Measurement and Determinants of Technical Efficiency of Higher Secondary Stage of Education in India: A State-Level Study using Data Envelopment Approach

Sangita Choudhury
Ph.D. Scholar
Department of Economics, Jadavpur University

Arpita Ghose
Professor of Economics
Department of Economics, Jadavpur University

Abstract

This paper contributes to the existing literature by estimating technical efficiency of Indian higher secondary stage of education (IHSE) exploring state-level data and by constructing two separate frontiers for two groups: (i) General Category States (GCS); and (ii) Special Category States (SCS)&Union Territories (UT),using non-parametric Data Envelopment Approach (DEA) under variable returns to scale for the period 2010-11 to 2015-16 and finding out the determinants of technical-efficiency separately for each of these two groups. The division of these two groups of the Indian states can be supported by the observed heterogeneity and differences in existing fiscal and economic conditions among GCS and SCS & UT. The paper uses output oriented approach for measuring technical efficiency (OUTTE).The findings reveal, that some of the GCS and SCS & UT are technically inefficient for some of the sample years for IHSE and hence it is possible to increase *GCS/ SCS &UT output of H.S. level, given the existing input. The OUTTE differs within and between each group. A second stage regression analysis suggests***,** *OUTTE is favourably impacted (a) for GCS by(i)ratio of government education expenditures to aggregate government expenditure for the state,(ii) proportion of girls enrolment to boys at higher secondary (H.S.) level,(iii) proportion of para teachers at H.S. level and (b) for SCS &UT, by(i) percentage of Scheduled Tribe enrolment, (ii) percentage of Scheduled Caste enrolment,(iii) Proportion of Female to Male Teachers. On the other hand OUTTE is adversely impacted (a) for GCS, by (i) percentage of H.S. schools without building, (ii) percentage of H.S. schools without girls' toilet and (b) for SCS & UT, by proportion of single classroom school. Additionally, non-linear relation is found between OUTTE and government education expenditures for SCS & UT.*

Keywords: *Efficiency Analysis of Education, Microeconomics, Data Envelopment Analysis, India*
JEL Code: *I21, B21, C61, O50*

1. Introduction

The existing literature suggests that the country which uses infrastructural capital inefficiently experience a growth penalty in the form of smaller growth benefit from infrastructure investment (Hulten 1996). Thus, how well the country uses its exsisting infrastructure is more important than how much of it the country is equipped with. Hence, measurement of efficiency of use of infrastructural capital is needed. Human capital is the major determinant of infrastructural capital, which depends in turn on the development of education system as supported by endogenous growth literature (Lucas (1988); Romer (1986; 1990) among others). Mankiw, Romer and Weil (1992) showed that, other things being equal, a country with higher amount of human capital will be endowed with a higher level of per capita

income. Both the differences in labour productivity and overall levels of technology arise because of the difference in education and the creation of human capital (Barro (1991)). The idea of development of education system as important mechanism for building human knowledge capital has been accepted by the developing nations. Government of India allocates around 4% of GDP in education. The education expenditure as a percent of total public expenditure was around 10.6 % in 2018-19(Economic Survey).
Higher secondary, (i.e., senior secondary stage, as higher level of secondary education) is a stepping stone to higher education level which equips and empowers students with skills needed for entering the labour market. Gross enrollment ratio (GER) in Indian higher secondary education (IHSE) reflects significant improvement from 31.06% in 2010-11 to 55.40% in 2016-17 (Source: Unified District Information System for Education). *Given the significant advancement of GER for IHSE, one may be interested in knowing whether* different Indian states and union territories (UT) are technically-efficient at higher secondary level, i.e. are they producing maximum possible output given the existing resources at IHSE? *It is possible that, India may be sacrificing economic growth because of the existence of technical-inefficiency. In this contex, it is also important to determine the major factors influencing technical efficiency (TE) of IHSE. This paper addresses these issues.*

