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EFFICIENCY IN ELEMENTARY EDUCATION IN URBAN INDIA: AN EXPLORATORY ANALYSIS USING DEA

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Abstract

Increasing literacy in the Indian states is possible by increasing enrolments in elementary education. This study explores the later by primary and upper primary enrolments for nineteen major Indian states for the year 2012-13. Using a non-parametric approach, namely DEA, the results for urban primary and upper primary enrolments indicate that many of the states may be able to improve efficiency of input usage or maximize enrolments more efficiently provided that an adequate infrastructure could be expanded which keeps pace with rising population growths in the states. In rural areas an additional supportive input, namely, electricity supply for villages may also help in enhancing the objective of increasing elementary education in the states.

Keywords: *Efficiency; DEA; Education; India*

JEL Codes: *C14 ; H52*

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INTRODUCTION

India's education system is divided into different levels which include education at pre-primary, primary, elementary and secondary levels, as well as undergraduate and postgraduate levels.

Government has laid emphasis on primary education up to the age of fourteen years, referred to as elementary education in India. In fact, 80% of all recognized schools at the elementary stage are government run or supported, making it the largest provider of education in the country.

Official figures in 2011 show that there are 5,816,673 elementary school teachers in India and 2,127,000 secondary school teachers in India. From time to time, there have been several efforts to enhance quality in education. Among them, District Education Revitalization Programme (DERP) was launched in 1994 with an aim to universalize primary education in India by reforming and vitalizing the existing primary education system. 85% of the DERP was funded by the central government and the remaining 15 percent was funded by the states. This programme led to 160000 new schools including 84000 alternative education schools delivering alternative education to approximately 3.5 million children. It was partly also supported by UNICEF and other international programmes.

Besides an improved high Gross Enrollment Ratio of 93–95% for the last three years in some states, it also had emphasis on improvement in staffing and enrollment of girls. Another widely publicized current scheme for universalization of Education is the Sarva Shiksha Abhiyan (SSA) which is one of the largest education initiatives in the world.

Owing to quality or availability reasons, nearly 27% of Indian children are privately educated and this percentage is much higher in urban areas. According to the latest DISE survey, there is a considerable percentage of untrained teachers (para-teachers; 54.91%) in private schools, compared to 44.88% in government. However, the number of private schools in India is still low - the share of private institutions is 7% (with upper primary being 21% and secondary 32%). Keeping in view the vital role that the elementary education plays in overall literacy in the country, it is thus important to explore the efficiency of this sector.

Objective

In the Indian context there has been so far no attempt made to measure technical efficiency in the education sector. In this paper, we make an attempt to find out technical efficiency using a non-parametric approach known as Data Envelopment analysis.

The DEA methodology, originating from Farrell's (1957) seminal work and further by Charnes, Cooper and Rhodes (1978), assumes the existence of a convex production frontier. The production frontier in the DEA approach is constructed using linear programming methods. The term "envelopment" stems from the fact that the production frontier envelops the set of observations[1].

The general relationship that we consider is given by the following function for each state i:

$$Y_i = f(X_i),\ i=1...n \tag{1}$$

where we have Yi –our output measure; Xi – the relevant inputs

If $Y_i < f(X_i)$, it is said that unit i exhibits inefficiency. For the observed input levels, the actual output is smaller than the best

[1] Charnes, A.; Cooper, W. and Rhodes, E. (1978), Coelli et al. (2002) and Thanassoulis (2001) offer introductions to DEA.

attainable one and inefficiency can then be measured by computing the distance to the theoretical efficiency frontier.

The analytical description of the linear programming problem to be solved in the variable-returns to scale hypothesis is sketched below for an output-oriented specification. Suppose there are *k* inputs and *m* outputs for *n* Decision Management Units (DMUs). For the i-th DMU, we can define *X* as the (*k* x *n*) input matrix and *Y* as the (*m x n*) output matrix. The DEA model is then specified with the following mathematical programming problem, for a given i-th DMU:

$$
\begin{aligned}
&\text{Max}_{\delta,\lambda}\ \delta \\
&\text{Subject to } -\delta y_i + Y\lambda \geq 0 \\
&\qquad\qquad x_i - X\lambda \geq 0 \\
&\qquad\qquad n1'\lambda' = 1 \\
&\qquad\qquad \lambda \geq 0
\end{aligned}
\tag{2}
$$

In problem (2), δ is a scalar (that satisfies $1/\delta \leq 1$), more specifically it is the efficiency score that measures technical efficiency. It measures the distance between a unit and the efficiency frontier, defined as a linear combination of the best practice observations. With $1/\delta < 1$, the unit is inside the frontier (i.e. it is inefficient), while $\delta = 1$ implies that the unit is on the frontier (i.e. it is efficient).

