Benchmarking educational development efficiencies of the Indian states: a DEA approach

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Received 28 April 2010
Revised 20 October 2010
Accepted 9 March 2011

Abstract

Purpose – In pursuit of achieving Education-For-All goals of universal primary education and improving quality of education, the Indian Government has been providing substantial resources to Indian states. The responsibility of providing access and quality remains the states' responsibility. Assessment of educational development will therefore become a focal point of the Center for Education Policy & Guidelines Formulation. While educational development indices help in ranking states, they do not help in capturing best practices and assessing the efficient utilization of resources. Assessment of the Educational Development Efficiency can augment educational development indices in vogue. The purpose of this paper is to develop an Educational Development Efficiency (EDE) model to benchmark the Indian states.

Design/methodology/approach – This paper uses an input-process-output conceptual framework to identify the dimensions of educational development. This paper employs Data Envelopment Analysis (DEA) to compare relative efficiency of 28 states and seven Union territories in India and benchmark them. In order to strengthen the discriminatory power of DEA, cross-efficiency model was used. Factor analysis was performed to determine the inter-relationships between variables. The efficiency impacting variables were identified using multiple regression analysis.

Findings – This paper benchmarked Indian states on educational development based on their performance. Gross enrolment ratio, students' academic performance and infrastructural investments were identified as the three key variables impacting states' EDE. This paper has shown that the educational administrators can use the EDE model to identify the best practices from efficient states. Insights into utilization of input resources to enhance educational development and consequent improvement of state efficiencies are presented. Four components have been identified to analyze the states' educational development progress – namely, financial adequacy, school resource strength, educational quality and educational access.

Practical implications – Contributions of this paper pertain to evolving a decision support model for national education policy planners, besides providing analytic support to the administrators of the states to benchmark and emulate the efficient educational programs.

Originality/value – This paper is one of the few published studies concerning the evaluation of educational development programs launched in the Indian schools and providing a cross-comparison of the Indian states for the purposes of performance benchmarking as well as exploring the influencing factors.

Keywords Educational development, Data Envelopment Analysis, Benchmarking, Policy planning

Paper type Research paper

1. Introduction

In the year 2000, 164 governments along with the partner institutions adopted an implementation framework to achieve all the six goals pertaining to Education-For-All (EFA) initiative. Four of these six goals were related to increasing access to school

International Journal of Educational Management
Vol. 26 No. 1, 2012
pp. 99-130

0951-354X
DOI 10.1108/09513541211194400

education, achieving universal primary education and improving quality of education (UNESCO, 2008). Many countries enacted compulsory education laws to enforce right to education. The success of EFA hinges on transforming education systems through educational development initiatives given political will and adequate financial resources. In the Indian context, education was accorded the status of fundamental right and by 2002 law was amended in the Constitution to the effect of guaranteeing free and compulsory education for children aged 6 to 14 (UNESCO, 2008).

Post Independence, National Education Policy of 1968 marked a significant step in the history of Indian education. Adopting this policy, more than 90 per cent of country's rural habitations have schooling facilities within a radius of a kilometer. However the problem of access, quality, quantity, utility and financial outlay for national education persists (GOI, 1998). Now, through large union budget outlays Indian government expects to not only increase access to but also improve quality of education. 10.7 per cent of government spending has been earmarked for the education sector (UIS, 2007).

As a percentage of population at the typical age of graduation, India reports its Upper secondary graduation ratio at 22 per cent – the least among the 19 World Education Indicator (WEI) countries (UIS, 2006). Continued poor academic performance despite huge financial outlays, has brought the focus onto quality of education through the Right to Education Bill of 2005 and the 11th five year plan (Shah and Agrawal, 2008). *Sarva Siksha Abhiyan* (SSA), meaning Education-For-All, continues to be one of the flagship educational initiatives of the Indian Government in its 11th five-year plan.

Index-based approach for measuring educational development has been attempted in the Indian context (Mehta and Siddiqui, 2009). However, an indicator or index-based approach enables ranking the development initiatives, but not necessarily to benchmark them. Benchmarking requires not only capturing best practices but also analyzing the efficient utilization of resources. Educational development can be envisaged as an input-output multi-dimensional construct, which includes financial, physical and human resources, access to education, quality of education and performance outcomes (both academic and non-academic). Further, exploration of the relationship between various parameters within the construct warrants a non-parametric approach. Therefore, benchmarking educational development can be achieved through an input-process-output efficiency model. We define educational development efficiency (EDE) as adequate and appropriate allocation as well as efficient utilization of resources in order to achieve educational outcomes through effective development and deployment of programs.

In the late nineties, the educational development programs across all the districts in the Indian states were guided by the overall objectives of SSA, which resulted in the formulation of uniform plans across all the states. This, however, did not take into account the state-specific needs. The 11th five-year plan addressed this lacuna by providing a guideline to have a bottom-up approach to educational planning and management – based on state-specific vision and mission. It further emphasized the need for evolving the right metrics for achieving educational goals at the state level (MHRD, 2006). While the Central Government of India continues to provide the financial resources and guidelines, the states are responsible for the design, development and implementation of state-specific educational development programs.

With 28 states, seven union territories (UTs), and 22 official languages (GOI, 2007), Indian states are diverse with reference to a wide-variety of factors such as physical, climate, cultural, demographic, economic, population, ethnical and religious. The diversity of the Indian states is further accentuated by widely varying literacy rates and heterogeneous population, which pose a great challenge to the education policy planners in India. Appendix 1 (Table AI) illustrates Indian diversity in terms of state-specific population, number of schools and average number of teachers per school.

For a diverse nation like India, exploration of the relationship between the input and output parameters germane to educational development warrants the adoption of a non-parametric approach. Since the need is to analyze the performance of the states, this paper treats each Indian state as a distinct entity and employs data envelopment analysis (DEA), a non-parametric approach, to assess the educational development efficiency (EDE) of states and benchmark them. In order to determine the inter-relationship between variables and the impact of variables on the DEA efficiencies (reflecting educational development efficiencies), factor analysis and regression analysis were employed.

The rest of the paper is organized as follows. Section 2 defines educational development. Section 3 surveys the application of DEA in the education sector. Section 4 describes the conceptual framework and the approach to assess educational development for the purpose of benchmarking the states. Section 5 identifies the variables impacting educational development. Section 6 analyzes Indian states' educational development efficiencies and benchmarks the states. Section 7 discusses the variables impacting educational development efficiency. The last section highlights the utility of the conceptual framework developed in this paper from the perspectives of policy planners and administrators.

2. Educational development in India

Owing to her complex and diverse nature, India's achievements in the educational initiatives have been a mixed bag. To place India in an international perspective, while 17 per cent of world's population is in India (World Bank, 2010), yet 46.98 per cent of the world's illiterates are in India (UIS, 2008). Corroborating the illiteracy, 36.66 per cent of the out-of-school children in the world are in India. However on a positive note, India has seen a 69 per cent improvement in the last decade as far as out-of-school children population is concerned and the school life expectancy has gone up by two years during the same period. Number of enrolments and teacher numbers have increased significantly. This improvement in the Indian school going population can be directly attributed to the efforts taken by the 10th and 11th five central year plans – and the states' educational development initiatives.

Dr Abdul Kalam, former President of India, expressed his views on role of education on societal transformation as:

> The whole purpose of education in a country like India is to develop and enhance the potential of human resources and transform it into knowledge society leading to economic growth. Quality teachers and quality content play key roles in such a process (Kalam, 2007).

Raising the levels of enrolment, learning achievement and increased participation of girls dominate the policy agenda of the Ministry of Human Resources Development

(MHRD) in India – despite achieving impressive milestones in the field of elementary education. An overview on the summary of Educational statistics of elementary education in India and the factors impacting educational development in India will give the readers a feel of the challenges in the Indian educational development initiatives.

2.1 Indian elementary education: summary statistics

National University of Educational Planning and Administration (NUEPA) was established by Ministry of Human Resource Development, Government of India in 1969 which was then called National Staff College for Educational Planners and Administrators. NUEPA has been accorded status of a deemed University in the recent past. NUEPA through its District Information System for Education (DISE) – a comprehensive database on elementary education in India provides vital information for policy formulation and for preparation of district elementary education plans. The structure (and volume) of Indian Education system as captured in the DISE is categorized into 28 states and seven Union Territories, 609 Districts, 7115 Blocks, 562,809 Villages, 1,196,663 Schools, 5,218,578 Teachers and 1,79,342,817 enrolled students.

Infrastructure related. The number of schools increased from 853,601 in 2002-2003 to 1,196,663 in 2006-2007. Of these schools, 87.15 per cent are in rural India; 70.12 per cent of primary schools have permanent building. Student-classroom ratio (SCR) has shown improvement. Average SCR seems to be at 40. However some states like Bihar, Jharkhand and West Bengal still have high SCRs at 96, 60 and 51 respectively. Attracting and retaining students can best be achieved by providing good facilities at schools. By 2006-2007, drinking water facility and common toilets increased to 85 per cent and 58 per cent respectively. Number of computers in schools increased dramatically. A total of 13.43 per cent of schools report to have a computer. Maharastra as a state has the highest number of schools with computers (33.42 per cent).

