The Economic Effects of Electricity Deregulation:

An Empricial Analysis of Indian States

Anupama Sen and Tooraj Jamasb

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Keywords Electricity, India, reform, deregulation, regional impacts

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The Economic Effects of Electricity Deregulation: An Empirical Analysis of Indian States

Anupama Sen[1][2]
Oxford Institute for Energy Studies
Department of Land Economy, University of Cambridge

Tooraj Jamasb[3]
Electricity Policy Research Group, Faculty of Economics, University of Cambridge

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Abstract

As developing countries seek to improve their economic prospects, electricity reform has been widely viewed as a central part of this effort. While the focus of most research to date has been at economy or utility level, there has been much less research on regional outcomes. India presents a unique case, as its states share a common economic and political system, whilst having been given considerable flexibility in how they implement reform, thus allowing a comparative analysis of alternative approaches. This study contributes through an econometric analysis of the determinants and impact of electricity reform in India, giving special regard to its political economy and regional diversity. It assesses how electricity reform in India has affected key economic variables that determine sectoral efficiency, prices and investment flows. We use panel data for 19 states, spanning 1991-2007, using dynamic panel data estimators. Results show that individual reform measures have affected key economic variables differently; thus the nature of reform in individual states would determine these economic outcomes. Findings suggest that due to political economy factors influencing reform, outcomes have tended to be adverse in the initial stages, as previously hidden distortions become apparent. The performance of reforms, however, may improve as it progresses beyond a 'baseline' level.

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[3] Corresponding author. Faculty of Economics, Austin Robinson Building, Sidgwick Avenue, Cambridge CB3 9DD, U.K. Tel: 0044 (0)1223 335271. Fax: 0044(0)1223 335299 Email: Tooraj.Jamasb@econ.cam.ac.uk

1. Introduction

Over the past few decades, as developing economies have struggled to pull their populations out of poverty, electricity sector restructuring has been regarded as a crucial facilitating factor for higher levels of economic development (Estache, 2004). The design, implementation, and performance of such restructuring has been widely discussed in the literature on infrastructure reform (Laffont, 2005; Vickerman, 2004; Harris, 2003; Demurger, 2001; Gray, 2001; Newbery, 1999; Littlechild, 1999; Galal et al, 1994; Vickers and Yarrow, 1991). Electricity reforms, initially undertaken in parallel with 'Structural Adjustment Programmes', are still evolving, and have been moulded to reflect the complex economic and political dynamics of developing countries (Jamison et al, 2004).

In India, reform has been riddled with inconsistencies, yet, progressive to an extent, in the sense that policy has kept it moving forward. Its most distinctive aspect has been the struggle to achieve a framework that removes the sector from political influence. Decades of electricity provision by state-owned enterprises created a web of interlocking distortions, triggered by the manipulation of the sector as a tool for obtaining political leverage, as early as 1977 (Tongia, 2003). Since then, electricity has often been offered by incumbent governments, at unsustainably low or zero prices, to farmers who form the bulk of the electorate. Considerable amounts of literature exist, documenting and tracing the development of these economic distortions in electricity provision brought about by the political economy of the sector in India (Victor & Heller, 2007; Chattopadhyay, 2004; Dossani, 2004, Dubash & Rajan, 2002; Tongia, 2003; Kalirajan et al, 1998). Despite the subsequent wastages created, this policy continued, for a long time, to be sustained through cross-subsidies from industry[4]. Consequently, average prices began varying inversely with average costs, ultimately leading to large deficits and inadequate capital for reinvestment, miring the sector in technical and financial problems, at the time of initial reforms in 1991.

Electricity reform in India can be classed in three phases: generation reform[5] following the 1991 liberalisation, which largely failed; state-led initiatives in the mid-90s which resulted in mixed outcomes; and, distribution reform, involving the consolidation of previous legislation and mandatory reform procedure, detailed in Electricity Act 2003 (Tongia, 2003). The elements of reform in Indian states have tended to follow a generic reform model (Jamasb, 2006; Besant-Jones, 2006; Jamasb et al, 2004; Newbery, 1995) involving the implementation of independent regulation, restructuring, and privatisation of competitive functions, conducted in sequence. Thus, the *true* reform phase can be said to have lasted from 1998-2003 and beyond, as 1998 marked legislation instituting independent regulation at the state level. Since then, a slew of measures have been mandated through Electricity Act 2003; these include (i) the establishment of state independent regulatory commissions (ii) unbundling and corporatisation of state-owned enterprises into companies for generation, transmission and distribution (iii) tariff rationalisation (removal of cross-subsidies and rebalancing prices) (iv) open access to transmission and distribution networks for third-party use (v) private participation in distribution. Additionally, the prevalence of Independent Power Producers (IPPs) in generation supplements these measures. The combination of all the above is meant to lead to a more competitive and efficient form of electricity provision, where prices equate or move closer to costs. Most Indian states have independent regulators, but differ on the extent of reform implementation[6].

[4] Industry was charged higher prices in efforts to make up for the losses suffered through subsidising farmers.
[5] Independent Power Producers entering into supply contracts with state governments.
[6] Appendix III shows the position of states relative to each other, on electricity reform.

This study analyses the determinants and impact of electricity reform in Indian states using the econometric investigation of panel data, whilst accounting for the influence of political economy factors. India presents a unique opportunity for an empirical study, as its 29 states[7] share a common economic and political system, whilst having considerable flexibility in implementing electricity reforms[8]. This allows the comparative analysis of reforms, whilst overcoming obstacles faced in cross-country comparisons, such as cost conversions, inflation, and data compatibility. The next section assesses the gap in empirical literature. Section 3 discusses methodology and data; Section 4 contains results and Section 5 concludes.

2. The Gap in Literature

Although existing empirical literature on electricity reform includes a plethora of analytical methods to fulfil varying research objectives, it has focused on cross-country assessments of macro-level impacts, and does not contain substantial work in a comparative spatial form. Further, existing literature primarily focuses on developed economies, whereas developing economies are subject to country-specific factors, resulting in counterintuitive outcomes (Victor, 2004; Jamasb et al, 2004). We restrict ourselves to mentioning those studies most relevant to the aims and methods employed in this analysis. Thus, there have been some notable assessments of the extent and magnitude of reform; in particular, Bacon (1999) and Bacon and Besant-Jones, (2002) use 'scorecards' for this. Another relevant category includes econometric and other quantitative techniques assessing the determinants and outcomes of reforms; Zhang, Parker and Kirkpatrick (2002) identify the effects of reform in developing countries by testing whether the switch to private provision leads to better efficiency and price outcomes (Jamasb at al, 2004). The institutional environment in the electricity sector[9] has also been studied empirically; Victor (2004) investigates the causes, pace and outcomes of the electricity reform in Brazil, China, India, Mexico and South Africa, and finds parallels between reforms in different sectors in creating an environment conducive to investment. Related studies examine the impact of reforms on attracting private investment, which in turn is positively correlated with defined property rights (Jamasb et al, 2004). 'Efficiency' analyses present a mixed picture of success, as the distribution of any efficiency gains is contingent on the strength of the regulatory framework (Jamasb et al, 20044; Mota, 2003). An extension of this category focuses on quantifiable social impacts of deregulation (Galal et al, 1994; Domah and Pollitt, 2001; Toba, 2004). Galal et al (1994) pioneered the popular use of this technique in a social-cost-benefit-analysis of the divestiture of two Chilean electricity companies, focusing on changes in efficiency, investment and consumer welfare. Related empirical studies extrapolate these social impacts to investigate sustainable development (Dubash, 2002).

A developing methodological literature exists on the econometric assessment of reform on a set of defined performance measures. Nagayama (2007) analyses the effects of reform on industrial and household electricity prices using a panel data set of 83 developing countries in three world regions[10] for 1985-2002. The study follows Steiner (2001) and Hattori and Tsutsui (2004), investigating the impact of reforms on a set of performance measures, where each measure is a function of (i) country-specific effects, (ii) a set of controls and, (iii) a set of regulatory reform indicators. Nagayama hypothesises that privatisation and competition will only work with independent regulation. Cubbin and Stern (2005) investigate whether, for 28 developing countries, from 1998-2001, the existence of a regulatory law and higher quality

[7] The National Capital Territory of Delhi has been included as a state.
[8] Electricity is a 'concurrent' subject in the Indian Constitution, allowing states considerable autonomy.
[9] The establishment of a credible independent regulatory institution.
[10] This does not include Asian developing countries.

regulatory governance was associated with superior electricity outcomes. The scope of the study is limited by data, and by the fact that efficiency indicators can be expanded to include variables such as commercial loss reductions (Cubbin and Stern, 2005). Some studies give weight to the *supply* side in reform outcomes. Weinmann and Bunn (2004) analyse how industry structure and resource endowment of a country affect the feasibility of reform. This precludes that given a set of structural characteristics ‘substantial’ policy reforms are only effective to an extent.

Although a comprehensive review is beyond our scope, it is observed from existing literature that a commonly-observed set of impacts of electricity reform on key variables affected at the macro level begin to emerge; sector efficiency, electricity prices, and forms of investment (investment within the electricity sector and new investment flows). This study undertakes the investigation of these economic outcomes for the case of Indian states.

3. Methodology and Data

The method adopted is one outlined in a review by Jamasb et al (2004), where existing empirical studies are examined and critiqued in categories comprising sets of relevant hypotheses. Thus, a set of core hypotheses were developed to examine the behaviour of key economic variables in the Indian context. These were then operationalised using appropriate econometric techniques.

H1. Alongside other infrastructure types, the stock of electricity infrastructure in an Indian state makes a positive and significant contribution to its industrial economic output.

This hypothesis aims to outline the contribution of electricity within other infrastructure, to industrial economic output in Indian states, as an obvious but necessary step. The contribution of infrastructure to economic growth has been well-established in literature (Grossman and Helpman, 1994; Ferguson et al, 2000; Ghosh, 2000; Gray, 2001; Demurger, 2001; Roller and Waverman, 2001; Fink et al, 2002; Calderon and Serven, 2003; Esfahani and Ramirez, 2003; Vickerman, 2004; Vagliasindi, 2004; Cubbin and Stern, 2005; Purfield, 2006). Other infrastructure types examined here include telecommunications, roads, and railways.

H1.1 The stock of electricity infrastructure in an Indian state makes a positive and significant contribution to its industrial GDP.

H1.2 The stock of electricity infrastructure in an Indian state makes a positive and significant contribution to its industrial GDP per capita.

This hypothesis is examined in two separate regressions, for two dependent variables; total GDP of the industrial sector, and GDP per capita of the industrial sector, at constant prices (1993-94). The total length of transmission and distribution lines, percentage growth in direct exchange lines, total length of national highways and total length of railway tracks, for Indian states, are used to represent electricity, telecommunications[11], roads, and railways infrastructure, respectively. Population numbers are used as controls. As most of these indicators are measures of total stock[12], it follows that the same may be influenced to an extent by the capacity of each state to support such stock; in other words, by its size. Population is therefore used as a proxy, as it provides a measure of size that is not time-

[11] The telecoms indicator was chosen based on data availability; direct exchange lines refer to a fixed line connection between a telephone instrument and the local telephone exchange.

[12] Apart from the telecoms indicator.

invariant[13]. Further, population includes migrant workers, and larger populations could possibly, but not necessarily, be indicative of positive effects of economic prosperity, and also of purchasing power. All of the aforementioned are possible outside influences on the dependent variables. Additionally, we account for interaction effects between electricity and other infrastructure. Two interaction variables were developed for infrastructure thought to act in cohesion with electricity i.e. electricity and rail, and, electricity and roads. Telecommunications was taken to be relatively free of interaction with electricity, as tremendous expansion in mobile connectivity has ensured this independence. Both sub-hypotheses are tested first with and then without the interaction variables.

H2. Indian states more advanced in reform are more likely to have experienced improvements in technical and operating efficiency, in electricity provision.

Efficiency improvements were among the commonly observed impacts of reform. Reforms involve restructuring of the electricity industry, and unbundling of its components into separate companies dealing with the functions of generation, transmission, and distribution and retail supply. This precedes a change in management, which results in commercially-oriented operations, in contrast to the management style of former state-owned monolithic companies. There may be revised targets on performance parameters, such as loss reduction. Consequently, technical efficiency improves, resulting in efficient utilisation of existing capacity and capital. Studies show that efficiency improvements tend to be passed on, either directly to consumers, through price reductions or dividend payouts[14], or indirectly, through reinvestment in the system network (Galal et al, 1994; Domah and Pollitt, 2001; Harris, 2003; Ennis and Pinto, 2004; Jamasb et al, 2004; Mota, 2003; Toba, 2004; Pollitt, 2004). This could particularly benefit industrial consumers, given that they bear the greatest distortions. A multivariate form of regression is used; three interrelated dependent variables are selected to represent technical efficiency, as the latter encompasses aspects that cannot be measured by one variable alone[15]. These are Plant Load Factor or PLF (%)[16], gross generation (Million Kilowatt Hours) and transmission and distribution losses (%). PLF is directly related to the improved ability of the sector to increase its utilisation of generation capacity. Transmission and distribution losses refer to the ability of companies to reduce technical and non-technical losses, which in some states have been as high as 40%[17]. There may be a tendency for losses to remain high in the initial stages of reform, as previously hidden distortions are revealed following deregulation. Gross generation relates to improved PLFs and additions to generating capacity, facilitated by the entry of private actors.

The independent variables used include six reform indicators[18]; these were based on cross-country analyses by Bacon (1999) and Bacon and Besant-Jones (2001), which identify six measures considered important to an electricity reform, undertaken in sequence. If a country's reform included a measure, it was scored 1; if not, 0. Each country also had a total score out of six. We adapted this approach for each Indian state, for each year in the data series. Two further independent variables were constructed here; the ratio of industrial to domestic price

[13] This conforms to the properties of the fixed effects technique used in operationalising this hypothesis. Time invariant variables may not be used in fixed effects estimations, as they are eliminated in the transformation process.
[14] This signifies a form of return to consumers invested in public electricity companies, as is the case in India.
[15] We outline this further, later in this section.
[16] Plant Load Factor is the percentage of total thermal generation capacity being used at any one point of time by the system; it is pertinent in the Indian case, as 70% of generation is thermal. Over time, PLF in India has increased to >70%.
[17] E.g. Bihar.
[18] These indicators are listed, along with all other variables, in Table 3.1.

of electricity (a commonly used indicator) and more particularly, of industrial to agricultural price of electricity, to represent cross-subsidisation from industry to other consumers. In India, it is not residential (domestic) consumer prices that influence industrial price levels, as much as agricultural prices. Farmers have historically influenced electricity policy, as they constitute the majority of the electorate, at 70% of the working population. Among control variables, the percentage of hydro capacity is used to represent natural resource advantages; states endowed with hydroelectricity could benefit from lesser coal dependency and higher efficiency levels; it may also affect the extent of deregulation, as hydroelectric reserves are state-controlled. Finally, state GDP per capita is used to control for effects relating to the state economy.

H3. Electricity reform has had a substantive impact on electricity prices for the end-consumer.

A common impact of reforms (Steiner, 2001; Domah and Pollitt, 2001; Kikeri and Nellis, 2004; Pollitt, 2004; Hattori and Tsutsui, 2004; Nagayama, 2007), is that on prices for the consumer. As outcomes might depend on non-economic factors, there could be a lag between implementation and impact. Relative to the impacts observed in other developed or even developing economies, the impacts on electricity prices for Indian states are distinctive, owing to the complex processes underlying the pricing mechanism, which are influenced by political, socio-cultural, and other non-economic factors. As these necessitate a clearer definition of price, this hypothesis is further broken down:

H3.1. Reform has had a substantive impact on the average unit price of electricity.
H3.2. Reform has had a substantive impact on the industrial unit price of electricity.

H3.1 examines the impact of reform on average prices across all consumer segments. In the Indian case, it is difficult to predict the outcome and direction of average prices alone, as the latter have several underlying elements that are complex to untangle. Thus, in H3.2, we untangle further, the impacts on average prices for *industrial* consumers. In general, reforms aim at correcting price distortions. In the case of a developing economy, this would imply a reduction in excessive rates for industrial users, and an increase in prices for subsidised consumers, which generally comprise agriculture. The dependent variables used in each hypothesis, respectively, are average price of electricity per unit and, average price of electricity per unit for the industrial consumer[19], both measured in Rupees per Kilowatt Hour and adjusted for inflation (1993-94 prices). Independent and control variables include the six reform measures, and per capita GDP of Indian states at constant prices.

