics of electricity system development such as scale economies and innovation. However, their analysis underplays the spatial considerations that, it is argued, are also critical in understanding the form of development of the electricity system. This chapter endeavours to provide insight into how India's electricity sector reached the position it had in the 1990s when much of the literature picked up the narrative. Applying the structured approach suggested in chapter 3, particular focus is given to the institutional, geographical and electricity system specific characteristics of India's electricity sector that help explain why the sector has evolved in the way it has. Drawing on the theoretical insights of path dependency introduced in chapter 2, it is argued that fresh insight can be delivered on the analysis of contemporary challenges in India's electricity sector. These insights may improve on policy recommendations developed through political economy analyses of the reform programme that under-emphasise the path dependent role of the deep forces of institutions and physical and economic geography in influencing change[31].

This chapter therefore examines some of the formative influences on the Indian electricity sector that, it is argued, have had long lasting effects on the success of the sector. Firstly, there is an exploration of why India chose to place primary implementation responsibility for electricity development with the individual states. This draws evidence from the colonial and independence movement historical context, political and legislative structure and national planning. Next, there is an analysis of some of the institutional and endowment characteristics of the states that give rise to the potential for the uneven attainment observed over time. The ramifications of state governance - the unevenness in electricity system that resulted - and responses to the issues created by the decision are then elucidated. This is a demonstration of the resistance of state sector performance to policy action and therefore suggests path dependence at work. Finally, reflecting the interplay of spatial governance decisions and the rapid innovation occurring in thermal generation and transmission technology and demonstrating the importance of giving consideration to the universal technical and economic norms that shape electricity system development, the considerable impact of a state-level focus on electricity system investment on technology innovation are examined. It is demonstrated that the decision on the spatial governance level has impacts, not solely through the institutional capacities and

[31] Kodwani discusses the history of the political context within which current electricity regulatory structures have evolved - leveraging the institutional framework provided by Levy and Spiller (Levy and Spiller 1994) as well as Stern and Holder (Stern and Holder 1999) discussed in the chapter 2. However, other than some analysis of the role of the INC and political competition, the historical insights are limited (Kodwani 2006).

endowments of the individual states but also through state institutions having little incentive to evaluate investment decisions at a scale beyond their own boundaries.

4.2 Placing implementation responsibility with the states

4.2.1 Direct colonial influences

The decision to make the states responsible for electricity is important. Belief in the appropriateness of state level control of the sector can be traced back to the Montagu-Chelmsford Report published in 1918 (Montagu and Thesiger 1918). This report formed the basis of the 1919 Government of India Act that was superseded by the 1935 Government of India Act, which in turn was highly influential on the Indian constitutional debates. The motivation for the Montagu-Chelmsford Report and the Government of India Acts was to optimise the administration of the Indian provinces from a centralised British national government and was therefore focused on identifying those activities that could safely be delegated to more local administration – rather than making a choice between Indian national government and Indian provincial government. However, despite these different motivations, the influence of the British Government of India Acts on the Indian constitution – specifically, the separation of responsibilities between the centre and the states – was considerable.

The Montagu-Chelmsford report detailed a possible approach for the governance of India and particularly the role of the provinces in government. Two appendices to the report detailed the responsibilities that should be transferred to the provinces (the transferred list) and those responsibilities that were theoretically provincial responsibilities and could be transferred at an appropriate time (the provincial list). Electricity, along with oil and coal were recommended for the provincial list – but not considered ready for actual transfer to provincial control at that time (national railways were excluded). The recommendations were translated into legislation in the 1919 Government of India Act and electricity was placed on the reserved list – the equivalent of Montagu and Chelmsford's provincial list (although coal, oil and the railways were not). The rationale for placement of responsibilities in the 1919 Act was determined by criteria focused on the opportunity for the states to develop socially and economically.

The 1935 Government of India Act subsequently recognised the difficulty of prescribing responsibilities as either provincial or central and introduced the concept of concurrent responsibility (a mechanism also developed in the Canadian and Australian constitutions). Concurrent subjects (discussed in more detail in the following section) were determined:

- where federal legislation may be desirable for international conventions;
- to preserve uniformity;
- to give a lead to the provinces as in the case of labour legislation;
- to regulate matters extending beyond one province as in the case of diseases of animals (Government of the United Kingdom 1935).

This concept was carried forward and accepted in the constituent assembly debates where the Indian constitution was formulated (Constituent Assembly 1946). The constitution therefore explicitly categorises the responsibilities of the national government (the centre) and the states in three lists: the union list, the state list and the concurrent list (Government of India: Ministry of Law and Justice 2007). Electricity ultimately became the 38th item on the concurrent list[32].

Following the direction set in the Government of India Act, 1935, it was agreed that primary implementation responsibility for concurrent list activities lies with the states – the centre only engaging to the extent necessary to ensure that federal objectives are not compromised.

> The other class of concurrent subject consists mainly of the regulation of mines, factories, employer's liability and workmen's compensation, trade unions, welfare of labour, industrial disputes, infectious diseases, electricity...... In respect of this class, we think that the Federal Government should, where necessary, have the power to issue directions for the enforcement of the law, *but only to the extent provided by the Federal Act in question* (Shri T. T. Krishnamachari, Constituent Assembly 1948b: 30-Dec-1948) (italics added).

4.2.2 Post independence national politics and legislation

India today is a democratic union with twenty eight states and seven centrally administered union territories (Ministry of Law and Justice 2007). The country is best described as a hybrid unitary / federal nation as there are considerable powers held at the national level but there is also devolution of power to the states as detailed in the constitution and discussed above. The constitutional structure was determined relatively hastily in 1947 in the context of the partition of India and Pakistan – a time of turmoil in India. Prior to partition, greater devolution to the states was envisaged but partition brought both a focus on a strong central government for purposes of national security and, to an extent, did away with the need to accommodate Muslim distrust of a Hindu dominated central government:

[32] The responsibility for sectors in some cases generated considerable discussion in the constitutional debates but electricity was passed as a concurrent subject without any dissenting opinion (Constituent Assembly 1949).

> [Jawaharlal Nehru stated] The severe limitation on the scope of central authority in the Cabinet mission's plan was a compromise accepted by the Assembly much, we think, against its judgment of the administrative needs of the country, in order to accommodate the Muslim League. Now that partition is a settled fact, we are unanimously of the view that it would be injurious to the interests of the country to provide for a weak central authority that would be incapable of ensuring peace, of coordinating vital matters of common concern and of speaking effectively for the whole country in the international sphere. At the same time, we are quite clear in our minds that there are many matters in which authority must lie solely with the Units and that to frame a constitution on the basis of a unitary State would be a retrograde step, both politically and administratively. We have accordingly come to the conclusion - a conclusion which was also reached by the Union Constitution Committee - that the soundest framework for our constitution is a federation, with a strong Centre (Constituent Assembly 1947: 20-Aug-1947).

4.2.2.1 Political structure

The country is characterised by fourteen linguistic groups, a large Muslim religious minority and a hierarchical social structure made up of over three thousand caste groupings (Frankel 2005). The political structure developed by the independence movement was fundamentally influenced by the need to reflect the demands of these competing constituencies.

The Indian National Congress has been the dominant force in Indian politics from independence until the mid 1990s. The INC formed the government almost continually up to 1996[33]. However, the nature of the ruling coalition has evolved over time. As a unified opposition to English rule, the INC was inevitably initially made up of many internal political constituencies in the regions that held different philosophical positions on development strategy. Balancing internal politics became a key feature of the INC both before and after independence (Frankel 2005). Sinha articulated this effectively:

[33] With brief interludes of government by the Janata party – that evolved into the current BJP party - in 1977-1980 and 1989-1991.

The state development strategy created political patronage so that the regional party units could be incorporated in the national winning coalition. The Congress party, organised regionally, encouraged the regional leaders to make claims on the central public sector (Sinha 2005).

Since the 1990s, there has been movement towards the election of regionally focused parties – that have in turn formed themselves into two coalition structures – the national democratic alliance headed by the INC and the united progressive alliance headed by the BJP. As of June 2007, there were 38 separate parties represented in the Indian national government (Government of India, undated).

Therefore, both in the INC dominated era and the subsequent two-party coalition period, there has been a political imperative for leaders at the centre to win the favour of local politicians in the regions of India. This has ensured a continuing base of power resting with locally elected politicians and a necessity for central government to reward local supporters. The electricity industry with its massive investment requirements provided a suitable vehicle for channeling financial resources and political power to state-level elites[34].

4.2.2.2 Electricity legislation

A sizeable body of legislation and regulation has built up to manage the evolving electricity industry. Legislation reflects the prevailing political situation but the lack of strength and clarity of legislation has reinforced the potential for states to demonstrate considerable differences in their approach to electricity system development and also created weakness in central governance that has been challenging to rectify. The Electricity Act 1910 was the first thorough piece of

[34] Evidence of the value of state electricity systems to state governments is discussed in the context of the legislation supporting the introduction of state electricity boards below.

legislation covering the industry, primarily focused on the obligations of electricity supply companies to ensure the safety of customers. The Electricity (Supply) Act 1948 had broader objectives:

Statement of objects and reasons. - The coordinated development of electricity in India on a regional basis is a matter of increasingly urgent importance for post-war reconstruction and development….It has, therefore, become necessary that the appropriate governments should be vested with the necessary legislative powers to link together under one control electrical development in contiguous areas by the establishment of what is generally known as the 'grid system' (Gopal and Mehrotra 2000: 453).

The 1948 Act goes on to state that two considerations indicate the necessity for central legislation:

i) the need for uniformity in the organisation and development of the 'grid system'
ii) the necessity for the constitution of semi-autonomous bodies like Electricity Boards to administer the 'grid system' (Gopal and Mehrotra 2000: 454).

The Electricity (Supply) Act 1948 therefore placed primary responsibility for electricity system development with new state level agencies implemented under the Act – the state electricity boards (SEBs). The phrase 'semi-autonomous' in the extract from the Act preamble is telling. Kale notes that the level of autonomy from state control of the new SEBs was contested within the states, with some states (e.g. Mysore and Madras – now Karnataka and Tamil Nadu) resisting the call for independent SEBs. These states already owned and managed their states' electricity systems and benefited from the control over resources this entailed (Kale 2007)[35]. Kale also cites constitutional debate discussion arguing for autonomous SEBs:

[35] The most vocal dissent came from the Madras Presidency (now Tamil Nadu) that had already put 90% of its electricity system under state government ownership. The primary concern was that the profits from the industry would be taxed by the centre – resulting in a large funds transfer away from the state – "[Shri Ananthasayanan Ayyangar] it is from electricity that the slender resources of the Madras government are being supplemented". Attempts were made by the Madras representatives – primarily Shri Ananthasayanan Ayyangar - to exclude the profits from SEB operation from central taxation – but these failed. (Constituent Assembly 1948a).

[Shri K. Santhanam, Madras Presidency] What are the British Government doing?...Then again even in America when they wanted to start a national undertaking they established a Tennessee Valley Authority. These democratic governments knew what nationalization meant; they knew that these industrial undertakings should not be left to the vagaries of ministerial change…Ministers may change, and changing Ministers may have changing policies; but the day to day administration of industrial undertakings should be continuous and should not be disturbed by political considerations (Constituent Assembly 1948a: p50).

To seek a compromise between these differing perspectives the 1948 Act was weakly enforced by the timing of the creation of SEBs.

The remaining provisions of this Act [setting up the SEBs] shall come into force in a State on such date, not later than two years from the coming into force of the sections, schedule and table mentioned in sub-section (3) as the state government may, by notification in the official gazette appoint:

Provided that the central government *may as respects any state extend the said period of two years* and in such event the remaining provisions of the Act shall come into force in that state on such date… (Gopal and Mehrotra 2000: 454). (Italics added).

Thus, those states that chose to do so could substantially delay the creation of an SEB – and indeed did so. Karnataka and Tamil Nadu did not create an SEB until 1957.

The preamble to the 1948 Act went on to recognise that the 1910 Act did not provide a sufficiently robust framework for developing these new institutions and therefore proposed the new legislation along the lines of the Electricity (Supply) Act 1926 introduced in the UK. On closer inspection, the comparison with the 1926 UK legislation is not robust[36]. A principle component of the UK's 1926 Act was the creation of the Central Electricity Board. The CEB, however, did not take ownership of UK generation – this was not to occur until nationalisation in 1948. In contrast, the

[36] This is despite being commonly referred to in the literature and explicitly stated in the introduction of the 1948 Act by N. V. Gadgil in the constituent assembly debates (Constituent Assembly 1948a).

creation of the SEBs in India supported the public ownership of generation[37]. The 1948 Indian Act therefore created a more vertically integrated industry model with SEBs ultimately gaining responsibility for most generation, transmission and distribution within their states. The 1926 UK Act supported a highly fragmented generation and distribution sector with centralised transmission and load dispatch. Further, the UK's CEB control area was national and the size of market that it controlled (5,817 GWh in 1926, (Hannah 1979) was not equaled by any Indian state until Maharashtra reached this consumption level in 1969. Copying elements of UK national policy and implementing them at the state level in India without consideration of the technological, institutional and market size differences between the two contexts created a degree of incoherence in the 1948 Act with respect to spatial scale that has been a source of recurring trouble in the Indian industry.

The Act did provide for a further nodal agency at the national level – the Central Electricity Authority to (amongst other things):

i) develop a sound, adequate and uniform national power policy in relation to the control and utilisation of national power resources;
ii) act as arbitrators in matters arising between the State Government or the Board and a licensee or other person as provided in this Act (Gopal and Mehrotra 2000: 472).

However, the overall responsibilities of the CEA were trivial relative to the UK's CEB – specifically, the CEA had no responsibilities for transmission or load dispatch, nor did any other national level entities at this time. The CEB was successful in both prioritising generation from the most efficient generators (having no conflict of interest from owning its own generators) and substantially reducing the reserve

[37] There was no compulsion to bring private generation under public control but practically all private operators eventually reverted to the SEBs. Five private sector operators continue to hold grandfathered rights from prior to the 1948 Act.

requirements through load balancing across the grid. These potential efficiency improvements, irrespective of technical feasibility (discussed below) were inhibited in India by the institutional structure defined under the 1948 Act. Only one representative from the constituent assembly debates (Prof. Shibban Lal Saxena representing the United Provinces – now largely Uttar Pradesh) recognised the weakness of the CEA structure and argued for much stronger central control of the electricity sector:

I have carefully analysed the bill and I find that the central authority is not clothed with any real powers…I think this is a fatal defect in the bill. If we want to develop electricity all over the country according to a comprehensive national plan, it can only be done by central initiative…I tried to compare the powers of the central authority here with those in England also. The central authority, I find, is much more powerful there and it is the authority which is the moving power and which can make the regional board function[38] (Constituent Assembly 1948a: p56).

Saxena's amendments, however, were not carried and the CEA was created with powers only to plan and recommend. The rejection of strong central control was driven by two factors:

- the desire by most states to have control over their own destiny (Kale 2007);
- the belief that the technical maturity (i.e. scope of transmission network) and economic scale of the Indian electricity sector was not sufficient to require coordinated investment at the national level.

The second factor is evidenced by comments by the Minister for Works, Mines and Power, N. V. Gadgil, who, in presenting the electricity bill for discussion, had immediately ruled out the potential for a national grid:

[38] The reference to England is in respect to the new Central Electricity Generating Board created in 1948 rather than the earlier Central Electricity Board created under the 1926 Electricity (Supply) Act on which the 1948 Indian Act was modeled.

> It will be realised that distances in India obviously rule out the possibility of a nation-wide grid system, such as is already in existence in many small countries abroad (Constituent Assembly 1948a).

This was undoubtedly true for a country the size of India in the late 1940s – taken in the context of the entire country. However, a problem had been created by taking the UK's 1926 legislation as a model but applying it to a federated structure on a different scale and level of electricity system maturity. The reliance on state-level electricity system management with a weak central control function largely eliminated all opportunities for even regional cooperation in the development of India's electricity system[39]. The political need to devolve responsibility (and financial resources to the states) together with the constitutional power ceded to the states, has therefore created an on-going challenge to the centre's ability to influence the implementation of electricity system development in the individual states and successfully improve the quality of the system across the country. This was, of course, recognised by policymakers and planners undertook a variety of approaches to ameliorate the structural problem.

4.2.3 Planners' recognition of regional difference

The political imperative to devolve responsibility for electricity implementation to the states required the acknowledgement of another challenge: the distinct unevenness in the level of development across India. The planning process was the primary mechanism for undertaking economic and social development and it dominated the development of the electricity system in the first decades following independence.

[39] An exception was the Damodar Valley Corporation Act 1948. This was modeled on the Tennessee Valley Authority in the USA. It gave central government powers for the development of the Damodar Valley in Bihar and West Bengal to harness the hydroelectric potential of the Damodar River and the coal reserves of the region.

However, immediately following independence, overall national development was considered the imperative. Electricity investment followed broader industrial development opportunities. Therefore, a policy of matching investments in electricity generation, transmission and distribution with projected growth in demand was adopted as described in the first five-year plan:

The development of power generating capacity should be coordinated with the development of load. If the lag between power generation and load building is long, interest charges on capital mount up and make the undertaking uneconomic. Load planning for any large power system is integrally related to the industrial and economic planning of the regions within a reasonable distance of the generating station. (Planning Commission, Government of India 1951a: Sec 70).

Two messages stand out in this statement:

- Generation is to be developed to support economic activity;
- It is not considered feasible to transmit electricity long distances.

This policy, however, explicitly did nothing to reduce unevenness in development. The role of the central financial flows in mitigating regional differences was eventually reinforced by the Industrial Policy Resolution of 1956:

In order that industrialisation may benefit the economy of the country as a whole, it is important that disparities in levels of development between different regions should be progressively reduced. The lack of industries in different parts of the country is very often determined by factors such as the availability of the necessary raw materials in certain areas has also been due to the ready availability of power, water supply and transport facilities which has been developed there. It is one of the aims of national planning to ensure that these facilities are steadily made available to areas which are at present lagging behind industrially or where there is greater need for providing opportunities for employment provided the location is otherwise suitable. Only by securing a balanced and coordinated development, of the industrial and the agricultural economy in each region, can the entire country attain higher standards or living. (Government of India, Ministry of Industry, 1956: Sec 15).

This statement is a clear departure from the strategy laid out in the 1st plan only 6 years previously. How did the strategy change over this short period? At the 1st

meeting of the National Development Council in 1952, emphasis was still being argued for the development of industry in resource rich states for the national benefit:

> The Chief Minister, Orissa, Shri Nabakrushna Chaudhri observed that from the national point of view States like Madhya Pradesh, Orissa, Assam, and others having natural resources and scope for industrial development should be the concern of the whole country (Planning Commission, Government of India 2005a: 4).

At the 3rd NDC meeting in 1954, Nehru echoed the same thought process whilst discussing the need for geological surveys in the country:

> Now you start industrialising, you have to decide where to put a steel factory or something else or a fertilizer factory or some chemical factory. Now unless you know fully what the resources of the various parts of the country are you may very well put that factory in the wrong place and repent for it later (Planning Commission, Government of India 2005a: 26).

However, by January 1956, at the 6th NDC meeting the narrative had evolved. The shift was based in the increased political pressure to demonstrate inter-regional equality and the acceptance by the leadership of the need for rapid industrialisation[40] - requiring industrialisation to be dislocated from the location of natural resources[41]. Confidence in the possibility of delivering these two competing objectives was provided by Professor Mahalanobis, chief statistician at the planning commission and instigator of the technocratic approach recommended for plan development:

> Dealing with the question of regional disparities in the geographical sense, Prof. Mahalanobis observed that regional disparities could be measured in a rough way by per capita expenditure. The difference was of the order of 40 per cent between the south and northwest. This disparity could not be removed by a system of doles; the only way was to increase production capacity and actual production in the different areas. This in turn meant that a great deal more thought would have to be given regarding the utilisation of the available resources (Planning Commission, Government of India 2005a: 112).

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[40] The INC was, at this time, still endeavoring to establish a strong national basis for its political power. It had, for instance, a historically weak influence in the former princely states and had to find mechanisms to bring and keep local politicians inside the INC (Frankel 2005).

[41] Generating employment opportunities was a key driver in the second plan. To achieve this, industrial development beyond the usual major cities was recognized as a necessity (Zaidi and Zaidi 1979) p138.

Thus from the second plan, the need to deliver balanced development across the country became part of the planning process. Initial endowments in terms of resources or pre-existing economic activity would no longer be sufficient rationale for incremental electricity infrastructure investment. The role of planners in tempering the effects of resource and economic activity distribution are discussed in more detail below but first the channels through which institutions and physical and economic geography have influenced the Indian electricity system are explored in more detail.

4.3 Institutions and resources impact state-led implementation

4.3.1 Colonial governance structure and institutional capacity

As discussed above with reference to the Indian planners, once the decision was taken to place implementation responsibility for electricity sector development with the states, the capacities of those states to succeed in this task became relevant. The style of government adopted by the British in India may have influenced state electricity sector development. Not only did the British colonial presence influence the form and structure of Indian politics (in the shape of the Indian National Congress) but it is argued that the style of governance selected by the British in different parts of India has had a persistent effect on the institutional strength of Indian states (Banerjee and Iyer 2005, Banerjee et al. 2005, Iyer 2005). The British government adopted two different approaches to ruling their Indian colonies – direct rule or rule through native or princely states. Iyer (2005) provides a detailed examination of the two approaches to government giving consideration to the reasons why the British may have considered one form of government over another (for example, did the British cherry pick the richest regions for direct rule). Following Iyer's work, it is argued that direct British rule resulted in the development of weaker institutional structures that are observable today in poorer delivery of public goods – specifically electricity - in those regions. This assertion is tested in chapter 5.

4.3.2 Resource distribution

4.3.2.1 Coal

Coal or large hydro plants comprise the bulk of electricity generating capacity. Coal is particularly relied upon for electricity generation in the north and east (figure 4.1) – West Bengal, Jharkhand, Chhattisgarh and Bihar. Coal is of greatest value to the economies of the states in the north and east of the country – notably Jharkhand, Chhattisgarh and Madhya Pradesh (figure 4.2). However, as figure 4.1 illustrates, it is striking that coal is of considerable importance for electricity generation throughout India with only the hilly states in the north relying on coal for less than 20% of their generating capacity [42]. A statistical examination of the data shows a strongly significant correlation between the value of coal to a state economy and its use of coal for electricity generation (table 4.1).

[42] Due both to the easier availability of hydropower and practical difficulties and cost of transporting coal by rail to hilly, landlocked areas.

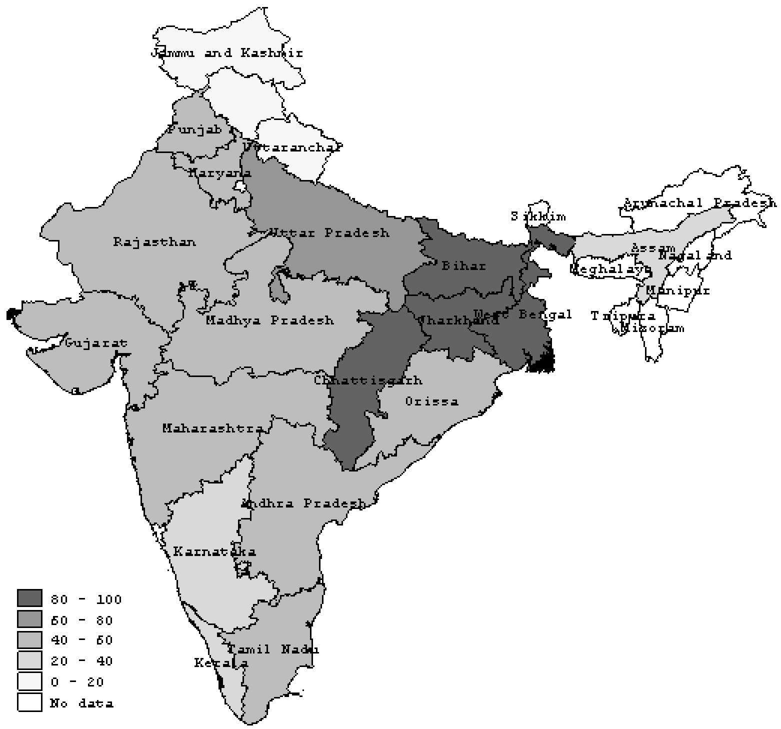

Figure 4.1: Percentage of state generating capacity using coal, 31-Oct-2007
Source: Central Electricity Authority 2007

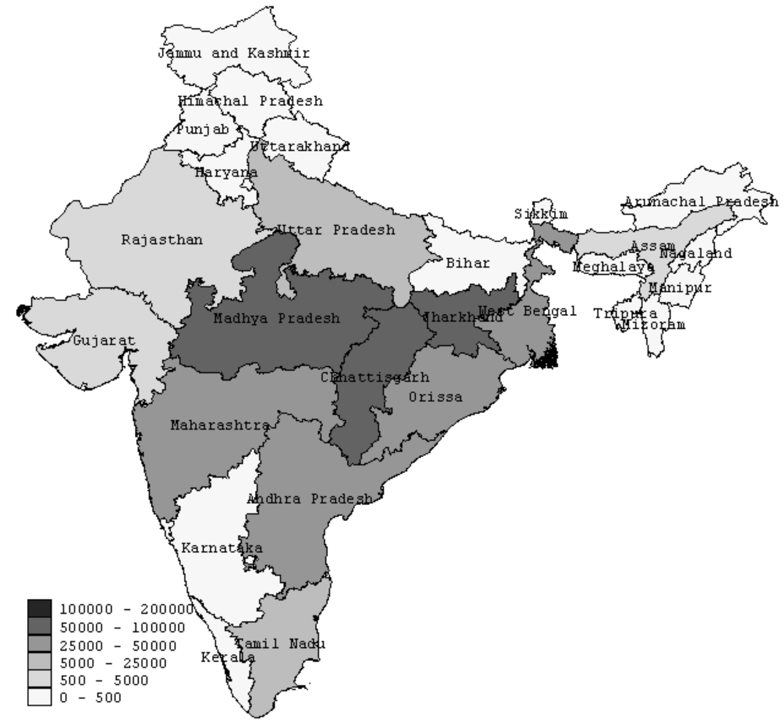

Figure 4.2: Value of coal mining (Rs. Million), 2005–2006
Source: Central Statistics Organization 2008

Table 4.1: Regression results for value_of_coal and coal_%

Source	SS	df	MS
Model	4555.25754	1	4555.25754
Residual	9413.8539	18	522.991884
Total	13969.1114	19	735.216392

Number of obs	20
F(1, 18)	8.71
Prob > F	0.0085
R-squared	**0.3261**
Adj R-squared	0.2887
Root MSE	22.869

coal_%	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
value_of_coal	.0005358	.0001816	2.95	**0.009**	.0001544	.0009173
_cons	37.84811	6.456282	5.86	0.000	24.28396	51.41225

Source: (Central Statistics Organization 2008), (Central Electricity Authority 2007)

The value of coal to a state economy and the percentage of coal in electricity generation are highly correlated (p value = 0.009). However, the R-squared result of 0.3261 shows that only 32.6% of the variation in the percentage of coal in electricity generation is explained by the value of coal in the economy[43]. Unsurprisingly, other factors are also influential.

The relationship between coal reserves and the use of coal for generation is complex. Firstly, although India is well endowed with coal, the majority of reserves are of poor non-coking quality. At the time of the first five-year plan in the early 1950s there were estimated to be 20,000 million tonnes of coal in India but only 5,000 million tonnes of that were high quality coking coals (Planning Commission, Government of India 1951b). The planning commission reserved the use of high quality coal grades for the production of iron and steel. The concentration of coal reserves in the east of the country meant thermal power stations in distant states had to transport fuel considerable distances by rail. Freight charges became a major component of fuel cost. This encouraged thermal power

[43] This correlation becomes even tighter and explains up to 50% of the variation if Bihar is excluded from the analysis. Prior to 2001, Bihar was a coal rich state and arguably has an economy constructed around this fact. However, with the creation of Jharkhand in 2001 all of Bihar's coalfields were lost to the new state.

station operators to procure the highest-grade coal possible (reducing freight charges per unit of energy) – in contradiction of the planning commission's objectives. Therefore, in 1956, the locational advantages of the coal owning states in the east of the country were neutralised by the introduction of the freight equalisation policy whereby central government subsidy eliminated the additional cost of delivering coal to distant parts of the country[44].

The immaturity of transmission technology (and its deployment in India – discussed at length in section 4.4.2 below) meant that long distance transmission of electricity from pithead located thermal plants was not feasible until the 1970s. Therefore, there was acceptance of the need to transport coal to thermal generating plants close to load centres (high-demand locations) – in the west and south of the country. Once the thermal plants were built close to load centres, the cost of transporting coal was locked in and resistant to the elimination of the freight equalisation subsidies in the 1990s. As late as 2007, coal accounted for over 43% of rail commodity transportation (by weight) (Indiastat 2008b). Freight charges still comprise a major part of the landed cost of coal for generating stations. Planning Commission research demonstrates that the freight component of power grade coal travelling 750 km from coalfield to generating station increased from 44% to 58% between 1981 and 2000 (Rao 2003).

[44] The scale of this subsidy that primarily benefited the west and south of the country can be seen in contemporary coal freight rates ranging from 103.8 Rs / tonne for 100km delivery to 1096.1 Rs. / tonne for 1500km delivery (Rao 2003).

India is also relatively well endowed with lignite and, importantly its distribution is different to the distribution of coal. Lignite is primarily found in Tamil Nadu, Gujarat and Rajasthan. India's lignite reserves have a heat rating similar to the lowest coal grades (F and G) – having a moisture content of as much as 50% (Rao 2003). The low energy value per unit weight has ensured that pithead location of generators is required. The Neyveli Lignite operation in Tamil Nadu was India's first true pithead generating plant and was opened in 1962 (Neyveli Lignite 2004).

It is clear that local availability of coal encourages its use for electricity generation within a state. However, the over-riding importance of coal for electricity generation in India – coupled with the constraining lack of long distance transmission technologies resulted in a need for development of coal-fired generating stations across India and the exploitation of energy-poor lignite where possible. Implementation of the freight equalisation policy moved the cost of transporting coal across India from the state generators to central government and locked in reliance on coal across much of India.

4.3.2.2 Hydropower

Hydropower potential is broadly but not evenly distributed across India. There are six primary river basin systems:

- The Indus, Ganga and Brahmaputra in northern India
- The central Indian river system
- The East flowing peninsula rivers
- The west flowing peninsula rivers

The Indus, Ganga and Brahmaputra are all primarily fed from the Himalaya and include extensive snow-based storage of water. The others are primarily monsoon fed. This impacts the flow characteristics and hydro potential of the systems. The northern basins have much more regular flow with monsoon rains being enhanced by snowmelt. As figure 4.3 illustrates, the other basins can see marked changes in river flow through the year and therefore require considerable reservoir capacity or recognition that hydro electricity output will vary considerably through the year.

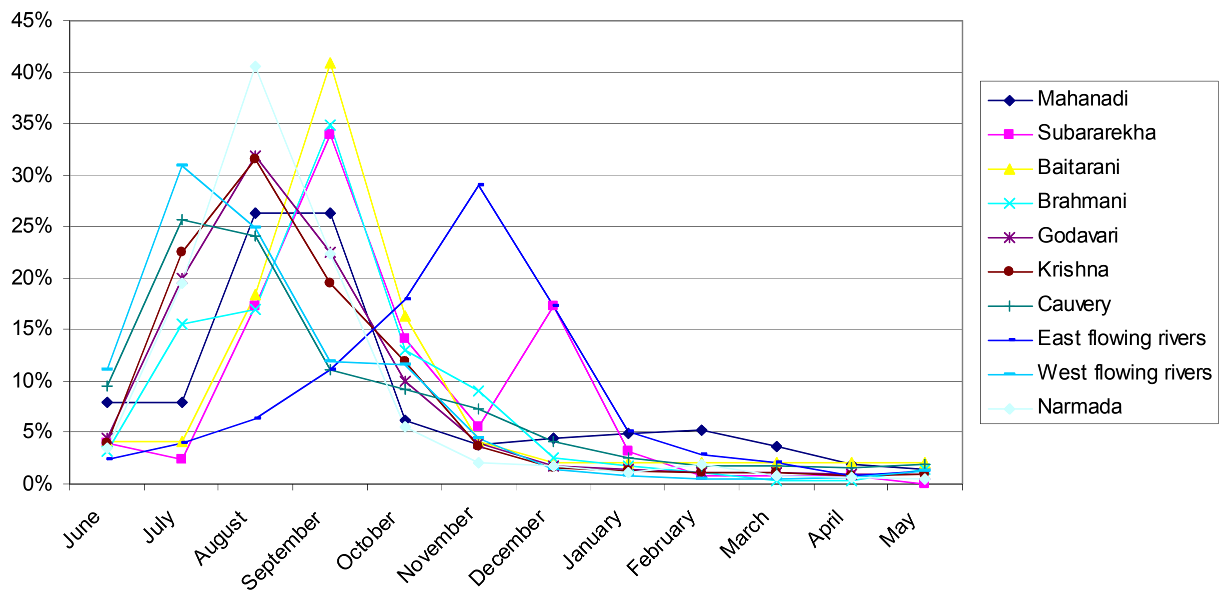

Figure 4.3: Seasonal flow characteristics of select rivers
Source: Central Water Commission 2006

On hydrological characteristics alone, the Himalayan rivers appear the most attractive for hydro development but in fact, the rivers in the central plains and the west and eastern coasts in the south of the country were developed more rapidly.

Unlike coal where rail freight is feasible, it is not physically possible to ship hydropower closer to load centres prior to transforming that energy into electricity. This has meant that hydropower investment has been constrained by availability of demand and development and implementation of transmission technology[45]. Remoteness has therefore inhibited hydropower development in the hilly and sparsely populated northern states. It has taken two developments to drive increased exploitation of the hydro potential of the Himalaya:

– The creation of a centrally owned and managed operator – the national hydropower corporation (NHPC) that has been able to invest in technically complex projects for the benefit of several states.
– Improvements in transmission technology and its use in India to evacuate electricity from the hilly north to distant load centres.

Figure 4.4 presents the percentage of potential hydropower capacity that has already been installed. The heavy exploitation in the northern plains and the west is clearly visible as is the success Tamil Nadu has achieved in exploiting its potential. Of particular importance is the observed untapped potential of the Himalaya in the north (and to a lesser extent in the south). The Himalayan states do have considerably more hydro potential than other states but despite this, there is considerable under-performance compared to states in more favourable locations (notably Madhya Pradesh, Maharashtra and Karnataka).

[45] This is illustrated by the boost given to hydropower in Scotland in the 1930s from the introduction of the UK national grid (Hannah 1979).

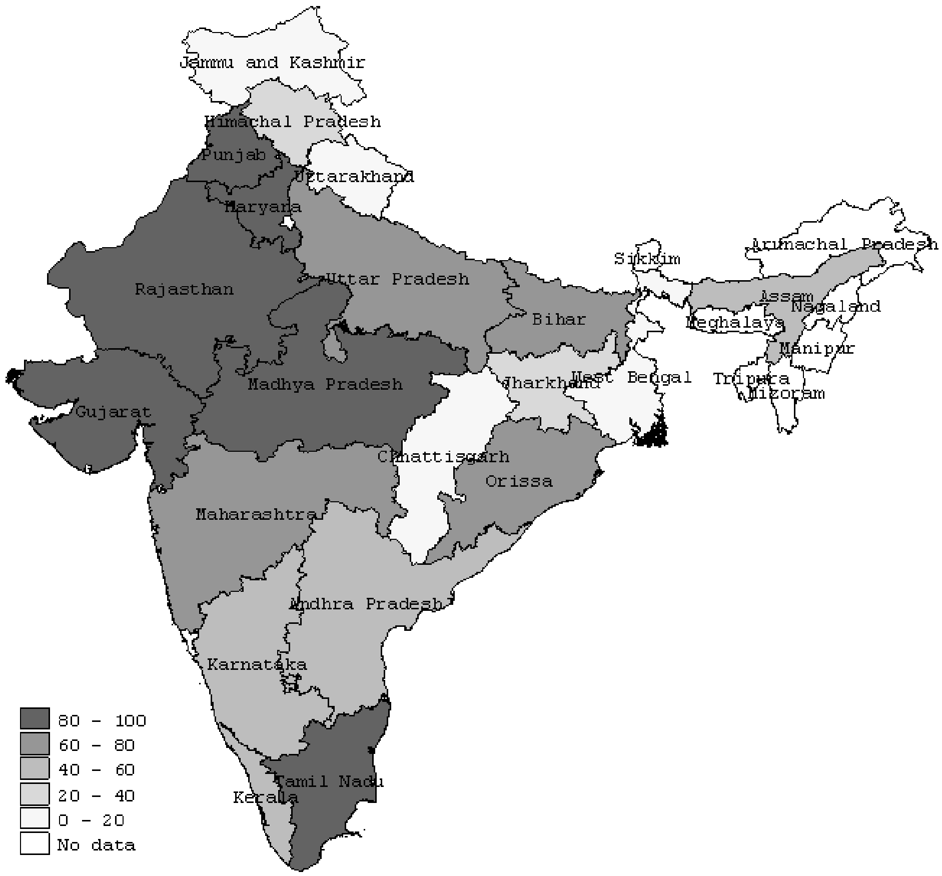

Figure 4.4: Hydropower implemented as percentage of potential, 15-Nov-2007
Source: Indiastat 2007

Each hydropower plant has its own cost profile. Table 4.2 provides cost of generation data for those states that provide cost breakdowns by generating plant[46]. The two lowest cost states for hydro generation are Himachal Pradesh and Uttarakhand – two of the three hilly states in the north (Jammu & Kashmir, the third hilly state had no reported facilities meeting the criteria for selection).

[46] State managed assets only included here. NHPC, DVC and other centrally owned generators are excluded, as are private providers.

Table 4.2: Average cost of hydro generation for selected states, 2005 - 2006

	Average cost of generation (Rs. / KWh) (Rs.1 = £0.13)
Chhattisgarh	0.502
Gujarat	0.515
Haryana	0.999
Himachal Pradesh	0.35
Karnataka	0.689
Madhya Pradesh	0.493
Maharashtra	0.945
Orissa	0.414
Punjab	0.786
Rajasthan	0.865
Tamil Nadu	0.617
Uttar Pradesh	0.405
Uttarakhand	0.305
West Bengal	0.894

Source: Central Electricity Authority 2008b
NB: Includes facilities greater than 25MW regardless of age. Significant outlier generating plants with greater than Rs.4 / KWh excluded (one each from Himachal Pradesh, Tamil Nadu and West Bengal)

The favourable run-off characteristics of the snow fed rivers in the north can be seen to lead to cost of power advantages (as well as other benefits such as reduced generation fluctuation that can be amplified by variation in monsoon rainfall in the south).

The slow take up of the hydro potential in the north appears to be a lost opportunity that reflects a slow pickup of long distance transmission technology. It also reflects the decision to allow states to manage their own system development. Although examples exist of states entering into partnership agreements to build generating capacity in other states, it has only been since the creation of the National Hydropower Corporation

(NHPC) in the 1970s that the potential in the north has begun to be exploited to the benefit of many states[47].

4.3.3 How planners responded to uneven regional development

The Indian constitution has an inherent imbalance that has caused friction in planning and development since independence. The centre owns the primary right of revenue raising (through taxation, duties and other means) whereas the states have primary implementation responsibility across broad swathes of the economy – including electricity. This separation of responsibilities has created an opportunity for political haggling over the disbursal of centrally gathered taxation revenues. Two primary mechanisms exist for distributing the taxation revenue. Development spend (largely capital spend) is primarily channeled through the planning system and managed by the planning commission[48]. Revenue expenditure is controlled by the finance commission. The states have been heavily dependent on central government plan transfers to fund state electricity sector investment.

Financial flows managed by the planning commission have been large in every period since independence and the contribution of planning finance directed towards the electricity sector has been a large component of the whole. The opportunity for using

[47] For example, the 840 MW Chamera complex in Himachal Pradesh provide electricity for Himachal Pradesh, Haryana, Delhi, Jammu & Kashmir, Chandigarh, Rajasthan, Utter Pradesh and Uttarakhand.

[48] Standard plan support for development comprises of 30% grant finance and 70% loan finance – unless the state is classified as a special category state (such as Jammu & Kashmir, Himachal Pradesh and the states in the north east). The split is designed to recognize the split between revenue expenditure that is covered by grant and capital expenditure that is covered by loans as it is expected to attract a return that can service the loan. However, states have increasingly used plan spend for revenue purposes – with the actual revenue element approaching 50%. This has put pressure on state finances as loan liabilities to the centre have increased without a commensurate increase in productive assets within the states (Saxena 2005).

these investments to mitigate regional development unevenness was considerable. However, the opportunities for lobbying by the states and conferring patronage by the centre have also been readily apparent.

The Gadgil formula was introduced in the 4th five-year plan, aiming to reduce the subjectivity of plan transfers and therefore reduce the impact of political maneuvering between the centre and the states regarding plan allocations. Introduction of the formula affected the relative plan transfers for a number of states.

Table 4.3 details the ranking of per capita plan flows targeted on electricity, funded by central government and distributed to the states. The table presents data for the period from 1961, when most of the state reorganisation had occurred, until 1997, the last plan before liberalisation activities began to take effect. A number of the states that on average ranked lowest in per capita electricity investment initially, remain those states with poor electricity systems today – Bihar, Assam and West Bengal.

Table 4.3: 2nd to 8th plan rank of per capita investment in electricity system

	Ad hoc allocation		Gadgil formula		Revised Gadgil formula		2nd revised Gadgil formula	
	Rank of per capita electricity investment							
	2nd plan	3rd plan	4th plan	5th plan	6th plan	7th plan	8th plan	Average rank
	1961	1966	1974	1979	1985	1990	1997	
Andhra Pradesh	12	11	11	7	13	15	14	12
Assam	15	7	15	15	8	11	12	12
Bihar	13	13	14	16	15	17	17	15
Gujarat		9	7	6	5	7	9	7
Haryana			3	2	2	2	3	2
Himachal Pradesh	9	16	5	8	4	3	4	7
Jammu & Kashmir	1	4	2	5	7	8	1	4
Karnataka	8	3	13	11	11	14	7	10
Kerala	5	5	9	17	14	16	16	12
Madhya Pradesh	11	8	16	4	6	4	8	8
Maharashtra	6	10	4	3	3	5	10	6
Orissa	4	6	12	12	17	9	5	9
Punjab	2	1	1	1	1	1	2	1
Rajasthan	7	12	10	14	9	12	6	10
Tamil Nadu	3	2	8	13	16	6	11	8
Uttar Pradesh	10	14	6	9	10	10	13	10
West Bengal	14	15	17	10	12	13	15	14

Source: Planning Commission various years

Plan rhetoric would suggest that higher capital flows would increasingly have been seen moving to these states. This did not occur. In terms of electricity spend, Himachal Pradesh, Maharashtra and Uttar Pradesh were unambiguously better off through the introduction of the Gadgil formula. Karnataka, Orissa and Tamil Nadu lost out.

Political lobbying inevitably moved towards the influencing of the Gadgil formula itself through debate at the national development councils and two reviews of the formula have been undertaken since its inception in the 4th plan. The details of the components of the formula and its revision are presented in table 4.4.

