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Indebtedness, Fiscal Discipline and Development Spending – A Non-parametric Approach

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Abstract

Indian states exhibit considerable heterogeneity in terms of revenue mobilizing capacities and efforts, development spending and fiscal dependence on the central government. In this context, the paper compares the fiscal performance of major Indian states in terms of two non-parametric performance evaluation models for the period 2009–10 to 2014–15. The study thus uses the conventional two stage framework for efficiency evaluation as well as the two stage conditional performance model. The outcomes enable us to identify front-runners as well as laggards in the area of fiscal management. Further, the study showed that the gross capital formation experienced by the states significantly influences state performance in India. However, the impact of outstanding liabilities on efficiency performance was statistically insignificant.

Keywords: Indian states, fiscal performance, efficiency, data envelopment analysis, bootstrap

JEL Classification: H21, H63, C61

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1 Introduction

Indian fiscal system is characterised by asymmetries in revenue mobilisation capacity across national and sub-national governments. Thus there are both vertical and horizontal imbalances. Vertical fiscal imbalances imply the presence of asymmetries in revenue mobilisation power between the national and sub-national governments. Horizontal imbalances, on the other hand, imply asymmetries in the potential and actual capacity of resource generation between states. Further, there are substantial differences in the degree and nature of government budgetary spending across the states. This could be due to a variety of factors including variations in the level of industrialisation, legacy of outstanding liabilities and governance philosophy. The presence of vertical fiscal imbalance has attracted considerable attention from the researchers in public finance and public policy. There are also several research studies which devoted their attention to the comparative tax mobilisation performance of Indian states. In comparison, there are only a few studies which involved comprehensive coverage of comparison of fiscal health of Indian states. The objective of the present study is to contribute to the existing literature in terms of comparative performance evaluation of states. In the matter of efficiency evaluation, the present study made a departure from the methodology adopted by the extant literature. First, by utilising the entire data set at a time for efficiency evaluation enabled us to make an inter-temporal comparison of performance against a common frontier which has been constructed on the basis of the panel data. Secondly, in addition to the conventional envelopment model, we have deployed the robust bootstrap based conditional performance benchmarking model where several environmental/contextual variables are also included in the estimation framework. Our objective is not only to find out the variations in performance but also to link such performance variation with the environmental/contextual variables.
The paper has six sections and unfolds in the following manner. Section 2 provides an overview of fiscal imbalances across the states. Section 3 discusses the related literature. Section 4 provides a brief discussion about the linkage of economic growth with government spending and resource mobilisation. Section 5 describes the methodology. Section 6 includes results and discussion. Section 7 concludes.

2 Fiscal scenario of Indian states

As we have mentioned earlier, Indian states have limited tax mobilisation power. Consequently, the states continued to experience stagnancy in revenue mobilisation during the preceding millennium while the expenditure burden continued to rise due to increasing social sector commitments. For example, between 1980–81 and 2000–01, the ratio of own current revenues to current expenditure of Indian states has declined from 60% to less than 49%.
In the year 2003, the Central government in India introduced the Fiscal

Responsibility and Budgetary Management Act in the parliament with the objective of institutionalisation of fiscal discipline and effecting improvement in the management of public funds. Following the passage of FRBM Act by the Central government, 28 states enacted Fiscal Responsibility and Budgetary Management regulations during the period 2003-2010 with the objective of time-bound containment of revenue and fiscal deficits as well as the debt/GSDP ratio. While it is true that in the recent years fiscal health of the states has shown signs of betterment, significant variations in fiscal indicators continue to persist among the states. Table 1 provides a snapshot view of the variability in several fiscal indicators across the states for the year 2014-15.

Table 1: Inter-state variations in fiscal indicators (2014–15)

Descriptive Statistics	Own Revenue as a % of Revenue Expenditure	Development Expenditure/Aggregate Disbursement	Interest Payment/Revenue Receipts	Committed Expenditure/Revenue Expenditure
Mean	59.5	65.6	11.9	29.8
Maximum	84	76.2	20.8	47
Minimum	30.7	48.5	4.2	20.1

Source: RBI (2017): State: A Study of Budgets 2016–17.

In the post-FRBM phase, fiscal indicators have improved somewhat for the states in general. However, as pointed out by Simone and Topalova (2009), empirical evidence in suggest that the impact of fiscal rules on fiscal performance of Indian states is rather weak if we adjust for the central transfer to the states.

Further, substantial inter-state variations in fiscal scenario continue to exist across the states due to variations in revenue mobilisation capacity, composition and quality of expenditure and outstanding liabilities. There are also many idiosyncratic factors at play. For example, two states may have similar GSDP levels. Yet the potential and actual revenue mobilisation may differ widely between them depending on the relative presence of the organised manufacturing and service sectors in them. States also differ considerably in terms of outstanding liabilities. The objective of the present study is to focus on this horizontal imbalance as manifested in their performance for the years 2009–10 to 2014–15.

3 Performance of Indian states: related research work

In the Indian context, there is no dearth of research literature which discussed the problems relating to fiscal deficit and debt sustainability at the sub-national level. Important recent studies include, inter-alia, Dholakia and Karan (2004), Goyal et al.

(2004), Rajaraman et al. (2005) and Rangarajan and Prasad (2012).
In comparison, there are very few research studies which benchmark the comparative performance of Indian states. On the basis of their scope of work, such research studies can be classified to three distinct categories: (i) research studies which primarily concentrated on the tax mobilisation performance of the states, (ii) research studies which studied fiscal performance including both revenue and expenditure side and (iii) studies on macroeconomic performance.
The important research studies taking the first path include Mohanty et al. (1999), Coondoo et al. (2001) and Garg et al. (2017). Jha et al. (1999) measured pure tax efficiency of fifteen major Indian states (Andhra Pradesh, Assam, Bihar, Haryana, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamilnadu, Uttar Pradesh and West Bengal) for the period 1980–81 to 1992–93 using a stochastic frontier approach. The study showed that there is a moral hazard problem in the design of central grants as the devolution of greater quantum of resources as grants tend to reduce the tax efficiency of states. The less poor states are more efficient in tax collection. The rankings of states by tax efficiency for the various years do not converge. An index of aggregate tax efficiency is calculated and it appears that this index has been stagnating over the years. It is argued that the weight placed on tax effort in the formula determining central grants to state governments should be increased to improve tax efficiency of state governments. Coondoo et al. (2001) examined the comparative tax performance of 16 states in India for the period 1986–87 to 1996–97 using a quantile regression approach whereby TSR (tax-SDP ratio) was related to per capita net state domestic product at constant (1980–81) prices. On the basis of their study, they classified the in-sample states in to four categories: best, medium, declining and worst. The best performing states included the south-western states, medium performing category included Bihar, Haryana, Madhya Pradesh and Uttar Pradesh. The worst performing states were three other eastern states and three states (Andhra Pradesh, Maharashtra and Punjab) exhibited declining tax performance. Garg et al. (2017) measured the tax capacity and tax effort of 14 major Indian states from 1992–92 to 2010–11 using Stochastic Frontier Analysis. They used the Battese-Coelli (1995) model for estimating tax mobilisation efficiency of Indian states where the inefficiency term is a linear function of a set of explanatory variables. The study considered fiscal, administrative and governance, structural and political variables which explain the tax inefficiency of Indian states. The study confirmed the existence of large variations in tax effort index across states and this seemed to be increasing over time. Econometric analysis suggested that economic and structural variables have significant impact on the tax capacity.
The important research on the construction of fiscal performance indices include Bhide and Panda (2002), Dholakia (2005), Mundle et al. (2016), Mohanty and Mishra (2016) and Sinha (2017, 2018). Bhide and Panda (2002) proposed a composite index of budget quality on the basis of the following components: (i) quality of revenue