Charnes, Cooper and Rhodes (CCR 1978, 1981) introduced Data Envelopment Analysis (DEA), a linear programming method, for efficiency measurement of decision making units (DMU) in multiple inputs and multiple outputs framework. They used non-profit public entities like schools, hospitals, court which produce measurable output from measurable inputs. However, there is lack of market price of output (and sometimes some inputs**).** They constructed a benchmark production function under the assumption of constant returns to scale (CRS). Later Banker, Charnes and Cooper (1984) generalized CCR (1978, 1981) incorporating variable returns to scale (VRS). The advantage of DEA is that prior specification of functional form of the criterion function is not required. Empirical literature uses DEA in measuring TE of school education namely, Ray (1991), Arshad (2014), Gavurova et al (2017), Haug and Blackburn (2017), Ciro and Torres (2018), Masci, De Witte, K. and Agasisti (2018), Sotiriadis et al. (2018) for different countries; and Tyagi (2009); Sankar (2007), Sengupta and Pal (2010, 2012), Mohapatra (2015), Ghose (2017), Singh and Pant (2017) for India, among others. There is dearth in Indian studies relating to technical efficiency in school education. Singh and Pant (2017) evaluated efficiency of twenty two state boards of Indian higher secondary education for the year 2013, using non-parametric estimation technique and proposed a combined DEA and artificial neural network approach with the objective of future prediction of efficiency levels for several upcoming years by simulation of outputs. However, the study did not analyze the determinants *of TE of* IHSE. Mohapatra (2015) estimated the efficiency of secondary education, however did not considered the determinants of the estimated efficiency score.

The present paper contributes to the literature significantly in the following directions: First of all, the major departure of this paper is its approach of estimating TE for IHSE by not using a single frontier for 28 states and 7 union territories. Rather, it assumes General category states (GCS) and special category states (SCS) & union territories (UT) are not homogeneous since they operate under different fiscal and economic environment. Development grant as received by the Indian states as a part of overall assistance from the center is determined as a composite of loans and grants. The relative ratios of loans and grants are different for SCS&UT and GCS. For GCS, ratio of grants and loans is 30:70. The same ratio for SCS&UT is set as 90:10 (Planning Commission Government of India, Report of the Working Group on State's Financial Resources for the twelfth five year plan (2012)). Secondly, the paper estimates TE of IHSE for 17 GCS and 18 SCS&UT over 2010-11 to 2015-16 under VRS, by creating two separate frontiers ; one for GCS and the other for SCS&UT against a single year TE estimation. Thirdly, while carrying out the determinant analysis separately for the two groups GCS and SCS&UT at second stage, the paper tested the individual impact of each of the explanatory variables, as against the existing literature which constructed and determined the effect of composite index for different indicators (Sengupta and Pal 2010, 2012). This is because the individual effect of the explanatory variable is important for adopting appropriate policies. It is possible that some of the individual variables under this composite indicator are significant while some are not. Such cases cannot be differentiated by using the composite indicator.

The analysis carried out in the present paper will be helpful to identify the unsatisfactorily performing states with respect to TE and also the factors influencing the variation of TE. Thus, appropriate policies can be framed for enhancing efficiency of the bad performing states.

Rest of the paper is organized as follows. Section 2 discusses methodology of estimation of TE, determinants of TE and the relevant data sources. Section 3 reveals estimated results. Section 4 represents concluding remarks and policy prescriptions to enhance TE of IHSE.

2. Methodology of estimation, Determinants of TE and Data sources

2.1 Methodology of estimation of TE

There are two components of efficiency: technical efficiency (TE) and allocative efficiency (AE). TE of a DMU (Decision Making Unit) is measured by either (i) output-oriented (OUTTE) approach showing the maximum output quantities that can be proportionately increased without altering input quantities or (ii) input-oriented (INPTE) approach representing the maximum amount of input quantities, which can be proportionately reduced without changing quantities produced as output. Allocative efficiency reflects the ability of a DMU to use the inputs in optimal proportions, given their respective price. The measurement and the determinants of TE, in particular OUTTE, are attempted here.

TE measurement is a two-step problem. First, a benchmark production function, known as frontier, has to be constructed which is supposed to be perfectly efficient. Secondly, comparison of the observed performance of DMU with the benchmark is the basic approach of measuring TE.

Figure 1 represents OUTTE and INPTE in case of single input and output framework.

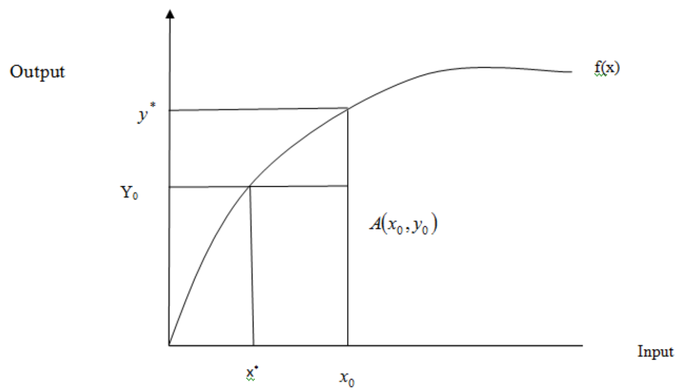

Figure 1: Output Oriented & Input Oriented Technical Efficiency

In Figure 1, input x and output y is measured along the horizontal and the vertical axis respectively. Point A (x_0, y_0)represents the actual input-output bundle of a DMU and $y^* = f(x_0)$holds, where y * is the maximum output producible from input x_0. OUTTE of DMU at point A = $\frac{y_0}{y^*}$ which is the comparison of actual output with the maximum producible quantity from the observed input.