H4. Electricity reform in Indian states has had a substantive effect on pricing.

As opposed to *prices*, this hypothesis aims to unravel the impact on the actual *pricing mechanism* of electricity in different states, following the implementation of reforms. As observed in studies of other developing and developed economies' electricity programmes, pricing corrections are brought about through reductions in cross-subsidies and corrections in the relationship of average cost to average price per unit (Steiner, 2001; Hattori and Tsutsui, 2004; Nagayama, 2006). This hypothesis explores these changes in the Indian context, and provides insight into the impact on prices in the previous hypothesis, in terms of potential causality[20]. This hypothesis is further broken down and examined:

[19] These are averaged across two categories of industrial consumers; High Tension (large industry) and Medium/Low Tension (medium/small industry).
[20] The factors causing price changes, which *per se* are outcomes of reforms.

H4.1 Electricity reform in Indian states has had a substantive effect on the pricing mechanism of electricity with regard to relative industrial to domestic (residential) electricity price.

H4.2 Electricity reform in Indian states has had a substantive effect on the pricing mechanism of electricity with regard to relative industrial to agricultural electricity price.

H4.1 attempts to establish the effects of reform on subsidies from the industrial to the domestic consumer segment. Although these subsidies are a common characteristic of developed countries' electricity sectors, they are observed to a lesser extent in India, where the predominant historical relationship lies between industry and agriculture. H4.1 could potentially reveal the impacts on the pricing mechanism in states where the composition of the agricultural consumer segment is lower, relative to other consumer segments[21]. Thus, the dependent variable is the ratio of industrial to domestic price per unit of electricity. H4.2 examines the issue of cross-subsidisation. Cross-subsidies are mainly provided from industry to agriculture, and this has led to a culture of free electricity provided to farmers in states where the electricity sector has been used for political leverage. Reform and independent regulation aim at reducing cross subsidies, introducing competitive pricing for industrial consumers and a basic tariff for farmers. Pricing corrections are expected to have certain knock-on effects, such as curbing wastage among farmers, to whom the marginal cost of electricity is sometimes zero. The dependent variable is modelled on the concept of the industrial to residential price ratio, used in countries where industries mainly subsidise residential consumers (Steiner, 2001; Hattori and Tsutsui, 2004; Nagayama, 2006). Thus, the ratio of industrial to *agricultural* prices is used as a dependent variable. Independent variables in both cases include the reform indicators, and controls for economy effects (per capita GDP in states at constant prices).

H5. Electricity reform has led to investments into the distribution and supply network, thereby improving quality of service.

Along with price rationalisation, quality of supply is a major factor in fostering sector competitiveness, and contributing to an environment encouraging industrial development and local entrepreneurship. This hypothesis may be read with H2, which looked at the efficiency impacts of reform. Improved efficiency could lead to cost-savings and the release of previously constrained capital which might be reinvested into the system (Zhang et al, 2003; Harris, 2003; Pollit, 2004). Privatisation is not a necessity for efficiency improvements; as noted in Newbery (1995), experience suggests that efficiency depends more on the form of regulation than ownership[22]. Therefore, efficiency gains and resultant effects on reinvestment would hold in the Indian context, although there are only two states with privatised distribution. The independent variables include the reform indicators, industrial to agricultural price ratio as indicative of the extent of cross-subsidisation (reductions in this would reflect competitive pricing)[23], the industrial to domestic price ratio as a supplementary indicator of price corrections, and a control variable for economy effects (per capita GDP of states). Both ratios are used as control variables, as pricing can in this context be considered a direct policy measure (through 'tariff orders') in Indian states, rather than a competitive outcome of reform. The dependent variable is the energy shortage (%). Data availability on network quality is limited, as accurate records have often not been maintained by utilities. For instance, the peak

[21] For example, Delhi, which has the highest rate of urbanisation in India.
[22] Changes in ownership should be accompanied by mandatory competitive practices, and this mandate could be implemented by the regulator.
[23] Reductions in cross subsidies would in themselves lead to the release of previously constrained capital, thus improving efficiency.

deficit (%) might be argued to be more suited to this hypothesis; however, reliable data was unavailable. The results of this hypothesis must therefore be regarded with reference to the chronic energy shortage that currently exists across India, and the existing generation capacity.

H6. Electricity sector reform has led to substantive changes in electricity consumption by the industrial consumer segment.

Changes in the composition and magnitude of electricity consumption in a growing developing economy can be revealing of the net downstream impact of a reform programme. It might be possible to discern, whilst accounting for other factors unrelated to reforms, the probable response of industry to specific reform measures, by relating these to patterns of industrial consumption over time. Two indicators of industrial consumption are used in separate regression specifications; namely, total industrial consumption and per capita industrial consumption. The first would be indicative of absolute changes in industrial consumption, and the second would be indicative of the distribution of these; that is, whether the response is even across all industrial consumers, or whether consumption from specific segments of industry goes up disproportionately relative to others. The same independent variables are used in both regressions; the reform measures, industrial to agricultural price ratio, industrial to residential price ratio, and per capita GDP for economy effects (representing the contribution of the economic environment to consumption).

The data used is set out in Table 3.1. Data were constructed from public sources, and some protected portions, with requisite permission; specifically, the Power Ministry and State Electricity Regulatory Commissions. Sources included the Planning Commission, Power Finance Corporation, Central Electricity Authority, Central Statistical Organisation (CSO), the EPW Research Foundation and The Energy and Resources Institute. The time period spans 1990-2007 at the most, and 1990-2004 at the least, as per availability. All 29 states[24] are not included in this analysis. Among the 11 excluded states are 7 that comprise the entire northeastern region[25], which have been traditionally considered underdeveloped smaller economies and prone to experiencing governance problems and civil unrest. Data on these is unavailable, owing to the lack of a sustained system of record keeping at the ground level. Further, 3 [26] of the 11 states were created in 2000, and sufficient data does not exist for a comprehensive study; moreover, the inclusion of these smaller states might distort results. Finally, the tourist economy of Goa has been conditionally included, on the basis of data availability; it has been classified as under-industrialised[27] as it has a tourism-based economy. Therefore, its exclusion in some cases does not preclude economically substantive results. The states included account for over 85% of the population[28]. Annual data were used, and monetary units adjusted for inflation using the Wholesale Price Index (WPI). For GDP computations, the base 1980-81 was revised in 1993-94. Thus, data prior to 1993 was rebased to 1993-94 prices. Where aggregate GDP data was unavailable, it was constructed following CSO guidelines, by aggregating the economic output of the mining and quarrying, construction, manufacturing, and, electricity, gas and water sectors. Appendix I contains descriptive statistics for the variables used in this analysis[29].

[24] We have included the National Capital Territory of Delhi as a state.
[25] Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura.
[26] Jharkhand (out of Bihar), Chhattisgarh (out of Madhya Pradesh), Uttaranchal (out of Uttar Pradesh).
[27] In the Annual Survey of Industries.
[28] Based on 2004-05 population figures.
[29] We follow an approach advocated by Ziliak and McCloskey (1996; 2004), observing for size of coefficients, *economic* significance of variables, and standard deviations, in addition to statistical significance.

Table 3.1: List and Description of Variables

	Variable	Description	Units
Reform Variables	**IPPS***	Presence of Independent Power Producers in a state	Dummy (0/1)
	REG	Presence of an Independent Regulatory Agency in a state	Dummy (0/1)
	UNB	Separation of generation, transmission & distribution segments in a state	Dummy (0/1)
	TAR	Passing of tariff orders in a state (correcting price distortions)	Dummy (0/1)
	OPREG**	Introduction of Open Access to the transmission & distribution network by third parties	Dummy (0/1)
	DPVT***	Privatisation of the distribution segment (amongst two or more companies)	Dummy (0/1)
	REFINDEX	Aggregate Reform Index	Total score out of 6
Other Variables	**INDGDP1**	State Industrial GDP; adjusted for inflation at constant (1993-94) prices	Million Rupees
	INDPC	State Industrial GDP per capita; adjusted for inflation at constant (1993-94) prices	Rupees
	ELEC	Length of transmission & distribution lines in a state	Circuit kilometres
	RDS1	Length of national highways in a state	Kilometres
	RAIL	Length of railway track in a state	Circuit kilometres
	TEL	Growth in number of direct exchange lines in a state	Percentage (%)
	INTER1	ELEC * RAIL	Circuit kilometres
	INTER2	ELEC * RDS1	Circuit kilometres
	PRATIO1	Ratio of industrial to domestic price of electricity; adjusted for inflation at constant (1993-94) prices	Rupees per unit
	PRATIO2	Ratio of industrial to agricultural price of electricity; adjusted for inflation at constant (1993-94) prices	Rupees per unit
	PLF	Plant Load Factor of grid-connected thermal power stations in a state	Percentage
	TDL	Transmission & distribution losses in a state	Percentage
	GRGEN	Gross Generation of thermal power plants in a state	Million Kilowatt Hours
	INPRICE	Average industrial price of electricity in a state; adjusted for inflation at constant (1993-94) prices	Rupees per unit
	PRICE	Average price of electricity in a state; adjusted for inflation at constant (1993-94) prices	Rupees per unit
	INDCON	Industrial consumption of electricity in	Million Kilowatt Hours

		a state	
	INDCONPC	Industrial consumption of electricity per capita in a state	Kilowatt Hours
	PWDF	Percentage Energy Deficit in states	Percentage
	HYDRO1	Hydroelectric generation capacity in a state	Percentage
	PCGDP	Per capita state GDP; adjusted for inflation at constant (1993-94) prices	Million Rupees
	POPN	Population of states	Millions of people

*Data obtained from the World Bank's PPIAF Database[30].
** Open access is usually introduced in phases based on consumer size, and in Indian states comes with wheeling and cross subsidy surcharges imposed by the Transmission Company or independent regulator.
*** Only two states have privatised distribution completely.

The dataset comprises a number of cross-sections, with a relatively short time series (approximately 17), constituting an unbalanced panel. Given that the cross-sections represent Indian states, which are decentralised, somewhat self-contained economic systems, there is presumably a range of state-specific unobserved factors influencing the behaviour of each. Hence we use techniques from panel data econometrics, which are best placed to deal with this heterogeneity in the micro-units[31]. Within panel data, the choice lies between fixed effects (FE) and random effects (RE) estimators, which differ in the way they model the unobserved heterogeneity. The FE estimator deals with it explicitly in the estimation process by putting in a dummy for each individual; it is thus also referred to as the Least Squares Dummy Variables (LSDV) estimator. The RE estimator implicitly recognises it, and assumes the different intercepts as having been drawn from a bowl of possible intercepts, so they may be interpreted as random, and treated as though they were a part of the error term. The FE estimator is always consistent[32], but the RE estimator, where applicable[33], is more efficient[34], as the method of transformation used in the estimation process saves on degrees of freedom. In order to conform to desirable properties of an estimator (unbiasedness), RE estimators are applicable solely under the assumption that the individual effects (and hence the composite error term) are uncorrelated with the explanatory variables. Standard procedure dictates that this choice is usually determined through the use of a Hausman Test.

However, the cross-sections in this dataset represent Indian states, which are autonomous systems; these differences could thus represent unobserved heterogeneity. If this unobserved heterogeneity was contained in variables indicative of factors such as the institutional environment, or levels of governance, it is highly likely that the unobserved heterogeneity, and hence the individual effects, would be correlated with the independent variables i.e. factors such as governance and institutions could influence explanatory variables. Thus, the core assumption for a RE model could be violated in this case. We thus use FE estimators. A second justification for FE estimators here is that the data does not represent a random sample; further, as the total number of states (cross-sections) is limited, the data comprises a

[30] The IPP variable pertained to the start of operations of a generation project.
[31] Kennedy (2008) provides a detailed exposition of panel data techniques and the choice of fixed versus random effects estimators in applied econometric research.
[32] The estimator converges in probability to the true value of the parameter.
[33] The variables being used and the relationships being hypothesised must satisfy certain assumptions.
[34] Minimises variance amongst unbiased estimators.

finite sample. The model specification is thus: $Y_{it} = \alpha_i + \beta X_{it} + \eta_i + \varepsilon_{it}$, which represents a fixed effects *static* model. For static models, FE estimations were carried out on the data. The estimates were tested for non-spherical errors using a Likelihood-Ratio (LR) Test for panel-level heteroskedasticity and a Wooldridge test for serial correlation. Where non-spherical errors were detected, the estimations were adjusted for these. Thus, for hypotheses using static models, two FE model estimations have been reported for consistency of results. The first with robust-variance estimates using STATA's *xtreg* and *vce(robust)* commands; the second with an error term that is first order autoregressive, or AR (1), using STATA's *xtregar* command.

For some of the relationships hypothesised, standard economic reasoning implies that the behaviour of some dependent variables may not only be determined by the set of independent and control variables specified in the equation, but also on past values of themselves; namely, past decisions have an impact on current behaviour (Bruno, 2005). We use a dynamic specification for these $Y_{it} = \gamma Y_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it}$ where γY_{it-1} is the coefficient and the lagged value of the dependent variable and $X_{it}\beta$ represents the matrix of coefficients and the explanatory variables. Thus, in order to estimate hypotheses that include a dynamic element, dynamic LSDV panel data models are used. However, it must be noted that the data used in this analysis has a small time dimension, '*T*'. It is established in econometric literature that a LSDV model with a lagged dependent variable generates biased estimates when *T* is small; thus, LSDV performs well only when *T* is large (Judson and Owen, 1999). Kiviet (1995) devised a bias-corrected LSDV estimator (LSDVC), later refined by Bun and Kiviet (2003), which is generally seen to have the lowest RMSE[35] for panels of all sizes; its applicability was, however, limited to balanced panels. A version of the bias-corrected LSDV estimator (LSDVC) for unbalanced panels was developed by Bruno (2005), which operates under two assumptions; first, it has a strictly exogenous selection rule, and second, it classifies the error term ε_{it} as an 'unobserved white noise disturbance'. The procedure for obtaining results from a LSDVC estimator from an unbalanced panel is through the STATA routine *xtlsdvc*; uncorrected LSDV estimates are first obtained. Then, using Kiviet's higher order asymptotic expansion techniques, the small sample bias of the estimator is approximated (Bruno, 2005). The approximations terms, however, all evaluated at the unobserved true parameter values, are of no direct use for estimation; thus to make them operational, the true parameter values are replaced by estimates from some consistent estimator (Bruno, 2005). The chosen estimator is plugged into the bias approximations formulae, and the resulting bias approximation estimates $\overline{\beta_i}$ can be subtracted to obtain the corrected LSDV estimator as follows: $LSDVC_i = LSDV - \overline{\beta_i}$, where *i* = 1,2 and 3, indicating the accuracy of the bias approximation[36]. The choice of consistent estimators used to initialise the bias approximations lies between the Anderson-Hsiao, Arellano-Bond and Blundell-Bond estimators.

A number of other consistent Instrumental Variable (IV) and Generalised Method of Moments (GMM) estimators have been proposed in econometric literature as an alternative to LSDV in the modelling of dynamic panel data. However, Bruno (2005) evaluates the relative performance of LSDVC in comparison to LSDV, Anderson-Hsiao, Arellano-Bond and Blundell-Bond estimators for unbalanced panels with small N and concludes that the three versions of LSDVC computed by STATA outperform all other estimators in terms of bias and

[35] Root Mean Square Error
[36] In STATA the default is set equal to 1.

RMSE. We thus choose to use LSDVC models for those hypotheses that involve dynamic relationships, and report results from all three estimators used to initialise the bias corrections (Anderson-Hsiao, Arellano-Bond and Blundell-Bond). The variables used as regressors conform to the exogenous selection rule, in that they include dummies to represent the various measures of electricity sector reform and deregulation. Amongst the regressors used are price ratios, which can also be considered exogenous in this context, as these indicate an attempt to model the underlying rate of change, rather than the variables themselves. The use of ratios also solves any problems with multicollinearity amongst the regressor variables (Kennedy, 2008). Standard test statistics are also reported; the Arellano-Bond estimator reports a test for first and second order autocorrelation, respectively. The null hypothesis is no autocorrelation. The presence of first order autocorrelation in the differenced residuals does not imply that the estimates are inconsistent, but second-order correlation would. Additionally, the Blundell-Bond estimator reports a Sargan test of overidentifying restrictions; the estimates should test significantly different from zero in order to reject the null that overidentifying restrictions are valid. Fractional polynomial prediction plots of the relationship between the dependent and independent variables are included, as a visual depiction of results[37].