Teacher related. Totally 5.22 million teachers are engaged in imparting elementary education in India. On an average, a school in India has 4.4 teachers. 46.5 per cent of teachers are female. As a direct reflection of increase in teacher volume, the pupil-teacher ratio (PTR) has seen consistent improvement. National average PTR is hovering comfortably in the high 20s. It is expected to improve further with more teachers' training and induction. However some states like Bihar, Jharkhand, Uttar Pradesh and West Bengal still show high average PTR at 54, 45, 50 and 48 respectively.

Enrolment related. The number of schools (360,892 in 2001-2002 to 852,920 in 2005-2006) receiving school development grant and teaching learning material grant have increased admirably. These are predominantly government schools. Majority of the states have utilized more than 90 per cent of the grants received. All these positive improvements in school access, infrastructural, teacher and grant indicators show direct impact on enrolment numbers and academic performance. The enrolment in upper primary classes has increased from a low of 37.72 million in 2004-2005 to 47.49 million in 2006-2007.

Performance related. The academic performance of students as reflected in the examination results also look to be improving. Boys in the primary classes who have passed the exams with more than 60 per cent have risen from 44.96 per cent in 2006-2007 to 48.67 per cent in 2007-2008. Similar statistic about girls stands at 45.12

per cent and 48.80 per cent respectively. When the upper primary academic performance is viewed, there does seem improvement over years however the percentages are lesser than the primary academic performance. Boys in the Upper primary have their performance levels at 38.83 per cent and 43.02 per cent, while the girls are at 40.06 per cent and 44.05 per cent for the years 2006-2007 and 2007-2008 respectively (Mehta, 2009).

2.2 Factors impacting educational development efficiency in India

Despite positive reinforcements through policy and law as initiated by the government of India, India still is short by 125,000 primary schools and 200,000 upper-primary schools (Shah and Agrawal, 2008). By ensuring that these schools are made available, India would then have an appropriate student-classroom ratio, ratio of primary to upper-primary schools.

Some of the key factors impacting educational development in India are: The enrolment ratios vary across states. Indian diversity factor calls for state-specific educational development initiatives. The academic performances of students at the elementary education levels are still far from satisfactory. The Union Budget of India has allocated USD USD 7.3 Bn towards Educational development in the 11th five-year plan. The allocation is expected to increase in coming years. India has the largest student population at 0.14 billion in primary education, China has 0.12 billion pupils (World Bank, 2010).

The four goals of SSA are increase the availability of schools, improve quality of learning, attract more students by providing food and create an environment conducive for education. Lack of facilities would only negatively impact enrolments and to impart quality of education. The access, infrastructure and teacher categories play crucial roles in enhancing Educational Development in India. Shah and Agrawal (2008) indicated that Gross enrolment ratio is a direct measure of extent of access to education for children and performance of students is a direct measure of quality of education imparted.

Student classroom ratio, teacher student ratio, school size and social relations seem to have impact on the students' continuance (survival rate) in a school (Lee and Burkam, 2000). Official statistics from MHRD show serious gaps in terms of universal access to infrastructure of comparable quality, efficiency of schools and improving retention. We have seen that considerable emphasis on decentralized management is gaining ground (Aggarwal, 2000). Decisions need to be made by the smallest operating units possible. Dr Ouchi, a thought leader in the arena of public school management in USA, in an interview with Kleiner (2006), opined that schools needed to be run as business units with principals having autonomy to run them. Performance management of heads and teachers (which includes training, professional development etc.) impact quality of primary education (Brown, 2005). Thus access to education, infrastructure setup, teachers and management components become important input factors affecting Educational Development as a process which impact student learning.

2.3 Education development initiatives: major challenges in India

Participating in education depends on both on the supply of schools and demand needs of students. Vidyashankar and Prakash Sai (2009) present the preference shown for private-schools' over public schools in India. While 7 per cent of schools in India are private they host 40 per cent of enrolled students. On the supply side there is this alarming shortage of number of both, primary and upper primary schools in India (Shah and Agrawal, 2008), but on the demand side, the private schools are preferred over the public schools. The reason for private school preference could be the perception of better quality derived from lesser teacher absenteeism, lower pupil-teacher- ratio, better teacher qualifications, higher number of female teachers and younger teachers (Muralidharan and Kremer, 2006).

Table I outlines the relationship between some of the educational development dimensions and national diversity factors.

Indian multi-dimensional diversity coupled with the magnitude of diverse population, the number of schools and the multi-faceted goal-requirements of educational initiatives makes educational development and its measurement in India a complex exercise. With increasing population, decreased public education expenditure as a percentage of GDP per capita, low EFA Development Index rank, high illiteracy rate and high out-of-school children population – the questions that India is facing are: How much money should be allocated for increasing access and improving quality? How can one efficiently allocate the limited financial resources to meet the magnitude of educational challenge across the diverse Indian states, where each of them are at different levels of educational achievements in terms of access and quality? How can the not-so-well-performing states learn from the best practices of the well-performing-states? This paper makes an attempt to address some of the aforesaid questions.

3. Literature review

Benchmarking, construed as one of the best management practices, enables business units to gain insights into their performance *vis-à-vis* their peer units. It helps the unit to identify key processes for its improvements from the best in the peer group (Lee *et al.*, 2006). Performance benchmarking results can be used by governments and regulators to identify areas of potential performance improvement (George and Rangaraj, 2008).

DEA has been extensively applied for benchmarking purpose and efficiency analyses in banks (Mostafa, 2007), railways (George and Rangaraj, 2008), school districts in Utah (Chakraborty and Mohapatra, 1997), healthcare (Friesner *et al.*, 2005), telecommunication services (Debnath and Shankar, 2008), energy and transport

Table I.
Major challenges in educational development

Major challenges	National diversity factor
Access	Geographic, Demographic, Climatic, Population size
Reach	Economic, Geographic, Demographic
Medium of instruction	Ethnical, Cultural, Language
Teaching standards, teacher availability	Literacy Rates, Ethnical, Cultural, Economic
Teacher-student ratio	Population size, Demographic, Literacy rates
Student-classroom ratio	
Infrastructure implementation	Geographic, Demographic, Population size
Resource requirements	Population size, Demographic
Quality of education	Literacy rates, Religious, Cultural, Population size
Educational measurement	Demographic, Population size, Literacy rates

services (Ramanathan, 2005), resale operations of charity organizations (Joo *et al.*, 2007), primary schools in china (Hu *et al.*, 2009), etc.

Literature review provides insight into efforts taken towards educational development and education production in schools and higher education. Improving the quality of teaching (Ojala and Vartiainen, 2008), access to education, infrastructure setup (Roberts, 2009), administrative services and financial resource utilization (Chakraborty and Mohapatra, 1997; Waldo, 2001), effects of teacher (Silins and Murray-Harvey, 1999) and school leadership (Jacobson *et al.*, 2005) and the same happen to be the key focus areas for educational development in any country.

It is also evident from the body of literature that the schools' effectiveness and efficiency are measured by the output performance of students. Therefore, policy makers and schools must orient their efforts towards launching learner-centric policies and initiatives. It is in this context that Burkhardt *et al.* (1995) presented an organizational framework for restructuring schools.

DEA has been used in the school system to assist schools and school districts from multiple perspectives such as: guiding schools in identifying role-model schools (Thanassoulis, 1996; Thanassoulis and Dunstan, 1994), evaluating operational efficiency and efficient utilization of financial resources (Chakraborty and Mohapatra, 1997; Hu *et al.*, 2009), effect of private schools competition on efficiency in public education (Waldo, 2001, 2002, 2006), evaluating school districts educational performance efficiency (Ruggiero *et al.*, 2002), discussing managerial implications and comparing efficiency of rural vs. urban schools (Soteriou *et al.*, 1998) etc. Appendix 2 (Table AII) presents a representative list of literature survey where DEA has been applied in a school environment.

Education quality involves the input, process and output and multiple constituencies of a school (Cheng and Cheung, 2003). Thus education quality, educational development, school effectiveness, efficiency and performance measurement should therefore consider multiple constituencies, e.g. policy makers, parents, school management, teachers, students etc.). Students' performances in some subjects or tests have been considered as output measures in almost every study, which attempted to measure school effectiveness and educational development. In this context, it may be noted that these studies only differ in the conceptualization of inputs and process variables.

Teacher related variables such as teaching hours, teacher qualification, teacher-student ratio, number of teachers etc. were considered by Mante and O'Brien (2002), Cheng and Cheung (2003), Waldo (2001, 2002, 2006), Fare *et al.* (2006) and Ojala and Vartiainen (2008). Ruggiero *et al.* (2002) and Waldo (2006) considered staff salary as an important component as well. Soteriou *et al.* (1998) and Waldo (2006) included parents' educational qualifications in their assessment of school efficiency in addition to financial resources such as staff salaries, grants utilized for teaching materials, operational costs.

