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DOES REGULATION PROMOTE SUSTAINABLE DEVELOPMENT OUTCOMES? EMPIRICAL EVIDENCE FROM THE INDIAN ELECTRICITY SECTOR

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Abstract

There was an expectation that the independent regulatory institutions that India created for its electricity sector would drive the sector along a sustainable trajectory. However, there has been a dearth of empirical studies analyzing the effect of electricity sector regulation on sustainable sector outcomes. The paper in this context empirically examines whether electricity sector regulation influences the sectoral outcomes at the state level. For analytical purposes, the present study considers a sample of 12 Indian states (provinces). While it captures electricity sector regulation by constructing a composite index that it connotes as a "regulatory index," it applies a sustainable development framework that it operationalizes through an indicator-based approach to measure the sectoral outcomes. Finally, it employs the panel data estimation technique with a fixed-effect model to establish the relationship between regulation and sectoral outcomes. The results suggest that, while regulation is a crucial determinant of sectoral outcomes in the economic and environmental dimensions, social sector outcomes experience a negative impact. These results have clear policy implications for larger overarching policy questions of energy security and the sustainable development of the sector.

Keywords: regulation, Indian electricity sector, sustainable development outcomes

JEL Classification: K20, K32, L38, L51, L94

Contents

1. INTRODUCTION

More than two decades of power sector reforms in India appear to have metamorphosed the sector in many ways. While some major aspects of the sectoral growth have experienced commendable progress, some crucial aspects of the sector's operation continue to show poor performance. The generation capacity reached a new high of 356,817 MW by May 2019 (Government of India 2019) from a meager 1,361 MW in 1947. The private generation capacity rose to an unprecedented peak of 165,144 MW in 2019, constituting around 46% of the total installed capacity. A variety of competitive market forms of transactions are increasingly replacing the regulated regime. The trading of power in the short-term market has thrived with the setting up of power exchanges. Power procurement and the discovery of power prices increasingly occur through competitive bidding mechanisms. There has been visible progress on the renewable energy development in the country in the recent past, with specific policy thrusts on solar and wind energy. The renewable installed capacity now constitutes nearly 22% of the total installed capacity. The progress largely manifests in terms of a dramatic fall in renewable energy costs through new modes of power procurement, such as competitive bidding, and the ramping up of grid interactive renewable capacities. The government has unveiled new programs to correct the existing market- and policy-level distortions in the sector. It envisages that recent schemes, such as Ujwal DISCOM Assurance Yojana (UDAY) and Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY), will overhaul the distribution segment with some success. The government has also amended the tariff policy to reflect the changed realities of the sector and to capture the true cost of the supply.

At the same time, there are pockets that require strategic policy interventions and focused policy actions, as they continue to reflect the dismal state of malfunctioning and reveal serious, deeply entrenched infirmities in the sector's operation and functioning. The distribution segment of the industry is experiencing huge financial pressure, with the debt amount reaching 4.3 lakh crores, largely due to problems with delayed payments, issues around tariff rationalization, and political economy constraints emanating from subsidy disbursement. The policy efforts in this sphere to restructure the debt of distribution companies known as DISCOMs through the UDAY scheme do not appear to be producing the desired outcomes. Though there were early signs of recovery, lately, it has become apparent that deep-seated malaise exists and that the solutions offered through schemes like UDAY are temporary and ad hoc in nature and cannot address the problems in their entirety. The sector continues to suffer from problems of poor quality of power and reliability of the supply (Harish et al. 2014). The provisioning of six hours of power supply has become the norm rather than the exception in rural areas of the country. A recent survey has succinctly highlighted that more than 50% of households in the country receive less than 12 hours of electricity in a day (Government of India 2019). Moreover, scholars have questioned the sustainability of the existing energy systems in the current regime, characterized by a rising power demand coupled with an increasing population in a fast-growing economy (Luthra, Mangala, and Kharb 2015). The poor per capita electricity consumption in the country, which stands at a meagre 1,149 kWh—one-third of the global average, somewhat reflects this. Geopolitical constraints further add to the woes. International sanctions leading to the skyrocketing of energy import bills impose additional challenges. Literature pointed to the fact that oil price shocks could affect the country's GDP as well (Taghizadeh-Hesary et al. 2019a, 2019b). The latest statistics suggest that the oil import bills have increased by 27% from $88 billion in 2017–18 to $112 billion in 2018–19. In addition, climate-related threats are likely to intensify further

in the future and have the potential to accentuate the challenges of the sector. Given the intricate relationship between energy and climate change, decoupling energy from climate change adds another layer of complexity to the sector's functioning and management.