The vector λ is a (*n* x *1*) vector of constants that measures the weights used to compute the location of an inefficient DMU if it were to become efficient, and *n1* is an n-dimensional vector of ones. The inefficient DMU would be projected on the production frontier as a linear combination of those weights, related to the peers of the inefficient DMU. The peers are other DMUs that are more efficient and are therefore used as references for the inefficient DMU. The restriction $n\,1'\,\lambda = 1$ imposes convexity of the frontier, accounting for variable returns to scale. Dropping this restriction would amount to admit that returns to scale were constant. Problem (2) has to be solved for each of the *n* DMUs in order to obtain the *n* efficiency scores.

Figure 1 presents the DEA production possibility frontier in the simple one input-one output case. States A, B and C are efficient States. Their output scores are equal to 1. State D is not efficient. Its score [*d2/(d1+d2)*] is smaller than 1.

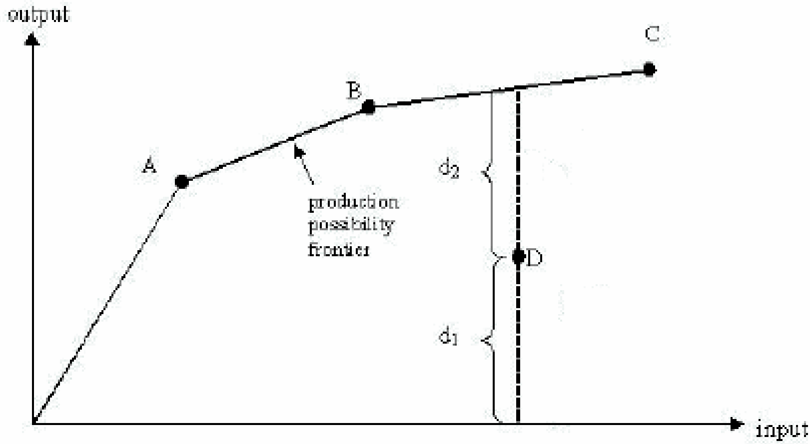

Figure 1: DEA Production Possibility Frontier in One Input-One Output Case

In the education sector, in other countries, previous research on the performance and efficiency of the public sector and its functions that applied nonparametric methods mostly used either FDH or DEA and find significant inefficiencies in many countries (Purohit, 2014). Notable studies include Gupta and Verhoeven(2001) for education and health in Africa, Clements (2002) for education in Europe, Afonso, Schuknecht, and Tanzi (2005) for public sector performance expenditure in the OECD, Afonso and St. Aubyn (2005a, 2005b) for efficiency in providing health and education in OECD countries. De Borger, Kerstens, Moesen and Vanneste (1994), De Borger and Kerstens (1996), and Afonso and

Fernandes (2006) find evidence of spending inefficiencies for the local government sector. Some studies apply both FDH and DEA methods. Afonso and St. Aubyn (2005b) undertook a two-step DEA/ tobit analysis, in the context of a cross-country analysis of secondary education efficiency. Sutherland, D., R. Price, I. Joumard and C. Nicq(2007) develop performance indicators for public spending efficiency in primary and secondary education in OECD countries using both DEA and SFA. This paper assesses the potential to raise public spending efficiency in the primary and secondary education sector. To draw cross-country comparisons of the efficiency in the provision of education, the paper develops a set of comparable indicators which reflect international differences in the levels of efficiency in the primary and secondary education sector both within and among countries. The paper identifies significant scope to improve efficiency by moving towards best practice.

Using data for a sample of developing countries and transition economies, the paper by Emanuele, Guin-Siu and De Mello (2003) estimates the relationship between government spending on health care and education and selected social indicators. Unlike previous studies, where social indicators are used as proxies for the unobservable health and education status of the population, this paper estimates a latent variable model. The findings suggest that public spending is an important determinant of social outcomes, particularly in the education sector. Overall, the latent variable approach yields better estimates of a social production function than the traditional approach, with higher elasticities of social indicators with respect to income and spending, therefore providing stronger evidence that increases in public spending do have a positive impact on social outcomes.