expenditure measured by the share of revenue expenditure (net of interest payments, subsidies and defence), (ii) quality of capital expenditure measured by share of capital expenditure (net of defence), (iii) quality of revenue as measured by the net tax revenue of the centre to GDP ratio, (iv) degree of fiscal prudence as indicated by fiscal deficit-GDP ratio and (v) degree of fiscal prudence as indicated by revenue deficit-GDP ratio. Dholakia (2005) developed a composite index of fiscal performance which can be considered as an alternative to the Fiscal Self Reliance and Improvement Index recommended by the Eleventh and Twelfth Finance Commissions for assessing fiscal discipline of the Indian states. The Fiscal Performance Index was constructed out of three indices – a Deficit Index, an Own Revenue Effort Index and an Expenditure and Debt Servicing Index. Dholakia used the Fiscal Performance Index to rank the performance of Indian states for the period 1990–91 to 2002–03. Mundle et al. (2016) compared the governance performance of major Indian states for the years 2001–02 and 2011–12 from the stand points of services, infrastructure, social services, fiscal performance, justice, law and order and quality of legislature. For judging fiscal performance, two indicators were considered: proportion of development expenditure to total expenditure and the ratio of own tax revenue to total tax revenue. They found three high income states (Gujarat, Tamil Nadu and Haryana), two middle income states (Karnataka and Andhra Pradesh) and one low income state (Chattisgarh) as the best performers in the area of fiscal performance. Mohanty and Mishra (2016) constructed a Fiscal Performance Index for seventeen non-special category states for the time span 2003–04 to 2014–15 on the basis of multiple fiscal parameters. The Fiscal Performance Index is a composite index constructed from five major sub-indices including Deficit Index, Revenue Efficiency Index, Expenditure Quality Index, Debt Index and Debt Sustainability Index. Each of these five major sub-indices was based on two minor sub-indices. They used the relative distance method as well as the standard normal method for the construction of index. They found significant inter-state variations in the index.

The third category of research [Sahoo and Acharya (2012), Acharya and Sahoo (2017) and Mohanty et al. (2020)] concentrated on the construction of macroeconomic performance indices. Sahoo and Acharya (2012) constructed macroeconomic performance index of 22 Indian states using radial and non-radial DEA for the period 1994–1995 to 2001–2002. The study constructed the index of performance based on three output indicators GSDP (Gross State Domestic Product), fiscal balance and price. Both the radial and non-radial models provided significantly different ranking as supported from the Kendall's tau-b rank correlation score of 0.775 at 1 percent level of significance. Acharya and Sahoo (2017) assessed the dynamic macroeconomic performance (DMEP) of fifteen major Indian States using three macro indicators (gross state domestic product (GSDP), fiscal deficit as percentage of the GSDP and price measured by the GSDP deflator). Keeping in mind consistency in data availability and the post-liberalization period, the period of study spanned over 1993–94 to 2014–15. The study revealed that the states which exhibited higher

macroeconomic performance were less poverty ridden and also faced lower inequality. Sinha (2017, 2018) estimated the fiscal performance of Indian states using non-parametric approaches and considered the impact of contextual variables. The two studies compared the results obtained from the application of DEA and FDH (Free Disposal Hull) methods. Mohanty et al. (2020) constructed a robust macroeconomic performance (MEP) index of the Indian economy using data envelopment analysis. The study constructed MEP and Eco-MEP indices of the Indian economy from 1980–1981 to 2018–2019 using seven major macro indicators, namely, economic growth, employment rate, terms of trade, inflation rate, fiscal deficit, pollution, and climate change. The outcomes reveal that both the indices have quite similar best performing years worst performing years, and have also captured the major events which adversely affected the Indian economy during the past decades.
The present study can be included in the second category. It seeks to add value to the extant literature on this topic in mainly two respects. First, evaluation of efficiency performance of Indian states in a panel data framework where by the performance of the states is compared against a common frontier constructed for the entire period. Second, to go beyond the conventional framework of analysis so as to include contextual variables more directly in the model. Further, the present study compares both unconditional and conditional performance benchmarking approach and estimates returns to scale based on a bootstrap based approach.

4 Government spending, resource mobilisation and economic growth

In the context of an emerging economy, a state has an important role to play in promoting economic growth and development. In order to see how economic growth is related to state finances, let us consider a very simple static macroeconomic framework (which is broadly adopted from Sinha (2017) with minor modifications). Consider a state with the following income and budgetary identities:

$$Y_t = C_t + X_t + I_t + G_t, \tag{1}$$

$$G_t = R_t + F_t - rB_t, \tag{2}$$

where Y_t stands for GSDP (Gross State Domestic Product), C_t for private aggregate consumption, X_t for net exports to other states, I_t for private investment and G_t for government spending. R_t represents the total non-debt resources of the state and includes four components: own tax revenues, non-tax revenues, share of central government taxes and transfers from central government under various heads, F_t represents fresh borrowing and r represents the rate of interest payable on the borrowed amount B_t. Finally, $F_t = fY_t$, where f stands for the incremental debt-GSDP ratio. From equations (1) and (2) we get the following relationship:

