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INPUT AND OUTPUT ORIENTED EDUCATIONAL EFFICIENCY: A STATE LEVEL STUDY BASED ON DEA APPROACH

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ABSTRACT:

Aim: *The Aim of this research paper is to investigate whether educational inputs are able to produce desirable outputs for the system or is there any requirement of reallocation of educational resources. Investigation of the education sector's efficiency is crucial in the context of budget constraints facing all over the globe. The study assesses input and output oriented technical efficiency of states of India from 2012-13 to 2021-22 using a panel DEA approach.*

Methodogy: *In order to analyse the technical efficiency empirically, the study employs a panel dataset covering 36 states and union territories of India over the period 2012 to 2021. Due to data unavailability, Telangana is excluded from the dataset, resulting in a balanced panel of 35 states and union territories. The dataset includes three output variables, namely Net Enrolment Ratio (NER) at the elementary level (Classes I-VIII), NER at the secondary level (Classes IX-X), and the transition rate from elementary to secondary education.*

Implications: *The input and output-oriented CRS and VRS technical efficiency among states have discussed broadly in this study. • The large and populous states consistently have performed badly in both CRS and VRS methods under both input and output-oriented efficiency results.*

Findings: *The result reveals considerable disparity among states regarding efficiency under both CRS and VRS framework. The large and populous states have performed at the bottom, while smaller states have enhanced their performances. This shows that inefficiency in education among states arise both from management deficiency and improper scale of operation. The study provides important policy implications for the betterment of education sector of states.*

KEYWORDS: *Data Envelopment Analysis (DEA), Education Development Index (EDI), Technical Efficiency, Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS)*

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1. INTRODUCTION

The foundation of efficiency in resource utilization in any sector revolves around two terms- scarcity and choice (Samuelson & Nordhaus, 2010; Lipsey & Chrystal, 2015). The studies related to efficiency especially in education sector got prominence after global financial crisis, albeit a few studies were there earlier. Inefficiency in educational resources imply that the sector has potentiality to produce more output than its current production with same amount of input usage or it can reduce input quantity to produce the same level of educational output (Coelli et al. (2005). Education is regarded as the flag bearer of social transformation, economic growth, sustainability and equality (Tilak, 2003, Jha, Das, Mohanty and Jha, 2008). According to Solow (1956), country-wise differences in productivity and thereby per capita income are because of variation in Human Resource Development. Importance of education and its investment basically have evolved from growth theories of Solow (1956), Lucas (1988) and Romer (1990a, b). Lucas (1988) and Romar (1990) advocated 'New Endogenous Growth' model to explain per capita income variation among countries through the differences in human capital. Educational investments complement the growth journey through better employment and wage opportunities (Muralidharan, 2013). Becker (1993) emphasized on human capital formation for a country's growth. Empirical studies reveal among the three levels of education primary education provides highest return. Again, return is more for women education, for general curricula and for low-income countries. (Psacharopoulos, 1994).

The worldwide adoption of fiscal austerity-oriented policies in the face of growing fiscal pressure have put significant constraints on education sector that necessitate a careful evaluation of how scarce resources are utilized (World Bank (2018). Fiscal tightening characterized by curtailing of spending in many sectors, rationalization of subsidies results in reduced budgetary allocations for social sectors, making it imperative for governments to ensure that existing resources must result in desired outcome. (Alesina & Ardagna, 2013; Gupta & Tiongson, 2003). This underscores the importance of studying technical efficiency in education, which examines whether educational entities convert available inputs such as teachers, classrooms, grants, and instructional time into desired outputs including enrolment, retention, and learning achievements in an optimal manner. By identifying variations in performance, efficiency analysis provides evidence for reducing wastage, improving input mix, and targeting interventions more effectively, thereby safeguarding equity and quality even under tight fiscal conditions.