The study by Cunha and Rocha (2012) applies DEA techniques to evaluate the comparative efficiency of public higher education institutions in Portugal. The analysis is performed for three separate groups: public universities, public polytechnics and the several faculties of the University of Porto. By using several inputs and outputs at the institutional level, the authors identify the most technically efficient institutions that may work as benchmarks in the sector. The results suggest that a great portion of institutions may be working inefficiently, contributing to a significant waste of resources. This exploratory study is considered a first step towards a deeper understanding of the efficiency determinants of higher education institutions.

Wolszczak-Derlacz and Parteka (2011) examine efficiency and its determinants in a set of higher education institutions (HEIs) from several European countries by means of nonparametric frontier techniques. The analysis is based on a sample of 259 public HEIs from seven European countries across the period of 2001–2005. They conduct a two-stage DEA analysis, first evaluating DEA scores and then regressing them on potential covariates with the use of a bootstrapped truncated regression. Results indicate a considerable variability of efficiency scores within and between countries. Unit size (economies of scale), number and composition of faculties, sources of funding and gender staff composition are found to be among the crucial determinants of these units' performance. Specifically, they found evidence that a higher share of funds from external sources and a higher number of women among academic staff improve the efficiency of the institution.

Sav (2012) provides stochastic frontier cost and (in)efficiency estimates for private for-profit colleges with comparisons to public and private colleges. The focus is on the 2-year US higher education sector where there exists the largest and fastest-growing entry of for-profit colleges. Unbalanced panel data is employed for four academic years, 2005–2009. Translog cost frontiers are estimated with an inefficiency component that depends upon environmental factors defined by college-specific characteristics. More experienced public and private non-profit colleges are found to be more cost efficient relative to the newer entrants. In addition, the newer for-profits exhibit greater efficiency variability but also show some evidence of efficiency gains over the academic years. There is some cursory evidence that for-profit entry is positively correlated, albeit weakly, with greater public college sector inefficiency.

The study by Ahmed (2012) investigates the public sector's efficiency in educational expenditure in the two major provinces of Pakistan. The data of Punjab and Sindh at the district level have been used and DEA has been conducted. The efficiency scores and rankings for districts in each of the provinces have been computed and analyzed.

A study of the efficiency of Uganda's public education system has been carried out by Winkler and Sondergaard (2008). This study carried out a rapid unit cost survey of 180 public and private primary schools in six districts across three regions to provide this information. This study documents the magnitude and extent of the leakage and misuse of educational resources. When possible, it identifies the principal causes of inefficiencies. However, in general, further research is needed to pinpoint causes and thus identify cost-effective solutions. For example, the study documents the problem of an inequitable and inefficient assignment of teachers across districts and schools. The internal efficiency of public secondary education is low and unit costs are high. The reasons for low efficiency include low workloads, poor teacher deployment and high teacher salaries. A significant portion of secondary school teachers are underutilized.

Data Base

In order to explore efficiency in elementary education, we used data published on web by National University of Educational Planning and Administration, New Delhi on behalf of Department of School Education and Literacy, Ministry of Human Resource Development, Government of India, 2014 (NUEPA, 2014). Utilizing this data base we focused on 19 major Indian States. These included Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal.

We used enrollments at urban primary and urban upper primary level as dependent variables. Using Principal component analysis we tried a set of variables which represented facilities: like no. of classrooms, age of establishment of school, student-classroom ratio, drinking water, boys toilets, girls toilets, electricity connection, computers; manpower variables: like pupil-teacher ratio, no. of female teachers, SC and ST students enrolments and policy variable like school development grant (SDG) and teaching learning material grants (TLM) utilized. In order to do so we identified variables which were not highly correlated. The results for these correlations are presented in Table 1 and 3. These results indicated that in case of Urban primary enrolments the possible variables that could be used for identifying principle components could be Average number of instruction days, student-classroom ratio, single class rooms, drinking water, boys toilets, manpower variables like SC students enrolments and policy variable like school development grant (SDG) utilized (Table 1). In regard to urban upper primary enrolments the possible variables that could be used for identifying principle components could be average number of instruction days, schools established since 2002, single class room schools, school development grant (SDG) utilized, boys toilets, upper primary schools with secondary. Based on these results we calculated factor scores and criteria of eigen value greater than one to select the factors for Data Envelopment Analysis and these are presented in Table 2 and 4. Thus for urban primary factor scores relating to Average number of instruction days, Schools established since 2002, Single class room schools and Student class room ratio were used as inputs for DEA (Table 2). Likewise for urban upper primary factor scores relating to Average number of instruction days, Schools established since 2002 and Single class room schools were used in DEA as input variables[2].