It is necessary to contextualize all of the above developments in the historical foundations of the power sector development. The electricity policy making in the country has had a checkered history. There have been several patchy and sporadic efforts in the past to correct the prevailing distortions. However, none of them were able to generate the much-needed change. Finally, all these led to the drafting of comprehensive reform action plans through the enactment of the Electricity Act 2003. The Act had three major provisions: the crafting of independent regulatory entities as watchdogs of the sector, the unbundling of the sector into generation, transmission, and distribution segments, and, most importantly, the infusion of competition into all the segments of industry functioning by introducing a variety of instruments and apparatus. The idea of creating new regulatory entities at both the federal and the provincial scale entailed the premise that the regulator would play a balancing role by protecting the interests of the electricity consumers as well as safeguarding private investors' interest by creating an apolitical sphere to decide techno-economic matters (Dubash 2007). The government created these entities as independent quasi-judicial bodies with a considerable amount of apparatus to decide on tariffs, licensing matters, and the promotion of competition and, moreover, to ensure balanced and inclusive growth. It expected that the regulators would drive the sector along a sustainable development trajectory and enable it to meet the larger overarching goals of economic growth and development. As 20 years have now elapsed since the pronouncement of the Electricity Regulatory Commissions (ERC) Act 1998, the time has come to ask the question of whether the electricity regulatory bodies that the government created as new institutional mechanisms to drive the sector have lived up to their expectations and contributed to the sustainable development of the sector.

This paper attempts to examine this timely question empirically. This question becomes more pertinent and pronounced in the present context given the thrust on sectoral integration and the need to ensure energy security in a mission mode. The question of achieving energy security has taken pride of place in the energy policy making in India, as the country strives to be independent in meeting its future energy requirements. For instance, the proposed e-mobility plan of the Government of India aims to capitalize on its current focus on clean energy revolutions and simultaneously to reduce India's ever-increasing oil import bill. However, there have been clear gaps in understanding and analyzing the placement of the electricity sector regulators in the country as key entities to drive the sector and achieve the larger overarching goals of energy security.

The structure of the paper, against this background, is as follows. Section 2 briefly offers the historical foundation of electricity reform in India. Section 3 critically reviews the existing literature analyzing the impact of regulation on electricity sector outcomes and identifies the key gaps in the Indian context. The fourth section offers a detailed description of the data, the methodological approach adopted, and the analytical tools that the study employs. Section 5 details the key results and discusses them in the Indian context. Section 6 discusses the role of the regulator in driving the sustainable development outcomes and energy security. The final section concludes the paper.

2. HISTORY OF ELECTRICITY REFORM IN INDIA

Tracing the history of the Indian electricity sector reveals that it primarily operated as a publicly owned vertically integrated monopolistic structure for the major part of the 20th century. The sector also manifested the philosophy of the state-led economic growth of India during the Nehruvian growth policy era of post-independence India (Dubash and Rajan 2003). In the case of the electricity sector, the responsibility for development rests with both the central government and the state governments, as the constitution of India defines the sector as a "concurrent subject." This wisdom and thinking that the electricity sector is a prime vehicle of growth also resonated in the 1948 electricity legislation, which laid primacy in its public ownership (Kale 2004; Kumar and Chatterjee 2012). However, over the years, the state-owned integrated utility management system has proven to be unsustainable (Reddy 2002; Bhattacharyya 2005). The state ownership management system, which state electricity boards (SEBs), as the key state-level agency for sectoral development and management, primarily managed and operated has become the subject of a subversive political agenda and political malfeasance. In many cases, the state governments' excessive interference resulted in poor financial performance of these bodies. Laxity in the financial management of their resources coupled with soft budget constraints posed serious financial threats with irreversible damage to these entities. All these opposed the stated goals of assigning primacy to these bodies as the "be all and end all" of the sectoral operation and management. The dismal state of sectoral functioning manifested in many ways, such as the inadequate annual capacity additions, increasing frequency of blackouts and brownouts, poor and unreliable quality of the power supply, and poor provisioning of the rural electricity supply.

The need for reform became apparent early, around the late 1980s. However, the first effective attempt to reform the sector occurred in the early 1990s with a specific thrust on privatizing the sector. The emphasis was on introducing piecewise reform by focusing on privatizing the generation segment by creating legislative provisions for "independent power producers (IPPs)." As a response to the initial reform efforts, there was euphoria among private investors. However, this enthusiasm did not last long due to obstructive policy provisions and policy-level incoherence and inconsistencies. A lack of clarity at the policy scale intensified the procedural complications and became a major roadblock hindering private investors from foraying into the sector (Shukla and Thampy 2011; Kumar and Chatterjee 2012). For instance, the Enron episode is a clear manifestation of such policy-level inconsistencies and subversive policy provisioning.

Another spell of reform initiative, largely advocated by several international bodies, such as the World Bank and DFID, followed this initial reform effort; is often referred to as condition-based reform packages, and they largely operated at the state level. The World Bank carried out the first experiment with such a reform in the state of Odisha[1] around the mid-1990s. Several other states, such as Andhra Pradesh and Haryana, continued this reform momentum, following their state-specific reform plans and legislation. Apart from these piecemeal efforts of the states, the Government of India made several patchy and sporadic efforts at the national scale that had implications for the sector. Toward that end, a major reform initiative was to "draft Electricity Regulatory Commissions (ERC) Act in 1998." However, the feeling was that, while the ERC Act 1998 had novel features, what the country required was a comprehensive reform action plan that would completely overhaul the sector and have the ability to mitigate the deep-seated malaise of the sector,

[1] In 2011, the Government of India approved the name change of the State of Orissa to Odisha. This document reflects this change. However, when referring to policies that predate the name change, the formal name Orissa is retained.

very much entrenched in its functioning (Kumar and Chatterjee 2012). This thinking finally led to a comprehensive reform action plan resulting in the "Electricity Act 2003." The act led to the redrawing of the sectoral artifacts and outlined the future trajectory for the sector.