An exception to the general model specification has been made for hypothesis two (H2), where the equation is specified in a multivariate form, which conditions the choice of technique. The motivation for this specification is twofold. First, H2 looks at the concept of technical efficiency in entirety, and not in terms of a disjointed set of concepts; the three dependent variables are presented as parts of a whole, and belonging to the same 'universe' of variables. Secondly, the variables are by nature expected to display certain interdependent relationships, which might later be confirmed through econometric and statistical observation. Although the generic equation is specified in a multivariate form, the nature of the data impedes the use of a multivariate regression model to arrive at results; in a multivariate panel data regression, a separate equation is estimated for each panel, and then parameters of the independent variables are constrained to be the same. Each panel for a multivariate model, in this case, is 17 years deep; however, after accounting for missing data, there are insufficient observations to run a multivariate analysis on each panel. To overcome these impediments, we use a three-stage least squares regression, using *Reg3* in STATA. *Reg3* estimates a system of structural equations, where some equations may contain endogenous variables among the explanatory variables. These endogenous explanatory variables are the dependent variables from other equations in the system[38]. Thus, three-stage least squares can be thought of as producing estimates from a three-step process: (a) It develops instrumental variables for all the endogenous variables; these instrumented variables can simply be considered as the predicted values resulting from a regression of each endogenous variable on all the exogenous variables in the system. (b) A consistent estimate is obtained for the covariance matrix of the equation disturbances. These estimates are based on the residuals from a two-stage least squares estimate of each structural equation. (c) A GLS-type estimation is performed using the covariance matrix estimated in the second stage, with the instrumented values in place of the right hand side endogenous variables. We now proceed to report results.

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[37] These were constructed using STATA's *twoway fpfitci* command, which calculates the prediction for *yvar* based on the estimation of a fractional polynomial of *xvar* and plots the resulting curve along the confidence interval of the mean; *fpfitci* plots are a tool for graphically estimating relationships between variables prior to a regression analysis.

[38] The dependent variables are explicitly taken to be endogenous to the system and as such are treated as correlated with the disturbances in the system's equation. Thus, Y1 is estimated on *all other variables in the system*, followed by Y2 and Y3, respectively.

4. Econometric Results

4.1 Electricity within Infrastructure

Each sub-hypothesis was estimated using non-dynamic fixed effects panel data models, as this hypothesis is meant to be transitory, and thus to provide an initial indication of the sort of results one might expect from Indian data. Panel data for 19 states and 17 years were used. Two types of fixed effects estimations were carried out; one with robust standard errors using the *robust(vce)* command in STATA (Model One), and the second adjusted for serial correlation[39] (Model Two). The former focuses on estimating coefficients on the independent variables, whilst the latter focuses on modelling the error term.

Total Industrial Economic Output

The model estimation for H1.1 can be expressed in terms of the following fixed effects equation:

$$INDGDP1_{it} = \alpha + \gamma_i + \beta_1 ELEC_{it} + \beta_2 RDS1_{it} + \beta_3 TEL_{it} + \beta_4 RAIL_{it} + \beta_5 INTER1_{it} + INTER2_{it} + \beta_6 POPN_{it} + \varepsilon_{it} \quad \text{---- (1)}$$

The equation is estimated with and without the interaction variables, in order to discern the effects of the infrastructure variables by themselves, on industrial GDP. The results from H1.1, *with* the interaction effects, for both fixed effects models, are presented in Table 4.1.

Table 4.1: Electricity Relative to Other Infrastructure Types
Dependent Variable: Total Industrial GDP (Million Rs.)

	With Interaction Terms		Without Interaction Terms	
	Model One INDGDP1	**Model Two INDGDP1**	**Model One INDGDP1**	**Model Two INDGDP1**
INTER1	-0.00000772	-0.00000874	Dropped	Dropped
	(0.0000153)	(0.0000226)		
INTER2	0.00000714	0.000000676	Dropped	Dropped
	(0.00000987)	(0.0000146)		
ELEC	0.146^{++}	0.120	0.138**	0.0810*
	(0.0893)	(0.122)	(0.0409)	(0.0320)
RDS1	10.98**	8.282	14.03***	8.799*
	(3.457)	(7.348)	(2.485)	(3.407)
TEL	-820.2***	-672.5***	-824.9***	-667.5***
	(191.0)	(157.0)	(189.7)	(154.0)
RAIL	0.396	8.267	-1.711	6.206
	(4.968)	(8.338)	(4.017)	(6.309)
POPN	184.9	1260.5*	133.2	1312.7*
	(758.1)	(620.1)	(707.5)	(589.5)
_cons	89506.4	28040.6	90338.8	31517.1
	(54296.2)	(22356.9)	(46040.5)	(19655.0)
N	142	124	142	124
R^2	0.641		0.639	
adj. R^2	0.623	0.244	0.626	0.256

Standard errors in parentheses. $^{++}p < 0.10$ $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

The interaction terms show negligible, insignificant coefficients. The coefficients on ELEC are roughly of the same size in both estimations, but significant only for Model One, at the 10% level. This indicates that electricity infrastructure has contributed positively to total

[39] With AR(1) disturbances.

industrial economic output in Indian states, but the nature of the contribution is difficult to establish and separate from interaction effects. Similarly, the coefficient on roads holds significant only for Model One, yet is positive and of roughly the same size for both models Whilst observing for comparative effects of different infrastructure types, specifically with regard to ELEC and RDS1, reference can be made here to Appendix I (Descriptive Statistics). If we follow an analytical approach put forth by McCloskey & Ziliak (1996; 2004), it is not just statistical significance, but rather the economic significance of regression results, which matters to a researcher engaged in applied economic research. Economic significance can be assessed using the size of the coefficients and the amount of variation in the variables being measured. Thus, ELEC has a small coefficient (0.146) and a high standard deviation (215633.9), whereas RDS1 has a large coefficient (10.98) and relatively smaller standard deviation (1426.451). Thus the *net* effect of both these regressors on the dependent variables will likely be of a similar magnitude. The coefficients on TEL are negative and highly significant for both models. At face this might appear an adverse result. However, TEL represents the percentage growth in the number of direct physical exchange lines, and is indicative of an underlying *growth rate.* Given that mobile connectivity in India has grown exponentially since liberalisation of mobile telecommunications over the past 5 years, a decline in the growth rate of fixed lines could have taken place; this effect is captured here by the variable TEL. Thus, the results show that industrial economic output is related to a decline in the growth rate of fixed line connections, which can be attributed to the substitution of the latter with mobile connectivity[40]. A variable for mobile penetration over time was unavailable.

The coefficients on RAIL are positive but insignificant. POPN shows positive coefficients, and a significant result in the case of Model Two; these should be interpreted with caution as, some highly populous states have tended to have very poor rates of industrial development. The results from the estimation of H1.1, *dropping* the interaction effects, for both fixed effects model estimations, are presented alongside, in Table 4.1. Here, the effects are amplified as a result of the analysis of each indicator independent from the interaction terms. ELEC shows positive, significant coefficients for both models, indicating a substantive contribution of electricity infrastructure to total industrial GDP. RDS1 shows positive significant results, indicating a strong contribution of road infrastructure to industrial GDP. The results for TEL remain the same as those estimated with interaction effects, predictably, and the same justification holds. The coefficients on RAIL are insignificant for both models, but negative in Model One, providing inconclusive results. POPN shows positive coefficients. Again, the interpretation is debatable but POPN serves only as a control variable here[41].

[40] Due to the unavailability of data, the TEL variable was also used to construct an *index,* as opposed to percentage growth rates; however, the results did not differ substantially. Hamilton (2003) investigates whether fixed lines and mobile telephony are complements or substitutes, using evidence from Africa. The study suggests that it is possible that mobile and main lines are sometimes substitutes, where fixed line access is low, and at other times complements in consumption.

[41] A general consideration that might arise here is whether the population and infrastructure variables are affected by multicollinearity, as states with greater populations might be expected to have greater amounts of infrastructure. However, this becomes an issue of concern only in the instance of perfect multicollinearity (exact linear relationships between explanatory variables) as this results in a singular matrix, such that the transformation and thus econometric estimation, cannot be carried out. An examination of the correlation coefficients confirms that there is no perfect correlation between population and the infrastructure variables (popn/elec=0.7240; popn/rds1= 0.8540; popn/rail=0.8862; popn/tel=0.0522). This indicates the absence of perfect multicollinearity, rendering the results valid. Moreover, in Indian states, it is often the case that states with larger populations are often the poorest ones (e.g. Uttar Pradesh has the highest state population, and is one of the least-developed), and thus do not have an infrastructure stock proportionate to their population size. Concerns of multicollinearity are thus alleviated through both economic and econometric reasoning.

Reviewing the results from both regressions on INDGDP1, it is possible that the negative coefficient on INTER1 could be partly explained by the negative coefficient on RAIL, thus strengthening the conclusion that electricity has a positive (and in most cases, significant) contribution to INDGDP1. Overall, the model fit is seen to be better for Model One, for estimations with and without the interaction effects, as indicated by the R statistics.

Industrial Economic Output Per Capita

The model estimation for H1.2 is expressed in terms of the following fixed effects equation:

$$INDPC1_{it} = \alpha + \gamma_i + \beta_1 ELEC_{it} + \beta_2 RDS1_{it} + \beta_3 TEL_{it} + \beta_4 RAIL_{it} + \beta_5 INTER1_{it} + INTER2_{it} + \beta_6 POPN_{it} + \varepsilon_{it} \quad \text{----------- (2)}$$

This hypothesis is examined first with, and then without the interaction effects. The results from the estimation of H1.2, *with* the interaction effects are presented in Table 4.2. The coefficients on the interaction variables are negligible, indicating the absence of substantive influence on INDPC. INTER1 is significant for Model One, but has a negative, negligible coefficient. ELEC shows positive coefficients for both estimations, but holds significant to a moderate level only for Model One. The coefficients on road infrastructure are positive for both estimations, and significant for Model One. Thus, both ELEC and RDS1 show a positive contribution to INDPC, but to a nebulous extent.

Table 4.2: Electricity Relative to Other Infrastructure Types
Dependent Variable: Per Capita Industrial GDP (Rs.)

	With Interaction Terms		**Without Interaction Terms**	
	Model One INDPC	**Model Two INDPC**	**Model One INDPC**	**Model Two INDPC**
INTER1	-0.00000127*	-0.000000604	Dropped	Dropped
	(0.000000522)	(0.00000107)		
INTER2	-0.000000148	2.07e-08	Dropped	Dropped
	(0.000000356)	(0.000000913)		
ELEC	0.00754**	0.00382	0.000657	0.000914
	(0.00269)	(0.00462)	(0.000565)	(0.000708)
RDS1	0.418*	0.355	0.402***	0.337
	(0.184)	(0.424)	(0.0963)	(0.204)
TEL	-19.98***	-16.70**	-20.19***	-16.29**
	(5.325)	(4.995)	(5.069)	(4.791)
RAIL	0.527**	0.227	0.288*	0.110
	(0.188)	(0.282)	(0.143)	(0.221)
POPN	39.73	-3.345	29.49	-1.049
	(38.70)	(16.76)	(34.80)	(15.98)
_cons	-251.2	2345.3**	1120.2	2743.8***
	(1777.4)	(799.3)	(1454.7)	(583.8)
N	71	62	71	62
R^2	0.562		0.541	
adj. R^2	0.513	0.051	0.506	0.066

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results for TEL match up with those estimated for H1.1. The results from the estimation of H1.2, *dropping* the interaction effects, are presented in Table 4.2. ELEC shows relatively small and insignificant coefficients for both models, suggesting that it might not contribute much, in isolation, to industrial output per capita. The coefficient on roads is positive for both estimations, but highly significant only for Model One. The results for TEL hold consistent, indicating that, as explained before, TEL is associated with higher industrial output per capita.

Figure 4.1: Fractional Polynomial Prediction Plot for Electricity Infrastructure versus Total Industrial GDP

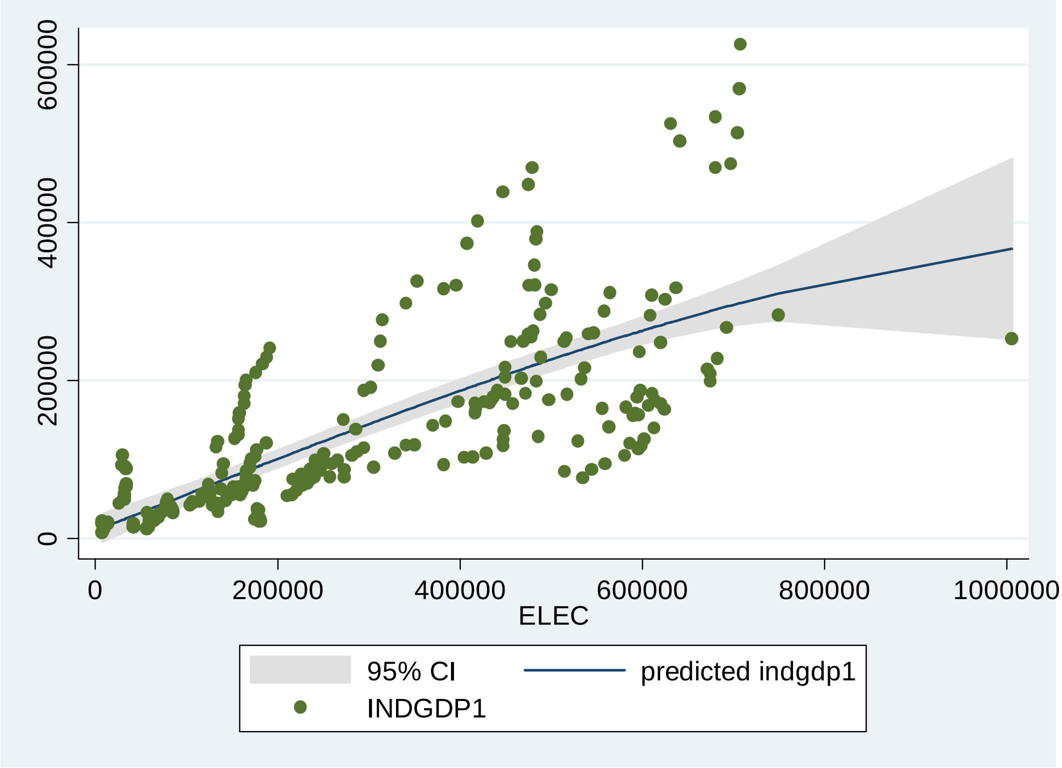


Figure 4.2: Fractional Polynomial Prediction Plot for Road Infrastructure versus Total Industrial GDP