India has made significant progress in terms of literacy and enrolment over the years. The Gross Enrolment Ratio (GER) for SC children in primary and upper primary schools has increased from 96.8 to 113 percent and 65.3 to 98.3 per cent between 2000-01 to 2013-14. For ST children the same figures were 12.1 and 31.1 percent respectively in 2013. However, a high dropout rate in all the levels of education, especially among marginalized communities, is quite visible (MoSPI, 2006; UNESCO, 2014). Moreover, quality aspect of school education has failed to grown with educational investment. As per the report of ASER, the arithmetic and reading ability of students of 8th standard in India had declined from 65.2 percent and 83.6 percent in 2008-09 to 40 percent and 69 percent in 2018-19 respectively (ASER, 2018). Thus, it is important to investigate whether educational inputs are able to produce desirable outputs for the system or is there any requirement of reallocation of educational resources. This study tries to analyse input and output-oriented technical efficiency of school education of Indian states from 2012-13 to 2021-22.

2. REVIEW OF LITERATURE

The pioneering work regarding education efficiency was initiated by Charnes et al and Bessent et. al during 1980s and remarked that if there is no possibility to enhance educational output for a given level of investment or no scope to compress any input for a fixed set of educational output, then that system of education is considered as efficient (Bessent and Bessent, 1980). Thereafter, many researchers and policy makers analysed efficiency at different levels using different methodologies and inputs and outputs. Many of them use parametric methods like Stochastic Frontier Analysis (SFA), while others choose non-parametric methods to measure efficiency. Among the non-parametric ones, the mostly used methods are Data Envelopment Analysis (DEA) and Free Disposal Hall (FDH). Bessent et. al (1982) used DEA method to evaluate efficiency of 167 elementary schools in the Houston Independent School District. Among 167 schools, only 53.2 percent schools were found to be efficient as remaining 78 schools were inefficient as per the result. The inputs used were-enrolment and attendance rate, percentage of non-minority students to total enrolment, number of teachers per thousand students, percentage of students paying full lunch price, public spending per students, teachers' attendance, teachers' academic qualification and years of experience, number of special programmes introduced in school etc., while Iowa Test of Basic Skills for grade-iii and grade-vi were taken as outputs. A similar study was conducted to compare the efficiency differences between government and private schools of Spain by using DEA. The output taken was PISA-2006 data. They found that public schools performed better than the private ones during the study period if student's socio-economic background, school resource differences and individual management inefficiencies are not considered (Mancebón et. al, 2010). Winkler and Sondergaard (2008) analysed technical efficiency of 180 public and private schools of Uganda across 6 districts. The result of determinants of technical efficiency highlighted that improper deployment of teachers, low workload as compared to salaries were the main factors behind inefficiency of schools. Banker et. al, 2004, in their study of finding technical and allocative efficiency of Texas school districts over a period of six years, that is, from 1993 to 1999 found an increasing trend of technical inefficiency and a constant trend of allocative inefficiency during the study period. They employed panel DEA method for their study. Guzman & Cabanda (2009) also employed panel DEA method to study efficiency of private education institutions of Philippine from 2001-05. The result showed average efficiency value to be 0.807, which means approximately 20 percent institutions were inefficient in that period.

In the context of India, several studies used both parametric and non-parametric method. Chudasama (2020) made a state-wise comparison of rankings between Education Development Index (EDI) developed by NUEPA and efficiency index calculated through DEA. The study highlighted the fact that states with high performance in EDI need not necessarily efficient in input utilization. Tyagi et. al (2009) evaluated elementary education efficiency of 28 major states of India during 2009 to 2020. The average value of efficiency index was found to be 0.79 and variation in scores ranged between 52 and 94.5 percent. Several NER states like Meghalaya, Mizoram and Manipur ranked at the bottom, while states like Goa, Kerala and Haryana stood at the top. Further, the study revealed that school infrastructure, public education expenditure, literacy and urbanisation rate influence efficiency positively. In contrast to that, the percentage of SC and ST enrolment, recruitment of contractual teachers, reduces school efficiency.