In the overall schema of reform action plans, as the Electricity Act 2003 envisaged, regulatory commissions as institutional innovations gained pride of place as new vehicles of governance to usher in the desired sectoral transformations (Dubash 2003; Kumar and Chatterjee 2012). People also considered these entities to be a harbinger of change to drive the sector along a sustainable development trajectory. The government empowered them with a variety of instruments and apparatus to correct the erstwhile distortions and expected them to infuse a commercial orientation and corporate rigor into the sector's functioning. The design of these bodies also offered potential windows for deeper engagement both with consumers and with private players (Dubash 2007). Over time, they gained additional responsibilities beyond the conventional regulatory tasks to contribute to the overarching goals of environmental sustainability and consumer welfare (Sarangi et al. 2019). However, of late, observations have shown persistent failures in addressing the age-old problems insulating the sectoral functioning from political intrusions (Dubash et al. 2019). Research has also pointed out that, given the intricate nexus between the sectoral performance of the electricity sector and the energy security challenges in the face of the increasing focus on sectoral integration (Sarangi et al. 2019), insulating regulators from political intrusions become imperative for the sector to follow a sustainable development path. Hence, there is a clear need to analyze and examine the importance of electricity regulators in driving the sectoral performance.

3. A BRIEF REVIEW OF THE IMPACT OF REGULATION ON SECTOR OUTCOMES

The literature connecting the regulatory impacts on sectoral outcomes dates back to the academic discourse on the importance of institutions for economic growth and development that Rodrik (2000) propounded. This discourse has further led to the realm of regulations and has argued that regulations as institutions have played a pivotal role in driving sectoral outcomes. With regard to the electricity sector, studies have often posited that regulation is a reflection of the complex interaction of several institutions placed at different scales of governance. This phenomenon of complex interaction is more pronounced in developing country settings, given that a major part of the economy runs in informal modes (Estachi and Lewis 2009; Veljanovski 2010). While, theoretically, studies have established the role and importance of regulation as an institution driving the economy, drawing empirical evidence of such a relationship is a tenuous exercise and there has been a dearth of scholarly attention to this issue, limited to only a few sectors (Brown et al. 2006). One sector that has received relatively more scholarly focus is the telecom sector (Stern and Cubbin 2005).

Scholars such as Gutierrez (2003a) and Montoya and Trillas (2009) have made efforts to examine and assess whether regulation plays a pivotal role in influencing the performance of the telecom sector. Most of the related studies have employed various econometric tools and techniques to analyze such impacts. To understand more about the nuances of such a nexus between regulation and its consequent impact on sectoral performance, it is necessary to highlight their findings. L. H. Gutierrez, an exponent in this field examining the effect of regulation on several performance dimensions of the telecom sector, carried out some interesting studies in this domain of research. In a

thought-provoking piece (Gutierrez 2003a), he investigated whether telecom sector regulation affects the telecom sector's performance by collecting data on twenty-two Latin American countries for the period between 1980 and 1997. The findings suggest that a well-structured regulatory governance environment can generate positive sectoral impacts, such as network expansion and greater efficiency. In a similar piece of research, he concluded that political factors and institutional variables influence network expansion positively (Gutierrez 2003a). Another group of scholars (Montoya and Trillas 2009) in this field attempted to determine whether regulatory independence has any impact on the performance of the telecom sector by analyzing 23 Latin American countries. They concluded that all forms of independence, whether *de facto* or *de jure*, shape the sectoral performance positively (Montoya and Trillas 2009).

However, scholarly experiments in the realm of electricity and the energy sector to demonstrate empirically the link between regulation and sectoral performance have been limited and have largely examined the topic at a very broad level. One of the earliest studies, by Bargara, Henisz, and Spiller (1998), to analyze the impact of electricity sector regulation on sectoral performance concluded that an incremental institutional environment is highly correlated with increasing size of the installed generation capacity. A study that Cubbin and Stern (2006) conducted revealed quite similar findings. They tested the impact of regulation on per capita generation by taking a sample of 28 developing countries. The findings suggest that a positive correlation exists between regulatory governance and higher generation capacity after controlling for variables such as the gross domestic product (GDP) and several other macro-economic variables. Establishing the causal relationship between the creation of regulatory bodies and the consequent impact on the sectoral performance of 220 electricity utilities across 51 developing countries, Estache and Rossi (2007) showed in a scholarly piece that the presence of a regulatory environment enhances firm efficiency and results in better consumer welfare. Andres et al. (2008) carried out a more structured and systematic analysis of the impact of regulatory governance systems on sectoral performance. The comprehensive analysis of such a relationship highlighted the fact that regulation and regulatory governance systems positively influence the outcomes in the electricity sector.

However, a handful of studies those carry out empirical estimations establishing the impact of regulation on sector performance do not reveal any conclusive findings. For instance, a study focused on the Latin American context (Pargal 2003) revealed that there is no clear linkage between regulation and sector outcomes. Similar findings are also observable in other studies (e.g., Rungsuriyawiboon and Coelli 2004). Rungsuriyawiboon and Coelli (2004) investigated whether incentive-based regulatory structures influence sectoral performance in the US context and found that no such relationships connect regulation with sectoral performance.