$$Y_t = \frac{C_t + X_t + l_t + R_t - rB_t}{1-f}, \tag{3}$$

where $0 < f < 1$.
Equation (3) shows that, apart from consumption expenditure and exports to other regions, the level of income (and its growth rate) depends positively on mobilized investment and mobilisation of (non-debt) resources. Y_t also depends on f (incremental debt-GSDP ratio) so that changes in f improves output for the current period but increases burden of debt servicing for the subsequent periods.
The neo-classical growth model suggested that the rate of return on investment is a decreasing function of the capital stock and thus investment will flow from developed to the less developed regions thereby reducing the disparity in development in the long run. However, this view point ignores that the growth process is partly endogenous and that human capital formation has an important role to play in the growth process. Thus the quality of government expenditure has an important role to play in the growth process depending on whether it facilitates the formation and improvement of human capital.
The role played by development spending on the growth process has been recognised in several empirical studies. Diamond (1989) pointed out that capital expenditure on social sector such as housing, welfare and health improves growth performance. Baum and Lin (1993) investigated the differential impact of different types of various types of government expenditure on economic growth. Their study showed that the growth rate of educational expenditure has a significant positive impact on economic growth. Ramirez (2004) found that public infrastructure spending as well as private capital formation have a highly significant positive effect on the rate of output growth. He also found that private capital responded positively to improvement in public infrastructure. However, the inverse is not necessarily true. Erden and Holcombe (2005) applied a standard investment model to a panel of developing economies for 1980–1997. The study found that public investment complements private investment. Further, the study also found that, on average, a 10 percent increase in public investment is associated with a 2 percent increase in private investment.
Taking cue from this, we specify the investment function as $I = I_p + vG_t^d$. Here I_p represents private investment, G_t^d represents development spending by the government in period t and v represents a multiplier. Then we have

$$Y_t = \frac{C_t + X_t + I_p + vG_t^d + R_t - rB_t}{1-f}. \tag{4}$$

It is commonly accepted that the quality of spending at the sub-national level can be an important driver of economic growth. The next question that arises is whether all types of development expenditure are equally efficient. There are several studies which sought to examine the linkage between expenditure on physical infrastructure or social sector on economic growth. There were also attempts to see the differential impacts of productive and unproductive government expenditure. The result is, however, mixed. Barro (1990, 1991) found that output growth is inversely related to the share of government consumption in GDP. Devarajan et al. (1996) used data for 43 developing countries for a period of 20 years to show that a rise in the share of current expenditure (in total spending) had a positive impact on economic growth and the relationship between capital component of public spending was found to negatively impact per capita growth.

While there are mixed outcomes of research studies relating the nature of public spending with economic growth, there is also a broad agreement that public sector investment in critical areas like social infrastructure like transport, education or health can have a growth inducing character and that such public sector investment do promote private sector capital investment.

5 Research methodology

The present section contains three segments. Sub-section 5.1 outlines the two stage process involved in the unconditional performance evaluation framework while 5.2 describes the two stage conditional performance benchmarking methodology outlined in Simar and Wilson (2007, 2011). Sub-section 5.3 describes the methodology involved in the bootstrap based testing for returns to scale (Simar and Wilson 2002).

5.1 Efficiency estimation-the unconditional model

In presence of multiple input and output indicators, the performance of a productive unit is measured in terms of its position relative to an idealised economic/production frontier. The theoretical foundations could be found in the contributions of Koopmans (1951), Farrell (1957) and Shephard (1953, 1970, 1974). Armed with the assumptions of convexity of production set, free disposability of inputs and outputs and ray unboundedness, Charnes, Cooper and Rhodes (1978) introduced the methodology of efficiency estimation in the multiple output-multiple input case (under constant returns to scale). This analytical framework was further extended to the case of local technology (with the dropping of ray unboundedness) by Banker, Charnes and Cooper (1984). As is well known, DEA enables the construction of a data-driven economic/production frontier so the efficiency of an observed unit can be estimated by way of comparison with the frontier which serves as the reference technology.

The methodologies cited above compute technical efficiency on the basis of cross-section data for a particular time period implying that the benchmarks used for the evaluation of efficiency are period specific. Consequently, the efficiency scores are not comparable over time. The contributions of Klopp (1985) and Färe et al. (1994) permitted researchers to consider inter-temporal efficiency changes. However, for the construction of a single frontier based on panel data one needs to assume that the technology is unchanged for the period under observation so that there is no incidence of frontier shift during the period.

In order to elaborate the methodology, we consider a productive unit which is characterised by a set of n inputs $X \in \mathbb{R}_+^n$ which is used for producing a set of m outputs Y ($Y \in \mathbb{R}_+^m$). The production set comprises of technically feasible combinations of (X, Y) which may be defined as

$$P_s = \{(X, Y) \in \mathbb{R}_+^{n+m},\, X \text{ can produce } Y\}.$$

We assume that the production set is characterised by free disposability and convexity:

(i) Free disposability of inputs and outputs implies that if $(X, Y) \in P_s$ then (X_1, Y) and $(X, Y_1) \in P_s$ where $X_1 \geq X$ and $Y_1 \leq Y$. The inequalities between vectors are understood component wise.

(ii) Convexity implies that if (X_1, Y_1) and $(X_2, Y_2) \in P_s$ then $(X_c, Y_c) \in P_s$ where $X_c = \omega X_1 + (1 - \omega)X_2$ and $Y_c = \omega Y_1 + (1 - \omega)Y_2$ and $\omega \in [0, 1]$.

While estimating efficiency, we are concerned about the boundary of the production set. An input-output combination is efficient if it lies on the boundary. On the other hand, it is inefficient if it lies below the boundary. The input and output oriented measures of Farrell efficiency are given by $E_i(X, Y) = \inf[E_i | E_i(X, Y) \in P_s]$ and $E_o(X, Y) = \sup[E_o | (X, E_oY) \in P_s]$ (calculated under constant returns to scale). If (X, Y) is inside P_s, $E_i(X, Y)$ and $E_o(X, Y)$ correspond to the proportionate reduction in inputs/proportionate expansion in outputs required to make the productive unit efficient. Using data envelopment analysis, we can estimate input and output oriented technical efficiency (derived from Farrell's distance function) under variable returns to scale in the following manner:

$$E_{iDEA}(X, Y) = \inf \left\{ E_i \mid E_iX \geq \sum_{j=1}^{J} \lambda_j X_j;\, Y \leq \sum_{j=1}^{J} \lambda_j Y_j;\, \Sigma_{j=1}^{J} \lambda_j = 1 \right\}, \tag{5}$$

$$E_{oDEA}(X, Y) = \sup \left\{ E_o \mid X \geq \sum_{j=1}^{J} \lambda_j X_j;\, E_oY \leq \sum_{j=1}^{J} \lambda_j Y_j;\, \sum_{j=1}^{J} \lambda_j = 1 \right\}. \tag{6}$$

During estimation, we classify firms on the basis of returns to scale depending on the value of the sum of λ. If $\sum_{j=1}^{J} \lambda_j < 1$, then the firm exhibits increasing returns to scale, for $\sum_{j=1}^{J} \lambda_j > 1$, the firm exhibits decreasing returns to scale and for $\sum_{j=1}^{J} \lambda_j = 1$ the firm exhibits constant returns to scale.