Results

The results of data envelopment analysis (DEA) are presented in Table 5. These results pertain to variable returns to scale. However, the constant returns-to-scale (the CCR, or Charnes, Cooper, and Rhodes score) is a kind of "global" efficiency measurement which can be decomposed as:

CCR score = (pure) efficiency score x scale efficiency = VRS score x scale efficiency

The results in this sheet show CCR scores and the scale efficiencies as defined above. Note that if a unit is fully efficient under the constant returns-to-scale assumption, it is also fully efficient under the variable returns-to-scale one, but the converse is not necessarily true.

The "Returns-to-scale" column contains the characterization of the area where each unit operates, that is, whether scale inefficiencies are due to increasing or decreasing returns-to-scale. Thus in the Tables 5 we have focused on CCR scores (or constant returns to scale technical efficiency, CRST score) and efficiency rankings based on these are discussed.

As presented in Table 5, there are a number of states which fall below CRST score of one. Thus the states are compared to their peers using rank one as highest efficiency and numerical higher values of ranks

[2] In order that these factors do not generate too many DMUs as efficient, in further calculations we subtract mean from each of the data dimensions. This produces a data set whose mean is zero. However, in DEA it is necessary that inputs and outputs should be strictly positive; the PCA results are increased by the most negative value plus one to get strictly positive data (Afonso and Aubyn, 2006).

indicate relatively more inefficient state. To explore further this efficiency aspect we considered all states (19 states) group average (or mean) and compared with the individual state's CCR. The states which are having efficiency score one do not need such measures (Table 5). These include Andhra Pradesh, Maharashtra and West Bengal for Urban Primary and Andhra Pradesh and Maharashtra for Urban Upper Primary respectively. Thus these are considered efficient as per DEA criteria. We also present group averages for CCR scores in last row (columns 4 and 8) of Table 5. Using deviations from these group averages it can be observed that there is a substantial scope for improvement in efficiency of low ranking states. It is highest for both urban primary (45 percent) and upper primary for Goa (31 percent) followed by Uttarakhand (43 percent and 31 percent for primary and upper primary respectively) (Table 5).

Table 1: Correlation Matrix for Urban Primary Enrolments

Average number of instruction days	1								
Schools est. since2002	0.1025	1							
Single class room	0.1812	0.0496	1						
Student class room ratio	0.3852	-0.0619	0.1064	1					
Sdg utilised	0.0109	-0.3208	-0.0533	0.0168	1				
Tlm utilised	-0.0806	-0.0609	-0.2782	-0.0766	0.3985	1			
drinking water%	-0.4189	0.0446	-0.3879	-0.2207	-0.0876	0.0196	1		
Boys toilets	0.1294	0.198	-0.3164	0.1802	0.1512	0.0996	0.4053	1	
Sc primary	0.3956	0.3769	-0.0893	0.145	0.0992	-0.2182	-0.0047	0.0522	1

Source: Estimated.

Table 2: Principal Components Urban Primary Enrolments

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.0735	0.345306	0.2304	0.2304
Comp2	1.7282	0.15661	0.192	0.4224
Comp3	1.57159	0.558533	0.1746	0.597
Comp4	1.01306	0.172482	0.1126	0.7096
Comp5	0.840574	0.128964	0.0934	0.803
Comp6	0.711609	0.174243	0.0791	0.8821
Comp7	0.537366	0.152203	0.0597	0.9418
Comp8	0.385163	0.246222	0.0428	0.9846
Comp9	0.138941	.	0.0154	1

Source: Estimated.