Empirical analyses establishing the relationship between regulation and electricity sectoral performance in the Indian context are conspicuous by their absence. Some scholars have made some rudimentary efforts employing indicator-based approaches to test the regulatory effectiveness (Mahalingam et al. 2006). However, very limited scholarly attention appears to have targeted the assessment of the role of regulation in affecting the sector outcomes in a convincing and robust manner.

The review that this section carries out identifies the presence of several key aspects of research gaps in the realm of regulation and the consequent impact on electricity sector performance in India. First, while scholarly research has emphasized the multi-country analysis of such impacts, the intra-country analysis of these impacts has not received the desired scholarly focus. Second, there has been a limited focus on examining certain regulatory institutional characteristics to capture informal governance

elements, for example accountability and transparency. Third, hardly any scholarly studies have attempted to examine the role of regulators in driving the sustainable development of the sector. Building on these research gaps, the present study focuses on analyzing the impact of the regulatory institutional environment prevailing in India's electricity sector on the performance of the sector, with specific emphasis on the sustainable development of the sector.

4. DATA, METHODOLOGICAL APPROACH, AND FRAMEWORK

For analytical purposes, this study considers a sample of 12 Indian states over a decade, from 2001 to 2010. The study period was limited till 2010, building on the premise that the enunciation of the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010 may have brought several structural changes to India's electricity sector. Hence, it appears to be logical to carry out a separate study using recent data on this topic. The study chose the sample states through a two-step screening process. It took the establishment of state-level regulatory entities before or during 2003 (the year of enactment of the Electricity Act) as the first step of screening to identify the study states. It rationalized the use of 2003 as a benchmarking year on the basis that the 2003 Act brought a paradigm shift to the sector (Bhattacharyya 2005). The first level of screening resulted in the identification of 18 states. Then, the second level of screening excluded states with unique differences. For instance, the study excluded Delhi as a state with high urban characteristics. This two-step screening process produced 12 states that qualified as the final set of study states.

The data collation used multiple sources. Several secondary sources of data, such as the Central Electricity Authority's (CEA) "Annual Electricity Statistics" and the Power Finance Corporation's (PFC) "Performance Report of State Power Utilities" were major sources of data. The study supplemented these sources with other secondary sources, such as annual reports of various ministries and regulatory agencies and tariff orders of state electricity regulatory commissions (SERCs) of various years. To triangulate and validate the collated data and information further and finalize the variables and indicators, expert consultations took place in various phases of the research cycle.

As a conceptual framework, the present study employed the "sustainable development framework" that Kemmler and Spreng (2007) espoused to assess the electricity sector outcomes. The framework offers a practical approach to sustainable development by drawing from the three pillars notion of sustainability, that is, economy, environment, and society. As an analytical tool, the present study employed the indicator-based methodological approach for assessing sectoral outcomes. In fact, researchers have considered such an approach to be the major analytical approach to assessing the sectoral outcomes in the electricity sector (Brown and Sovacool 2007; Kemmler and Spreng 2007; Meyar-Naimi and Vaez-Zedah 2012; Vithayasrichareona, Macgilla, and Nakawirob 2012).

Measuring the strength of regulation was the next methodological step. Researchers have contended that the scholarly efforts in the direction of developing a sound theoretical framework have been limited. No such framework exists that the study could adopt directly in the present context. Hence, the authors followed the approach of Martin and Jayakar (2013), which combines theoretical arguments, empirical observations, and logical reasoning. They used a composite index for the purpose of mapping the regulation by applying some quantitative metrics.

The next and final methodological step was to examine the effects of regulation on the electricity sector's performance. The literature has suggested that panel data regression techniques are the most dominant method that studies have deployed as an analytical tool for such assessments. Further, the majority of studies have used fixed-effect panel regression techniques for such analyses (Stern and Cubbin 2005). Following the reasoning of fixed-effect panel regression, it emerges from the literature that this model is applicable in cases in which there are unique time-invariant features that do not correlate with other countries' characteristics. Similar arguments apply in the case of the present study, in which state-specific characteristics are time-invariant and unique to specific states. This logic augurs well with the "constitutionality of energy as a concurrent item"; hence, it is quite reasonable to argue that time-invariant elements exist at the state level, which could shape the electricity sector's outcomes. Based on these rationales, the present study applied the fixed-effect panel regression model as the analytical tool. The following section presents the key results and a discussion.