3. Data and Methodology

In order to analyse the technical efficiency empirically, the study employs a panel dataset covering 36 states and union territories of India over the period 2012 to 2021. Due to data unavailability, Telangana is excluded from the dataset, resulting in a balanced panel of 35 states and union territories. The dataset includes three output variables, namely Net Enrolment Ratio (NER) at the elementary level (Classes I-VIII), NER at the secondary level (Classes IX-X), and the transition rate from elementary to secondary education. In addition, 14 input variables were identified: total schools per 1,000 school-aged population, teachers per school, proportion of teachers with academic qualification graduate and above, primary Pupil-Teacher Ratio (PTR), secondary PTR, functional electricity, availability of playground, availability of library or reading corner or book bank, schools having functional toilet facility, schools having functional drinking water, schools having ramps, availability of medical check-up, internet access, and computer availability.

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Volume 13(5), January2026

The multiple output nature of data makes the application of non-parametric techniques like Data Envelopment Analysis (DEA) more suitable than the parametric ones (Johnes, 2006; Ray, 2004). Moreover, DEA doesn't need a pre-specified functional form (Charnes et. al, 1978; Banker et. al, 1984) and distributional assumption about the error term (Greene, 2008). For the education sector, DEA is highly used as inputs and outputs are non-marketed in nature (Worthington, 2001; Emrouznejad & Thanassoulis, 2005). As DEA is highly sensitive to missing values, the study first addressed data gaps through interpolation and extrapolation techniques to generate a consistent and balanced panel. This ensured that all units across the 10-year period had complete information, making them comparable within the DEA framework. Following this, the input variables were aggregated into three composite indices using Principal Component Analysis (PCA). The infrastructure index was constructed using functional electricity, playground, library/reading corner/book bank, toilet facility, drinking water facility, and ramps. The quality index included the proportion of teachers with graduate and above, medical check-up facilities, internet connectivity, and computer availability. Finally, the access and availability index was derived from total schools per 1,000 school-aged population, teachers per school, primary PTR, and secondary PTR.

DEA is a kind of non-parametric technique used to measure the relative technical efficiency of Decision-Making Units (DMUs) in a multiple input-output scenario. If we assume 'm' outputs and 'k' inputs for 'n' DMUs, then X and Y can be regarded as (k x n) input matrix and (m x n) output matrix, respectively. For i-th DMU, both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) production technologies are employed in both input-oriented and output-oriented specifications.

Under the CRS assumption, which was originally proposed by Charnes, Cooper and Rhodes (CCR), the production technology is assumed to exhibit proportional scaling. For the i-th DMU, the input-oriented CRS model is formulated as:

$$\min_{\theta,\lambda} \ \theta$$

Subject to

$$X\lambda \leq \theta x_i, Y\lambda \geq y_i, \lambda \geq 0.$$

Here, θ is regarded as the radial contraction factor where θ <1 implies technical inefficiency and θ = 1 implies technical efficiency.

The output-oriented CRS model is represented as:

$$\max_{\phi,\lambda} \ \phi$$

subject to

$$X\lambda \leq x_i, Y\lambda \geq \phi y_i, \lambda \geq 0.$$

Here, θ represents as the expansion factor for outputs. Technical efficiency is measured as 1/ θ and any value less than 1 indicates inefficiency.

The VRS model as initiated by Banker, Charnes and Cooper (BCC), relaxes the CRS assumption by allowing the scale of operations to influence performance. It imposes convexity constraints to account for increasing, constant, or decreasing returns to scale. For the ith DMU, the input-oriented VRS DEA model is specified as:

$$\min_{\theta,\lambda} \ \theta$$

subject to

$$X\lambda \leq \theta x_i, Y\lambda \geq y_i, \mathbf{1}'\lambda = 1, \lambda \geq 0.$$

The convexity constraint $1' \lambda$ implies that the efficient frontier is formed as a convex combination of existing DMUs and thus incorporating scale effects.