Educational resources such as library books and number of books at home (Soteriou *et al.*, 1998; Hu *et al.*, 2009), school premises (Waldo, 2001) and size (Silins and Murray-Harvey, 1999) contributed towards measuring school performance and effectiveness. Roberts (2009) indicated in his paper that the school infrastructure did not contribute to school effectiveness from the engineering perspective. On the contrary, the infrastructure should be measured from educations' functions viewpoint for determining a correlation to student performance outcome. School leadership was explored by Soteriou *et al.* (1998) and Jacobson *et al.* (2005), in the context of its influence on student performance and school effectiveness.

Aggregated schools' studies were found in Chakraborty and Mohapatra (1997). The study by Chakraborty and Mohapatra (1997) did not confine to the school level – but aggregated to school districts level and assessed the performance and productive efficiency of Public education system across 36 secondary school districts in the USA. Sutherland and Price (2007) correlated institutional indicators with technical efficiency at both school and country level and cost efficiency at country level. They aggregated input institutional indicators into three categories namely:

(1) resource allocation;

(2) budget management; and

(3) market framework.

The output was efficiency scores based on PISA score data.

Though DEA applications in Indian educational set-up are limited (Khan *et al.*, 2008), studies pertaining to DEA for evaluating the efficiency of operations in the higher education context in India can be found. A study focused on integration of DEA and Knowledge management methods for evaluating efficiency of technical education system exists (Wadhwa *et al.*, 2005). Khan *et al.* (2008) studied the service quality evaluation of technical institutions using data envelopment analysis. Debnath and Shankar (2009) applied DEA to assess the performance of Indian B-Schools. This paper contributes to the body of knowledge germane to applying DEA in the context of Indian School Education by assessing the public education system across 609 districts aggregated into 28 states and seven union territories (UTs).

4. Conceptual framework and approach

With an eye to improve educational quality through methods of planned change, Schereens' (2004) depicts education as a productive system in which inputs are transformed to outcomes. He elaborates this input-process-output model by including the contextual dimension which act as the source of inputs. He further states that the "central black box" can be defined at various levels namely, national education system or a school or a classroom. We find in literature that this input-process-output model has been used, with the central "black-box" in some cases being – nations, in some others – districts (Chakraborty and Mohapatra, 1997) and schools in some cases (Thanassoulis, 1996; Thanassoulis and Dunstan, 1994; Cheng and Cheung, 2003).

4.1 Educational development efficiency model

Schereens (2004) model has been adopted in this paper for conducting educational development analysis. The model while defining educational quality provides the efficiency perspective. Since Indian states' constituted the central "black box" in this model, the efficiency thus assessed will directly reflect the efficiencies of the states' progress in educational development. Access to education, infrastructure, teachers and management components have been identified as important input factors affecting educational development in Section 2.2. The need for enhancing enrolment numbers and student learning outcomes within the availability of limited resources has been highlighted in Section 2.3. Figure 1 presents the conceptual framework derived out of Schereens' model for evaluating educational development efficiencies of the states.

4.2 Approach

Efficiency of any entity can be measured either by using a parametric approach or a non-parametric one. While the parametric approach uses econometric methods, the non-parametric approach uses mathematical programming. This paper uses a non-parametric method in data envelopment analysis (DEA).

Benchmarking the Indian states' performance on educational development is a multi-step one. Figure 2 outlines the step-by-step approach taken in benchmarking the Indian states. The conceptual framework defined in section 4.1 and the data sources helped finalize the input and output variables. They were then normalized for alignment to the DEA principles. After determining the efficiencies using DEA, variables impacting the efficiency were analyzed through regression analysis. In parallel, factor analysis was employed to find the inter-relationships between the variables.

The three streams of analysis – DEA efficiencies' calculation, regression analysis and factor analysis, have been undertaken for benchmarking the Indian states; deriving state-level policy directions; and defining state-specific educational development initiatives.

4.3 Introduction to DEA

DEA, a linear programming technique, reports a relative-efficiency score by computing the ratio of outputs to inputs of each entity. In DEA parlance, an entity is often referred to as decision making unit (DMU). DEA has seen great variety of applications for use in evaluating the performances of different kinds of DMUs with different activities in different contexts. The inherent complexity (often unknown) of relationship between

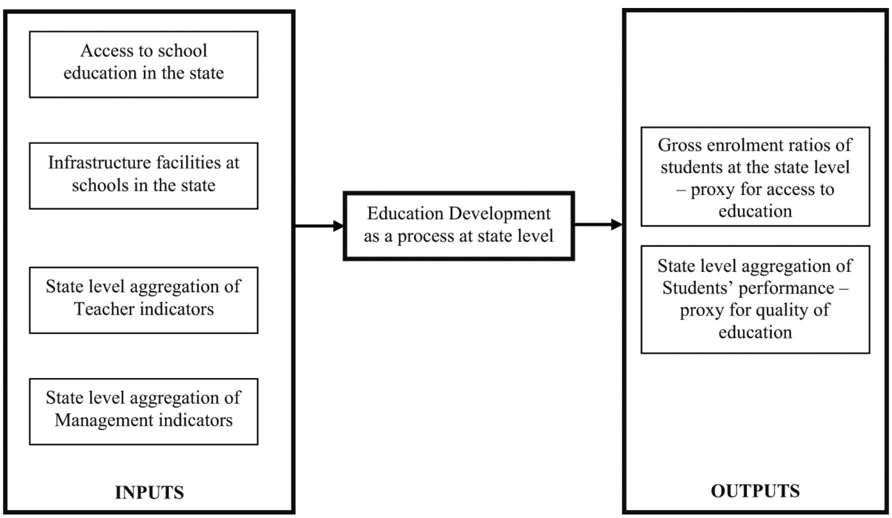

Figure 1.
Educational development efficiency (EDE) model

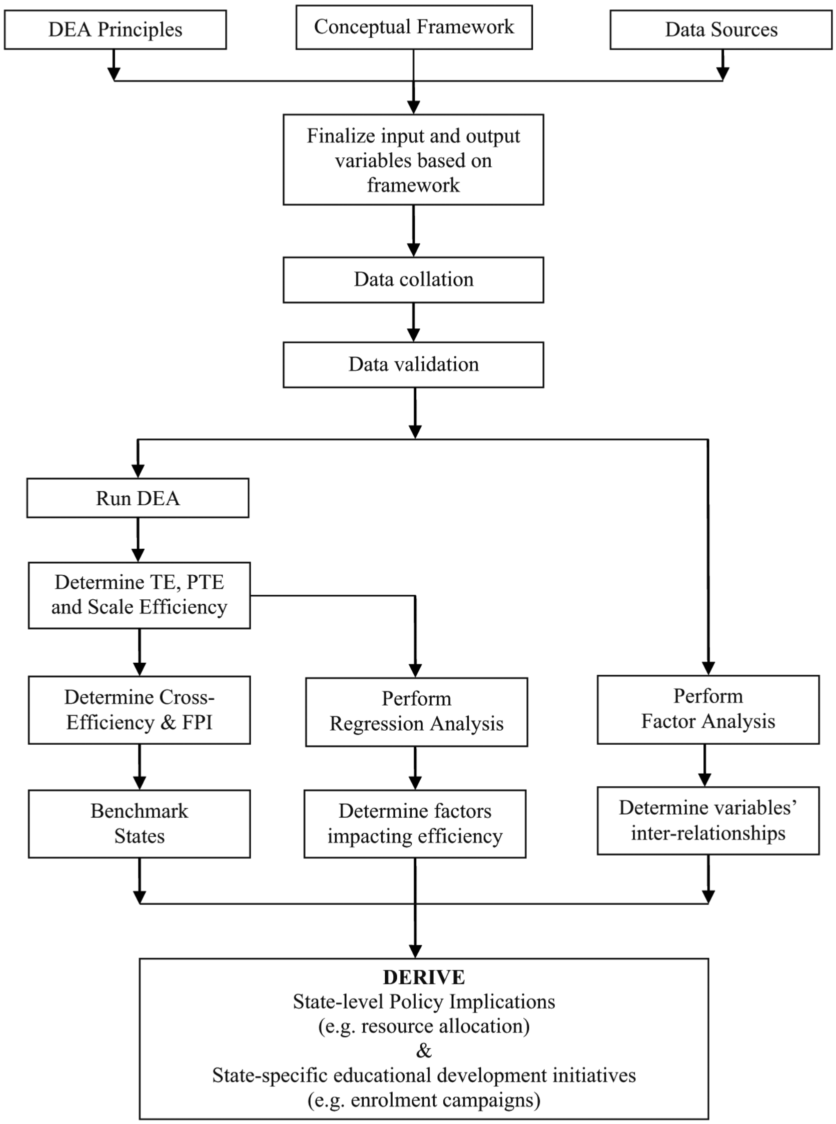

Figure 2.
Step-by-step approach to benchmark Indian states

the inputs and outputs of these DMUs would have rendered it relatively difficult for other approaches to compute efficiency of such DMUs (Cooper *et al.*, 2007).

DEA provides insights into activities and therefore, into workings of DMUs, that have been previously evaluated by other traditional parametric methods. For example, studies of benchmarking practices with DEA have identified sources of inefficiencies in DMUs which otherwise were found efficient through other methods (Cooper *et al.*, 2007). In certain situations, in order to improve discrimination of DMUs, a basic DEA model has to be supplemented with other methods. Most popular concepts for discrimination methods are:

- cross-efficiency approach;
- multi-criteria DEA approach;
- global efficiency approach;
- assurance region method; and
- multi-criteria benefit/cost analysis (Despotis, 2002).