5. DATA ANALYSIS, RESULTS, AND DISCUSSION

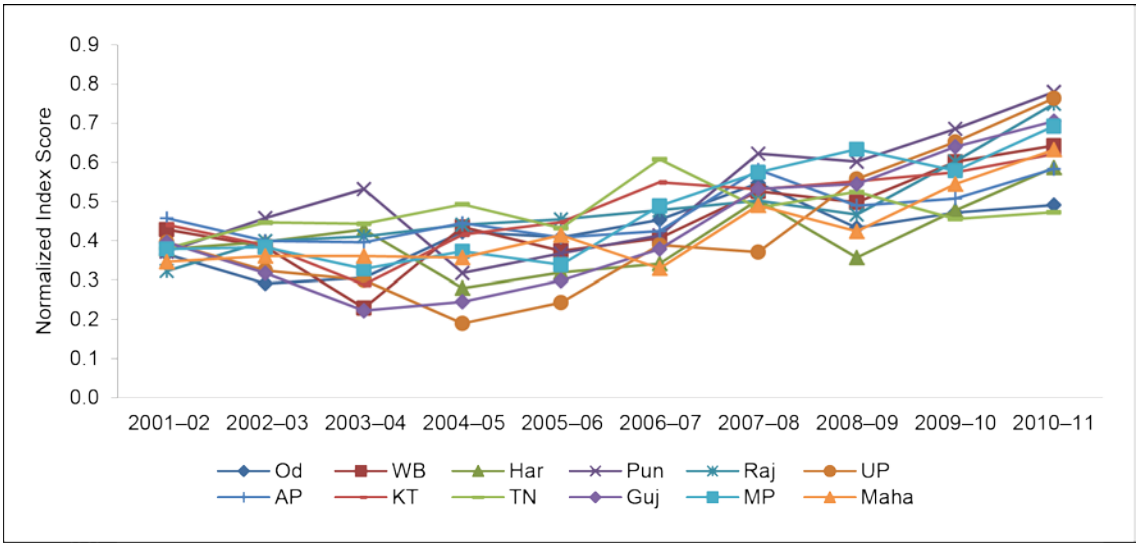
The first part of the analysis in this section emphasizes the assessment of the electricity sector outcomes and then measures the strength of regulation. Finally, the study attempts to capture empirically the impact of the regulatory environment through an index on sectoral outcomes.

5.1 Assessing the Electricity Sector Outcomes

This sub-section briefly presents the assessment of electricity sector outcomes by applying a sustainable development framework that Kemmler and Spreng (2007) advocated. Detailed assessment methods and results are available from Sarangi et al.'s (2019) study. A series of steps identified and selected the most relevant set of indicators, which represent three dimensions of sustainable development. A detailed literature mapping and a review is carried out to identify the indicators that scholars have used for such an analysis. This process obtained a list of seven key indicators. The next step in this process of indicator selection was to map the legislative and regulatory goals that the government has pronounced for the sector. Finally, the study applied a set of criteria consisting of a) the relevance in the Indian context, b) the availability of data, and c) the measurability aspects of such indicators as enunciated by OECD (2008). These steps resulted in the selection of a list of 14 indicators. The study found that some indicators were overlapping and required merging, which finally reduced the total number of indicators to 11, spilt between three different dimensions of sustainability. Given that grouping is a complex and cumbersome exercise, the authors conducted expert consultations to group these indicators into the three dimensions of sustainability. Under the economic dimension of sustainability, the study considered four key indicators, specifically AT&C (aggregate technical and commercial) losses, average revenue (AR) and average cost of supply (ACS), installed generation capacity by private investors, and captive power plant (CPP) installed capacity. Similarly, within the social dimension, it identified four highly relevant indicators, namely residential per capita electricity consumption, deficit of electricity, sales to the agricultural sector as a percentage of total sales, and subsidy amount disbursed. Finally, the environmental dimension contained three indicators, renewable electricity generation as a percentage of the total electricity generation, auxiliary consumption (of thermal power plants), and CO_2 emission generation per unit of power generation (from thermal power plants only). The study

followed the standard method of assigning similar weights to each dimension to integrate these indicators and estimate the composite index.

Figure 1: Performance of All States Together



Note: Od stands for Odisha,[a] WB for West Bengal, Har for Haryana, Pun for Punjab, Raj for Rajasthan, UP for Uttar Pradesh, AP for Andhra Pradesh, KT for Karnataka, TN for Tamil Nadu, Guj for Gujarat, MP for Madhya Pradesh, and Maha for Maharashtra.

[a] In 2011, the Government of India approved the name change of the State of Orissa to Odisha. This document reflects this change. However, when referring to policies that predate the name change, the formal name Orissa is retained.

Source: Sarangi et al. (2019).

It is easy to elicit from the above figure (Figure 1) that the combined sectoral outcome considering all the dimensions of sustainable development reveals an upward movement of the sector, though stark differences are apparent in the performance of individual states.

5.2 Measuring the Strength of Electricity Sector Regulation

In this sub-section, the authors make an effort to assess and measure the strength of state-level electricity sector regulation. However, the objective measurement of the strength of regulation is quite cumbersome. Given the absence of theoretical frameworks for measuring the strength of regulation, ideally the study should base the analysis on practical considerations. Though Levy and Spiller (1994) attempted to distinguish the regulatory system and its elements into two broad categories, regulatory content and regulatory governance, it is not very clear how to convert these elements into measurable indicators. Taking cognizance of these difficulties, the present analysis applied a simple quantitative approach of measuring the regulation through the construction of composite indices. The authors chose a set of regulatory variables as the first step in constructing the regulatory index. They chose these regulatory variables carefully to represent the regulatory environment of the sector. However, Martin and Jayakar (2013) succinctly stated that the choice is beset with the difficulty of defining and identifying “what would be the appropriate set of regulatory variables” that could epitomize the regulatory institution of a sector. To minimize such complexities, the present study compiled a comprehensive list of regulations from various legal, legislative, and regulatory pronouncements. It supplemented this list with regulatory variables that

some scholarly discourses had identified (Mahalingam et al. 2006).[2] It performed further validation of such regulatory variables through an expert consultation process. Table 1 presents the list of regulatory variables that the authors chose for the study.