For small samples, DEA estimation of efficiency can lead to biased estimate of the frontier. While for large samples, best practice frontier would converge to the theoretical frontier [Banker (1993)], for a finite sample size, the frontier estimator would lie below the theoretical frontier. Secondly, the corresponding efficiency estimates are sensitive to the sampling variations of the obtained frontier.

The bootstrap method [Efron (1979)] enables enlargement of sample size through resampling. However, in the context of efficiency estimation, one needs to use smoothed bootstrap methodology which uses kernel estimators for the purpose of smoothing the naive bootstrap estimates [suggested by Silverman (1986)]. Simar and Wilson (1998, 2000) introduced the bootstrap efficiency estimation method using the smoothed bootstrap approach.

In the unconditional model, the influence of contextual variables on the efficiency scores is explored in the second stage by a variety of approach. Banker and Natarajan (2008, 2019) suggested the use of log of efficiency scores as the dependent variable. Ray and Neogi (2007) made boxcox transformation of the dependent (efficiency) variable. A significant proportion of efficiency literature [e.g. Bjurek et al. (1992), Chillingerian (1995)] applied censored (Tobit) regression. Simar and Wilson (2007, 2011) advocated the use of truncated regression. Basilio et al. (2016) applied fractional clog-log model in the second stage.

In case of censored regression, the dependent variable in the regression model is either left-censored or both left-censored and right-censored, where the lower or upper limit of the dependent variable can be any number. In the left censored case, the censored regression model can be represented as:

$$\begin{gathered} y_l^* = x'\beta + u, u \sim iid\left(0, \sigma^2\right), \\ y = a \text{ if } y_l^* \leq 0, y = y_l^* \text{ if } a < y^*, \end{gathered}$$

where y_l^* is a latent (unobserved) variable; y is the observed variable; x is a vector of explanatory variables; a is the lower limit of the dependent variable; β is a vector of unknown parameters; u represents the disturbance term.

5.2 Conditional performance evaluation and second stage regression

Following Simar and Wilson (2007, 2011), we introduce a set of external variables Z ($Z \in \mathbb{R}_+^r$) into the system which influences the production process. However, Z is neither an input nor an output. In the present context, a firm's choice of X and Y is constrained by the influence of Z. We now have an extended production set which includes the external environment:

$$P_z = \{(X, Y)|Z = z, X \text{ can produce } Y\}.$$

Following Simar and Wilson (2007), we assume that one is confronted with a set of (sample) observations $S_j = [(x_j, y_j, z_j)]$, $j = 1, 2, \ldots, J$ (J is the number of decision making units). The statistical model is based on the following assumptions.

(1) The sample observations (x_j, y_j, z_j) in S_j are realizations of identically, independently distributed random variables with probability density function $f(x, y, z)$ which has support over $P_s \times R^r$.

(2) The production set is closed and convex. The output feasibility set (the set of feasible outputs for a given level of inputs) is closed (ensuring the existence of optimal production plans), convex and bounded for all $X \in \mathbb{R}^m_+$ and the input requirement set (the set of all input bundles required to produce a given level of outputs) is closed and convex for all $Y \in \mathbb{R}^n_+$.

(3) All production necessitates some inputs i.e. $(X, Y) \notin P_Z$, if $X = 0$, $Y \geq 0$, $Y \neq 0$.

(4) The inputs and outputs are strongly disposable. Strong disposability of output implies that $Y' \leq Y \in P_Z \to Y' \in P_Z$ and $X' \geq X \in P_Z \to X' \in P_Z$. At least one inequality should be strict.

(5) For all $(X, Y) \in P_Z$ such that $(X, E_oY) \notin P_Z$ for $E_o > 1$, the joint density function $f[(X, Y)|Z]$ is strictly positive and continuous in any direction towards the interior of P_Z for all Z.

(6) For all (X, Y) in the interior of P_Z, Farrell efficiency $E(X, Y|P_Z)$ is differentiable in both its arguments.

Given these assumptions, the output oriented measures of efficiency in the extended model are given by

$$E_{oDEA}[(X, Y) \mid Z = z] = \sup \left\{ E_o \mid X \geq \sum_{j=1}^{J} \lambda_j X_j; \right.$$
$$\left. E_oY \leq \sum_{j=1}^{J} \lambda_j Y_j;\ Z = z;\ \sum_{j=1}^{J} \lambda_j = 1 \right\}. \quad (7)$$

Further, the output oriented measure is related to the environmental variables in the following manner:

$$E_o = f_o(x, \beta) + u, \quad (8)$$

where f_o is a smooth, continuous function and β is a vector of parameters and u is a continuous iid random variable independent of Z. Random variable u is distributed $N(0, \sigma^2)$ with left truncation at $(1 - f_o(Z, \beta))$.

Simar and Wilson (2007) pointed out two major shortcomings of the conventional two stage approach for estimation of efficiency and finding out linkage with environmental variables through censored regression (in the second stage). First, the efficiency scores obtained in the first stage have serial correlation to among themselves. This is because

the efficiency of any observed firm is computed by taking in to consideration the entire dataset as the reference set. Second, in case the sample size is small, the input/output variables (and consequently the error term) are strongly correlated to the environmental variables resulting in biased estimation of the relationship.
The two stage model of Simar and Wilson (2007) requires the application of double bootstrap for the estimation of efficiency and uses truncated regression in the second stage for establishing the relationship between efficiency scores and environmental variables. In case of truncated regression, neither the dependent nor the independent variables are available in the sample beyond the specified range. Thus the left truncated regression model has the form: $y_l^* = x'\beta + u$ for $x'\beta + u \geq \alpha$. But nothing is observed otherwise. Truncated regression models are usually estimated by the Maximum Likelihood method. Under the assumption that the disturbance term u is normally distributed with mean 0 and variance σ^2, the log-likelihood function can be written as:

$$\log L = \sum \log \left[\theta \left(\frac{y - x'\beta}{\sigma} \right) - \log \sigma \right] - \sum \log \left[1 - \varphi \left(\frac{a - x'\beta}{\sigma} \right) \right],$$

where $\varphi(\cdot)$ and $\theta(\cdot)$ denote the cumulative distribution and probability density function respectively of normal distribution and a is the level at which truncation occurs.