For the same output bundle y_0, the input quantity can be reduced proportionately till the frontier is reached. So, y_0 can be produced from minimum input x *. Thus INPTE for DMU at a point A=$\frac{x^*}{x_0}$. The TE score of a DMU takes a value between0 to 1. A value1 indicates DMU is fully technically efficient.

The TE of the DMU depends also on returns to scale; CRS or VRS.

Figure 2 illustrates the basic ideas behind DEA and returns to scale. Four data points (A, C, B', and D) are used here to describe the efficient frontier under VRS. In a simple one output case, only B is inefficient, lies below the frontier, showing capacity underutilization. So unit B can produce more output at point B' on the frontier (which is equal to theoretical maximum) utilizing same level of input at X_1. Under CRS the frontier is defined by point C for all points along the frontier, with all other points falling below the frontier indicates capacity underutilization. So capacity output corresponding to VRS is smaller than the capacity output corresponding to CRS.

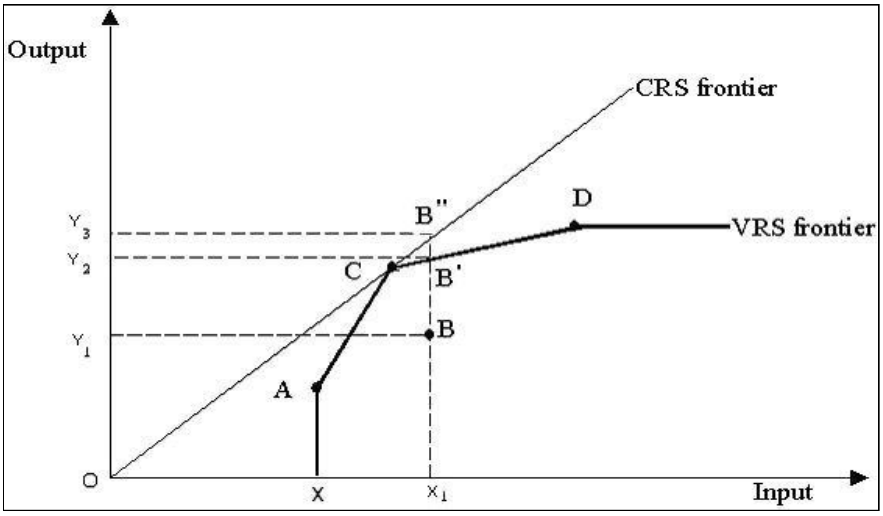

Figure 2: The Production Frontier and Returns to scale

Given the actual input output bundle, output oriented technical efficiency (OUTTE) is estimated here by constructing the frontier under VRS using non-parametric DEA following Banker, Charnes and Cooper (BCC) (1984), after making a number of fairly general assumptions about the nature of the underlying production technology, namely, (i) all actually observed input-output combinations are feasible, (ii) the production possibility set is convex, (iii) inputs are freely disposable, (iv) outputs are freely disposable.

2.1.1Methodology for finding Output Oriented TE Score

Suppose that there are *N* DMUs. Each of them is producing 'g' outputs using 'h' inputs. The DMU t uses input bundle $x^t = (x_{1t,} x_{2t,........} ..x_{ht})$ and produces the output bundle $y^t = (y_{1t,} y_{2t,........} ..y_{gt})$. This paper assumes VRS.