Similarly, the output-oriented VRS model is expressed as:

$$\max_{\phi,\lambda} \ \phi$$

subject to

$$X\lambda \leq x_i, Y\lambda \geq \phi y_i, \mathbf{1}'\lambda = 1, \lambda \geq 0.$$

ISSN: 2347-1697
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Volume 13(5), January2026

Here θ denotes the amount of proportional output needs to with the efficiency score of 1/ θ. The VRS structure allows the model to separate pure technical inefficiency from scale inefficiency, making it particularly useful for identifying whether DMUs are operating at an optimal scale.

4. RESULT OF OUTPUT-ORIENTED MODEL (CRS and VRS):

The output-oriented average technical efficiency scores under both CRS and VRS from 2012-13 to 2021-22 show wide variations of efficiency among the states. The output-oriented efficiency investigates how much a DMU can enhance its level of output without adding marginal input. The mean score of output-oriented efficiency under CRS (0.318) is much lower than VRS (0.964), implying the existence of severe scale related inefficiency among states.

Table 1: Output-oriented Technical Efficiency under both CRS and VRS

States	Corrected Average TE, CRS, 2012-2021	Rank	Corrected Average TE, VRS, 2012-2021	Rank	Scale Efficiency	Rank
Andaman & Nicobar Islands	0.89551554	2	0.997956828	4	0.897348979	2
Andhra Pradesh	0.062846049	26	0.948396443	17	0.066265589	26
Arunachal Pradesh	0.661040197	3	0.994985113	5	0.664371947	3
Assam	0.106966512	18	0.983139088	9	0.108800996	18
Bihar	0.054324328	28	0.906695076	22	0.059914661	28
Chandigarh	0.485665063	9	0.99980894	2	0.485757872	10
Chhattisgarh	0.078469746	22	0.936742892	18	0.083768713	22
Dadra & Nagar Haveli	0.465083095	11	0.991130461	7	0.469245083	11
Daman & Diu	0.405615823	12	1	1	0.405615823	12
Delhi	0.197947545	14	1	1	0.197947545	14
Goa	0.509569153	8	1	1	0.509569153	9
Gujarat	0.049946597	29	0.889604466	27	0.056144723	29
Haryana	0.099890984	19	0.962921365	13	0.103737426	19
Himachal Pradesh	0.346140149	13	1	1	0.346140149	13
Jammu & Kashmir	0.163662952	15	0.890792088	26	0.183727442	15
Jharkhand	0.068071495	23	0.920040994	21	0.073987458	23
Karnataka	0.064975515	25	0.961591754	14	0.06757079	25
Kerala	0.152526892	16	0.999431274	3	0.152613687	16
Lakshadweep	1	1	1	1	1	1
Madhya Pradesh	0.036095066	32	0.891944395	25	0.040467843	32
Maharashtra	0.043531147	31	0.984829291	8	0.044201718	31
Manipur	0.516266575	6	0.980191696	10	0.526699601	7
Meghalaya	0.587118217	4	1	1	0.587118217	4
Mizoram	1	1	1	1	1	1
Nagaland	0.484409427	10	0.904988639	23	0.535265755	6
Odisha	0.085820336	21	0.920240411	20	0.093258604	21
Puducherry	0.510892765	7	0.994450044	6	0.513744022	8
Punjab	0.097155791	20	0.959090741	15	0.101299895	20
Rajasthan	0.045783423	30	0.932591774	19	0.049092673	30
Sikkim	1	1	1	1	1	1
Tamilnadu	0.066826011	24	0.964533097	12	0.069283274	24

ISSN: 2347-1697
International Journal of Informative & Futuristic Research (IJIFR)
Volume 13(5), January2026

Tripura	0.563551136	5	1	1	0.563551136	5
Uttar Pradesh	0.025259742	33	0.898563156	24	0.028111259	33
Uttarakhand	0.145915265	17	0.969474946	11	0.150509578	17
West Bengal	0.060305728	27	0.953935213	16	0.063217845	27
Average	0.318205379		0.963944862		0.322809985	
S.D	0.311677833		0.039166834		0.311255857	
C.V	0.979486374		0.04063182		0.96420765	