Despite an understanding that the inclusion of a larger set of regulatory variables would strengthen the "regulation index," difficulties arose because of a lack of relevant regulatory information and often a lack of access to the most relevant data. For the purpose of this study, authors chose a set of 14 key regulatory variables as the representative variables to measure the strength of regulation.

Table 1: Variables Capturing the Electricity Sector Regulatory Environment

Regulatory Variables	Legal and Legislative Provisioning	Representative Regulatory Dimension
Releasing of annual reports	Section 105 (EA 2003)	Regularity in reporting
Advisory committee regulation	Section 87 (EA 2003)	Service standard quality
Setting up of a forum for consumer grievance redressal	Section 42 (5) (EA 2003)	Dealing with consumer complaints
Appointing an ombudsman	Section 42 (6) (EA 2003)	Dealing with consumer complaints
Prescribing a multi-year tariff (MYT)		Transparency and clarity in future cost trajectory
Regulation on the trading of power	Sections 86(1) (b) and (j) (EA 2003)	Promote competition and greater penetration of the market
Conduct of business regulation		Improving the accounting systems
Standard of performance regulation	Sections 57 (1) and 58 (EA 2003)	Social obligations
Supply code regulation		Quality of service standards
Grid code regulations	Section 86 1(h) of (EA 2003)	Quality of service standards
Open access regulations	Section 42 and Section 181 (EA 2003)	Promote competition and greater penetration of the market
Availability-based tariff (ABT) regulations	Section 181 (2) (zd)(zp) (EA 2003)	Tariff systems and structures
Renewable portfolio obligation (RPO) regulation	Sections 61, 62 (1), 66, 86 (1) (e), and 181 (EA 2003)	Environmental obligations
Renewable energy certificate (REC) regulation	Sections 61, 62 (1), 66, 86 (1) (e), and 181 (EA 2003)	Environmental obligations

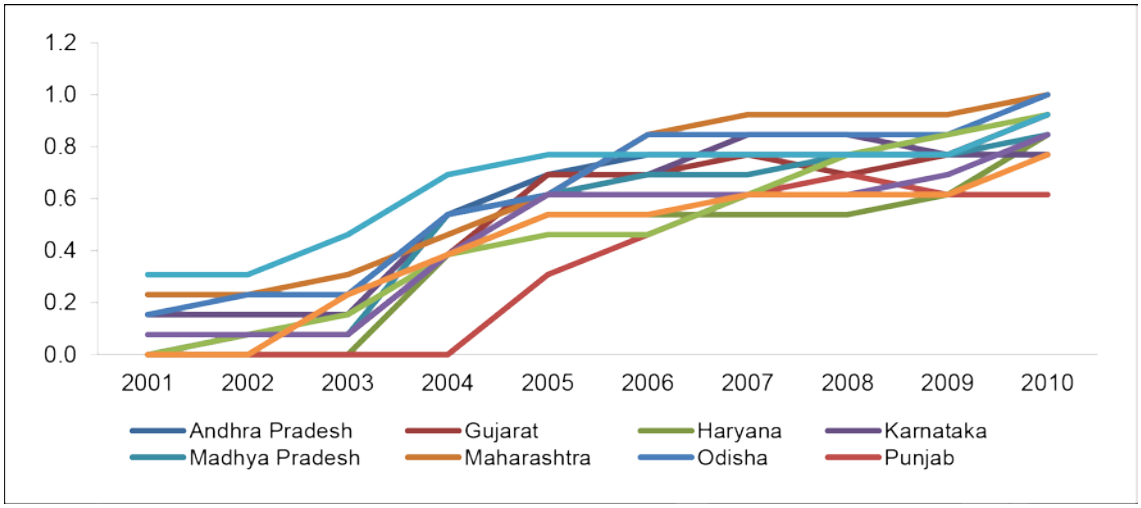
Source: Authors' compilation and construction.

Given the associated complexities, the study followed a rudimentary approach for measuring the strength of regulation. Though the method is rudimentary, some other studies have deployed similar approaches (Gutierrez 2003a) in the past. The method first codes the variables and assigns them equal weights to construct composite indices. Figure 2 below graphically presents the strength of regulation for 12 states for the duration of 10 years.

[2] The study identified variables such as the releasing of annual reports, regulation for the advisory committee, regulations to address consumer grievances, regulations to set up consumer grievance redressal forums, conducting of business regulations, standard of performance regulations, and so on.

Figure 2 displays some interesting results. It is noticeable that there is a steep rise in "regulatory index" values after the legislation of the Electricity Act 2003, implying a clear manifestation of the effects of the Electricity Act 2003 on the framing of regulations. A comparative analysis of states' performance indicated that Odisha and Maharashtra were better performers than their counterparts, such as Punjab and West Bengal.