Table 4.4: Breakdown of Gadgil formula

	Original formula	1st revision	2nd revision	Notes
Population	60	60	55	
Per capita income	10	20	25	
Ongoing irrigation and power projects	10			
Tax effort	10	10		Plan disbursements related to states own revenue generation
Fiscal management			5	States success in mobilising funds relative to targets set
Special problems	10	10	15	Drought, flood, sparse population, urban slums etc

Source: Ramalingom and Kurup 1991

The Gadgil formula acted at the macro level and there was no formulaic approach for targeting plan investment at individual development items. Those states with particularly poorly performing electricity sectors were therefore, after the first revision from the sixth plan onward, dependent on a pleading of special need to extract additional funding (after carry over electricity projects were excluded from the formula). Attempts were made to include a measure of infrastructure weakness in the 2nd revision of the formula – but the lobbying by Shri Bindeshwari Dube, the chief minister of Bihar failed:

> He suggested that the weightage of 10 per cent for tax efforts and 10 per cent for special problems could be given up and, instead, the funds distributed on the basis of infrastructure backwardness (National Development Council 1985: 89).

The Gadgil formula withdrew much of the latitude the centre had at its disposal to skew investment towards particular states and provided no mechanism following its revision to direct investment specifically at areas with weak infrastructure – severely limiting its capability to reduce unevenness in electricity system development[49]. The lack of balance in the revised Gadgil formula is supported by evidence from state representations at the 42nd to 44th NDC meetings in 1990 / 1991. Representatives of the poorer states (notably Bihar, Orissa, Madhya Pradesh and West Bengal) argued for the need for further adjustment of the formula and the richer states (notably Punjab, Gujarat, Maharashtra and Tamil Nadu) argued for retaining the status quo (Planning Commission, Government of India 2005c).

4.3.4 The ambiguity of concurrent status

As discussed above, electricity generation was given concurrent status in India's constitution. This ambiguity has created further challenge for implementing consistent policy across the country, but has also given the national government the opportunity to attempt to address issues perceived within individual states.

As discussed, the 1948 Electricity (Supply) Act positioned the state electricity boards as the primary implementation bodies within the electricity sector. The structure of the planning system as laid out in the 1956 Industrial Policy Resolution resulted in the centre having a responsibility for strategy and funding development projects, but the states were responsible for implementation and by the 1970s this was proving to be ineffective. By 1974-75, the SEBs were on average only recovering 83.4% of their costs (Kannan and

[49] In many sectors, the centre has attempted to circumvent these restrictions through the creation of centrally sponsored schemes (CSS) that channel funds without the formulaic restrictions of primary plan transfers. Most CSS focus on social development goals. In the electricity sector, the APDRP programme (Accelerated Power Development and Reform Programme), run by the Ministry of Power, investing in state level distribution systems is an example of this approach to regaining control over the direction of centre-state transfers to solve specific issues.

Pillai 2002)[50] and were reliant on subsidy from general state budgets to operate. In the 1960s the centre had begun to engage in the generation sector with the development of the nuclear power programme – the first nuclear power station opened at Tharapur in Maharashtra in 1969. By the early 1970s, there were increasing calls for increased central generation at the NDC meetings:

He [Shri Bansi Lal, Chief Minister, Haryana] referred to the shortage of power which was having an adverse effect on industry and agriculture in the Punjab and Haryana. In view of the difficulty which was being faced, the Central Government should have some big projects by which power could be supplied to Punjab, Haryana, Rajasthan, Uttar Pradesh and other States (National Development Council 1973: 120).

Technology innovation increased the need and opportunity for central engagement in generation. The emergence of nuclear power is one example. As discussed in section 4.4 below, improvements in the exploitation of long distance transmission technologies and the greater confidence in building large generating units were important drivers. Exploitation of these innovations opened up the potential for both tapping Himalayan hydro potential for the benefit of many states and the creation of large thermal generating stations in pithead locations for multi-state benefit. As stated by Shri Kamlapathy Tripathi, Chief Minister, Uttar Pradesh:

There was tremendous scope for harnessing perennial Himalayan rivers to generate power and there were several focal points where thermal power could be generated and transmitted to benefit a group of States. The Chief Minister stressed that unless spatial distribution of Plan outlays was deliberately tilted in favour of the comparatively backward areas, the regional disparities would not be reduced (Planning Commission, Government of India 2005b: 132).

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[50] Cost recovery declined to as little as 75.3% in 1990-91. This is compared with the target set of 3% net profit recommended by the Venkataraman Committee (Kannan and Pillai 2002).

The centre determined to re-assert control over development by empowering itself to develop electricity generating capacity (primarily through two public sector undertakings the national thermal power corporation and the national hydropower corporation). Ostensibly, the argument for increased central involvement was the potential for tapping nuclear power and developing large hydro resources for the benefit of multiple states and the exploitation of coal reserves through large pithead thermal plants as stated in the 6th five-year plan document:

> Power development has become increasingly capital intensive and the construction of big hydro power projects or large pithead thermal power stations involves investments of an order which is beyond the capacity of individual States. With increasing capital intensity, it has become more important than before that the country should derive optimal benefit by the integrated operation of power stations, which confer the dual benefit of minimising costs and improving system reliability (Planning Commission, Government of India 1981b: Sec 15.37).

It is evident that the NTPC has indeed been primarily focused on delivering large pithead generating stations. With the exception of the Badarpur plant in Delhi (which was a plant built in the state sector in the 1970s and subsequently handed over to the NTPC), all NTPC coal-fired generating plants are in coal-producing areas. In addition, unit capacity is less than 200MW or more in only 14% of NTPC generating units, i.e. most NTPC units are relatively large.

The 1980 report of the committee on power (the Rajadhyaksha Committee) was able to be more strident in its view – not having to reach agreement with each of the states through a body such as the NDC - and suggested that concern over the capture of the state electricity boards by state governments has resulted in poor financial and technical performance:

> The weaknesses in the management of the utilities, in particular the SEBs,…arise partly out of the desire of some State Governments to exert a high degree of day to day control on the operations of the Boards, and partly due to management culture, inherited from the bureaucratic style of functioning, that most SEBs had when they were government departments. Report of the (Rajadhyaksha) Committee on Power quoted in (Kannan and Pillai 2002: 305).

The report argued that the majority of new capacity should be built by central government undertakings and that an ultimate goal of 45% central share was envisaged to ensure technical and financial efficiency (Planning Commission, Government of India 1981a).

Certainly, statistics on the level of financial and technical inefficiency of the SEBs bear out this assessment. The Rajadhyaksha report notes that there were, on average 7 employees per MW of installed capacity in India at the time of the report in 1980. This compared unfavourably with a value of 1.2 in the USA, 1.5 in Japan and 1.7 in the UK (Kannan and Pillai 2002). The plant load factor of thermal generating stations was 56% in 1976-77 and had declined to 45% by 1979-80 (Planning Commission, Government of India 1981a). Figure 4.5 charts the variation in PLF of thermal electricity generators for a selection of states and three central government owned generators for the period 1991 – 2002. The National Thermal Power Corp (NTPC) has consistently delivered high PLF results, as has Neyveli Lignite. Some states such as Andhra Pradesh, Karnataka and Tamil Nadu have begun to deliver high PLF figures also but others such as West Bengal, Assam and Bihar continue to manage only very poor plant utilisation.

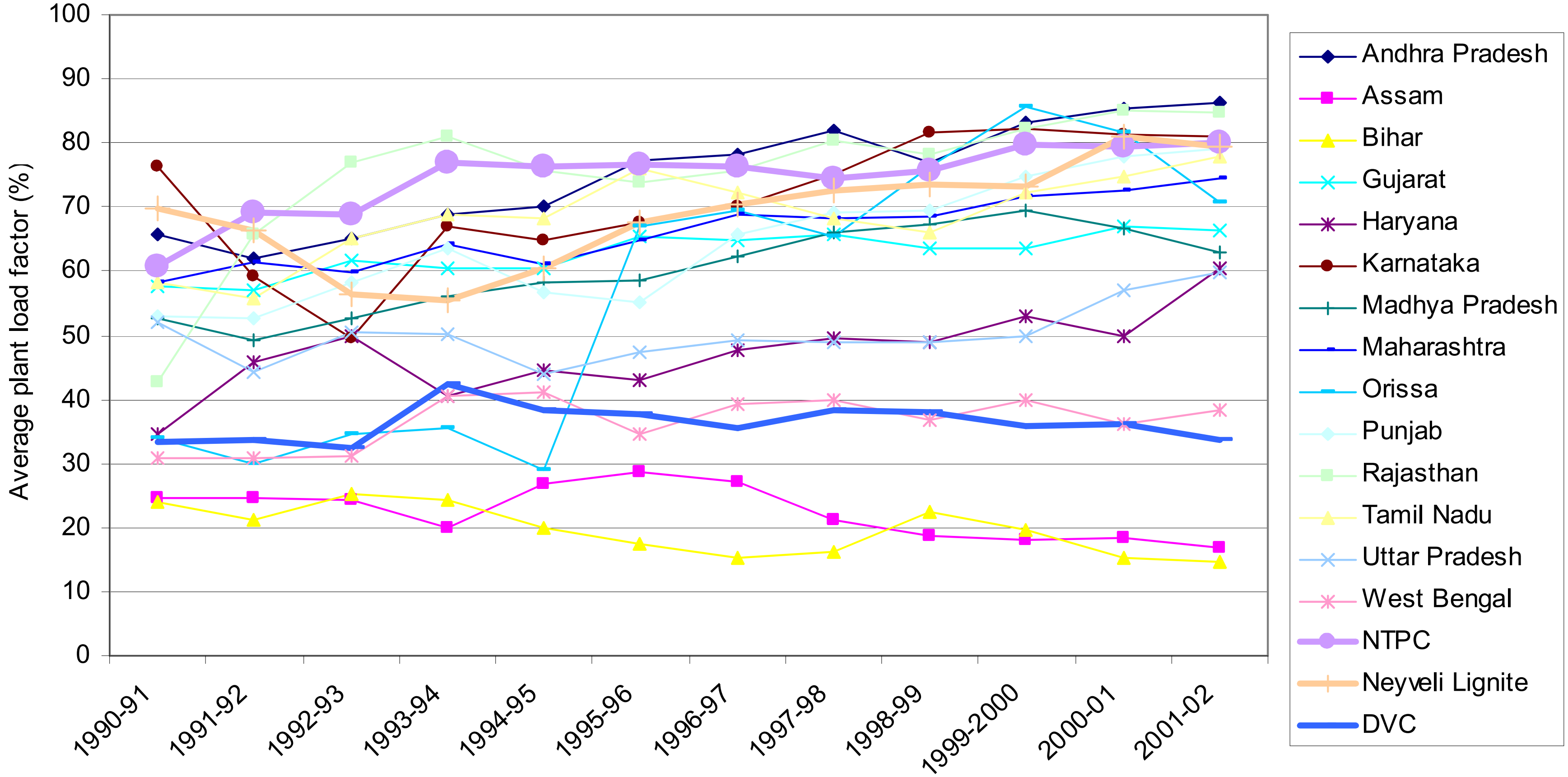

Figure 4.5: Plant load factor of selected states and central undertakings
Source: Planning Commission, Government of India 1999, Planning Commission, Government of India 2002b.

Plant load factor needs to be considered with some care. A low PLF may not only be symptomatic of poor resource management but may also reflect the structure of a generating company's assets[51]. Older, smaller plant is expected to yield a lower PLF. Plant age contributes to the low PLF observed for DVC – a central undertaking with markedly lower results[52]. NTPC plants, being of more recent vintage[53] are also larger and increasingly employ fluidised bed boiler technologies that are better suited to Indian coal types (Kannan and Pillai 2002). Plant load factor is also high relative to many developing country electricity systems as practically all of India's generating plant is run as base load. Due to systemic and chronic supply shortfalls, all plant is run continuously rather than reserving some plant to support peak demand periods only (indeed, there are not yet time of day tariffs in India to support the investment in peaking power plant). A more appropriate benchmark is therefore with the PLF of international base load plant[54].

Legislative support for central engagement was provided by the 1977 amendment to the 1956 Industrial Policy resolution that gave support for the centre's role in the electricity-generating sector (Government of India, Ministry of Industry 1977). The role of the centre has continued to grow and as at February 2009 equaled 33% of installed capacity (with the state sector owning 52% and the private sector the remaining 15%) – short of the recommendations in the Rajadhyaksha report but a

[51] A very high PLF is not necessarily a healthy sign either. PLF is calculated as actual generation as a ratio of theoretical generation. Scheduled downtime is therefore included in the numerator. Running plant too hard and avoiding scheduled downtime to meet PLF objectives can result in premature wear on the plant and increased forced outages later. Availability, rather than PLF is an internationally accepted indicator of plant efficiency (Kannan and Pillai 2002).

[52] 16 out of the 23 thermal plants (70%) owned by the DVC were commissioned prior to the 1990s (Central Electricity Authority 2008a).

[53] 43 of 76 coal fired thermal units (47%) owned by NTPC were commissioned prior to the 1990s. Of the 43 pre-1990 units, 35 were commissioned in the 1980s (Central Electricity Authority 2008a).

[54] For example, the PLF of coal-fired and gas fired plant varied between 57% and 69% and 54% and 69% respectively between 2004 and 2008 (Digest of UK Energy Statistics 2009).

material increase from the baseline of 1977 when the centre's role was formalised (Central Electricity Authority 2009).

4.4 Impacts on the pace of technology innovation

To demonstrate the material impact of decisions regarding the governance of India's electricity system, the impact of those decisions on the technology choices available to the state electricity boards is presented. The technology innovations available in world electricity infrastructure markets have influenced the economics of delivering electricity. However, the institutional structure in place in a region also profoundly affects the speed with which technologies are adopted and economic benefits achieved. This issue is examined with specific focus on how rapidly India adopted technology to reduce unit cost in generation and to balance loads across a region and uncouple the need to co-locate generation and electricity loads through transmission technology. Evidence is presented that governance structure decisions and the physical and economic geography of the country have had a considerable influence over the technology choices rationally available to the state electricity systems – demonstrating some technology path dependence of those decisions and geographic starting points.

4.4.1 Generation

As discussed in chapter 3, the development of electricity systems exhibits a set of common technical characteristics. However, the availability of technology innovations in one market does not imply that those innovations are exploited or exploitable in other markets. Hirsh argues that the structure of the American industry – comprised of a very large number of primarily privately owned electricity generators supported by a small number of equipment suppliers (primarily GE, Westinghouse Electric and Allis-Chalmers) resulted in a high degree of competitive innovation in terms of generator cost effectiveness (Hirsh 1989). This drive for cost-effectiveness was driven by improving thermal efficiency and economies of scale. The U.S therefore saw the pursuit of scale economies more rapidly than other countries. Figure 4.6 shows the maximum sized generating unit commissioned annually for the USA and India (the USA represented by the higher line in the figure). The U.S. industry rapidly increased the size of plant deployed up to the end of the 1980s[55]. This pursuit of scale reaped financial rewards for the U.S industry. Hirsh cites an Electrical World survey (October 1967) that identifies a 25% cost / KW difference between new small plants (75–99 MW) and large plants (300–999 MW)[56].

Indian generators were, however, much slower in increasing the size of generating units – and driving down unit costs through economies of scale. Only in 1984 did India successfully install a 500 MW generating unit with privately owned Tata's commissioning of the Trombay coal fired plant in Maharashtra – a feat achieved in the U.S. in 1960[57].

[55] At the start of the 1990s, there was a structural switch to smaller plant size (with the exception of nuclear plants that continued to exploit scale economies but are not included in figure 4.7) - coincident with the introduction of combined cycle gas turbines and increasing consumer environmental pressure. Hirsh argues that the U.S. generators were dissatisfied with the reliability of the 1,000 MW plus generating units and therefore retrenched to better proven technology in the 500 – 600 MW range (Hirsh 1989).

[56] The literature includes a number of analyses of scale economy from the U.S. generating sector – primarily undertaken in the 1960s and 1970s. Cowing and Smith provide a literature review (Cowing and Smith 1978).

[57] The UK commissioned its first 500MW coal fired generating unit in 1965 (Burbridge 1988).

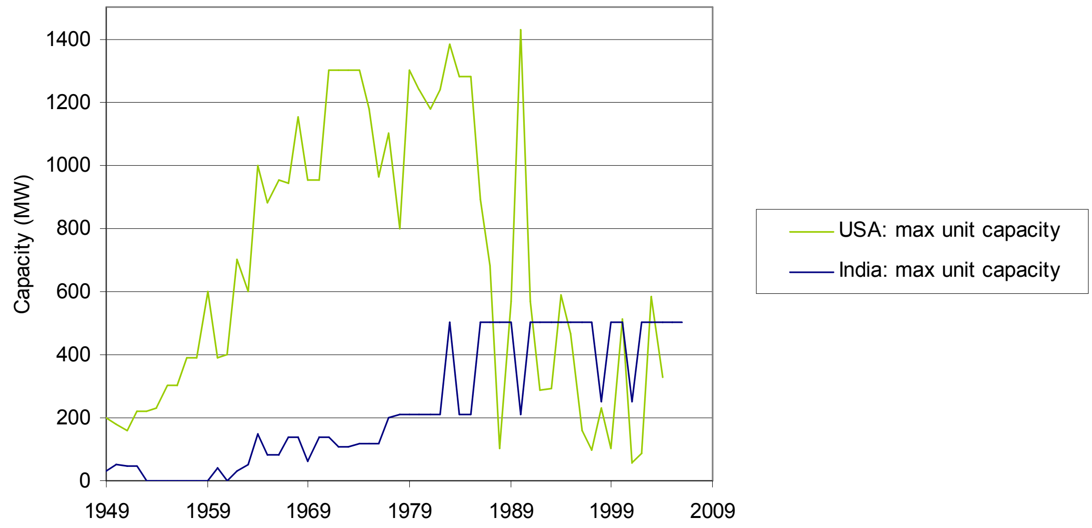

Figure 4.6: Maximum steam turbine capacity in new plants
Source: Hirsh 1989, Energy Information Administration 2009b, Central Electricity Authority 2008a

In 2003, H. L. Bajaj, chairperson of the CEA belatedly acknowledged the value of moving to 500 MW generators:

The contribution of bigger unit sizes has also been increasing and today 200/210 and 500 MW units constitute about 60% of total thermal capacity. The 500 MW units have operated for the last 20 years and have been consistently showing better performance than the lower unit sizes (Central Electricity Authority 2003: Forward).

As the CEA further recognised in 2003, in the context of India, larger scale generators delivered additional benefits in facilitating overall capacity expansion more quickly:

Amongst several factors affecting pace of capacity addition, unit size is considered to be very important and with this view it was thought to consider adopting higher unit sizes for advancing the pace of capacity addition as required (Central Electricity Authority 2003: 15).

Analysis of current generation costs for coal fired plant backs up this assertion. There is a significant negative correlation between average unit size and cost of generation as shown in table 4.5. This analysis examines a sample of state-owned generating stations in 2007[58]. The correlation is highly significant with a p-value of 0.000 demonstrating significance at a greater than 99.9% likelihood although the amount of variation in cost explained by unit size is less than 30% (R-squared = 29.26). This is understandable as there have been many identified contributors to the poor economic efficiency of generating plant other than size (e.g. age, fuel quality, management capacity).

Table 4.5: Regression results – cost of power against average unit capacity

```
      Source |       SS       df       MS              Number of obs =      49
-------------+------------------------------           F(  1,    47) =   19.44
       Model |  92216.8037     1  92216.8037           Prob > F      =  0.0001
    Residual |  222988.59     47  4744.43808           R-squared     =  0.2926
-------------+------------------------------           Adj R-squared =  0.2775
       Total |  315205.393    48  6566.77903           Root MSE      =   68.88

------------------------------------------------------------------------------
avg_unit_capb|     Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
cost_per_KWh |-.5218884   .1183764    -4.41   0.000    -.7600309   -.2837459
       _cons|    282.73   28.32731     9.98   0.000     225.7428    339.7172
------------------------------------------------------------------------------
```

Source: Central Electricity Authority 2008b, Central Electricity Authority 2008a.

A number of arguments can be put forward to explain this near-quarter century lag in the take-up of 500 MW generating sets. Certainly, India's electricity industry has some peculiar characteristics that encourage caution in taking up technology available elsewhere – specifically, a tropical climate with temperatures in excess of 40 degrees centigrade, humidity as high as 98% and high ash content coal (Jain 2009a). There is a natural conservatism in the industry that prefers incremental improvement to rapid change. The Indian electricity sector had a poor experience of moving from 110MW standard generator sizes to 200 / 210 MW in the 1970s (Gupta 2009). Much of the

[58] Not all states are represented. Andhra Pradesh and Kerala did not provide a breakdown of cost by generating station in the CEA's 2007 report. Many other states did not provide separate costs for generation from each unit. For this reason, an average unit size was calculated to match the reported entity size in the cost of generation report.

technology for the new plant was indigenously sourced. Poor reliability of the new equipment resulted in plant load factors as low as 40% being experienced[59]. In contrast, the 29 out of 34 500MW plants built in India up to March 31, 2007 have successfully used indigenous technology from BHEL – evidence of learning and increased maturity of India's indigenous power engineering industry.

Coal has been a perennial issue for electricity generators. As discussed above much of India's coal has high ash content in comparison to most countries' coal sources. The poor quality of coal, even after processing through coal washeries means that care has to be taken when introducing technology that had been originally designed for a higher fuel quality[60].

However, political decisions have also contributed to the problem in two principal ways:

- The decision to develop indigenous technologies to support critical industries such as electricity generation (discussed below);
- The decision to place responsibility for generation with the states resulting in many small markets that did not have the means or need for the larger generating stations for their own needs.

India acquired most of its technology from either the UK or Soviet block countries in the first decades after independence whilst it attempted to build an indigenous

[59] Stabilisation teams ultimately managed to identify the inherent design defects in the new plant and the manufacturer, BHEL, rectified the issues – largely free of charge indicating clearly that responsibility for the issues by the manufacturer was admitted (Central Electricity Authority, undated).

[60] The development of fluidised bed technology has mitigated this issue somewhat as this technology is more resilient to fuel quality (Kannan and Pillai 2002).

industry (Jain 2009a). Nehru had pushed forward a policy of self-reliance – building on the Swadeshi movement (self-sufficiency) that had been part of the independence movement (Frankel 2005)[61]. At the 3rd National Development Council meeting in 1954, Nehru made clear his frustration in buying technology from overseas:

> Now, if we think in terms of building up our industry, we must give up the idea of continually getting machines from abroad. We must build them here…. Anything that comes from abroad is more expensive than anything produced by Indian labour even though it may cost ten times as much (Planning Commission, Government of India 2005a: 24).

India began the development of indigenous capability in generation and transmission in the 1950s, concentrating manufacturing capability under Bharat Heavy Electricals Ltd (BHEL) in the 1960s. However, this proved to be a challenging and time-consuming initiative for a variety of reasons including:

- complex licensing arrangements with around 50 foreign companies;
- technology licensing that rapidly became out of date due to international technology advances;
- difficulty sourcing raw materials such as specialised steels;
- delays in developing in-house experience and skills due to the nature of the technical assistance programmes entered into as means of launching the indigenous industry (Surrey 1987).

This import substitution policy gradually closed opportunities to gain access to the technology innovations developed overseas by, for example, GE and Westinghouse in the U.S.

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[61] This strategy received validation through the import substitution model recommended by sections of the academic development community at that time (Prebisch 1950)

Given the maturity of the Indian states' electricity system in terms of size of market and inter-connection, it was arguably appropriate to limit the size of individual units to ensure system stability. In the U.S, a rule of thumb known as the rule of 7 to 10 suggested that no unit should be added to a system that increased total capacity by more than 7-10% to ensure system stability in the event of the failure of that unit (Hirsh 1989)[62]. However, the effective use of this rule depends on the size of the control area being managed. Under this guideline, an Indian state would require existing capacity of 5 GW to safely introduce a new 500 MW generating unit. No state met these criteria until Maharashtra's capacity had grown to 5,572 MW in 1984 – the same year that the Trombay plant was commissioned[63]. However, examining consumption at the regional level it can be shown that both the western and southern regions exceeded 5 GW of capacity as early as 1977. With an institutional framework that explicitly supported inter-state management of the sector, it would have been possible to move forward with larger scale generating units a decade earlier than was the case if states considered their opportunities independently. However, facilitating this would have required an adequate inter-state transmission system (and robust regional load dispatch institutions) to be in place.

4.4.2 Transmission

As with generating technology, India was relatively slow in taking up innovations in transmission technology. Table 4.6 presents a set of transmission milestones. A

[62] Contemporary techniques used in Indian grid management involve the calculation of a power number expressed in MW / Hz that allows the interpretation of the likely frequency droop experienced by the loss of a generating unit (Central Electricity Authority 2003). In the Indian system, load shedding commences if frequency drops to 48.5 Hz.

[63] It should, however, be noted that the rule of 7 – 10 was guided by the reserve margin historically available in the U.S. i.e. sufficient reserve being available in the system to survive the loss of up to 10% of generating capacity. The situation in India with a chronic supply shortfall is different in that effectively no reserve exists. The rule of 7 – 10 is not therefore strictly transferable although it is still of value in management of system stability in terms of restricting the potential loss from one generating unit failure.

substantial lag can be observed between the emergence of new transmission technologies in the global market and their pick-up in India. The lag has consistently been 25-30 years from first implementation globally to India's take-up of the technology.

Table 4.6: Take-up of transmission technology in India

	1st global implementation	Indian implementation
110 kV	1911 (Germany)	Pre-independence
220 kV	1929 (Germany)	2nd plan (1956-)
400 kV	1952 (Sweden)	6th plan (1979-)
800 kV	1965 (Canada)	8th plan (1996)
High voltage direct current	1956 (Sweden)	1991

Source: Planning Commission (various years)

Given India's size and the uneven distribution of primary energy sources (discussed above), it is somewhat surprising that new transmission technologies were not more aggressively adopted. As transmission technology has developed (primarily increasingly higher voltage AC transmission and high voltage DC transmission which minimise technical losses) there has been increased potential for mitigating some of the characteristics of geography that had previously constrained electricity system development and of developing larger control areas to more effectively balance load and open up opportunities to exploit scale economies more aggressively.

There is a considerable cost associated with failing to integrate the states transmission systems. The lost opportunity from sharing generating economies of scale between states is discussed in the preceding section. There are also potential savings to be made from balancing load across a broader control area. UK experience from the initial creation of the national grid in the 1930s suggests the availability of considerable potential savings. In the 1920s, up to 40% of capacity was held as reserve, by the late 1930s this had been reduced to 10% through interconnected operation across the grid resulting in a capital saving of £22m by 1937[64] (Hannah 1979).

Why was the introduction of the technology in India so slow? As with generation, the desire to encourage indigenous development of technology played its part. BHEL was a key player in transmission technology also. The heavy need for aluminium to construct transmission lines put initial strain on aluminium suppliers and the complexity of aligning plans between these large industrial sectors was problematic. The aluminium sector struggled to meet its targets in the early plans (Planning Commission, Government of India 1961). By the 6th plan, a lack of aluminium was explicitly cited as a reason for delay in the development of transmission lines (Planning Commission, Government of India 1981b). However, in the 7th and 8th plans, a lack of electricity generation was affecting the ability of firms to produce aluminium – making very clear the challenge of actively planning such a complex system as the Indian economy (Planning Commission, Government of India 1985b, Planning Commission, Government of India 1998b).

The potential opportunities available from using longer transmission lines and increasing system integration were clearly recognised. As early as the 2nd plan (ending in 1961) mention was made of developing a grid:

> As a result of advances in transmission techniques, large blocks of power can now be economically transferred over distances of 300 to 400 miles. This makes it possible to harness hydroelectric potentials in different regions and to utilise power in widely separated centres of industry (Planning Commission 1956: Sec 50).

[64] To put this figure in context, initial estimates for the construction of the initial UK grid ranged from £24m - £29m (Hannah 1979).

The transmission system has grown rapidly over the review period as shown in figure 4.7. The right hand scale describes the growth in transmission as measured by circuit km deployed. However, analysis of transmission grid density as measured by circuit km / MW of generating capacity (the left axis in figure 4.7) suggests that transmission investment has been weak – and, since the 1970s been getting weaker, in comparison to generating capacity investment.

P. Singh, CEO of Power Grid Corp of India, suggests that electricity transmission investment has historically been driven by generation rather than a desire to build a robust grid i.e. transmission investment has only been undertaken for the purposes of integrating generating capacity with its intended load:

Transmission plan in this country has always been generation-based. Power Grid has been pleading that it is not going to help if we just have a generation-based transmission system because there are bound to be imbalances. System improvement is a must and interconnection essential, basically the concept of a national grid (Srinivasan 2004).

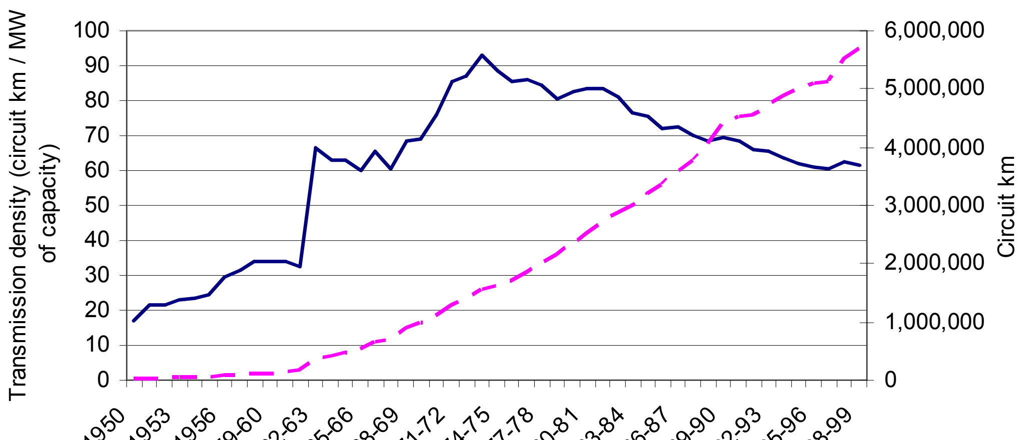

Figure 4.7: Electricity transmission system density (1950-1999)
NB: data exclude distribution lines prior to 1962-63
Source: Indiastat 1999

The declining transmission density since 1975 illustrated in figure 4.7 is evidence of this practice. As the electricity system matures, it would be expected to see grid density increasing as the load and generation balancing potential of a broader based grid is realised to support system stability. This has not yet occurred in India. Kannan and Pillai identify chronic under-investment in transmission and distribution as a key issue for the entire system. They suggest that the recommended 1:1 ratio between investment in generation on the one hand and transmission and distribution on the other has been completely skewed in favour of generation – resulting in the sustained decline in transmission density illustrated on the left hand axis of figure 4.7 (Kannan and Pillai 2002).

There is a strong institutional and financial argument for this under-investment and slow pick-up of transmission technology. As with generation, responsibility for transmission in India initially rested solely with the states. In the 1960s, it became clear that the states alone were unlikely to capitalise on the opportunities for regional load balancing by inter-connecting their grids. In the 3rd plan in 1964, five regional electricity boards (REBs) were set up to coordinate activity across each region and inter-connectors began to be developed[65]. Planners were optimistic.

> With the formation of the regional grids and establishment of central load despatch stations, selection of new generation schemes would be so made as to fit with the load characteristics of the region and generally to serve the regional requirements as a whole. (Planning Commission, Government of India 1970c: Sec 12.10)

However, the REBs had responsibilities but with few resources. The executive management of the REBs were the chairmen of the respective state electricity boards together with representation from the CEA (Rao 2004)[66]. Development plan finance

[65] Connections include the connection of the Mysore (Karnataka) grid with Tamil Nadu, Andhra Pradesh and Kerala, and the Riband grid in Uttar Pradesh was connected with the DVC-Bihar-West Bengal grid.

[66] Legislative support for the regional electricity boards was not forthcoming until 1991 through the Electricity Law (Amendment) Act (Government of India 1991).

continued to be delegated directly to the states. During the 4th and 5th plans, centrally sponsored schemes were set up to build inter-state transmission links and inter-connectors. However, the relative investments remained low despite the rhetoric about the importance of inter-state transmission[67]. 4th plan proposed expenditure by the centre on transmission and distribution equaled Rs. 318m out of a total electricity sector budget of Rs. 24,475.7m – 1.4% of the total (Planning Commission, Government of India 1970a). This declined to 1.3% in the 5th plan (Planning Commission, Government of India 1976). By the 6th plan, central transmission spend had increased to 3.7% but the majority of transmission investment funds continued to flow to the states that had little perceived incentive to invest in inter-state transmission (Planning Commission, Government of India 1981a). Legislative support for inter-state electricity transmission was not provided until the Electricity Laws (Amendment) Act of 1998 provided explicit provision for a central transmission authority and inter-state transmission systems.

Improved inter-state transmission provided an opportunity to exploit scale economies in generation, deliver cost savings and improved quality of service through broader load sharing. This did not immediately require a national grid: more rapid exploitation of higher voltage transmission within individual regions could have brought considerable benefit. This has now been recognised in India and the investment in transmission is improving with respect to capacity investment and is skewed in favour of inter-state and inter-regional transmission. 11th plan transmission spend is

[67] Excerpt from 5th plan: "Particular consideration has also been given to infra and inter-State transmission lines, setting up and strengthening of regional load despatch centres, and investments on distribution." (Planning Commission, Government of India 1976).

scheduled to be Rs.750bn of central investment and Rs.650bn of state investment[68] in contrast to Rs.1,109bn central spend and Rs.796bn state spend on capacity additions (Government of India, Ministry of Power 2007). However, the focus on generation first and foremost and the institutional structure that placed most investment in the hands of individual states resulted in the slow development of inter-state linkages and continued inefficient management of electricity systems as smaller state-sized islands[69].

4.5 Conclusions

Before undertaking a statistical regression analysis of the development of India's states' electricity systems it has been necessary to introduce an approach to articulate the breadth of disciplines required in analysing the development of electricity systems. Several key concepts were introduced in chapter 3:

- The universal characteristics of electricity systems – primarily economic and technical - that have framed the potential direction of their development around the world;
- The historic backdrop in which electricity system development decisions have been made;
- The political and institutional space in which the system is being developed that has influenced the ability to implement that system;
- The geographical, place-specific characteristics that have influenced the choices framed by these techno-economic characteristics.

[68] Although the largest element of this – Rs.540bn is earmarked for inter-state transmission lines to support new central sector generation.
[69] Small is only defined in terms of electricity consumption. In terms of population, some states such as Uttar Pradesh are considerably larger than most countries.

In this chapter, these concepts have been applied to the Indian electricity system to answer three questions:

– Why was responsibility for electricity system devolved to the states?
– What was the impact of and response to this decision in the context of the country's historical context and geographical endowments?
– How spatial governance choices reached beyond the capabilities of individual states to influence the introduction of new technology in India?

The political diversity across India, superficially reconciled through the INC at independence, in reality made a political necessity of the INC's need to consolidate power across the country. This drove the decision to place primary responsibility for electricity system implementation with the states. The policy decision provided many opportunities to reward local political constituencies and thereby consolidate the country as a strong federation of states. This political motivation for devolving power for electricity system development to the states was supported by the previous colonial governance structures that focused on provincial management rather than management of all India. The constitution, born out of practical experience of British rule, supported the concept of strong states and was therefore a natural means by which the INC could consolidate its power and build the nation. However, this contrasts with the approach taken with the other key network infrastructure existing at this time – the railways, which were placed under central control from the outset. This suggests a lack of vision regarding the value of a national electricity infrastructure that was known and accepted for the more mature railway technologies.

The Electricity (Supply) Act of 1948 that provided the basis for the emergence of independent India's electricity systems was conceived during this period of nation building and political consensus building. Although it mandated the creation of the state electricity boards, it was weak in its enforcement of the timing of their creation – allowing states to continue to manage their electricity systems as they wished – arguably setting the tone for on-going meddling by the state in the SEBs - conceived as semi-autonomous bodies. The 1948 Act also provided only weak support for the Central Electricity Authority. This failure to construct a central institution with effective implementation powers over the national electricity system was, with hindsight, a major flaw in the post-independence institutional structure of India's electricity system.

Devolution of implementation responsibility for electricity to the states made the unevenness of development between the states increasingly visible and inevitable. The planning system was the primary vehicle for mitigating this unevenness – sourced from differences in institutional capacity and resource availability. However, the planning system largely failed to mitigate the inherent unevenness between the states. Indeed, central policy exacerbated regional difference through policies to maximise industrial development in existing industrial centres in the early years after independence and through the freight equalisation policy that eliminated any advantage coal-rich but weak regions had over their coal-poor but industrialised peers. The Gadgil formula – designed to reduce the political lobbying inherent in the plan disbursement process, had the effect of restricting the centre's ability to skew plan investment in the direction of those states whose electricity system development (and other infrastructure) were under-performing.

It therefore became increasingly obvious that the centre had to engage directly in the development of the states' electricity systems. The role of technology innovation is important in this development. The limited size of individual state electricity systems provided little incentive to develop higher capacity (and lower unit cost) generating sets. The lack of a robust inter-state transmission mechanism – caused by a philosophical bias towards increasing generation, inadequate investment in inter-state transmission and very weak legislative and institutional support for inter-state transmission – limited the market size for larger scale generation. This problem was exacerbated by a political decision to encourage the development of an indigenous electricity system manufacturing capability – that resulted in a comparatively slow take-up of technology.

The centre was ultimately well placed to develop larger generating plants (both coal fired and hydropower from the Himalaya) for the benefit of multiple states. However, the earlier decisions regarding state management and an emphasis on generation over transmission driven by weak regional and central institutions have arguably cost India at least a decade in the implementation of technologies. These technologies had the potential to improve the speed of commissioning new capacity, reduce the cost of generation through scale economy and load balancing and reduce the likelihood of service loss through wider system management.

The next chapter presents a quantitative analysis of the states' performance in developing their electricity systems using a specially constructed panel data set for the large states from 1961 to 2000. Accepting the pivotal role of the states in delivering electricity to their populations discussed above, a multivariate regression analysis of electricity consumption and state characteristics based on history, institutions, physical geography and agglomeration forces, is undertaken. Are there characteristics that have a significant influence on the electricity system under both central planning and the liberalising electricity industry? Do these provide evidence of path dependence in the influences on the states' electricity systems?

5 Planning to liberalisation: multivariate regression of a panel of state characteristics and electricity consumption

5.1 Introduction

The previous two chapters have provided insights into how India's political economy has intersected with the drivers and challenges of developing an electricity infrastructure and have analysed in some detail the setting within which India's electricity system development has taken place. Particularly, the question of why responsibility for the implementation of the electricity system was given to the individual states was addressed, as was the role of central planning in the development of the electricity system. The aim of this chapter, given the critical role of the states, is to interrogate this data to gain understanding of the significant influences on electricity system development through comparative analysis of the states – structured as a panel data set covering each of the large Indian states from 1961 to 2000. Particular focus is given to uncovering evidence of the existence of path dependence in system development both by the selection of explanatory variables that pre-date the period under analysis and by interrogating the data in separate periods.

There is a small but valuable literature that has undertaken cross-section or panel data analyses focused on the determinants of infrastructure investment (Bergara et al. 1997, Gassner et al. 2007, Henisz 2002). Within this literature, there is a subset that specifically focuses on the electricity sector – primarily focused on the institutional factors influencing the success of electricity reform and privatisation programmes

(Bacon and Besant-Jones 2001, Brown and Mobarak 2009, Henisz and Zelner 2006, Zhang et al. 2002, Stern and Cubbin 2005, Zhang et al. 2005).

Bergara performed one of the first econometric analyses of the influence of institutions on the electricity sector. He performed a cross-section analysis of 91 countries to develop an understanding of the influence of institutional factors on the investment decisions of electricity utilities with installed generating capacity acting as a proxy for investment decisions. The study leverages the insights developed by Levy and Spiller in the seminal paper on the institutional influences on telecommunications regulation (Levy and Spiller 1994). The study concluded that "the credibility and effectiveness of a regulatory system (and hence its ability to facilitate private investment) vary with a country's political and social institutions" (Bergara et al. 1997: 5). The selection of institutional variables was broad but there was less attention provided to non-political explanatory variables (per capita GDP, ratio of industrial production to GDP, urban population percentage and hydro generation percentage). Zhang et al undertook a panel data analysis of 51 countries between 1985 and 2000 with broad geographical coverage (recognising a previous weakness in the literature that had focused either solely on developed economies or Latin America). The focus of this study was on the effects of privatisation, competition and regulation on electricity sector performance concluding that competition indicators are best correlated with electricity sector performance and that privatisation and regulation had greatest explanatory power over electricity availability indicators when acting together. Zhang et al highlight a number of the challenges apparent in undertaking this type of study in developing countries. Rich data on private electricity generation was unavailable so a dummy variable had to be used identifying a country with any private generation – a weakness acknowledged by the authors. Regulation was measured by the employment of a dummy variable identifying those countries with an independent regulatory agency. Quality of service could not be used as a dependent variable due to lack of data – again, a common challenge with this type of study. Zhang et al, following Bergara et al, used similar non-institutional control variables such as GDP per capita, ratio of industrial output to GDP and level of urbanisation. Brown has adopted similar methods to understand the allocation of electricity distribution between different classes of customer - industrial, agricultural and domestic (Brown and Mobarak 2009). The greatest focus in this study is an indicator of democracy – using a time-varying dummy variable derived from the Polity IV database. Again, non-institutional variables include urbanisation, ratio of industrial activity to GDP (and ratio of agricultural activity to GDP) as well as a set of controls for the ratio of different primary energy sources. The study finds that the level of democracy in a society has a significant effect on the sectoral distribution of electricity consumption – driven by the decisions of political actors to favour one constituency over another.

What these studies fail to fully address, with their focus on contemporary indicators of institutional strength are the conclusions drawn by Levy and Spiller: "the success of a regulatory system depends on how well it fits with a country's prevailing institutions" (Levy and Spiller 1994: 242). By focusing on contemporary indicators of institutional qualities, little insight is gained into the source of those institutional endowments and therefore the choices available to policy-makers to pull away from a potentially sub-optimal path. The importance of context is echoed by Jamasb et al in a paper defining appropriate indicators to support the study of electricity sector reform:

sector endowments and characteristics such as size, resource mix, historical development, define the initial market structure and starting point and can influence the reform path and outcome (Jamasb et al. 2004: 5).

In a related paper, Jamasb et al also raise the concern that much of the literature to that date had failed to recognise the potential endogeneity of institutional explanatory variables in cross-country and panel data studies. It is argued that electricity sector performance is both influenced by institutions but also, those institutions are influenced by sector performance (Jamasb et al. 2004).

This chapter builds on the empirical approaches taken by the studies of electricity sector reform but with the focus on the intra-country case of India and analysing a longer time series than previous analyses. The focus on long-run path dependent processes supports the inclusion of historical proxies for institutional quality such as the form of British rule (discussed in detail below) that mitigate some of the concerns of endogeneity. Greater emphasis is also placed on geographic factors than has been the case in most analyses – particularly indicators of agglomeration economics and physical geography and endowments. These are arguably particularly relevant in understanding unevenness in a sub-national study where there are considerable (but far from perfect) homogeneities between the states with respect to polity, economic culture and legislative structure. The inclusion of a longer time series than most analyses – stretching from 1960 to 2000 and covering a long period prior to any liberalisation activity in India provides an opportunity to contrast the significance of explanatory variables under different central government regimes – central planning and liberalisation[70]. Henisz and Zelner (2006) undertook an analysis of electricity utility infrastructure deployment rates between 1970 and 1994 with a focus on political interest groups and veto points. Despite the opportunity provided by using a longer time series, there was no analysis of how the explanatory power of the selected explanatory variables may have changed over time as the governance structures of electricity utilities evolved through the study period. The liberalisation of the Indian economy that accelerated in the 1990s[71] provides an opportunity to investigate whether a structural break exists in the influences on the states' electricity systems[72]. Note, the intention is not to develop a predictive econometric model (i.e. capture all the influencing factors on electricity system development). Rather, the objective is to examine the potential role of a selected set of indirect influences, as suggested by the literature, on system development. This chapter therefore endeavours to understand whether path dependent influences on the electricity sector exist and whether they have diminished over time or whether the current period of liberalisation is, in fact, amplifying the effects of institutional and geographical differences across the country that had been mitigated by the earlier policies of central planning. The chapter proceeds as follows. Section 2 discusses the research design, hypotheses and methodology. Section 3 provides details on the data – including constraints, a discussion of dependent variable selection and details of the explanatory variables. Section 4 provides the results of various regression runs and a discussion of findings.