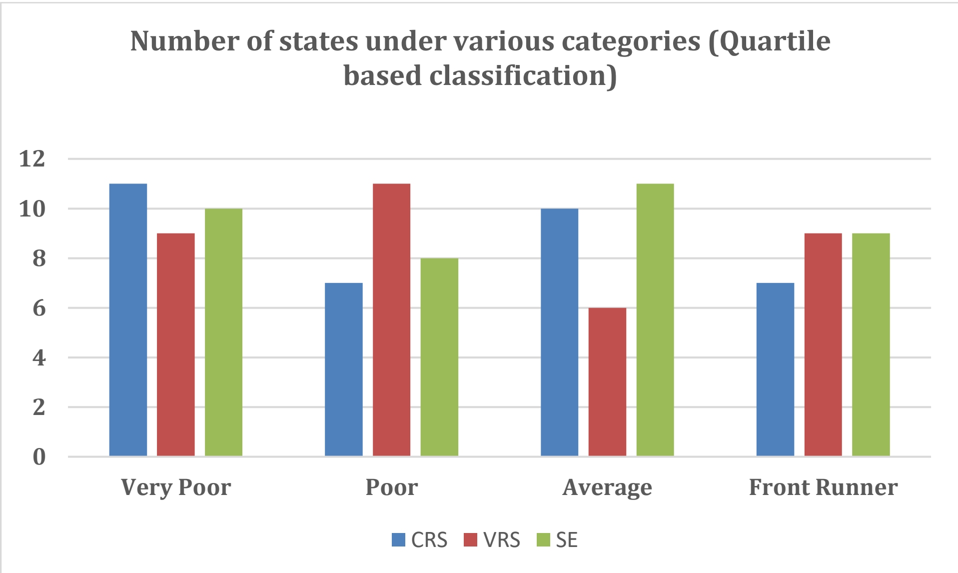
Source: Authors' calculation based on UDISE+, Census, ASER and NAS report data.

Among all states, the two of the states of NER such as Mizoram and Sikkim and the union territory of Lakshadweep have performed extremely well in all three categories, signifying their scale as well as managerial efficiency. The CRS efficiency score captures both scale and managerial efficiency. The CRS technical efficiency value ranges from 0.025 in Uttar Pradesh to one in a few small states. However, the variation in VRS efficiency is lower as reflected by a lower C.V value, indicating that states are relatively efficient in resource management but are facing the problem of improper scale of operation, as VRS shows pure technical efficiency independent of size. The scale efficiency, which is the ratio of CRS to VRS, shows that the large and populous like UP, Assam, MP, Bihar etc. have displayed low scale efficiency which means that educational outcome of them could be improved if they operate under optimal scale. In opposite to that, smaller states like Mizoram, Sikkim, Arunachal and union territories like Goa, Lakshadweep, Andaman and Nicobar have achieved high scale efficiency.

Table 2: Quartile based classification of Output-oriented TE under CRS, VRS and Scale Efficiency

Quartile	Percentile Range	Category	Approx. CRS Range	Approx. VRS Range	Approx. S.E Range
Q1	0–25th	**Very Poor**	<0.06	< 0.934	< 0.06
Q2	25th–50th	**Poor**	0.06-0.15	0.934 – 0.98	0.06 – 0.15
Q3	50th–75th	**Average**	0.15-0.51	0.98 – 0.99	0.15 – 0.52
Q4	75th–100th	**Front Runners**	≥0.51	≥ 0.99	≥ 0.52

Source: Authors' calculation based on output-oriented technical efficiency scores.



Source: Authors' calculation based on quartile values.

The quartile-based classification of output-oriented efficiency scores highlights that only seven states have come under front-runner category under CRS. The numbers have increased to nine in both VRS and Scale efficiency category. Under CRS, several NER states like Tripura, Meghalaya, Sikkim,

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Volume 13(5), January2026

Arunachal Pradesh, Mizoram and two union territories Andaman & Nicobar and Lakshadweep have qualified as top-runners. Delhi, Himachal Pradesh, Daman & Diu and Jammu & Kashmir come under average category. The states that have been performing under poor category are-Chhattisgarh, Odisha, Punjab, Haryana, Assam, Uttarakhand and Kerala. The remaining large states such as Uttar Pradesh, Madhya Pradesh, Maharashtra, Gujrat, Bihar, West Bengal, Andhra Pradesh, Karnataka, Tamil Nadu and Jharkhand come under very poor performer category.