Table 3: Correlation Matrix for Urban Upper Primary Enrolments

Average number of instruction days	1							
Schools est. since2002	0.0276	1						
Single classroom schools	0.2502	-0.1678	1					
Single teacher	0.4506	0.0796	0.4747	1				
Student class room ratio	0.3357	-0.1184	0.0183	0.3628	1			
Sdg utilised	0.247	0.2373	0.1354	0.2584	0.0795	1		
Boys toilets	0.0218	0.2282	-0.0705	-0.2374	0.1918	0.1983	1	
Upperprimar y with s econdary	0.3309	0.4258	-0.0281	-0.0149	-0.1915	0.492	-0.0597	1

Source: Estimated.

Table 4: Principal Components Urban Upper Primary Enrolments

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.2010	0.4142	0.2751	0.2751
Comp2	1.7868	0.5087	0.2233	0.4985
Comp3	1.2781	0.4093	0.1598	0.6582
Comp4	0.8687	0.1140	0.1086	0.7668
Comp5	0.7548	0.1351	0.0943	0.8612
Comp6	0.6196	0.2846	0.0775	0.9386
Comp7	0.3351	0.1791	0.0419	0.9805
Comp8	0.1560	.	0.0195	1.0000

Source: Estimated.

Further if we glance at the budgetary expenditure on education both as percent of GSDP and percent of aggregate budgetary state expenditures (Table 6), we find that Maharashtra and West Bengal are spending more than all state average of 16.2 percent (percent of aggregate budgetary state expenditures) but Andhra Pradesh is spending 12.9 percent which is less than all state average in 2012-13. Likewise as percent of GSDP all the three efficient states are spending less than all India average and also less than the lowest efficiency states like Goa (2.96) and Uttarakhand (3.55 percent) (Table 6, column 4). This suggests that the efficiency is largely due to better technical or input usage efficiency in these states.

Table 5: Efficiency and Ranks of Major Indian States in Urban Primary and Urban Upper Primary 2013

	enrolments urban primary				Enrolments urban upper primary			
State	**Scale efficiencies**	**Returns-to-scale**	**CCR score**	**ranks**	**Scale efficiencies**	**Returns-to-scale**	**CCR score**	**ranks**
Andhra Pradesh	1.0000	constant	1.0000	1	1.0000	constant	1.0000	1
Assam	0.9115	increasing	0.1065	17	0.8984	decreasing	0.0894	17
Bihar	0.2403	increasing	0.2403	13	0.9897	decreasing	0.1521	14
Chhattisgarh	0.9320	increasing	0.1975	15	0.8643	decreasing	0.1268	16
Goa	0.0464	increasing	0.0464	19	0.0464	increasing	0.0464	19
Gujarat	0.6042	increasing	0.6042	8	0.9260	decreasing	0.4803	6
Haryana	0.9928	increasing	0.1758	16	0.9148	decreasing	0.1554	13
Jharkhand	0.8590	increasing	0.3062	11	0.3290	increasing	0.3290	10
Karnataka	0.7311	increasing	0.7311	6	0.9051	decreasing	0.4871	5
Kerala	0.4554	increasing	0.4554	10	0.9852	increasing	0.2675	11
Madhya Pradesh	0.8609	increasing	0.7002	7	0.8440	decreasing	0.5428	4
Maharashtra	1.0000	constant	1.0000	1	1.0000	constant	1.0000	1
Odisha	0.3569	increasing	0.2930	12	0.9633	decreasing	0.1316	15
Punjab	0.9984	decreasing	0.2078	14	0.8677	decreasing	0.1617	12
Rajasthan	0.9822	decreasing	0.5962	9	0.8556	decreasing	0.3666	9
Tamil Nadu	0.9383	increasing	0.9383	4	0.8550	decreasing	0.6340	3
Uttar Pradesh	0.9524	decreasing	0.8769	5	0.7192	decreasing	0.4097	7
Uttarakhand	0.8913	increasing	0.0709	18	0.8462	decreasing	0.0517	18
West Bengal	1.0000	constant	1.0000	1	0.8742	decreasing	0.3772	8
		Mean	0.5025			Mean	0.3584	

Source: Estimated.