Figure 2: Regulatory Strength of the Study States over Time



Note: Od stands for Odisha,[a] WB for West Bengal, Har for Haryana, Pun for Punjab, Raj for Rajasthan, UP for Uttar Pradesh, AP for Andhra Pradesh, KT for Karnataka, TN for Tamil Nadu, Guj for Gujarat, MP for Madhya Pradesh, and Maha for Maharashtra.

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Source: Authors' compilation and construction.

5.3 Impact of Regulation on Sector Outcomes

The last important sub-section aims to establish the causation, if any, between regulation and sustainable development outcomes. Though studies have deployed many econometric techniques to analyze such causation, they have made no clear suggestion concerning the most appropriate econometric model. However, the dominant approach that scholars have employed is panel data regression techniques (Stern and Cubbin 2005). The majority of cases have used fixed-effect panel data regression for such analysis. There are also studies that have employed several other techniques, such as the difference-in-differences approach, to establish such causation (Estache and Rossi 2007).

The present study is also in line with other empirical studies that have employed fixed-effect panel data regression techniques to investigate whether the regulatory environment in the study states have influenced the sustainable development outcomes. Following the reasoning of fixed-effect panel regression, it emerges from the studies that this model is applicable in cases in which there are unique time-invariant features, which the model should not correlate with other countries' characteristics. Similar arguments are applicable in the present study case, in which state-specific characteristics are time invariant and unique to specific states. This logic accompanies the "constitutionality of energy as a concurrent item in Indian governance settings"; hence, it is quite reasonable to argue that time-invariant elements exist at the state level, which could shape the

electricity sector outcomes. Based on these logics, the present study applied the fixed-effect panel regression model as the analytical tool.

The study operationalized the model by considering three key independent variables as predictor variables, namely the strength of regulation, net state domestic product (NSDP) per capita, and growth rate of net state domestic product (NSDP), and different dimensions of sustainable development outcomes, both individual and combined, as dependent variables. While "regulation" as an "x" variable represents the effectiveness of the regulatory environment by mapping the key features of independent electricity sector regulation, the variable "per capita NSDP" aims to capture the economic status of the study states. Finally, the study chose the "growth rate of NSDP" as the third important predicator variable, which captures the dynamic context of the changing socio-economic profile of the study states. The authors also expected the third variable to help in capturing the prevailing key macro-economic growth characteristics, such as the growth rate of urbanization, the pace of industrialization, and maybe the use of natural resources. Capturing these dynamic elements would also offer some interesting insights into resource distribution in an economy that would have implications for the sustainable development outcomes. The outcome composite index incorporates both combined and disaggregated dimensions, such as economic, environmental, and social, as response variables in the model.

With the above explanations, the proposed model for the study is as follows:

$$\boldsymbol{Y_{it}} = \boldsymbol{\alpha} + \boldsymbol{\beta X_{it}} + \boldsymbol{\varepsilon_{it}} \text{ , where i = 1....n; and t = 1..... T……} \quad \text{(Equation 1)}$$

In the above equation, it is possible to interpret $\boldsymbol{\alpha}$ as an unknown intercept, whereas X_{it} = (X_{1it}, X_{2it}.....X_{kit}) are predicator variables, which include the regulatory strength as well as other selected control variables. β = (β_1, β_2 ...β_k) are the respective coefficients of each explanatory variable. Finally, ε_{it} is the error. The response variable Y_{it} stands either for combined sector outcomes or for disaggregated sector outcomes, representing various individual sustainable development dimensions, such as the economic dimension, the environmental dimension, or the social dimension. We can consider X_{it} as a vector, which is a representative of various predicator variables, such as "per capita NSDP," "NSDP growth rate," and "regulation." Table 2 below presents the findings of four different regression equations with different variables of interest for the response variable. Hence, it structures the results accordingly.

It is observable from the above table (Table 2) that, in all the above regression models, the R-square figures are quite low, which clearly suggest that the model has omitted several other variables as predictor variables. However, a decomposed presentation of the response model by individual sectoral outcomes highlights several interesting findings that are worth presenting. Regulation as an independent variable of interest emerges as a statistically significant variable, though at the 10% level, at least for two individual outcome variables, specifically economic and environmental outcomes. This has clear policy implications. On the other hand, the table shows that the regulator as a key predictor is negatively associated with the social sector outcomes. This particular finding requires detailed deliberation and explanation. It is also very much in tune with the existing literature in this domain. It corroborates the findings from Gutierrez (2003a) and Estache and Rossi (2007), who revealed that regulation played an important role and was statistically significant in their studies. However, the present study differs from the similar scholarly efforts of Pargal (2003) and Zhang, Kirkpatrick, and Parker (2008), in which regulation as a predicator variable emerged as a non-significant variable.