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[70] Data limitations have made such an analysis prohibitively difficult for large cross-developing country studies but India has a consistent data record at the state level to support such an analysis.
[71] There is an argument to compare two equal periods to maximize the dataset for all regressions. It may also be noted that the gradual process of liberalization predates 1991 by a number of years. Indeed, some historians have suggested that liberalisation can be traced back to Indira Gandhi's final term in office from 1980-84 (Frankel 2005). However, due to the use of panels, sufficient data exists to support a meaningful regression of the post 1991 period and, from the liberalisation perspective, despite moves to commence liberalization in the 1980s, nothing occurred that directly influenced the electricity sector until the Industrial Policy Resolution of 1991 (Government of India, Ministry of Industry 1991).
[72] Refer to chapter 2 for a detailed definition of liberalization in the context of the Indian economy.

5.2 Approach

5.2.1 Research design

It is necessary to define the rationale for undertaking a long-term analysis of the electricity sector's development. The period selected for the analysis is 1961 to 2000. The selection of these specific dates is discussed in the data section below. Infrastructure investments, particularly electricity investments are associated with large capital requirements, long lead times and lengthy payback periods. There can therefore be a considerable lag between policy implementation and manifestations of those changes within the sector – such as increased capacity, generation or consumption. Equally, as discussed in the preceding chapters, it is argued that there are both geographical characteristics and material rigidities within the institutional entities engaged in electricity infrastructure investment at both the national level and within individual states that have a profound and resistant influence on the development of the electricity system. Further, as discussed in the introduction, the selection of a time-period that spans both a central planning and liberalising approach to economic management, facilitates the exploration of the different impact of path dependent processes under the two regimes. To provide evidence for these assertions it is instructive to take as long a term view as is possible within the constraints of data availability and structural homogeneity. The use of panel data techniques maximises the availability of data and is critical given the small overall population size and relevant research period. This research design provides insight into a number of factors that have not changed over time but do vary between different states (such as historical governance structure, resources and topographical characteristics). India's federal structure provides a valuable opportunity to investigate the influence of individual state level characteristics on the development of their electricity systems.

5.2.2 Hypotheses

Overall Hypothesis	
The development of the electricity sector in India's states is path dependent and resistant to policy action.	
Objective 1	Identify the key factors influencing the long run effectiveness of the States' ability to develop their own power sectors (1961 – 2000)
1.1. Demography	A concentrated population results in a more rapid development of the electricity system.
1.2. Geography	A poor geographical endowment in terms of resource availability and topography will lead to a less developed electricity system.
1.3. History	A history including direct colonial rule will, through a weaker institutional foundation, lead to a less developed electricity system.
1.4. Politics	Strong special interest groups (such as an agricultural lobby) as well as a high representation of disadvantaged groups (scheduled castes and scheduled tribes) lead to a lower level of development of the electricity system.
1.5. Concentration	Agglomeration economies result in economic strength within a state and its neighbours positively affecting electricity consumption.
Objective 2	Identify evidence for the existence of a structural break in electricity system development in 1991 resulting from the commencement of electricity system liberalisation.
2.1 Planning	Development planning is sufficiently powerful to mitigate the path dependent influences creating unevenness in electricity system development.
2.2 Liberalisation	Liberalisation exacerbates effects of underlying institutional and geographical influences of system development.

The research design implicitly assumes that the period prior to 1991 was characterised by strong central planning and that significant differences between the two periods observable across all states may be attributed to this factor. Further research might endeavour to analyse the effect of the declining role of central planning at a more fine-grained level through, for instance, using state-by-state plan financial flows as an explanatory variable.

By splitting the panels into two separate time series representing the periods pre and post the signalling of major liberalisation in the economy it is possible to capture the total effect of liberalisation (which manifests in the broader economy as well as in the governance of the electricity sector). An alternative approach may have been to represent specific aspects of electricity liberalisation as discrete explanatory variables. However, two concerns were felt with this approach. Firstly, it is challenging to capture the qualitative depth of implementation of a liberalisation strategy in simple numeric indicators as demonstrated by ESMAP (1999). Secondly, measurable progress at the state level actually occurred at similar times whereas the cultural shift state by state post-1991 has been manifestly different.

5.2.3 Methodology

5.2.3.1 Random effects vs. fixed effects

Panel data analysis (analysis of a number of subjects through time) provides a toolset to ensure both the time dimension and inter-state dimension can be evaluated in determining the significance of correlation between the dependent variables and the selected explanatory variables. Panel data methods provide two common models of analysis – the fixed effects model and the random effects model. The fixed effects model evaluates correlation within the time series for each panel member (i.e. state). The random effects model evaluates correlation both within the time series for each panel member as well as across the panel members for each period in the series. A fixed effects model might be appropriate if there is no assumed systematic difference between the panel members[73]. However, in the case of this analysis it is expected that

[73] Jamasb also notes that from an econometric theory perspective, fixed effects models are better suited in situations when a specific set of cases are studied – which is the case in this analysis with all relevant states included (Jamasb 2006). However, Jamasb goes on to note that specification tests (e.g. the

real differences do exist between the states and the analysis needs to capture these differences. It is also hypothesised that time invariant characteristics – such as geographical features and historical institutional factors have a significant role to play in explaining the subsequent performance of the states' electricity systems – factors that can only be tested by comparison across the states through a random effects model.

A random effects model is therefore necessary to test the hypotheses presented. It should be borne in mind that a random effects model is not guaranteed to provide unbiased estimates of standard errors associated with the identified explanatory variable coefficients. A standard approach to determine whether a random effects model can be safely applied is through a Hausman test[74]. Results of a Hausman test on the specified model are reported in the results section below.

5.2.3.2 Selection of regression methods

There are a number of implementations of panel data models available. Selection of an appropriate model – and specifically, the most efficient and unbiased estimation procedure depends on the detailed characteristics of the data as well as the specified error component model. The following criteria have been considered:

- Is the data set balanced or unbalanced (data exists for all panel members for all periods)? In this case, the data is mildly unbalanced. Data exists for all states for almost all periods for which the authorities have collected data. Where data does

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Hausman test – see below) may support the selection of random effects models (Steiner 2001, Hattori and Tsutsui 2004).

[74] This test compares the covariance matrix of the regressors in the fixed effects model with those in the random effects model. The null hypothesis is that there is no correlation. If there is a statistically significant difference between the covariance matrices of the two models, it is interpreted as evidence against the random effects assumption (Wooldridge 2002).

not exist for an individual state, it is due to administrative difficulty in collecting data at that time. An example is the difficulty experienced in collecting data in Jammu & Kashmir in 1981 due to border conflict. It is not felt that this degree of unbalance requires particular attention in the subsequent analysis. Data is also missing for those states that were created or reorganised during the research period (Punjab, Haryana and Himachal Pradesh)[75].

- Is heteroskedasticity suspected in the error terms (errors correlated to scale of dependent variable)? It is reasonable to assume that there will be cross-panel heteroskedasticity given the heterogeneous nature of the selected states (even after discarding the smallest states from the sample there is still a large population difference between states – a population of 6 million in Himachal Pradesh compared to 166 million in Uttar Pradesh). First order scale effects are removed by working with per capita data. However, there is still the potential for second order scale effects such as economies of scale in electricity generation that may result in systemic differences in the magnitude of errors between states[76]. It would therefore be prudent to apply a robust estimation method that is not sensitive to the assumption of homoskedastic error terms and a model implementation is therefore required that supports robust variance-covariance estimation.
- Is the panel dynamic (i.e. is a lagged version of the dependent variable used as an explanatory variable)? A lagged value for electricity consumption has been considered as an explanatory variable based on the premise that, at the micro level,

[75] There is a possibility of bias resulting from the management of regions prior to those regions being granted autonomy. For example, it may be hypothesized that Punjab under-invested in the region that subsequently became Haryana. In addition, Himachal Pradesh may have received lower levels of investment as a union territory than when it was granted greater control over its own economic development as a state. It may be expected that the pace of growth of the electricity system in both these states exceed the average for all states following independence.

[76] The drivers of scale economies in electricity generation have been discussed in chapters 3 and 4.

individual electricity consumers are unlikely to radically reduce consumption once they have made the investment to get a connection, purchase electricity consuming appliances etc. Tiwari finds, in a study of residential electricity consumption in Mumbai, that consumption is indeed price and income inelastic due to long run investment in both property-type and electricity-consuming appliances (Tiwari 2000). The presence of lagged instances of the dependent variable in the regression points to the need to apply a specific implementation such as that proposed by Arellano and Bond implemented in Stata as xtabond (Arellano and Bond 1991). However, this implementation is recommended for panel data sets with a large number of subjects and only a few periods. These conditions are not met and therefore this technique is not applied. A further reason for excluding lagged variables from the final model is a pragmatic compromise driven by the loss of observations resulting from incorporating a lagged version of the dependent variable – especially given that due to lead times associated with capital investment in the electricity industry – a lag of five years is appropriate.

– Is it likely that the panel members have different sensitivity to the explanatory variables (the intercept and / or slope of the regression coefficients may vary by state)? A hypothesis of this study is that individual states have differing capacities to develop their electricity systems based on a set of historical and geographical factors. It is therefore appropriate to construct a test that allows the state intercept or both the intercept and slope to vary – a random intercept and random slope model respectively. To capture this complexity, a mixed model is required that supports a random variable for the intercept and slope coefficient. Stata supports this approach with the xtmixed implementation (Rabe-Hesketh and Skrondal 2008).

- What error component model is appropriate given the data structure? – i.e. are there state specific errors only or both state and time specific errors? It is assumed that state variability exists – this is primarily what is being tested. Therefore, state specific errors should be anticipated. A one-way model would be appropriate if it is not expected that there is time-influenced variability common to all states. This assumption is theoretically difficult to support. A common source of cross panel time-based variability in country studies is exogenous macro-economic shocks that affect all countries (e.g. global commodity price shocks). In the context of this study, this type of external shock remains valid but an additional source of influence affects all states – national economic policy. Electricity system investment across the states is driven by planning policy and national level resources available for investment. It is suggested therefore that all the states' electricity system development will be correlated to the strength of the national economy. Methodologically, this effect can be captured in a time-sensitive error component. It is possible to model this error structure in Stata using a mixed model (Rabe-Hesketh and Skrondal 2008) and this is done initially. As an additional robustness test, another common approach for implementing this type of model is to explicitly define variables for the time component of the analysis – in this case, dummy variables are created for each of the plan periods and time specific effects will be captured within these dummy variables. Random effects regressions are undertaken incorporating these dummy variables to evaluate the significance of time specific correlation common to all states[77].

[77] The plan period dummies are not included in the more complex mixed models for purposes of presentational clarity. However, the effects were found to be similar to those of the FGLS regression.

In reality, standardised package implementations to support each of the characteristics described above in a single solution are unavailable. It is therefore necessary to both compromise and use alternative approaches as a robustness test of the analysis. The initial implementation selected is the mixed model using maximum likelihood estimation that allows for random intercepts and coefficients, and supports an implementation strategy for two-way random effects models.

5.2.4 Model Functional Form

Given the above discussion, the following model functional form is used as an ideal specification.

$E_{it} = \alpha_{it} + \beta_1 D_{it}(d_1 \ldots d_n) + \beta_2 G_{it}(g_1 \ldots g_n) + \beta_3 H_{it}(h_1 \ldots h_n)) + \beta_4 A_{it}(a_1 \ldots a_n) + \beta_5 P_{it}(p_1 \ldots p_n) + \beta_6 T(t_1 \ldots t_n) + \gamma_1 + \gamma_2 + \varepsilon_{it}$

Where:

i represents a set of Indian states

t represents a series of annual time observations

E represents the dependent variable – per capita electricity consumption.

$D(d_1 \ldots d_n)$ represents a set of demographically based explanatory variables

$G(g_1 \ldots g_n)$ represents a set of geographically based explanatory variables

$H(h_1 \ldots h_n)$ represents a set of historically based explanatory variables

$A(a_1 \ldots a_n)$ represents a set of agglomeration theory based explanatory variables

$P(p_1 \ldots p_n)$ represents a set of politically based explanatory variables

$T(t_1 \ldots t_n)$ represents a set of time based dummies representing the 5 year plans

γ_1 and γ_2 represent the standard deviation of the intercept and coefficient to capture differences in the intercept and slope of the state's regression coefficients.

As discussed in section 5.2.2 above, ε_{it} should ideally represent a 2-way error component model decomposed into the following structure: $u_i + v_t + w_{it}$ where u_i represents unidentified state specific errors, v_t represents unidentified time specific errors (such as systemic point in time shocks e.g. oil shock, balance of payments crises) and w_{it} represents the remaining residual error. This is tested explicitly in the mixed model run but, as discussed above, is also modeled as a set of time dummies in the standard random effects regression.

5.3 Data

5.3.1 Constraints

The starting point of the time series is constrained by data availability. In 1956, the State Reorganisation Act was introduced that altered the initial state structure introduced after independence that had been heavily influenced by colonial governing boundaries (Government of India 1956). Statistical data publication commenced along the new jurisdictional boundaries in 1958. Performing statistical analysis prior to 1958 is therefore severely hampered by the need to disaggregate data reported under the earlier organisational boundaries and, indeed, in many cases data is not provided in a sufficiently disaggregated form to support re-aggregation under the modern state structures. Further, Bombay state was reorganised in 1960 – creating Maharashtra and Gujarat. The time series for both states commences in 1960. However, many of the explanatory variables are only available from 1961 so this date is selected as the start date for the regression analyses. Haryana was created in 1966 from the southeastern portion of Punjab. The time series for both states commences in 1966. Himachal Pradesh held union territory status until 1971. Due to the different governance structures for union territories (fundamentally reduced local autonomy), the time series for Himachal Pradesh begins in 1971. The upper bound of the time series reflects a further reorganisation of the states with the creation of Chhattisgarh, Jharkhand and Uttarakhand out of Madhya Pradesh, Bihar and Uttar Pradesh respectively. The states were created in late 2000 but statistics are available for the former territories for the financial year ending March 31, 2001[78]. 2001 also marks the latest census data available for the country as a whole. However, 2001 is also the year that the Central Electricity Authority changed the definition of electricity consumption (as discussed in more detail in the next section). This methodological change in data collection renders comparison with previous years unreliable. Therefore, the end date for the research period has been set at 2000.

The selection of states to be included in the analysis has been driven by three considerations:

- Data availability
- Degree of homogeneity – primarily size of state in population terms[79]
- Degree of autonomy in decision making

Specifically, only those states that provided statistics for the entire period under analysis have been included (with the exception of the state reorganisations mentioned above)[80]. This excludes the new states created in 2000 (Chhattisgarh,

[78] It would be plausible to extend the period under analysis by aggregating the data for the three new states into their pre-2000 territories. However, the benefits gained by increasing the size of the dataset would be outweighed by the potential error introduced by aggregating data across independent states that have adopted separate electricity policies.

[79] A common criticism of cross-country panel data analyses rests in the degree of heterogeneity between countries that result in a large country-specific error component (Islam 1995). Intra-country analyses can reduce this effect especially if highly differentiated states (in this case low population states) are excluded from the analysis.

[80] There are also a small number of data gaps for Assam and Jammu & Kashmir due to the lack of census data in 1981 and 1991 respectively.

Jharkhand and Uttarakhand). Union territories are also excluded due to their small size and because they are constitutionally less able to control their own affairs than the States[81]. A number of states have been excluded because of size – namely Goa, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura.

Data has been compiled from a number of official sources. Notably, hard copy editions of the India Statistical Abstract series have been accessed for generating capacity, actual generation and consumption data. The series has been published since 1949 on a close to annual basis although there are years where, for a variety of reasons, the abstract was not published. Data has therefore been captured for all years where it was made available by the Indian Government[82].

5.3.2 Dependent variables

The hypothesis defined above calls for an evaluation of the degree of development of the electricity system. Selection of an appropriate indicator of electricity system development for an individual state requires care. Three alternative but related dependent variables are considered[83]:

- Per capita grid connected electricity generating capacity
- Per capita grid connected actual electricity generation
- Per capita electricity consumption

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[81] New Delhi is not small in population terms but still has limited autonomy and is also highly urbanised and constrained territorially resulting in a need to import much of its required electricity from neighbouring states. This results in it being structurally different from the majority of the states and it is therefore excluded from the analysis.

[82] The missing years in the series are 1961, 1970, 1976, 1979, 1988, 1989, 1991-1994, 1996 and 2001.

[83] Other potential indicators are suggested in the literature. For example, Ayogu argues that capacity of transmission and distribution infrastructure is the key determinant of electricity system effectiveness (Ayogu 2007). There is merit in this recommendation. However, as Ayogu himself states, it is unlikely that such data will be consistently available. This is certainly the case in India, particularly in earlier periods.

Generating capacity is a commonly used dependent variable in studies of electricity system development (Canning 1998, Bergara et al. 1997, Henisz and Zelner 2006). At the national level, these data are usually readily available. Actual generation is also used (e.g. (Zhang et al. 2002) but ensuring the accuracy of this data over a long period can be more challenging than for capacity data[84]. Some studies have also focused on sector efficiency as measured by utilisation rates (Steiner 2001).

Figure 5.1 is a schematic presentation of the structure of Indian capacity, generation and consumption statistics. Capacity and generation data include all state utility generation (the state electricity boards or their post-liberalisation descendents) and privately owned utilities (the five remaining privately owned utilities with grandfathered rights from prior to the 1948 Electricity (Supply) Act and independent power producers set up in the post-liberalisation period). However, cross state and national border generation is excluded, as is generation from centrally owned generators. Therefore, when examining at a scale below the national level, challenges of cross-boundary transmission becomes much more material [85]. A particular challenge arises in India with using either generating capacity or actual generation due to the influence of central generation on the data. Central generation is not evenly distributed through the country – being concentrated in areas with large coal reserves or hydropower potential. Clustering of central generation in certain states may depress the need for build up of additional state owned generation. In addition, central

[84] Capacity data must, however, be treated with some care. Stated 'name plate' capacity may over-estimate actual capacity – particularly as plant ages and capacity re-rating either does not take place or does not make its way into official aggregated reports. The World Bank suggests that only 60% of typical developing country generating capacity is available, on average, at any time – compared to 80% for a well-run system (World Bank 1994).

[85] Transmission across international boundaries is also becoming increasingly common in developing as well as developed countries. Studies that rely on capacity data to evaluate electricity system development will increasingly have to make adjustment for capacity implied in the importing and exporting of electricity.

generation, although physically located in a given state, is commonly transmitted to serve multiple state markets. Historically, capacity and actual generation data were collected for state owned and centrally owned assets separately. There is insufficient data available to apply an accurate apportioning of central generation to recipient states particularly for the earlier years in the time series. It is therefore challenging to specify, from the supply side, the actual electricity available for consumption in each state. Consumption data does not suffer from this drawback.

None of the above candidate dependent variables, including consumption figures, capture two potentially important additional factors – notably the distribution of electricity access within a state's population[86] and the quality of service experienced by electricity consumers (Hulten 1996). Quality of service is an important measure that, left un-captured, may misrepresent the value of an electricity system to the population and underestimate the positive effects of investment (Guild 2000). For instance, investments that reduce the number of unplanned outages may not appear in any of the three indicators defined above but may have economic and developmental benefits[87].

[86] Breakdowns of electricity consumption by economic sector but not by geography (e.g. rural / urban) or income group are available that go some way to shedding light on the distribution of the benefit of electricity system development. National Sample Survey Organisation studies are available that provide some insight into distribution of electricity consumption but not at the frequency required nor do they capture the actual consumption of electricity – only the availability of a connection (National Sample Survey Organization 2008).

[87] These include an ability to rely more confidently on a service, support the use of more sophisticated machinery and potentially remove the need for duplication of service provision – e.g. captive power generators for industrial and commercial firms (Lee and Anas 1992). Canning recognized this issue and included measures of transmission loss as a proxy for service quality in his database of infrastructure (Canning 1998) – although transmission losses do little to represent the consumer experience in terms of service interruption or voltage / frequency stability

Prior to 2001, consumption was calculated as total generation plus central generating station allocation, net imports from other states or countries less generating station auxiliary consumption and transmission and distribution losses[88]. It is therefore clear that consumption data provides the most complete view of the actual use of electricity within each state – giving due account to electricity produced elsewhere but distributed and consumed within the state. From a development perspective, consumption of electricity is a more direct indicator of the quality of each state's electricity system – being focused on end use and being agnostic with regard to the location of generation[89]. It should also be noted that the pre-2001 definition of consumption is arguably a more robust indicator of the value of the electricity system to the economy and society. Post-2001, the exclusion of inefficiencies in generation (through high auxiliary electricity demand and more importantly, transmission and distribution losses) has the potential to flatter electricity consumption figures.

[88] Captively generated consumption is not included in consumption figures (this includes consumption by the railways from their own generating facilities).
[89] Fundamentally, from a development perspective, the indicators that matter are those that measure infrastructure service rather than infrastructure stock (Guild 2000). Electricity consumption serves as a better proxy of the service provided by the electricity system than that provided by generating capacity.

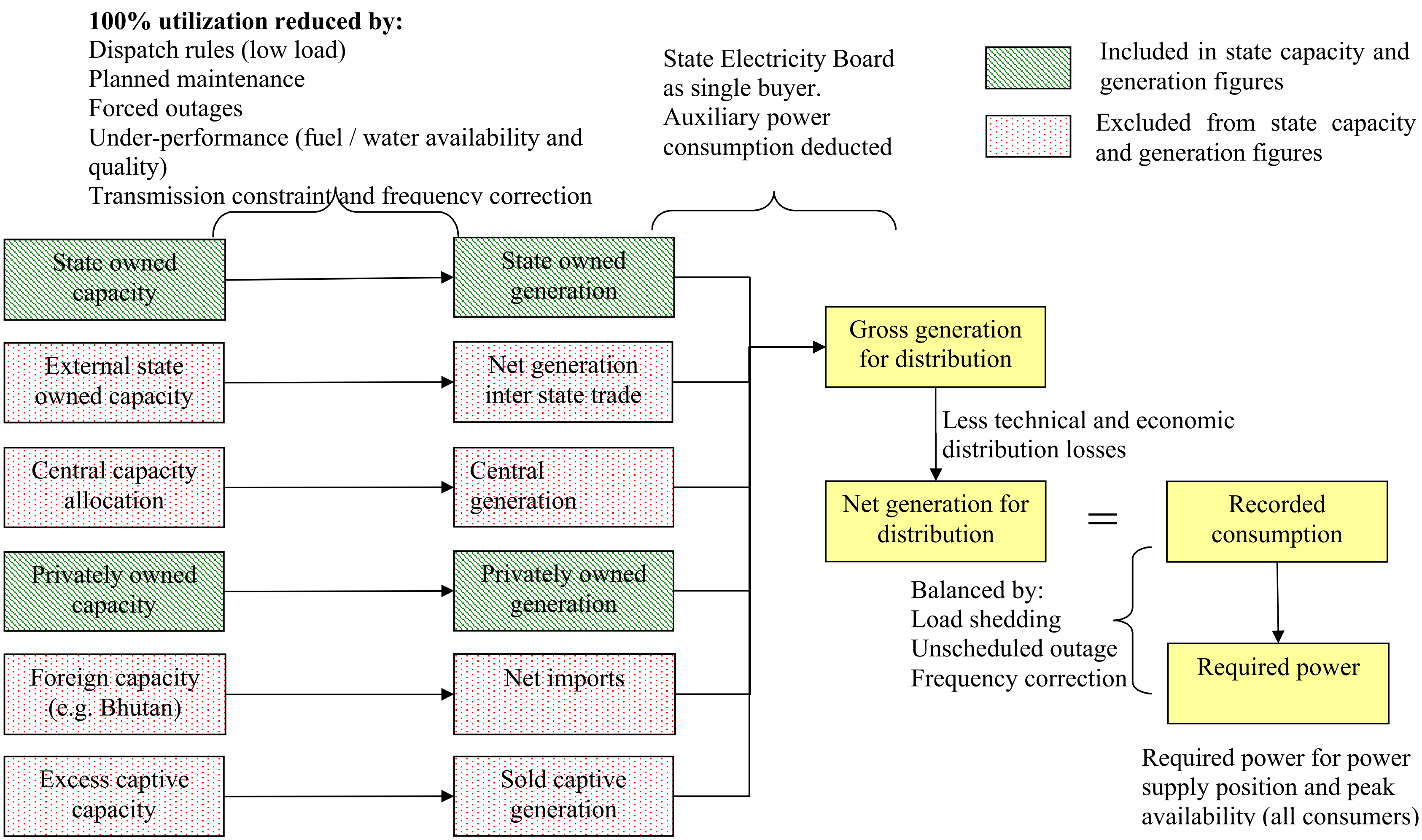

Figure 5.1: Electricity capacity, generation and consumption data schematic

Finally, to improve the comparability of state data it is necessary to transform the data with respect to state size. Two potential approaches are considered:

- Electricity indicator per unit of state domestic product
- Electricity indicator per capita

Of the two measures, a per capita transform is better suited given the broad definition of development explored in chapter 2 (i.e. not a narrow focus on economic growth) and is supported by much of the literature (e.g. Canning 1998).

5.3.3 Explanatory variables

Candidate explanatory variables, focused on indicators reinforcing processes of path dependence, are drawn from the literature. As discussed in the introduction, there is a small but valuable literature examining the determinants of electricity sector investment. The focus has primarily been on the institutional and political influences on electricity reform programmes. The broader development literature, however, as discussed in chapter 2, has made greater progress in exploring underlying rather than proximate influences on development (economic growth in the case of most broad development analyses). Given the particular nature of electricity system development care has to be taken in selection of potential explanatory variables from the broader development literature - candidate explanatory variables do not always reflect the particular challenges of electricity system development – and therefore require some adaptation. Details of the selected explanatory variables are discussed below and are summarised in table form in section 5.3.5.

5.3.3.1 Geographical Endowment

Development economics literature generally recognises the importance of certain immutable characteristics of a region's geography in economic development. A commonly identified characteristic is whether a region is landlocked as identified by Sachs and Warner (Sachs and Warner 1995). This is driven by expected higher transport costs experienced by landlocked territory – together with a related potential lack of economic openness. However, given this study's focus on electricity systems and the over-riding importance of the railways rather than shipping as a means of transporting primary energy (coal), it is not felt that landlockedness has any specific explanatory power for the electricity system development (other than indirectly through the channel of potentially higher state income as found by Sachs and Warner). However, topography also has the potential to influence infrastructure development (Banerjee and Somanathan 2007). Various measures of topography could be used. In this study – given the focus on electricity systems, those topographical features that have the potential to act as barriers and increase the cost of either the transportation of coal or the development of transmission infrastructure are considered. As Canning notes in creating his database of infrastructure stocks – the cost of providing infrastructure varies with geography (Canning 1998). An indicator has been developed that reflects the proportion of steeply sloped land, snow-bound and glacial land, rocky, ravenous and waterlogged land with respect to total land area[90]. The expected result is that those states with more geographical barriers will see slower development of their electricity system.

[90] The indicator is calculated as a percentage of the specified land categories relative to total state land area using data sourced from Indiastat (Indiastat 2003) – the land categories are those created by the Ministry for Rural Affairs.

The availability of natural resources – specifically potential primary energy sources is also considered. From the literature, the following potential channel of influence is suggested – namely that areas with considerable natural resources may suffer from the resource curse as discussed in chapter 2 and result in lower electricity system development due to lower overall economic growth. The resource curse literature itself suggests a number of possible channels of influence (Collier and Goderis 2007). At a state rather than national level only some channels of influence for the resource curse are viable – notably those that rely on institutions rather than exchange rates and terms of trade. In addition, the resource curse can only manifest if the natural resource is tradable. In the context of India's electricity system, this has been true for coal since independence due to the availability of a highly developed railway infrastructure[91]. It is therefore hypothesised that those states with considerable coal production may have fallen prey to a manifestation of the resource curse that resulted in less energy production and consumption in the home state and lower economic activity. For the purpose of this study therefore, decadal coal production figures have been collated and interpolated for intervening years.

5.3.3.2 Demographic variables

As discussed above, the dependent variable in the analysis is transformed into its per capita equivalent – recognising the importance of population size in evaluating the utility of electricity system development. However, from an electricity system perspective, not

[91] On the other hand, the other major primary energy source – hydroelectricity, has not been an effective tradable commodity for much of the research period due to the immaturity of transmission networks and physical inability to move the primary energy source itself.

only is it suggested that population size is important in determining the benefits of system growth – but the distribution of population is a determinant of that growth. As identified in the introduction, a number of studies examine the degree of urbanisation as a candidate explanatory variable in infrastructure studies (Bergara et al. 1997, Canning 1998, Zhang et al. 2002, Esfahani and Ramírez 2003). This is based on the premise that the per capita cost of creating infrastructure assets such as electricity systems is reduced in more densely populated areas[92]. This study follows this approach and includes a measure of urbanisation captured by the decadal India census. Intervening years are populated by interpolation.

However, India is a large and heavily rural country - over 70% of the population lives in rural communities (Indiastat 2001a). Urbanisation data does not give a sufficient definition of the distribution of population within the country. It is suggested that electricity system development is influenced by the broader level of distribution of the population through the country. An additional indicator has therefore been developed to measure distribution of population between the districts of each state[93]. A spatial gini coefficient has been calculated at decadal intervals from census data that describes the degree to which population is distributed between the districts (Henderson and Wang 2007, Asadoorian 2008)[94].

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[92] This is also reflected in the reality of electricity system development in the developed world in the late 19th and early 20th centuries – where early development was focused on urban areas (Hughes 1983).

[93] It is recognised that district level data is not particularly fine grained in the context of Indian states with population size of 10 million+ relatively common. However, this is the lowest spatial scale of population data available consistently through the period under analysis.

[94] The gini coefficient is calculated such that if population is evenly distributed the gini value will be zero; if the entire population lies within a single district the gini value is 1.

5.3.3.3 Historical context

The potential for historical factors to influence contemporary development is theoretically founded in the principles of path dependence explored in chapter 2 (Arthur 1989, David 1993, Martin and Sunley 2006). A particular field of enquiry – initially focused on overall economic development - is the effect of colonial influences on modern post-colonial states (Sokoloff and Engerman 2000, Acemoglu et al. 2001, Lange 2004). The primary channel through which history affects current development is based in the structure of institutions. It is argued that this effect is particularly strong in the field of infrastructure development due to the major role of public sector regulatory bodies and public ownership as initially identified by Levy and Spiller (1994). This work was leveraged by Banerjee and Iyer in the context of public good provision (Banerjee and Iyer 2005). They noted that Indian districts that had a land revenue system based on collection of revenues by a local class of landlords significantly under-performed other districts on a number of measures including agricultural yields but also as number of broader measures of social infrastructure provision such as education and health. This was despite the fact that this assignment of land revenue system was effectively the result of certain historic accidents (Iyer 2007). This analysis uses the British revenue system dummy formulated in the above study in the context of electricity system development. The dummy takes a value between 0 and 1 depending on the proportion of districts that were under direct or indirect British rule respectively.

Another historical characteristic that may influence contemporary behaviour is the role of private sector institutions. Esfahani and Ramirez created a private sector dummy to determine whether the extent of private ownership was a factor in the development of a broad range of infrastructure services (Esfahani and Ramírez 2003). As discussed in chapter 4, after independence the Indian states were directed by the Electricity (Supply) Act 1948 to create state electricity boards to manage electricity generation and distribution within the state. Practically all previously privately owned electricity infrastructure was rolled under the SEBs. However, five private electricity licensees have remained in operation to the present day (under grandfathered rights allowed under the 1948 Act). The potential for these private companies to influence the development of their states' electricity systems is examined by the creation of a dummy variable to identify those states in which a private licensee was in operation throughout the research period. The argument behind the inclusion of a private sector dummy in this analysis differs from that suggested by Esfahani and Ramirez. In their case, the argument is a classic neoliberal assessment of whether a privately operated infrastructure provider will operate more efficiently than an equivalent in the public sector. In this study, the potential for inefficient interaction between a private sector operator and an SEB in a single jurisdiction may actually have hindered system development through the loss of potential economies of scale that were otherwise available to those states that had no private competition. A negative relationship between the existence of private electricity providers and overall electricity consumption is hypothesised.

5.3.3.4 Agglomeration economies

In the tradition of Myrdal, Hirschman and Hansen (Myrdal 1957, Hirschman 1958, Hansen 1965) and others, it is assumed that the existing level of economic activity is a significant contributor to future accumulation or growth. More recently, new economic geography has endeavoured to explain the spatial distribution of activity (Fujita 1988, Krugman 1991, Venables 1996)[95]. A key insight is that an initial (random) difference in endowments between regions can lead to long lasting differences in performance and therefore act as an important driver of path dependence. This has been explored in terms of economic growth in India through examination of whether historic income levels are a good predictor of future income levels (Ahluwalia 2000, Rao et al. 1999, Kurian 2000, Bajpai and Sachs 1996).

The economic development literature discussed in chapter 2 indicates that there is a strong relationship between economic growth and electricity consumption (Zhang et al. 2002, Ghosh 2002) although the direction of causality is still disputed and probably runs in both directions (Chen et al. 2007, Jumbe 2004). For control purposes, state domestic product (SDP) is included as an explanatory variable. SDP needs to be considered with caution. The norms and procedures for capturing regional scale equivalents for national income accounts are imprecise and comparisons both between states and within states over time should be treated with some skepticism. In this instance, log transformed net state domestic product in current prices is used. The use of current prices removes potential error induced by changes to indexing strategy over the long period of this analysis. Log transformation assists in ensuring the data is stationary as exponential growth is the anticipated norm for economic indicators such as GDP. Net state domestic product – eliminating financial flows across state boundaries better captures the economic health of the individual state. A World Bank time series has been employed –

[95] Ottaviano and Thisse provide a useful review of this literature (Ottaviano and Thisse 2004).

available from 1960 to 1994, and official MoSPI figures are used for the latter part of the time series (Ozler et al. 1996, Ministry of Statistics and Programme Implementation: National Accounts Division 2007).

The agglomeration literature has been extended to recognise that a given region's success may not solely depend on its own historical success but also on the progress of its neighbours – based on the perspective that a flourishing neighbour will provide an additional attractive market – described as spillover effects (Romp and De Haan 2007). In the context of India's electricity systems, the SEBs have been organised under a set of five regional electricity boards (REBs) since the 1960s. There is therefore a potential REB effect in the development of the states' electricity systems. The electricity consumption of each state's REB members (excluding that state) is included in the regression with the expectation that higher regional electricity consumption will support higher state consumption.

5.3.3.5 Political Influences

The major politics-related contribution to the literature focuses on the quality of the institutional environment for infrastructure investment. The argument is based on the premise that investment will only occur in a 'credible policy environment for investors' (Henisz and Zelner 2006, Henisz 2000, Knack and Keefer 1995) – i.e. an environment with minimal political interference and strong, independent regulation. Valid as this consideration is in a liberalised electricity sector open to independent power producers, it is not fitting for much of the period of study for India - where private capital was excluded and almost all investment was driven by central and state governments.

Attractiveness to investors, however, does become increasingly relevant post-1991. Other considerations felt to be important in the literature are:

- the prevalence of disadvantaged groups – namely scheduled castes and scheduled tribes;
- the size and strength of influential interest groups identified in the literature (rich farmers, industrial companies).

A body of research examines public good provision in regions with considerable ethnic fractionalisation (Alesina et al. 1999, Easterly et al. 2006, Kimenyi 2006). There are two possible mechanisms for this. Easterly's proposal is that the majority grouping chooses to divert fewer of their own resources into non-excludable goods consumed, in part, by other ethnic groups. The other mechanism, that could play out in a federal structure such as India's is that a weak minority group has insufficient ability to lobby for public good spending in their state. Banerjee and Somanathan have explored this question in the context of India and amongst other considerations, have examined the role of scheduled caste and scheduled tribe size as explanatory variables for public good provision – including the degree of rural electrification (Banerjee and Somanathan 2007). Betancourt and Gleason reach similar conclusions with regard to the influence of the proportion of scheduled caste members on the reduced delivery of non-infrastructure public goods - doctors, nurses and teachers (Betancourt and Gleason 2000). To test this hypothesis, a time series of the proportion of scheduled caste and scheduled tribes members has been constructed from decadal census data.

The literature also suggests that the agricultural lobby is a key barrier to improving the efficiency of the electricity system (Kale 2007, Kannan and Pillai 2002, Rao 2004). The agricultural sector's interest in electricity is based in the dominant use of electricity in irrigated farming and in the massive subsidy provided to the sector through provision of below cost or even free electricity. Tariff structures are complex but average agricultural tariffs as reported to parliament in 2006 varied between Rs.0 and Rs.2.77 per KWh. This compared with Rs.1.52 – Rs.7.44 per KWh for equivalent commercial consumption and Rs.1.57 – Rs.7.04 per KWh for the lowest category of industrial consumption (Indiastat 2006b). However, lobbying activities cannot readily be examined directly. It is proposed that the percentage of irrigated agricultural land to total land provides an indicator of the degree to which the agricultural community can benefit from below cost electricity supply. Decadal data is available from the census and is interpolated for intervening years[96].

The largest consumer of electricity in India is the industrial sector. It is therefore necessary to test whether electricity consumption is primarily driven by the size of each state's industrial economy rather than by the other factors discussed above. Henisz and Zelner argue that a large industrial share in electricity consumption acts as a 'lobby for discipline' (Henisz and Zelner 2006: 267). There are concerns with using a direct

[96] An alternative strategy might have been to use agricultural electricity tariff as a proxy for the benefits available to farmers. There are two problems with this approach. There is limited data availability for the entire period under analysis. In addition, there has historically been limited metering and chronic non-payment for electricity consumed by farmers suggesting that tariff may not have been a meaningful influence on farmers' actions in many cases.

measure of industrial electricity consumption, as there is potential endogeneity – even with a lag in the industrial consumption variable[97]. It is also possible for disaffected industrial concerns to cease to be a 'lobby for discipline' and develop captive generation capabilities instead – at which point their consumption becomes invisible to the majority of electricity statistics. Conscious of this risk, an alternative indicator has been selected - productive capital employed per capita. The strength of using this data as a proxy for industrial influence is that it provides an indication of the relative importance of industry to each state without any direct influence from the strength of the electricity system. However, a complicated inter-relationship between electricity use, economic growth and industrialisation remains that is challenging to unravel. This data has been captured at decade intervals and interpolated between those dates.

5.3.4 Ensuring stationary data

All selected regression techniques assume stationary data – i.e. data that does not show any serial correlation over time. Nelson and Plosser first discussed role of non-stationary in macro-economic studies – noting that most such time series were, in fact, non-stationary and required de-trending prior to executing regressions (Nelson and Plosser 1982). Per capita electricity consumption exhibits an exponential trend. To ensure the data is stationary it is necessary to de-trend the data using log transforms and first order differencing. This comes at a cost of a reduction in the number of observations available

[97] Henisz lagged the ratio of industrial electricity consumption by only one year that is arguably too short a period to eliminate endogeneity given the lead-time associated with bringing new generating capacity online.

for interrogation[98]. Unit root tests (augmented Dickey-Fuller) were performed for the individual time series for each state to test stationarity both before and after transformation. Results showed that for most states the above transformation had rendered the time series stationary although a few states (e.g. Gujarat) continued to show some trend. However, it was judged that the additional loss of data from second order differencing would have outweighed the improved stationarity in the time series of a small number of states.

A number of explanatory variables required similar transformation to ensure like for like comparison – notably those that are based in financial or other economic criteria. Full details of transforms undertaken are provided in section 5.3.5 below.

[98] However, Kennedy notes that the risk of assuming stationarity where it does not exist generally outweighs the cost in reduced data points of applying first order differencing (Kennedy 2008).

5.3.5 Summary of Data

Data Element	Time Series	Details	Stationary?	Label	Source
Dependent variable					
Per capita electricity consumption (GWh)	1960 – 2001 with gaps		No – log transform and first difference	Consum	India Statistical Abstract
Explanatory variables					
Geography					
Geographical barrier	Dummy	Topography identified as a transportation or transmission barrier	Yes	Barrier	India Statistical Abstract
Coal production	1960 – 2001 with gaps	Physical coal production in tonnes. Interpolated decadal observations	No – log transform and first difference	Coal	India Statistical Abstract
History					
Direct British rule during colonial period	Dummy	Dummy variable between 0 and 1 depending on the proportion of districts with direct British revenue collection (0 denotes direct British control)	Yes	British	(Iyer 2007)
Pre-independence private electricity providers	Dummy	Set to 1 if a private power company existed throughout the research period.	Yes	Private	(Rao 2004)
Demography					

Data Element	Time Series	Details	Stationary?	Label	Source
Population density	1961 – 2001	Interpolated census data. Gini coefficient of district populations	Yes	Density	University of Maryland, plus primary census data[99]
Urban population	1961 – 2001	Interpolated census data. % of total population	Yes	Urban	Census
Agglomeration					
NSDP	1961 - 2005		No – log transform and first difference	NSDP	World Bank (to 1994). MOSPI thereafter.
Per capita consumption in REB	1960 – 2001	Sum of region consumption excluding this state.	No – log transform and first difference	Region	Indian Statistical Abstract
Politics					
Proportion of SC and ST	1961 - 2001		Yes	Caste Tribe	Census
% of irrigated agricultural land	1961 – 2001 with gaps	Decadal observations interpolated	No – first difference	Irrig	Indian Statistical Abstract
Capital employed per capita	1961 – 2001 with gaps	Interpolated from decadal observations	No – log transform and first difference	Capital	Indian Statistical Abstract

[99] The University of Maryland Indian census dataset was used as a practical expedient as it provided the required data in electronic form. However, recourse to the primary hardcopy census reports was occasionally required. Specifically, the University of Maryland database did not include data for Haryana and Himachal Pradesh; the district area data for 1991 was incorrect and a small number of other data inconsistencies were corrected with reference to the primary source.