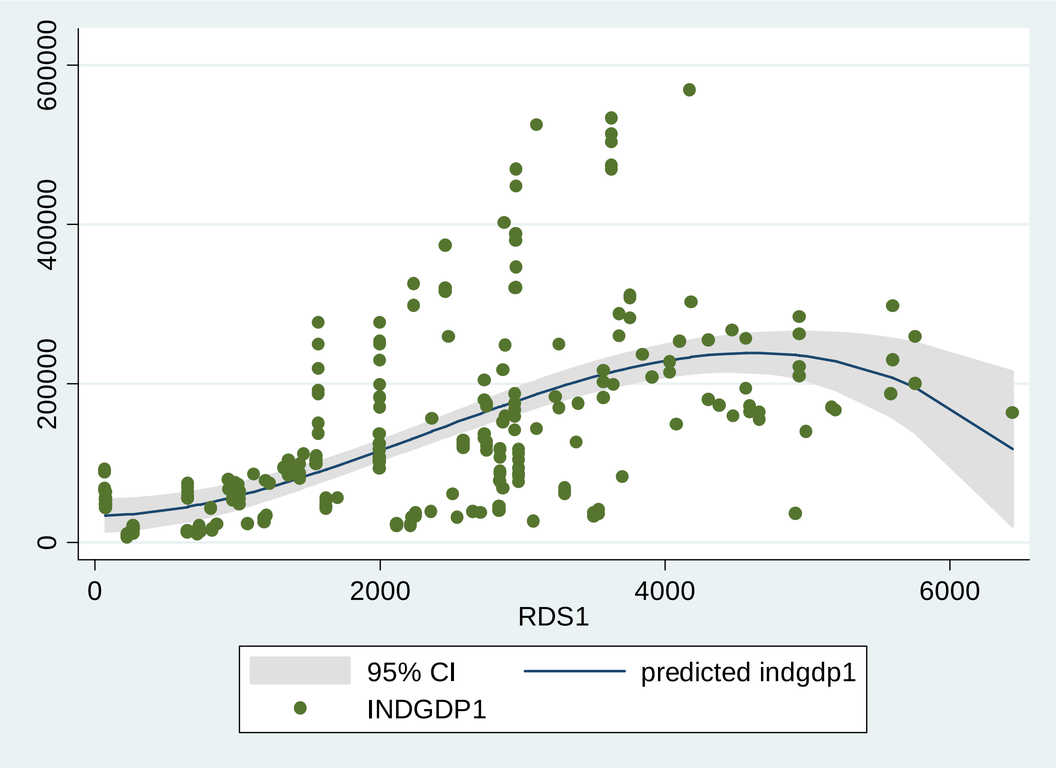


Figure 4.3: Fractional Polynomial Prediction Plot for Fixed Telecoms Infrastructure versus Total Industrial GDP

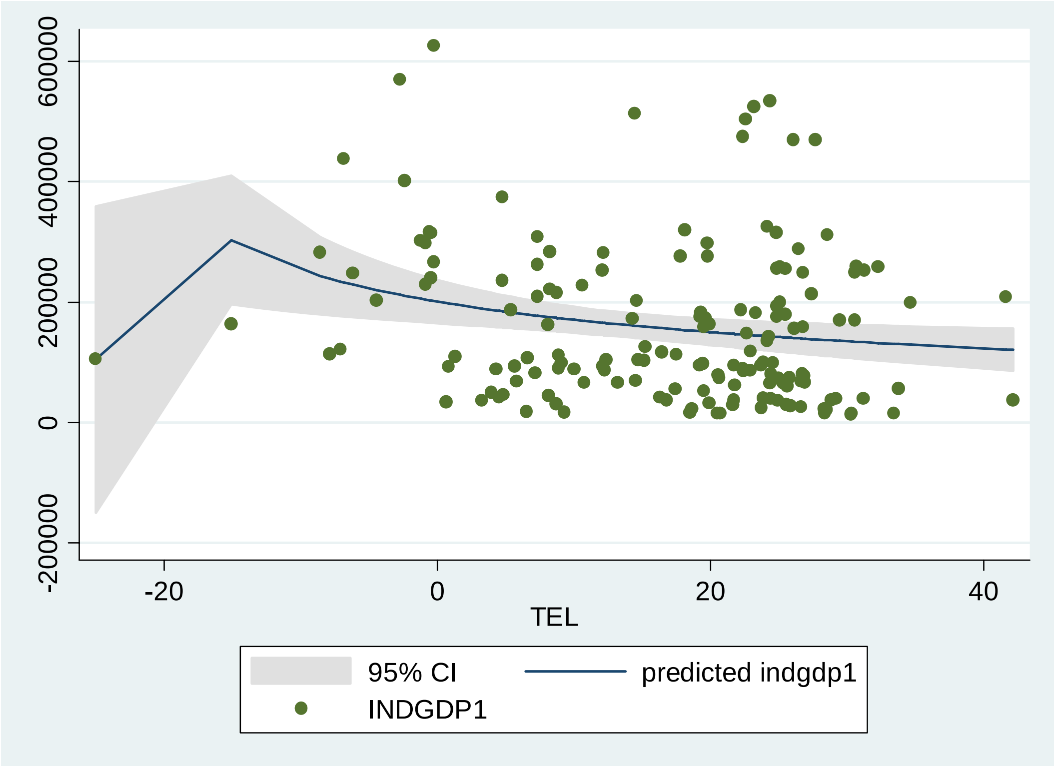
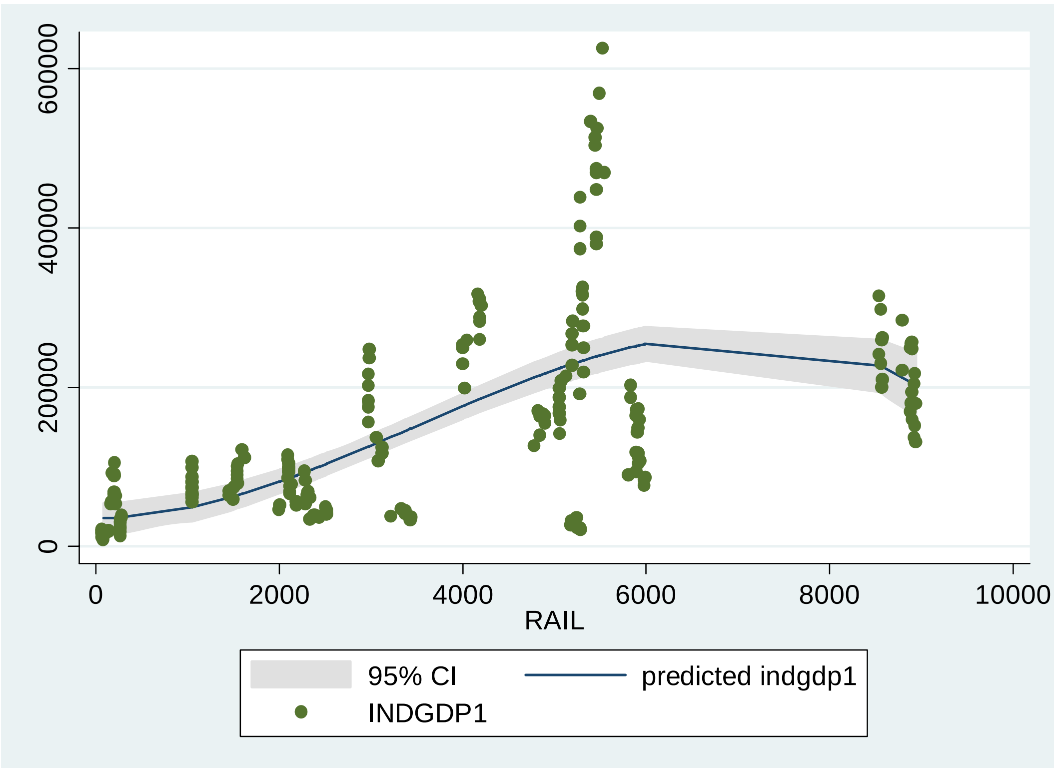


Figure 4.4: Fractional Polynomial Prediction Plot for Rail Infrastructure versus Total Industrial GDP



RAIL shows a positive, significant coefficient for Model One. In the case of INDPC, Model One is found to explain a larger proportion of the associated impacts, as seen by the R statistics. Figures 4.1 to 4.4 depict fractional polynomial prediction plots of the relationship between each of the independent variables and total industrial GDP. Electricity demonstrates a strong positive relationship with total industrial GDP. The overall conclusions from H1 are that electricity has contributed substantially and significantly to total industrial output in Indian states. However, its contribution to industrial output per capita, appears mixed, and not as potent as telecoms or roads. A possible limitation of the above is that the variables used reflect the availability of electricity networks, rather than the level of electricity usage; and some states may have higher average consumption than others. However, suitable indicators for consumption levels were not available.

4.2 Efficiency Impacts of Reform

This hypothesis is examined using equation (3) and a three-stage least squares method.

f (PLF+TDL+GRGEN) =f (IPPS+REG+UNB+TAR+OPREG+DPVT+PRATIO1+ PRATIO2+PCGDP+HYDRO1) ------------------ *(3)*

The equation has been specified in a multivariate form, which conditions the choice of technique within regression analysis. The justification relates to the dependent variables and to data limitations. Efficiency can be measured by both commercial and technical parameters. Data on commercial efficiency in India is incomplete and unreliable; in some instances, audits were carried out as late as 2002[42]. It is expected that commercial efficiency parameters will have improved post-reform, but data on the same was not available. Arguably, examining commercial efficiency would most easily set out the impacts of reform, as financial insolvency is widely perceived to have been the root of the crisis. However, due to the reasons mentioned above, the focus of the hypothesis is on technical efficiency and its associated impacts with commercial efficiency. Subsequently, technical efficiency parameters may be interrelated, and thus are expected to display certain interdependent relationships; thus, for instance, we could hypothesise an interdependent inverse relationship between PLF and GRGEN specifically in the presence of IPPs, and observe for the same in the analysis[43]. Thus, this hypothesis looks at the concept of technical efficiency in entirety. This property qualifies the multivariate specification, and helps to capture relationships that might be lost in individual specifications. Annual data are analysed for 18 Indian states, covering 17 years. The econometric results are presented in Table 4.3.

Plant Load Factor (PLF)

Significant results are obtained for four variables. Unbundling (UNB) shows a positive, highly significant effect on PLF. The splitting of the sector leads to a fragmented structure, particularly in the initial stages. Thus, plants may be pressed to improve their PLF. This effect is substantive, as the coefficient on UNB is large. Tariff orders (TAR) have a positive, significant effect on PLF as cost-reflective tariffs encourage higher levels of PLF. Power shortages and subsidies have traditionally led industries to opt for more captive generation than would be economically justified. Thus, price corrections brought about by

[42] Prior to the Delhi privatisations.

[43] Higher levels of PLF relate to lower levels of GRGEN and vice versa, conditional upon the existence and extent of Independent Power Producers (IPPS). The presence of IPPS in a state augments GRGEN; thus, PLF levels, which have traditionally been lower than average across India, are expected to fall further, as a greater number of plants generate electricity to the system, easing up the pressure on individual plants to generate at full capacity. This relationship is counterintuitive to that expected in a conventional reform programme. However, as earlier, the Indian reform experience is distinctive, in that political economy has long influenced its direction and outcomes.

TAR lead to lower prices for industrial consumers, who are drawn back to the state grid since off-grid options become uneconomical; thus the system is under pressure to improve PLF to meet demand. PRATIO2 has a positive, highly significant effect on PLF. A higher PRATIO2 indicates higher industrial prices, relative to lower agricultural prices, reflecting high cross-subsidisation[44]. The latter leads to high agricultural consumption, which puts pressure on plants to meet demand, thus PLF may increase. HYDRO1 has a negative, highly significant effect on PLF. Note that PLF only includes thermal generation. Hence, higher HYDRO1 leads to a lower PLF. Hydroelectricity is cheaper and more efficient to produce, and states with higher levels of HYDRO1 have an advantage over those without. Thus, PLF will be low as the pressure on the thermal system reduces.

Transmission and Distribution (Energy) Losses (TDL)

Four variables are significant. REG has a positive, highly significant coefficient on TDL. This is an expected result as initial reform measures tend to reveal previously hidden levels of network losses. Prior to reform, State Electricity Boards would often report losses clubbed with agricultural consumption, to hide true levels of losses. UNB has a positive, highly significant coefficient on TDL, again indicating that in initial reform stages, the sector has to contend with true losses that are revealed during restructuring. Again, DPVT has a positive, significant coefficient on TDL as true levels of losses are revealed in the initial stages of reform. Moreover, in distribution privatisations, the basis for awarding bids have been whether annual loss reduction targets match with those projected by government analyses. The Delhi privatisations were carried out on this basis in 2000, and required an audit to establish the actual levels of TDL. The private owners were expected to meet predetermined loss reduction targets in subsequent years. PRATIO2 has a negative, significant coefficient on TDL. A high PRATIO2 indicates high industrial prices relative to agricultural prices and cross-subsidisation. In such a situation, agricultural consumption increases to excessive levels. There may thus be a tendency for state-owned companies to include network losses with agricultural consumption to conceal inefficiencies in operations.

Gross Generation (GRGEN)

IPPS shows a positive, significant coefficient on GRGEN as the introduction of IPPs adds to generation capacity. This could also be interpreted in relation to earlier results on PLF; IPPS leads to a lower PLF and a higher GRGEN, indicating a relationship between the two, because with the addition to generation capacity, availability of electricity in the system increases; thus, poorly maintained plants exhibit a low PLF because of too much 'downtime'. TAR shows a positive, highly significant coefficient on GRGEN. TAR lowers prices for industrial consumers, which could lead to a greater demand for grid-connected electricity from the industrial consumer segment, and hence GRGEN increases. DPVT shows a negative, significant coefficient on GRGEN indicating a reduction in generation whilst the system reconciles to supplying electricity in the restructured sector. PRATIO2 shows a positive, highly significant coefficient on GRGEN. This, a high PRATIO2 increases GRGEN. A high PRATIO2 indicates higher industrial prices relative to agricultural prices, and is thus reflective of higher cross-subsidies. This implies high agricultural consumption. GRGEN would thus have to increase to meet increased demand. HYDRO1, as expected, shows a

[44] The average PRATIO2 was graphed over time, across the sample of states, against an index of industrial prices and an index of agricultural prices for the same sample (constructed from the argument. It was seen that industrial prices tended to rise at a higher rate than agricultural prices of electricity, and are thus the main driver of changes to PRATIO2.

negative and highly significant coefficient on GRGEN, indicating that states with higher levels of hydro will have lower levels of GRGEN (thermal).

Thus, some overall conclusions can be drawn. Almost all the measures of reforms have some implication for efficiency. For PLF, unbundling and the passing of tariff orders have the most significant impacts. For TDL, independent regulation, unbundling, and distribution privatisation have significant impacts. Finally, for GRGEN, the existence of IPPs, passing of tariff orders and distribution privatisation most significantly influence this variable. In India, the nature of the impact is highly influenced by the extent of cross-subsidisation. In the case of PLF, independent variables that lead to an increase in levels are taken to be a positive impact, provided the cross subsidies to agriculture (PRATIO2) are not exorbitant, as higher levels of PLF could be due to a load from increased agricultural consumption, often including wastage. In the case of GRGEN, reform measures that lead to higher generation would be a positive outcome, except in the instance of high cross-subsidies; in case of the latter, it is an indication of excessive agricultural demand. In case of TDL, a sign of workable reform is when previously hidden levels of losses come to light; hence, TDL should initially rise with reform; again, controlling for cross subsidies becomes essential, as high subsidies could induce companies to club losses with agricultural consumption.

Table 4.3: Efficiency Impacts of Electricity Sector Deregulation
Dependent Variables: PLF (%), T & D Loss (%), Gross Generation (MKWh)

	(1)	(2)	(3)
	PLF	**TDL**	**GRGEN**
IPPS	-4.926	-2.780	3732.5*
	(4.061)	(1.448)	(1777.9)
REG	-0.663	6.979***	1142.9
	(4.712)	(1.481)	(2362.4)
UNB	26.25***	7.753***	-5315.6
	(4.989)	(1.843)	(3099.0)
TAR	10.71*	-2.336	8523.5***
	(5.082)	(2.005)	(2316.0)
OPREG	-2.917	0.504	7128.0
	(12.65)	(4.577)	(7416.1)
DPVT	-15.52	6.291*	-12040.6*
	(10.93)	(2.476)	(5531.2)
PRATIO1	-1.305	-0.413	-648.9
	(1.345)	(0.522)	(779.6)
PRATIO2	0.397***	-0.0488*	91.19**
	(0.0872)	(0.0204)	(30.52)
PCGDP	0.000598	0.0000323	0.440
	(0.000341)	(0.000104)	(0.234)
HYDRO1	-0.147**	-0.0299	-99.17***
	(0.0477)	(0.0206)	(23.38)
N	**245**		

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Some final conclusions for the above hypothesis may be stated as follows. First, the time lag between implementation of reforms and their outcome seems to be the shortest for PLF; this is followed by GRGEN, and finally, by TDL. Increasing the PLF by itself is unsustainable, as, assuming plants attain their highest possible levels of PLF, there will still be a need to increase generation beyond this threshold to keep up with rising demand. Thus, measures encouraging GRGEN should be carried out in line with demand projections. TDL will require a time lag to attain economic sustainability, as a reform reveals true levels of losses in the early stages. All of the above suggests that states which have not only implemented greater measures of reform, but have implemented these *early on*, should have experienced substantive efficiency improvements. This has been exhibited in the state of Andhra Pradesh, where reforms were implemented from 1998 onwards, and levels of TDL have been reduced to 18% from around 30%. Thus, TDL might also be viewed as a long-term indicator of the efficiency impact of deregulation. The measures that affect TDL most significantly are, REG, UNB, and DPVT (or equivalent measures). It follows that the net impact could be that a state which implements a reform halfway, might end up worse off than a state that implements reform to near-completion, in terms of efficiency. This is because levels of TDL would stabilise only through long-term initiatives. As a chronic energy deficit exists across India, efficiency improvements can reduce wastage and technical losses, and could, alongside addition to installed capacity, and reduce the deficit. In light of the long lag times required to bring new capacity into the system, efficiency improvements could contribute significantly to managing short term peak demand.