This paper benchmarks India states using DEA scores, scale efficiency scores and the discriminatory power enhancing cross-efficiency scores.

The performance of any DMU, in DEA, is assessed by measuring the key inputs to and outputs from the process under consideration. In this paper, the DMUs under assessment are the states in India and the process under consideration is educational development.

In this paper, global technical efficiency (TE), local pure technical efficiency (PTE), super efficiency, scale efficiency and cross-efficiency models have been employed data analysis.

See Appendix 3 for the basics on data envelopment analysis and the DEA principles employed in this paper.

First, the input-oriented CCR (global technical efficiency, global TE) efficiencies of the states were assessed. This was followed by the input-oriented BCC (pure technical efficiency (PTE)). Input-oriented reduced CCR (super efficiency – RCCR) was then assessed to rank the tied efficient states. In order to determine the source (inherent operations or their respective scale) of inefficiencies in the inefficient states, scale efficiencies (SE) were calculated. The false-positive states were determined using the combination of cross-efficiency scores (CE) and the false-positive index (FPI). CE scores also helped in discriminating the various efficient states.

Data envelopment analysis was done using DEA Excel Solver software (Zhu, 2003). SPSS software was used to carry out the factor and regression analysis.

5. Identification of variables

UNESCO (2008) developed an EFA Development Index (EFADI). The key outcomes represented in this index are net enrolment ratio, literacy rate, gender parity, and survival rate to grade five. While the EFA Index helps in ranking, such indices do not help in identifying the underlying educational factors that contribute towards educational efficiency and effectiveness. Therefore it becomes difficult for the policy makers to determine policies based on indices.

In order to evaluate efficiency of states and benchmark them, it is necessary to have an objective, operational and measurable educational development assessment system which can help in measuring the states' educational development efficiency. The framework for measuring educational development efficiency (EDE), proposed in this paper, augments the Educational Development Index (EDI) developed by Mehta and Siddiqui (2009).

The key difference of the EDE model over EDI model is, that the EDI model ranks the states based on the EDI calculated, whereas the EDE model not only ranks but also benchmarks states with respect to each other based on the efficient utilization of the resources. Additionally, the EDE model helps in providing insights on evaluating the sources of inefficiencies namely, either through scale or due to disadvantageous regional conditions. Identifying the best practices from the efficient states and the slacks in the inefficient states become a possibility. Also, the EDE model helps in understanding and extracting the underlying factors that contribute towards efficiencies. The policy makers can then focus on these underlying factors and make informed decisions on disbursing the limited financial resources.

In order to evaluate the efficiencies of the states in their educational development initiatives, we need a set of input, process and output parameters (variables) which directly reflect the access and quality needs of Indian educational requirement. The 11th five year plan (MHRD, 2006) measures the educational development through various indicators. Mehta and Siddiqui (2009) in their EDI model have used measures to assess the states' educational development indices. Using these two as the base, we have identified a set of input, process and output variables, as shown in Table II, for analyzing the educational development efficiency of the Indian states. Appendix 4 (Table AIV) outlines the alignment EDE variables to DEA principles.

5.1 Input variables of DEA

Number of primary and upper primary schools directly corresponds to the reach that a state has towards the potential student population. Arnab and Anjan (2009) have shown that in the Indian context receiving adequate public funds is important for proper functioning of the schools. From the norms of financial interventions under SSA, SDGR and TLMGR are directly related to public funds allocated to the schools.

Muralidharan and Kremer (2006) indicates that a low pupil-teacher ratio, number of female teachers and trained teachers increase have a direct bearing on the learning outcomes. In addition to pupil-teacher ratio, we have also included

Categories	DEA variables	Description
ACCESS (Input)	NUMSCH000	# of primary schools per 1,000 population
	NUMSCHUP000	# of upper primary schools per 1,000 population
INFRASTRUCTURE (Input)	PERWTOBC	Percentage of schools having the appropriate infrastructure – water, toilet, *pucca* building and computer
	ASCR	Average student classroom ratio
TEACHER (Input)	FEMTEA	Percentage of female teachers
	APTR	Average pupil teacher ratio
	QUALTEA	Percentage of teachers with graduate and higher qualifications
MANAGEMENT (Input)	TRAINTEA	Percentage of professional trained teachers
	SDGR	Percentage of schools which received School development grant
	TLMGR	Percentage of schools which received Teaching learning material grant
OUTCOMES (Output)	GER	Gross Enrolment Ratio (total enrolment divided by population)
	PERPASS60	Percentage of students who have passed with marks over 60 per cent

Table II.
Input and output variables in the EDE model

student-classroom-ratio as an input variable to strengthen the assessment of quality aspect of education as this corresponds directly to the quality of teaching and degree of individual attention that a teacher can exercise towards students. These input variables are in direct relevance to the goals of flagship education initiative (SSA) of the 11th five year plan.

Number of schools per thousand (NUMSCH000, NUMSCHUP000). This is the number of schools at primary and upper primary level per every thousand population in each state.

Infrastructure setup (PERWTOBC). This is the number of schools in each state which have appropriate infrastructure setup. The infrastructure components include schools with proper building structure, computers, drinking water facility and toilet facilities. The input is represented in percentage.

Average student-classroom ratio (ASCR). Student-classroom ratio (SCR) is a ratio between total enrolments in a school to total number of classrooms in that school. Average student-classroom ratio is the average SCR across the schools in the state.

Number of female teachers (FEMTEA). Total number of female teachers in the state. This is represented as a percentage. This is derived by dividing the total number of female teachers from the total number of teachers in the schools – aggregated at the state level.

Average pupil-teacher ratio (APTR). Pupil-teacher ratio (PTR) is a ratio between total enrolments in a school to total number of teachers in that school. Average pupil-teacher ratio is the average PTR across the schools in the state.

Teacher qualification (QUALTEA). This input variable indicates the number of teachers in schools with graduate and higher qualification aggregated to the state level. This is represented in percentage.

Trained teachers (TRAINTEA). This indicates the number of teachers who received in-service training during the previous academic year across the state. This is represented in percentage.

School development grant (SDGR). Number of schools in the state that received school development grant. These are funds provided for school infrastructure development and replacement of non-functional school equipment. This is represented in percentage.

Teaching-learning material grant (TLMGR). Number of schools in the state that received teaching-learning material grant. These are funds provided to a school for pedagogical development and teacher training related activities. This is represented in percentage.

5.2 Output variables of DEA

We have used GER and number of students with examination scores over 60 per cent as the output variables which reflect the goals of SSA and also a part of EFA Index.

Enrolment (GER). One of the important indicators of educational development is the total number of students who have enrolled. Gross enrolment ratio acts as proxy for enrolment and is the ratio between total enrolments to total population in that age group.

Students' performance (PERPASS60). Performance of students is measured by the marks that they have scored in their final exams in their respective classes. It is understood that higher the marks secured, better is the quality of education imparted in the school. This output variable captures the number of students who have scored more than 60 per cent in their examinations. This is represented in percentage aggregated at the state level.

5.3 Variables for factor analysis and regression analysis
The DEA-EDE input and output variables from Table II were considered for performing the factor analysis. For the purpose of multi-regression analysis, global technical efficiency (CCR-I) was used as the dependent variable and the DEA-EDE input variables and output variables were treated as independent variables.

The output of DEA, factor analysis and regression analysis are presented and discussed in the next two sections.

6. DEA results and discussion

Global technical, pure technical, scale, super and cross-efficiencies constitute the DEA output. Table III shows CCR-I, BCC-I, SE, RCCR, CE and FPI values for all the Indian states and Union Territories.

6.1 Global, pure technical and scale efficiency analyses
Three categories are evidenced from Table III. The discriminatory characteristics are defined primarily around CCR-I efficiencies and secondarily around BCC-I efficiencies. States in the first category have low TE. The characteristics of this category fulfill any one or all of the following conditions: $TE < 0.5$, $PTE <= 1$ and $SE < 0.5$. States in the second category exhibit any one of the following conditions: TE values higher than 0.5 but not 1, $PTE = 1$ and SE values lie between 0.5 and 1. The last category states are fully efficient. These states have TE and PTE values as 1. Table IV shows the mean values of variables in each of the three categories.

Almost all of the states show relatively good (local) pure technical efficiency and the first two category states show relatively poor global technical efficiency (thru scale of operations) when compared to the third category. The first two category states' PTE values clearly indicate that they are using their local resources well for, e.g. hiring teachers from the local region, procuring water and other infrastructure related resources from local region.

Category 1 states. States in this category display very poor global technical efficiency (TE) mainly contributed by their poor usage of regional conditions (scale of operations). However, these states do have relatively good (local) pure technical efficiency (PTE). Six of the states (Assam, Bihar, Daman & Diu, Goa, Meghalaya and Uttar Pradesh) have their PTE at 1 meaning they are operationally fully efficient.