5.3 Bootstrap based estimation of returns to scale

Estimation of efficiency performance of the states is never complete unless we collect information about returns to scale exhibited by them. Färe and Grosskopf (1985) suggested that this could be achieved by comparing the output oriented distance functions under constant and variable returns to scale respectively. Suppose $D_o^{crs}(X, Y)$ and $D_o^{vrs}(X, Y)$ represent the Shephard output distance functions under constant returns to scale and variable returns to scale respectively. In that case, the observed state (decision making unit) exhibits non-constant returns to scale if $D_o^{crs}(X, Y)/D_o^{vrs}(X, Y) < 1$. However, without having a formal testing procedure, it is not possible to find out whether the true frontier exhibits non-constant returns to scale or this result is due to sampling variations.
Simar and Wilson (2002) criticised the traditional approach of estimation of returns to scale on the aforementioned ground of absence of statistical tests. As an alternative, they proposed a bootstrap procedure for testing hypotheses concerning returns to scale. They suggested several test statistics including, mean of ratios, ratio of means and ratio of means less unity in respect of distance functions under constant and variable returns to scale. The test statistics are then bootstrapped for the purpose of statistical inference. For this, Simar and Wilson (2002) introduced a two stage testing procedure for inferring about returns to scale. In the first stage, one is required to test the null hypothesis that the technology exhibits constant returns to scale (globally)

relative to the alternative hypothesis that the technology exhibits variable returns to scale. If the null hypothesis is rejected by the first stage test then a second stage testing is performed which checks the null hypothesis that the technology exhibits (globally) non-increasing returns to scale against the alternative hypothesis that the technology represents variable returns to scale. Simar and Wilson (2002) suggested ratio of means or mean of ratios tests for the first stage while for the second stage they suggested mean of ratios less unity test.

6 Data, results and discussion

The present section describes the input, output and contextual variables used in the present study. Further, the section presents the estimation outcomes related to the efficiency performance, returns to scale and linkage of efficiency with the contextual variables used in the current study.

6.1 Description of variables

Performance Benchmarking of the states under observation (and second stage analysis) necessitates the identification of input/output indicators and of environmental variable(s). In the present study, we have used two input indicators, three output indicators and two environmental variables (Table 2). The ability to undertake fiscal activity by a state depends on its ability to mobilise financial resources and this in turn depends on the aggregate income level of the state. Consequently, GSDP (Gross State Domestic Product) is included as one of the input indicator. In the Indian context, States have limited resource mobilisation capacity and they are heavily dependent on devolution of resources from the central government. Thus, the second input indicator included in our model is the net devolution of resources from the central government which constitutes an important source of fund for undertaking development work.

For measuring the level and quality of state activity, three output indicators are included: Own Tax Revenue, Development Spending and Index of Fiscal Prudence. Mobilisation of own tax resources is an important indicator of the intention on the part of the states to maintain fiscal discipline. The Reserve Bank of India (2017) cited several instances of fiscal consolidation contributed partly due to improvements in own tax revenue for both the pre and post global crisis period (2008–09). The quality of government spending is found to be an important facilitator of growth and development. Reserve Bank of India (2018) studied the impact of Development Expenditure/Total Expenditure on per capita GSDP growth of Indian states in terms of a dynamic panel data model and the coefficient was found to be statistically significant. Consequently, development expenditure has been taken as a proxy for the quality of expenditure undertaken by the states. Due to the absence of adequate data on the type of development expenditure undertaken at the disaggregated level (and also because of data comparability issues across states) we had to be content with the aggregate development spending only. The numerator of the last output indicator (index of fiscal discipline) includes the total resources mobilized for state from not debt sources including both tax and non-tax sources and consequently depends on the aggregate income of the concerned state. The ratio of non-debt resources and total expenditure is an important indicator of fiscal health of the observed state.

In the present study, we have taken two contextual/environmental variables – log of Gross Capital Formation and Outstanding Liabilities. The first variable significantly influence tax resource mobilisation capacity at both national and sub-national level as it facilitates the growth of organised industry and service sector. The second one i.e. outstanding liabilities increases committed expenditure of the state. Therefore, the higher the level of outstanding liabilities at any point of time, the more difficult it is for the state to undertake development initiatives and maintain fiscal balance. The RBI study (2018) finds the impact of Debt/GSDP nonlinear in nature – low debt level is conducive for growth but higher levels of debt are growth retarding.

The period of analysis in the current study is 2009–10 to 2014–15. The analysis begins from the post-global crisis (2008–09) phase. By this time, phasing in of FRBM was almost complete for the in-sample states. It may be mentioned here that from 2017 the Goods and Services Tax (GST) system has been introduced in India leading to a major structural shift in India. In the preceding year (2016–17), demonetisation was undertaken which had significant impact on the growth process and consequently impacted sub-national finances. It is one of the important reasons for limiting the study period. The inputs and outputs are checked for positive correlation. Estimation of efficiency is made using the output oriented approach and under variable returns to scale. Choice of returns to scale is made on the basis of bootstrap based testing of returns to scale. The sample includes 16 major Indian states. The data have been deflated as per the standard procedure in order to facilitate meaningful comparison over time. In addition to the traditional DEA model, bootstrap based efficiency estimation has been applied in order to incorporate the impact of environmental variables on the efficiency performance of the in-sample states. Further, since estimation of efficiency scores are subject to sampling variations, the application of bootstrap enabled us to capture uncertainty by generating interval estimates of efficiency scores. Computations have been made using rDEA package which runs on 'R'. For details about rDEA see Simm and Besstremyannaya (2016).

Table 2: Input and output indicators for performance benchmarking

Particulars	Variables
Input	Gross state domestic product, Net Devolution of Resources from the Central Government
Output	Own tax revenue, development spending, Index of Fiscal Prudence
Environmental variable	Log of Gross Capital Formation, Outstanding liabilities to GSDP ratio

6.2 Estimation of technical efficiency

Table 3 makes a presentation of the mean (Shephard) efficiency estimates for both the DEA models (conditional and unconditional). Thus the table provides four sets of mean efficiency estimates – (i) mean efficiency scores for the conventional model, (ii) second stage mean bias-corrected efficiency scores, (iii) mean lower bounds and (iv) mean upper bounds of the second stage efficiency estimates (related to 95% confidence interval) for the two stage Simar-Wilson (2007) model. Tables 4 and 5 provide the state wise efficiency scores for the unconditional and conditional models (second stage estimates only).

Table 3: Mean efficiency scores of in-sample Indian states

Descriptive Statistics	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
Mean efficiency (DEA estimate)	0.8885	0.9419	0.9185	0.9398	0.8759	0.8983
Mean efficiency – second loop bias corrected estimates	0.8497	0.9028	0.8885	0.9096	0.8646	0.8876
Mean Lower bound of bias corrected estimates	0.8099	0.8629	0.8556	0.8767	0.8264	0.8609
Mean Upper bound of bias corrected estimates	0.9160	0.9649	0.9313	0.9598	0.9185	0.9239

We are interested in the inter-temporal and cross-sectional trends observed in the efficiency scores. Table 3 shows that mean DEA efficiency was above 90% for the phase 2010–11 to 2012–13 and for the remaining three years (2009–10, 2013–14 and 2014–15) the same exhibited greater variability. Similar trends were observed for the bias-corrected bootstrap DEA estimates. Performance variations across the observed states are available from Tables 4 and 5 and also from Tables 17 and 18 in Appendix 7. Three states (Andhra Pradesh, Maharashtra and Karnataka) remained in the top 25% in terms of performance for both the DEA models. On the other hand, Jharkhand and West Bengal occupied the last two positions (in terms of mean efficiency performance) for both the models. The difference in year wise and mean efficiency performance across the states is due to differences in the three output indicators (relative to the input usage) for the in-sample states.