4.4 The Price Impacts of Reform

Price by itself is a complex construct in the Indian scenario, going beyond economic principles, and involving socio-political elements. Data on average prices was available for 19 states and for 19 years (1986–2005), with missing values. Data on industrial prices was available for 19 states and 16 years (1990-2006). Price would tend to be influenced not just by reform measures and suitable controls, but also by its past values. A dynamic specification is thus used to explore price impacts. Moreover, using a lagged value of the dependent variable would also account for the effects of omitted variables. The model estimation used is a Bias-Corrected Least Squares Dummy Variables (LSDVC) model, as this is deemed most appropriate for this analysis. The main assumption of the LSDVC model is the exogeneity of the regressor variables. As the regressors here are a set of measures that are introduced in a logical sequence at different times, and control variables that are *per se* independent of reform measures, this assumption can be considered fulfilled. The estimation is carried out using all three options for initialising the bias correction; thus, results using the Anderson-Hsiao (AH), Arellano-Bond (AB) and Blundell-Bond (BB) estimators for bias-corrections are presented. The reporting of all three options also helps check the consistency of results.

Average Price of Electricity

This sub-hypothesis was thus examined in a dynamic panel data specification with an equation of the following form:

$$PRICE_{it} = \gamma L.PRICE_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it} \text{ ----------------- (4)}$$

γ represents the coefficient and the lagged value of PRICE; $X_{it}\beta$ represents a vector of coefficients and independent variables; these include the dummy variables for the six main reform measures, and a control variable, namely PCGDP; η_i is the individual effect representing the unobserved heterogeneity in cross sections; ε_{it} is the error term. HYDRO1 is not explicitly used as a control, to avoid undue stress on the dataset; as it can influence the extent to which a reform is undertaken, it is considered embodied in the set of reform indicators. The effect of HYDRO1 may also be captured in the lagged value of PRICE. The results from the LSDVC estimations are presented in Table 4.4. Test results relevant to the estimators showed no second order correlation; the Sargan test showed that the estimations were not robust, yet not weakened by too many instruments. L.PRICE has a positive, significant coefficient. IPPS, although insignificant, shows a positive coefficient across all three estimations. This is in conformity with the fact that electricity sold by IPPs has historically been at very high rates, based on Power Purchase Agreements entered into by state governments, to assure investors of a return. These mechanisms have included a guaranteed 16% return on equity, and later, a fixed and variable cost recovery arrangement. PCGDP shows a positive coefficient across all three estimations, but it is significant at the 10% level for the AH and BB estimators, and at the 5% level for the AB estimator. This result indicates that richer states have higher prices.

Moreover, average prices encompass several consumer segments, and the price increase might come from any one or more of them. One possibility is that PCGDP reflects the purchasing power of a state's population and ability to pay cost-reflective tariffs. The latter could thus have an effect on electricity prices. REG and UNB show positive but insignificant coefficients across all three estimations. As average prices encompass several segments of pricing, these two measures, being in the initial stages of reform, may not be sufficient to influence an immediate decline. Moreover, any reduction in prices of a specific consumer segment would have to be substantially strong to bring about a notable decline in the average electricity price.

Table 4.4: The Price Impacts of Deregulation I: Average Price of Electricity-Estimation using Bias-Corrected LSDV Models
Dependent Variable: Average Price (Rs. per unit)

	Model One	**Model Two**	**Model Three**
	Anderson-Hsiao	Arellano-Bond	Blundell-Bond
	PRICE	**PRICE**	**PRICE**
L.PRICE	0.827^{***}	0.788^{***}	0.831^{***}
	(0.0666)	(0.0533)	(0.0464)
IPPS	0.0148	0.0128	0.0196
	(0.0320)	(0.0272)	(0.0293)
REG	0.0319	0.0253	0.0194
	(0.0352)	(0.0330)	(0.0328)
UNB	0.0546	0.0555	0.0556
	(0.0439)	(0.0390)	(0.0405)
TAR	-0.00951	-0.0104	-0.00684
	(0.0381)	(0.0363)	(0.0367)
OPREG	-0.0671	-0.0763	-0.0705
	(0.0780)	(0.0764)	(0.0766)
DPVT	-0.0747	-0.0257	-0.0570
	(0.0682)	(0.0588)	(0.0598)
PCGDP	0.0000108^{++}	0.0000114^{*}	0.0000106^{++}
	(0.00000660)	(0.00000566)	(0.00000563)
N	321	321	321

Standard errors in parentheses; $^{++}$ $p < 0.10$ * * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Average Industrial Price of Electricity

As discussed earlier, the average price is a difficult variable with which to unravel the impacts of deregulation. Thus, it was deemed necessary to examine the same hypothesis for the average *industrial* price, in order to discern an impact. Again, a dynamic panel specification is used; the dependent variable is industrial price.

$$INPRICE_{it} = \gamma L.INPRICE_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it} \qquad \text{--------------- (5)}$$

The results are presented in Table 4.5, and results are significant for most variables. The Arellano-Bond estimation shows no second order correlation, and the Sargan test of over-identifying restrictions for both estimations indicates that the estimations are not robust, but not weakened by too many instruments. However, the presence of second order autocorrelation is detected for the Blundell-Bond estimator, and thus the results from the same might not be accurate. They are however, broadly in line with the other two models.

The coefficients on L.INPRICE are positive and significant across all three estimations. REG shows a positive, significant coefficient across all three estimations (but at the 10% level for Blundell Bond), implying that the establishment of a regulator increases industrial prices. In developing countries, true levels of price distortions tend to be revealed during initial reform. REG precedes restructuring, and thus the impact on prices might not be immediate. TAR shows a negative, significant coefficient across all estimations, in line with theorised impacts, namely, that the passing of tariff orders leads to lower industrial prices, as this measure is aimed at rationalising prices. OPREG shows a negative coefficient, significant at 10% for two out of three estimations. This is an expected result; OPREG indicates the presence of Open Access to the grid, and is meant to facilitate competitiveness in supply, especially for industrial consumers. Thus, it should lead to lower industrial prices. Finally, PCGDP shows a positive and significant coefficient for two out of three estimations; this can be interpreted as richer states having higher demand, and thus relatively higher industrial prices, although these might still be competitive. In this case PCGDP is mainly an indicator of demand-driven influence on the industrial price.

Table 4.5: The Price Impacts of Deregulation II: Industrial Price of Electricity-Estimation using Bias-Corrected LSDV Models
Dependent Variable: Industrial Price (Rs. per unit)

	Model One Anderson-Hsiao **INPRICE**	**Model Two** Arellano-Bond **INPRICE**	**Model Three** Blundell-Bond **INPRICE**
L.INPRICE	0.554^{***}	0.513^{***}	0.606^{***}
	(0.0800)	(0.0675)	(0.0612)
IPPS	0.0984	0.0901	0.0982
	(0.105)	(0.0876)	(0.0935)
REG	0.199^{*}	0.199^{*}	0.161^{++}
	(0.0867)	(0.0901)	(0.0927)
UNB	0.0167	0.0310	0.0395
	(0.108)	(0.107)	(0.113)
TAR	-0.234^{*}	-0.222^{*}	-0.229^{*}
	(0.101)	(0.0973)	(0.100)
OPREG	-0.344	-0.354^{++}	-0.317^{++}
	(0.237)	(0.190)	(0.197)
DPVT	-0.00399	0.0336	-0.00508
	(0.185)	(0.159)	(0.171)
PCGDP	0.0000297	0.0000354^{*}	0.0000303^{++}
	(0.0000262)	(0.0000177)	(0.0000187)
N	260	260	260

Standard errors in parentheses; $^{++}$ $p < 0.10$ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figures 4.5 and 4.6 depict fracpoly plots of the relationship between average price and the reform index, and industrial price and the reform index, respectively. The average price shows a stabilising trend, and the industrial price shows a declining trend, with every successive higher score. Several conclusions can be drawn here. As expected, the impact of reforms on average price is difficult to discern, as there are presumably many other factors, including non-economic ones, which influence their direction and magnitude. The results for H3.1 support this view; the lag of electricity prices would, as explained earlier, account for the influence of omitted variables, and the results show a positive significant coefficient for L.PRICE.

Figure 4.5: Fractional Polynomial Prediction Plot: Average Electricity Price versus Reform Index

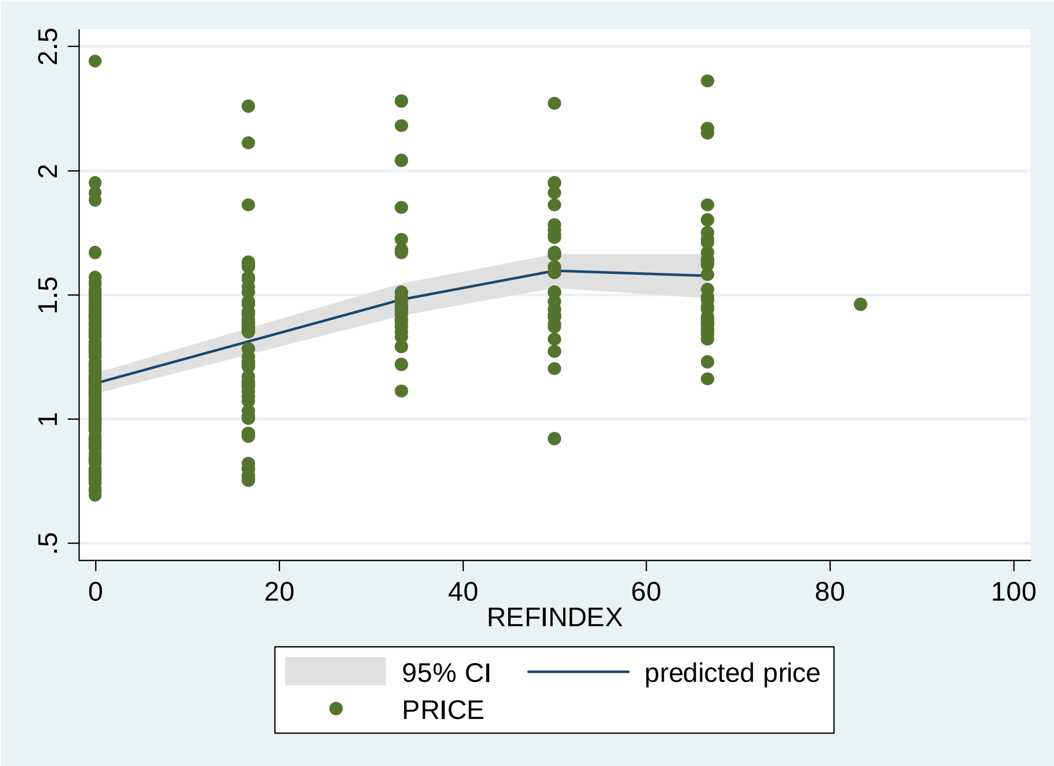
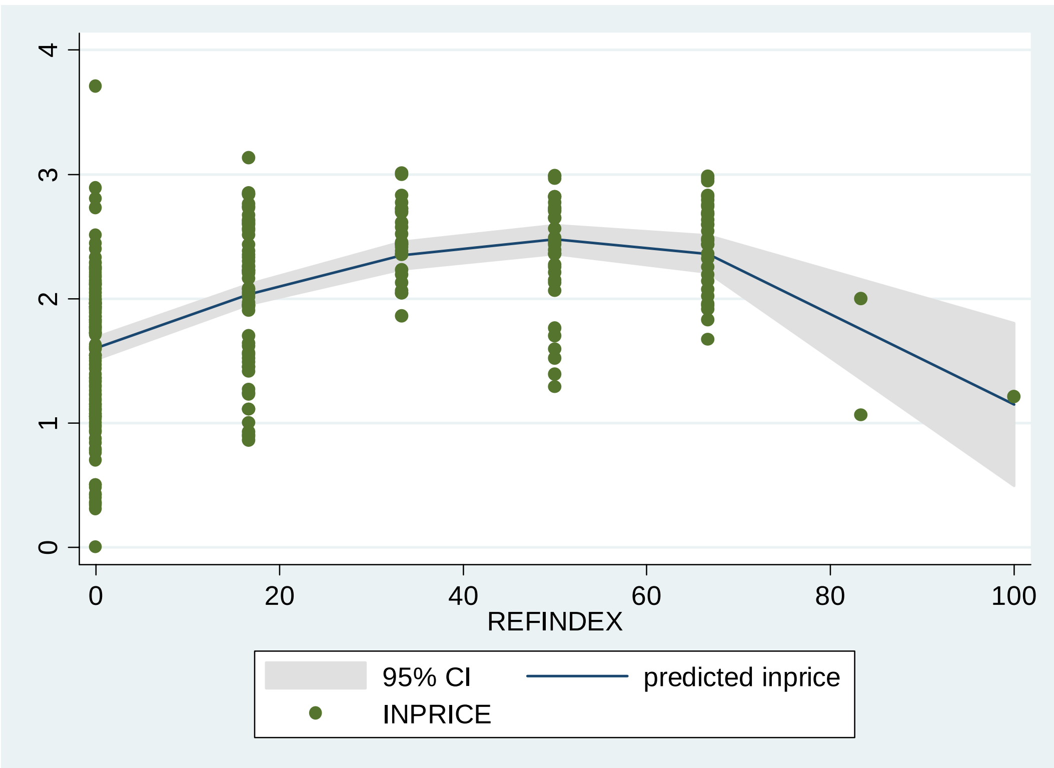


Figure 4.6: Fractional Polynomial Prediction Plot: Industrial Electricity Price versus Reform Index



Moreover, PCGDP shows the other significant (and positive) coefficient on electricity price, indicating that richer states demonstrate a substantial influence on prices. These results are consistent across all estimations. The impact of reforms on industrial prices is easier to establish, as carried out in H3.2. The overall conclusion that can be drawn from the analysis of H3.2 is that the impact on industrial prices seems to occur only with the implementation of the measures of reform that fall in the latter half of the reform sequence, such as TAR, OPREG and DPVT. This is again, demonstrated by the prediction plots for industrial electricity price. Thus, a halfway reform may proliferate a trend of increasing prices for industry.

4.5 The Pricing Impacts of Reform

In addition to price, it is important to explore the impact of electricity sector reforms on *pricing* to determine whether the price impacts on price are reflective of changes in relative prices. Moreover, the pricing mechanism in India is distinctive to other countries, and is influenced by state specific socio-political factors. In fact, one of the original aims of electricity reforms was to bring about a correction in distorted pricing practices for electricity, as the financial health of the sector is closely tied to this. Two sub-hypotheses are formulated and examined. The first models this impact using PRATIO1; the second utilises the same concept for the dependent variable PRATIO2. Data for both cover 19 states and 16 years (1990-2006). The latter is also meant to be an indicator of cross-subsidies in Indian states. The same regression techniques are used here as in H3.

