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

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ABSTRACT

As developing countries seek to improve their economic prospects, electricity deregulation 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.

Overview

This paper presents an econometric assessment of the performance of electricity sector reforms, applicable to developing economies with federal structures, using the case of Indian states. 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, unbundling, tariff (price) corrections or rationalisation, open (third party) access to distribution networks, and privatisation of competitive functions, conducted in sequence. The first three measures can be seen a *structural* in nature, and the last three, as *competitive.* The most distinctive aspect of electricity deregulation in India, also commonly encountered in other developing economies, has been the struggle to achieve a framework that removes the sector from political influence. Decades of electricity provision by state-owned enterprises led to 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 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 the development of these economic distortions in electricity provision brought about by the political economy of the sector (Victor & Heller, 2007; Chattopadhyay, 2004; Dossani, 2004, Dubash & Rajan, 2002; Tongia, 2003; Kalirajan et al, 1998). Despite the wastages created, this policy continued, for a long time, to be sustained through cross-subsidies from industry[1]. 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 reform in 1991.

The paper begins by identifying a gap in existing empirical work on the outcomes of electricity deregulation, wherein although the existing literature 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). It is observed from existing literature that a commonly-observed set of impacts of electricity reform on

[1] Industry was charged higher prices in efforts to make up for the losses suffered through subsidising farmers.

key variables affected at the macro level have emerged; sector efficiency, electricity prices, and forms of investment (investment within the electricity sector and new investment flows). The analysis proceeds to undertake the investigation of these economic outcomes for the case of Indian states following an approach by Jamasb et al (2004), wherein a set of hypotheses relating to each expected impact is outlined. An appropriate set of indicators representing cause (a set of six reform measures and relevant control variables) and effect (impacts relating to efficiency, prices and investment) was developed for the analysis, and a panel dataset was subsequently constructed for 19 states spanning the reform period, 1991-2007. Dynamic panel data estimators were then applied to test for the occurrence of the hypothesised impacts. Results indicated that the hypothesised outcomes have occurred, but in a counterintuitive manner. They have tended to be negative in the initial stages of reform, which encompass measures of *structural* reform, due to the revelation of previously hidden distortions, conditioned by the political economy of the sector. These outcomes were then seen to stabilise and in some cases, improve, once deregulation had been implemented through to the measures representing *competitive* reform. The paper identifies the stage at which outcomes tend to improve as the 'baseline' level. The findings hold substantial policy and methodological relevance in terms of broader applicability and research into achieving the baseline level.

Empirical Methodology

A set of hypotheses were constructed, each addressing a potential economic outcome of deregulation, based on existing empirical work[2].

H1. Indian states more advanced in reform are more likely to have experienced improvements in technical and operating efficiency, in electricity provision.

Reforms involve restructuring and unbundling, which precede a change in management, and 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. Studies show that efficiency improvements tend to be passed on, either directly to consumers, through price reductions or dividend payouts[3], or indirectly, through system reinvestment Three interrelated dependent variables were used to represent technical efficiency. These are Plant Load Factor or PLF (%), gross generation (Million Kilowatt Hours) and transmission and distribution losses (%). The independent variables used included six reform indicators (measurable both separately, and collectively as an Index); these were adapted from cross-country studies by Bacon (1999) and Bacon and Besant-Jones (2001). Two further independent variables were constructed; the ratio of industrial to domestic price of electricity (a commonly used indicator in developed economies) and more particularly, of industrial to agricultural price of electricity, to represent cross-subsidisation from industry to other consumers, as in India, it is not residential (domestic) consumer prices that influence industrial price levels, as much as agricultural prices. Among control variables, the percentage of hydro capacity is used to represent natural resource advantages. Finally, state GDP per capita is used to control for effects relating to the state economy.

H2. Electricity reform has had a substantive impact on electricity prices for the end-consumer.