The states in this category utilize either higher infrastructural resources namely, number of schools, water facilities, school building facilities, computers (PERWTOBC) or use higher percentage of teachers with professional qualifications (QUALTEA) and yet have low enrolment rates (GER3) and poor percentage of students scoring more than (PERPASS603) 60 per cent. For, e.g. Uttar Pradesh, Goa and Haryana have similar utilization levels of Infrastructure as that of Karnataka (which is in category 3). Goa has better ASCR, APTR and Number of qualified teachers than Karnataka. Haryana is comparable with Karnataka in the ASCR and APTR count and is better in the number of qualified teachers. Yet we find these states in the low efficiency category. The reasons for the lower efficiencies of these states are that their efforts towards

Table III. Efficiencies of Indian states

DMUs	CCR-I	BCC-I	SE	RTS	RCCR	CE	FPI
Andaman Nicobar Islands	0.6759	1.0000	0.6759	Increasing	0.67592	0.4237	1.5952
Andhra Pradesh	1.0000	1.0000	1.0000	Decreasing	1.08492	0.6627	1.5090
Arunachal Pradesh	1.0000	1.0000	1.0000	Decreasing	1.29216	0.4026	2.4840
Assam	0.3396	1.0000	0.3396	Increasing	0.33960	0.1950	1.7418
Bihar	0.2065	1.0000	0.2065	Increasing	0.20646	0.1154	1.7889
Chandigarh	1.0000	1.0000	1.0000	Increasing	1.44712	0.4327	2.3108
Chhattisgarh	0.4749	0.9691	0.4900	Increasing	0.47486	0.2703	1.7567
Dadra & Nagar Haveli	0.9499	1.0000	0.9499	Increasing	0.94989	0.3335	2.8482
Daman & Diu	0.4595	1.0000	0.4595	Increasing	0.45947	0.2419	1.8991
Delhi	1.0000	1.0000	1.0000	Increasing	1.42140	0.6896	1.4501
Goa	0.3626	1.0000	0.3626	Increasing	0.36260	0.2237	1.6207
Gujarat	0.5529	0.9932	0.5566	Increasing	0.55286	0.3428	1.6126
Haryana	0.3752	0.9491	0.3954	Increasing	0.37524	0.2159	1.7381
Himachal Pradesh	1.0000	1.0000	1.0000	Decreasing	1.77366	0.6832	1.4636
Jammu & Kashmir	0.6887	1.0000	0.6887	Increasing	0.68873	0.3345	2.0592
Jharkhand	0.1983	0.9833	0.2017	Increasing	0.19831	0.1047	1.8932
Karnataka	1.0000	1.0000	1.0000	Constant	3.31789	0.8311	1.2032
Kerala	0.9353	1.0000	0.9353	Increasing	0.93527	0.5271	1.7744
Lakshadweep	0.8283	1.0000	0.8283	Increasing	0.82830	0.5076	1.6319
Madhya Pradesh	0.6269	0.9024	0.6947	Increasing	0.62688	0.3413	1.8366
Maharashtra	0.8208	1.0000	0.8208	Increasing	0.82079	0.5088	1.6134
Manipur	1.0000	1.0000	1.0000	Constant	1.22881	0.4503	2.2208
Meghalaya	0.4022	1.0000	0.4022	Increasing	0.40224	0.1539	2.6131
Mizoram	1.0000	1.0000	1.0000	Decreasing	1.78961	0.4194	2.3843
Nagaland	1.0000	1.0000	1.0000	Constant	2.31363	0.6670	1.4993
Orissa	0.1553	0.9984	0.1556	Increasing	0.15534	0.0873	1.7792
Puducherry	1.0000	1.0000	1.0000	Constant	1.25153	0.6976	1.4334
Punjab	0.3032	0.9250	0.3278	Increasing	0.30320	0.2005	1.5124
Rajasthan	0.8367	1.0000	0.8367	Increasing	0.83672	0.4119	2.0316
Sikkim	1.0000	1.0000	1.0000	Increasing	2.39538	0.5020	1.9918
Tamil Nadu	1.0000	1.0000	1.0000	Decreasing	1.67206	0.9446	1.0587
Tripura	1.0000	1.0000	1.0000	Increasing	1.00849	0.5183	1.9293
Uttar Pradesh	0.3467	1.0000	0.3467	Increasing	0.34669	0.1738	1.9952
Uttarakhand	0.2453	0.9404	0.2608	Increasing	0.24526	0.1523	1.6106
West Bengal	0.6350	1.0000	0.6350	Increasing	0.63503	0.2757	2.3031

Mean values of variables and TE	DEA efficiencies (TE, PTE and SE) TE < 0.5, PTE <= 1, & SE < 0.5 Category 1	0.5 < TE, SE < 1& PTE < = 1 Category 2	TE, PTE, SE = 1 Category 3
Number of primary schools per 1,000 population	11.75	9.30	13.85
Number of upper primary schools per 1,000 population	6.17	6.50	7.85
Infrastructure (%)	72.28	65.64	50.11
Average student-classroom ratio	37.08	30.30	23.46
Average pupil-teacher ratio	31.75	28.20	20.69
Female teachers (%)	42.95	46.07	50.18
Qualifications of teachers (Grad and Above) (%)	50.53	46.79	57.98
Trained teachers (%)	69.80	84.84	67.45
School development grant (% of schools)	75.58	86.78	76.61
Teaching-learning materials grant (% of schools)	72.18	86.06	69.06
Students' scores of 60% and above (%)	29.45	44.38	37.67
Gross enrolment ratio	55.71	72.65	85.95
Global technical efficiency	0.32	0.76	1.00
States	Orissa, Jharkhand, Bihar, Uttarakhand, Punjab, Assam, UP, Goa, Haryana, Meghalaya, Damn and Diu, Chattisgarh	Gujarat, MP, WB, Andaman and Nicobar, J &K, Maharshtra, Lakshadweep, Rajasthan, Kerala, Dadra & Nagar Haveli	Andhra P., Arunachal P., Chandigarh, Delhi, HP, Karnataka, Manipur, Mizoram, Nagaland, Puducherry, Sikkim, TN and Tripura

Table IV.
Three categories, mean values of variables and DEA Categories

educational development namely enrolment and academic performance are poor when compared to Karnataka. Since the educational quality criteria namey ASCR, ASCR, teachers' availability and their qualifications, are comparable to a state in the Category 3, the focus in these states, therefore need to be on teacher training and enabling teachers in developing teacher learning material resources through TLMGR, for enhancing student learning outcomes and on improving enrolment.

By and large, category 1 states show poor enrolment numbers as well as lower academic performance results when compared to other two categories. The reasons for that can be directly attributed to under service in educational access. The number of schools when compared to the population size is glaring when we compare this with Categories 2 and 3. This therefore is further reflected in higher student classroom ratio and pupil teacher ratio – the school performance enhancing variables. Due to this large gap between supply side (number of schools) and demand side (population), the other school performance enhancing dimensions namely number of female teachers and their corresponding qualifications also needs special attention. Therefore Category 1 states need to focus both on educational access (through building more schools) and on educational quality by having more qualified and trained teachers.

Category 2 states. Almost all of the states in this category are locally fully efficient except Gujarat and Madhya Pradesh. But all are globally inefficient only because of their disadvantageous regional conditions (suboptimal scale size). The reasons for local inefficiencies of Gujarat and Madhya Pradesh are contrasting: While Gujarat inefficiency stems from its poor enrolment numbers (17.85 per cent below category mean), Madhya Pradesh's inefficiency stems from poor academic performance (24.33 per cent below the category mean).

In this category Kerala and Dadra & Nagar Haveli needs notice. They are the only states in this category with TE in the 1990s. The outputs of Kerala are relatively on par with Delhi (Category 3) and Dadra & Nagar Haveli's inputs (except infrastructural variables) are relatively on par with Karnataka (Category 3). Kerala's efficiency could have been better had it used lesser resources (SDGR and TLMGR) than Delhi as evidenced by scale being its inefficiency contributor to its TE. Dadra & Nagar Haveli's efficiency could have been better had it shown higher enrolment numbers or higher academic performance. We could possibly deduct that if Dadra & Nagar Haveli improves its infrastructural facilities then enrolments could go higher and thereby could improve its TE. The number of teachers with qualifications equivalent to graduate and higher is low. This is reflected in poor academic performance results which in turn affects the school efficiency. The states in this category need to focus on hiring teachers with the right qualifications.

Looking at Category 2 states we see that they use higher infrastructure resources, school development grant and teacher learning material grant and even have around 6.5 per cent higher quality learning outcomes than Category 3 states. Yet, the mean TE of Category 2 is 24 per cent lower than the Category 3 states. The lower TE is mainly contributed by the 13.3 per cent lower gross enrolment ratio (GER) value of category 2 states. The lower GER is because of two reasons: first, category 2 states have comparable number of schools as that of category 3, but their population is almost three times category 3 states. We can therefore conclude that Category 2 states' focus be on increasing the enrolment efforts. They also need more schools than Category 3, to increase educational access to the population.

It is also evident from Table III – that all the states in Categories 1 & 2 show increasing return to scale indicating the possibility of increasing efficiencies by increasing their scale of operations.