The rankings under scale efficiency are almost similar to CRS rankings, only Jharkhand and Manipur have improved from very poor to poor and average to front runner category. In VRS category, Odisha, Arunachal and Jammu & Kashmir have shown management inefficiency as their positions have dropped from poor to very poor, front runner to average and average to very poor category respectively in comparison to CRS. However, Daman and Diu, Delhi, Goa and Himachal Pradesh have improved their pure efficiency and emerge as top-runners along with some North Eastern states except Assam. Assam has performed as poor performer in CRS, VRS and Scale efficiency.

5. RESULT OF INPUT-ORIENTED MODEL (CRS and VRS):

Input-oriented technical efficiency represents efficiency in input or resource utilization. In an educational institution, if there is any possibility to compress the quantity of inputs without compromising the current level of output, then the institution is said to be technically inefficient. The analysis of input-oriented efficiency reveals wide heterogeneity among states regarding their input usage and management. The average efficiency score under CRS is 0.328 which means institutions face high deficiency in optimum scale operations and can reduce almost 67 percent of its resources to achieve similar outcome. The inequality in resource management among states is very high in both CRS (C.V = 0.95) and VRS (0.70) system. However, the scale related efficiency variation is lower in input-oriented efficiency as compared to output-oriented model. The VRS model show relatively high means score (0.53), indicating the fact that most of the deficiency comes due to not operating in optimum scale size rather than management deficiency.

Table 3: Input Oriented Average Technical Efficiency

States	CRS	Rank	VRS	Rank	Scale Efficiency	Rank
Andaman & Nicobar Islands	0.903774	2	0.989164	2	0.913675	4
Andhra Pradesh	0.066979	26	0.203147	20	0.329708	26
Arunachal Pradesh	0.664908	3	0.933614	4	0.712187	9
Assam	0.112329	18	0.206171	19	0.544836	18
Bihar	0.057486	28	0.067582	27	0.850614	5
Chandigarh	0.488085	11	0.948348	3	0.514669	20
Chhattisgarh	0.082379	22	0.165715	21	0.497114	24
Dadra & Nagar Haveli	0.468171	12	0.915199	5	0.511551	22
Daman & Diu	0.444976	13	1	1	0.444976	25
Delhi	0.200535	14	0.868737	6	0.230835	29
Goa	0.514172	7	1	1	0.514172	21
Gujarat	0.051945	29	0.077613	25	0.669285	11
Haryana	0.101747	19	0.164839	22	0.617254	13
Himachal Pradesh	0.504674	9	1	1	0.504674	23
Jammu & Kashmir	0.173027	15	0.225501	18	0.767297	7
Jharkhand	0.074053	23	0.077442	26	0.956241	2
Karnataka	0.071644	24	0.469426	12	0.152621	33
Kerala	0.159117	16	0.83296	7	0.191026	31
Lakshadweep	1	1	1	1	1	1
Madhya Pradesh	0.040662	32	0.057495	28	0.707227	10