The specific production possibility set under VRS is given by

$$T^{VRS} = \left\{ (x, y) : x \geq \sum_{j=1}^{N} \lambda_j x^j ; y \leq \sum_{j=1}^{N} \lambda_j y^j ; \sum_{j=1}^{N} \lambda_j = 1; \lambda_j \geq 0; (j = 1,2....N) \right\} \quad \ldots 1$$

the output oriented measure of TE of any DMU t under *VRS technology* requires the solution of the following LP problem

$\max \phi$

Subject to $\sum_{j=1}^{N} \lambda_j y_{rj} \geq \phi y_{rt}$; $(r = 1,2,....g)$;

$\sum_{j=1}^{N} \lambda_j x_{ij} \leq x_{it}$; $(i = 1,2,.....h)$;

ϕ free $\lambda_j \geq 0$; , $(j = 1,2........N)$

$\sum_{j=1}^{N} \lambda_j = 1$

....2

OUTTE of DMU t can be determined by using equation (3).

$$TE_o^t = TE_o^t(x^t, y^t) = \frac{1}{\varphi^*} \quad \ldots .3$$

Where ϕ^* is the solution of equation (2) showing the maximum value of ϕ .The maximum output bundle producible from input bundle x^t is y* and is defined as y*= $\phi^* y^t$.

Relevantly, differences between this educational production function and the standard micro production function are worth mentioning. First of all, since the output produced in education is not tangible output; to represent the output some suitable measures are required.

This paper considers two outputs as measured by (i) Retention rate and (ii) Percentage of students passed in higher secondary (H.S.), representing quality of output and four inputs as measured by (i) Number of H.S. schools per lakh population, (ii) Teacher-pupil ratio, (iii) Classroom-student ratio and (iv) Percentage of teachers with qualification post graduate and above at H.S., representing quality of teacher input.

Secondly, computation of the shadow prices of both inputs and outputs are needed, as both the outputs and inputs used do not have prices. The state is used as a unit of account. OUTTE of GCS and SCS & UT is estimated separately by constructing two different frontiers for GCS and SCS&UT. Average state level figures for inputs and outputs of the respective state as available from secondary data source, are used here.

To identify the determinants of estimated OUTTE, considering 17 GCS and 18 SCS&UT separately for 2010-11 to 2015-16, the paper uses the second stage regression taking into account following determinants.

2.2 Possible determinants of technical efficiency (OUTTE)

(a) Poor Infrastructural indicators: Government of India cannot provide sufficient infrastructures to schools mainly because of the financial constraints. Thus, many schools are forced to operate with extremely poor infrastructure. To investigate whether existence of such poor infrastructure variables significantly and negatively affect OUTTE of GCS and SCS & UT at H.S. level, this paper tests whether (i) Percentage of H.S. schools without building,(ii) Percentage of classrooms in “bad” condition at H.S., (iii) Proportion of single classroom school at H.S., (iv) Proportion of single teacher school at H.S., (v) Proportion of contractual teachers at H.S. school, (vi) Percentage of H.S. schools without drinking water facility, (vii) Percentage of H.S. schools having no girls toilet, (viii) Percentage of H.S. schools without electricity and (ix) Percentage of H.S. schools without computer and internet connection adversely affect OUTTE of these two groups of states at HS level**.**

(b) Social indicators: Government of India through the policy of social inclusion attempts to ensure that more people from the disadvantageous groups like Scheduled Caste (SC), Scheduled Tribe (ST) and the girl students should get the benefit of formal education. The females in the country need to operate under very stringent social norms and are denied the benefit of formal education in many cases. To see whether OUTTE of GCS and SCS & UT of H.S. level are positively affected by the inclusion of socially disadvantageous groups, the effects of the following variables on OUTTE are considered: (i) Percentage of SC enrolment at H.S. level, (ii) Percentage of ST enrolment at H.S. level, (iii) Proportion of female to male teachers at H.S. level, (iv) Proportion of girls’ to boys’ enrolment at H.S. level.

(c) Macro indicator: To test whether OUTTE of GCS and SCS & UT at H.S. level get influenced by general economic condition of the state, effect of per capita net state domestic product (PCNSDP) (measured at constant 2011-12 prices) on OUTTE is tested here.

(d) Policy Indicator: As a policy indicator, the effect of government education expenditure (as a ratio to aggregate expenditure for the state) on OUTTE for two categories of states at H.S. level is investigated.
Along with the above variables, influence of ‘Percentage of H.S. Schools with Parent-Teacher Association’ on OUTTE of GCS and SCS&UT at H.S. level is also verified.