5.4 Results

As discussed in the previous section, the model specification incorporates a number of historical and geographical time invariant explanatory variables that would be dropped from a fixed effects analysis. Therefore, a consistent random effects analysis is a pre-requisite for the interrogation of the time invariant explanatory variables. As an initial check of the validity of focusing on random effects models, a Hausman test is performed following OLS regressions under fixed then random effects (the Hausman test cannot be run with robust error estimation). The results are outlined below:

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)   sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+------------------------------------------------------------
-------
Caste        |   -.2108882    -.1067844       -.1041038        .4218199
Tribe        |    .6411213     .0534065        .5877149        .6877955
Irrig        |     1.49347     .5790956        .9143748        .8834899
Density      |   -.4261345    -.0219016       -.4042329         .275743
Coal         |   -.0501298    -.0487469       -.0013829        .0238664
Capital      |     .129732     .1390574       -.0093254        .0179467
NSDP         |   -.0696158    -.0727181        .0031022        .0072471
Region       |    .4373986      .431281        .0061175         .019405
--------------------------------------------------------------------------
b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

                  chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        5.46
                Prob>chi2 =      0.7075
```

With a p-value of 0.7075 we are not able to reject the null hypothesis that only the fixed effects estimator is consistent. This result provides validation that the analysis of random effects may continue with confidence. Before final selection of explanatory variables for testing, potential collinearity problems are investigated. A collinearity matrix is shown below:

	British	Barrier	Private	Caste	Tribe	Urban	Irrig	Coal	Density	Capital	NSDP	Region
British	1.0000											
Barrier	0.2119	1.0000										
Private	0.0319	-0.1281	1.0000									
Caste	-0.2029	-0.0689	-0.2765	1.0000								
Tribe	-0.5217	-0.2402	0.1630	-0.2625	1.0000							
Urban	**0.4644**	-0.2001	**0.4961**	-0.2429	-0.2116	1.0000						
Irrig	-0.0911	-0.2106	-0.1485	0.3526	-0.1621	-0.0341	1.0000					
Coal	0.0364	-0.1779	0.0959	-0.1148	0.1253	0.1246	-0.0721	1.0000				
Density	0.0575	0.0878	0.5654	-0.0507	-0.1375	**0.4554**	-0.2906	0.1761	1.0000			
Capital	-0.0152	-0.0630	-0.1201	0.0114	0.0080	-0.2487	0.0400	0.0049	-0.0695	1.0000		
NSDP	-0.0163	0.0548	-0.0419	0.0268	0.0152	-0.0217	-0.0065	0.0664	-0.0321	-0.1613	1.0000	
Region	0.0917	-0.0006	0.0029	-0.1439	-0.0344	0.0370	-0.0861	-0.0333	0.0265	0.2672	-0.1801	1.0000

The explanatory variable urban population percentage appears to demonstrate material correlation with gini coefficient, British revenue system and the private power dummy (highlighted in bold) – having a covariance > 0.4 with each of these explanatory variables. The collinearity with population density gini coefficient is readily understandable. Correlation with British revenue system suggests that current urban concentration has a historical catalyst[100]. Correlation with the private power dummy recognises the fact that the strong private electricity producers selected large urban areas for their businesses – common with the growth norms for electricity systems in most countries. Due to this degree of collinearity that would cause mis-estimation of p-values and coefficients, urban population percentage has been removed from the set of explanatory variables.

A two-way error component model regression was initially performed – recognising that individual errors are likely across the states and through time. To support this form of analysis in Stata, following an approach suggested by Goldstein and demonstrated in Stata by Rabe-Hesketh and Skrondal, a variant of the xtmixed model has been employed (Rabe-Hesketh and Skrondal 2008, Goldstein 1987). However, a likelihood ratio test performed to compare the two-way model to a standard random effects model with one-way errors under MLE suggests that the more sophisticated two-way error model may not be delivering any improvement to the fit of the model[101]. For simplicity, therefore a random effects model with one way error and

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[100] The alternate direction of causality – suggesting that the British adopted direct rule in more urbanised parts of India is also plausible.

[101] Two other model specifications – one with a random intercept by state and one with a random intercept and slope by state – were also undertaken. The random intercept only model proved to provide a sufficiently good fit compared to the more sophisticated random intercept and slope model. However, neither model was demonstrably a better specification than a standard one way random effects model when tested using likelihood ratios.

common intercept and slope is used for the remainder of the analysis below with maximum likelihood estimation [102]. An equivalent regression was also run, as suggested above, using time dummies instead of explicit modeling of a two-way error. Coefficients for the candidate explanatory variables were consistent with the mixed model. Two of the five-year plan dummy variables generated significant results – the third and sixth plans.

Having refined and simplified the model specification a set of three regression runs is undertaken to explore how the relationship between the dependent variables and the candidate variables has evolved over the research period. Specifically, the first regression tests the strength and significance of the relationship between the dependent and explanatory variables over the entire period. The second regression focuses on the first three decades of the research period - a period during which the development of the economy in general and the electricity system in particular was dominated by the central planning process. The third regression examines how the explanatory power of the candidate variables has changed with the shift in India's economy towards liberalisation and indicative-only central planning. Summarised results showing coefficients, standard errors and p-values for the three regression runs are presented in table 5.1.

[102] The two way model also experienced numerical solver difficulties – and very low error term coefficients – further evidence that the two way model, may in hindsight, have been a mis-specification of the model.

Table 5.1: Results of regression runs for 1961-2000, 1961-1990 and 1991-2000

	Regression 1: 1961-2000			Regression 2: 1961 – 1990			Regression 3: 1991 – 2000		
	Coefficient	Std Error	P value	Coefficient	Std Error	P value	Coefficient	Std Error	P value
British	-.0108441	.0138941	0.435	-.0128512	.015209	0.398	.0467746	.0272658	0.086
Barrier	.0738623	.0371504	0.047	.0672534	.0393897	0.088	.1026842	.0900522	0.254
Private	-.0083286	.0182057	0.647	-.0212945	.0193509	0.271	-.0682214	.0411459	0.097
Caste	-.0992017	.1243884	0.425	-.0741572	.1437724	0.606	-.4137163	.226525	0.068
Tribe	.0397634	.1015293	0.695	.1454013	.1115548	0.192	-.1905743	.1854764	0.304
Irrig	-.3006719	1.774748	0.865	-.0946122	1.913635	0.961	-1.518651	7.33715	0.836
Density	-.0211721	.035945	0.556	-.0051174	.039106	0.896	.1028597	.0739963	0.165
Coal	-.0576763	.0556989	0.300	-.0624743	.0551538	0.257	-2.149336	.7517013	0.004
Capital	.1468813	.0519112	0.005	.1046724	.052901	0.048	3.012762	.730909	0.000
NSDP	-.0797794	.0637549	0.211	-.0899095	.0642588	0.162	-.3929569	.194459	0.043
Region	.4316163	.08262	0.000	.5039953	.0841244	0.000	-.999609	.3007094	0.001
Constant	.0550798	.0321201	0.086	.0470033	.0349146	0.178	.0387685	.064393	0.547

A number of interesting observations are apparent from comparing the significance and strength of the explanatory power of the variables over the whole period as compared periods separated by the structural break of the commencement of liberalisation. Firstly, however it is clear that a number of candidate explanatory variables fail to prove useful in explaining electricity consumption in any of the periods.

Scheduled tribe proportion, area under irrigation and population distribution gini coefficient all fail to yield a statistically significant correlation under any of the periods analysed. The non-significance of scheduled tribe populations directly contradicts evidence in the literature related to the provision of public goods (e.g. (Banerjee and Somanathan 2001). Banerjee's study was based at the district level and focused solely on rural areas. It may be concluded that the effect of discriminated groups may be more closely felt in local rather than state and national politics. From an electricity perspective, Banerjee's rural focus provides insight into primarily two consuming sectors (domestic and agricultural) – that represent between approx. 30% and 60% of total electricity consumption. Again, at the aggregate level it is possible to suggest that the effect on consumption of electricity of disadvantaged groups is overwhelmed by other effects influencing, for instance, industrial and commercial consumption.

The non-significance of irrigated land may be an issue of variable endogeneity that requires instrumentation to resolve. The variable had been selected as a proxy for political influence of agricultural electricity consumers – with the assumption that greater influence of the agricultural consumer on the electricity system, the poorer the motivation to develop the system as agricultural consumers generally pay a below cost tariff (Kale 2007). However, area under irrigation would also directly influence electricity consumption (as irrigation pumpsets were increasingly electrified through the study period[103]). Thus, the direct political effect of increased agricultural influence over the electricity system is mitigated by increased consumption that comes with higher levels of irrigation.

The lack of significance of the political variables contradicts both conventional wisdom on the problems of India's electricity system and the results of case study analyses (Hansen and Bower 2003, Kale 2007). This suggests there is not a single political rationale for under-performance but also that individual state case study results cannot be readily transferred to other contexts. It is likely that a combination of political lobbies and discriminatory potential interacts with other measures of institutional strength to enable or suppress political influence as suggested in (Henisz and Zelner 2006). However, the significance of the scheduled caste indicator in the final period is an interesting observation and suggests that discriminatory practices are more evident in a more market-oriented period than when direct government policy has driven electricity system investment decisions. This theme recurs throughout this discussion.

It is probable that the gini coefficient is not a sufficiently granular measure although district level data was the most granular available. In addition, the effect of population concentration may change over time. In the early development of the electricity

[103] Pumpset energisation became an explicit policy objective following food shortages in 1965-66 the immediate success of which is reported in the 4th five-year plan which states that pumpset energization stood at 192,000 units in the 1960-61 financial year but rose to an estimated 1,087,600 in the 1968-69 financial year (Planning Commission, Government of India 1970).

system, population concentration is a key catalyst for the initial build-out of the system. However, as attempts continue to reach an increasing share of the population, a more homogeneous population distribution becomes advantageous. With hindsight, the gini coefficient probably fails to capture the essence of the challenge for electricity system development that, as the system matures, becomes less one of dispersal of the population but rather the remoteness of remaining unconnected populations.

The power of the candidate explanatory variables to explain the change in electricity consumption is not strong for the full period and in the first period. Only the indicators related to agglomeration economy (per capital productive capital and regional electricity consumption) together with the geographical barrier indicator are significant giving support for hypothesis 2.1 that planning can mitigate the effect of state characteristics on electricity system development. However, supporting hypothesis 2.2, the explanatory variables demonstrate much more correlation with the dependent variable in the second period. The explanatory variables are discussed in turn.

The British revenue system is not significantly correlated with electricity consumption in the first period but has a particularly strong relationship in the second period. On initial evaluation, this appears counter-intuitive. One might expect deep-seated institutional influences that demonstrate path dependence to exert a weaker influence as time passes. However, it is suggested that an accommodating national institutional context needs to be in place to allow the institutional differences of the individual states (locked in during the colonial period) to manifest themselves. The first research period was characterised by strong central planning for electricity system development. Certainly, the individual states were responsible for operating their own electricity systems but investment in system growth came, in large part, from the centre. As time has passed, two things occurred:

- The emphasis on system efficiency has increasingly swung to operations and maintenance as opposed to new plant build – exercising the institutional and managerial capabilities of the states rather than the investment efforts of the centre.
- The states have (particularly since 1991) had responsibility for attracting private capital to support the development of independent power projects. The more institutionally robust states have had greater success in attracting private capital.

It would appear that the role of the state relative to the centre has strengthened with economic liberalisation. Thus, the suggested historical institutional qualities of the states demonstrate greater influence over the ability of the states to deliver their electricity systems in a liberalised environment than a central planning context (that has greater policy efforts to minimise uneven development).

The geographical barrier variable demonstrates a significant relationship in the early period but not in the later period. Interestingly, the relationship is positive. It was hypothesised that this relationship would be negative – recognising the difficulty in building electricity systems across difficult terrain. Close examination of the data shows that Jammu & Kashmir and Himachal Pradesh have a dominating influence (with 61% and 32% of land identified as difficult terrain)[104]. A constrained regression

[104] To compare, the next ranked states in terms of geographical barrier are Rajasthan and West Bengal with only 6% of territory identified as challenging.

using these two states alone demonstrates a strongly negative relationship across the entire period as the theory suggested providing limited support for hypothesis 1.1 (although the relationship only passes a significance test at the 15% level). This suggests that a threshold proportion of difficult terrain may be necessary before it becomes an impediment to electricity system development.

The private power dummy is not significant overall or in the first period. However, a material, negative and significant correlation is observed in the second period. This fits with the theoretical position that the existence of private sector competitors results in weaker overall growth in electricity consumption. However, why is this relationship only significant in the second period under analysis? Two arguments would suggest that the effect of private power operators would weaken over time. Firstly, the aggregate size of the electricity sector has grown strongly over the research period in all states and a channel of influence of private power operators was the reduced potential for accessing economies of scale by having competing providers within a state. Over time, this pressure would have lessened. Secondly, as the economy liberalised in the 1990s, it might be expected that states with existing successful private sector electricity operators would have had greater success in embracing the opportunities made available through liberalisation (such as, for instance, attracting additional private capital into electricity generation). This factor is backed up by evidence on the distribution of private power projects in India. Over 25% of new private power plants developed in India since 1991 have been located in the three states with erstwhile private electricity companies (Gujarat, Maharashtra and West Bengal). In terms of capacity additions, over 50% were located in these three states (TERI 2006c). Despite this, the presence of private power operators is negatively correlated with the growth in electricity consumption. This suggests an accountability issue as states have increasingly been left to develop their own systems. It is argued that the presence of the private incumbents has had a negative effect on the activities of the state electricity boards in those states – perhaps allowing them to relinquish the imperative to improve the quality of their own systems. This effect suggests an opportunity for further research.

The relationship between productive capital employed (as a proxy for industrialisation), is significantly and positively correlated with electricity consumption. However, the coefficient measuring the effect is considerable larger in the second period. This mechanism is expected to work both through the direct effect of higher industrialisation driving higher electricity consumption but also indirectly through broader agglomeration economies – spillover effects between industries and also the force for discipline effect felt to be exerted by 'good' industrial consumers. It is possible that the relationship between industrial electricity consumption and total consumption was weaker in the first period – with more firms still having greater reliance on traditional energy sources - coal or diesel. It is also possible that the force for discipline failed to be effective in the first period as central planning played such a key role in state electricity system expansion in this initial period. However, there is no ready evidence for this. It is apparent that the spillover effect of strong industrial production in a state has proven to be attractive to both private sector and public sector generators in the 1990s – industrial customers face the highest tariff levels in all states – and therefore higher margins for merchant and independent power producers (including central sector generators). Commercialisation of the sector in the 1990s has driven those generators with a choice of location to favour those states with a strong industrial market. This represents strong evidence for hypothesis 2.2 but also weakens the evidence for hypothesis 2.1 as planning failed to break down the relationship between industrial strength and growing electricity consumption.

The results for coal production are illuminating. It can be seen that overall and during the first period there is no significant relationship and the suggested coefficient is relatively weak. However, during the 1990s the relationship becomes highly significant and strongly negative. The hypothesis is that coal-producing regions may succumb to the resource curse and, as a result, have under-developed broad economies (and consequently lower electricity consumption). This appears to be a further manifestation of the withdrawal of the centre from the direct control and management of national capital and infrastructure planning that accelerated during the 1990s – supporting hypotheses 2.1 and 2.2. As discussed, a major driver of electricity system investment has always been the five-year plan process. The declining role of central investment has enabled the underlying motivations of individual states to materially influence electricity system development. The resource curse effect, under a liberalised economic regime with lower central support, becomes visible. This theme is picked up in the next chapter in the context of electricity trading to examine in more detail whether certain states see resource trading as a preferred economic strategy to broader based economic development.

The results for the explanatory effect of state domestic product demonstrate a similar pattern to coal production. The relationship is insignificant over the full period and in the first period (with a low negative coefficient). Theory suggests that higher income and higher electricity consumption move in tandem. However, this theory is founded in a neoclassical economic context of free markets. In India, there has been explicit concerted policy action to broaden economic development across the country and the planning mechanism, as discussed in previous chapters, has provided various means to share resources. The conflicting interplay between the economic forces driving the virtuous circle of higher income and higher electricity consumption on the one hand and direct policy action to share economic development throughout the country probably explain the overall lack of significance of the relationship of SDP with electricity consumption one way or the other. However, during the 1990s the relationship becomes significant and more strongly negative. This appears anomalous – particularly in the context of the increasing liberalisation of the economy. If anything, one would expect the neoclassical economic forces to predominate in this period and demonstrate a positive relationship between SDP and electricity consumption. Close examination of the data shows that two states appear to be outliers in this period – Jammu & Kashmir (showing much higher per capita electricity consumption growth than suggested by SDP growth) and Orissa (showing much lower per capita electricity consumption than suggested by SDP growth). Rerunning the regression with these two outlier states suppressed yields similar results to the entire period – no significant relationship. There are rational reasons for suppressing the outlier results from these two states. Orissa was the first state to undergo radical electricity sector restructuring in the mid 1990s (vertical unbundling and privatisation). This represents a structural change in Orissa that resulted in an immediate focus on profitability rather than system expansion in the second half of the decade. This is evident from the decline in per capita electricity consumption in the state from 278 to 152 MKWh per million of population between 1997 and 2000[105].

[105] The fall primarily comprised industrial and agricultural consumption. Domestic consumption

Jammu & Kashmir, on the other hand, coming out of a period of considerable political instability and insecurity in the 1980s was given considerable central support to increase the pace of development. During the 1990s, electricity consumption expanded from 167 MKWh per million people in 1990 to 286 MKWh in 1999, despite relatively low SDP growth. Overall, therefore, there appears to be no strong relationship between SDP growth and electricity consumption growth.

Regional electricity consumption is seen to be a highly significant explanation of state electricity consumption in both periods and overall. However, interestingly, the sign of the relationship switches from positive to negative between the first and second periods. The suggested theoretical support for the neighbour effect comes from the agglomeration advantages of a state being closer to richer neighbours – that are able to provide markets for goods and services. In the first period, this effect may well explain the significant positive relationship between a state's electricity consumption and that for its region. However, in the second period two other factors have the potential to overwhelm this effect:

- The development of regional electricity grids that supported the transmission of electricity between states
- The growth of central generation stations explicitly structured to be able to serve multiple states.

During the 1990s, there were only limited formal institutions for buying and selling electricity across state lines – except for the transferring of central allocations and occasional bilateral trades from shared facilities. It is argued that states with weak

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dropped by a proportionately smaller amount.

electricity consumption may have increasingly seen opportunities to trade away electricity allocations to neighbours through transmission networks that were now capable of supporting this sort of economic activity. This effect appears to have been strong enough during this period to result in a statistically significant negative relationship between state and regional electricity consumption. In the 2000s, the transmission grid has been further increased in scale and formal electricity trading structures have been put in place that may present even stronger evidence for weaker states selling electricity as a means of improving state finances. This theme is picked up in chapter 6 and examined in detail.

The model employed above has used the maximum likelihood estimation due to the efficiency of the method. However, this efficiency can come at the expense of robustness (Wooldridge 2002). To challenge this choice, the regressions have been re-performed with both Stata's conventional variance-covariance estimator and a robust method. Table 5.2 details the explanatory variables that ceased to have a significant correlation under the two alternate estimation methods resulting from these tests.

Table 5.2: anomalies of regressions under different estimation methods

Period	Conventional estimation	Robust estimation
1961 – 2000	Barrier (marginal[106])	Barrier (marginal)
1961 – 1990	Barrier	Barrier
1991 – 2000	British (marginal) Private (marginal) Caste (marginal)	Caste (marginal)

The first thing that is clear is overall, there is considerable stability to the results across the different estimation approaches. This provides confidence that the basic model specification is sound. The degree of consistency under the robust estimation

[106] The discrepancy is labeled marginal if the correlation would have passed significance testing at the 15% level.

method in particular gives confidence as this method relaxes some of the more restrictive data and model assumptions such as a need for homoskedastic errors. However, of particular concern is the result for geographical barrier. As discussed above, the geographical barrier dataset is heavily influenced by two states (Jammu & Kashmir and Himachal Pradesh). There is little variation in the data for other states. It is therefore prudent to treat the results generated for this explanatory variable with caution. Other than this, it is suggested that the model specification and data set prove to be reasonably resilient to implementation approach.

5.5 Conclusions

In this chapter, the many competing opinions and qualitative evidence for how and why the Indian electricity sector has developed in the way it has have been set to one side to allow the evidence sourced from the data to inform the discussion. Using a long time series and the natural experiment produced by the state level management of much of the electricity sector in India it has been possible to build on the existing literature that has endeavoured to examine institutional factors to understand the success of electricity reform. The long time series, selection of historical and geographical indicators and performance of separate regressions for the pre and post-liberalisation period have enabled the testing of the hypothesis that the development of the electricity sector in India's states exhibits path dependence to deep-seated institutional factors and initial endowments and may therefore be resistant to policy action. Two principle objectives were defined:

- To identify the key factors influencing the long run effectiveness of the States' ability to develop their own power sectors (1961 – 2000).
- To explore evidence for the existence of a structural break in electricity system development in 1991 resulting from liberalisation.

The strongest influence on state electricity system development over time relates to agglomeration economies. The level of productive capital employed presents a strongly significant positive relationship with electricity consumption over the whole research period. Regional electricity consumption is also significant throughout – although as noted, the growth of neighbouring states' electricity consumption became negatively correlated with state consumption in the second period – potentially as opportunities for trading electricity (and relinquishing central allocations) increased (discussed in the next chapter). Surprisingly, however, the actual per capita wealth of a state actually appears to have limited impact on a state's ability to develop its electricity system. Overall, this delivers evidence for the rejection of hypothesis 2.1. Central planning has not been sufficiently strong to overcome the forces of agglomeration economy[107].

The role of physical geography and endowments is more mixed. There appears to be a relationship between the presence of geographical barriers and system development but the effect is only apparent if the proportion of terrain in the state is considerable and results are not robust to different estimation methods, providing only limited support for hypothesis 1.2. The presence of coal has no influence in the early period but does so in the second, post-liberalisation, period. This is evidence for the second hypothesis of a structural break in the management of the electricity system – greater central planning mitigated the potential of the resource curse in the first period – support for hypothesis 2.1. It suggests that, as hypothesis 2.2 states, there is a need for

[107] From chapter 4 it may be recalled that at different times through the plan period, agglomeration economies were both explicitly accepted as a price of overall development but at other times, explicit attempts were made to tackle this cause of economic unevenness.

liberalised market institutions to be in place for a state to select the option of generating income from the sale of resources rather than developing those resources for its own benefit.

The lack of correlation between indicators of political influence (both positive lobbying and discrimination of weak groups) and growth in electricity consumptions is evidence for the lack of any systemic political failing in the structure of India's electricity systems. However, caste did show a correlation in the 1990s suggesting that discriminatory practices may have become more evident with liberalisation – reinforcing hypotheses 2.1 and 2.2. If this evidence is evaluated alongside case studies taken from the literature, it suggests that political interference in electricity system development in India is very much a case-by-case problem. An alternative conclusion, of course, is that the selected explanatory variables were poor proxies of the effects of political activity on system development (quantifying political influence for statistical analysis is a notoriously difficult activity). Overall, there is little evidence from this study to suggest that hypothesis 1.4 holds true in a consistent and systemic manner across India.

The lack of influence of demography has a number of potential causes. The lack of population distribution data at a sufficiently granular level may have inhibited the power of the population distribution gini coefficient. Equally likely, the role of population distribution differs as the electricity system matures and is much more closely related to the marginal conditions rather than average conditions – i.e. during early development, electricity systems around the world have been encouraged by dense, economically active urban areas. This was seen in India with the early development of systems in Kolkata, Ahmadabad and Mumbai. As universal access is sought, the remoteness of the marginal communities contributes to the slowness of system development – rather than the average distribution of electricity across the state. Again, this study provides little evidence of a systemic relationship for hypothesis 1.1 as measured by district level population density distribution.

The role of historical characteristics of the states is particularly interesting. The presence of private power producers has shown a significant negative correlation with the growth in electricity consumption in the second period as theory suggested. Despite not being especially robust to different regression techniques, these results do provide evidence in support of hypothesis 2.2. The role of the British revenue system is particularly insightful. The historical effect of the style of British rule appears to have been nullified in the first period during which the role of central planning and investment in capacity expansion was critical – providing evidence for the support of hypothesis 2.1. However, in the later period the relationship became strongly positive as suggested by the results of Iyer and provides strong evidence to support for hypothesis 1.3 under the right enabling conditions and therefore for hypothesis 2.2.

Overall, path dependence does appear to have a degree of influence over the states' ability to develop their electricity systems although there is evidence that central planning has effectively mitigated a number of these influences. However, agglomeration economies appear to create a considerable force towards reinforcing existing concentrations of electricity consumption that proved resilient to planning efforts. There is also evidence that liberalisation of the electricity system represents a structural break or 'juncture' in the way states electricity systems are managed.

Liberalisation has amplified the potential for underlying state characteristics to reassert their influence – as the protective force of prescriptive planning from the centre has declined – reinforcing the potential path dependence. The quality of state level institutions as indicated by the type of British revenue system together with the negative correlation with coal production and regional electricity consumption all suggest that poorly run states have failed to manage the development of their electricity systems as effectively as their better run peers.

These conclusions are somewhat disturbing for both the national government and those states that are achieving less success. It is apparent that there are potential path dependencies in the electricity sector. The geographical and institutional starting point is shown to have influence over the future direction and speed of development of the sector. These influences are strongly reinforced by the continuing presence of agglomeration economy effects – despite the stated best efforts of planners over the review period. Liberalisation and the associated move towards indicative planning at the national level have seriously affected a principle policy instrument to mitigate underlying weaknesses of individual states and have allowed underlying characteristics to re-assert their influence over the states' potential. Opportunity exists for states to exploit the freedom of a liberalised electricity system (with greater technical integration through the national grid and electricity trading infrastructure) to place other economic objectives ahead of electricity system development. Through incompetence or narrow self-interest by elites, it has become possible for states to exploit their resources rather than develop their own electricity systems and provide universal access to their populations. Analysis of these questions is the subject of the next two chapters. Chapter 6 focuses on electricity trading as facilitated under the unscheduled interchange mechanism. A statistical analysis is undertaken to seek evidence for states with weaker electricity systems exploiting their electricity allowance from the central sector to raise income rather than consuming the electricity within their own state. Chapter 7 turns to the question of provision of universal access to electricity and questions whether the rural electrification policies developed in the current decade have included sufficient mechanisms to shift the failing states away from their historic path of under-performance and create a new path that may deliver universal electricity access for their populations.

6 Consequences of reform with institutional weakness: evidence from unscheduled interchange financial flows

6.1 Introduction

The spatial nature of India's electricity system is changing. The historic structure of the industry based on state-level generation supporting local markets with limited cross state integration has been slowly evolving since the 1950s. Since the 1990s, the pace of change has accelerated substantially to the point where India now has a national electricity grid with the ability to trade electricity throughout the country. Two factors have acted as the primary facilitators of change:

- Liberalisation and restructuring in the electricity industry;
- The technical integration of the electricity system.

Together these facilitators are enabling rapid change in the governance of India's electricity system. As with other developing countries, a primary motivation for reform has been increased financial viability and ability to attract private capital and corporate values into the sector (Jamasb 2006, Joskow 1998). This leaves a question of how reform is influencing the social benefits delivered by the sector. This chapter and the next focus on two different policy case studies that are influenced by path dependent institutional interactions. The first focuses on the potential unintended consequences of delivering sophisticated inter-state electricity trading mechanisms considering their interaction with long-standing institutional structures. The second examines the policy framework developed to deliver universal electricity access and evaluates whether sufficient policy tools have been conceived to overcome the institutional constraints that may have caused a lack of success in previous rural electrification programmes.

There is a growing literature that has critiqued the utility sector reform programme (Besant-Jones and Tenenbaum 2001b, Rosenzweig et al. 2004, Watts 2001, Williams and Ghanadan 2006, Woo et al. 2006, Yi-chong 2005, Yi-chong 2006, Buzar 2007). Within this literature, there has been a particular focus on the public value implications of reform (Reddy 2001, Dubash 2003, Steenhuisen et al. 2009, Jones 2009, Ehrhardt 2000, de Bruijn and Dicke 2006, Sihag et al. 2004). It is increasingly clear that approaches to reform have been too formulaic (Yi-chong 2006). Importantly, there has also been a readiness to lift experience from ill-fitting developed country contexts. Reddy argues that developed country rationales for electricity sector reform were primarily technologically driven whereas the motivation for reform in developing countries was "capital shortages, financial sickness of utilities and poor quality of electricity delivered" and that therefore the logic of industrialised country reform is "prima facie irrelevant" to developing countries (Reddy 2001: 76). This theme is built on by Rosenzweig et al who observe a predilection to acquire the most current tools:

> There has been a clear compulsion to implement 'state-of-the-art' market-based models that have been designed and, to some degree, implemented in other countries that are invariably endowed with a more highly developed power system that is in good physical condition and with compatible commercial and legal systems" (Rosenzweig et al 2004: 23).

Besant-Jones and Tenenbaum recognise the importance of the differing starting points for the reform process (Besant-Jones and Tenenbaum 2001b), focusing on price (above or below cost), capacity (insufficient or excess), coverage (closeness to universal access) and institutions (trustworthiness and track record of regulatory institutions). Per Besant-Jones and Tenenbaum's four principle starting point characteristics, India's electricity systems are characterised as having tariffs below average cost of supply, chronic under-supply, far from universal access and young regulatory institutions with little track record of consistent performance or success. Set against this, the electricity trading mechanisms developed in India in the last five years are 'state of the art' and successful application requires an institutional context that matches that sophistication[108].

Dubash argues that the social compact that drove initial electricity sector construction is no longer relevant in industrialised countries with near-universal access to high quality electricity services. However, in developing countries the failure to meet this social contract remains a key challenge for the industry and government (Dubash 2003). De Bruijn and Dicke provide a definition of public value in the context of utility regulation:

In the discourse on public values in the context of utility sectors, the central idea is that the state is responsible, either directly or indirectly, for safeguarding substantive public values such as universal services, continuity, quality of service, affordability, user and consumer protection (de Bruijn and Dicke 2006: 719).

It is not at all clear whether the reform programme has resulted in any public value benefit in a developing country context – particularly given the public values such as access that are important in a developing country context. As Williams and Ghanadan put it:

Public benefits such as access, social pricing, and environmental protection, though sometimes discussed during legislative debates, have rarely been included in actual reform design. There is little evidence to date that such benefits trickle down naturally

[108] The unscheduled interchange mechanism, discussed in detail below, is actually an indigenous policy instrument but is nonetheless highly sophisticated and expects institutional buy-in and strong management controls within the sector for it to work effectively.

from reform, and in the absence of countervailing policies the economic logic of reform can easily work against them (Williams and Ghanadan 2006: 838).

The literature therefore anticipates challenges with the deployment of sophisticated governance solutions in developing country electricity sectors and equally, anticipates that reform programmes are likely to do little to further the 'social compact' that is still perceived to be a critical part of the delivery of electricity in developing countries. This chapter takes a narrow case study that has not previously been examined with respect to institutional behaviour – the application of the unscheduled interchange mechanism in India – to explore the suitability of such a policy given the institutional legacy and the continuing challenge to achieve universal electricity access. The underlying state characteristics that correlate with particular approaches to the unscheduled interchange system are explained and an underlying causal theory for such behaviour is suggested. In this way, building on the electricity reform literature cited above, some specific empirical evidence is presented of an identified problem of implementing a sophisticated electricity system governance mechanism in a developing country context and the potential negative implications for the public value of the provision of electricity.

India now has two primary grids – the North-East-West (NEW) completed on 26th August, 2006[109] and the southern grid[110] (Narasimhan and Vyas 2008). The two are connected through asynchronous HVDC links (at Gazuwaka connecting the east and south and at Bhadrawati connecting the west and south). It is thus possible to trade

[109] The eastern and northeastern grids were synchronised as early as 1991.The eastern and northern grids were synchronised in 2002 and the east and west grids were synchronized in 2003 (Narasimhan and Vyas 2008).
[110] The southern and western grids were synchronised in the early 1990s but technical challenges caused this to be abandoned (Narasimhan and Vyas 2008).

electricity widely across the country. The processes of liberalisation have provided the institutions to support considerable electricity trading – particularly:

- Corporatisation of central generating plants – running the plants as commercial enterprises (although ownership remains public.
- Encouragement of captive generation and cogeneration with open access to the grid (section 38 of the Electricity Act 2003 specifies that the central transmission utility – PGCIL is obligated to provide non-discriminatory open access (Government of India, Ministry of Power 2003)[111].
- The corporatisation, in limited cases privatisation and creation of competition (in some states) in electricity distribution.
- The creation of a commercial national grid company (the Power Grid Corporation of India Ltd – PGCIL).

These changes in technical and institutional structure have made possible the introduction of three electricity-trading mechanisms:

- A national power exchange - launched in June 2008 (India Energy Exchange 2008).
- A market for bilateral power trades with the creation of electricity trading brokers under section 52(2) of the Electricity Act 2003[112] (Government of India, Ministry of Power 2003). CERC issued order 56 / 2003 on 30th January, 2004 detailing the regulatory structure for inter-state electricity trading (Central Electricity Regulatory Commission 2004c).

[111] CERC clarified open access rules in April 2004 (Central Electricity Regulatory Commission 2004b).
[112] Trading was undertaken from time to time under earlier legislation and was first tested under the new regulatory regime by PTC Ltd in 1999 (Central Electricity Regulatory Commission 1999).

– A mechanism for rewarding grid discipline – the unscheduled interchange payment process within the availability based tariff structure launched in April 2004 (Murali 2008).

Overall, 85% of generation is covered by long-term contracts leaving 15% of generation available for short-term trading under one of the mechanisms above (Bakshi 2009). The integrated transmission infrastructure coupled with the market institutions to facilitate trading have the potential to release considerable economic value by exploiting the supply and demand differences and cost imbalances between regions. Policymakers anticipate that the combination of open access and transparent pricing, based on a systemic demand-supply imbalance that is keeping traded prices high compared to cost of generation, will also encourage increased investment in independent and merchant electricity generators. However, there are other possible ramifications of the recent changes. The systemic mismatch of electricity demand and supply in the short and medium term are providing super normal profits to generating incumbents. This is causing considerable concern within the larger deficit states – with accusations of profiteering becoming more common[113]. Of course, the attraction of super normal profits is an important motivation for merchant power producers to consider investing in India. There is a regulatory balancing act to manage the perceived excessive profits of incumbents that are, from one perspective, receiving windfall gains against the rate of return necessary to encourage new entrants into the market to help close the demand-supply gap.

[113] CERC order 15/2007, discussing the raising of UI rates includes submissions against the proposal from a number of states including Uttar Pradesh, Punjab and Haryana citing profiteering by central generators, and huge financial flows from deficit states to surplus states amongst other arguments for not raising the UI rate (Central Electricity Regulatory Commission 2007a).

This chapter interrogates financial data relating to unscheduled interchange (UI) payments to provide insight into decision-making processes of the states' electricity buyers (primarily the state electricity boards). How can the financial flows associated with over or under-drawing from the grid be interpreted? Does this market mechanism amplify or reduce the unevenness apparent in the Indian electricity system?

To explore these issues, net UI payments for the first half of 2008 are analysed. Bilateral electricity trades are not analysed in this study due to practical difficulties in attributing trades to states[114]. Power exchange trades are also excluded from the analysis as the market is still in it infancy and power exchange trades comprised only 0.47% of electricity generation in September 2008 compared with 92.99% through long term power purchase agreements, 3.34% through short term bilateral trades and 3.2% through the UI mechanism (Central Electricity Regulatory Commission 2008b).

The extent to which the states use the UI mechanism varies considerably. To understand the drivers of these differing approaches, a model is constructed to test a number of hypotheses regarding the size and direction of flow of electricity through the UI market mechanism. This study is concerned with understanding the behaviour of the states (and state controlled entities) as buying entities in the UI mechanism – not the selling role of the central government public sector undertakings in supplying electricity into the grid.

[114] Many bilateral trades have a commercial organisation acting nationally or across a number of states as one of the counterparties making it problematic to attribute the trade to any particular location. Details of the location of measurement of the transaction on the grid for the purposes of agreeing contract value are provided so it may, in further study, be possible to interrogate this data to infer location of the trade counterparties.

The rest of the chapter is laid out as follows. Firstly, the mechanics and legislative / regulatory support for the unscheduled interchange mechanism are briefly discussed. Secondly, a set of theoretical hypotheses for engagement in the UI mechanism, based on the economic structure of the mechanism and institutional criteria are defined. Thirdly, the model is discussed in more detail with the assumptions and practical challenges of working with the data laid out transparently. Fourthly, engagement in the UI mechanism is analysed statistically and results are presented. Finally, the results are interpreted and some of the consequences of introducing the market mechanisms are revealed.

6.2 The unscheduled interchange mechanism

UI is the most complex of the new forms of electricity trading. UI is one part of the availability based tariff (ABT) structure that was introduced in section 24 of the CERC (Terms and Conditions of Tariff) Regulations, 2004 (Central Electricity Regulatory Commission 2004a). ABT is currently only implemented for the centrally owned generators (state owned generators are still primarily paid on a single part tariff) and are paid by all states benefitting from the generation of a given generator. It splits the wholesale tariff into three parts:

- A capital component reflecting the fixed costs of the generator (i.e. those that need to be paid irrespective of any generation).
- A variable component reflecting the cost of generation – primarily the fuel cost. The generator receives payment from a recipient state equal in cost to the proportion of scheduled electricity to be injected into the grid for that state.
- The UI component is the cost incurred by the generator for under-injecting into the grid and an additional payment to the generator for injecting more than

scheduled. Equivalently, any electricity purchased (e.g. a DISCOM) makes a payment for over-drawing per schedule and receives a payment for under-drawing per schedule. However, critically, the size of the extra payment or cost is dependent on the grid conditions (specifically, the frequency) for each period.

The mechanics of scheduling are briefly as follows[115]. A day ahead, the generator provides details of expected output for the following day to the regional load despatch centre (RLDC). Submissions from each generator are aggregated and then broken down for each state and provided to the respective state load despatch centres (SLDCs). The SLDC determines their strategy for meeting expected demand for the following day and report their drawal requirements for that day. The RLDC then informs the generator of their generation schedule (broken down into 96 fifteen-minute blocks).

The key to the UI mechanism is that there is no obligation to conform to the injection and drawal schedule. The generator can inject more than scheduled into the grid in the knowledge that they will continue to receive payment for that extra electricity – but only at a price determined by the UI rate schedule. Figure 6.1 details the current UI schedule as well as three previous schedules as published by CERC. Importantly, it can be seen that if frequency is high (i.e. demand is low relative to supply) then the UI payment received by the generator declines until it reaches zero at a frequency of 50.5. Rationally, the generator will increasingly be encouraged to back down generation as frequency rises – acting as an automatic feedback loop – reducing frequency.

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[115] The details of the UI mechanism draw heavily on the ABC of ABT by Bhushan (2005) together with the relevant CERC documents.

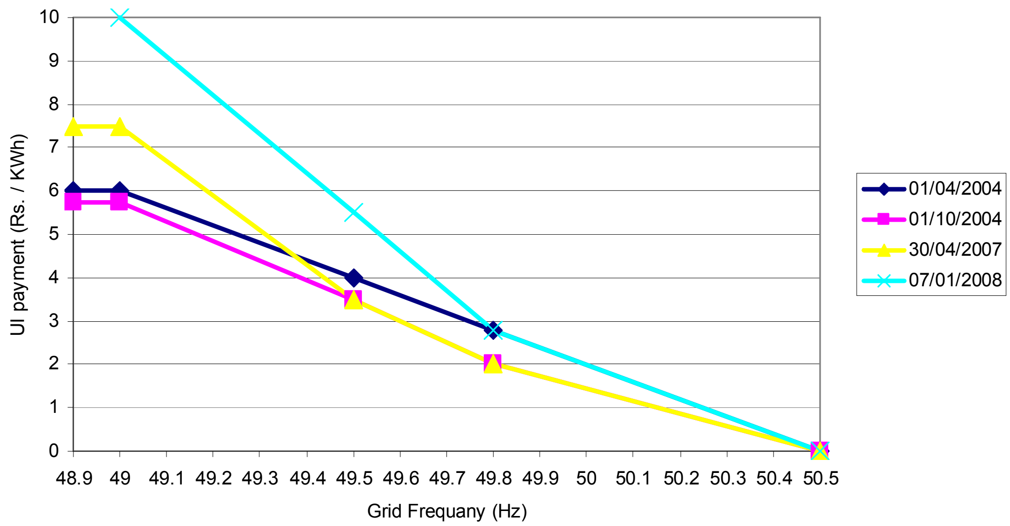

Figure 6.1: UI rate schedule as published and amended by CERC
Source: Central Electricity Regulatory Committee (various documents)

The mechanism has an analogous effect when grid frequency is low (the more common scenario in the chronically under-supplied Indian system). At low frequency where demand is exceeding supply, the UI rate is high and acts as an incentive for the generator to increase output. Through this action, frequency stability can be restored.

Note the intent is not to endeavour to stabilise frequency at or around 50 Hz although this would be the norm in an industrialised country electricity system. As CERC describes it:

Frequency is the most critical parameter in power system operation. The standard practice followed globally is to maintain the grid frequency at or very close to the rated value (50.00 or 60.00 Hz, as the case may be) all the time. A deviation beyond 0.05 Hz would be considered alarming in developed countries, and a deviation beyond 0.1 Hz would be unimaginable. However, in India we had a history of frequency varying from below 48.0 Hz to above 52.0 Hz, and remaining beyond these levels for hours together, which led to innumerable grid collapses in Eighties and Nineties. (Central Electricity Regulatory Commission 2007a: 13).

Rather, frequency fluctuation in the range 49 to 50.5 Hz is tolerated as a pragmatic recognition of the challenges of imposing more rigid grid discipline and is not considered problematic. Outside these parameters, however, the cost of over or under generating become penal (Rs. 0 receipt for generating when frequency is greater than 50.5 and a penalty payment of Rs. 10 for under-generating when frequency is less than 49 Hz). In reality, due to the chronic under-supply into the Indian electricity grid, low frequency is the norm. Table 6.1 provides details:

Table 6.1: Percent of time grids perform within frequency ranges. Apr–Sep 2008

	Below 49 Hz	Between 49.0-50.5 Hz	Above 50.5 Hz	Max. freq Hz	Min. freq Hz
Northern, Eastern, Western, North-Eastern grid					
April, 2008	29.75	70.24	0.01	50.53	48.44
May, 2008	3.23	96.07	0.7	50.71	48.65
June, 2008	4.9	95.03	0.07	50.62	48.67
July, 2008	9.25	90.75	0	50.51	48.5
Aug, 2008	5.21	94.45	0.34	50.72	48.67
Sep, 2008	13.04	86.95	0.01	50.56	48.58
Southern grid					
April, 2008	9.98	89.97	0.05	50.81	48.56
May, 2008	5.36	94.59	0.05	50.91	48.51
June, 2008	14.48	85.5	0.02	50.69	48.52
July, 2008	31.63	68.35	0.02	50.54	48.27
Aug, 2008	18.8	81.16	0.04	50.62	48.25
Sep, 2008	5.69	94.27	0.04	50.79	48.34

Source: Central Electricity Authority 2008c

The UI mechanism also requires a strategic response from the electricity buyer (primarily the state electricity board or other publically owned body as defined under the Electricity (Supply) Act 2003). The impact of behaviour is detailed in table 6.2.

Table 6.2: Matrix of results of diverging from schedule under UI mechanism

	Behaviour	Pay into / receive from UI pool
Generator	Under-inject	Pay into
	Over-inject	Receive from
State electricity buyer	Under-draw	Receive from
	Over-draw	Pay into

Source: author's interpretation from Bhushan 2005

Given the typical frequency condition of the Indian grids as shown in table 6.1, the cost of UI is typically at the higher end of the range indicated in figure 6.1. UI is payable or receivable only on the divergence of generation and drawal from schedule. The mechanism has the form of a non-cooperative game (Mukhopadhyay and Dube

2005) in which the players act independently yet the payments and receipts received by each player in the market are dependent on the actions of all other players in the market. A generator choosing to generate more than scheduled is gambling that other generators are not all doing likewise as the possible resultant over-supply could result in the UI payment for that period being very low. Equally, an electricity distributor choosing to over-draw per their schedule is gambling that other distributors on the grid are not also planning to over-draw – which would push the UI price to very high levels. It is also possible for the generator to attempt to game the system by deliberately scheduling generation at a level much below their capacity. This may be done in the expectation that frequency is likely to be low at peak times of the day and plans can be made to quickly ramp up generation to gain access to high UI prices – effectively forcing the distributor to pay substantially above marginal cost. Recognising this potential, section 22(2) of the Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2004 make provision for identifying and punishing gaming. The RLDC is empowered to investigate any actual generation in excess of 105% of scheduled in any 15-minute period and 101% over the course of a day – and has the power to eliminate any UI payments received due to gaming. The UI mechanism is also prone to outright abuse and non-payment by the generators and (more commonly) the electricity buyers. UI is fundamentally a zero sum game in which payments and receipts net to zero. Non-payment by, for instance, states over-drawing per their schedule results both in those states effectively getting free electricity at the expense of states that have under-drawn or generators that have exceeded their schedule. This is a common scenario and box 6.1 discusses a particularly egregious example in the case of Uttar Pradesh.

Box 6.1: Non-payment of UI – the case of Uttar Pradesh

The unscheduled interchange mechanism appears theoretically elegant. However, it is only able to deliver on its objective of enforcing grid discipline if the mechanism is strictly enforced. The Electricity Act 2003 provides the means to enforce payments under the UI mechanism and these have been tested on numerous occasions since the introduction of UI in 2003. A number of states, including Madhya Pradesh, Bihar, Jharkhand and Jammu & Kashmir, have been served orders for non-payment of UI dues by CERC under the powers provided by the Act. However, the largest and most long-running dispute that has tested the powers and willingness to act of CERC has been with regard to Uttar Pradesh (UP).

UP had already been served with orders in both 2003 (petition 20/2003) and 2005 (petition 33/2005). Petition 131/2007 related to non-payment of UI dues amounting to Rs. 5,779.9 million as at 30/11/2007. This had grown to Rs. 7,670 million outstanding as at 31/3/2008. CERC noted in its 5/11/2007 interim order that UP had demonstrated a pattern of behaviour of non-payment of UI dues that had only been remedied previously by persistent regulatory pressure. Given this and the scale of outstanding dues, it was felt that:

"…on account of continuing overdrawal from the grid by UPPCL this year and laxity in payment of UI charges, the outstanding UI amounts are growing at an alarming level and urgent remedial action is called for" (Central Electricity Regulatory Commission 2007b: 2).

UP's response to the charge included the following mitigating reasons:

- The need to over-draw due to the huge gap between supply and demand that have been exacerbated by increases in the UI rates.
- The increase in the UI ceiling rate from Rs.5.70/kWh to Rs.7.45/kWh has been challenged in the State High Court.
- UP receives insufficient allocation of electricity from northern region central generating stations in relation to its power supply position.

The standard response from CERC to explanations of non-payment has been a declared lack of interest in the underlying reasons followed by a demand to meet an appropriate schedule of payment. In the case of order 131/2007, however, CERC has been more vocal – as the following excerpts from their response illustrates.

"We must point out that it is the respondent itself who is primarily responsible for planning to meet the demand of consumers in the State, and existence of such demand–supply gap is indicative of inadequate planning and action over many years. Even today, there is little evidence of adequate concrete action." (Central Electricity Regulatory Commission 2007c: 4)

"If UI amounts are not paid, it amounts to abstraction of energy from the grid and not paying for it, in other words, nothing short of a theft." (Central Electricity Regulatory Commission 2007c: 5)

"…the Commission has presently no alternative but to revert to physical curtailment of supply, even if it jeopardises the grid security, since allowing continued UI payment default would only encourage total anarchy in grid operation, which this Commission can not allow." (Central Electricity Regulatory Commission 2007c: 7)

CERC ordered UP to repay all outstanding dues in six monthly installments or power supply from central generation stations would be curtailed without further discussion. This has taken place in the context of an on-going battle between UPPCL and CERC regarding the hikes in the UI ceiling rate. CERC had to take recourse to the Indian Supreme Court to over-turn a Uttar Pradesh High Court decision to disallow the UI rate increase. Eventually an accommodation was reached between CERC and UPPCL that provided for payment of UI arrears in 10 equal payments and for on-going UI charges to be capped at the old ceiling rate of Rs. 7.45 rather than the current agreed rate of Rs. 10.

Payment schedules were complied with until October, in which there was an underpayment of almost Rs. 640 million. CERC held UPPCL in breach of compliance with directions and fined the utility Rs.100,000. The final twist in the conflict was delivered in the order dated 12/2/2009 in which it was confirmed that the managing director was also guilty of non-compliance with CERC directions (under powers provided in section 149 of the Electricity Act 2003). However, citing the peculiar conditions of the case, a decision was taken not to use the powers available under the act to imprison or fine the responsible party, Shri Awanish Awasthi.

6.3 Theoretical hypotheses

Given the structure of the UI mechanism, there are a number of strategies that an electricity buyer might choose to adopt to maximise benefit from the mechanism. Figure 6.2 defines four possible scenarios (other than the default scenario of abiding precisely to the pre-agreed drawal schedule).

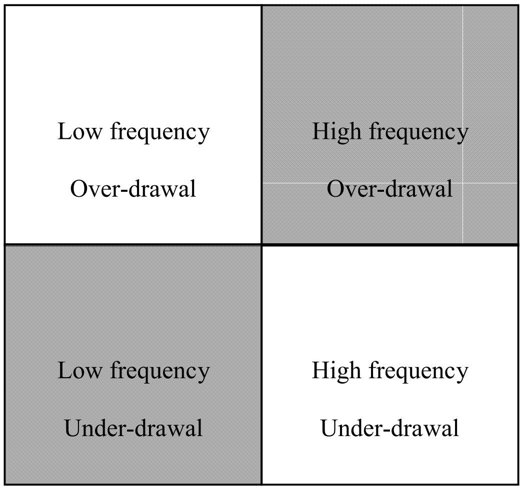

Figure 6.2: Four square representation of buyer scenarios under UI
Source: Author's interpretation from Bhushan 2005

Bhushan's ABC of ABT Bhushan 2005 suggests a set of strategic responses by the state (the state load despatch centre to be precise) based on demand and the frequency level[116]. It is assumed that the shaded scenarios do not require careful evaluation as the course of action is unambiguous – if under-drawal is required at low frequency the state will be heavily rewarded for forgoing scheduled drawal. If over-drawal is desired when frequency is high, the extra drawal will be attainable at a very low UI rate. The difficulty arises when over-drawal is desired under conditions of low frequency when a punitive UI price will have to be paid or under-drawal is required under conditions of high frequency when a very low UI price will be received. Table 6.3 details the strategic response for the key unshaded scenarios shown in figure 6.2.

[116] And also based on a theoretical presumption of rational economic behaviour.

Table 6.3: suggested response to demand under different frequency conditions

Condition	
Over-drawal in low frequency situation	Under-drawal in high frequency situation
Increase central station requisition to full entitlement (if not fully requisitioned earlier).	Restore customer load that may have been shed.
Maximise generation at intra-state stations having variable cost less than the prevailing UI rate.	Back down intra-state generation having variable costs higher than the prevailing UI rate.
Harness captive and cogeneration to the extent available at a price lower than the prevailing UI rate.	Reduce drawal schedules for the central generating stations whose energy charge is higher than the prevailing UI rate.
Explore the potential of purchasing power through a bilateral trade.	Arrange a bilateral sale.
Curtail customer load	

Source: Bhushan 2005

Bhushan's suggested responses under different conditions suggest some criteria that might influence the states' decision on how to act. The following hypotheses, based on assumed rational economic behaviour by commercially minded institutions, have been identified and these are tested for validity:

– States with a high cost of self-generated electricity are incentivised to import electricity from outside their state. An evaluation of whether to accept a high UI price for over-drawal will be done with reference to the marginal cost of generating that additional required electricity within the state.
– States that have set high tariffs are more able to accept the high cost of over-drawal under supply-constrained conditions. A state that is able to recoup the high cost of UI when forced to overdraw in a low frequency situation will have a higher incentive to draw the additional electricity rather than curtail customer load.
– States with chronic under-supply as represented by a heavily negative power supply position have to make greater use of market mechanisms to fulfill customer demand.

Bhushan's analysis of strategies available to electricity buyers are heavily based on a presumption of economic rationalism. However, it has been broadly discussed in preceding chapters that the electricity industry is prone to politicisation and that deep-seated institutional rigidities can influence electricity system development – and that institutional actors behave in only a boundedly rational way. Given this perspective, it is possible to conceive of some additional hypotheses for explaining engagement with the UI mechanism. Based on an institutional approach it is possible to conceive of some critical hypotheses that challenge the motivations of the buying institutions.

- States with unserved rural customers choose to benefit financially by under-drawing their scheduled entitlement of electricity rather than working to extend their network and meet the demand of their potential customers.
- States with a low institutional capacity fail to benefit from the complex UI mechanism.
- States with coal as a material contributor to the economy (and therefore an institutional history of profiting from natural resources) perceive electricity as an additional tradable energy resource to be exploited for profit.

In the next section, a model is created that allows for the testing of this set of hypotheses and the selection of data is discussed in detail.

6.4 Model specification and data considerations

It is proposed that multivariate linear regression is undertaken to probe the states' drivers for engaging with the UI mechanism. The following model has been constructed:

$UI_i = \alpha + \beta_1(psp_i) + \beta_2(cog_i) + \beta_3(ait_i) + \beta_4(consum_i) + \beta_5(coal_i) + \beta_6(brit_i) + \beta_7(village_i)$

Where:

i = each of the nineteen large states (excluding the north east region as complete information was unavailable for the period under study)

UI_i = unscheduled interchange payment for the period Apr – Sep 2008 in Rs. million.

psp_i = a measure of power supply position for the period Apr – Sep 2008. Both aggregate power supply position in MU (Standard Indian terminology for GWh) and power supply position as a percentage of consumption are tested. Data for actual figures for September 2008 taken in October 2008

cog_i = marginal cost of generation for the financial year 2006 / 07 (latest available data)

ait_i = average industrial tariff as at end of year 2005 (latest consolidated data available)

$consum_i$ = several measures of electricity consumption for the financial year 2004 / 05 in MU (latest available data).

$coal_i$ = value of coal as a percentage of gsdp for the financial year 2005 / 06 (latest available data).

$brit_i$ = dummy variable representing the form of British government during the colonial era.

$village_i$ = indicator of village or household electrification. Several alternative official data sources are tested.

6.4.1 Dependent variable – unscheduled interchange

The dependent variable in the analysis is the total net UI payment (or receipt) for the period (first half of the financial year – Apr-Sep 2008). Aggregate financial indicators for the extent of trading activity are selected rather than measures of quantity of electricity traded. Reports have been aggregated from the four relevant regional load despatch centres. The monthly reporting requirement of the regional load dispatch centres requires only the net UI financial flow by state to be reported. The western region RLDC, provides a fifteen-minute breakdown of scheduled and actual drawal along with the prevailing frequency to facilitate calculation of UI and the deviation of actual power drawal from that planned for the period. However, not all regions place this data in the public domain.

UI account flows are reported on a weekly basis by each of the RLDCs. Data are provided for both generators and electricity buyers. Buyer data is provided on a state-by-state basis. Net UI flow for each state is calculated as the simple sum of each weekly UI flow for the 26 weeks covered by the research. Note there is a presumption in this analysis that the UI account is actually settled. Although there have been numerous instances of failure to pay UI dues (as described in box 6.1), the regulator has, to date, always succeeded in negotiating a payment plan for paying down overdue balances – thus, the state does in the end pay.

The explanatory variables in the model specification have been selected based on possible commercial or political motives for engaging in electricity trading defined above. These shall be considered in turn.

6.4.2 Power supply position

It has been hypothesised that a state will only enter into electricity trading if it is unable to meet its demand obligations at reasonable cost from its own resources, long-term power purchase agreements and central allocations. Put another way, the greater the gap between demand and supply, the greater the incentive to secure additional supply through short term bilateral trading or over-drawing from the grid and incurring UI charges. Chronic under-supply of electricity in India has resulted in the monthly reporting of the size of that demand – supply shortfall at the state level (a statistic not captured in western electricity systems with a more robust demand–supply balance). Power supply position and peak demand met are the two measures of the demand–supply gap in India. Power supply position is measured in MKWh and evaluated over a period and reported monthly and financial year to date by the CEA in its monthly reporting suite (Central Electricity Authority 2005a). Supply can be measured with some precision but demand is more problematic. Actual consumption is known but this is, by default, equivalent to actual supply less losses and auxiliary use. Power supply position actually measures the quantity of load shedding and forced outage (on the assumption that a shed load and unexpected loss of supply is demand unmet). Peak demand met (measured in MW) reports the maximum difference between demand and supply for any fifteen-minute period in the reporting period.

By the nature of its calculation, it can be seen that power supply position is inclusive of inter-state trading i.e. the calculation is made after the inclusion of all short-term electricity trades. This is problematic as it makes the power supply position variable somewhat endogenous as power supply position can be reduced, for example, by increasing the quantity of electricity purchased bilaterally or overdrawn from the grid.

6.4.3 Marginal cost of generation

The marginal cost of self-generated electricity is potentially critical to the commercial decision to undertake inter-state trading. Based on the assumption that, at the margin, electricity buyers will be seeking to meet demand at lowest cost, the cost of generating the next unit of electricity from state-owned resources is to be evaluated against the market price of importing that electricity. If it costs more to generate that electricity internally (based on the variable cost of generation – primarily fuel - not the sunk capital cost) than it would cost to buy in the market or over-draw from the grid and pay UI charges then the state-owned generator should be backed down or not scheduled. The UI price is consistent across the northern / eastern/ western grid with a potentially separate price for the asynchronous southern grid (as the frequency may be different on the southern grid). Therefore, those states with a high marginal cost of self-generated electricity ought to have a greater propensity to go out to the market to meet marginal demand.

Cost of electricity generation by station is provided to the central electricity authority by the respective states on an annual basis (Indiastat 2006a). The latest available data for the financial year 2006 / 2007 has been used in this study. The numbers submitted provide average cost of generation by generating station (Kerala provided aggregate figures only). Marginal cost of generation is not provided. However, the chronic under-supply apparent in all states (and illustrated by reported data on power supply position above) allows an approximation to be made. For the purposes of this study, the marginal cost of generation for each state is assumed to be the cost of generation of the most expensive unit in the state's portfolio based on the hypothesis that dispatch will be accomplished through some rational merit order process within each system operator[117].

[117] Occasionally, the most expensive generator makes an insignificant contribution to overall generation and is therefore excluded on the basis that it is unlikely to influence decision making.

6.4.4 Average industrial tariff

Analogous to the cost of power discussion, it is hypothesised that motivation to engage with inter-state electricity trading is influenced by the tariff that can be secured for selling on that electricity in the local distribution market. Tariffs in India are determined by state level regulatory authorities under the supervision of CERC. Tariff orders are costly negotiated contracts and, in most cases, do not change frequently. Tariffs vary considerably by state and by category of consumer within state. Agricultural consumers in all cases face the lowest tariffs, followed by domestic customers, commercial customers and finally industrial consumers that commonly pay substantially more. The industrial consumer, from an economic perspective, is the marginal customer i.e. if there is an additional quantum of electricity available, the industrial customer should be serviced first as they will generate the largest receipts. The level of industrial tariffs is therefore used in this study to explain propensity to act in the inter-state trading markets. Industrial tariffs, in all states are broken down into a number of sub-categories based on the size of load. Therefore, an unweighted average of industrial tariffs has been developed. Data provided by Indiastat has been used in this case – as the most recently available consistent aggregation of tariff data across all the states (Indiastat 2006a).

6.4.5 Electricity consumption

It is hypothesised that those states with higher electricity consumption have a greater inclination to engage in electricity trading. This is based on the premise that those states with a stronger marketable demand for electricity will have greater incentive to procure additional electricity through trading to support that demand.[118] Care must be taken when analysing the influence of electricity consumption levels on electricity trading. Due to the inability to store electricity in material quantities there is an identity relationship between electricity supply and electricity consumption. Whatever is supplied (net of trading) has, by definition to be consumed. The quantity of electricity traded (if not specifically, the value) is automatically endogenous to the consumption indicator. Prior to 2001, consumption was calculated as generation less electricity used in power station auxiliaries and less transmission and distribution losses (Central Electricity Authority 2005b). However, post 2001 the Central Electricity Authority determined to follow international practice and employ UN standard methodology for measuring electricity consumption – production + imports - exports (United Nations Statistics Division 2004)[119].

To mitigate this endogeneity, consumption data is lagged. Therefore, consumption data from 2004 is selected (Central Electricity Authority 2005a) – 2004 being the earliest date for which appropriately granular data is available for all states (including the new states, Chhattisgarh, Jharkhand and Uttarakhand) following the year the Electricity Act was introduced.

A second consideration is whether aggregate consumption data should be selected or whether per capita data would be more appropriate. Figure 6.3 plots net UI payments against electricity consumption with the bubbles representing state population.

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[118] The consumption metric measures actual, realised demand – rather than the latent demand of those, for example, not currently connected in to the electricity grid.
[119] Note that transmission and distribution losses are not factored into this definition of consumption. In the case of India, with high technical and economic losses, this shift to the U.N methodology has resulted in a potential over-statement of (legal) electricity consumption.

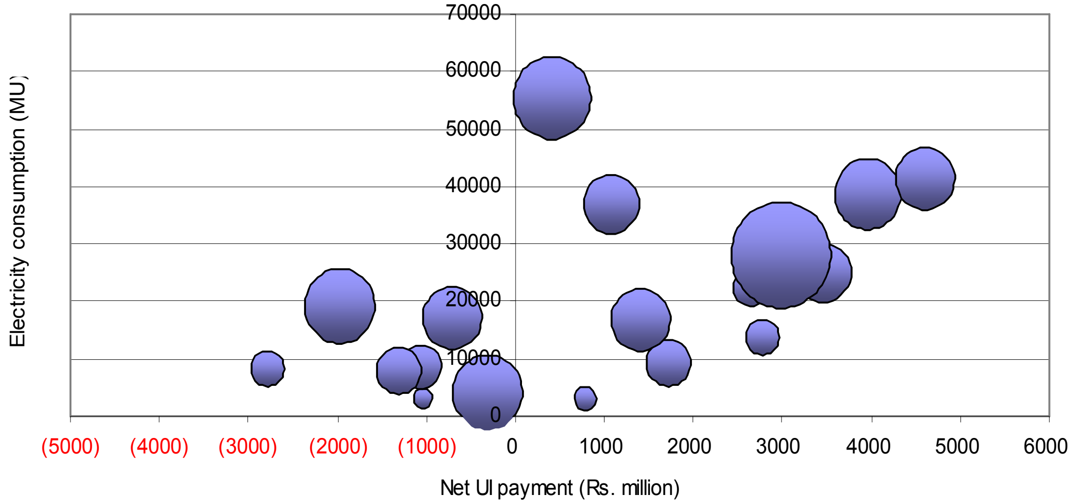

Figure 6.3: X-Y plot of UI payment against consumption (bubble area = pop.).
Source: As per aggregate UI data and electricity consumption data

Although there appears to be some correlation between population size and the absolute size of net UI payments (i.e. the larger states have a slight tendency to have larger UI flows), the relationship does not appear strong. However, to analyse the potential effects both aggregate electricity consumption and per capita consumption are considered in the model.

Finally, as discussed, electricity consumption is equated to total generation (per UN statistical conventions). Total generation includes captive generation by industrial units for their own use. It can be argued that the existence of large quantities of captive generation capacity bears little influence on a state's decisions in terms of supplying its own customers. Therefore, captive generation is excluded (as detailed in table 8.9 of the annual review).

6.4.6 Availability of indigenous coal

The selection of an indicator of coal availability as an explanatory variable has a different theoretical basis to the selection of the previously discussed explanatory variables. The theoretical foundation for the selection of this variable is based on the potential for the resource curse to influence electricity-trading decisions. As discussed in chapter 2, the resource curse can act through several mechanisms. The commonly quoted foreign exchange / terms of trade mechanism are clearly not applicable to a single state within a country analysis. However, the institutional channels through which the resource curse can act are applicable at the state level. The hypothesis to be tested is that an energy resource rich state is institutionally set up to extract financial returns from the sale of energy resources. Historically, this has commonly implied the sale of coal but with the creation of a national electricity grid and economic structures to trade, electricity may have become a marketable commodity that can be exploited in an analogous way to how coal has historically been exploited.

Selection of data to test this hypothesis is based on the theoretical premise that the resource curse will act through institutional channels that have formed over time. The historic availability of coal is therefore potentially important to the analysis. The relative importance of coal to the economy might also be of importance – based on the premise that those states with a less diversified economy may have historically had a greater incentive to build up the institutional structures to extract rents from natural resource exploitation. Several approaches might be adopted.

- Use of a dummy variable set to 1 for those states with material coal reserves and zero otherwise;
- Absolute value of reported coal reserves;
- Current data on coal production;
- Current data on the materiality of coal to the state economy;

Each has its weaknesses. The use of a dummy variable does not support any differentiation in behaviour based on the size of coal reserves. However, it can be argued, that a propensity to exploit energy reserves is not sensitive to the size of those reserves once a threshold level has been reached. The absolute level of coal reserves has proven to be volatile over time, as surveys have resulted in recategorising of known reserves. This may render spurious the role of the absolute level of coal reserves in forming an institutional environment in which financial exploitation of natural resources is formed. Likewise, current data on coal production may do little to increase understanding of the historical foundations for the institutional environment. In addition, a current snapshot of the importance of coal in a state's economy (as measured by the value of coal production as a percentage of GSDP) may provide little insight into the historical motivations to develop institutions based on the exploitation of natural resources. To complicate the analysis, the state reorganisation in 2001 affected coal rich states. In particular, the bifurcation of Bihar into Jharkhand and Bihar resulted in Bihar moving from a coal rich state to a state with no coal reserves at all (as all the coalfields were in the part of the state that became Jharkhand). Similarly, the creation of Chhattisgarh resulted in the loss of coalfields to Madhya Pradesh. Thus, the reconstruction of historical data that recognises the current state structure is problematic.

Given the challenges, a coal reserves dummy developed using data provided by Indiastat is used (Indiastat 2007a). Also, both the value of coal mining and percentage contribution of coal mining to the state economy has been selected – using value of coal production[120] statistics compiled by the Central Statistics Organisation (Central Statistics Organization 2008) and gross state domestic product data (GSDP) provide by the Reserve Bank of India (Reserve Bank of India 2008)[121]. This has primarily been done to ensure the sample size for the statistical analysis remains sufficient for a robust analysis – by allowing for the inclusion of the three new states formed in 2001.

6.4.7 British rule

In chapter 5, the long-term ramifications of the style of British rule adopted in different parts of India were tested against a long time series of electricity consumption data. The same data are used here to determine whether a correlation exists with the approach to the use of the UI mechanism. As before, the proportion of each modern day state under different forms of British rule has been estimated using the data provided by Iyer (2005). The channel through which this interaction works remains the same – a set of locked in institutional capabilities that influence both the ability to engage in sophisticated market activities and the motivations to achieve particular outcomes.

6.4.8 Village electrification

An important perspective on the availability of market mechanisms in the electricity system is that disempowered consumers may lose out in preference to an opportunity to increase revenues through under-drawal from the grid. Part of the potential of this effect is captured in including a measure of consumption in the model. However, this only captures the effect of existing customers on UI. In India, in contrast to most developed countries, there is a large population that is not classified as a consumer as

[120] Lignite mining, which is reported separately in the official statistics, is used in the analysis and affects the data for Gujarat, Rajasthan and Tamil Nadu.
[121] Data is taken for 2006 at current prices with the exception of Jammu & Kashmir from where the latest data available is from 2005.

they do not yet have access to the electricity system at all. It is hypothesised that efforts to expand access to electricity to these disadvantaged communities may be subordinated to the opportunity to monetise electricity by limiting drawal from the grid rather than improving access to perceived low value rural customers. On-going electrification efforts are largely focused on rural electrification. There are two primary indicators of rural electrification used in India and both have been included in initial regressions:

- Village electrification – a village is deemed electrified if there is a suitable step-down transformer located in the village, if public buildings such as schools are electrified and if at least 10% of households are electrified.
- Household electrification looks at individual households and is therefore the more accurate measure of the availability of electricity to end consumers.

Village electrification is reported monthly through the CEA and data is taken from the end of the review period - September 2008 (Central Electricity Authority 2008d). However, household electrification is measured by sample survey only and is therefore both less frequent and potentially less accurate. This study uses data from the most recent National Sample Survey Organisation survey undertaken in 2007, measuring household use of electricity for lighting - on the assumption that a household with electricity access will, as a first step, switch to electric lighting (National Sample Survey Organization 2008).

6.5 Analysis of UI financial flows

The above discussion suggests a number of potential hypotheses for explaining the use of the UI mechanism by the states. However, there are only 19 possible observations comprising the full set of large states in the four large regions. This population size restriction limits the complexity of model that can be tested using linear multivariate analysis. Seven hypotheses have been proposed and a number of alternative indicators of the effects have been suggested. In order to focus in on the most promising explanatory variables for the size of UI payment / receipt, a bivariate linear regression has been performed on each candidate explanatory variable in turn. The results are captured in table 6.4.

Table 6.4: Results of bivariate regression of explanatory variables against UI

UI_Rs	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
power_supply position_MU	-201015.4	206522.6	-0.97	0.344	-636740.1	234709.3
_cons	-4.92e+08	6.10e+08	0.81	0.431	-7.94e+08	1.78e+09
power_supply_position_%	-2.49e+07	7.44e+07	-0.33	0.743	-1.82e+08	1.32e+08
_cons	6.16e+08	8.41e+08	0.73	0.474	-1.16e+09	2.39e+09
mc_power	607496	382055.6	1.59	0.130	-198570.9	1413563
_cons	4.21e+08	5.42e+08	0.78	0.448	-7.22e+08	1.56e+09
avg_industrial tariff	6038534	5349702	1.13	0.275	-5248350	1.73e+07
_cons	-1.56e+09	2.18e+09	-0.72	0.484	-6.16e+09	3.04e+09
gross_consumption	46486.14	22487.25	2.07	0.054	-957.8101	93930.09
_cons	-4.50e+08	7.71e+08	-0.58	0.567	-2.08e+09	1.18e+09
per_capita_consumption	4980809	2160053	2.31	0.034	423496	9538121
_cons	-1.03e+09	9.24e+08	-1.11	0.281	-2.98e+09	9.20e+08
coal_rich_dummy	-1.86e+09	9.11e+08	-2.04	0.057	-3.78e+09	6.49e+07
_cons	11.72e+09	6.27e+08	2.74	0.014	3.97e+08	3.04e+09
value_of_coal	-2996.811	1394.746	-2.15	0.046	-5939.466	-54.15479
_cons	1.67e+09	5.93e+08	2.82	0.012	4.20e+08	2.92e+09
coal_%_of_gsdp	-2.14e+10	8.08e+09	-2.64	0.017	-3.84e+10	-4.32e+09
_cons	1.55e+09	5.05e+08	3.08	0.007	4.87e+08	2.62e+09
british_rule_dummy	2.42e+09	1.09e+09	2.22	0.041	1.17e+08	4.72e+09
_cons	-5.40e+08	7.66e+08	-0.71	0.490	-2.16e+09	1.08e+09
village_electrification	3.79e+07	2.41e+07	1.57	0.135	-1.30e+07	8.88e+07
_cons	-2.48e+09	2.17e+09	-1.14	0.268	-7.05e+09	2.09e+09
rhhs_electric_light_%	2.72e+07	1.78e+07	1.53	0.144	-1.03e+07	6.48e+07
_cons	-9.76e+08	1.28e+09	-0.76	0.456	-3.67e+09	1.72e+09

It is possible to see that a number of the hypotheses can be rejected immediately. There appears to be no significant correlation (at a 95% level) between net UI payments / receipts and the following explanatory variables:

– power_supply_position_mu
– power_supply_position_%
– mc_power
– avg_industrial_tariff
– gross_consumption
– coal_rich_dummy
– village_electrification
– rhhs_electric_light_%

Before confirming rejection of the hypotheses supported by these explanatory variables, it is valuable to reflect on the theoretical basis for their original inclusion.

On the surface, the lack of correlation between power supply position and engagement with UI is surprising. Evidence presented by states failing to settle their UI dues has frequently focused on a particularly adverse power supply position as a reason for over-drawing from the grid on a consistent basis. (See box 6.1 above and CERC Order 54/2008 relating to Bihar (Central Electricity Regulatory Commission 2008c) and 55/2008 relating to Madhya Pradesh (Central Electricity Regulatory Commission 2008d) – although both Bihar and Madhya Pradesh have under-drawn from the grid in the review period). Power supply position data for the period shows that some states with relatively good power supply positions such as Chhattisgarh (-2.9%), Himachal Pradesh (-0.2%) and Orissa (-1.6%) have a positive UI balance – suggesting under-drawal from the grid – a rational position. However, Bihar (-16.3%), Jammu & Kashmir (-22.7%), Jharkhand (-7.3%) and Madhya Pradesh (-14.8%) have larger power supply position shortfalls and yet have under-drawn considerably from the grid in the review period. Other effects are clearly at work. Another challenge with selecting power supply position as an explanatory variable is the likely endogeneity of power supply position to UI. Ex ante, expected power supply position shortfall is a key determinant of the SLDC's decision on whether to under-draw or over-draw from the grid.

It was hypothesised that the marginal cost of power would be a key determinant of use of the UI mechanism. In a typical developed country electricity system with balanced supply and demand, the marginal cost of generation is, indeed, a key determinant in determining the dispatch schedule. Generators compete on cost to be selected to fulfill demand and recoup their variable costs and fixed capital costs (with due attention given to the speed of ramping up and backing down). However, it has been seen that in the Indian context, with chronic under-supply in all states (even after trading and over-drawing from the grid) – it is common for all available plant to be online whenever possible – the marginal cost criteria does not get to be applied as there is no substitution between generating plants being considered. As Yi-chong puts it in his critique of the World Bank's involvement in electricity reform:

> there cannot be competition among generation units unless there is sufficient generation capacity. In other words, a shortage of electricity supply would preclude competition whether there is structural reform or not (Yi-chong 2006: 810).

It appears that the sensitivity of generators to their marginal cost remains as only a theoretical influencer on UI while conditions of chronic under-supply remain.

The lack of correlation with the average industrial tariff may be due to the weakness of the indicator as a proxy for the opportunity cost of not over-drawing from the grid. Industrial tariff was selected as an indicator of revenue generating potential from selling in over-drawn electricity as industrial tariffs are generally highest and therefore represent the optimal marginal revenue. However, there are two issues: firstly, there are multiple industrial tariffs in each state and the development of an average may have diluted the power of the marginal revenue effect. Secondly, the state may not be acting in an economically rational mode and may in fact be meeting the needs of political constituencies with the over-drawn electricity. Examination of Bihar’s (order 54/2008) and Madhya Pradesh’s (order 55/2008) submissions to CERC with respect to non-payment referenced above, provides evidence – citing civil agitation due to loss of domestic power and the need to support agricultural irrigation in each state respectively.

The lack of significant correlation with gross consumption of electricity is also somewhat surprising given that the dependent variable is not controlled for population or economy size. It is likely that this is due to an artifact of the data structure. Gross consumption is very highly correlated with the size of the state economy as measured by net state domestic product. It is also significantly correlated to population size. Therefore, gross electricity consumption is a reasonable proxy for both the economic and actual size of the economy. Given also that aggregate UI can be both positive and negative, it can be seen that a linear relationship between UI flow and gross electricity consumption would require that larger states exhibit one behaviour (significant over or under drawl) and small states exhibit the other. This is not a hypothesis with any clear theoretical foundation.

The lack of significance of the coal rich dummy value is presumably due to the loss of information caused by the distillation of coal resource availability into a binary valuation. In reality, there are considerable differences in the importance of coal to the economies of the various coal producing states and it can be argued that if coal is a small part of an overall economy then it is less likely that institutional structures will have developed to maximise the opportunities for exploiting natural resources.

Finally, the lack of significant correlation of village electrification and rural households using electricity for lighting and the use of the UI mechanism is interesting. To recall, the hypothesis tested was that those states with the poorer record of rural electrification have a greater inclination to under-draw from the grid and gain financially rather than invest in rural electrification to improve long-term development prospects. The data does not support this hypothesis. Given the evidence, it appears that the level of rural electrification is not a factor considered by the electricity supply industry in the states – the rural unelectrified population is wholly outside the market.

Three candidate explanatory variables survive the first round of testing:

- Per_capita_consumption (pcc)
- Coal_%_gsdp (coal)
- British_rule_dummy. (brit)

A multivariate linear regression is shown in figure 6.4.

Source	SS	df	MS
Model	3.2943e+19	3	1.0981e+19
Residual	5.0144e+19	15	3.3429e+18
Total	8.3087e+19	18	4.6160e+18

Number of obs	=	19
F(3, 15)	=	3.28
Prob > F	=	0.0501
R-squared	=	0.3965
Adj R-squared	=	0.2758
Root MSE	=	1.8e+09

UI_Rs	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Pcc	3767068	2643607	1.42	0.175	-1867647	9401783
Coal	-1.80e+10	1.08e+10	-1.67	0.116	-4.11e+10	5.04e+09
Brit	4.03e+07	1.55e+09	0.03	0.980	-3.26e+09	3.34e+09
_cons	-1.23e+08	1.09e+09	-0.11	0.911	-2.44e+09	2.19e+09

Figure 6.4: multivariate linear regression of UI and selected explanatory variables

None of the explanatory variables now appears to be significant although the overall P-value of 0.0501 is almost significant at the 95% level. This result suggests collinearity between the explanatory variables. Each pair of explanatory variables is tested for correlation in figure 6.5:

coal	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
brit	-.0664694	.0231124	-2.88	0.010	-.1152324	-.0177064
_cons	.0642154	.0162435	3.95	0.001	.0299447	.0984862

pcc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
brit	312.7965	94.67958	3.30	0.004	113.0401	512.553
_cons	196.8099	66.54106	2.96	0.009	56.4205	337.1992

pcc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
coal	-1195.382	1003.166	-1.19	0.250	-3311.877	921.1132
_cons	406.8214	54.53269	7.46	0.000	291.7674	521.8753

Figure 6.5: collinearity test using pair wise regression of explanatory variables

It can be readily seen that British_rule_dummy correlates significantly with both per_capita_consumption and coal_%_of_gsdp (with p values of 0.004 and 0.01 respectively). There is no significant correlation between per_capita_consumption and coal_%_of gsdp. This suggests that British_rule_dummy can be dropped from the model as it is adding little additional value to the fit of the regression. Figure 6.6 presents the results of rerunning the regression with British_rule_dummy omitted:

```
      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  2,    16) =    5.26
       Model |  3.2941e+19     2  1.6471e+19           Prob > F      =  0.0176
    Residual |  5.0146e+19    16  3.1341e+18           R-squared     =  0.3965
-------------+------------------------------           Adj R-squared =  0.3210
       Total |  8.3087e+19    18  4.6160e+18           Root MSE      =  1.8e+09

------------------------------------------------------------------------------
     UI_Rs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------+------------------------------------------------------------------
pc_consump |    3807764    2062974     1.85   0.084    -565544.8     8181072
coal_perc  |  -1.82e+10   8.88e+09    -2.05   0.057    -3.70e+10    6.39e+08
     _cons |  -1.12e+08   9.59e+08    -0.12   0.909    -2.14e+09    1.92e+09
------------------------------------------------------------------------------
```

Figure 6.6: regression with British_rule_dummy dropped

The overall model is now comfortably significant at the 95% level and an R-squared value of 0.3965 suggests that approximately 40% of the variation in UI_Rs is attributable to the two explanatory variables. However, the individual explanatory variables are now only significant at the 90% level (figure 6.7).

```
      Source |       SS       df       MS              Number of obs =      19
-------------+------------------------------           F(  2,    16) =    5.26
       Model |  3.2941e+19     2  1.6471e+19           Prob > F      =  0.0176
    Residual |  5.0146e+19    16  3.1341e+18           R-squared     =  0.3965
-------------+------------------------------           Adj R-squared =  0.3210
       Total |  8.3087e+19    18  4.6160e+18           Root MSE      =  1.8e+09

------------------------------------------------------------------------------
     UI_Rs |      Coef.   Std. Err.      t    P>|t|     [90% Conf. Interval]
-----------+------------------------------------------------------------------
pc_consump |    3807764    2062974     1.85   0.084     206051.9     7409476
coal_perc  |  -1.82e+10   8.88e+09    -2.05   0.057    -3.37e+10   -2.68e+09
      cons |  -1.12e+08   9.59e+08    -0.12   0.909    -1.79e+09    1.56e+09
------------------------------------------------------------------------------
```

Figure 6.7: selected regression with confidence level set to 90%

The individual data observations were also examined more closely to determine if any outliers in the population of 19 states were exerting a significant influence over the results. Studentised residuals have been generated to facilitate comparison of residual values across the population and the highest and lowest values are -1.588 (Himachal Pradesh) and 1.739 (Andhra Pradesh) – which are reasonable values. A Cooks D analysis is also undertaken to identify the effect of each observation on the parameter estimates. Jharkhand has the highest value, which at 0.363 is high relative to the number of observations but not extremely so. It appears reasonable to conclude that none of the observations has an extreme influence over the results and all observations may be kept in the population without manipulation.

Given the small population, it might be argued that a robust method for calculating standard errors be more appropriate. In addition, analysis of the normality of the residuals suggests that the data is not perfectly suited to OLS regression methods (a kdensity function is plotted against a standard normal curve in figure 6.8.

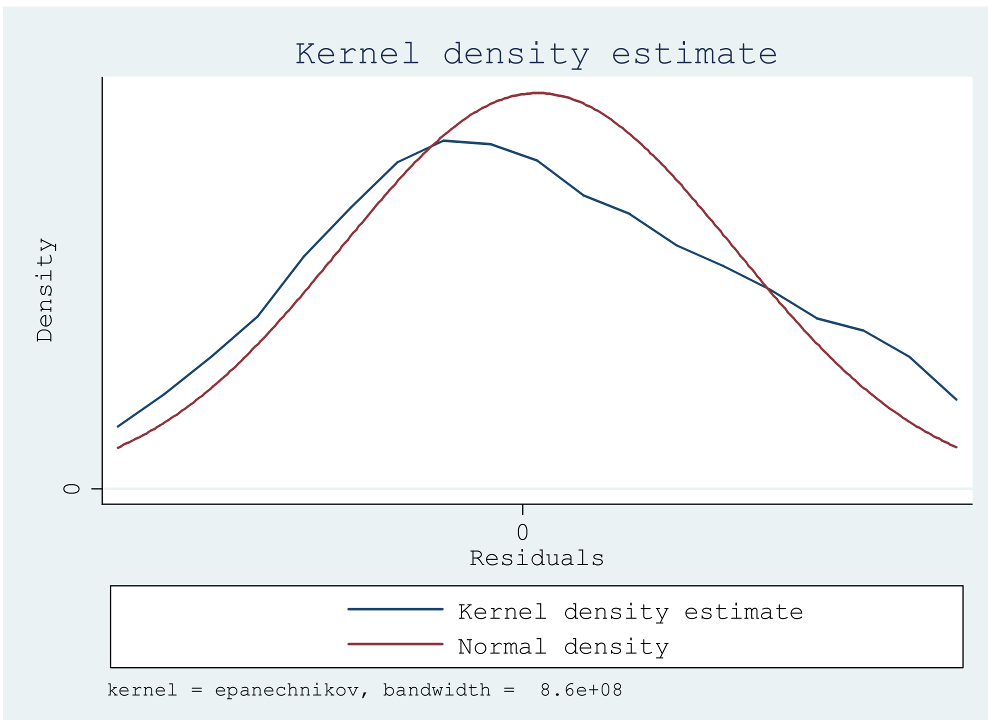

Figure 6.8: kdensity graph of residuals with skew from a normal distribution

It can be seen that the residuals do not perfectly conform to a normal distribution – although the fit is reasonable. A Shapiro-Wilk W test for normality, however, yields a P-value of 0.332 – suggesting that the hypothesis that the residuals are normally distributed cannot be rejected.

Given, the above potential concerns the regression is re-run using Stata's implementation of the Huber-White sandwich estimators approach. Using this approach, a much more significant result is derived (figure 6.9):

```
Linear regression                                      Number of obs =      19
                                                       F(  2,    16) =    9.18
                                                       Prob > F      =  0.0022
                                                       R-squared     =  0.3965
                                                       Root MSE      =  1.8e+09