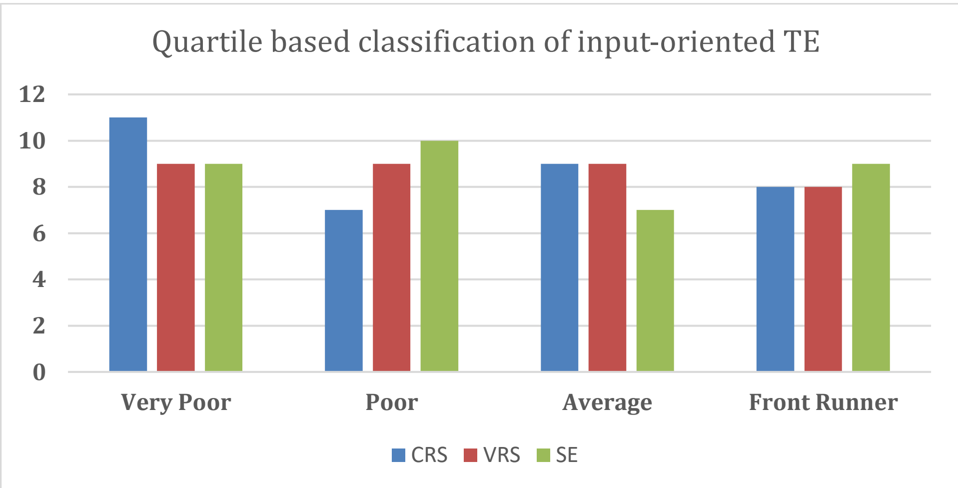
Maharashtra	0.050302	31	0.323875	15	0.155312	32
Manipur	0.521432	6	0.83067	8	0.627724	12
Meghalaya	0.625351	4	0.777334	9	0.804481	6
Mizoram	1	1	1	1	1	1
Nagaland	0.489141	10	0.521394	11	0.938141	3
Odisha	0.091979	21	0.158041	23	0.581993	16
Puducherry	0.511848	8	0.695184	10	0.736277	8
Punjab	0.100936	20	0.338276	13	0.298382	27
Rajasthan	0.05134	30	0.087179	24	0.5889	15
Sikkim	1	1	1	1	1	1
Tamilnadu	0.07141	25	0.3345	14	0.213483	30
Tripura	0.569699	5	1	1	0.569699	17
Uttar Pradesh	0.028326	33	0.047619	29	0.594843	14
Uttarakhand	0.148216	17	0.284478	16	0.521012	19
West Bengal	0.062608	27	0.247097	17	0.253376	28
Average	0.328664		0.538531		0.586102	
S.D	0.313661		0.37854		0.254713	
C.V	0.954351		0.702912		0.434587	

Source: Author's calculation based on UDISE+, Census, ASER and NAS report data.

Table 4: Quartile based classification of Input-oriented TE under CRS, VRS and Scale Efficiency

Quartile	**Percentile Range**	**Category**	**Approx. CRS Range**	**Approx. VRS Range**	**Approx. S.E Range**
Q1	0–25th	**Very Poor**	<0.07	<0.18	<0.47
Q2	25th–50th	**Poor**	0.07-0.16	0.18-0.47	0.47-0.58
Q3	50th–75th	**Average**	0.16-0.51	0.47-0.94	0.58-0.75
Q4	75th–100th	**Front Runners**	≥0.51	≥0.94	≥0.75

Source: Author's calculation based on quartile values.



Source: Author's calculation based on quartile values.

The quartile-based classification under CRS elucidates that eight states namely Manipur, Tripura, Meghalaya, Arunachal Pradesh, Andaman and Nicobar, Lakshadweep, Sikkim and Mizoram come under front-runner category, with quartile value greater than 0.51, indicating effective utilization of educational inputs under limited administrative setup with optimal scale. The states that come under average category under CRS with quartile value lying between 0.16-0.51 are- Jammu and Kashmir,

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Volume 13(5), January2026

Delhi, Daman and Diu, Dadra and Nagar Haveli, Chandigarh, Nagaland, Himachal, Puducherry and Goa. Again, Chhattisgarh, Odisha, Punjab, Haryana, Assam, Uttarakhand and Kerala come under poor category, indicating structural rigidities, sub-optimal allocation of resources and inefficient governance in education sector. Lastly, the very poor performers showing high inefficiency and input wastage are- Uttar Pradesh, Madhya Pradesh, Maharashtra, Gujrat, Bihar, West Bengal, Andhra Pradesh, Tamil Nadu, Karnataka and Jharkhand.