Ratio of Industrial to Domestic Prices

The ratio of industrial to domestic prices is a conventional indicator of the effectiveness of a reform programme, especially in developed countries, before reforms, since industries tend to subsidise residential consumers in these countries. Thus, ideally, the ratio should come down with the implementation of reforms. In India, the extent of cross-subsidisation by the industrial consumer segment to the domestic consumer segment is not as clearly defined or to the same extent as the cross-subsidy from industry to agriculture. The model specification, conceptually similar to H3, is defined in the following equation:

$$PRATIO1_{it} = \gamma L.PRATIO1_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it} \text{ -------------- (6)}$$

$X_{it}\beta$ represents a vector of coefficients and independent variables; these include the six measures of an electricity deregulation programme and a control variable, namely PCGDP. HYDRO1 is not used as a control; as its effect is embodied in the set of reform indicators. The results from all three LSDVC estimations are presented in Table 4.6. There is no first or second order autocorrelation, and the Sargan test statistic is insignificant in all cases, indicating that the model estimations do not use an inordinately large number of instruments.

TAR shows a negative coefficient, significant at the 10% level for all estimations, implying that the implementation of a policy on regular tariff orders leads to a reduction in PRATIO1. This is expected, as tariff orders are aimed at bringing about corrections in pricing. PCGDP shows a negligible positive coefficient, significant at the 10% level only for the AH estimation. IPPS, REG and UNB show negative but insignificant coefficients across all estimations. OPREG shows a positive but insignificant coefficient, implying a marginal rise in PRATIO1. These results must be interpreted in the context of the extent of subsidy to the domestic consumers, and the party that bears this subsidy, which in the cases of many states, may not be industry, but the state government. Moreover, the extent of subsidy to the domestic segment is presumably far lesser than agriculture, and might be sustained at consistent levels over time, in comparison to cross-subsidies to agriculture, which tend to swing between zero and flat rates, depending on the political situation. Thus, to reiterate, the effect on PRATIO1 might not be as relevant in the Indian context, as compared to PRATIO2.

Table 4.6: The Pricing Impacts of Deregulation I: Ratio of Industrial to Domestic Prices-Estimation using Bias-Corrected LSDV Models
Dependent Variable: Ratio of Industrial to Domestic Price

	Model One	**Model Two**	**Model Three**
	Anderson-Hsiao	Arellano-Bond	Blundell-Bond
	PRICE	**PRICE**	**PRICE**
L.PRATIO1	0.139^{++}	0.111^{++}	0.173^{*}
	(0.0729)	(0.0702)	(0.0702)
IPPS	-0.244	-0.241	-0.276
	(0.237)	(0.227)	(0.265)
REG	-0.0160	-0.0100	-0.0489
	(0.262)	(0.251)	(0.279)
UNB	-0.128	-0.107	-0.108
	(0.270)	(0.262)	(0.298)
TAR	-0.496^{++}	-0.473^{++}	-0.459^{++}
	(0.256)	(0.248)	(0.279)
OPREG	0.0926	0.101	0.135
	(0.521)	(0.504)	(0.569)
DPVT	-0.0999	-0.157	-0.0975
	(0.618)	(0.602)	(0.697)
PCGDP	0.0000368^{++}	0.0000416	0.0000298
	(0.0000555)	(0.0000533)	(0.0000625)
N	258	258	258

Standard errors in parentheses; $^{++}$ $p < 0.10$ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Ratio of Industrial to Agricultural Prices

This sub-hypothesis attempts to determine the impact of reforms on cross-subsidies that flow from industry to agriculture. Ideally, the ratio should decrease with the implementation of reforms. This is an important part of reform, as it leads to several knock-on effects; the reduction of subsidies leads to corrections in pricing, and places a marginal value on electricity for agriculturalists, curbing wastages by the latter. It also has a bearing on the financial health of the sector, and is linked with commercial and technical loss reduction. The model specification is as follows:

$$PRATIO2_{it} = \gamma L.PRATIO2_{it} + X_{it}\beta + \eta_i + \varepsilon_{it} \text{ ----------------- (7)}$$

$X_{it}\beta$ represents a vector of coefficients and independent variables; these include the six main measures of an electricity deregulation programme, and PCGDP as a control variable,; η_i is the individual effect; and, ε_{it} represents the error term. The results are presented in Table 4.7. The Arellano-Bond estimation shows second order autocorrelation, making its results questionable. However, the Blundell-Bond estimation reports a Sargan test statistic that is ‘not robust, yet not weakened by too many instruments’, making its results valid, along with the Andersen-Hsiao estimation. As expected, L.PRATIO2 shows a positive significant coefficient for all estimations. UNB shows a negative and significant coefficient for all three estimations, indicating a reduction in PRATIO2. UNB leads to the separation of the competitive segments in the sector, namely, generation and distribution, from its monopoly segment, transmission. Moreover, distribution is usually undertaken by companies that serve specifically allotted areas of the state. Thus, an element of transparency is immediately injected into the operations of the distribution sector. This separation would presumably make it easier for distribution companies to recover their dues from their area-specific consumers. Further, UNB is usually undertaken alongside corporate practices, and this would expectedly lead to a reduction in hidden costs and wastage. Referring back to H3.2, it was established that UNB alone does not reduce industrial prices. Thus, it can be concluded that UNB reduces cross-subsidies, but not to an extent that is enough to have an effect on industrial price *per se*. OPREG shows a large, positive and significant coefficient across all estimations, indicating that it increases PRATIO2. OPREG implies that industrial consumers can purchase electricity from a third party, and that industrial users can produce own electricity at captive plants, and use the grid to wheel it to their production facilities. State governments could lose considerable business, and hence the revenue of state-owned companies would fall; this would have an impact on the cost of electricity to agriculturalists that are subsidised by industry. Thus, industrial consumers who choose OPREG are subjected to a cross-subsidy surcharge, to make up for this revenue loss, and to avoid cutting off subsidies to agriculture completely.

Table 4.7: The Pricing Impacts of Deregulation II: Ratio of Industrial to Agricultural Prices-Estimation using Bias-Corrected LSDV Models

Dependent Variable: Ratio of Industrial to Agricultural Price

	Model One	**Model Two**	**Model Three**
	Anderson-Hsiao	Arellano-Bond	Blundell-Bond
	PRICE	**PRICE**	**PRICE**
L.PRATIO2	0.299***	0.309***	0.364***
	(0.0704)	(0.0699)	(0.0683)
IPPS	2.476	2.000	1.845
	(5.035)	(4.763)	(5.133)
REG	3.996	3.743	3.244
	(5.105)	(4.783)	(5.005)
UNB	-16.24*	-15.04*	-16.03*
	(7.594)	(7.131)	(7.496)
TAR	-4.756	-4.801	-4.874
	(5.996)	(5.571)	(5.952)
OPREG	25.24*	25.13*	25.89*
	(10.47)	(9.759)	(10.25)
DPVT	17.07	15.67	17.67++
	(12.31)	(11.33)	(11.96)
PCGDP	-0.000808	-0.000705	-0.000822
	(0.00100)	(0.000938)	(0.00105)
N	246	246	246

Standard errors in parentheses; ++ $p < 0.10$ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

OPREG might therefore lead to an increase in PRATIO2, as the cost of electricity remains high for industrial consumers that opt for it. In practice, OPREG might work more effectively if there is sufficient competition in distribution to neutralise the effect of the cross subsidy surcharge. DPVT shows a positive coefficient significant at 10% for the Blundell-Bond estimation. As distribution privatisation has been undertaken only in two states (Orissa and Delhi) out of which the success of the first has been questioned, too little time may have lapsed to arrive at a conclusive result for the impact of DPVT on PRATIO2. Figures 4.7 and 4.8 depict fracpoly plots of the relationship between average price and the reform index, and industrial price and the reform index, respectively. Both plots show a clear decline of price ratios with the implementation of successive measures towards the completion of a programme. Some overall conclusions can be drawn from the results of H4; the main one being that the impact on pricing is seen as distinctive from the impact on prices; price ratios have more of a distributional character. What appear to be major changes in the pricing mechanism may not reflect in the final prices of electricity for end-consumers.

Figure 4.7: Fractional Polynomial Prediction Plot: Ratio of Industrial to Domestic Price of Electricity versus Reform Index

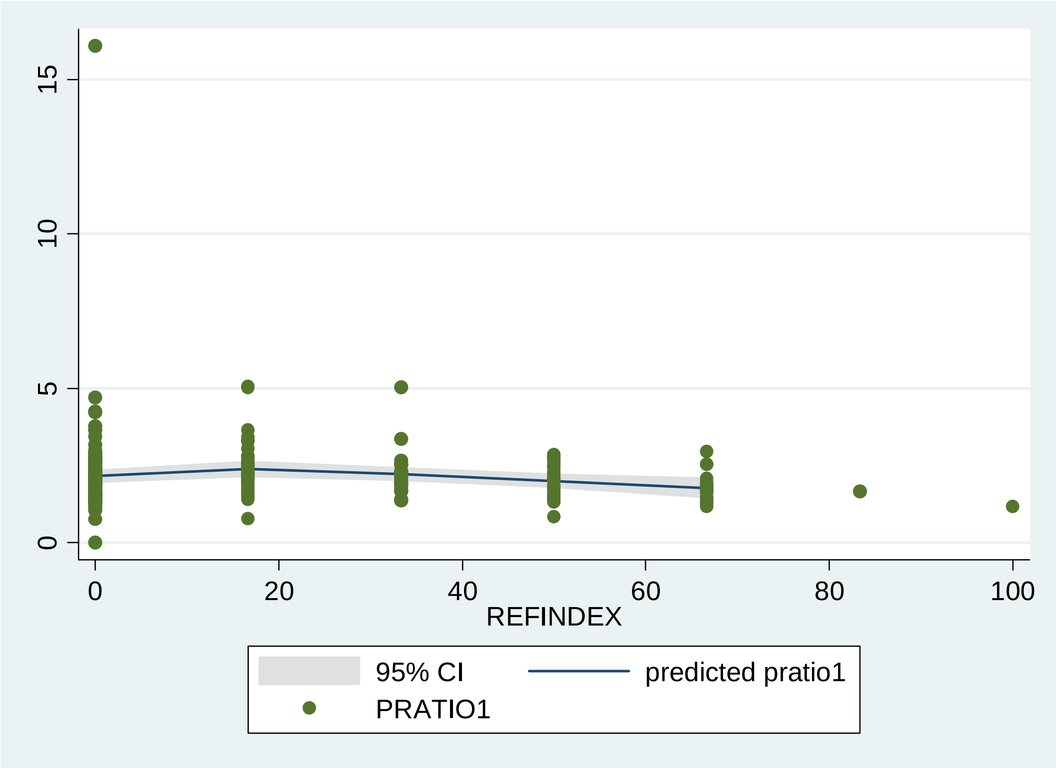
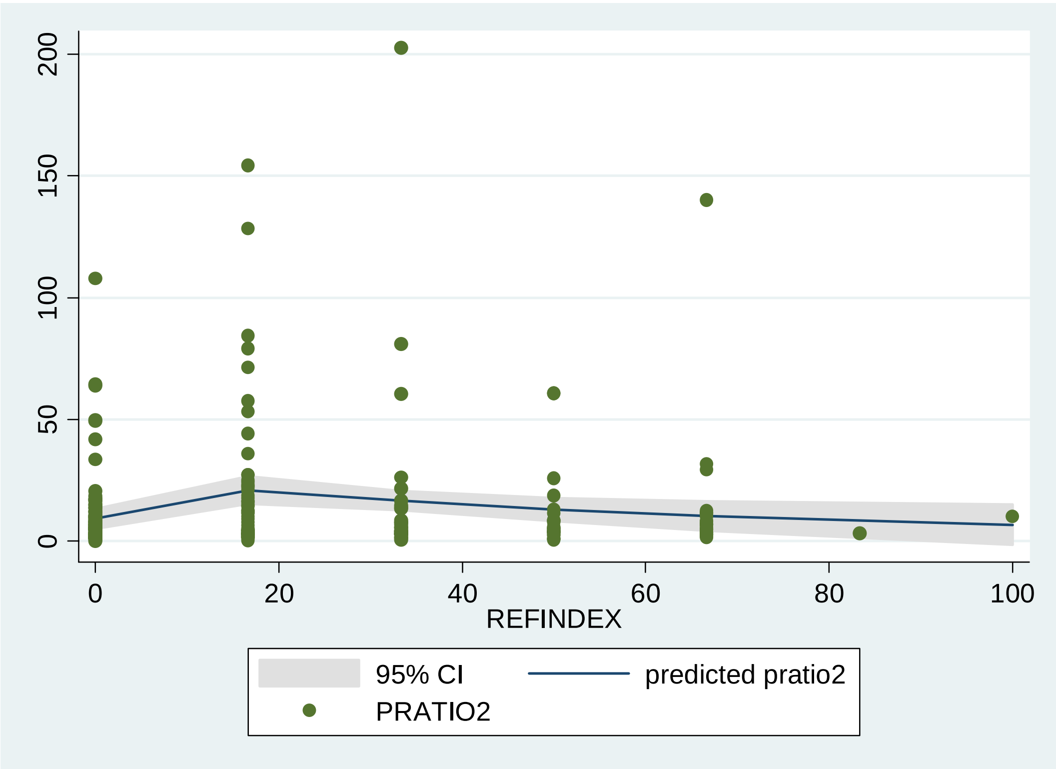


Figure 4.8: Fractional Polynomial Prediction Plot: Ratio of Industrial to Agricultural Price of Electricity versus Reform Index



However, changes in prices have knock-on effects within the electricity sector itself, in terms of its commercial and technical viability. The impact on PRATIO1 is not as great in magnitude and direction as the impact on PRATIO2. Nor is it seen to contain too many underlying influences; it is directly influenced via measures implemented through tariff orders. Changes in this ratio seem to have remained consistent over time. PRATIO2, on the other hand, is open to several underlying influences; however, measures such as open access to the grid and distribution privatisation may only influence this ratio in the presence of sufficient competition, as these measures could drive up the cross subsidy, if implemented in isolation. Thus, PRATIO2 is highly sensitive to reform measures.

4.6. The (Re) investment Impact of Reform

This hypothesis aims to establish whether deregulation has led to improvements in network quality, and supply to end consumers. It is assumed that efficiency improvements may have a visible high-end impact on parameters representing network quality. The dependent variable used is the percentage shortfall in meeting *total* energy (electricity) demand or PWDF; this is different from the *peak energy deficit*, to which the current crisis in the sector is attributed. Reductions in PWDF are associated with distinct economic benefits; it could have potential positive impacts on the management of the peak energy deficit, thereby impacting quality of service. The data used cover 17 states and 14 years (1991-2004). A dynamic specification is used. The model used is Bias-Corrected Least Squares Dummy Variables (LSDVC) estimation, using all three options for initialising the bias correction. The equation representing the model specification is:

$$PWDF_{it} = \gamma L.PWDF_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it} \text{ ----------------- (8)}$$

$X_{it}\beta$ represents a vector of coefficients and independent variables; these include the six reform indicators, and control variables. The price ratios are included amongst the latter as price is administered through direct measures (tariff orders) and can also be considered an influence on reform. The main assumption of the LSDVC model is exogeneity of the regressors. The reform indicators (dummy variables) used here all conform to this; the price ratios represent changes in the underlying growth rate of variables, rather than the variable itself, and hence can be considered exogenous to the other regressors. The results from the estimations are presented in Table 4.8.

The data available for exploring this hypothesis with PWDF is extremely limited; as a result, although the coefficients are computed for all variables, standard errors are not computable for around half of the independent variables. These have most likely been lost in the transformation process, due to insufficient information, or too many gaps[45] in the dataset. Significant variables here are UNB and TAR, which show negative coefficients across all estimations, implying that these measures contribute to mitigating the energy shortages in states. UNB leads to the operational and management separation of generation, transmission, and distribution; this leads to the adoption of better corporate practices and oversight on technical parameters, as opposed to those in a state-owned monolith. Distribution entities are also assigned specific regions for service. Hence, logically speaking this would contribute to better load management, overall, and impact on the energy availability in a state. TAR leads to the passing of tariff orders aimed at rationalising prices of electricity amongst the different consumer segment. Prior to the passing of tariff orders, most states have had highly distorted pricing, involving large cross subsidies, and in some cases, free electricity to farmers.