------------------------------------------------------------------------------
           |               Robust
     UI_Rs |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------+------------------------------------------------------------------
pc_consump |    3807764    1710610     2.23   0.041       181433     7434095
coal_perc  |  -1.82e+10   6.61e+09    -2.75   0.014    -3.22e+10   -4.17e+09
     _cons |  -1.12e+08   8.43e+08    -0.13   0.896    -1.90e+09    1.68e+09
------------------------------------------------------------------------------
```

Figure 6.9: selected regression with robust standard error estimation

It can be concluded that per capita consumption of electricity and the value of coal as a percentage of GSDP are both significant predictors of the level of UI payments and receipts for the period reviewed. What can be inferred from this analysis?

6.6 Interpretation of results

The results of the regression analysis are interesting and somewhat counter-intuitive – certainly from the perspective of rational economic decision-making. The lack of correlation between the level of UI payments and receipts and various measures of power supply position, cost of power and electricity tariff suggest that states are not engaging with the UI mechanism in the manner Bhushan suggests. As discussed above there are weaknesses in the indicators used for power supply position and tariff. However, the lack of correlation between UI levels and the cost of indigenously produced electricity is, at first glance particularly surprising. One would expect a marginal cost evaluation to be performed when determining scheduling. Put in terms of a developed country electricity system – the rank ordering of dispatch by marginal cost of electricity appears to have broken down. As discussed, this is presumably due to the conditions of chronic under-supply across India.

Instead, what is demonstrated is a relationship between UI and explanatory variables based on political and historical institutional factors. The significant bivariate correlation between UI and the British rule dummy variable (dropped due to collinearity in the final regression) is further indication of the hypothesis that long-standing institutional structures play a significant role in determining current outcomes in the electricity market – even following liberalisation.

More importantly, the relationship between UI and the value of coal to the economy of the state suggests that electricity has been recognised by those states as a commodity that can be used to generate revenue. Theoretically, of course, all states have the potential to exploit their allocation of centrally generated electricity as a means of generating additional revenues. However, the fact that there is a strongly significant relationship between being a material coal producer and similarly exploiting electricity production for financial gain suggests that there is an institutional predilection to raise revenue through commodity sale rather than through other industrial or commercial activities. It is possible that, given the technology advances and trading institution set-up, that electricity has begun to be used as a natural resource that can be exploited for financial benefit rather than solely as an input into local economic development and social progress. This is evidence that the resource curse is active in these states.

The significant correlation between per capita consumption of electricity and the size and direction of UI flows is somewhat puzzling. Recall, that a lagged value for consumption was used to handle the endogeneity of the consumption indicator (ensuring that per capita consumption levels were not high precisely because a state had over-drawn from the grid and vice versa). The relationship is, however, positive in that higher per capita consumption levels are significantly correlated with high UI payments (resulting from overdrawal from the grid) whereas low consumption levels are correlated with high UI receipts (resulting from under-drawal from the grid). Why might a state with historically low per capita electricity consumption choose to under-draw their entitlement from the grid? One possible explanation is that the rural poor in these states are a politically weak constituency and that those with no access to electricity at all are unable to gain that access and therefore the per capita electricity consumption levels are kept low. Access to electricity as measured by village electrification and rural households using electricity for lighting were not found to be significantly correlated with UI flows. However, close analysis of the data shows that (with the exception of Himachal Pradesh and Jammu & Kashmir – both with extremely high levels of village electrification) all the states under-drawing from the grid were in the bottom half of states as determined by rural household light electrification. There is also a very significant correlation (at the 99.9% level) between rural electrification as measured by access to electric light and per capita electricity consumption. Is it possible that the states used to exploiting natural resources as a primary source of revenue generation (that also have low per capita electricity consumption based on continuing low rural household electrification levels) are choosing to earn revenue from the under-drawal from the grid rather than commit to meeting their universal service obligations?

6.7 Conclusions

There are challenges associated with using electricity-trading data to understand states' motivations in managing their electricity systems. There is a relatively small volume of data to interrogate[122]. The UI mechanism only contributes approximately 3.2% of a state's electricity supply – most of the rest being locked down by longer-term power purchase agreements. More importantly, there are clearly numerous state specific motivations for using the trading mechanisms in particular ways that are unlikely to be captured effectively by a general model covering all states. However, the alternative approaches would involve closer case study analysis of individual states and an expert interview based approach to uncovering truth that is susceptible to bias by politically motivated responses. It is felt that a quantitative approach is a valuable contribution to the literature in this field and sufficient evidence is uncovered to warrant resource effort on individual state case-based studies.

The quantitative results presented are also reinforced by an increasing body of qualitative evidence. The potential for rent seeking at the expense of universal service obligation fulfillment has been reported by customers in tariff consultations with the state electricity regulatory commissions:

Sale of power at profit from Board's share to other states through Power Trading Corporation keeping the consumers in the State in darkness should be avoided (Bihar State Electricity Regulatory Commission 2006: 47).

The concern has also been raised in the media – as the following quote from the Business Line suggests:

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[122] At the time of writing only six months of full UI reporting data was available. It is therefore plausible that seasonal effects may have an influence – further study with a longer time series would mitigate this concern.

While power trading was expected to lead to a decrease in the demand-supply gap and an eventual reduction in the price of electricity, the increasing price of traded electricity has led to disturbing trends such as State utilities choosing to trade in power rather than fulfilling their non-remunerative `universal service' obligations (Murali 2008).

The CERC has also recognised the issue and does have powers under section 62(1) of the Electricity Act to fix maximum and minimum tariffs for electricity trades in periods of electricity shortage:

The Appropriate Commission shall determine the tariff in accordance with provisions of this Act for: supply of electricity by a generating company to a distribution licensee: Provided that the Appropriate Commission may, in case of shortage of supply of electricity, fix the minimum and maximum ceiling of tariff for sale or purchase of electricity in pursuance of an agreement, entered into between a generating company and a licensee or between licensees, for a period not exceeding one year to ensure reasonable prices of electricity (Central Electricity Regulatory Commission 2008a: 12).

There is increasing pressure for CERC to act on this issue as identified in a staff paper published in September 2008:

It is felt that one of the more plausible reasons for increase in the sale price of electricity in short-term is profiteering by the sellers in period of increasing shortages. This has also enhanced the perverse incentive for distribution utilities to cut down the supply to their own consumers and make money in short-term market (Central Electricity Regulatory Commission 2008a: 11).

The problem the regulator has is that an appropriate UI rate is necessary to encourage marginal generators in to the market in times of shortage (primarily generators reliant on liquid fuels). Reduction in the UI rate to limit the incentive to profiteer damages the competing goal of encouraging additional capacity into the market – and there is ultimately only one solution for potential profiteering and that is the elimination of systemic and chronic power supply deficits across the country.

The regulator does have the theoretical capability to impose sanctions on states that fail to deliver to the customers under their quality of service obligation as discussed in detail in chapter 7. However, the absence of robust data collection on service quality gives the regulator little tangible evidence with which to discipline the utility. The chronic power supply shortages across the country make it difficult to sanction a potentially profiteering state when both the buyer and seller are experiencing continual electricity deficits.

UI decisions may be executed strategically to maximise short-term revenues but could also be an indication of ad hoc management of the system without any explicit political influence[123]. However, there is significant evidence that the short term needs of balancing supply with actual connected demand on the system (as evidenced by the positive correlation between UI flows and per capita electricity consumption) are outweighing the long term objectives of increasing universal access to electricity. It may be argued that those states with low per capita consumption that are in receipt of large UI flows (for under drawing their scheduled allocation of centrally generated electricity) are failing to value the long-term development stimulus potential of increased indigenous electricity consumption. Based on a short-term marginal revenue perspective, it may appear rational to transmit what is perceived to be excess electricity from the eastern region to other parts of the country – but this has the potential to turn the eastern region into a permanent electricity ghetto. This ghettoisation has been facilitated by the introduction of an infrastructure to support the physical transmission of electricity and the trading regimes to manage the

[123] Although the consistent direction of UI financial flows (towards the eastern states) suggests that a strategic decision is a more likely explanation than ad-hoc mismanagement.

economics of that transfer. The UI mechanism in particular, for all its elegance as a means of creating grid discipline through self-interested incentives, is an extremely opaque tool from the perspective of understanding how electricity and financial resources are flowing within India. A bilateral trade is easily understood and transparent – and more difficult to defend politically to an electricity-starved electorate. UI, on the other hand, requires a more detailed analysis to understand its ramifications in terms of real resource flows.

The theoretical foundations for the resource curse have been discussed in chapter 2. There appears to be little literature relating to potential resource curse effects in the trading of electricity. The reasons for this may be straightforward. Classic resource curse examples require the marketability of a single or small number of resources to dominate a region's economy. Electricity trading is unlikely to fulfill this criterion in any economy[124]. A relatively small additional marketable resource is unlikely to encourage the development of institutions to maximise rent seeking in this market at the expense of other sectors of the economy[125]. However, it is possible that a region that has already developed institutional structures to maximise the gain from natural resources may seize the opportunity presented by the commodification and tradability of electricity to extract rents from the sale of electricity (or rights to electricity) also[126]. Thus, the tradability of electricity does not generate a resource curse response. Rather,

[124] Democratic Republic of the Congo is a possible exception with the Congo River having an estimated 100,000 MW of hydro potential and the proposed Grand Inga facility having planned generation of 45,000 MW and an export market including Angola, Mozambique, Zambia, Botswana and South Africa (Wroughton 2009). Laos may be a further exception (Chirarattananon and Nirukkanaporn 2006).

[125] UI receipts, even for the biggest beneficiaries of the UI mechanism are still a small fraction of the revenues available from coal sales. – ranging from 1% of coal sales for Jharkhand and Madhya Pradesh, to 3.5%, 4.5% and 4.9% for Orissa, Chhattisgarh and West Bengal respectively.

[126] The ethics of the commodification and trade of electricity is beyond the scope of this discussion. Leys provides a critical evaluation of the increasing role of markets in the public sphere (Leys 2001).

pre-existing institutions evolved to extract rents from natural resources may exploit an opportunity to extract further rents from electricity trading – a demonstration of a path dependent effect based on historical reliance on natural resources. What makes this concerning from a social progress perspective results from the systemic electricity supply shortfall that is still apparent across India[127]. The decision to trade away rights to electricity is not based on a well-functioning market delivering price signals to the state electricity boards as might be experienced in liquid electricity markets with general balance between supply and demand such as the Scandinavian NordPool. In the Indian case, the choice to under-draw from the grid may have the direct result of denying in-state customers an electricity supply.

Further research at the individual state level is required to develop these themes. Are the eastern states reinforcing a resource cursed approach to economic development – relying on natural resources to accumulate wealth – with electricity now taking its place with coal as a key tradable commodity? Is this happening at the expense of the electricity disenfranchised? The next chapter turns to the question of the electricity disenfranchised by undertaking an evaluation of the current rural electrification programme and the potential for policy to disrupt the institutionally ingrained approach that has caused previous rural electrification programmes to fail to meet expectations.

[127] Starting points matter and a particular difference between industrialised and developing country reform is that in developing countries a chronic supply shortage is a likely norm (Besant-Jones and Tenenbaum 2001).

7 Can rural electrification policy overcome institutional path dependence?

The lack of universal access to electricity in India is a principal policy concern. The country still has over 400 million people without access to electricity – mainly in rural areas (International Energy Agency 2007)[128]. Recognising this, the government has set an aggressive goal of universal electrification by 2012. However, the aspirational nature of this target is insufficient to provide confidence, given a history of under-achievement, that this goal will be reached. India is attempting to provide universal electricity access at the same time as it is revolutionising the management and governance structure of its electricity systems (Dubash and Bradley 2005). In chapter 5, quantitative evidence has been presented that shows the importance of institutional and geographical factors in reinforcing path dependence in the development of the electricity systems of the individual states. Chapter 6 provided evidence that path dependent institutional factors have influenced the manner in which individual states have engaged with the unscheduled interchange mechanism. These factors might also be expected to influence rural electrification. This chapter examines the policy instruments introduced in 2005 to deliver universal access to electricity and question whether those instruments provide appropriate and sufficient means to bring the institutional change or support necessary to ensure success in the rural electrification programme across India[129].

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[128] Electricity is, of course, only one component of the energy mix for rural communities and the specific importance of electricity vis a vis other energy sources has been challenged (Bekker et al. 2008, Bhattacharyya 2006).

[129] The chapter does not attempt to answer questions of the technical challenges of achieving rural electrification – improved distribution capabilities such as SWER, off grid solutions, local grids etc.

In chapter 2, the degree of determinism in path dependence was explored from a theoretical perspective. Recent literature, particularly sourced from political science, has begun to question the dynamics of institutional change and has been introduced as a framework for analysis. As Duit describes it:

> if institutions are the explanation for stability, how can we understand processes of institutional change (Duit 2007: 1098).

The focus, therefore, is less on the channels of influence of path dependence but, more constructively, what changes or support are needed to progress from one path that may be locking in a sub-optimal equilibrium position for a region to a new resilient path that may move the region to a more desirous equilibrium state.

To date, there is a limited literature on India's current rural electrification policy framework – with examples including (Dubash and Bradley 2005, Modi 2005, Srivastava and Rehman 2006, Bhattacharyya 2006, Bhattacharyya and Srivastava 2009, Ernst & Young 2007, Rejikumar 2005, Modi 2006) [130] . Bhattacharyya undertook a brief analysis of the potential of the RGGVY programme shortly after the introduction of the programme. He identified a set of areas of concern: organisational issues, regulatory issues, financial concerns, supply shortage, reliance on grid expansion, political patronage and governance issues (Bhattacharyya 2006). The focus of the paper was on the potential for the success of the programme at the national level and although there was acknowledgement of the different challenges faced by the states, the aim was not to examine the capabilities of individual states. Further, Bhattacharyya did not, given the early stage of the programme at the time of

[130] There are also a number of studies from the period immediately prior to the introduction of the current policy regime (International Energy Agency 2002, Rehman and Bhandari 2002, Sinha 2003, World Bank 2004)

writing, provide a detailed analysis of implementation details or capacity support. Finally, no attempt was made to place the policies within any theoretical framework of institutional change that would have supported an evaluation of the potential effectiveness of the policy given the path dependent processes evident at the state level. Bhattacharyya and Srivastava explored the rural electrification challenge further with a 2009 paper focused on the regulatory challenges implicit in the franchisee programme that is a cornerstone of the new policy and the role of regulation in tariff setting (Bhattacharyya and Srivastava 2009). There is a thoughtful discussion of the different proposed models for franchisees and the interaction of the models with the regulatory process. However, again, the analysis is not performed within any framework of institutional capacity analysis – nor are other components of the rural electrification process considered. Indeed, Bhattacharyya's objectives are to evaluate conflict between the programme and the prevailing regulatory structure rather than an evaluation of the potential for the policy framework to succeed in providing the institutional support necessary to deliver successful rural electrification. Rejikumar briefly discusses the potential for the franchisee structure to deliver success where previous programmes have failed but at that point, there was no record of accomplishment on which to attempt to evaluate results (Rejikumar 2005).

Dubash identifies the changing political context in the early 2000s and the introduction of the Electricity Act in 2003 as substantive changes in the institutional context that may result in greater success than previous initiatives. However, Dubash goes on to note that:

> The existence of new political momentum and supporting legislation behind rural electrification by no means guarantees success in rapidly enhancing access to electricity in rural India. Indeed, there remain considerable obstacles, notably

institutional and financial, to achieving rural electrification (Dubash and Bradley 2005: 71).

Dubash does not attempt to explore these issues – focusing instead on the strengths and weaknesses of on-grid, off-grid and hybrid solutions to rural electrification. This chapter therefore undertakes the following evaluation: does the current rural electrification policy programme provide sufficient incentives to ensure sufficient institutional capacity necessary to make rural electrification a success in all India's states? This has been undertaken in the context of the analytical framework of path dependence outlined in chapter 2. The chapter proceeds as follows. First, there is a discussion of the evolution of the rural electrification strategy in the five-year plans – the primary institutional tool for supporting rural electrification across the states for the first four decades following independence. The impact of plan priorities, in terms of the infrastructure deployed on the ground, is also explained to provide a context for the electrification attainment achieved. There is then a discussion of the changing definition of rural electrification in India. Secondly, the progress of rural electrification over time against a set of alternative indicators by state is analysed – demonstrating a persistent pattern of under–performance by some states irrespective of the rural electrification definition selected. This persistent pattern of under-performance indicates the possible influence of path dependence. Thirdly, recognising the consistent under-performance of some states against this variety of rural electrification indicators and different policy regimes, focus is given to the contemporary policy environment as defined by the Electricity Act 2003 and the RGGVY programme (a key part of the Bharat Nirman programme for rural development and discussed in detail below). This consistent under-performance under a variety of policy initiatives justifies the use of a path dependence-based analytical framework in evaluating current policy and its potential for disrupting the sub-optimal equilibria experienced in some states. This analysis is begun with a summary of the national legislative and regulatory structure supporting the states' rural electrification efforts. Critical attention is then given to the policy efforts to support rural electrification in the institutionally weak states and the adequacy of these policies and their ability to overcome the institutional factors that may have locked in under-performance is evaluated. Finally, in conclusion, the potential for success in delivering universal electricity access by 2012 as targeted in the 11th five-year plan is evaluated.

7.1 Historical policy approaches

7.1.1 Planning strategy

The planning process has been the principle means for progressing rural electrification since independence and the subject has been an important narrative featured in all five-year plans. The five-year plans and associated National Development Council meetings have always been in part a political tool. Constituencies had to be appeased, aspirational language has been the norm, and results have commonly not met expectations. Given this context, it is unsurprising that there has been regular recognition and articulation, spanning all the plans, of the broad developmental benefits of rural electrification for all states:

> [1st plan] Extensive use of electricity can bring about the much needed change in rural life in India. It cannot only improve methods of production in agriculture and encourage cottage and small scale industries but can also make life in rural areas much more attractive and thus help in arresting the influx of rural population into cities (Planning Commission, Government of India 1951b: para 29).

> [9th plan] Electricity is not only the basic pre-requisite for industrialisation but it also contributes significantly to increasing agricultural productivity and other job and income generation activities, besides enhancing the quality of life in rural areas and

controlling migration from rural to urban areas. Electricity, therefore, deserves to be classified as a basic amenity along with others like housing, drinking water, health and education (Planning Commission, Government of India 1998b: para 6.122).

However, despite the acknowledgement of the broad social benefits of rural electrification, an over-riding agricultural productivity narrative began in the 1st plan and continued through the 8th plan (1992-97) although gradually weakening from the 5th plan (1974-79) onwards. This focused on the potential for cheap electricity to drive up agricultural yields primarily through tubewell irrigation across the country. Little emphasis was placed on the profitability of the electricity sector. It was perceived to be a critical development service to be delivered for the national good.

[1st plan]…as a part of the "Grow More Food Campaign ", pumping units have been installed on rivers or wells for agricultural purposes. The supply of *cheap electric power* is essential for large scale development of tube-wells or lift irrigation from rivers (italics added) (Planning Commission, Government of India 1951a: para 32).

[4th plan] Attention should be focused on energising as many clusters of irrigation pumps as possible, irrespective of the statistics regarding number of villages electrified, as the above approach is the only way to increase agricultural production in large areas which do not have the benefits of canal irrigation (National Development Council 1965: p305).

The Minimum Needs Programme in the 5th plan (1974-79) brought more focus on village electrification (with almost 100,000 electrified villages being added to the 150,000 already electrified). In the 6th plan (1980-85) there was recognition both of the gains made in rural electrification but also, for the first time, on the unevenness in that progress and the limited extent to which it was reaching individual households:

…a disaggregated analysis discloses wide interstate and intra-State differences in coverage. Even in villages to which the power supply lines have been drawn, the proportion of rural families using electricity continues to be quite low and the impact on rural industrialisation has also not been significant (Planning Commission, Government of India 1981b: para 15.32).

The 7th plan (1985-89) re-iterated the challenge of delivering electrification to the individual household noting that 64% of villages were electrified but only 8% of rural households. Rural electrification priorities continued to adjust in the 8th plan (1992-97) away from irrigation. The shift was towards domestic electrification and improving the quality of electricity supply to encourage the development of non-agricultural commercial electricity consumption in rural areas.

The challenges of rural electrification were well understood. As early as the 2nd plan (1956-61) the high cost of rural electrification was recognised as was the inevitable impact on the ability to deliver. Acknowledging poor performance to date, planners undertook a review of the progress of rural electrification in the 8th plan. A number of issues were identified that recognised the costs of rural electrification and the effects of the agricultural productivity bias:

- The subsidised cost of agricultural electricity was criticised both for the effects on SEB finances but also on the level and efficiency of water consumption;
- The rural electrification programme was blamed for much of the increase in transmission and distribution losses (amounting to half of the 22-23% T& D losses for all India) due to relatively long distance transmission using low tension lines (66KV and below) to electrify villages[131];

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[131] Current good practice suggests that 8-8.5% distribution losses should be expected in the Indian context (Wadhwa 2009) i.e. the 11 – 11.5% suggested is only 3% higher than 2009 good practice. Given this benchmark, the focus of blame on rural electrification appears unwarranted. The lack of metering and disorganised billing and collection suggests that rural electrification per se is being scapegoated for high transmission and distribution losses.

– The sizeable agricultural load (primarily for irrigation) was blamed for the poor quality of electricity delivered for rural domestic use[132].

The 9th plan (1997–02) signaled a change in emphasis regarding priorities with increasing recognition of the potential harm of excessive pumpset energisation both because of water table decline and because of the strain placed on state electricity supplies caused by inefficient use of heavily subsidised electricity in the agricultural sector[133]. The 10th plan (2002-07) saw the consolidation of village electrification as the primary goal of rural electrification – completing an evolution of the narrative that began in the 5th plan in the 1970s. Importantly, the 10th plan also recognised the importance of extending the criteria of success beyond village electrification and towards seeing the use of electricity in rural households on a day-to-day basis:

> The actual benefits of the investments made in the rural electrification programme can only be realised if the people are in a position to use electricity for their day-to-day activities as well as for industrial and commercial activity. Therefore, the second phase of the rural electrification programme, apart from seeking 100 per cent electrification, must also ensure more widespread use of electricity by the rural people in a time-bound manner (Planning Commission, Government of India 2002a: p914).

The 11th plan (2007-2012) was developed in the context of the 2003 Electricity Act being in place and the RGGVY programme having been developed and provided aspirational targets for village and household electrification to be completed by the completion of the plan period in 2012. By this time, pumpset energisation had completely disappeared as a visible focus of policy action in the plan narrative (although the activity continued – supported by plan funds).

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[132] Current initiatives to separate agricultural feeders from those for domestic use in states such as Gujarat confirms the veracity of this issue – albeit fifteen years after the initial identification of the problem.

[133] The 9th plan reports a potential energy efficiency saving of 57 billion KWh with investment in efficient pumps (Planning Commission, Government of India 1998b).

The evolving rural electrification narrative in India's development plans can be seen to have moved through several transitions. From 1950 through the mid 1970s, electrification of irrigation was paramount. From the mid 1970s to the mid 1990s, village electrification increasingly began to be perceived as a key developmental goal although agricultural use remained predominant. The 40+ years of focus on agricultural supply resulted in an infrastructure that was tailored to agricultural needs – as well as quality levels acceptable to agricultural use. It is common for agricultural power to be provided at night when other loads are limited to minimise the potential or overall shortages and load shedding. Unfortunately, in most states, a single distribution infrastructure was implemented that made it difficult to provide a different service level to rural domestic customers as opposed to agricultural consumers.

Further, although village electrification became increasingly targeted from the mid 1970s, the recognition of the importance of household electrification within that goal was only rarely acknowledged. It was not until the late 1990s that, village electrification and finally household electrification in the 2000s became the primary goal of rural electrification policy. Given this evolving policy target, it is therefore important to look at actual progress in the states over time. First, however, the evolving definition of rural electrification is explored in some detail.

7.1.2 Definitions of rural electrification

In India, tracking the evolving rural electrification narrative, the official definitions of rural electrification have been adapted over time. The original definition of village electrification is as follows:

a village should be classified as electrified if electricity is being used within its revenue area for any purpose whatsoever (Planning Commission, Government of India 1998b: para 6.123).

As Kalra et al note, this implies that a village was identified as electrified if a single transmission pole was present within the boundary of the village (Kalra et al. 2007). More pertinently, the electrification of a single irrigation pump within the village boundary would result in that village being considered electrified. Notification of an adjustment to the definition of village electrification was made in the 9th five-year plan in 1998:

A village will be deemed to be electrified if electricity is used in the inhabited locality, within the revenue boundary of the village for any purpose whatsoever (Planning Commission, Government of India 1998b: para 6.123).

The subtle change in definition – ensuring that the electricity is used in the inhabited locality of the village rather than merely anywhere in its revenue boundary (which could include a village, a cluster of hamlets and all the fields and forests in between) was ostensibly designed to encourage a shift in emphasis of rural electrification from agricultural to domestic use (Kumar 2009b). In reality, however, it made little substantive difference in measuring the benefit village communities were receiving from the electrification programme.

A further attempt to improve the definition of electrification was made in 2004 and the new definition was picked up in electrification statistics from the 2004/5 financial year onwards. The amended definition of an electrified village is provided below as specified under the Ministry of Power's O.M. No.42/1/2001-D(RE) dated 5th February 2004 and confirmed in the Rural Electrification Policy in 2006.

A village would be classified as electrified based on a Certificate issued by the Gram Panchayat, certifying that –

a) Basic infrastructure such as Distribution Transformer and Distribution Lines are provided in the inhabited locality as well as a minimum of one Dalit Basti / hamlet where it exists; and

b) Electricity is provided to public places like Schools, Panchayat Office, Health Centers, Dispensaries, Community Centers etc.; and

c) The number of households electrified are at least 10% of the total number of households in the village (Government of India: Ministry of Power 2006: p6).

The revised definition of village electrification is clearly a considerable improvement on the earlier definitions and is based on certification of electrification by the local administrative body rather than a central bureaucracy. However, it still requires only 10% of village households and one of the potentially several hamlets[134] associated with the village to be electrified to qualify the village as electrified. Given that the RGGVY programme has set targets for household electrification, it has resulted in a need for reporting of two sets of electrification statistics (Mohan 2009b). These relate to the extent of electrification – as defined above and those relating to the intensification of electrification – increasing the number of households electrified beyond the 10% threshold – with the ultimate goal of universal service being 100% electrification of all the households in all villages.

Other definitions of household electrification have been employed in the decadal census and by the National Sample Survey Organisation (NSSO). These organisations, using survey methods, both use the presence of electric lights in the household as an indicator of electrification. NSSO also does occasional surveys of village amenities

[134] The hamlets are also likely inhabited by the most socially disadvantaged members of the village community.

and provides data on the availability and use of electricity in surveyed villages (categories of use including household, street lighting, agriculture and industry).

It is clear that the Indian government has yet to be fully transparent in reporting the extent and quality of its rural electrification programme although there has been progress over the last five years. It is arguable that lack of ambition in gathering high quality household electrification statistics has hindered the progress towards universal service as states have been able to present a level of service expansion that has been largely illusory[135].

7.2 Statistical evidence of persistent failure

Over time, three separate indicators of rural electrification have had prominence:

- Pumpset energisation was given priority from the 1st plan through the 8th plan;
- Village electrification has been an important part of the narrative since independence but state level breakdowns of village electrification (per the original weak definition) have only been consistently collected since the 1970s;
- Household electrification (the ultimate objective of rural development policies) has been only intermittently captured through surveys (both census and national sample survey organisation studies). Complete household electrification is only now beginning to be reported through the RGGVY programme as part of the

[135] Two enhancements would aid clarity - household electrification levels as a percentage of total households and quality of service reporting – including hours of service, responsiveness to outage due to equipment failure and measures of electricity quality (voltage and frequency). Progress on the former is much improved for villages taking part in the RGGVY programme but little progress has yet to be made on quality of service reporting (Mohan 2009b).

intensification efforts with respect to village electrification – but only for those villages explicitly included in an RGGVY project.

7.2.1 Pumpset energisation

Figure 7.1 illustrates the growth of pumpset deployment against an estimate of potential calculated in 1995 (to normalise the data with respect to state size and hydrology). It can clearly be seen that the states can be categorised in to two groups.

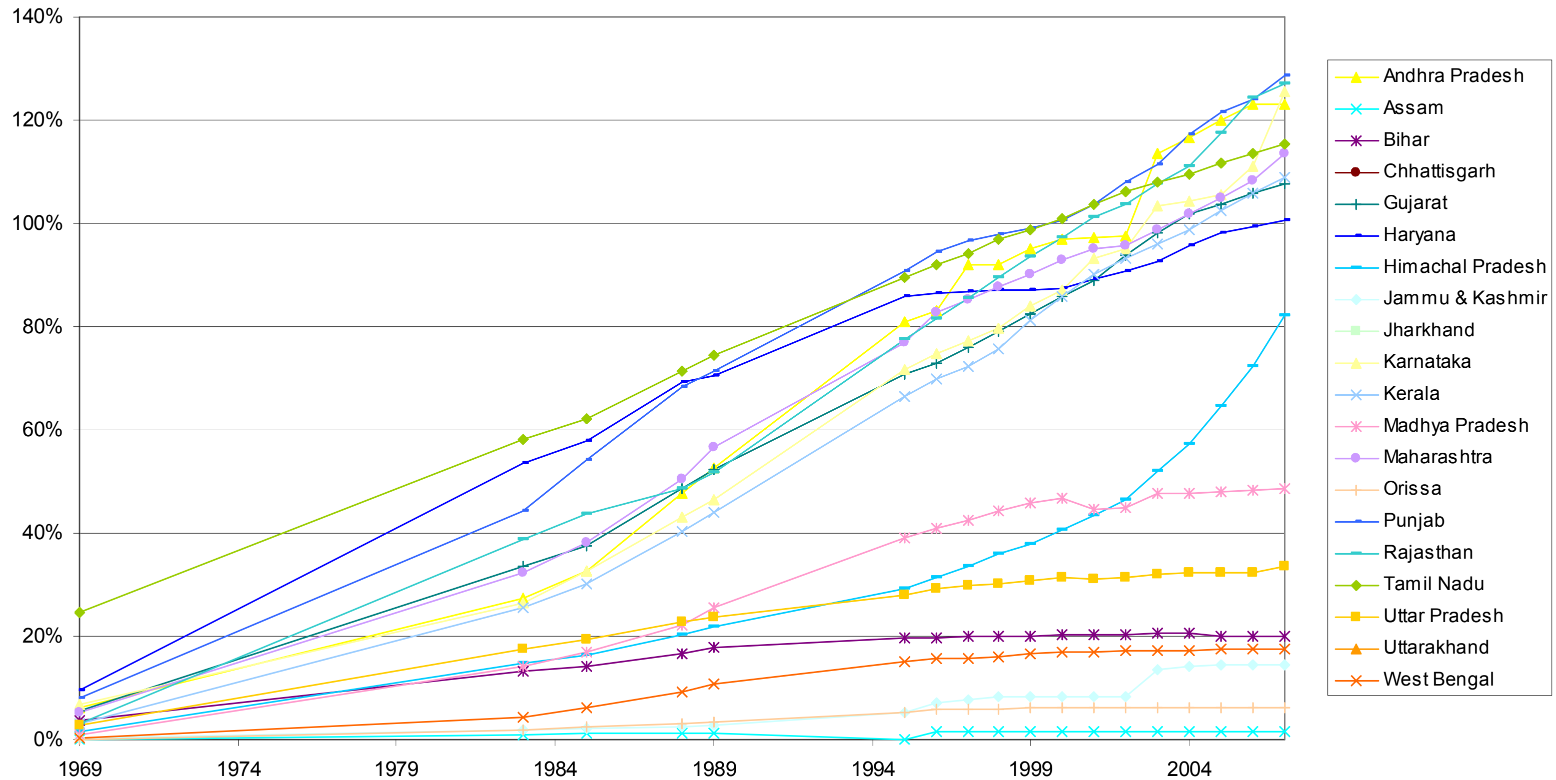

Figure 7.1: State pumpset energisation as percentage of potential
Source: TERI 2006c, Indiastat 2001b, Indiastat 1989, Indiastat 2008c, Indiastat 2007c, Planning Commission, Government of India 1970c

One group has successfully achieved steady growth in pumpsets against their potential (Andhra Pradesh, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Punjab, Rajasthan and Tamil Nadu) and another group that has failed to meet their potential (Assam, Bihar, Jammu & Kashmir, Madhya Pradesh, Orissa, Uttar Pradesh and West Bengal)[136]. Himachal Pradesh appears to be the only state that has successfully broken ranks from the lagging group since the mid 1990s and is rapidly catching up with the leading group.

7.2.2 Village electrification

From the early 1970s state level village electrification statistics began to be reported and the wide divergence of progress between the successful states and the laggards became increasingly obvious. Figure 7.2 details the growth in village electrification. The seemingly impressive growth over the period illustrated is evident as is the difference between states. All but a handful of states are shown to have close to 100% village electrification by the start of the 1990s – with Assam, Bihar, Madhya Pradesh, Orissa, Uttar Pradesh and West Bengal beginning the period behind the other states and failing to catch up.

[136] This list is consistent (with the exception of Rajasthan) with the states identified in the 7th plan as failing to meet pumpset rollout targets in the 6th plan (Planning Commission, Government of India 1985).

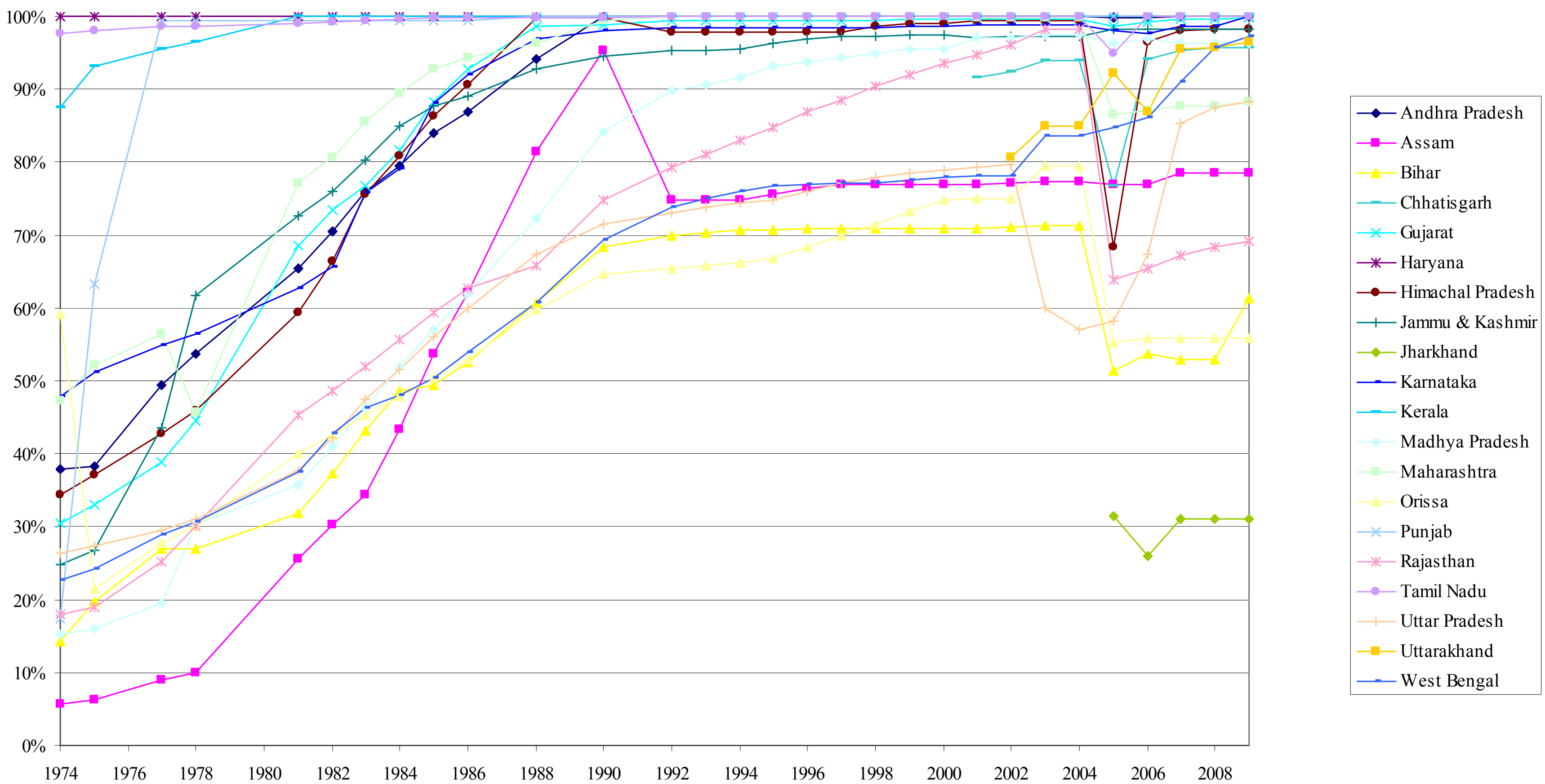

Figure 7.2: State-wise village electrification efforts, 1974 – 2009.
Source: Indian Statistical Abstract (various years), Government of India: Ministry of Power 2009, Indiastat 2008a, Indiastat 2007b

It is also evident that the village electrification rate slowed abruptly for all states from the beginning of the 1990s. The 1990s was a period of increasing financial challenge for the central and state governments. Plan financing failed to meet expectations in both the 8th and 9th pans (1992 – 2002). A principle reason for the financial weakness was the increasing loss levels of the state electricity boards (Planning Commission, Government of India 1992, Planning Commission, Government of India 1998a). Reform pressures through the 1990s to run SEBs on a commercial basis increased the incentive to avoid rural electrification projects that had little short-term financial benefit (Bhattacharyya 2006).

Rajasthan appears exceptional in continuing to progress through the 1990s and managing to move from the lagging to the leading group. However, focusing on the 1990s to the present, the effect of the village electrification redefinition in 2004 is apparent[137]. It is evident that Rajasthan's progress in the 1990s was largely illusory once a more stringent village electrification definition was employed.

7.2.3 Household electrification

Rural household electrification has not been monitored as closely or frequently as pumpset energisation and village electrification. Prior to the introduction of the RGGVY programme the only information available on household level electrification is found in the national sample survey organisation studies of household conditions and the decadal census – both of which recorded the use of electricity for lighting in

[137] The dip in village electrification reflects the definitional change that took place in that year. In Jammu & Kashmir, Jharkhand and Uttarakhand the readjustment is observed a year later in 2006 whereas in Uttar Pradesh a large drop is observed in 2003

rural households. It is reasonable to assume, given low cost of electric lighting and poor quality of substitutes (e.g. kerosene lanterns), that electric light is the most likely first application of electricity in the household and can therefore serve as a valid proxy for household electrification. With the launch of RGGVY, there is an attempt to track household electrification. Figure 7.3 plots progress in household electrification. The first thing that is striking about household electrification, consistent with the evidence for village electrification, is the lack of progress achieved since the early 1990s. As with other measures, there is a clear difference between the more and less successful states. However, whatever, the level of attainment, progress since the first data point in 1994 has been very poor.

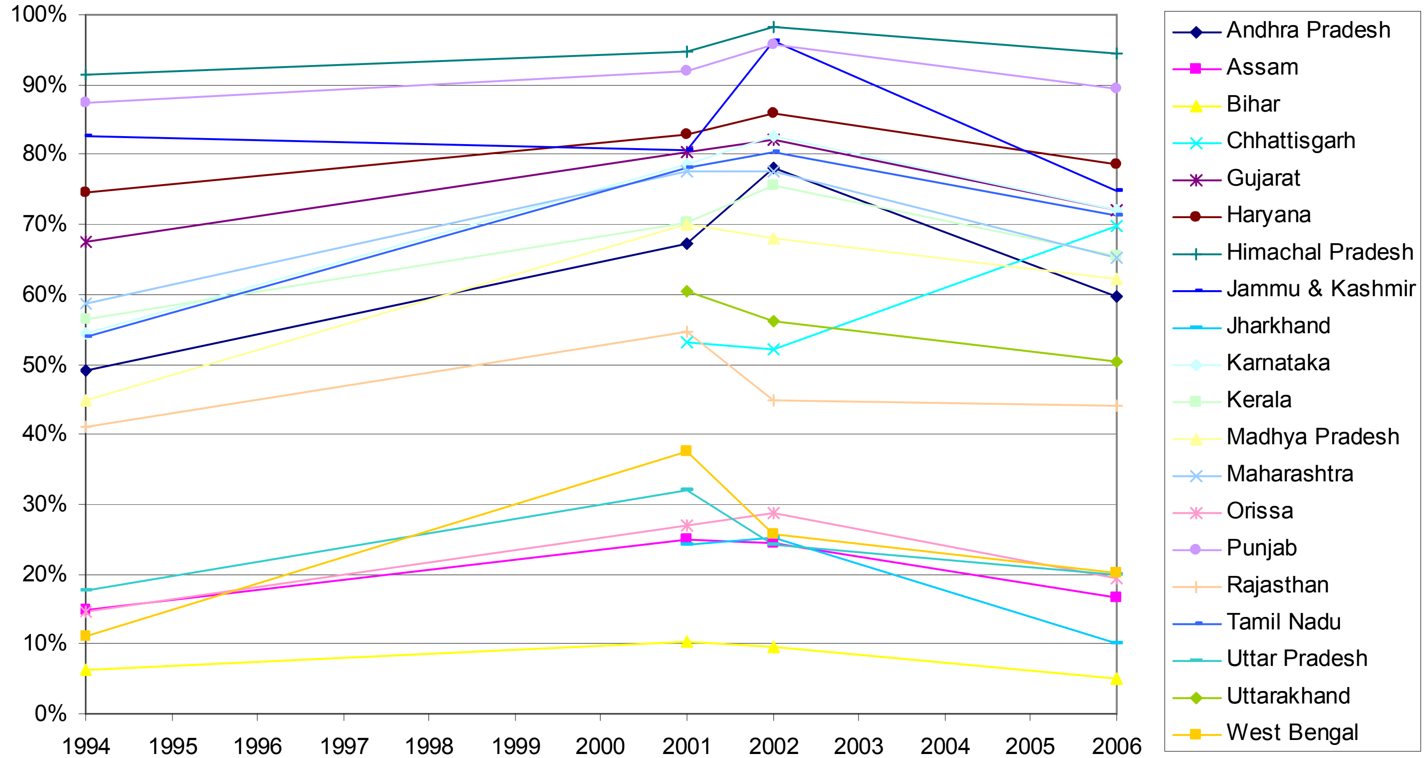

Figure 7.3: Rural household electrification

Source: 1994 data, National Sample Survey Organization 1994; 2001 data, Office of the Registrar General and Census Commissioner 2001; 2002 data, National Sample Survey Organization 2004; 2006 data, TERI 2006c

NB: Data for 1994, 2001 and 2002 represent percentage of rural homes that use electricity for lighting. 2006 data represents percentage of homes judged as being electrified by Ministry of Power

Only Andhra Pradesh, Karnataka, Madhya Pradesh and Tamil Nadu are able to demonstrate double-digit growth in household electrification over the period. For many states, there has been a decade of missed opportunity for states provision of electricity for their rural populations.

Interpretation of the different indicators of rural electrification suggests that there is more similarity than difference between them. It is evident that the same group of states have, in fact, struggled to achieve success against each of the indicators of rural electrification – notably Assam, Bihar (and Jharkhand after the bifurcation of the states), Orissa, Uttar Pradesh and West Bengal. Given the analysis in the previous chapters, it is unsurprising that the eastern states plus Uttar Pradesh have struggled to achieve household electrification – this is consistent with previous findings that the federal structure and constitutional separation of responsibilities for electricity, together with state-level institutional weakness has constrained the creation of the electricity system overall in these states (Uma Shankar 2009)[138]. However, it remains to be analysed whether those states are likely to fall further behind given the liberalised electricity system and current rural electrification policies. This is important as the six states of Assam, Bihar, Jharkhand, Orissa, Uttar Pradesh and West Bengal account for almost two thirds of unelectrified households across India (TERI 2006c). The next sections provide some answers to this question.

[138] The federal structure is not universally perceived as the key issue. Kumar, for instance, suggested that it is the diversity within the country, rather than constitutional structure that has resulted in considerable unevenness in rural electrification attainment (Kumar 2009a).

7.3 Providing sufficient policy support for weaker states

It has been demonstrated in section 7.2 that, irrespective of the rural electrification definition selected and period reviewed, a number of states have consistently under-performed relative both to their peers and to absolute measures of rural electrification success. Rural electrification progress under RGGVY has shown substantial improvement over previous attempts at rural electrification. It has been suggested that there has been greater progress in the first four years of the RGGVY programme than during the previous 20 years of other schemes (Uma Shankar 2009). The longest running programme for rural electrification has been the Kutir Jyoti programme providing basic electricity services to BPL (Below Poverty Line) households. This programme was 100% grant funded from the centre but implementation was left to the states - removing any state arguments that financial weakness caused under-performance (Bhattacharyya 2006). Given the perennial challenge in achieving progress in some states and the continuing ambiguity caused by the concurrent status of electricity in the constitution, have the current policies recognised the institutional weakness of some states and been designed with adequate support to ensure successful implementation regardless of the institutional quality of the state? The principle policy support features are considered in turn but first the legislative and regulatory support for rural electrification that underpins the efforts of all the states is discussed.

7.3.1 Legislation and regulatory structure

The principles of universal access to electricity and associated rural electrification were not explicitly stated in India's original electricity legislation – the Electricity (Supply) Act 1910 and the Electricity (Supply) Act 1948. Section 22 of the 1910 Act merely details the obligations on the distribution licensee to supply energy - non-discriminatory access to electricity connections for any customer within the licensee's area of operation with very little guidance on extending the area of operation.

The Electricity Regulatory Commissions Act, 1998 that provided the legislative support for the creation of independent electricity regulators at the national and state levels was also largely silent on matters of rural electrification. Section 13 of the Act specified the functions of the commission in detail but universal access and rural electrification were absent from the eleven mandatory and four advisory functions defined (see box 1).

Section 14 of the Act provided for the creation of a central advisory committee to represent the interests of "…commerce, industry, transport, agriculture, labour, consumers, non-governmental organisations and academic and research bodies in the energy sector" – but notably not potential customers (Government of India, Ministry of Power 2003 Sec 14(2)). However, section 15, detailing the objectives of the central advisory committee, specifies that the committee shall advise the central commission on "…matters relating to quality, continuity and *extent* of service provided by the licensees" (italics added) (Government of India, Ministry of Power 2003 Sec 15(iii)).

Box 1: Functions of the Central Electricity Regulatory Commission
As entrusted by the Electricity Act, 2003 the Commission has the responsibility to discharge the following functions (Government of india, Ministry of Power 2003: Sec 79) .
Mandatory Functions:

(a) to regulate the tariff of generating companies owned or controlled by the Central Government;
(b) to regulate the tariff of generating companies other than those owned or controlled by the Central Government specified in clause (a), if such generating companies enter into or otherwise have a composite scheme for generation and sale of electricity in more than one State;
(c) to regulate the inter-State transmission of electricity ;
(d) to determine tariff for inter-State transmission of electricity;
(e) to issue licenses to persons to function as transmission licensee and electricity trader with respect to their inter-State operations.
(f) to adjudicate upon disputes involving generating companies or transmission licensee in regard to matters connected with clauses (a) to (d) above and to refer any dispute for arbitration;
(g) to levy fees for the purposes of the Act;
(h) to specify Grid Code having regard to Grid Standards;
(i) to specify and enforce the standards with respect to quality, continuity and reliability of service by licensees.
(j) to fix the trading margin in the inter-State trading of electricity, if considered, necessary;
(k) to discharge such other functions as may be assigned under the Act.

Advisory Functions:-

(i) formulation of National electricity Policy and tariff policy;
(ii) promotion of competition, efficiency and economy in the activities of the electricity industry;
(iii) promotion of investment in electricity industry;
(iv) any other matter referred to the Central Commission by the Central Government.

The state regulatory commissions, enacted through their own state level legislation, embraced without exception the functions for the state electricity regulatory commissions as specified for the central regulator. Sections 38 and 39 of the Act provide provision for the central and state governments to be able to guide the CERC and SERCs respectively in matters pertaining to the public interest. This clause provides an opportunity for central and state government to influence the criteria by which the regulators function regarding public interest matters such as rural electrification.

It was not until the Electricity Act, 2003 that universal access to electricity gained explicit legislative recognition. Sections 5 and 6 of the Act define the policy as follows[139]:

Section 5. (National policy on electrification and local distribution in rural areas): The Central Government shall also formulate a national policy, in consultation with the State Governments and the State Commissions, for rural electrification and for bulk purchase of power and management of local distribution in rural areas through Panchayat Institutions, users' associations, cooperative societies, non-Governmental organisations or franchisees.
Section 6. (Joint responsibility of State Government and Central Government in rural electrification.): The concerned State Government and the Central Government shall jointly endeavour to provide access to electricity to all areas including villages and hamlets through rural electricity infrastructure and electrification of households (Government of India, Ministry of Power 2003).

The wording for section 6 comes for the Electricity (Amendment) Act 2007 (Government of India, Ministry of Power 2007). The original act had the following wording: "The Appropriate Government shall endeavour to supply electricity to all areas including villages and hamlets." The amended wording, demonstrating the challenge of managing concurrent constitutional subjects, makes explicit the need for the central government to remain engaged to ensure success of the rural electrification programme – particularly given the weak performance of some of the states as discussed below.

The 2003 Electricity Act implicitly clarified the role of the regulator in support of rural electrification. Notably, the regulators' responsibility (both central and state) is limited, from a distribution perspective, to controlling the activities of licensees. Both the erstwhile SEBs and unbundled distribution companies are licensees under the Act. However, for the purposes of extending rural electrification, the need to become a

[139] Section 4 provides for the development of off-grid solutions for remote villages. In reality, despite considerable academic attention, off-grid rural electrification is a small part of the whole in India (Kumar 2009b).

licensee has been waived for rural electrification franchisees (as stated in section 13 of the Act) – thus removing the franchisees from direct regulatory oversight (Government of India, Ministry of Power 2003, Kumar 2009a).

The regulators, however, do have a duty to ensure a certain standard of performance – enabling the regulator to be active in driving up service quality (including to rural customers). The Act provides power to the regulator under section 57 to impose financial penalties on licensees and franchisees that fail to achieve prescribed service quality levels and / or mandate consumer compensation.

The Act provides a small number of other provisions to clarify responsibilities with respect to rural electrification. Section 43 specifies the duty to provide service upon request. This is the replacement for section 22 of the old 1910 Act discussed above Importantly, and unsurprisingly, no timeframe is specified for fulfilling a request for delivery of an electricity supply in an area where that supply does not currently exist and the SERC is responsible for determining that timeframe.