The DEA scores provide us with a composite index of performance. From the efficiency score itself, it is not possible to understand the relative contribution of the three output indicators (own tax revenue, development expenditure and the index of fiscal prudence) in the efficiency performance of the in-sample Indian states. In order to understand the difference in efficiency performance which is attributable to each of the three output indicators, we may consider Table 6 which presents the ratio of observed and projected outputs for the unconditional DEA model. The table shows that differences in tax revenue mobilisation across the states are the

Table 4: DEA Efficiency scores of the in-sample Indian states (point estimates)

State	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	Mean Efficiency
Andhra Pradesh	0.9242	0.9939	1.0000	1.0000	1.0000	0.9462	0.9774
Bihar	0.8022	0.9196	0.8945	0.9389	0.8828	0.9356	0.8956
Chhattisgarh	1.0000	1.0000	1.0000	0.9418	0.9295	0.8320	0.9506
Gujarat	0.9000	0.9273	0.9128	0.9822	1.0000	0.9084	0.9385
Haryana	0.8720	0.9022	1.0000	1.0000	0.9136	0.8699	0.9263
Jharkhand	0.9134	0.8693	0.9141	0.8703	0.7563	0.8369	0.8601
Karnataka	0.8937	1.0000	0.8969	0.9852	1.0000	0.9405	0.9527
Kerala	1.0000	0.9478	0.8127	0.9260	0.9710	0.7714	0.9048
Madhya Pradesh	0.9310	1.0000	0.9687	0.9381	0.6718	0.9674	0.9128
Maharashtra	0.9580	0.9635	0.9622	1.0000	1.0000	1.0000	0.9806
Odisha	0.9136	1.0000	0.9481	0.9962	0.6556	0.9429	0.9094
Punjab	1.0000	1.0000	0.8965	0.8766	0.9720	0.7889	0.9223
Rajasthan	0.8071	0.9347	0.8945	0.9117	0.7008	0.9122	0.8602
Tamil Nadu	0.8771	0.9035	0.8796	0.9057	0.9925	0.9147	0.9122
Uttar Pradesh	0.8114	0.9711	0.9610	0.9591	0.8973	1.0000	0.9333
West Bengal	0.6117	0.7380	0.7549	0.8058	0.6704	0.8057	0.7311

Table 5: Bootstrap DEA Efficiency scores of the in-sample Indian states (final estimate)

State	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	Mean Efficiency
Andhra Pradesh	0.9567	0.9471	0.9208	0.9280	0.9289	0.9452	0.9378
Bihar	0.7200	0.9183	0.8700	0.9481	0.8980	0.9373	0.8820
Chhattisgarh	0.9034	0.9108	0.9313	0.9271	0.9372	0.8153	0.9042
Gujarat	0.9614	0.9615	0.9154	0.9340	0.9222	0.9411	0.9393
Haryana	0.7113	0.8511	0.9348	0.9080	0.9537	0.8616	0.8701
Jharkhand	0.7403	0.7915	0.8457	0.8371	0.6928	0.8274	0.7891
Karnataka	0.8943	0.9451	0.9028	0.9426	0.9308	0.9478	0.9272
Kerala	0.9215	0.9011	0.7974	0.8794	0.9645	0.7976	0.8769
Madhya Pradesh	0.9117	0.9173	0.9645	0.9421	0.7613	0.9461	0.9072
Maharashtra	0.9607	0.9609	0.8853	0.9427	0.9374	0.9280	0.9358
Odisha	0.8420	0.9150	0.9401	0.9698	0.7307	0.9543	0.8920
Punjab	0.8978	0.9195	0.8601	0.8417	0.9414	0.7545	0.8692
Rajasthan	0.7970	0.9338	0.8804	0.8996	0.8233	0.9208	0.8758
Tamil Nadu	0.8883	0.8736	0.8496	0.8945	0.9366	0.9461	0.8981
Uttar Pradesh	0.8271	0.9550	0.9708	0.9651	0.7663	0.8787	0.8938
West Bengal	0.6623	0.7438	0.7467	0.7928	0.7090	0.8001	0.7425

most important source of heterogeneity in efficiency performance. Overall, we can say that the legacy of borrowing in the past, insufficient tax revenue mobilisation (relative to gross state domestic product) and neglect of development spending are three factors which explains which some states have been found efficient from the fiscal management point of view while some others have done so badly. Differences in the quality of sub-national governance and the uneven presence of organised industries and services sector across the in-sample states are two other important reasons which have influenced their tax mobilisation effort and focus on development initiatives.

Table 6: Decomposition of performance

Output Indicator	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	Mean
Own tax revenue	0.7933	0.8822	0.7615	0.8135	0.7609	0.7287	0.7900
Development Expenditure	0.8884	0.9231	0.9139	0.9127	0.8724	0.8939	0.9007
Index of fiscal prudence	0.8094	0.9404	0.9185	0.9306	0.8208	0.8982	0.8863

Table 7: Bootstrap based test of returns to scale

Test statistic	Type of bandwidth used	Value of test statistic	Threshold value for rejecting the null hypothesis	Rejection of null hypothesis
Ratio of means of distance functions under constant and variable returns to scale	Cross validation	0.8352	0.1	TRUE
Mean of ratios of distance functions under constant and variable returns to scale		0.8336	0.1	TRUE
Ratio of means of distance functions under constant and variable returns to scale	Silverman	0.8352	0.1	TRUE
Mean of ratios of distance functions under constant and variable returns to scale		0.8335	0,1	TRUE

6.3 Returns to scale exhibited by the states

We have used the two test statistics suggested by Simar and Wilson (2002) for ascertaining the returns to scale exhibited by the in-sample states for the years under observation. The first statistics involves computation of means of the ratios of distance functions under constant and variable returns to scale ($S_1 = \frac{1}{n}\sum \hat{D}_{crs}/\hat{D}_{vrs}$). The

second statistics compares the ratio of means of distance functions under constant and variable returns to scale ($S_2 = Mean(\hat{D}_{crs})/Mean(\hat{D}_{vrs})$). Both the tests try to examine the validity of the null hypothesis that the states exhibit constant returns to scale against the alternative hypothesis that the states exhibit variable returns to scale. Testing has been done using two alternative bandwidth types-cross validation and Silverman (1986) rule. The results are presented in Table 4. The results are based on 100 bootstrap replications of the test statistic. Both the tests indicate that the null hypothesis is to be rejected and the p-value of 0.01. Thus outcomes of both the tests confirm presence of variable returns to scale.
Table 7 provides summary information regarding returns to scale exhibited by the in-sample states for the period under observation. The state wise information is available Table 18 in Appendix 7. Table 5 shows that over the period under observation, there is a gradual decline in the number of states (except for 2013–14) exhibiting increasing returns to scale. On the other hand, the number of states exhibiting decreasing returns to scale continued to increase (with a similar exception for 2013-14).