We first examined 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 a sub-hypothesis, we untangled further, the impacts on average prices for *industrial* consumers. In general, reforms aim at correcting price distortions. This would imply a reduction in excessive rates for industrial users, and an increase in prices for subsidised consumers. The dependent variables used were average price of electricity per unit and, average price of electricity per unit for the industrial consumer[4], both

[2] A list of references is provided in this abstract.

[3] This signifies a form of return to consumers invested in public electricity companies, as is the case in India.

[4] These are averaged across two categories of industrial consumers; High Tension (large industry) and Medium/Low Tension (medium/small industry).

measured in Rupees per Kilowatt Hour and adjusted for inflation (1993-94 prices). Independent and control variables included the six reform measures, and relevant controls.

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. It provides insight into the impact on prices in the previous hypothesis, in terms of potential causality[5]. We first looked at subsidies from the industrial to the domestic consumer segment using the ratio of industrial to domestic price. Although these subsidies are a common characteristic of developed countries' electricity sectors, in India, the predominant relationship lies between industry and agriculture. We thus then examined the issue of cross-subsidisation using the ratio of industrial to *agricultural* prices in a sub-hypothesis. Independent variables in both cases included the reform indicators, and controls.

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

This hypothesis may be read with H2, which looked at efficiency. 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; Pollitt, 2004). The independent variables included the reform indicators, industrial to agricultural price ratio as indicative of the extent of cross-subsidisation (reductions in this would reflect competitive pricing)[6], 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 were 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 was the energy shortage (%). Data availability on network quality is limited, as accurate records have often not been maintained by utilities. For instance, the peak 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 wetime. Two indicators of industrial consumption were used in separate regressions; namely, total industrial consumption and per capita industrial consumption. The first was indicative of absolute changes in industrial consumption, and the second of the distribution of these; that is, whether the response was even across all industrial consumers, or whether consumption from specific segments of industry went up disproportionately relative to others. The same independent variables were used in both regressions; the reform measures, price ratios, and per capita GDP for economy effects (representing the contribution of the economic environment to consumption).

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[7] are not included in this analysis. The states included account for over 85% of the population[8]. Annual

[5] The factors causing price changes, which *per se* are outcomes of reforms.

[6] Reductions in cross subsidies would in themselves lead to the release of previously constrained capital, thus improving efficiency.

[7] We have included the National Capital Territory of Delhi as a state.

[8] Based on 2004-05 population figures.

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.

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[9]. As, the cross-sections in this dataset represent Indian states, which are autonomous systems, these differences could 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, we use fixed effects estimators. The model specification is: $Y_{it} = \alpha_i + \beta X_{it} + \eta_i + \varepsilon_{it}$, which represents a *static* model. 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 Least Squares Dummy Variables (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[10] for panels of all sizes. A version of the bias-corrected LSDV estimator (LSDVC) for unbalanced panels was developed by Bruno (2005). The choice of consistent estimators used to initialise the bias approximations lies between the Anderson-Hsiao, Arellano-Bond and Blundell-Bond estimators. We thus chose to use LSDVC models for those hypotheses that involve dynamic relationships. An exception to the general model specification has been made for the efficiency hypothesis, where the equation is specified in a multivariate form, which conditions the choice of technique, namely a Three Stage Least Squares (3SLS) estimator. The motivation for this specification is twofold. First, it 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 are later confirmed through econometric and statistical observation.

Results

The results showed that 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; of the efficiency indicators, improvements have occurred most visibly in the

[9] Kennedy (2008) provides a detailed exposition of panel data techniques and the choice of fixed versus random effects estimators in applied econometric research.
[10] Root Mean Square Error

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 price (tariff) corrections. However, measures that go beyond these, such as third party 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 programme. 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[11]. 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 price corrections 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[12], 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. 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.

Summary and Conclusion

This analysis empirically demonstrates 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 *Index* of reform used in this analysis, this would pertain to the measures undertaken beyond three (out of six), or beyond *structural* reform measures. These results and methodology might be extendable to other developing economies with similar federal structures.

Key References

[11] 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.

[12] 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.

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