Section 5 of the Act, as stated above, called for the development of a national plan for rural electrification. A national electricity policy was published on 12th February, 2005 and was followed by the rural electrification policy published by the Ministry of Power on 23rd August, 2006 (Government of India: Ministry of Power 2006), (Government of India: Ministry of Power 2005). The RGGVY programme, discussed in detail below, was launched in April 2005 in the context of the legislation and policy direction provided in the above documents[140]. The programme brought together all previous rural electrification initiatives with the goal of electrifying all villages and habitations, providing access to electricity to all households and providing a free electricity connection to all below poverty line (BPL) households.

This policy framework provides the tools for delivering universal access to electricity in India. The policy covers all the states but given the uneven attainment in rural electrification achieved through previous policy efforts is there sufficient policy support in the current policies to overcome the institutional weakness inhibiting progress in a number of states?

7.3.2 The franchisee model

The franchisee model is an innovation in the RGGVY programme designed to both generate demand in local communities and improve the collection rates and loss statistics. The franchisee model is a mandatory part of the programme designed to ensure sustainable revenues from rural consumers. This is to be achieved by engaging local community organisations or entrepreneurs in the management of the distribution sector. Will the franchisee model provide an approach that will support improved electrification implementation in rural areas?

The programme recognises a number of franchise models (Bhattacharyya and Srivastava 2009). The degree of engagement (and level of sophistication of the franchise operator) varies considerably from model to model but all require considerable managerial capacity in the state distribution licensee and the state

[140] A number of national level reviews of the RGGVY policy framework have been undertaken (Bhattacharyya 2006, Kalra et al. 2007)

regulator. A pool of capable individuals is also assumed in the village communities in which the franchisees are to be set up. As of the latest available RGGVY management reports, franchisee structures have been set up in 10 of the large states (Assam, Bihar, Chhattisgarh, Haryana, Karnataka, Punjab, Rajasthan, Uttar Pradesh, Uttarakhand and West Bengal). The level of sophistication and extent of the deployment varies considerably between the states. Chhattisgarh and Karnataka have franchisee operations covering over 15,000 villages each. Punjab has coverage for all rural feeders (excluding agricultural feeders). Bihar has commenced the process of setting up franchisees for over 20,000 villages. The other states have considerably smaller implementations. The majority of franchisee deployments to date are based on the simplest revenue collection models in which the distribution company remains responsible for the supply of electricity, maintenance of distribution networks and merely outsources customer acquisition, meter reading, billing and collection to the franchisee (Bhattacharyya and Srivastava (2009) provide a useful summary of the alternative models).

A small number of franchisee reviews have been performed to date (by REC and TERI and focused on Assam, Karnataka, Madhya Pradesh, Rajasthan and West Bengal - Integrated Research and Action for Development 2007a, Integrated Research and Action for Development 2007c, Integrated Research and Action for Development 2007b, TERI 2007). These provide some evidence for the efficacy of the franchisee model and allow early conclusions to be drawn over whether the model will prove beneficial or problematic to the institutionally weaker states. The surveys undertaken are at a relatively early stage in the franchise model rollout and are not yet able to answer questions of the sustainability of delivery at scale[141]. The surveys also vary methodologically. However, a qualitative comparative analysis of the survey results for the five states reviewed has been undertaken with a focus on a small number of key attributes of the programmes:

- Revenue collection
- New customer recruitment
- Loss levels and service quality

Franchisees are incented to achieve improvement in the quality of revenue collection in rural areas and grow the rural consumer base. For example, in Madhya Pradesh, the franchisee is billed for electricity supplied by the utility at a tariff of Rs. 1.0 per unit. The franchisee is able to keep all revenues collected with retail tariffs ranging from Rs. 2.65 to Rs. 3.40 depending on usage – providing an incentive to maximise bill collection and reduce theft (as the electricity theft affects the local franchise business rather than the utility). In Assam, the franchisee is able to keep 15% of all billed revenues (after allowing for 10% technical losses). Table 7.1 provides limited operational results from the surveys performed to date. The impressive increase in revenue collection is evident – to be expected given the incentives created fro the franchisee to maximise revenue collection.

[141] With the exception of Assam that had set up a franchise structure for rural electrification in 2004 prior to the introduction of the RGGVY programme – although the term “agent” rather than “franchisee” was used.

Table 7.1: Performance statistics from franchise progress surveys - franchise initiation to survey date (surveys all undertaken in 2007)

State	Franchise type	Growth in revenue	Growth in customers
Assam	Input based	95%	16%
Assam	Input based	Not provided	11 per village
Karnataka	Input based	95%	10-20%
Madhya Pradesh	Input based	~300%	31%
Rajasthan	Input based	16.85%	3%
West Bengal	Meter reading and bill distribution only	Not provided	Not provided

Source: Integrated Research and Action for Development 2007a, Integrated Research and Action for Development 2007c, Integrated Research and Action for Development 2007b, TERI 2007

The expansion in customer numbers is not, however, as impressive despite consumer mobilisation being a key aim of the franchise programme. The incentive structure for encouraging franchisees to expand the customer base may have two components:

– An indirect benefit gained by increasing overall revenues;

– A direct benefit of explicit payments for each new customer.

The indirect benefit is available to all franchisees but direct one-off payments for new connections is not a mandatory element of the franchise model and is not therefore provided in all cases. The West Bengal model, although more limited than the other franchise models as it did not, at the time of survey, include revenue collection, does provide for one-off payments of Rs. 30 and Rs. 20 for new customers (above and below poverty line respectively). Further, new connections are not within the power of franchisees to deliver independently – requiring utility authorisation and physical connection. The Rajasthan study identifies a potential pent up demand for new connections awaiting utility action due to shortage of equipment.

The outsourcing of the customer-facing elements of electricity distribution to local companies or organisations with informal network relationships and physical proximity with those customers appears to have considerable merit. Anecdotally, theft in particular, appears to have declined considerably (to almost zero in the Rajasthan and Assam surveys). However, the franchisee remains highly dependent on the utility for basic service provision. All surveys reviewed continued to report dissatisfaction amongst rural consumers with respect to voltage quality and daily hours of supply. The level of technical losses experienced in the distribution system was also an issue and remains a responsibility of the utility rather than the franchisee under the models most commonly seen in the field.

The franchisee model is not therefore a panacea and, as well as relying on the utility for basic service provision requires effective structuring and management by the utility. Of the franchise structures surveyed, profit-oriented approaches were dominant. Only West Bengal had a community focus based on self-help groups – an approach already in place for other rural development activities. The long-term sustainability of the franchisee system therefore depends in most cases, on adequate financial returns being available to the franchise owner. Financial viability is seen, from the survey results, to be primarily driven by the scale of the franchisees operation. In West Bengal, it was estimated that each franchisee required no fewer than 600 paying customers – the actual level was found to be 435. In Madhya Pradesh, franchisees were initially given a single distribution transformer and connected customers as their range of operation. This was found to be inadequate. In Assam, the number of distribution transformers allocated per franchisee was deemed adequate, but in a few cases, where the number of distribution transformers was limited to 1-3, the income of the franchisee was found to be unsustainably low.

The case of Karnataka provides evidence for the potential of the franchisee system to under-perform. The initial franchise operation surveyed ultimately proved to be unpopular with franchisees (primarily profit-oriented entrepreneurs). 12% of franchisees formed subsequently relinquished their franchise. A number of reasons that are the responsibility of the utility were cited for poor performance:

- Delay in payment to the franchisee by the utility;
- Failure by the utility to adequately train the franchisees;
- Inadequate provision of equipment such as spot billing machines;
- Inadequate franchisee income due to poor contractual structure – e.g. utility counter collections not accruing to franchisee despite managing billing process.

The lack of franchisee training was cited by other surveys as a challenge. No official capacity building was provided in the Madhya Pradesh programme. In Assam, 80% of surveyed franchisees claimed no formal training was provided by the utility and it was further observed that utility employee resistance to the franchisee programme was experienced because of fears of job losses. In Rajasthan, on the other hand, the quality of training provided by the utility was praised.

Overall, there is little evidence to suggest that the franchisee model is being adopted less effectively by the weaker states. Assam has developed a particularly effective and broad-based franchise structure. West Bengal has adopted a cooperative self-help group structure for franchising and is moving more slowly towards an approved model. It may find greater difficulty in sustaining the franchisee infrastructure over time or reaping the benefits of the franchise model due to the lack of personal incentive and the engagement of less educated franchise operators. However, the overall success of the franchise programme remains to be seen. The financial benefits in terms of improved revenue collection are evident from the studies conducted so far and should improve the financial viability of the utility and importantly, disprove the perception that rural electrification is an unprofitable activity to not be pursued aggressively. However, this success depends on the selection of an appropriate franchise model initially, the effective launching of the programme with an appropriate contractual remuneration structure, scale of operation and training, supported by the utility. All of this requires strong, consistent management by the utility and delivery by the utility on its own commitments – strengthening the distribution infrastructure, paying franchisees promptly and improving the overall electricity supply position. Finally, it is not clear that the franchise models being selected by the states are providing sufficient incentive to deliver universal electricity access by rolling out new connections to all households. Franchisees may not be receiving sufficient inducement to make the effort to encourage new customers particularly as the franchisee is not able to physically deliver the connection. Other policies are required to assist in the delivery of this objective.

7.3.3 Implementation capacity support

7.3.3.1 Independent implementing agencies

One facet of the new RGGVY programme that explicitly recognises the institutional weakness of some states in implementing programmes is the provision by the central government of expertise from central public sector undertakings (CPSUs) to act as implementing agencies for the rural electrification projects. All RGGVY programmes must have an implementation agency - primarily the SEB, unbundled distribution company or a designated CPSU (the central organisations partaking in the programme are the Power Grid Corporation of India, the NTPC, the NHPC and the Damodar Valley Corporation). Table 7.2 details the selection of implementing agency by the states. This is primarily undertaken at the district level although in some instances there are multiple projects per district – each with a separate implementing agency. It is clear that those institutionally weaker states – Assam, Bihar, Orissa, Uttar Pradesh and West Bengal – have all selected to take advantage of the managerial capabilities of the CPSUs to support the implementation of projects.

Table 7.2: RGGVY implementing agencies

	State	State Cooperative	CPSU
Andhra Pradesh	22	4	
Assam	16		7
Bihar	8		38
Chhattisgarh			16
Gujarat	23		2
Haryana	20		
Himachal Pradesh	12		
Jammu & Kashmir	7		7
Jharkhand	6		16
Karnataka	26	1	
Kerala	14		
Madhya Pradesh	45		3
Maharashtra	34		
Orissa			31
Punjab	17		
Rajasthan	34		7
Tamil Nadu	30		
Uttar Pradesh	57		10
Uttarakhand	13		
West Bengal	20		10

Source: Government of India, Ministry of Power 2009a

Most states, including the weaker ones, have, however chosen, in some districts, to delegate implementation to their own state institutions. There has been no central mandating of the use of CPSU implementing agencies – the choice lies with the states.

Implementation is still underway in most cases and it is therefore premature to formally evaluate the relative success of state vs. central implementation agencies – although this will be feasible as projects conclude. However, initial evidence does not look encouraging for state entity implementation. Table 7.3 examines the success to date of projects in Bihar in 2008 – comparing BSEB projects with those run by two CPSUs (PGCIL and NHPC). 2008 projects were selected to enable a like for like comparison because no BSEB run projects were sanctioned prior to 2008 whereas over half the CPSU projects in Bihar were already sanctioned prior to 2008 – thus those longer running CPSU projects are excluded.

Table 7.3: Status of RGGVY projects in progress in Bihar, sanctioned in 2008

			Financials (Rs. Million)			Village electrification			Number of connections to all rural households		
Implementing agency	District	Date sanctioned	Amount sanctioned	Amount released	% released	Coverage	Progress	%	Coverage	Progress	%
BSEB	Begusarai	Mar-2008	812	379	46.7	387	0	0	348,314	0	0
BSEB	Katihar	Mar-2008	1,872	851	45.4	1,031	0	0	408,659	0	0
BSEB	Khagaria	Mar-2008	287	148	51.5	133	0	0	108,458	0	0
BSEB	Madhepura	Mar-2008	520	259	49.9	234	0	0	233,305	0	0
BSEB	Saharsa	Mar-2008	569	290	51.0	267	0	0	202,101	0	0
BSEB	Samastipur	Mar-2008	995	443	44.6	455	0	0	494,274	0	0
BSEB	Sheikhpura	Mar-2008	293	139	47.4	162	0	0	60,738	0	0
BSEB	Supaul	Mar-2008	816	367	45.0	357	0	0	268,168	0	0
NHPC	Darbhanga	Apr-2008	843	307	36.5	290	3	1.0	537,161	16732	3.1
NHPC	Madhubani	Apr-2008	870	296	34.0	248	12	4.8	592,343	17264	2.9
NHPC	Paschim Champaran	Apr-2008	1,654	534	32.3	916	33	3.6	475,834	18446	3.9
NHPC	Purav Champaran	Apr-2008	723	284	39.3	96	15	15.6	474,121	14377	3.0
NHPC	Sheohar	Apr-2008	165	144	87.7	54	116	214.8	100,083	11200	11.2
NHPC	Sitamarhi	Apr-2008	755	259	34.3	245	10	4.1	410,854	18011	4.4
PGCIL	Arwal	Mar-2008	0	0	0.0	0	0	0.0	0	0	0.0
PGCIL	Jehanabad	Mar-2008	484	313	64.7	540	376	69.6	23,953	13375	55.8
PGCIL	Muzaffarpur	Mar-2008	1,788	518	28.9	335	335	100.0	291,343	31776	10.9
PGCIL	Muzaffarpur	Mar-2008	0	0	0.0	551	551	100.0	0	0	0.0
PGCIL	Vaishali	Mar-2008	1,354	377	27.9	336	336	100.0	148,828	14955	10.0
PGCIL	Vaishali	Mar-2008	0	0	0.0	543	543	100.0	0	0	0.0

Source: Government of India, Ministry of Power 2009a, Government of India, Ministry of Power 2009b

It is immediately clear that the BSEB projects have achieved no material progress despite eighteen months having elapsed since project sanction and 40-50% of the sanctioned funds having been released for these projects. This contrasts with projects implemented by the two CPSUs that have demonstrated considerable progress in both village and household electrification over the same eighteen-month period.

The evidence therefore suggests that the introduction of CPSUs as project implementation specialists is a positive and material policy improvement in supporting rural electrification in weaker states.

7.3.3.2 Utility personnel training

There is recognition that a lack of skills within the utilities has the potential to influence implementation outcomes. In 2002, a National Training Policy for the Power Sector was drafted (Government of India: Ministry of Power 2002). It stated that 1.5% of SEB personnel costs should be applied at a minimum to training and that the SEBs should move towards investing 5% of salary costs in training. A number of institutions have been put in place to support the training needs of the industry. These include the National Power Training Institute, an apex body coordinating training across all electricity sector disciplines and the Central Institute for Rural Electrification (under the Rural Electrification Corporation), established in 1979 and based in Andhra Pradesh that provides focused training for rural electrification professionals across India. Involvement in training requires the state electricity companies to allocate resources to training and given the chronically weak state of most SEB finances, this continues to be problematic. To mitigate the challenge of identifying training budgets and foster capacity building within the state utility sector the Ministry of Power has collaborated with US-Aid on an education programme covering many areas of distribution best practice including:

- Best Practices in Distribution Loss Reduction
- Best Practices in Agricultural Pumping Sets
- Financial Management of Distribution Business
- Best Practices in Distribution Systems O&M
- Customer satisfaction, communication and outreach

The programme, part of a broader collaboration titled DRUM (distribution reform, upgrades and management) focused on improving the quality of India's distribution networks. The broader programme, although nationally focused channeled the majority of resources into four pilot states – Delhi, Gujarat, Haryana and Karnataka. The institutionally weaker states were not involved. However, the training programme was open to all utility staff and the target was ultimately to reach 25,000 utility staff. As of the latest available MIS reports for the programme, 23,437 utility employees had received some sort of training. However, the regional breakdown is interesting. Only 16% of participants come from the weaker eastern region, compared to 33% for the western region, 26% for the northern region and 25% for the southern region (DRUM Project Secretariat 2008). The latest state-level breakdown available (May 2006) shows considerably lower engagement from Uttar Pradesh than Haryana, Delhi or Himachal Pradesh. In addition, West Bengal (the most promising improving state in the eastern region) trained twice as many personnel as Jharkhand or Orissa and 3.5 times more personnel than Bihar (DRUM Project Secretariat 2006). This is despite the programme being funded by a donor organisation and therefore freely available to all states and training being accessible at regional centres around the country.

7.3.4 Regulatory engagement

The widening role of regulatory authorities in the management of the states' electricity systems is a principle part of the liberalisation process and has the potential to bring a different emphasis to the continuing development of the electricity sector. Liberalisation has progressed at different speeds in the states since its commencement in 1991 and might increasingly be seen as both an indicator of progress and an influence on progress. Table 7.4 presents a snapshot of the progress towards liberalisation at the state level and demonstrates the considerable variation in performance. Of particular note are the relative ages of the state regulatory commissions and widely varying number of tariff orders introduced – representing very different levels of practical experience within the SERCs.

As discussed in section 7.4.1 above, the waiving of licensee requirements on rural electrification franchisees has explicitly removed the regulator from the governance structure for some aspects of rural electrification. Bhattacharyya provides a theoretical interpretation of the role of the regulator, particularly in the context of the franchisee model – identifying the potential confusion caused by the lack of regulatory authority over non-licensed rural electrification franchisees (Bhattacharyya and Srivastava 2009).

Table 7.4: Progress of electricity reform, 2008

	Haryana	Himachal Pr.	J&K	Punjab	Rajasthan	Uttar Pr.	Uttrakhand	Chattishargh	Gujarat
Constitution of SERC	Aug-98	Jan-01	Feb-07	Jan-04	Dec-99	Sep-98	Feb-02	Feb-08	Nov-98
Number of tariff orders	6	5	1	6	4	6	4	2	4
Date of last tariff order	2007	2007	2007	2007	2007	2008	2008	2006	2007
Unbundling	Yes				Yes	Yes	Yes		Yes
Corporatisation	Aug-99	Ext. Jul-08		Ext 30/11	Jul-00	Jan-00	2001	Ext Jul-08	Jan-05
Numbers	2				3	4	1		4
% of 11KV feeder meters	100	98	95	100	100	100	100	100	100
% consumer meters	90	100	40	86	95	91	97	74	93
ADPRP Sanctions (Crore Rs.)	432	323	1100	716	1193	1069	310	353	1083
ADPRP Investment Releases (Crore Rs.)	169	307	705	203	434	314	280	159	400
% ADPRP Utilisation	71	98	55	60	74	93	85	69	91

	Madhya Pr.	Maharashtra	Andhra Pr.	Karnataka	Kerala	Tamil Nadu	Bihar	Jharkhand	Orissa
Constitution of SERC	Aug-98	Aug-99	Mar-99	Aug-99	Nov-02	Mar-99	Feb-04	Feb-08	Aug-96
Number of tariff orders	6	6	8	6	6	2	1	2	7
Date of last tariff order	2008	2008	2007	2006	2008	2007	2006	2007	2006
Unbundling	Yes	Yes	Yes	Yes					Yes
Corporatisation	2002	Jan-05	1999	1999	Ext Oct-08	Ext Jan-09	Ext Sep-08	Ext Oct-08	Apr-96
Numbers	3		4	5					4
% of 11KV feeder meters	100	100	100	100	100	100	41	86	95
% consumer meters	72	87	88	86	100	86	50	75	81
ADPRP Sanctions (Crore Rs.)	663	1643	1127	1186	859	948	823	424	207
ADPRP Investment Releases (Crore Rs.)	179	436	567	464	249	442	313	154	74
% ADPRP Utilisation	57	69	85	81	50	76	93	54	20

Source: Government of India, Ministry of Power 2008b

The public interest clauses in the Electricity Act provide an opportunity for the regulator to remain centrally engaged as directed by state government. Further, the rural electrification policy explicitly stated the role of the appropriate commissions (i.e. both the central and state electricity regulatory commissions) in ensuring universal service obligations are met:

Under proviso to Section 43 of the Electricity Act 2003 (hereinafter referred to as Act), the Appropriate Commission while giving additional time, if any, for discharge of the universal service obligations would ensure that the national goal of providing access to households by year 2009 is complied with (Government of India: Ministry of Power 2006: p3).

However, in reality, there is little tangible evidence for these powers having been exercised. Only three state regulators explicitly include rural electrification considerations in their mission (Chhattisgarh, Haryana and Uttarakhand).

All the large states regulators have now issued retail tariff orders – prescribing the allowed maximum tariff level for each category of consumer. The tariff setting process has also included a consultation with all industry stakeholders. Few commentators question the pace of progress towards universal electrification. A rare example sourced from Andhra Pradesh is provided:

The National Electricity Policy and Rural Electrification Policy define village electrification as having been achieved only when a DTR is erected, public places in the village are electrified, 10% of households are electrified and have proper voltage for lighting at peak time. How many villages in AP are to be considered as not electrified under this definition and what are the plans to electrify them? What are the plans for electrifying 51 lakh unelectrified households by 2012? (Andhra Pradesh State Electricity Regulatory Commission 2005: p21).

The cost of electricity to poor rural consumers is a common cause of complaint. Seven states have lower tariff levels for rural consumers as compared to urban consumers (Bihar, Gujarat, Jharkhand, Karnataka, Uttar Pradesh, Uttarakhand, and West Bengal). Andhra Pradesh and Punjab continue to provide free power for agricultural purposes. Examples of consultation responses include:

It has been pleaded that low tariff should be allowed in rural areas for domestic consumers using up to 100 units per month (Andhra Pradesh State Electricity Regulatory Commission 2005: 79);

Power supply in rural areas is very bad. The tariff rates should be based on availability of power (Bihar State Electricity Regulatory Commission 2006: p46).

Table 7.5 provides some insight into relative tariff rates in the states taken from their respective 2006 tariff orders (or closest later tariff order if one was not issued for FY 2006). Comparison of tariffs between the states is not straightforward. States can vary tariff by residence (urban / rural), consumption and maximum load and set the cut-off levels between slabs according to their own state-level criteria. To support a comparison, two 'model' consumers have been selected – one representing a minimum consumption level[142], the other representing a relatively affluent rural domestic consumer. There is considerable progressiveness (and therefore cross-subsidy) in the tariff of all states between two theoretical classes of rural domestic consumers. All states provide heavy implicit subsidies to poor rural consumers.

[142] The calculation assumes that the customer is not recorded as below poverty line (BPL).

Table 7.5: Comparison of domestic rural tariffs, 2006.

	Tariff level (Rs.)			
	100W load for 5 hours per day (15 KWh / month)	< 2KW load and 200 KWh / month	Rank - small consumer	Rank - large consumer
Andhra Pradesh	21.75	610	15	9
Assam	47.25	790	4	1
Bihar	25	340	13	15
Chhattisgarh	11.25	330	18	16
Gujarat	45.5	550	5	10
Haryana	39.45	726	7	4
Himachal Pradesh	10.5	300	19	17
Jammu & Kashmir	28.5	360	12	14
Jharkhand	15	290	17	18
Karnataka	34.75	628.5	8	8
Kerala	30	530	10	11
Madhya Pradesh	39.75	710	6	6
Maharashtra	9	720	20	5
Orissa	30	400	10	12
Punjab	63.15	766	2	2
Rajasthan	105.65	735	1	3
Tamil Nadu	16.5	705	16	7
Uttar Pradesh	50	250	3	19
Uttarakhand	22.5	400	14	12
West Bengal	30.9	215.986	9	20

Source: Author's calculations from various SERC tariff orders

The 2003 Electricity Act determined that states and the state regulators should progressively move towards the elimination, by licensees, of cross subsidies. No time limit was placed on the elimination of cross subsidies and six years after the introduction of the Act, it is clear that tariff setting (difference between consumer classes) remains a political decision with limited opportunity for the regulator to exert its authority. Theoretically, rural electrification franchisees, not being licensees under the 2003 Electricity Act, are free to set tariffs at market rates. The regulator only has responsibility for the setting of bulk tariffs for wholesale purchase by the franchisee (Kumar 2009a)[143]. In reality, however, most states do not yet provide bulk supply tariffs for franchisees – the utility mandates both the cost of power and the retail tariff for the franchisee - the retail tariff being guided by the regulator.

Quality of supply is directly within the remit of the regulator and as research suggests, is a pertinent consideration in the take-up of electricity supply by rural consumers (Modi 2005). Stakeholder comments were lodged by seven states (Andhra Pradesh, Bihar, Karnataka, Orissa, Punjab, Rajasthan, and Uttar Pradesh) e.g.:

A number of consumer organisations expressed their deep concern about poor quality of supply to rural areas particularly to agricultural pumpsets. The villages are stated to have supply only for 2 to 3 hours a day (Bihar State Electricity Regulatory Commission 2006: p138);

A majority of the consumers from rural areas complained about the poor quality of supply viz. low voltage, poor repair and maintenance of lines, etc. (Chhattisgarh State Electricity Regulatory Commission 2005: p37);

About 60% of the population of the State live in villages and supply to these villages is given at odd time and also not of good quality hence these people should not be asked to pay at par with urban people. Power supply should be uniform for urban and rural people (Punjab State Electricity Regulatory Commission 2008: p163).

Tariff orders are therefore increasingly recognising the importance of service quality in the regulatory process. Ten states' regulators have signaled growing concern that service

[143] Bhattacharyya and Srivastava also note that the bulk tariff must be set at a level that ensures franchisee commercial viability (Bhattacharyya and Srivastava 2009). Two issues are apparent:

- To ensure generator and distributor viability, bulk tariffs for rural electrification are likely to be cross-subsidised by bulk prices for other market segments.
- The regulator should theoretically evaluate each franchisee's cost base and revenue potential independently to arrive at a correct bulk tariff for that franchisee – a considerable administrative burden on the regulator given that over 70,000 franchisees already exist.

quality obligations must be met in recent tariff orders. However, given the dire state of service quality, these powers have been little exercised to date. Regulators express a need to be sensitive to commercial ground realities (Kumar 2009a) – demonstrating a bias towards sensitivity to the distribution company rather than the consumer. Box 2 provides insight into the specifics of the narrative as played out in one state - Andhra Pradesh.

Box 2: Andhra Pradesh SERC's efforts to push for 24-hour rural electricity supply

Andhra Pradesh's 2005/6 tariff order acknowledged the issue of rural electricity supply quality and directed the distribution companies to determine the requirement to provide 24-hour rural supply and secure procurement of the necessary electricity – and report the approach in the next tariff submission (i.e. in 2006/07).

The 2006/7 tariff order merely further acknowledged the obligation and stated that the distribution companies must "make earnest attempts to see that this commitment is fulfilled" (Andhra Pradesh State Electricity Regulatory Commission 2006: p99).

In the 2007/08 the AP SERC acknowledged once again the distribution companies promises to fulfill their obligation and stated that the distribution companies may file their plans to meet the obligations in the 2008/09 tariff order - two years later than originally mandated in the 2005/6 order (Andhra Pradesh State Electricity Regulatory Commission 2007).

The 2008/9 tariff order provides limited status updates from the distribution companies (indicating attempts to provide 24 hour supplies when surplus power is available) – and a fresh directive from the SERC to provide 6 monthly reports on progress – together with a demand for the distribution companies to report by 31-Oct-2008 as to why tariffs should not be reduced for rural consumers that do not receive 24 hour supply. A fresh directive was also provided for the distribution companies to publicly report "compensation paid by the Licensee to consumers for deficiency of service as per the Regulations of the Commission" (Andhra Pradesh State Electricity Regulatory Commission 2008: p69).

The 2009 tariff order, despite a large number of stakeholder concerns regarding rural service quality relaxed the pressure on distribution companies requiring only that "The Licensees should take necessary steps to ensure reliable power supply to rural households" (Andhra Pradesh State Electricity Regulatory Commission 2009: p39). The distribution companies' response to stakeholder complaints amounted to "making all efforts", "Hopefully power sufficiency can be achieved in the near future", "this issue is being studied by the licensee".

In reality, electricity supply in Andhra Pradesh remains insufficient to support 24-hour supply without load shedding in rural areas. However, unwillingness by the regulator and the distribution companies to transparently recognize the ground reality and put in place an achievable medium term plan has clear consequences. The distribution companies are placed in a position where there is no discipline imposed on their efforts to achieve improved service quality and the regulator suffers declining credibility due to its unrealistic targeting, inconsistency and apparently empty threats.

Giving focus to the regulatory engagement with rural electrification of the institutionally weaker states (Assam, Bihar, Jharkhand, Orissa, Uttar Pradesh and West Bengal), a number of conclusions can be drawn. Firstly, all of the weaker states except for Assam and Bihar have wording explicitly focused on the importance of extending rural electricity services in their tariff orders. The only other state regulator to explicitly mention rural electrification coverage is Gujarat – and in this case, the reason is due to the closeness to the completion of rural electrification rather than the fact that progress is lagging. This suggests that the underperforming state regulators are, overall, cogniscent of the importance of improving rural electrification performance. However, the regulators appear to be currently at the stage of signaling concern rather than considering penalties as the Jharkhand regulator notes:

As regards providing connection to the rural consumers, lack of initiative from the Board clearly highlights their un-willingness to expand their consumer base and hence their revenue (Jharkhand State Electricity Regulatory Commission 2007: para 3.21.2).

In specifying directives to the Jharkhand SEB, the regulator merely requires the SEB to evaluate the subsidy level required to incentivise the rural electrification programme given the thrust of the Government on rural electrification to get all households electrified. It should be borne in mind that this direction came four years after the introduction of the 2003 Electricity Act. The Uttarakhand regulator, in its 2007/8 tariff order signaled its displeasure with the pace of household electrification:

The Commission expresses its displeasure on slow progress in releasing new connections under RGVVY Scheme and directs UPCL to accelerate this process (Uttarakhand State Electricity Regulatory Commission 2008: p126).

The Uttar Pradesh regulator to date has done no more than acknowledge the RGGVY targets and has yet to express an opinion on its perspectives on achievements to date. West Bengal Electricity Regulatory Commission's acknowledgement of rural electrification is only apparent in the 2007 tariff order for WBSEDCL in which a directive was made to report progress in the subsequent tariff order. However, the 2008 order makes no mention of rural electrification – an illustration of the sporadic focus provided by the regulators to rural electrification.

Bihar, Jharkhand, Uttar Pradesh and Uttarakhand's regulators have expressed some level of concern over service quality in rural areas in their tariff orders. In the case of Uttar Pradesh, the 2008 tariff order determined that no tariff increase for rural areas would be supported due to the low quality of service provided in that state (Uttar Pradesh State Electricity Regulatory Commission 2008). This illustrates the dilemma for the regulator. Imposition of financial penalties to discourage poor performance results in the further starving of the distribution company of resources to extend service (or be profitable with the existing rural service).

To summarise, regulators in the weaker states have acknowledged the importance of rural electrification but given the lack of a highly specific mandate in the legislative framework supporting the regulator and the loophole taking rural electrification franchisees out of the regulator's purview, there is considerable potential for the regulatory influence to be ineffective. Experience to date is characterised as weak, slow and sporadic. Explicit universal service obligations for the regulators would go a long way to moving regulatory engagement in rural electrification from rhetoric to action.

7.3.5 Financial support

7.3.5.1 RGGVY financing

The RGGVY programme recognises failings in the financial structuring of earlier rural electrification schemes in providing 90% grant funded with only 10% needing to be funded internally through internal resources or loans[144]. The Rural Electrification Corporation (REC) is the nodal agency under the Ministry of Power for sanctioning and disbursing funds. The REC was formed in 1969, funded by central revenues, with the explicit intent of supporting five-year plan investments in rural electrification. In recent years, however, the REC has expanded into financing other aspects of the electricity system – notably generation. Given the effect of the systemic power supply deficits in most states on rural electrification efforts (both extending coverage and improving quality), this diversification is reasonable. However, it makes it more difficult to interpret the relative emphasis on direct rural electrification initiatives within the individual states as other REC activities now dwarf investment in RGGVY. However, limited data is available. Table 7.6 presents disbursement data for selected states as reported to parliament in 2007.

[144] Below poverty line (BPL) households will continue to attract a 100% capital subsidy for electrification – continuing the incentive provided under the Kutir Jyoti programme.

Table 7.6: REC disbursements for RGGVY programme, 2007

Selected State-wise Amount Disbursed by Rural Electrification Corporation (REC) for Village Electrification under RGGVY in India	
States	Amount Disturbed (Rs. Million)
Andhra Pradesh	1.98
Bihar	42.769
Chhattisgarh	1.597
Gujarat	0.977
Haryana	1.233
Jharkhand	0.35
Karnataka	13.432
Madhya Pradesh	10.466
Orissa	0.35
Rajasthan	10.541
Uttar Pradesh	165.928
Uttarakhand	10.658
West Bengal	23.38

Source: Indiastat 2007b

There is a clear bias towards REC disbursements to the states with furthest to go with rural electrification. Bihar, Uttar Pradesh and West Bengal top the list. However, the level of disbursements is minimal for Orissa (and not reported for Assam). By 2009, the pipeline of proposals received can be seen to have resulted in released RGGVY funds increasingly being directed towards the weaker states. Table 7.7 presents a status report as at 01-Oct-2009.

The weaker states hold the top five positions in terms of released finance, a considerable turnaround from the status in 2007 – the improvement in uptake of financing from Assam, Jharkhand and Orissa is particularly evident. The relationship between sanctioned and released financing is also encouraging for many of the weaker states. Assam and Orissa, in acknowledgement of a later start have release rates of 35-40%, as does West Bengal. Bihar, Jharkhand, and Uttar Pradesh on the other hand have successfully achieved release rates of around 75%. Given the phased delivery-triggered nature of RGGVY financing, high release rates are an indicator of independently verified project success.

Table 7.7: RGGVY sanctioned and released by state, 1-Oct-2009

	Project cost sanctioned (Rs. million)	Total amount released (Rs. million)	Rank of released funds
Andhra Pradesh	8,401	4,503	11
Assam	16,604	6,778	6
Bihar	29,759	23,202	2
Chhattisgarh	11,052	2,533	13
Gujarat	3,604	976	17
Haryana	2,135	752	18
Himachal Pradesh	2,053	1,125	16
Jammu & Kashmir	6,359	3,734	12
Jharkhand	26,626	20,235	3
Karnataka	5,953	5,607	8
Kerala	198	264	20
Madhya Pradesh	15,333	4,634	10
Maharashtra	7,134	2,263	14
Orissa	35,751	12,420	4
Punjab	1,544	604	19
Rajasthan	12,545	6,172	7
Tamil Nadu	4,474	1,190	15
Uttar Pradesh	27,195	30,071	1
Uttarakhand	6,439	5,530	9
West Bengal	25,495	11,421	5

Source: Government of India, Ministry of Power 2009c

RGGVY financing, although perceived on the surface as generous, does have stringent expectations attached to it with material consequences. The RGGVY programme expects rural electrification operating costs to be self-funding. Failure to demonstrate self-financing from a revenue perspective through electricity sales can result in the grant component of the investment being converted to interest bearing loans (Government of India, Ministry of Power 2008a). Theoretically, any subsidy to rural consumers should be met by state budget transfers to the distribution company. However, these are not always forthcoming. Given the dire condition of state government finances – in many cases weakened further by electricity sector losses - the use of RGGVY funds therefore exposes the distribution companies to financial risk with potentially large contingent liabilities on the balance sheet that could further weaken the strength of the sector if the franchisee model fails and rural customers are not serviced economically.

7.3.5.2 APDRP programme

The APDRP programme, designed to improve the effectiveness of the states' distribution systems is managed in parallel with rural electrification within the Ministry of Power (Srivastava 2009). There is a policy relationship between the two programmes – with the success of APDRP being seen as a prerequisite for sustainable progress in rural electrification – although the APDRP programme itself is focused on dense electricity markets in urban areas, the improved financial viability of the DISCOMs or SEBS is perceived as a prerequisite for rural electrification (Mohan 2009). The APDRP programme was initially implemented in 2001 (Government of India, Ministry of Power 2001) but was initially deemed unsuccessful for the following reasons (Planning Commission, Government of India 2007):

- It was an investment driven programme without any outcome accountability;
- The project reports were ill prepared. They replicated the same type of investments without a full buy-in by the host utility;
- There was no baseline data established for distribution losses or on billing / collection efficiency making it difficult to determine what has been achieved;

– Unrealistic targets were set and the scheme provided no incentive for SEB staff cooperation.

The financial structure of the programme initially comprised of 50% state funding, 25% grant and 25% loan (90% grant for the special category states – a list that includes Himachal Pradesh, Jammu & Kashmir and Uttarakhand). To encourage engagement with the programme, the grant / loan mix was more favourable than usually provided for central plan financial assistance (a 30:70 ratio being the norm). In 2005, the central loan component was eliminated (Finance Commission, Government of India 2005). Central funds were distributed to the utilities via the state governments as additional central assistance. Unfortunately, this resulted in delays in the utilities receiving funds from state governments - delays of one year in funds release being common but delays extended to up to 20 months in the case of Himachal Pradesh and 2 years in the case of Orissa.

The programme also had an incentive component that provided grants of up to 50% of cash loss reductions to encourage delivery of actual desired results from the investment programme. However, despite 19 states attempting to access incentive payments for AT & C losses, independent verification resulted in only 9 states successfully demonstrating that loss reduction criteria had been met. Of the weaker states, only West Bengal was present in this list (Government of India, Ministry of Power 2008c).

The restructured APDRP programme (R-APDRP) was launched with the 11th plan and endeavoured to resolve the issues apparent with the earlier plan (Government of India, Ministry of Power 2008d). As with the original programme, the investment target was areas of high-density electricity consumption although higher priority consideration is now also to be given to heavy load rural areas where feeder segregation between agricultural and rural domestic use is desired. Projects are separated into two phases (part-A and part-B) – initially developing a baseline and then delivering improvements that can be measured against that baseline. 100% of the loans for part-A projects are to be converted to grants on independent verification of the required baseline. 50% of the loan for part-B (the implementation) is convertible to grants in five tranches on achieving a 15% AT & C (aggregate technical and commercial) loss rate. Interestingly, the importance of individual agents is recognised for the first time in a major electricity system improvement project and 2% of the grant for part-B projects is to be made available for incentive payments to individual utility staff members for target achievement.

Although 100% loans (convertible to grants) are available for part-A projects, 75% of the cost of part-B projects must be internally financed within state (or loans arranged through bodies such as the PFC or REC). From this perspective, there is little differentiation between the original APDRP programme and the restructured programme. Several issues remain apparent that limit the value of the programmes for the weaker states:

- A substantial proportion of the investment funds need to be internally sourced either from available state funds or from public or private sector lenders – discriminating against those states with weaker credit;

- Financial risk is apparent in the performance conditionalities relating to the incentive scheme – discriminating against those states with a weak implementation record;
- Central budgetary provision for the programme continues to be annual – resulting in financing uncertainty for multi-year programmes;
- Loss reduction targets to trigger incentive payments are doubled for those states with loss levels in excess of 30% (3% per annum as opposed to 1.5% per annum for states with baseline losses less than 30%).

The poor performance of the weaker states (with the exception of West Bengal – again, an indication of West Bengal's improving governance) in attaining incentive payments in the initial programme does not bode well for increased success under the restructured programme which, with more robust base lining, will require real rather than apparent success to trigger incentive payments. In addition, the tranched structure of payment will require a consistency of achievement over a five-year period to maximise incentive payouts – a feat only clearly achieved by Gujarat under the first programme.

Other additions to the programme appear to discriminate against the weaker states. The need to complete a Part-A project to deliver an independently verified baseline prior to commencing full-scale loss reduction activities is more challenging for those states that commence the programme with a less mature distribution system. For example, referring back to table 7.4, as of the end of the 2006/7 financial year Bihar had only successfully metered 41% of its 11kV distribution feeders (Jharkhand had 86% coverage, Orissa had

95% coverage) whereas most states already had 100% coverage[145]. The gaining of approval for the creation of loss reductions into certified emission reductions under the clean development mechanism is championed in the policy as an additional source of revenue to improve the financial returns to the states from the proposal. However, realisation of these opportunities is left to the individual states.

The increased robustness of the R-APDRP programme does, however, result in some features that may support greater engagement and attainment by the weaker states (Government of India, Ministry of Power 2008d):

- Funds are provided directly to the utility – avoiding the potential for state delay or diversion of investment loans and grants;
- Individual utility employee incentives for the first time encourage programme engagement.

Overall, it can be concluded that the APDRP programme restructuring has been designed more to reduce the likelihood of misuse of investment funds by the states rather than encouraging the weaker states to engage successfully in the programme.

7.4 Conclusions

Rural electrification remains a key challenge for India's planners and the electricity sector. India's challenge is not unique – bearing the hallmarks of lack of capital, skills and supply infrastructure commonly observed in a developing and emerging country

[145] It should be noted that 100% meter coverage in the Indian context should not be inferred as those meters actually being read or management and control information being captured from them and used.

context (with a few notable exceptions such as South Africa that benefited from excess capacity (Bekker et al 2008). It is also symptomatic of the broader challenge faced in formulating policy to improve the effectiveness of the electricity system across India. In different guises, rural electrification has been a key component of the development agenda since independence. Initially, electrification was seen as a means of improving agricultural productivity through the electrification of tubewell pumpsets. Progress was relatively rapid across the country (although attainment relative to potential varied considerably from state to state) and, indeed, played an important part on the green revolution and the improvements in agricultural productivity seen in the country since the 1960s. However, this strategy, together with an exceptionally loose definition of village electrification gave rise to a number of problems that have proven resistant to policy action:

- The expansion of electricity for agricultural purposes together with political pressure to heavily subsidise agricultural supplies has resulted in considerable misuse of electricity;
- A sense of entitlement to electricity supported by a heavy resistance to metering created a culture of non-payment;
- Initial emphasis on agricultural use resulted in an infrastructure ill-suited to the distribution of electricity for domestic as well as agricultural purposes;
- Flattering village electrification statistics in many states that did not represent the ground reality of progress at household or even village electrification;

Rural electrification was fundamentally unsupported by electricity legislation prior to the 2003 Electricity Act. Even the legislation supporting the formation of independent regulators in 1998 provided very limited support, beyond vague public interest obligations, for what was and remains a key objective for the electricity sector.

The 2003 Electricity Act provided this explicit support and was the catalyst for the formulation of the RGGVY programme – India's flagship rural electrification policy. The RGGVY programme provided an improved definition for rural electrification – recognising the ultimate goal of household electrification. However, the improved definition still failed to match the political rhetoric by only requiring 10% household electrification. Equally importantly, no measure of service quality was included in the definition because of both the practical challenges of systematically reporting service quality and the dismal reality of what such statistics would likely report.

Analysis of progress against the various measures of rural electrification clearly show that under both central planning and the post-1991 liberalised electricity system prior to the introduction of RGGVY, the same set of states have struggled to execute on rural electrification objectives. The institutional weaknesses discussed in chapter 5 offer a plausible causal explanation for SEB failure to deliver rural electrification – begging the question of how current rural electrification policy is recognising these weaknesses and supporting the poorest performing states.

The mandatory implementation of a franchise model at the local level is an innovative approach to both reduce commercial losses at the point of consumption and encourage the mobilisation of more consumers. The franchise models are institutionally complex and require some sophistication to ensure appropriate structure, implementation and governance. Early studies suggest that well-structured franchise operations can indeed result in reduced commercial losses. However, the financial sustainability of the franchise model is not yet clear nor is its scalability to the whole of rural India. The success of the franchise model still depends on a well-run distribution utility that pays its bills and provides a high quality electricity supply. Further, it is not clear that the franchise model, in of itself, provides sufficient incentive for the franchisee or the utility to expand the customer base.

Central government has provided for the injection of expertise from strong central public sector undertakings in the implementation of RGGVY projects. CPSUs have been engaged by all the weakly performing states and to a greater degree than their better performing peers. However, the decision to engage a CPSU or the indigenous SEB or DISCOM is the state’s to make and most of the poorly performing states have chosen to engage both CPSUs and SEBs in different districts. Early evidence suggests that the CPSUs are outperforming the indigenous project implementers – suggesting a higher potential for success than previous programmes. However, the lack of a central mandate to use CPSUs for implementation has allowed the states to continue to engage weak local institutions for political or other reasons.

Reasonable provision has been made for training of utility personnel across the country but the uptake of that training is skewed in favour of the better run utilities in the west and south. Even removing the question of cost, by examining programmes delivered free through donor financing, the weaker utilities demonstrate less engagement with training programmes.

The evolution of independent regulators in all states may be seen as a positive development for improved governance. In the case of rural development, however, the impact of the state regulators has been limited. The mandate held by the state regulators is weakened by the waiving of electricity license requirements for rural electricity franchisees. The lack of explicit mention of rural electrification or other universal access obligation in the statement of responsibilities of the regulators appears to be a major omission. Regulators have engaged in rural electrification from a perspective of tariff setting and service quality and, indeed, the weaker states' regulators have been more vocal in recognising the concerns of rural consumers. However, recognising ground realities, a desire to apply available sanctions (such as forcing consumer compensation for service quality failures) seems to be limited. Consistency of action also appears to be lacking. Continuing political involvement in tariff setting, particularly the slow progress in reducing cross subsidies, exposes the sector to increasing financial pressure as rural electrification extends the proportion of low tariff consumers in the revenue pool.