Table 8: Returns to scale – summary information

Particulars	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
No of states exhibiting CRS	1	5	3	1	2	0
No of states exhibiting IRS	11	4	4	2	4	1
No of states exhibiting DRS	4	7	9	13	10	15

Table 9 provides the descriptive statistics of scale efficiency. Table 6 indicates that with the exception of 2010–11 and 2013–14, there is a declining trend in the mean scale efficiency implying a greater divergence from the global technology.

Table 9: Descriptive statistics of scale efficiency

Particulars	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
Mean scale efficiency	0.9069	0.9238	0.8401	0.8162	0.8692	0.7100
Standard deviation of scale efficiency	0.0809	0.0872	0.1422	0.1560	0.1231	0.1235

6.4 Linkage with contextual variables

In this section, we present the estimation results of regression of Farrell output oriented efficiency scores on the two contextual variables (log of gross capital formation and outstanding liabilities to GSDP ratio) for the in-sample states covering the period under observation. In the DEA approach, censored regression has been used in the second stage (refer Table 10 for the results). In the bootstrap based conditional performance benchmarking approach, truncated regression has been used. Since the conditional evaluation of performance involves the application of bootstrapping of efficiency scores and truncated regression on the contextual/environmental variables in two stages, regression results are available for both the stages. However, for the purpose of drawing inference, the second stage results are important. Consequently, only the second stage results are reported in Table 11. In both the cases, inverse of Shephard output oriented efficiency scores (i.e. Farrell efficiency scores because the two measures are inverse of each other) are regressed on the two contextual variables. Thus the Farrell efficiency scores should be negatively linked with log of gross capital formation and positively linked with outstanding liabilities.

Table 10: Farrell efficiency linkage with contextual variables (unconditional model)

Parameters	Coefficient	Standard Error	Coefficient/Standard Error	p-value
Intercept	1.2470	0.0881	14.16	<0.0001
Log of Gross Capital Formation	-0.0135	0.0073	-1.846	0.0649
Outstanding Liabilities	0.0011	0.0015	0.7709	0.4408
Standard error of estimate		0.1504		

Table 11: Farrell efficiency score linkage with contextual variables (conditional model)

Parameter/variable	Point estimate	Lower bound	Upper bound
Intercept	1.2992	0.9824	1.8373
Log of Gross Capital Formation	-0.0262	-0.0680	0.0063
Outstanding liabilities	0.00028	-0.0066	0.0092
Standard error of estimate	0.1796	0.0842	0.2419

Tables 10 and 11 both suggest that the coefficients of log of gross capital formation and outstanding liabilities on Shephard efficiency reciprocal (Farrell efficiency scores) are negative and positive respectively implying the state efficiency performance is positively related to gross capital formation and inversely related to their outstanding liabilities. This is on expected lines. Capital formation promotes the growth of organised productive activities and urbanisation and facilitates tax mobilisation. On the other hand, the burden of outstanding liabilities increases resource drainage in the form of debt servicing and takes away its elbow room regarding development spending and fiscal management. However, the coefficient of outstanding liabilities in the unconditional model is not statistically significant while in the conditional model the output generated from the application of the command does not provide any information about the statistical significance of the regression coefficients.

7 Conclusions

In the present study, an effort has been made to compare the fiscal performance of select Indian states using two non-parametric efficiency estimation methods. In both cases a common inter-temporal frontier was constructed on the basis of the panel data for six years. This approach enabled us to make an inter-temporal comparison of performance and identify front runners and laggards in terms of fiscal performance. For understanding the average output projection requirement for the in-sample states, we may consider the Farrell output oriented efficiency instead of Shephard efficiency. Table 12 provides a comparison for the two approaches used in the study. The table shows that the mean projection requirement (which is an indicator of mean inefficiency of the in-sample states) under both the conventional and conditional DEA models fluctuated during the period. Thus, mean projection requirement declined between 2009–10 and 2010–11, increased during 2011–12, went down for 2012–13, rose again in 2013–14 and declined somewhat in 2014–15. Thus for the in-sample period, there is neither any evidence of convergence nor that of divergence.

Table 12: Mean Farrell efficiency for unconditional and conditional models

Particulars	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
Unconditional Model	1.1412	1.0678	1.0947	1.0678	1.1712	1.1203
Conditional Model	1.1925	1.1130	1.1306	1.1027	1.1721	1.1332

Since the two methods provide alternative ranking of the states, we are interested to know the rank correlation which is found to be 0.788. The ranks assigned by the two methods on the basis of average of the efficiency scores for the in-sample years are included Tables 17 and 18 in Appendix 7, respectively.

The present study has three important limitations which need to be pointed. First, more input and output indicators can also be accommodated. Second, the time span is relative short (six years only). Third, the present study has considered only two environmental variables – (log of) gross capital formation and outstanding liabilities to GSDP ratio. It is expected that future research studies will address these issues.

In spite of the aforesaid limitations, the present study brings to the fore the importance of good governance and the need for development initiatives with long term implications. At the national level, an important agenda of governance should be to facilitate the process of economic development in the less developed regions with a view to reduce inter-state disparity. At the same time, it is imperative at the sub-national level to put more emphasis on the implementation of long-term development plans and devise ways to mobilise tax revenues to finance such activities.