Category 3 states. The 13 states in this category are both globally and locally efficient. One can notice that almost all of the 13 states/UTs show high enrolment and better academic performance characteristics except Manipur, Mizoram and Sikkim. These states however show relatively higher enrolment numbers.

Out of the 13 states in this category, four of them (Karnataka, Manipur, Nagaland and Puducherry) show constant- returns-to-scale (CRS), four of them in the increasing-returns-to-scale (IRS) and the remaining five show decreasing-returns-to-scale (DRS). The four states in CRS are operating at most-productive-scale-size (MPSS) – which means that their input resources or outputs can be scaled linearly without altering their efficiencies. Andhra Pradesh, Arunachal Pradesh, Himachal Pradesh, Mizoram and Tamil Nadu have decreasing returns to scale meaning, while they can improve their efficiencies by decreasing their scale of operations. Chandigarh, Delhi, Sikkim and Tripura can improve their efficiencies further by increasing their scale of operations as they indicate increasing returns to scale.

The states in this category have relatively lower ASCR and APTR and they use lesser grants. While their enrolment ratios are higher, their academic performance is around 7 per cent below the Category 2 states. When we look at the individual input variables which directly relate to quality of educational performance, we find that Category 3 states have lower percentage of trained teachers (17.39 per cent lower) and the grants utilized for teaching-learning materials development (17 per cent lower). Focus for the category 3 states need to be on academic performance with specific attention towards teacher training and teaching materials development.

6.2 Super-efficiencies and cross-efficiencies' analyses

The super efficiency (RCCR) model helps in ranking the efficient Category 3 states. Using the RCCR efficiency scores one can conclude that Karnataka is the best among the efficient states in its efforts towards educational development. Tamil Nadu has a relatively good RCCR score. Yet as rightly indicated in the RTS column as decreasing this state can improve its efficiency further by decreasing their scale of operations as it uses relatively high input resources.

Of the 13 fully efficient states/UTs, Tamil Nadu seems the most efficient. This is proved by shifting the focus to its peer-appraisal (or CE) efficiency score from self-appraisal efficiency (TE) score. One can see that the distance between its CE and TE scores is the least (0.0554) when compared to the other efficient states. Karnataka stands next in that list with its CE distance from TE at 0.1689. False-positive Index (FPI) computation helps us to determine which of those efficient states benefited the most through this peer-appraisal. Arunachal Pradesh, Chandigarh, Manipur and Mizoram have been benefited the most through peer-appraisal. This means that, these four states are the least efficient amidst the 13 efficient units.

6.3 DEA summary

In summary, we feel that the Category 1 states need to focus both on enrolment and educational performance, Category 2 states need to have their primary focus on increasing their enrolment efforts and the primary focus for Category 3 states will be enhancing the educational performance.

Among the states in Category 3, Andhra Pradesh, Karnataka and Tamil Nadu, which are fairly large in size and have high literacy rates, can be used by policy makers and administrators as reference states in relation to how they have achieved higher enrolment and academic performance for a given utilization levels of infrastructural and teacher resources. Category 3 states can increase their quality of learning outcomes by focusing on teacher training initiatives as evidenced from the teacher-learning material grant variable.

7. Variables impacting EDE: analysis and discussion

Factor analysis depicts the inter-relationships between the variables. Regression analysis helps in identifying the variables impacting the educational development efficiency.

7.1 Factor analysis

The Bartlett's test for sphericity revealed that the (chi-square value = 253.561, df = 66 and $p < 0.001$) variables are correlated. The appropriateness of using factor analysis on the data set was further tested by performing Kaiser-Meyer-Olkin test (KMO test). The KMO measure of sampling adequacy (0.613) does indicate applicability of factor analysis. Tables V and VI present the factor analysis output and the derived four components.

The four components are:

(1) financial adequacy;

(2) school resource strength;

Rotated component matrix	Rescaled component 1	2	3	4
Number of primary schools per 1,000 population	0.142	0.053	0.253	0.949
Number of upper primary schools per 1,000 population	0.035	0.092	0.115	0.806
Infrastructure	0.207	0.834	0.313	0.19
Average student-classroom ratio	−0.049	−0.095	0.713	0.251
Average pupil-teacher ratio	0.063	0.11	0.708	0.446
Female teachers	0.124	0.600	−0.231	−0.448
Qualifications of teachers (grad and above)	−0.29	0.644	−0.371	0.29
Trained teachers	0.604	0.686	0.072	−0.067
School development grant	0.922	0.172	−0.065	0.052
Teaching-learning materials grant	0.917	0.064	−0.054	0.083
Students' scores of 60% and above	0.439	0.544	−0.075	0.091
Gross enrolment ratio	0.125	0.017	−0.91	0.012

Notes: Extraction method: Principal component analysis; Rotation method: Varimax with Kaiser normalization

Table V. Factor analysis

Underlying correlated variables for the four components			
School development grant Teacher learning material grant	Infrastructure Female teachers Qualification of teachers Trained teachers	Average SCR Average PTR GER	Num primary schools Num upper primary schools
COMPONENT 1 Financial adequacy	COMPONENT 2 School resource strength	COMPONENT 3 Educational quality	COMPONENT 4 Educational access

Table VI. The four components

(3) educational quality; and
(4) educational access.

Financial adequacy. The correlated variables which contribute towards this component are:

- allocation and utilization of school development grant (SDGR); and
- allocation and utilization of teacher- learning material grant (TLMGR).

According to the SSA financial norms, SDGR is used towards school infrastructure development and maintenance. TLMGR is used towards teaching-learning material development for the schools.

School resource strength. The correlated variables of this component are:

- number of female teachers;
- qualifications of teachers (higher than graduate);
- number of trained teachers; and
- infrastructure (water, toilet facilities, computer facilities and pucca building).

Educational quality. The correlated variables of this component are: Student-classroom ratio (SCR), Pupil-teacher ratio (PTR) and Gross enrolment ratio.

Educational access. The correlated variables of this component are: Number of primary schools and number of upper primary schools.

Educational administrators and policy makers can use the above four components to assess the states' progress in achieving the educational development goals of access and quality. For, e.g. one of the policy measures for addressing the educational access component could explore public-private-partnership (PPP) models. In several states in India, private players have been involved in setting up schools or managing the existing public schools where the school-to-population ratio is higher than 1:1000 (14 out of the 35 states have such a high school-to-population ratio). By increasing the number of schools, the SCR, PTR and GER will also improve in these states. Rajasthan is one such state with a ratio of 1:1163. This state has invited applications for establishment, management and operations of 50 senior secondary schools through PPP on design, build, finance, manage, operate and transfer (DBFMOT) basis (GOR, 2010).

Similarly, policy measures addressing the financial adequacy component could take into account effective allocation and distribution of funds. Hanushek (2003) indicated that more than increasing infrastructural resources, improving teacher quality has direct positive impact on educational academic performance. Thus, by keeping the allocation to the school development grant at a given level and by enhancing the teaching-learning materials grant, teacher quality can be improved, which in turn will have a positive impact on student's academic performance.

7.2 Regression analysis

Regression analysis indicates that the three important variables that impact the efficiency of the states' educational development initiatives are gross enrolment ratio (GER), percentage pass of students above 60 per cent and infrastructure. Table VII shows the regression results.

Gross enrolment ratio (GER) has been positively correlated with global technical efficiency. Though the out-of-school children population in the age group of 6 to 14 in India has been steadily coming down, the number still stands at 8.1 million children (TOI, 2009). Further, we notice from the DEA efficiency analysis that out of the 35 states – four of them are in decreasing returns to scale and four of them are at increasing return to scale. This indicates that majority of the states by merely focusing on increasing enrolment – can not only contribute towards nation's educational development but by doing so – will also increase their respective educational development efficiencies.

Students' score of 60 per cent and above percentage of marks positively influences global technical efficiency. The core mission of a school is to ensure access to education with good educational quality. Students' performance is a key measure of the educational quality. This regression result shows that academic performance has a positive correlation to the global technical efficiency. This thus reflects the importance of improving the quality of education through variables which improve academic performance namely teachers' quality, TLMGR etc. Just like GER, if the states focus on improving academic performance, then not only the overall educational quality gets a fillip, but so does their educational development efficiencies. The 11th five year plan has sanctioned 1,005,355 new teachers to be hired (MHRD, 2006).

Infrastructure negatively impacts the global technical efficiency. For a given infrastructural investment, it is important to focus on maximize enrolment and academic performance. In the 11th five-year plan, the Government has sanctioned for 222,297 new primary and upper primary schools, 670,189 additional classrooms (MHRD, 2006). All of these efforts towards enhancing infrastructure have been focused towards reducing the out-of-school children – which in turn enhances GER. Arnab and Anjan (2009) opined that adding larger amounts of funding for school infrastructure development diminished the effect of educational improvement. Hanushek (2003) added: "more than the school resources, what matters more for enhancing academic performance is teacher quality."

Regression results enumerated the focus areas for the Indian educational development initiatives. Being a very diverse nation with fairly large educational deficit, Indian education system should strive to provide educational opportunities for its burgeoning population and at the same time focus on the quality of education.