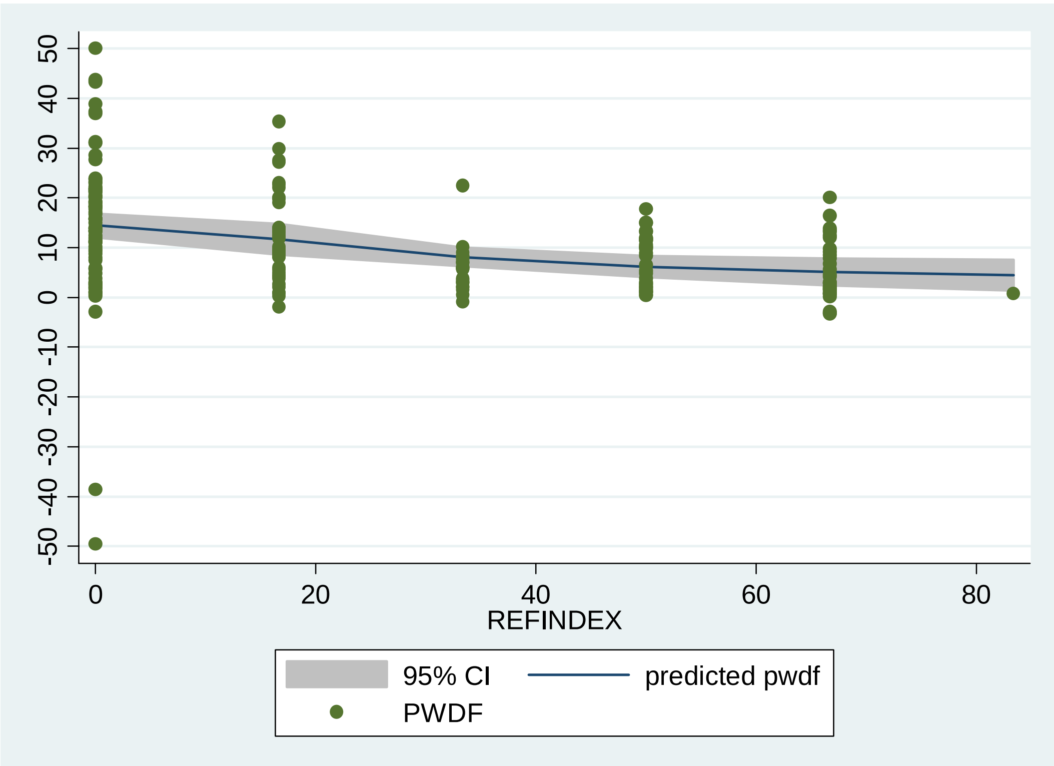
[45] STATA drops records with missing variables.

Table 4.8: The Reinvestment Impacts of Deregulation: Total Energy Deficit Estimation using Bias-Corrected LSDV Models; Dependent Variable: Energy Deficit (%)

	Model One Anderson-Hsiao PWDF	Model Two Arellano-Bond PWDF	Model Three Blundell-Bond PWDF
L.PWDF	-0.121	-0.133	-0.0744
	(0.241)	(0.227)	(0.226)
IPPS	-1.466	-1.494	-1.475
	(15.33)	(15.55)	(13.58)
REG	-4.667	-4.660	-4.545
	(9.619)	(9.745)	(8.556)
UNB	-2.368***	-2.395***	-2.221***
	(0.163)	(0.167)	(0.152)
TAR	-2.282***	-2.276***	-2.148***
	(0.00296)	(0.00291)	(0.00240)
OPREG	1.234	1.209	1.267
	.	.	.
DPVT	-10.78	-10.75	-10.58
	.	.	.
PRATIO1	-2.686	-2.652	-2.791
	.	.	.
PRATIO2	-0.00192	-0.00218	-0.000911
	.	.	.
PCGDP	-0.000606	-0.000616	-0.000617
	.	.	.
N	161	161	161

Standard errors in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 4.9: Fractional Polynomial Prediction Plot: Total Energy Deficit versus Reform Index[46]



[46] Examination of the graph shows that some data points indicate that the amount of unserved energy is negative. This could be attributed to a data anomaly. Future work could take this into account through the implementation

TAR would put a marginal value on electricity, thus curbing wastage, as the consumption patterns of the agricultural sector would adapt accordingly. Figure 4.9 depicts the fractional polynomial prediction plot of the relationship between PWDF and the reform index[47]. These show a decline in the total percentage energy shortage as one moves up along the index. Some limited conclusions can be drawn from this hypothesis. Electricity reforms appear to have a strong impact on mitigating the total energy deficit in states; however, this result must be interpreted in light of the fact that there is a chronic energy shortage across all Indian states, and thus the real concern here is management of supply, which has thus far failed to keep up with rising demand. Addition to generation capacity is important for addressing this.

4.7 Impact of Reform on Industrial Consumption

Industrial consumption is indicative of the response of industry to reforms, and thus can be considered a proxy of increased production and also of investment in new or existing production facilities within states. Changes in industrial consumption are also reflective of the cumulative impact of reforms. This hypothesis is examined separately for two dependent variables; INDCON and INDCONPC. The data used cover 19 states and 16 years (1990-2006). The same technique is used, as in H3 and H4. The equation representing the model specification for the first regression takes the following form:

$$INDCON_{it} = \gamma L.INDCON_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it} \text{ ------------------- (9)}$$

$X_{it}\beta$ is a vector of coefficients and independent variables - these include the six reform indicators and control variables. The latter include PRATIO1, PRATIO2 and PCGDP. HYDRO1 is not used here, as again, its effect is embodied in the reform measures; moreover, a set of regressions were attempted using HYDRO1, but failed to yield results. The results from the LSDVC estimations are presented in Table 4.9. There was no second order autocorrelation in the Arellano-Bond or Blundell-Bond estimations. The Sargan test statistic showed that the models are 'not robust, but not weakened by too many instruments'.

L.INDCON shows a positive and significant coefficient. In practice, industry would tend to proliferate in states where it has a sizeable presence, due to an established business environment. Hence, past levels of industrial consumption, being an indicator of industry presence, would determine current levels. IPPS show a large, negative and significant coefficient across all estimations (at 10% for the AH estimation), implying that industrial consumption is adversely affected by IPPS. This is expected, as IPPs in India have historically had contractual problems with state governments that purchase and distribute their product; they often carry; all of the above have resulted in IPPs' electricity being sold at higher than economical rates to consumers. OPREG shows a large, positive and significant (at 10%) coefficient across all estimations, indicating a large increase in industrial consumption. Open access facilitates greater consumer choice for industrial users, and usually complements a liberal policy on captive generation, where industrialists can produce electricity with minimal bureaucratic procedure. This measure has, as expected, led to an increase in industrial consumption as it eases the operating environment for industry. Contrary to expected results, DPVT shows a negative, significant coefficient across all estimations, implying that it leads to reduced industrial consumption. In the Indian context, privatisation has taken place in Orissa and Delhi, of which the Orissa privatisation consisted of the sale of companies to private

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of regression techniques using a truncated dependent variable, where the latter cannot take on a value less than zero.

[47] Summing up across all the reform indicators, each state receives a total score out of six; the construction of the index is clearly explained in the section on Data and Variables.

players without any restructuring involved. Thus, the outcomes have been mixed. The Delhi privatisation was carried out on the basis of a competitive bid and mandatory annual loss reduction targets for the private operators, thus, it has been deemed a success relative to the Orissa experience. However, this success may be attributable to management reform as much as to ownership change, and the former has been achieved, to an extent, without privatisation, in other states (e.g. Andhra Pradesh). Thus, insufficient experience has been gained in India, to draw a conclusion from this result, in comparison to other measures of competition. PRATIO1 and PRATIO2 show negative and significant coefficients across all estimations, implying that industrial consumption varies inversely with the level of cross-subsidy from industry to other consumers. This is an expected result.

Table 4.9: The Investment/Consumption Impacts of Deregulation I: Total Industrial Consumption- Estimation using Bias-Corrected LSDV Models
Dependent Variable: Industrial Consumption (MKWh)

	Model One Anderson-Hsiao **INDCON**	**Model Two** Arellano-Bond **INDCON**	**Model Three** Blundell-Bond **INDCON**
L.INDCON	0.992***	0.988***	0.983***
	(0.0602)	(0.0439)	(0.0351)
IPPS	-308.6^{++}	-336.4*	-333.0*
	(165.8)	(157.6)	(157.0)
REG	-167.6	-164.5	-128.3
	(196.5)	(184.6)	(187.7)
UNB	49.65	53.92	95.65
	(237.0)	(227.8)	(224.9)
TAR	-104.3	-11.03	-77.07
	(205.7)	(200.0)	(198.7)
OPREG	603.7^{++}	663.3^{++}	570.5^{++}
	(414.1)	(392.5)	(389.1)
DPVT	-344.0***	-439.3***	-311.0***
	(52.52)	(49.80)	(48.76)
PRATIO1	-21.27***	-21.39***	-37.29***
	(2.965)	(2.925)	(2.863)
PRATIO2	-4.546***	-4.496***	-4.807***
	(0.0447)	(0.0424)	(0.0390)
PCGDP	0.0780	0.0739	0.0776
N	244	244	244

Standard errors in parentheses; $^{++}$ $p < 0.10$ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The equation representing the model specification for the second regression takes the following form, with INDCONPC as the dependent variable:

$$INDCONPC_{it} = \gamma L.INDCONPC_{it-1} + X_{it}\beta + \eta_i + \varepsilon_{it} \text{ -------------------------- (10)}$$

The results from all three LSDVC estimations are presented in Table 4.10. Test results conformed to the properties of the LSDVC estimators. L.INDCONPC shows a positive and significant coefficient for all estimations, implying that INDCONPC is dependent to an extent on past values of itself. Again, IPPS show a negative coefficient, significant at 10%, for all estimations. The same justification as in the case of INDCON, would apply here. TAR shows a significant (at 10%) coefficient for two out of three estimations, and is also negative, implying that it reduces industrial consumption. This is counterintuitive, as clearer rules on tariffs should ideally attract more consumers. A possible explanation might be found in whether the tariff orders are multi-year or annual. Field interviews conducted with industrial consumers in the process of research revealed that industries had a strong preference for multi-year tariff orders, as there was greater scope for long-term planning of production and associated costs, in this case. In conformity with the results for INDCON, OPREG shows a positive and significant coefficient across all estimations.

Table 4.10: The Investment/Consumption Impacts of Deregulation I: Industrial Consumption per Capita- Estimation using Bias-Corrected LSDV Models
Dependent Variable: Per Capita Industrial Consumption

	Model One	**Model Two**	**Model Three**
	Anderson-Hsiao	Arellano-Bond	Blundell-Bond
	INDCONPC	**INDCONPC**	**INDCONPC**
L.INDCONPC	0.920^{***}	1.047^{***}	1.027^{***}
	(0.0722)	(0.0354)	(0.0315)
IPPS	-8.564^{++}	-7.528^{++}	-6.858^{++}
	(5.542)	(4.258)	(4.416)
REG	1.371	-0.0974	0.572
	(6.198)	(4.882)	(5.166)
UNB	2.142	4.538	4.068
	(7.626)	(5.989)	(6.201)
TAR	-6.777	-8.530^{++}	-8.161^{++}
	(6.498)	(5.229)	(5.500)
OPREG	3.995	4.627	4.385
	(12.67)	(10.64)	(11.06)
DPVT	-7.176^{***}	2.375^{++}	-0.291
	(1.659)	(1.347)	(1.383)
PRATIO1	-1.213^{***}	-1.218^{***}	-1.374^{***}
	(0.0952)	(0.0756)	(0.0786)
PRATIO2	-0.0850^{***}	-0.0898^{***}	-0.0875^{***}
	(0.00141)	(0.00110)	(0.00108)
PCGDP	0.00350	0.00243	0.00221
N	244	244	244

Standard errors in parentheses; $^{++}$ $p < 0.10$ * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

DPVT shows mixed results; a negative significant coefficient for the Andersen-Hsiao estimation, and positive significant (at 10%) for the Arellano-Bond estimation, implying the possibility of an increase in per capita industrial consumption with distribution privatisation. This could refer to an improvement in the distribution of electricity consumption amongst existing industrial consumers in a state; state-owned companies traditionally charged higher prices for industrial consumers, thus possibly leading to lower consumption among certain sections of industrial consumers. DPVT enables the removal of cross-subsidies, and improves the spread of existing consumption within the industrial segment, facilitating greater access. PRATIO1 and PRATIO2 show negative and significant coefficients, showing that cross-subsidies discourage industrial consumption. Figures 4.10 and 4.11 depict fracpoly plots of the relationship between average electricity price and the reform index, and industrial electricity price and the reform index. INDCON shows a slowly rising trend with the implementation of successive reform measures, whereas INDCONPC does not appear to be affected to the same extent, by reforms. Figure 4.12 is interesting, as it depicts a possibly lower amount of per capita consumption for states at the upper end of the reform spectrum. This could make sense, especially if these ‘reformer’ states have implemented measures liberalising the production and distribution of electricity in ways that exclude grid-provided power and encourage the purchase and wheeling of electricity from captive consortia.

Figure 4.10: Fractional Polynomial Prediction Plot: Industrial Consumption of Electricity versus Reform Index

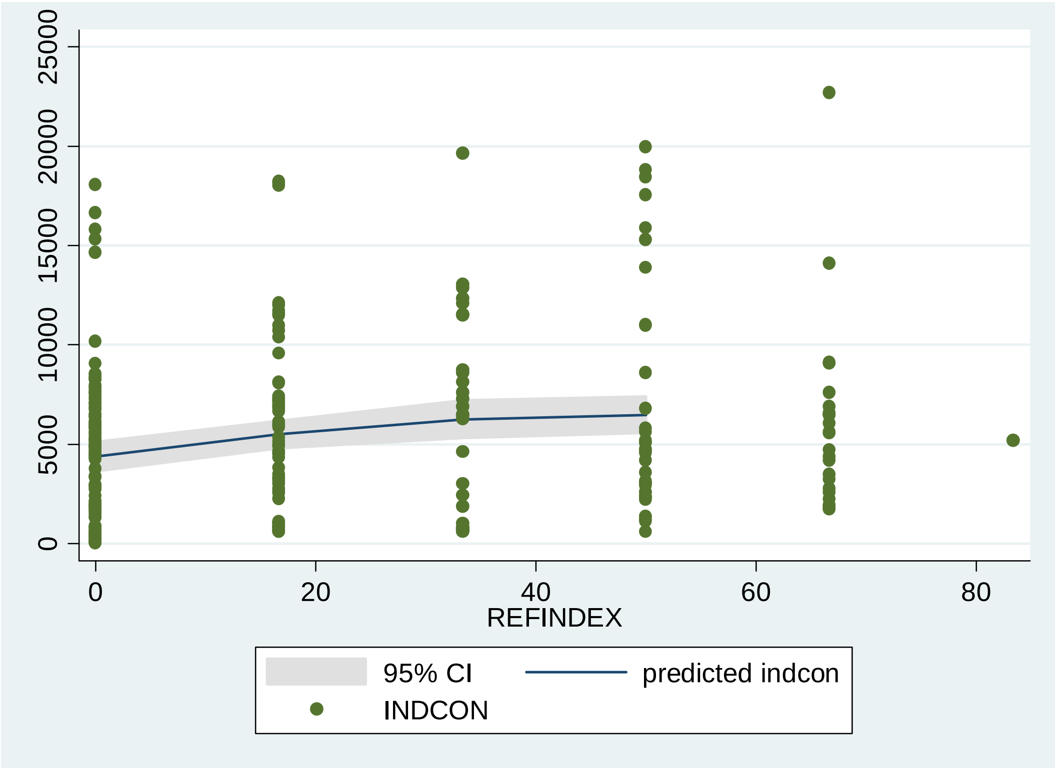
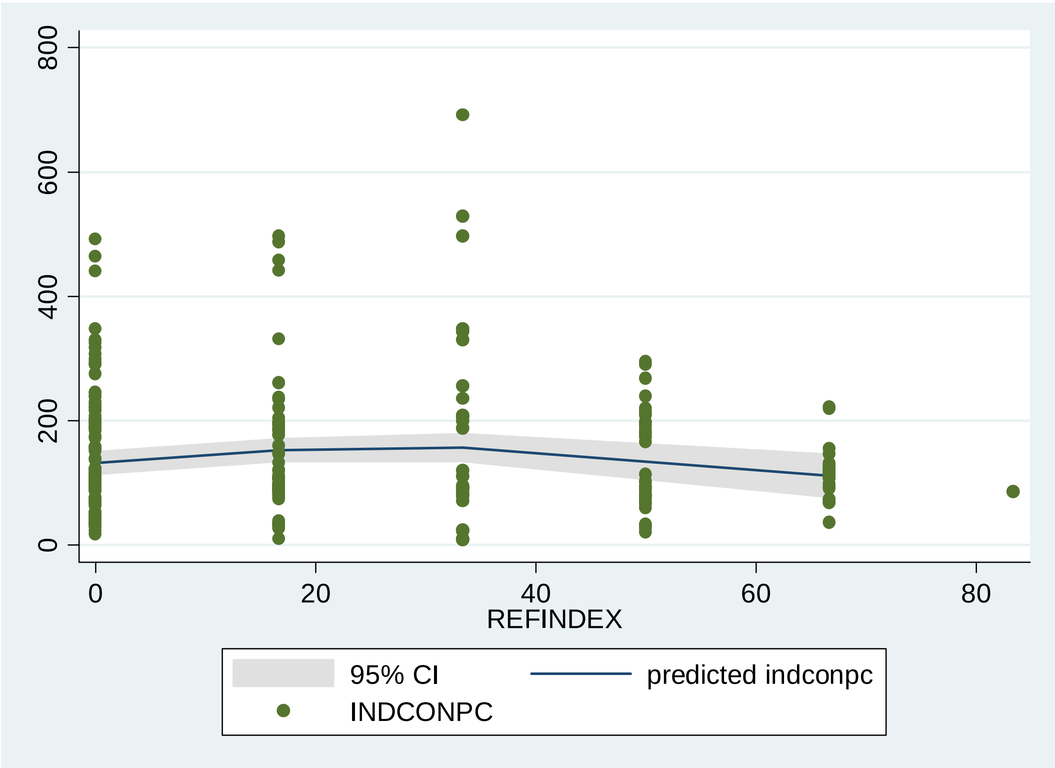