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Appendix

Table 13: Bootstrap DEA Efficiency scores of the in-sample Indian states (lower bound)

State	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
Andhra Pradesh	0.9194	0.9084	0.8608	0.8716	0.8691	0.8975
Bihar	0.6873	0.9035	0.8282	0.9360	0.8619	0.9236
Chhattisgarh	0.8254	0.8386	0.8869	0.8972	0.9020	0.7961
Gujarat	0.9309	0.9309	0.8805	0.8924	0.8579	0.9162
Haryana	0.6766	0.8152	0.8810	0.8343	0.9202	0.8304
Jharkhand	0.7020	0.7560	0.8156	0.8102	0.6685	0.8110
Karnataka	0.8619	0.8983	0.8804	0.9048	0.8724	0.9194
Kerala	0.8620	0.8647	0.7679	0.8411	0.9362	0.7800
Madhya Pradesh	0.8727	0.8498	0.9381	0.9282	0.7349	0.9223
Maharashtra	0.9320	0.9270	0.8471	0.8959	0.8856	0.8721
Odisha	0.8080	0.8469	0.9207	0.9516	0.7040	0.9406
Punjab	0.8198	0.8554	0.8273	0.8122	0.9048	0.7305
Rajasthan	0.7668	0.9126	0.8631	0.8788	0.7926	0.8962
Tamil Nadu	0.8659	0.8432	0.8163	0.8606	0.8843	0.9023
Uttar Pradesh	0.7904	0.9275	0.9463	0.9364	0.7413	0.8572
West Bengal	0.6370	0.7289	0.7294	0.7764	0.6870	0.7785

Table 14: Bootstrap DEA Efficiency scores of the in-sample Indian states (upper bound)

State	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
Andhra Pradesh	1.0035	1.0065	1.0027	1.0033	1.0346	0.9937
Bihar	0.7798	0.9487	0.9251	0.9653	0.9532	0.9559
Chhattisgarh	1.0799	1.0542	0.9946	0.9607	0.9947	0.8350
Gujarat	1.0104	1.0042	0.9608	1.0165	1.0184	0.9796
Haryana	0.7722	0.8976	1.0209	1.0613	1.0078	0.9109
Jharkhand	0.8085	0.8431	0.8856	0.8783	0.7344	0.8555
Karnataka	0.9294	0.9956	0.9263	1.0250	1.0046	0.9897
Kerala	1.0069	0.9562	0.8263	0.9362	1.0053	0.8183
Madhya Pradesh	0.9851	1.0228	1.0055	0.9640	0.8015	0.9701
Maharashtra	1.0039	1.0065	0.9261	0.9958	0.9940	1.0159
Odisha	0.8903	1.0387	0.9632	0.9888	0.7673	0.9755
Punjab	1.0547	1.0209	0.9105	0.8882	0.9791	0.7915
Rajasthan	0.8428	0.9631	0.9015	0.9235	0.8643	0.9494
Tamil Nadu	0.9138	0.9090	0.8869	0.9424	1.0015	1.0027
Uttar Pradesh	0.8810	1.0080	0.9976	0.9953	0.8038	0.9139
West Bengal	0.6937	0.7628	0.7665	0.8128	0.7313	0.8243

Table 15: Returns to scale exhibited by the in-sample Indian states

State	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
Andhra Pradesh	Increasing	Decreasing	Constant	Decreasing	Constant	Decreasing
Bihar	Increasing	Increasing	Increasing	Decreasing	Increasing	Decreasing
Chhattisgarh	Increasing	Constant	Constant	Decreasing	Increasing	Decreasing
Gujarat	Decreasing	Decreasing	Decreasing	Decreasing	Constant	Decreasing
Haryana	Increasing	Increasing	Constant	Constant	Decreasing	Decreasing
Jharkhand	Increasing	Increasing	Increasing	Increasing	Increasing	Increasing
Karnataka	Increasing	Constant	Decreasing	Decreasing	Decreasing	Decreasing
Kerala	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing
Madhya Pradesh	Increasing	Constant	Decreasing	Decreasing	Increasing	Decreasing
Maharashtra	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing
Odisha	Increasing	Constant	Decreasing	Decreasing	Increasing	Decreasing
Punjab	Constant	Constant	Increasing	Increasing	Decreasing	Decreasing
Rajasthan	Increasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing
Tamil Nadu	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing
Uttar Pradesh	Increasing	Decreasing	Decreasing	Decreasing	Decreasing	Decreasing
West Bengal	Increasing	Increasing	Increasing	Decreasing	Decreasing	Decreasing

Table 16: Scale efficiency of the in-sample Indian states

State	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
Andhra Pradesh	0.9805	0.9883	1	0.9767	1	0.8430
Bihar	0.9163	0.7423	0.9695	0.7486	0.9846	0.7211
Chhattisgarh	0.8390	1	1	0.9678	0.9244	0.4112
Gujarat	0.8794	0.8749	0.8502	0.9646	1	0.7368
Haryana	0.8949	0.9309	1	1	0.8976	0.8316
Jharkhand	0.7750	0.9910	0.9983	0.9003	0.9270	0.8668
Karnataka	0.9953	1	0.8177	0.9550	0.9458	0.7753
Kerala	0.9593	0.9817	0.8146	0.9081	0.7290	0.8533
Madhya Pradesh	0.9226	1	0.8888	0.7590	0.9592	0.7002
Maharashtra	0.7294	0.8200	0.8028	0.7823	0.8009	0.6841
Odisha	0.8491	1	0.7441	0.6701	0.9745	0.7388
Punjab	1.0000	1	0.92916	0.8842	0.8017	0.7227
Rajasthan	0.9641	0.8878	0.62819	0.6434	0.9160	0.6906
Tamil Nadu	0.8575	0.9361	0.79788	0.8326	0.7676	0.6613
Uttar Pradesh	0.9925	0.8375	0.62125	0.5531	0.6462	0.6265
West Bengal	0.9547	0.7896	0.57925	0.5137	0.6318	0.4974

Table 17: Efficiency based ranking of the in-sample Indian state (unconditional model)

State	Mean Efficiency (2009–10 to 2014–15)	Rank
Gujarat	0.9393	1
Andhra Pradesh	0.9378	2
Maharashtra	0.9359	3
Karnataka	0.9272	4
Madhya Pradesh	0.9072	5
Chhattisgarh	0.9042	6
Tamil Nadu	0.8981	7
Uttar Pradesh	0.8938	8
Odisha	0.892	9
Bihar	0.882	10
Kerala	0.8769	11
Rajasthan	0.8758	12
Haryana	0.8701	13
Punjab	0.8692	14
Jharkhand	0.7891	15
West Bengal	0.7424	16

Table 18: Efficiency based ranking of the in-sample Indian states (conditional model)

State	Mean Efficiency (2009–10 to 2014–15)	Rank
Maharashtra	0.9806	1
Andhra Pradesh	0.9774	2
Karnataka	0.9527	3
Chhattisgarh	0.9506	4
Gujarat	0.9384	5
Uttar Pradesh	0.9333	6
Haryana	0.9263	7
Punjab	0.9223	8
Madhya Pradesh	0.9128	9
Tamil Nadu	0.9122	10
Odisha	0.9094	11
Kerala	0.9048	12
Bihar	0.8956	13
Rajasthan	0.8602	14
Jharkhand	0.8601	15
West Bengal	0.7311	16