8. Conclusion

Indian education has often been termed the largest social sector, which needs large-scale, multi-pronged and multi-layered development programs. This study

		Unstandardized coefficients		Standardized coefficients		
Dependent	Independent	B	SE	Beta	*t*	Sig.
Global technical efficiency	Constant	−0.191	0.149		−1.285	0.208
	GER	0.012	0.002	0.648	6.902	0.000
	Students' score > = 60%	0.008	0.002	0.420	4.147	0.000
	Infrastructure	−0.004	0.001	−0.371	−3.610	0.001

Table VII. Results of multi-regression analysis established that different Indian states are at different levels of achieving the educational development and the Education-For-All (EFA) goals. The Central Government provides the necessary financial resources and guidelines towards educational development initiatives. It is the states' responsibility to meet the goals of educational access and quality. With the differing levels of states' educational development progress, assessing and analyzing the efficiency in allocation and utilization of the resources across states towards goals' attainment will remain a constant challenge for the Indian educational policy makers and the state administrators. This paper presents a framework for not only benchmarking the efficiencies of the states, but also in analyzing the contributing factors towards those efficiencies. This study establishes that educational development initiatives across states can be evaluated by employing input-process-output framework.

With access, infrastructure, teacher and management as the four input categories, educational development as a process, enrolment numbers and academic performance as outcome representatives, this paper evaluated the educational development efficiency (EDE) of Indian states and benchmarked them. Further, the EDE impacting factors were also identified. Such benchmarking of states using EDE will help increase accountability and transparency of the educational administrators.

While it is important to view each state independently and devise appropriate state-specific policies and educational development initiatives – the Ministry of Human Resources & Development (MHRD) should not lose sight of the best practices in the efficient, well-performing states so that these states can act as peer-states for inefficient states. This study helps MHRD in not only identifying such efficient peer-states, but also helps analyze the states' educational development progress across four components namely, financial adequacy, resource strength, educational quality and educational access.

To summarize the efficiency analysis across the states in India, we find that the south Indian states Andhra Pradesh, Karnataka, Kerala and Tamil Nadu are efficient in their contributions towards national educational development. The eastern states namely, Assam, Bihar, Jharkhand and Meghalaya seem to be the laggards. The eastern states Manipur, Mizoram, Sikkim and Tripura though are fully efficient yet when subjected to peer-appraisal tend to lag behind their peers. The northern and western states seem to perform moderately.

Our conclusion is that the major contributors to the efficiencies of states in their educational development initiative are the gross enrolment ratio and the academic performance (educational quality) outcome in the states and the major deterrent to the efficiencies of the states is the utilization of infrastructural resources. The schools' management can be urged to hire more qualified teachers and train them after identifying the necessary training needs which in turn enhance the academic performance. With greater teacher quality in schools, the schools would be able to attract and retain more children – thus having a direct positive impact on the Gross enrolment ratio as well. Policy planners need to pay greater attention to the provision of teaching-learning development as evidenced from the negative influence of infrastructure on the school efficiency.

Implications from our study are: Even though efforts to increase access and quality are equally important in India, currently there seems to be increased attention to infrastructural initiatives as is evident from the financial norms and sanctions in the

11th five year plan. Our view is that one could cap the funds allocated directly toward infrastructure enhancement and development and allocate the released funds towards educational initiatives which have direct impact on enrolment and academic performance. For, e.g. With the perception of private schools providing higher quality in education (Muralidharan and Kremer, 2006) devising initiatives for encouraging partnership-participation of private players in the management of government-managed and aided schools as Vidyashankar and Prakash Sai (2009) indicated that 7 per cent of schools in India are private hosting 40 per cent of enrolled students. This could increase the enrolment in the government-managed and government-aided schools.

The educational development efficiency model proposed in this paper can serve the following objectives: the national educational administrators can benchmark states and devise appropriate educational development guidelines for states to follow; state-level educational administrators can learn from peer states' best practices and also initiate appropriate state-specific educational development projects. This model can also help the school-administrative heads to focus on those school-specific-resources which positively impact schools' enrolment and academic performance.

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Appendix 1

State	Number of schools	Average number of teachers per school	Literacy rate	Population	Area (sq.km)	GDP contribution
Andaman Nicobar	350	10.1	81.3	3,56,152	8,249	15,620
Andhra Pradesh	100,932	5.1	60.47	7,62,10,007	2,75,068	26,91,730
Arunachal Pradesh	3,412	3.8	54.34	10,97,968	83,743	22,620
Assam	63,996	3.5	63.25	2,66,55,528	78,483	5,75,970
Bihar	54,884	4.3	47	8,29,98,509	94,164	7,96,820
Chandigarh	178	30.1	81.94	9,00,635	144	98,720
Chhattisgarh	48,968	3.2	64.66	2,08,33,803	1,35,194	5,19,210
Dadra and Nagar Haveli	276	3.8	57.63	2,20,490	491	7,001
Daman and Diu	86	7.4	78.18	1,58,204	122	5,028
Delhi	4,742	19.8	81.67	1,38,50,507	1,483	10,53,850
Goa	1,420	4.8	82.01	13,47,668	3,702	1,24,000
Gujarat	38,472	5.6	69.14	5,06,71,017	1,96,024	21,66,510
Haryana	16,980	4.8	67.91	2,11,44,564	44,212	10,06,760
Himachal Pradesh	16,614	3.6	76.48	60,77,900	55,673	2,54,350
Jammu and Kashmir	20,711	4.9	55.52	1,01,43,700	2,22,236	2,42,650
jharkhand	40,618	3.2	53.56	2,69,45,829	79,700	6,29,500
Karnataka	55,364	4.5	66.64	5,28,50,562	1,91,796	17,50,930
Kerala	12,183	10.5	90.86	3,18,41,374	38,863	13,27,390
Lakshadweep	30	13.9	86.66	60,650	32	1,909
Madhya Pradesh	125,858	3.2	63.74	6,03,48,023	3,08,144	11,85,860
Maharashtra	86,430	6.4	76.88	9,68,78,627	3,07,713	43,24,130
Manipur	3,869	5.9	70.53	22,93,896	22,327	64,380
Meghalaya	9,268	3.2	62.56	23,18,822	22,429	70,520
Mizoram	2,782	5.8	88.8	8,88,573	21,081	29,850
Nagaland	2,537	8.3	66.59	19,90,036	16,579	53,460
Orissa	51,198	2.9	63.08	3,68,04,660	1,55,707	7,14,280
Puducherry	668	11.4	81.24	9,74,345	492	64,570
Punjab	20,950	4.1	69.65	2,43,58,999	50,362	10,47,050
Rajasthan	100,965	3.9	60.41	5,65,07,188	3,42,236	12,41,990
Sikkim	1,226	8	68.81	5,40,851	7,096	20,400
Tamil Nadu	52,423	6.9	73.45	6,24,05,679	1,30,058	24,62,660
Tripura	3,679	8.4	73.19	31,99,203	10,492	66,010
Uttar Pradesh	168,969	3.6	56.27	16,61,97,921	2,38,566	27,37,850
Uttarakhand	19,161	2.6	71.62	84,89,349	53,566	2,57,760
West Bengal	67,265	3.9	68.64	8,01,76,197	88,752	23,60,440

Source: Economic Survey (2008)

Table AI.
Diversity of India in numbers

Appendix 2

Author(s)	Input variables	Output variables	Focus of the article
Thanassoulis and Dunstan (1994)	Mean verbal reasoning score per pupil on entry Percentage of pupils not receiving free school meals	Average GCSE score per pupil Percentage of pupils not employed after GCSEs	To guide secondary schools to improved performance through role-model identification and target setting
Thanassoulis (1996)	Mean verbal reasoning score per pupil Percentage of pupils not receiving free school meals	Average GCSE score per pupil Percentage of pupils placed after GCSEs	To guide secondary schools to be aware of the differential effectiveness of other schools and to redress their imbalances in their effectiveness
Chakraborty and Mohapatra (1997)	Teacher student ratio % of teachers with MA or PhD degree Expenditure per "average daily membership (ADM)" other than staff salary Net assessed value per ADM % of student buying their own lunch	Average scores in basic battery test Mathematics Reading Language/English Science Social Science	Performance and productive efficiency of US Public education system across 36 secondary school districts
Soteriou *et al.* (1998)	Age of teacher Education level of teacher Parents' education Socioeconomic status School size Number of books at students' home	International mathematical score	Efficiency of schools in Cyprus and discusses managerial implications. Also compares rural and urban area schools
Mante and O'Brien (2002)	Staff pupil ratio Adjusted special learning needs (SLN) index	Proportion of students with tertiary entrance rank (TER) scores >= 50 Year 12 apparent retention rate	To provide a new methodology to measure relative technical efficiency of state secondary schools in Australia
Waldo (2001)	Number of teachers Money spent on teacher material School premises Parents education	# of students passing all subjects # of students attending higher education	Influence of teacher characteristics and private school competition on efficiency of public education (Swedish national board)
Ruggiero *et al.* (2002)	Entry teacher salaries Enrollment % female headed households % handicapped students % limited English proficiency % high school students	Pupil evaluation program (PEP) scores % receiving Regent diploma % non-dropouts	To provide a framework for measuring outcome equity of school districts