Table 6: Expenditure on Education and Efficiency Estimates

				Expenditure on education as percent of Aggregate Expenditure			
	CCR score urban primary enrolments	CCR score urban upper primary enrolments	Education budget as % of GSDP	**2010-11**	**2011-12**	**2012-13**	**2013-14 (RE)**
Andhra Pradesh	1	1	2.39	12.5	13.0	12.9	13.5
Assam	0.1065	0.0894	6.04	22.0	20.3	20.6	19.2
Bihar	0.2403	0.1521	3.95	16.3	17.0	20.9	19.3
Chhattisgarh	0.1975	0.1268	3.36	18.6	17.7	16.3	19.2
Goa	0.0464	0.0464	2.96	15.4	14.8	15.4	15.0
Gujarat	0.6042	0.4803	1.79	15.9	15.8	14.3	14.8
Haryana	0.1758	0.1554	2.44	17.3	16.0	15.4	15.8
Jharkhand	0.3062	0.329	3.41	15.8	15.9	14.8	13.8
Karnataka	0.7311	0.4871	2.76	15.6	14.7	15.5	15.2
Kerala	0.4554	0.2675	2.87	17.0	17.7	17.2	16.6
Madhya Pradesh	0.7002	0.5428	2.74	14.2	12.4	13.2	14.4
Maharashtra	1	1	2.27	20.8	20.2	20.7	20.0
Odisha	0.293	0.1316	3.02	18.3	16.4	15.5	14.4
Punjab	0.2078	0.1617	2.15	11.7	14.8	15.3	15.4
Rajasthan	0.5962	0.3666	2.98	19.1	17.8	16.1	16.8
Tamil Nadu	0.9383	0.634	2.27	15.2	14.3	14.7	14.7
Uttar Pradesh	0.8769	0.4097	3.78	16.1	17.1	17.3	16.7
Uttarakhand	0.0709	0.0517	3.55	23.5	22.1	20.7	19.4
West Bengal	1	0.3772	2.74	19.7	19.1	18.1	16.7
All states			3.45	16.6	16.3	16.4	16.2

Source: RBI (2015) and GoI(2014).

Besides technical efficiency, in order to explain the deviations from respective group averages, we explored further by second step. Using various variables which could be considered external to system, we tried this by exploring explanatory variables which included population, rural and urban population separately, per capita income, per capita income growth between two recent years, tap water access index for rural and urban areas, number and percentages of villages electrified, irrigation pumps energized and population density. The results of urban primary and upper primary enrolments deviations depicted significance of different variables. These indicated, for instance, that deviations in efficiency from the group averages of states in case of urban primary enrolments could be explained by means of number of villages electrified and aggregate index for tap water access (Table 7). In case of urban upper primary it could be explained by water access index for urban areas (Table 8). Thus it suggests that basic access to water and electricity helps in improving the overall efforts towards more enrolments and thus achieving higher levels of literacy. This need to be coupled with improvement in efficiency in input usage. The results of our analysis are based on DEA with its inherent limitation that unlike parametric approaches (like stochastic frontier analysis or SFA), it does not provide a norm to compare efficiency and thus a further research using SFA may provide additional inputs towards enhancement of efficiency in education enrolments.

SECOND STAGE REGRESSIONS

Table 7: Dependent Variable: Urban Primary Deviations from Mean

Urban primary deviations Number of obs=19; F(2, 16)=7.18; Prob > F=.006 Adj R-squared =.407; Root MSE=53.264			
devfrommean	Coefficient	t	P>|t|
villages electrified	0.002	3.000	0.009
accessindex	1.117	2.570	0.020
constant	-100.176	-3.420	0.004

Source: Estimated.

Table 8: Dependent Variable: Urban Primary Deviations from Mean

Urban upper primary deviations Number of obs = 19 F(2,16) = 3.40; Prob > F = 0.0589 Adj R-squared = 0.2103; Root MSE = 70.814			
Dev from mean urban upper primary	Coefficient	t	P>|t|
urbantapaccess	1.07823	1.99	0.064
population 2011 rural	7.37E-07	1.56	0.139
constant	-69.1117	-2.21	0.042

Source: Estimated.

CONCLUSION

Increasing literacy in the Indian states is possible by increasing enrolments in elementary education. The later is explored in this study by urban primary and upper primary enrolments. Using a non-parametric approach, namely DEA, the results for these enrolments, we found that many of the states may be able to improve efficiency of input usage or maximise enrolments more efficiently provided that besides better utilisation of inputs, an adequate infrastructure could be expanded which keeps pace with rising population growths in the states. In some areas an additional supportive input, namely, electricity supply for villages may also help in enhancing the objective of increasing elementary education in the states.

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