2.3 Data Set and its Sources

The considered GCS are Andhra-Pradesh(AP), Bihar (BI), Chhattisgarh(CHHT), Goa(GO), Gujarat(GU), Haryana(HA), Jharkhand(JH), Karnataka(KA), Kerala(KE), Madhya-Pradesh(MP), Maharashtra(MH), Orissa(OR), Punjab(PU), Rajasthan(RA), Tamil-Nadu(TN), Uttar-Pradesh(UP) and West-Bengal(WB);and SCS&UT are Andaman & Nicobar-Islands(AN), Arunachal-Pradesh(ARP),Assam(AS), Chandigarh (CHAN), Dadra & Nagar Haveli (DN), Daman & Diu(DD), Delhi(DE) , Himachal-Pradesh (HP) ,Jammu & Kashmir(JK) , Lakshadweep (LAKH) , Manipur (MA), Meghalaya(ME), Mizoram(MI), Nagaland(NA) , Puducherry (PUDU) , Sikkim (SI) , Tripura(TR) and Uttarakhand (UTTA).
The secondary source state level data on two outputs and four input variables are collected from ‘District Information System for Education’ (DISE).The other data sources are Central

Statistics Office, Ministry of Statistics and Programme Implementation, Government of India and Budget documents of the state governments.

3. Empirical Findings

3.1Result of estimation of OUTTE

Estimated OUTTE under VRS for each of the sample years 2010-11 to 2015-16, the mean OUTTE over the sample period for different GCS and SCS&UT considering IHSE are represented in Table 1and Table 2 respectively. Table 1 and 2 also report the grand mean OUTTE (i) for all the years and all GCS and (ii) for all the years and all SCS&UT respectively.

Results suggest that neither all GCS nor all SCS&UT are fully technically efficient for all the years. OUTTE varies between GCS and SCS&UT and also within GCS/SCS.

Table 1: Output oriented Technical Efficiency scores of general category states (GCS) considering Higher Secondary stage of education

States	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	**Average (A.M.)**
Andhra Pradesh	1.000	0.946	0.940	0.938	0.981	1.000	0.97
Bihar	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Chhattisgarh	0.983	0.982	0.980	0.981	0.981	0.981	0.981
Goa	0.943	0.980	1.000	0.960	0.977	0.965	0.97
Gujarat	0.995	0.975	0.973	0.971	1.000	1.000	0.99
Haryana	0.998	0.979	0.980	0.971	0.971	0.967	0.98
Jharkhand	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Karnataka	0.992	0.992	0.994	1.000	1.000	1.000	0.996
Kerala	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Madhya Pradesh	0.953	0.948	0.952	0.955	0.928	0.928	0.94
Maharashtra	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Orissa	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Punjab	0.986	0.980	0.985	0.981	0.993	0.980	0.98
Rajasthan	1.000	1.000	0.961	1.000	1.000	1.000	0.994
Tamil Nadu	1.000	0.986	0.995	0.983	0.985	0.986	0.989
Uttar Pradesh	1.000	1.000	1.000	1.000	1.000	1.000	1.000
West Bengal	1.000	1.000	0.963	0.964	0.960	0.964	0.96
Grand Average							0.985

Source: Author's computation with DISE data set from 2010-11 to 2015-16.

Table 1 reflects mean OUTTE of 10 GCS; namely KE, KA, MH, RA, TN, OR, BI, JH, GU and UP lie above the grand mean OUTTE 0.985and supports the following information considering H.S. level of education.

(i) KE,OR, MH, UP, JH and BI are all throughout efficient, (ii) PU, MP, HA and CHHT remained throughout inefficient, (iii) GU and KA are inefficient initially but achieved efficiency subsequently, (iv)WB and TN started as efficient, but turned inefficient,(v) OUTTE has increased for KA and GU though it declined for GU in the intermediate year, (vi) OUTTE declined for WB, TN, MP, HA, PU and CHHT from initial efficiency.

Table 2: Output oriented Technical Efficiency scores of special category states (SCS) and Union Territories (UT) considering Higher Secondary stage of education

States	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	Average (A.M.)
Andaman & Nicobar Islands	1.000	1.000	0.868	0.863	0.869	0.864	0.91
Arunachal	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Assam	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Chandigarh	1.000	1.000	0.966	1.000	1.000	1.000	0.99
Dadra & Nagar Haveli	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Daman & Diu	1.000	1.000	0.876	1.000	1.000	0.779	0.94
Delhi	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Himachal Pradesh	1.000	0.992	0.967	0.993	1.000	1.000	0.99
Jammu & Kashmir	0.966	0.964	0.923	1.000	1.000	0.977	0.97
Lakshadweep	1.000	1.000	0.999	1.000	1.000	1.000	1.000
Manipur	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Meghalaya	1.000	1.000	1.000	1.000	0.984	0.991	0.99
Mizoram	1.000	0.985	0.982	0.990	1.000	1.000	0.99
Nagaland	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Puducherry	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Sikkim	1.000	0.921	0.922	1.000	1.000	0.971	0.96
Tripura	0.964	0.969	0.968	0.993	0.974	0.986	0.97
Uttarakhand	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Grand Average							0.983

Source: Author's computation with DISE data set from 2010-11 to 2015-16.