Table 2: Regression Results

	Parameter Estimates for Combined Sustainable Development Outcomes	Parameter Estimates for Economic Dimension	Parameter Estimates for Environmental Dimension	Parameter Estimates for Social Dimension
Regressor	**Combined Sustainable Development Outcomes**	**Economic Dimension**	**Environmental Dimension**	**Social Dimension**
NSDP per capita	**0.000*** **	0	**0.000*** **	**0.000** **
Standard error	*0*	*0*	*0*	*0*
NSDP growth rate	0.001	0.001	0.002	–0.001
Standard error	0.001	0.002	0.003	0.002
Regulatory strength	0.068	**0.114***	**0.176***	–0.076
Standard error	0.054	0.073	0.101	0.09
Constant	0.255	0.326	0.069	0.368
Standard error	0.025	0.034	0.047	0.042
R-square	0.317	0.137	0.385	0.01
Number of obs.	120	120	120	120

*** stands for statistical significance at the 1% level, ** stands for statistical significance at the 5% level, and * stands for statistical significance at the 10% level.

Source: Authors' construction.

However, another predictor variable, "per capita NSDP," emerged as a statistically significant variable, except for one model in which the response variable was economic sectoral outcomes. This clearly implies that the socioeconomic profile of the state has a positive influence on the sectoral outcomes. The literature can explain this. Brown et al. (2006) argued that several external macro-economic factors exist that influence the electricity sector outcomes. Finally, the study showed that the other predictor variable, "growth rate of NSDP," is statistically insignificant with a negative coefficient sign with respect to the response variable "social outcomes." It is possible to discern from the above that the "rate of change in affluence of a state" does not have any significant influence on the social dimension of sectoral development.

6. SUSTAINABLE DEVELOPMENT OUTCOMES, ENERGY SECURITY, AND THE ROLE OF REGULATION: POLICY LEARNINGS

A critical evaluation of the Indian electricity sector policy and legal pronouncements indicates that the regulatory objectives, more or less, concern the achievement of sustainable development outcomes, structured around three dimensions, economic, environmental, and social. While it is evident that the fast-deteriorating financial health of the sector has been one of the key imperatives for the sectoral reform in India, at the same time, the legislative and policy pronouncements implicitly indicate that the sector should give priority to social goals as well. The government's recent thrust to promote green energy by assigning incremental environmental roles to the electricity regulators has reflected the emphasis on the environment (Sarangi and Mishra 2009).

The above section indicates that regulation as an independent variable and its impact on social outcomes calls for detailed introspection, in the specific context of developing economies like India, where socio-economic equity and sustainable development challenges have overriding considerations. These findings corroborate similar arguments that Ogus (2004) posed. Ogus opined that the emphasis on reforms and regulations meant to correct the existing economic distortions are bound to neglect

the social aspects of sectoral reforms. To some extent, one of the earlier studies carried out in the Indian context reflected this (Mahalingam et al. 2006). It clearly stated that Indian electricity sector regulators are ill prepared to manage the social aspects of sectoral functioning.

On the other hand, the study found that regulation as a key independent variable has influenced the environment in a positive manner. This is very much in line with other studies (Williams and Kahrl 2008), which have suggested that regulatory environments positively influence the environmental outcomes of the electricity sector. This has implications for the energy security of the country as well, given the integration of sectors, such as the integration of the electricity sector and the transport sector through the envisaged e-mobility plan of the Government of India. In particular, the current idea is that regulators can drive the environmental dimensions of sustainability through a large number of regulatory pronouncements related to various environmental norms, standards, and guidelines.

All these points have clear policy implications. While strategic and sustained policy thrusts to drive environmental goals have led regulators to focus on the environmental dimensions of their functioning, this has not been the case when it comes to influencing the social dimensions of regulations. It appears that there has been a recalcitrant attitude at the policy level to emphasize the social goals that the regulatory agencies should realize. Hence, there is a need to bring out the desired policy dimensions to achieve the social goals through some regulatory actions.

7. CONCLUSION

This paper sheds light on the nuances of the regulatory environment of the Indian electricity sector and its consequent effects on its sustainable development sectoral outcomes. First, the authors chose a set of indicators to construct a composite index of sectoral performance, which they divided into three crucial sustainable development dimensions, specifically economic, environmental, and social. The next stage in this exercise was to frame an index that captures the key aspects of regulatory governance in India. Finally, the study employed a panel data regression technique to identify the link, if any, between “regulation” and “sectoral outcomes.” The findings reveal that the regulatory environment of the Indian electricity sector does influence the sector outcomes. However, when disaggregating sectoral outcomes as response variables, the impacts differ across outcomes. For instance, while the study found that “regulation” as an independent variable is a major influencing factor affecting both economic and environmental sectoral outcomes, at the same time, the results indicate that the state of regulation has a negative impact on social outcomes.

All these points have significant policy implications. For instance, it is possible to connect the environmental role of regulators to the larger question of energy security in the country. Hence, the current thrust on increasing the role of regulators to drive the environmental performance of the sector appears to be in line with the desired policy goals. However, there is a need for regulators to reinvent themselves in taking care of the social aspects of sectoral performance. Given that India is increasingly facing the challenges of equity and sustainable development, policies are necessary to make regulators key institutional entities to address such challenges.

However, it is worth highlighting here that readers should not consider the findings as sacrosanct. They are largely indicative in nature given that data availability limited the study. At the same time, the novelty lies in the first ever attempt to analyze empirically the effect of independent regulation on sectoral outcomes at the country level.

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