The classification of VRS efficiency measures also provides the similar pattern. The large states like Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, Gujrat, and Rajasthan have performed at bottom. Odisha, Haryana and Chhattisgarh have moved from poor in CRS to very poor category in VRS. This pattern suggests that inefficiency in several large states stems not only from scale diseconomies but also from managerial and administrative shortcomings, such as ineffective policy implementation, suboptimal teacher deployment, and inadequate monitoring mechanisms. Among NER states, Assam has continuously performed under poor category in both CRS and VRS production technologies. In contrast to that, the other states of NER such as Mizoram, Sikkim, Tripura have continuously performed excellent in all categories.

The average scale efficiency value of input-oriented model is found to be 0.586 which means many of the states are not operating at the most productive scale size. In this category, Jammu and Kashmir, Meghalaya, Bihar, Andaman and Nicobar, Nagaland, Jharkhand, Lakshadweep, Mizoram and Sikkim come under front-runner states. Interestingly, Bihar and Jharkhand are in very poor category in both CRS and VRS models. This means that despite poor resource utilization, the overall scale of educational operations in these states is broadly appropriate. Moreover, Daman and Diu, which is in the average and front-runner category in CRS and VRS respectively, falls under very poor performer states in scale efficiency categorization. Other than that, Karnataka, Maharashtra, Kerala, Tamil Nadu, Delhi, West Bengal, Punjab and Andhra Pradesh also fall under very poor category. Again, Uttar Pradesh, Madhya Pradesh, Haryana and Gujrat have improved their positions under scale efficiency and secured average performer position.

6. Discussion and Policy Implication

The input and output-oriented CRS and VRS technical efficiency among states have discussed broadly in this study. A few notable findings from efficiency results are:

- The large and populous states consistently have performed badly in both CRS and VRS methods under both input and output-oriented efficiency results. This underscores the fact that there is misalignment between resource expansion and output convertibility. These states suffer from managerial inefficiency along with scale related deficiency.
- The efficiency scores of large states in both input and output-oriented method have improved when VRS technology is considered, implying that scale related constraints are much stronger in these states as compared to management-oriented deficiencies. However, Bihar and Jharkhand have shown different result. Despite poor CRS and VRS efficiency, they emerge as front runners in scale efficiency. It indicates that inefficiency in Bihar and Jharkhand is not primarily driven by inappropriate scale, such as excessive fragmentation or under-provision of educational infrastructure. Instead, these states are constrained by ineffective utilization of resources at an otherwise optimal scale.
- Small NER states and union territories have performed excellently. This is probably due to administrative efficiency, relatively homogeneous demography, close monitoring system and efficient utilization of educational resources.

In the context of fiscal austerity, it is important to rationalize expenditure as most of large states are found to be inefficient which means their educational resources can be reduced to find similar output or utilizing same level of inputs outputs can be enhanced to reach the optimum frontier. Thus, large

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Volume 13(5), January2026

states should focus on efficiency enhancing reforms that can rationalize inputs such as rational teacher deployment, reduction of administrative overheads, consolidation of under-enrolled schools, and improved targeting of education expenditure toward disadvantaged regions. Strengthening district and block level planning mechanisms can help align resource allocation more closely with local needs, reducing inefficiencies arising from centralized decision-making. Similarly, small states should focus on maintaining efficiency consistently with compacted administrative setup. In order to enhance output-oriented efficiency, states should emphasize on quality over quantity. For this, teachers' training and capacity building programmes, performance-based incentives, proper monitoring system, strong administrative mechanism etc. should be implemented.

9. Conclusion

The study has made an assessment of input and output-oriented technical efficiency of Indian states using DEA approach for both CRS and VRS framework. The result shows large variation of efficiency among states. The performance of small states has found to be quite significant as compared to large states. The combined evidence from input-oriented and output-oriented efficiency measures underscores the need for a dual policy approach. On the one hand, input-oriented inefficiency highlights the scope for resource rationalization and improved managerial practices, particularly in fiscally constrained environments. On the other hand, output-oriented inefficiency emphasizes the importance of shifting policy focus toward improving learning outcomes, institutional effectiveness, and accountability mechanisms, rather than relying on expenditure-led strategies.

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