Table AII.
A list of DEA publications related to studies on school efficiency

(*continued*)

Author(s)	Input variables	Output variables	Focus of the article
Waldo (2002)	Teaching hours Special needs teaching Number of students Parents education	Grades of Swedish Language Mathematics English	Influence of Teacher characteristics and private school competition on efficiency of public education (Swedish national board)
Fare *et al.* (2006)	Teacher-pupil ratio Square meters per pupil Administrator pupil ratio Hours of instruction Other expenses per pupil	% promoted Average on 9th grade exam	To compute productivity, quality in Swedish public education (representing normalized model)
Waldo (March 2006)	Total school costs Number of students Mother's education	Credit value Full grades Adjusted credit value Adjusted full grades	Competition from private schools affecting efficiency in public education
Sutherland and Price (2007)	Aggregated Institutional indicators: Resource allocation Budget management Market framework	Efficiency scores based on PISA score data	To correlate educational efficiency indicators to the institutional indicators. Correlates institutional indicators with technical efficiency at both school and country level and cost efficiency at country level
Hu *et al.* (2009)	Student-teacher ratio Teachers' average teaching experience Ratio of teachers' educational background higher than junior college Ratio of teachers' professional title higher than secondary None-personal expenditure per student Total educational expenditure per student Number of books in the library per student Average income of teachers per month Average income of administrators per month Average hours students in school	Excellence rate in Mathematics; Chinese English Rewards per student Journal articles published per teacher Teacher rewards	To provide a solution whereby factors impacting school efficiency are considered for effective utilization of limited resources

Table AII.

Appendix 3. DEA basics

Global technical efficiency (TE) is the basic DEA CCR model developed by Charnes *et al.* (1978). This model attempts to maximize the efficiency value of a DMU-p from among a set of n by selecting optimal input and output weights for corresponding inputs and outputs. These weights are the decision variables. Mathematically this model is represented as:

$$\max \theta_p = \sum_{r=1}^{s} u_r y_{rp} / \sum_{i=1}^{m} v_i x_{ip} \quad \text{subject} \quad \text{to} \sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} \leq 1 \quad \text{for} \quad \text{all} \quad j, u_r, v_i \geq 0$$

where θp = efficiency of DMU p; r = 1,…, s (outputs); i = 1,…, m (inputs); j = 1,…, n (DMUs); y_{rp} is the amount of output r of DMU p; x_{mp} is the amount of input i of DMU p; ur = weight given to output r; and vi = weight given to input i. This fractional program can be solved as an LPP by either setting the denominator to some arbitrary constant value (say 1) and maximizing the numerator or setting the numerator to some constant value and minimizing the denominator.

DEA approach is to measure TE of a DMU p, (CCR score – θ_{pCCR}) in relation to other DMUs. Inefficiency that a DMU might have is contributed by two components, namely, inefficient operation of the DMU itself and/or by the disadvantageous (scale) conditions under which the DMU is operating. In this context, it is important to understand BCC (Banker *et al.*, 1984) score (of DMU p – θ_{pBCC}) which is termed as local pure technical efficiency (PTE).

If there are n DMUs producing s outputs in amounts y_{rj} (r = 1, …, s) using m inputs xij(i = 1, .., m) then the local pure technical efficiency (BCC model) for DMU p is mathematically represented as follows:

$$\min \theta_p - \mathrm{e}\left(\sum_{i=1}^{m} s_{i^-} + \sum_{r=1}^{s} S_{r^+}\right)$$

subject to:

$$\theta_p x_{ip} = \sum_{j=1}^{n} x_{ij}\lambda_j + s_{r^-} \text{where } i = 1, \ldots, m;$$

$$y_{rp} = \sum_{j=1}^{n} y_{rj}\lambda_{j^-} s_{r^+} \text{ where } r = 1, \ldots, s;$$

$$1 = \sum_{j=1}^{n} \lambda_j \text{ and } 0 \leq \lambda_j, s_{r^+}, s_{r^-} \text{ for all } i, r, j$$

where e > 0 is defined to be smaller than any positive real number.

If a DMU is fully efficient (100 per cent) in both CCR and BCC with constant returns to scale – then that DMU is considered to be operating in the most productive scale size (MPSS). If a DMU has full BCC efficiency but a low CCR efficiency, then it is considered locally efficient but globally inefficient due to the scale size of DMU. Thus the ratio of the CCR score to BCC score is termed as scale efficiency (SE).

$$\mathrm{SE_p} = \theta_{\mathrm{pCCR}} / \theta_{\mathrm{pBCC}} \text{ is the scale efficiency of DMU } p.$$

The reduced CCR (Andersen and Petersen, 1993) represented as RCCR (Super Efficiency model) helps in ranking of efficient units within themselves. In this model, by excluding the DMU from the constraint set, the efficiency of the DMU is maximized and made to exceed 1. This model is meant to be used for ranking only the efficient DMUs – as the inefficient DMUs' efficiency values remain in this formulation. The mathematical representation of this model will remain almost the same as that of CCR except that the constraint set will need to be modified to be written as "for all $j \neq p$" where $j = 1, \ldots, n$ (DMUs) and p is the DMU under consideration.

A basic DEA model could sometimes rate too many DMUs as efficient. Cross efficiency (CE) evaluations increases the discriminatory power of DEA. CE scores for each DMU are calculated by using the optimal weights of the peer DMUs. Averaging the CE scores of each DMU gives a new efficiency measure (also called peer-efficiency) which helps in discriminating the DEA efficient units and can also help in benchmarking units objectively. The CE matrix of each DMU can thus be derived by substituting its optimal weights with the optimal set of weights of the peer DMUs. Thus in the overall matrix, the diagonal elements will be the self-appraisal efficiency figure while the other elements are peer-appraisal efficiency values.

Cross-efficiency matrix as in Table AIII, can identify the DMUs, which have the maximum relative increase when the focus is moved from peer appraisals to self-appraisal efficiency figures. Such units are called false-positive units and the index which measure such a shift is termed false positive index (FPI). A false-positive DMU is one which weighs heavily on a specific or set of specific inputs or outputs making itself more efficient than other DMUs. FPI of a DMU is the ratio between efficiency score from CCR and the mean Cross efficiency score of that DMU.

$$\mathrm{FPI_p} = \theta_{\mathrm{pCCR}}/\mathrm{mCE_p theFPIofDMU}p$$

where θ_{pCCR} is the CCR efficiency of DMU p and $\mathrm{mCE_p}$ is the mean cross-efficiency score of DMU p.

DMU is deemed the most efficient where there is the least difference between the CCR and cross-efficiency scores.

Some of the DEA principles which need specific mention are:

- effective discrimination between Indian states (DMUs) can be achieved only when the number of DMUs is larger than the product of number of inputs and outputs (Cooper *et al.*, 2007),
- smaller input amounts and larger output amounts are preferred so that the efficiency scores reflect DEA principles (Cooper *et al.*, 2007),
- ensuring the sample size to be at least three times larger than the sum of the number of inputs and outputs – it's a rule of thumb (Cooper *et al.* 2007),
- homogeneous group of DMUs minimize the confounding effects while enabling comparable results (Avkiran, 1999).

	$\mathrm{DMU_1}$	……	$\mathrm{DMU_j}$	……	$\mathrm{DMU_n}$
$\mathrm{DMU_1}$	CE_{11}		CE_{1i}		CE_{1n}
……					
$\mathrm{DMU_j}$	CE_{i1}		CE_{ii}		CE_{in}
……					
$\mathrm{DMU_n}$	CE_{n1}		CE_{ni}		CE_{nn}

Table AIII. Cross efficiency matrix

Appendix 4

Table AIV.
Input and output variables' specifications

Input-output variables	Transformed variables	Nature of transformation	Reasons of transformation
Number of schools	Number of schools per thousand	Normalization	Impact input value, DMUs homogeneity
Total number of students	Student classroom ratio	Ratio normalization	DMUs homogeneity
Number of schools with *Pucca* (permanent) building Number of schools with drinking facility Number of schools with toilet facility Number of schools with computers	% of schools having pucca building, drinking facility, toilet facility and computers	Aggregated and % normalization	To fulfill DEA thumb rule on relationship between # of DMUs and number of variables
Number of female teachers	% female teachers	% normalization	DMUs homogeneity
Number of teachers with professional qualification	% teachers with professional qualification	% normalization	DMUs homogeneity
Number of teachers who were trained	% teachers who were given training	% normalization	DMUs homogeneity
Number of schools receiving school development (SD) grant	% of schools who received SD grant	% normalization	DMUs homogeneity
Number of schools receiving teacher learning material (TLM) grant	% of schools who received TLM grant	% normalization	DMUs homogeneity
Total number of enrolled students	Gross enrolment ratio	Ratio normalization and weight-enhancement	Impact weight flexibility DMUs homogeneity
Number of students scoring more than 60%	% of students scoring more than 60%	% normalization and weight-enhancement	Impact weight flexibility DMUs homogeneity

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