Figure 4.11: Fractional Polynomial Prediction Plot: Per Capita Industrial Consumption of Electricity versus Reform Index



5. Conclusion

The Indian experience is unique, as the impacts hypothesised are manifested through unconventional pathways, conditioned by the political economy of electricity reform. Moreover, expected impacts differ from those experienced in developed and developing countries, and vary with the extent of reform, as well as with each reform measure. The main results are summed up as follows; this analysis demonstrates that reformed electricity infrastructure has the potential for contributing substantially to output measured in absolute terms, alongside other infrastructure. Within electricity, of the efficiency indicators, improvements have occurred most visibly in the levels of transmission and distribution losses in reformer states. With respect to Plant Load Factor, there seems to be an immediate improvement with the implementation of unbundling and tariff rationalisation. However, measures that go beyond these, such as open access, and distribution privatisation, are seen to have a negative impact on PLF. This may not necessarily be indicative of low efficiency and could reflect a period of readjustment of the system, following restructuring; thus, 'efficiency' with respect to the conventional idea of PLF would require a redefinition in relation to the more advanced measures of reform. Gross generation as an indicator of efficiency, or rather, investment, shows increases with the implementation of the latter half of reform measures, but has to be interpreted in the context of demand, and of chronic electricity deficits that exist in almost every Indian state. The behaviour of prices conforms somewhat to the impacts proposed. Notably, price rises are not arrested and prices do not decrease until the implementation of the latter half of a reform. Moreover, per capita GDP of states tends to push up price levels; this is indicative of higher demand in these states.

An examination of states' individual histories reveals that political economy can reverse any impact brought about by a reform programme[48]. Although reform has succeeded in reducing and completely arresting price increases for industrial consumers in several states, the chronic shortage faced in Indian states since 2005 has nevertheless inflated prices once again. This has partly occurred due to profiteering activities by northeastern states that are rich in coal resources, which produce and trade electricity to deficit states at a very high premium, negating the benefits of reforms. Changes in pricing, or in the mechanism of cross-subsidies, have also occurred with the implementation of reforms. Overwhelmingly, it is the implementation of a regular policy on tariff rationalisation that has had the most direct impact. The introduction of measures oriented towards market-driven or indirect outcomes, have so far not been as effective as direct measures[49], suggesting that some corrections have to be forced into place before competitive factors come into play. With regards to sector reinvestment, establishment of an independent regulator, unbundling and tariff rationalisation may have had some positive impacts. This outcome must be interpreted in light of the fact that the federal government has parallel programmes operating to invest in distribution networks, and provides incentives for state governments to achieve certain preset targets. It was beyond the scope of this analysis to delve further into the untangling of these direct federal policy initiatives. Industrial consumption has shown a tendency to increase with the implementation of a complete reform. A fact that emerges here is that industries tend to prefer a connection to the state grid, when electricity from the grid is reliable and supplied at economical rates.

[48] For instance, free electricity to farmers before state legislative elections mandated by states such as Andhra Pradesh, ordinarily considered a leading reformer, goes against any economic interpretations.

[49] The introduction of Open Access seems to increase cross-subsidies in some cases, as seen in the econometric results. This is due to a high penalty for industries that choose to take advantage of this measure and leave the state grid, thus resulting in a loss of revenue for the grid-supplying utility.

This analysis has empirically demonstrated that reformed electricity infrastructure has the potential to contribute to economic output in absolute terms; following from this, electricity reforms are found to be associated with visible changes in key economic variables related to the electricity sector. The results of this empirical analysis indicate that once begun, if left half-way, this impact could quickly turn negative. Substantial changes in economic variables begin to occur only once a *baseline level* of reform has been undertaken; in the *Reform Index* used in this analysis, this would pertain to the measures undertaken beyond 3 (out of 6), or beyond *structural* reform measures.

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APPENDIX I: Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max	P25	P50	P75	IQR
INDGDP1	288	130964.00	118124.80	7005.75	624921.50	41960.02	93259.70	184624.30	142664.30
INDPC	152	3834.868	2903.11	244.00	15418.00	1568.00	3384.50	5057.50	3489.50
ELEC	284	279998.80	215633.90	7256.00	1005599.00	83161.50	190417.50	475596.00	392434.50
RDS1	266	2216.50	1416.45	72.00	6438.00	988.00	2168.00	2976.00	1988.00
RAIL	266	3481.30	2681.42	69.00	8944.00	1050.00	2981.00	5312.00	4262.00
TEL	160	16.82	11.57	-24.98	42.14	8.23	19.79	25.13	16.90
INTER1	229	1.38E+09	1.38E+09	500664.00	5.23E+09	1.97E+08	9.42E+08	2.47E+09	2.27E+09
INTER2	265	8.17E+08	8.86E+08	1724175.00	4.13E+09	1.27E+08	4.31E+08	1.37E+09	1.24E+09
IPPS	304	0.42	0.49	0	1	0	0	1	1
REG	304	0.38	0.49	0	1	0	0	1	1
UNB	304	0.19	0.39	0	1	0	0	0	0
TAR	322	0.31	0.46	0	1	0	0	1	1
OPREG	304	0.07	0.25	0	1	0	0	0	0
DPVT	304	0.05	0.22	0	1	0	0	0	0
REFINDEX	304	23.58	26.91	0.00	100.00	0.00	16.67	50.00	50.00
PRATIO1	266	2.18	1.09	0.00	16.09	1.69	2.07	2.45	0.76
PRATIO2	256	13.61	24.15	0.00	202.50	3.48	6.00	12.30	8.82
POPN	290	4.82E+07	3.66E+07	1163800.00	1.79E+08	2.09E+07	4.53E+07	6.84E+07	4.75E+07
PLF	266	48.20	26.99	0.00	90.60	24.84	53.95	69.10	44.26
TDL	270	28.30	10.33	11.01	57.09	19.81	25.32	35.08	15.27
GRGEN	290	48.15	36.64	1.16	178.83	20.90	45.30	68.43	47.53
INPRICE	282	1.95	0.65	0.00	3.71	1.54	2.02	2.43	0.89
PRICE	340	1.28	0.32	0.69	2.44	1.06	1.27	1.45	0.39
INDCON	255	5832.90	4426.08	512.26	22680.34	2436.65	5101.05	7392.26	4955.61
INDCONPC	255	125.72	72.91	8.84	347.70	80.26	104.97	179.51	99.25
PWDF	203	10.31	11.03	-49.6	50.00	2.90	9.00	15.80	12.90
HYDRO1	270	39.19	30.82	0.00	100.00	9.14	38.75	58.02	48.88

Variable	N	Mean	Std. Dev.	Min	Max	P25	P50	P75	IQR
PCGDP	290	10995.50	5196.22	2470.00	34205.00	7591.13	9646.00	13620.00	6028.87
CSINDEX	238	9.00	4.91	1	17	5.00	9.00	13	8
TSINDEX	238	7.50	4.04	1	14	4.00	7.50	11	7
STATEID	412	10.57	5.80	1	20	6.00	11.00	16.00	10.00

Appendix II: Test Results

Test Results for H1.1 (Industrial GDP)

TEST	Ho	RESULT H1.1 (Interaction)	RESULT H1.1 (No Interaction)
Likelihood-Ratio Test for Heteroscedasticity	Assumption: Nested in Hetero	LR chi2 (17) = 373.68	LR chi2 (17) = 372.83
		Prob>chi2 = 0.000	Prob>chi2 = 0.000
Wooldridge Test for Autocorrelation in Panel Data	No 1st order autocorrelation	Prob = 0.0066	Prob = 0.0041
		F (1,17) = 9.571	F (1,17) = 10.988
Durbin-Watson		1.2692579	1.2635494
Baltagi-Wu LBI		1.6165918	1.6143799

Test Results for H1.2 (Industrial GDP Per Capita)

TEST	Ho	RESULT (Interaction)	RESULT (No Interaction)
Likelihood-Ratio Test for Heteroscedasticity	Assumption: Nested in Hetero	LR chi2 (17) = 81.70	LR chi2 (17) = 69.98
		Prob>chi2 = 0.000	Prob>chi2 = 0.000
Wooldridge Test for Autocorrelation in Panel Data	No 1st order autocorrelation	Prob = 0.0423	Prob = 0.0355
		F (1,17) =5.826	F (1,17) = 6.383
Durbin-Watson		1.2028159	1.1257152
Baltagi-Wu LBI		1.4802919	1.4198106

Test Results for H3 (Prices)

Estimator	Test	Ho	Result H3.1	Result H3.2
Arellano Bond	1st order autocorrelation	No autocorrelation	z = -7.49 Prob>z = 0.000	z = -8.82 Prob>z = 0.000
	2nd order autocorrelation	No autocorrelation	z = 0.13 Prob>z = 0.8948	z = 1.91 Prob>z = 0.0557
	Sargan Test of Overid. Restrictions		chi2(52)=200.27 Prob>chi2=0.0053	chi2(90)=113.82 Prob>chi2=0.0457
Blundell Bond	AB Test for AR (1) in First Differences	No autocorrelation	z = -5.06 Prob>z = 0.000	z = -5.40 Prob>z = 0.000
	AB Test for AR (2) in First Differences	No autocorrelation	z = -0.04 Prob>z = 0.969	z = 2.31 Prob>z = 0.021
	Sargan Test of Overid. Restrictions		chi2(168)=220.63 Prob>chi2=0.004	chi2(103)=131.20 Prob>chi2=0.032

Test Results for H4 (Pricing)

Estimator	Test	Ho	Result H4.1	Result H4.2
Arellano Bond	1st order autocorrelation	No autocorrelation	z = -0.46 Prob>z = 0.6473	z = -9.97 Prob>z = 0.000
	2nd order autocorrelation	No autocorrelation	z = -0.40 Prob>z = 0.6899	z = 2.34 Prob>z = 0.0192

(H4 contd.)	Sargan Test of Overid. Restrictions		chi2(52)= 50.47 Prob>chi2= 0.9998	chi2(52)= 173.33 Prob>chi2= 0.000
Blundell Bond	AB Test for AR (1) in First Differences	No autocorrelation	z = -1.34 Prob>z = 0.181	chi2(168)=170.42 Prob>chi2=0.000
	AB Test for AR (2) in First Differences	No autocorrelation	z = -0.06 Prob>z = 0.952	
	Sargan Test of Overid. Restrictions		chi2(168)=116.90 Prob>chi2=0.165	

Test Results for H5 (Reinvestment)

Estimator	Test	Ho	Result
Arellano Bond	1st order autocorrelation	No autocorrelation	z = -1.61 Prob>z = 0.1063
	2nd order autocorrelation	No autocorrelation	z = -0.00 Prob>z = 0.9964
	Sargan Test of Overid. Restrictions		chi2(52)= 73.35 Prob>chi2= 0.0843
Blundell Bond	AB Test for AR (1) in First Differences	No autocorrelation	z = -3.77 Prob>z = 0.000
	AB Test for AR (2) in First Differences	No autocorrelation	z = -0.45 Prob>z = 0.655
	Sargan Test of Overid. Restrictions		chi2(168)=121.49 Prob>chi2=0.000

Test Results for H6 (Industrial Consumption)

Estimator	Test	Ho	Result (INDCON)	Result (INDCONPC)
Arellano Bond	1st order autocorrelation	No autocorrelation	z = -5.32 Prob>z = 0.000	z = -5.69 Prob>z = 0.000
	2nd order autocorrelation	No autocorrelation	z = -0.55 Prob>z = 0.5837	z = 0.70 Prob>z = 0.4845
	Sargan Test of Overid. Restrictions		chi2(52)= 186.12 Prob>chi2= 0.000	chi2(52)= 181.30 Prob>chi2= 0.000
Blundell Bond	AB Test for AR (1) in First Differences	No autocorrelation	z = -5.63 Prob>z = 0.000	z = -6.14 Prob>z = 0.000
	AB Test for AR (2) in First Differences	No autocorrelation	z = -0.75 Prob>z = 0.455	z = 0.69 Prob>z = 0.491
	Sargan Test of Overid. Restrictions		chi2(168)=211.02 Prob>chi2=0.000	chi2(168)=219.77 Prob>chi2=0.000

Appendix III: Status of Reform across Indian States

	STATE	IPPS	REG	UNB	TAR	OPREG	DPVT	TOT
1	Andhra Pradesh	1	1	1	1	1	0	**5**
2	Arunachal Pradesh	0	0	0	0	0	0	**0**
3	Assam	1	1	1	1	1	0	**5**
4	Bihar	1	1	0	0	0	0	**2**
5	Chattisgarh	1	1	0	1	1	0	**4**
6	Delhi	1	1	1	1	1	1	**6**
7	Goa	1	1	0	0	0	0	**2**
8	Gujarat	1	1	1	1	1	0	**5**
9	Haryana	1	1	1	1	1	0	**5**
10	Himachal Pradesh	1	1	0	1	1	0	**4**
11	Jammu & Kashmir	0	1	0	0	0	0	**1**
12	Jharkhand	1	1	0	1	1	0	**4**
13	Karnataka	1	1	1	1	1	0	**5**
14	Kerala	1	1	0	1	1	0	**4**
15	Madhya Pradesh	1	1	1	1	1	0	**5**
16	Maharashtra	1	1	1	1	1	0	**5**
17	Manipur	0	1	0	0	0	0	**1**
18	Meghalaya	0	1	0	0	0	0	**1**
19	Mizoram	0	1	0	0	0	0	**1**
20	Nagaland	0	0	0	0	0	0	**0**
21	Orissa	1	1	1	1	1	1	**6**
22	Punjab	0	1	0	1	1	0	**3**
23	Rajasthan	1	1	1	1	1	0	**5**
24	Sikkim	0	1	0	0	0	0	**1**
25	Tamil Nadu	1	1	0	1	1	0	**4**
26	Tripura	0	1	0	1	0	0	**2**
27	Uttar Pradesh	0	1	1	1	1	0	**4**
28	Uttaranchal	1	1	1	1	1	0	**5**
29	West Bengal	0	1	0	1	1	0	**3**
	TOT	**18**	**27**	**12**	**20**	**19**	**2**	

Note: This is the latest available data from the Ministry of Power, Government of India, dated 12/2007; it thus represents the time series used in the econometric analysis.