RGGVY funds are 90% grant. Having said this, a claw-back provision on failure to meet objectives imposes a considerable risk on the state electricity companies and the state government. A state that is not confident about its delivery capabilities may by wary of taking on a large contingent liability although evidence suggests that the weaker states are readily exploiting available funds. Further, central financial support only extends to the capital investment costs of rural electrification and the claw-back provision relates to running rural electricity services as a going concern. Given the history of under-performance of all the SEBs, the continuing political interference in tariff cross-subsidies and the particular unprofitable profile of rural consumers, it is likely that distribution companies in weaker states will ultimately experience greater financial instability as large numbers of rural customers cannot be serviced profitably and RGGVY grants revert to interest bearing loans on the balance sheets.

Financial support appears superficially generous. Recognising the importance of SEB profitability, the APDRP programme has been designed to stop the hemorrhage of revenues through AT & C losses and therefore place the distribution companies on a sounder commercial footing to support rural electrification. However, the APDRP programme, particularly following its restructure, exposes the weak states to considerable financial risk if AT & C loss targets are not met. There is also an expectation that 75% of investment funds can be internally sourced. Finally, annual loss reduction targets for the weaker states are higher than for the stronger states – reasonable on one level as there are potentially more low cost improvements to be made – but nonetheless it places pressure on the weak institutions to perform.

The RGGVY and R-APDRP programmes are currently being executed. It is not yet clear whether the new programmes will successfully allow the weaker states to close the gap with their better performing peers. Analysis of the programme structures suggests that considerable emphasis has been placed on rewarding success (and by definition – punishing failure). Policy parameters have been considerably tightened and release of funds has been tied to independent validation of project execution. The mandatory introduction of franchisees is being seen to improve revenue collection but remains reliant on a well-functioning distribution utility. The franchise model also provides greater incentive to maximise the revenue potential of existing customers rather than expanding the extent of the customer base. However, short of some utility personnel training programmes, incentive schemes for the R-APDRP programme and the voluntary selection of central organisations for RGGVY project implementation, policy emphasis appears likely to reward the able states for continuing delivery. Under-performing states may be further financially weakened when ambitious policy objectives are not met – with the result that tens of millions of rural households from the weaker states may remain unelectrified.

8 Conclusions

Electricity systems are complex to build and operate, capital intensive and spatially highly distributed. Energy and particularly electrical energy is also increasingly recognised as a key contributor to economic and social development processes. Therefore, building and efficiently operating an electricity system is an important policy objective for most societies. It has been argued in the preceding chapters that understanding electricity system development requires an interdisciplinary research approach that assigns sufficient weight to institutional, political and geographical factors along with the technical characteristics of electricity systems as well as the economic considerations more commonly observed in the literature.

The principle aims of this analysis have been to generate a set of insights into the evolution of India's electricity system to guide future policy formulation in India and to provide a case study to support equivalent policy formulation in other developing countries. A number of specific objectives were outlined in detail in chapter 1:

- To explain the reasons for and ramifications of the selection of the states as the principle implementation agent for electricity system build and operation;
- To identify the principle state-level characteristics that have been influential in the execution of electricity policy;
- To determine whether such state-level characteristics have had greater influence under central planning or the increasingly liberalised electricity markets;
- Using a case study example of unscheduled interchange payments, to show that the institutional weakness identified for some states can have unintended consequences

with the implementation of innovative but sophisticated policies for electricity system governance under the liberalisation programme;

- To examine whether institutional weakness is recognised as a barrier to successful delivery of India's rural electrification programme and evaluate the adequacy of policy innovations to mitigate such weakness.

These questions have been addressed within a theoretical framework that examines the way that initial conditions and path dependency strongly influence policy outcomes. These effects manifest through channels that are all influential in the approach to electricity system construction and the level of attainment achieved:

- the economic and technical foundations common to all electricity systems;
- the culture and polity of the country;
- the unique institutional and physical characteristics of the states;
- the choice of a sub-national unit such as a state or province as the principle governing unit for electricity system implementation and operation;
- the policy framework selected;

The scope of the research has been purposefully broad with temporal, spatial and disciplinary perspectives. This breadth has been necessary to capture the range of influences over time, investigate the evolution and lasting effect of those influences, be open to influences from a variety of disciplines and provide an experimental context to evaluate those influences in a cross-India state comparison.

The integration of a historical analysis that traces the explanatory sources of India's electricity system governance structure with contemporary cases that reflect current policy efforts provides strong evidence for the degree of path dependency potential in electricity system development. It also supports an analysis of the manner in which this path dependency interacts with a global shift towards liberalised electricity governance and the effects of these interactions in a developing country electricity system that remains characterised by chronic under-supply and a failure to provide universal electricity access.

In this concluding chapter, the initial objectives are revisited to evaluate the degree to which they have been adequately addressed. To assist in yielding greatest value from the research, the direct conclusions from the analysis are categorised into four themes that may more easily extend to other situations. Additional insights identified through the research have been drawn out and placed within these categories. The wider implications of the conclusions reached are explored – both for India and other countries with immature electricity systems. There is also reflection on the selection of the theoretical and methodological foundations for the research project with a particular emphasis on whether an inter-disciplinary approach, the use of path dependency and the comparative method enhanced or weakened the analysis. Finally, there is a consideration of opportunities for further research generated from this analysis.

Prior to this concluding analysis, the actual performance of the states as discussed in the principle research chapters, is presented and patterns of performance are given prominence. In chapter 5, per capita electricity consumption was used as an indicator of progress in electricity system development over a 40-year period. The top performing states showed remarkable consistency with Gujarat, Maharashtra, Punjab and Tamil Nadu being in the top five in every decade from 1960 to 2000. The descent of West Bengal and rise of Haryana is the only material change in the top performers. There was less stability in the weak performers with only Assam and Uttar Pradesh being represented in all five decades. The performance of Bihar, Orissa and West Bengal have shown relative deterioration over the period studied whilst Jammu & Kashmir, Rajasthan and Himachal Pradesh have demonstrated a relative out-performance over the period.

In chapter 6, unscheduled interchange financial flows were analysed to identify evidence of systematic selling of rights to central electricity generation. A number of states, with a significant correlation with the value of coal to their economy received the majority of UI funds for under-drawing from the grid. The states were Bihar, Chhatisgarh, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Orissa and West Bengal. Bihar / Jharkhand, Orissa and West Bengal were also featured in the declining and weaker states in chapter 5[146]. Uttar Pradesh was the only one of the weaker states from chapter 5 not represented in the under-drawing states in chapter 6. The behaviour of Uttar Pradesh with respect to the UI policy was discussed in some detail in chapter 6 with over-drawal from the grid coupled with non-payment of UI payments being apparent.

[146] The north eastern states were not included in the analysis in chapter 6 due to data limitations. Therefore, it is not known as to whether Assam might also be represented in the set of under-drawing states.

Chapter 7 examined the progress by the states towards rural electrification. Using a variety of measures of rural electrification and periods analysed there was considerable consistency in performance. Six states continually under-performed the others - Assam, Bihar, Jharkhand, Orissa, Uttar Pradesh and West Bengal. Again, there is remarkable consistency between the under-performance identified with respect to rural electrification and the overall level of per capita consumption and evidence of under-drawing from the grid.

Overall, examining very different aspects of electricity sector performance, a number of states – Assam, Bihar / Jharkhand, Orissa, Uttar Pradesh and West Bengal are failing to perform relative to their peers. Possible reasons for this persistent under-performance has been explored in the previous chapters and is reviewed below.

8.1 What has been determined by the research?

8.1.1 The spatial scale of governance structures

A political economy analysis of a country or province's electricity system development cannot effectively be done without an understanding of the nature of electricity systems – both their physical and economic reality and the spatial level at which the governance of the electricity system is managed. Further, recognising the importance of the spatial scale at which the electricity system is governed, the institutional maturity of that governing entity and its geographical endowments will influence the potential paths open to that region.

In India, the decision to place primary implementation responsibility for the electricity system with the states is demonstrated to be critical, strongly influencing the probable set of outcomes from the point of that decision – in other words, creating path dependency. However, it is also clear that this decision was not a random, exogenous event that occurred outside the sphere of the Indian governments – both central and state. Electricity was delegated to the states both because provincial level management of electricity was already the norm, it may not have been perceived as vital as the railways and because such delegation was a valuable bargaining chip for reinforcing a national consensus within the INC. The implications of governing electricity system development at too small a spatial scale were not a consideration in the decision to devolve responsibility to the states. This evidence of the politicisation of decisions regarding the governance of the electricity system is an important contribution to the literature in this field and remains relevant today. It is possible to argue that the technical and economic ramifications of governing electricity systems at too small a scale were unknowable in the late 1940s. However, the decades following independence were characterised by increasing problems caused by governing electricity at the level of the state and increasing attempts to reassert the power of the centre within an institutional context that made it difficult for the centre to exert its influence. In contemporary contexts in other countries, this research provides evidence for the importance of spatial scale in building and operating electricity systems and the costs of not organising electricity system investment, operation and governance at the national level must be set against any underlying political and institutional pressures to suggest otherwise. This is because the effects on the development of the electricity system can be profound and are discussed for the case of India in the next section.

8.1.2 Interaction of governance at different spatial scales

In India, the governance structure was further complicated by the concurrent responsibilities delivered under the constitution. There are different views within India regarding the extent to which the federal structure has created a particular challenge for electricity system governance (Srivastava 2009, Kumar 2009). One could argue that central government policy has, for constitutional reasons, been unable to give sufficient support – continuing to cede implementation responsibility to the states. Stronger central control may then be the prescription. An alternate view may be that central policy is unable to deliver enough sensitivity to state-level issues – the diversity of India argument. Under this scenario, it is necessary to be less prescriptive in terms of policy action – allowing the states to follow an approach best suited to their own context and characteristics. The reality in India has been increasing direction from the centre, financial support with ties, quality assurance and financial penalties for poor management and delivery.

India, despite commencing its initial electrification programme within a decade of the first global pioneers, has, over time, been relatively conservative in the embrace of technology. As discussed in chapter 4, India failed to develop its grid infrastructure quickly enough despite technologies being readily available. This is arguably also a consequence (presumably not intended) of the decision to place implementation responsibility for electricity system development with the states – based not directly on institutional weakness but on the spatial interplay between state-level management of the system and the technical and economic characteristics of electricity systems – as indentified and explained in chapter 4. It is suggested that two opportunities were missed:

- India under-invested in transmission infrastructure for many years due to the state-centric management of the system, weakness of regional electricity boards and weakness in the defined role of the Central Electricity Authority.
- The failure to give focus to inter-state transmission infrastructure limited the size of individual electricity markets and control areas – restricting the potential for investing in larger generating plant that would have realised considerable economies of scale for the sector.

The acceleration in development of large-scale central generating resources under the NTPC and NHPC from the mid-1970s is a clear acknowledgement of the failure of state-level generators to exploit available technologies due to limited internal markets, inward focus and inadequate physical and institutional infrastructure to facilitate inter-state trading of electricity.

The failure can be assigned to the lack of a strong regional and national owner of state grid integration prior to the creation of Power Grid Corporation of India. The missed investment opportunity had material consequences. The size of the grid control area remained smaller than optimal – creating greater challenges for load balancing and limiting the potential for deployment of larger (e.g. 500MW) thermal generating plant. Today, another wave of technology innovation is underway in the global electricity industry. Opportunities for India to leapfrog technologies exist in for instance smart transmission and distribution systems and demand-side management technologies to support load balancing. There is evidence of pickup of these technologies in some of the more advanced states such as Gujarat, Andhra Pradesh and Karnataka (e.g. broadband over power line technologies to bring internet services to rural communities and advanced metering technologies supporting more efficient and secure billing). However, it is highly likely that without central encouragement, many states will lose the leapfrog opportunity and for example, lock in old technology such as analogue meters and rudimentary data management and load management strategies.

8.1.3 The vulnerability of liberalisation models in the Indian context

A key set of conclusions of this research relate to the interaction between the particular characteristics of India's electricity institutions, broader geographical and cultural context with the electricity liberalisation activities begun in the early 1990s that were heavily influenced by experience gained in OECD countries. OECD country objectives for electricity sector performance have not been designed to meet the conditions experienced in a developing country. Specifically, OECD country goals are focused on managing supply cost-effectively and cleanly to meet demand and pushing energy efficiency and demand-side management to reduce the energy intensity of the economy. In the developing country context, the focus is on rapidly expanding capacity and generation to meet exploding demand – exacerbated by political pressure to meet social objectives by keeping prices lower than true cost – such motivations may well be incompatible with the corporate efficiency objectives coming through the reform agenda (Gaunt 2005). Further, as Eberhard notes, in developing and emerging economy contexts an OECD informed regulatory system may be "incompatible with the country's regulatory commitment and institutional and human resources endowment" (Eberhard 2007: 1).

At a national level in India, there is tension between policymakers' expectation of economic efficiency and reduced state intervention with the social goals that are still principle concerns of Indian policymaking. This research provides evidence that reinforces an increasing acknowledgement in the literature and amongst development practitioners of the difficulties in providing prescriptive solutions, based on experience gained in OECD countries, to developing country energy systems (Yi-chong 2006, Estache and Fay 2007).

Liberalisation is also shown to have different effects when the states are comparatively examined. In chapter 5, evidence for the effects of the liberalisation process on electricity system development at the state level, drawn from the interrogation of a panel data set constructed for this research project, argues that liberalisation has had an amplifying effect on the pre-existing institutional weaknesses evident in some states. Specifically, evidence was presented that the form of British rule in India's states continues to influence progress in electricity system attainment – echoing earlier studies using this indicator of institutional strength with respect to a broader range of public goods. Interestingly, the influence of the type of British colonial rule was only a significant influence on electricity consumption in the period following the onset of liberalisation – the effect had seemingly been masked under a regime of central planning. The process of liberalisation that in the 1990s was dominated by a drive for private sector investment and latterly by the creation of independent regulatory agencies adversely affected some states with respect to their peers. Those states that performed relatively less well were primarily those that experienced direct British rule during the colonial era.

A similar conclusion was drawn in a more focused case study in chapter 6. Evidence was presented that certain states, in the east of the country, had demonstrated a significant inclination to under-exploit their allocation of centrally generated electricity – despite having serious power supply position deficits. The increasing grid integration, trading regimes and incentive based grid discipline developed under the guise of liberalising electricity markets had provided an opportunity for states to choose to generate revenues from failure to exploit available electricity rather than taking all available supplies to improve the state's power supply position.

The underlying principles of liberalisation: competition, exposure to incentive-driven behaviours, greater freedom in decision-making and results rather than activity based governance, pre-suppose that the responsible governing agencies are able and willing to work within such a framework in the manner expected by the policy framework architects. This is evidently not the case – as demonstrated in chapter 6 and to a lesser extent chapter 7 - bringing into question the suitability of unfettered liberalisation in a context of institutional weakness. The results, of course, are mixed and the institutionally stronger, market-oriented states appear to have benefited considerably from the new legislative framework and governance institutions. The country as a whole has made strides in important areas of electricity system attainment such as the creation of a national grid system. However, pockets of considerable weakness clearly remain.

8.1.4 Institutional weakness – recognition and mitigation

This thesis, based as it is in the comparative evaluation of twenty Indian states, has not endeavoured to identify institutional weakness in the states from a 'bottom up' perspective. Instead, an indicator for institutional strength – the form of British rule adopted in the nineteenth century, identified and tested in the literature, has been applied to the context of India's electricity system development. The results from chapter 5 provide evidence that institutional structures, once conceived, can prove remarkably resistant to change. However, useful as such an indicator is for quantitative analysis, it leaves unanswered the question of what exactly is remiss in the institutional strength of certain Indian states today. It is unlikely that institutional structure is the primary cause of weakness as in the case of India's electricity system a common institutional structure is identifiable across the country (albeit with a number of differences in the structure of the newly unbundled state electricity boards). Rather, it is suggested that the operation of institutions within the defined structure is what differentiates the states – the actions of individual actors and the culture of the states. This is borne out by interview responses from industry experts. For instance, the Secretary of the Central Electricity Regulatory Commission stated that state regulator performance was heavily influenced by the effectiveness of the selection of the principle positions – particularly the political independence of regulator members (Kumar 2009). In a discussion with an NGO representative implementing renewable energy projects across India, it was noted that the ease of implementation (and therefore desire to commence projects) is highly correlated with the individual at the head of the state energy ministry (Mukherjee 2008). At a different level, in an interview with the ministry for new and renewable energy advisor who had responsibility for the early wind generation projects in Tamil Nadu, one of the biggest hurdles to successful implementation was felt to be active resistance of field engineering personnel within the Tamil Nadu state electricity board (Gupta 2008). However, a deeper understanding of the channels through which institutional weakness continue to act is beyond the scope of this research but provides a fruitful avenue for future case-based fieldwork as discussed below.

In chapter 7, a set of six states were identified as having struggled with rural electrification under both central planning and a liberalising electricity sector. In contrast to the broader expansion of the electricity sector in the 1990s and the unintended consequences of the unscheduled interchange mechanism, the rural electrification programme has endeavoured to explicitly recognise the institutional weakness of individual states and provide appropriate support to facilitate successful universal electricity attainment by all states. Institutional assistance has taken four key forms:

- Material support to bolster weakness in human resource capacity such as the provision of national level organisations to act as implementing agencies and the provision of employee training programmes to improve technical and managerial skill levels within the state electricity companies;
- Structural guidance to ensure good practice governance and organisation are used in all states – the franchisee system for rural electrification being a primary example;
- Financial incentives to encourage project success such as the incentive programme under APDRP that provides financial payments for electricity loss reduction. The

APDRP programme is also innovative in the allocation of funds for incentives to electricity utility employees at the individual level for successful delivery;

– Financial penalties for failure to meet agreed objectives - an example being the reversion of RGGVY grants to interest bearing loans if rural electricity markets are not run on a sustainable financial basis.

Of these four approaches, only the first and second actually attempt, in any way, to address institutional weaknesses that are argued to be the causes of project implementation failure. Direction on the appropriate model for governance of electricity distribution in rural areas through the franchisee system provides real value to the states. Unfortunately, the degree of choice and flexibility in the proposed structure provides many opportunities for a state utility to select the wrong model (although evidence suggests that most state utilities are adopting the same and simplest franchise model). However, as discussed in chapter 7 the franchise model is administratively complex and the level of support provided by the utilities to franchisees has been very mixed. The provision of implementation capacity and training opportunities to state utilities is unambiguously beneficial – the only pitfall being the voluntary nature of the programmes – with evidence suggesting that the institutionally weaker states have failed to take sufficient advantage of the opportunities presented.

The third and fourth forms of institutional support are unlikely to make any material difference to the success of the rural electrification programme. The level of explicit financial assistance in the form of grants is higher than previous programmes or standard central plan assistance. However, if the primary issue is one of institutional weakness rather than financial weakness, the promise of grants and the threat of financial penalties on project failure, will do little to enable the utility to use those funds more effectively than under previous programmes.

The efforts made to mitigate institutional weakness in the rural electrification programme contrast starkly with the lack of support or checks and balances in the evolving electricity market structure in India. One might argue that the efforts made for the RGGVY programme are directly related to the considerable amount of central government funding earmarked for the programme (5% of the entire projected central assistance for the 11th plan - (Planning Commission, Government of India 2007)) and a desire to protect the return on that investment. Nonetheless, the technocratic implementation of the unscheduled interchange incentive structure provides no mechanism for ensuring state electricity utilities do not act against the public interest.

8.1.5 Historic reasons for electricity sector under-performance matter

The mixed results of electricity development across the states since independence, the amplification of differences since the commencement of electricity system liberalisation, the unintended consequences of market mechanisms and ongoing challenge with delivering universal electricity access all provide evidence for the conclusion that policymaking has been insufficiently informed by an understanding of the causal reasons for the status quo in electricity system development. Improved understanding of the path dependent characteristics of the state contexts in which electricity system change is being undertaken will have a material impact on the outcomes of future policymaking. For instance, the early evidence of some of the innovative policymaking approaches with respect to rural electrification suggest that some of these lessons are being learned but that too much emphasis continues to be placed on addressing symptoms of proximate issues rather than addressing the core issue of institutional weakness and geographical handicap.

In some respects, this is an obvious conclusion. Each state in which electricity investment and operation is taking place, has a unique situation in which policy is played out. It is unsurprising that some states have been more successful than others have. What is probably more telling is the persistence of under-performance in a number of states as illustrated by the wide distribution in electricity consumption in the introduction. This is despite some very different policy approaches – from strict central planning and very heavy financial investment from the centre to a liberalised sector with greater emphasis placed on the institutional strength of in-state regulators and operators. Geographical and institutional shortcomings in some states are not sufficiently mitigated by policy action – indeed as policy efforts have become more sophisticated the potential for the institutionally weak states to fall further behind becomes increasingly likely. These thoughts open up some further implications that may be inferred from the research. These are discussed in the next section.

8.2 Are there wider implications of the findings?

The analysis performed has wider implications both within India and beyond. The difficulty India has experienced in encouraging the efficient performance of the states' electricity systems – and the particular problem of delivering universal electricity access suggest future challenges. It is clear that policy must recognise path dependent institutional weakness and provide support so all states are able to achieve required results and national plans can be believed. It is also clear that the relatively sophisticated regulatory agencies created in India may not be best adapted to the current condition of the electricity system in all states and the political contexts in which they are embedded. Having said this, Indian policy makers have demonstrated creativity and courage in policy formulation that, in some states where institutional conditions have been supportive, have demonstrated some considerable success and may prove valuable in other geographical contexts – provided the conditions are appropriate.

8.2.1 National planning implications

The continuing importance of the state in the implementation of the country's electricity system raises challenges at the national level. Development objectives are set at the national level. National plans are inevitably the sum of the parts of all implementing regions and plans are more easily written than implemented. Results are therefore somewhat dependent on the attainment of the weaker regions. This is particularly the case for a policy goal with 100% attainment as the measure of success – such as India's universal electrification goal. India has signed up to meet the millennium development goals – targets that are unlikely to be met without universal access to electricity – particularly in rural India where the majority of the country's poor live. Increasingly, energy security is also becoming more evident as a goal of national economic policy. Global environmental obligations relating to greenhouse gas emissions also look increasingly likely for India as international climate negotiations progress and India's economy and energy consumption grows. Such obligations, should they arise, may be challenging to meet given the historic inability of the central government to effectively influence performance in many of the states.

India's energy policy is heavily influenced by energy models developed for the government by Indian expert organisations such as TERI that produced a national energy map for India in 2006. The Planning Commission instigated an expert committee on integrated energy planning that also reported in 2006. These studies – both looking out to 2030, provide a technical and economic vision for how India's energy infrastructure (including its electricity infrastructure) needed to develop over the next 25 years. However, the studies were largely silent on the challenges to be faced at the implementation level – largely the state. Historically, a similar pattern can be perceived with a chronic failure to meet five-year plan objectives in the energy sector from the earliest plans in the 1950s. The evidence gathered and interrogated for this thesis provide a powerful indication that Indian energy plans will continue to fail in the context of state responsibility for implementation and continuing institutional weakness in a number of states. Plans and the policy instruments to deliver on those plans need to reflect the implementation challenge in the states that have demonstrated evidence of path dependent resistance to change and under-performance for 60 years.

8.2.2 Regulatory structure

As discussed, recommended regulatory structures initially constructed in a developed country context, focus on ensuring efficient and cost-effective operation, high service quality whilst ensuring adequate returns and attractive investment opportunities (Eberhard 2007). To a large degree, this structure has been deployed in India at the national and state levels. The regulatory model in India is little more than 10 years old and for most states, material regulatory activity has only been apparent in the last five years. Considerable human resources weaknesses remain (Stern 2009). The principle tools at the regulator's disposal are tariff setting at the bulk and retail level together with the setting of transmission charges and policing of open access arrangements to ensure non-discriminatory access to the transmission network for all generators[147]. The approach taken is one of aggregate revenue requirement analysis and fixing the return on capital employed. It is, however, clear that the actual performance of the Indian electricity system in most states remains a long way short of the economic operating conditions in the contexts in which the regulatory structures were conceived. Three conditions are very different in India that render the available regulatory instruments ineffective, and expose the unavailability of additional regulatory tools. Specifically:

- The chronic average and peak power supply position deficit means supply rarely meets demand.
- Quality of supply is highly inconsistent and not systematically measured.
- A large minority of the population is not yet supplied with electricity.

The regulator is politically unable to set tariffs at a market clearing level (by definition, there would be no systemic power supply position deficit if tariffs were set at such a level). The introduction of a national grid and short term trading mechanisms has uncovered a marginal value of electricity much higher than cost and standard tariff levels. There is political pressure to cap the short-term trade price and a 45-day cap was

[147] The regulators also have powers to ensure utilities deal appropriately with customer complaints and have an escalation procedure for disputes - all the way up to an Appellate court.

introduced in September 2009 despite the fact that a high price is exactly what is required to entice new generation entrants into the market (Central Electricity Regulatory Commission 2009).

It is therefore not possible for the regulator to deliver legally robust pronouncements on improving service quality or confidently employ sanctions for poor service quality. As identified in chapter 7 in the context of rural electrification, the regulator is able only to encourage expected service levels – while recognising the inability to deliver substantive change in the near term. Over time, this situation has a strong possibility of eroding confidence in the regulator.

The focus on efficiency and financial viability operates in direct contradiction to the goal of delivering universal electricity access – given the cost of delivery to village communities and low demand and ability to pay from many poor villagers. The regulator is placed in the difficult position of endeavouring to support a major government rural electrification programme that is simultaneously making it more challenging to help the state utilities restructure themselves and transition to a sounder financial position.

The selection of governance structure for electricity systems must be highly sensitive to institutional capacity and diversity within a country. The mandating of sophisticated regulatory authorities in all states irrespective of their institutional capacity may have forced an inappropriate governance structure onto some states – one-size-fits-all is manifestly unlikely to be successful yet both the Electricity Regulatory Commissions Act

1998 and the Electricity Act 2003 have provided little support for state-sensitive implementation of the new governance arrangements. A high level of institutional diversity coupled with considerable liberalisation can result in a form of economic Darwinism in which the stronger regions can develop more quickly at the expense of those less able to exploit the opportunities made available by the liberalised economic regime.

8.2.3 Novel policy instruments

India has instigated some novel policy instruments that, although not perfect and potentially not suited to all states, are of potential value in other developing country contexts. The unscheduled interchange mechanism, designed to improve grid discipline with financial incentives and penalties for good and bad operating performance respectively, is a relatively transparent means of encouraging industry actors to meet their agreed commitments with respect to grid injection and withdrawal. The fact that certain states have chosen to exploit the revenue generating potential of the mechanism rather than maximise the electricity available to their own economy is a weakness in the policy instrument rather than a fatal flaw. The direct and transparent imposition of financial penalties on grid abusers has improved grid discipline. Such a policy instrument, however, only has strength in an electricity system with incentives to overdraw due to potential demand outstripping available supply – whether systemically or only at peak periods.

The franchisee structure that forms a centrepiece of the rural electrification programme, although not unique to India, has been structured in India in a way that has provided a range of approaches. These can be adapted to the institutional capacity and needs of the implementing state. Further, over time, the franchisee operation can become more sophisticated. Devolving much of the electricity distribution responsibility to local operators provides an opportunity, with the right support that must be provided by state and central institutions, to deepen management and commercial capacity of the franchisee over time and increasing responsibility can be transferred to the franchisee as that capacity increases. Thus, a franchisee could begin with a basic responsibility for meter reading and bill delivery, progress to bill collection, connecting new customers, distribution system maintenance through to bulk purchase of electricity, tariff setting and theoretically local distribution competition. In reality, in all states, the franchisee system has begun operation at the more rudimentary end of the scale but a path to increasingly sophisticated franchisee operation is open as franchisees gain in experience and capability. This is an intelligent policy that does not try to solve the problem of institutional weakness but both supports greater local engagement over time but also and critically allows different states to develop their distribution governance arrangements at a speed that suits their own circumstances and starting position. This is perhaps an example of how India's policymakers can begin to reap benefits from the liberalised electricity sector and regulatory governance structure by creating well laid out development routes for electricity governance that the states can grow into as their capacities allow and then provide the resources to support the growth of those institutional capacities.

Before considering how this research could be extended it is valuable to reflect on the theoretical and methodological choices made for this project and demonstrate how they supported it.

8.3 How valuable is the theoretical and methodological approach?

8.3.1 Inter-disciplinarity

Did an inter-disciplinary approach improve the insights yielded from this research project or might a more targeted selection of discipline have been more appropriate? In each chapter, a brief discussion of the relevant literature was provided. In large part, the literature discussed was firmly positioned in one of several disciplines – most commonly development economics, economic geography or a loosely defined infrastructure and energy literature. In of itself, this lack of inter-disciplinary research is argument enough for attempting to fill the gap. However, there are more substantive reasons why an inter-disciplinary approach is particularly relevant in this area. Studies of economic activity may justifiably take a pure economic or economic geography approach (and some of the debate between these two disciplines is laid out in chapter 2). Equally, activities in which public sector bodies are primarily engaged can readily be approached through via political economy or even political science. In India (and many other countries), the electricity sector has shifted from being a primarily government responsibility to a quasi-free market industry since the liberalisation process took effect. Further, the technical characteristics of electricity generation and transmission result in electricity systems being influenced by economic and physical geography that is very much place-specific. Most economic approaches (including political economy approaches) give insufficient consideration to spatial issues. Economic geography, on the other hand, although it gives considerable weight to spatial considerations as would be expected, can miss the political economic issues (for instance the INC's need to devolve power to the states in the 1940s and 1950s due to an over-arching focus on national cohesiveness and political control over the entire country). Such lacunae are evident in each of the disciplines when approached in isolation. By embracing an inter-disciplinary approach the interaction between influences evident from each of the disciplines has been drawn together to deliver additional insights that have been missed in narrower (but admittedly sometimes deeper) studies. This is particularly clear with the inclusion of technical considerations of electricity systems. Too many studies have ignored the specifics of the industry being analysed (or, at best, abstracted the details to such an extent that the peculiarities of the industry are unable to inform the analysis). This weakness has resulted in an inability to recognise the interaction between the selected scale of governance of the electricity system and the choices available to system planners. Equally, analysis of the rural electrification initiative is rendered too simplistic without considerations of electricity supply quality, transmission and distribution constraints.

8.3.2 The usefulness of path dependence as an analytical lens

Path dependence as described in chapter 2 is an important concept because, unrecognised and unmitigated, it constrains future possibilities. In India's states' electricity systems, clear patterns of under-performance are evident from even a cursory analysis of the quantitative data. This leads the observer to presume either that some states are recurringly making sub-optimal decisions for random reasons – or that there are underlying characteristics of those states that make poor decisions or poor implementation more likely. The concept of path dependence provides a structured way of thinking about why recurring under-performance is evident in some states. However, a sophisticated interpretation of path dependence is required to avoid both simplistic conclusions and provide a constructive approach to policy formulation to break the constraints imposed by path dependence. Simplistic conclusions can be avoided by first of all unpacking the concept of path dependence to understand the channels through which past characteristics may influence current and future choices. In this research project, led by Martin's categorisation of channels of path dependence discussed in chapter 2, a number of very different channels of potential influence were identified. This categorisation provided weight to the decision to design this research project in an inter-disciplinary way and consider physicals and economic geography as well as the institutional considerations more commonly identified in economic development studies. An understanding of the explicit mechanisms through which past events and characteristics may influence future possibilities supported the selection of appropriate explanatory variables in the quantitative chapters 5 and 6. This was critical because, as discussed below, due to the research design (a focus on India's large states), the number of degrees of freedom available and hence number of explanatory variables that could reasonably be considered was quite limited. Selection of explanatory variables had to be theoretically informed. Feasible channels through which path dependency could act provided much of that theoretical support (together with limited support for variable selection taken from the economic development literature). Thus, the focus on, for example, both the nature of British rule and the levels of existing economic activity could be supported with confidence that there were sound theoretical reasons for those selections.

Ensuring the concept of path dependence has analytical value in formulating policy required the insight that path dependency is a probabilistic concept that does not result in deterministic conclusions. Theories of institutional change identify the importance of understanding the processes that cause path dependence in order that those causes can be specifically affected by appropriately designed policy. Thus, in chapter 7, rural electrification policy was analysed in the context of the perceived reasons why certain states had habitually struggled to meet rural electrification objectives. Without recognising path dependency as an issue in successful policy implementation it would have been much more challenging to evaluate the potential effectiveness of the proposed policy suite. The availability of the path dependency concept provided a benchmark against which the policies' likely effectiveness could be evaluated.

8.3.3 Comparative methodology

In embarking on this research project, one anxiety was the selection of research design and methodological approach. The selection of a many-N (as large an N as was possible) comparative study over selective case studies was a key decision. Given the inter-disciplinarity of the approach it was quite possible that too much complexity might have been introduced that could not feasibly be supported by a comparative method. In the quantitative chapters care had to be taken in the organisation and selection of explanatory variables to mitigate the risk of over-specification and minimisation of degrees of freedom. This process inevitably resulted in the exclusion of some of the richness of explanatory power. However, pre-qualification of candidate explanatory variables and close consideration of covariance between variables has enabled a focus on the most relevant and powerful explanatory factors.

Equivalent challenges were faced in the qualitatively led comparative chapters. The decision to consider technical, economic, physical and economic geography and institutional issues carried the very real risk of generating superficial conclusions that failed to give sufficient weight to any of the disciplinary approaches. The risk of superficiality was mitigated by drawing on appropriate literatures from the disciplines concerned to guide the level at which the analyses were pitched.

Clearly, it is not feasible for a comparative research project to deliver the depth of insight and understanding of location-specific complexity that carefully chosen case studies may have yielded. However, it is argued that additional insights have been possible through the adopted comparative approach that may have been missed by a reliance on selected cases.

In considering, for example the pace of rural electrification analysed in chapter 7, a case approach would not have highlighted the fact that a set of six states had continually under-performed – nor that there were few examples of states that had successfully broken rank and moved from the trailing to the leading group (Himachal Pradesh being the exception).

The introduction of technical electricity system characteristics into the historical analysis in chapter 4 provided evidence that institutional and political decisions have had real effects on the structure of India's electricity systems due to the inter-relationship of technically feasible generating station and grid scale and spatial scale of governance unit. Single-state case studies without the consideration of the technical constraints on electricity systems across those spatial boundaries would have had no means to identify this effect.

The examination of the possible effect of the style of British rule on post-independence would not have been testable in any meaningful way using a case study approach. The absence of any direct channel of influence between the form of British rule and later ability to successfully manage electricity system development would have required a remarkable institutional analysis in an individual case to uncover compelling evidence. The ability to undertake a statistical comparison has provided a strong indication that a correlation exists.

Equally, the ability to uncover statistical evidence of exploitation of centrally generated electricity allocations through the unscheduled interchange mechanism as argued in chapter 6 would have been challenging through a case study approach. In this case, the likely political sensitivity of the behaviour being investigated would have made case-based qualitative interview approaches to evidence gathering potentially highly unreliable due to the guardedness of expert interviewees. A comparative statistical approach allowed the reality of states UI decisions to be rigorously tested against a set of criteria that allowed the categorisation of states and highlighting that states that were amongst the poorest providers of electricity to their own citizens were making the greatest profits from the UI mechanism.

Another principle benefit of the use of a large-N comparative study is that the comparative study itself provides excellent guidance as to which units of study are most appropriate for deeper case-based analysis and which issues require similar in-depth study. Unsurprisingly, this research project has highlighted a number of questions that would benefit greatly from more in-depth study – likely using case-based methods to allow the complexity of individual place-specific characteristics to be identified but informed by the comparative analyses that have been undertaken in this research project. These recommendations for further study are discussed in the next section.

8.4 How could this research be used and extended?

Chapter 5 provides a particularly rich source of proposals for case study validation of findings. The quantitative results provided in chapter 5, in some ways suggest as many questions as they answer. Certainly, methodologically, the presence of significant correlations backed by theoretical expectation is valuable but requires subsequent detailed case analyses to validate or challenge the assertions made

The inter-disciplinary nature of this research project and the decision to both examine some contemporary case studies but also place these within an evidence-based framework recognising institutional and geographical factors as important influences on electricity system attainment, necessarily leaves many avenues of additional research to further validate or challenge the conclusions drawn. The methodological approach and research design – explicitly choosing to interrogate primarily official data sources and archives rather than focus on expert interviews with industry incumbents and apply this data to a broad a comparative study of Indian states generates additional opportunities to explore this field further. Examples of research opportunities that could fruitfully build on this study include:

- Equivalent studies in other large countries with different political, geographical and historical contexts but still classed as having immature electricity infrastructure such as Pakistan, Brazil, China or Nigeria – assuming sufficient data exists.
- Analysis of other current Indian electricity system challenges using a similar framework to that used in this study – such as the development of renewables, reliability /quality of electricity supply, exploitation of clean development mechanism funding; attraction of private sector investment to the states or progress with the renovation and modernisation programme for thermal power stations;
- Critical analyses of current Indian energy plans – challenging the national-level models developed given the insights gained of the importance of the states in policy implementation and the delivery challenges evident for a number of states.
- Deep case study analyses drawn from the two contemporary comparative cases presented in chapters 6 and 7. The results from the all-India comparative studies will benefit from single state studies that are able to unpack some of the concepts inevitably left at a higher level with a many subject comparison. These would enable a focus on the actions of individual actors in state institutions and their influence over, for instance, the rural electrification programmes in that state.

This study provides further evidence of the limits of the reform process in the context of ground realities and the need for regulatory and policy sensitivity to those realities. This demands a more nuanced understanding of the contexts within which electricity systems and their regulatory structures are developed. Certainly, the limited number of analyses that attempt to deliver a broad, inter-disciplinary understanding of electricity systems in developing countries is a weakness. Contributions to this literature should be encouraged and will surely be of considerable value to policymakers and development specialists working on delivering electricity services to the 1.6 billion people globally that remain without power.

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