Table 2 reflects mean OUTTE of 13 SCS&UT; namely ARP, AS, DN,DE, MA,NA, PUDU, UTTA, LAKH, ME, CHAN, MI and HP lie above the grand mean OUTTE 0.983 and provides the following information concerning H.S. education level :

(i)ARP,AS, DN, DE, MA, NA, PUDU and UTTA are throughout efficient, (ii)Tripura remained throughout inefficient,(iii) OUTTE increases for TR and JK,(iv) JK showed inefficiency initially and achieved efficiency later but in the terminal year again lost efficiency,(v)CHAN and LAKH are efficient all through except a single year (2012-13),(vi)AN, DD, ME and SI started as efficient but turned inefficient, (vii)AN, ME and DD show declining pattern of OUTTE.

Tables 1 and 2 reflect that grand mean OUTTE is marginally higher for GCS as compared to SCS&UT.

3.2 Factors determining OUTTE

Since the determinant analysis of OUTTE consists of data on 17 GCS and 18 SCS&UT for 2010-11 to 2015-16, one needs to test whether panel model is proffered over the pool model. *Application of Breusch-Pagan Lagrange multiplier test* (BPLM) *supports use of pooled model for both GCS and SCS&UT* over panel model. Further, Pesaran's cross-sectional dependence (CD) test confirms estimation of simple pooled model for GCS as well as SCS&UT due to non-existence of cross-sectional dependence in residuals. Different alternative specifications for GCS and SCS&UT are tried out and the best fits are reported in Table 3 and Table 4 respectively.

Table 3: Significant variables determining Technical Efficiency level of Higher Secondary stage of education for GCS

Variables	Co-efficient	t stat	P-value
Percentage of Higher Secondary schools without building	-.0005499	-1.83	0.070
Proportion of Para Teacher in Higher Secondary school	.0004828	2.00	0.048
Percentage of Higher Secondary schools without Girls' Toilet	-.0004066	-2.41	0.018
Proportion of Girls enrolment to Boys at Higher Secondary	.0002691	1.79	0.077
Government Expenditure on education (as a ratio to aggregate expenditure)	.0033951	3.68	0.000
Constant	.9412368	44.70	0.000
F(14, 87) = 3.73		Prob> F = 0.0001	

Source: Author's estimation with DISE data set from 2010-11 to 2015-16

Table 3 shows for GCS poor infrastructure, social and policy indicators turn crucial in determining OUTTE of IHSE. OUTTE for GCS is (i) adversely affected by poor infrastructure like (a) Percentage of H.S. schools without building (PHWB) and (b) percentage of H.S. schools without girl's toilet(PSWGTH) and (ii) favourably influenced by: (a) proportion of para teacher in higher secondary school (PPTH),(b) social indicator variable 'proportion of girls enrolment to boys at H.S. level'(PGTBEH) and(c)policy indicator- state government expenditure on education (as a ratio to aggregate expenditure for the state) (GEXPE). The variable para teacher is included as a determining factor since schools employ a significant number of para teachers to compensate for a shortage of sufficient number of full time teachers and hence it is important to examine whether such para teachers play any significant role in promoting OUTTE.

Table 4: Significant variables determining Technical Efficiency level of Higher Secondary stage of education for SCS and UT

Variables	Co-efficient	t stat	P-value
Proportion of Single Classroom School Higher Secondary	-.0026649	-1.99	0.050
Percentage of SC enrolment Higher Secondary	.0027004	4.50	0.000
Percentage of ST enrolment Higher Secondary	.0007387	5.14	0.000
Proportion of Female to Male Teacher Higher Secondary	.0001184	2.33	0.022
Government Expenditure on education (as a ratio to aggregate expenditure)	-.0256147	-2.90	0.005
Government Expenditure on education-Square	.0007642	2.95	0.004
Constant	1.140411	16.25	0.000
F(12, 95) = 4.09	Prob> F = 0.0000		

Source: Author's estimation with DISE data set from 2010-11 to 2015-16.

Table 4 reflects for SCS&UT infrastructural, social and policy indicators influence OUTTE. It is seen that OUTTE is (i) adversely affected by poor infrastructure like proportion of single classroom H.S. school(PSCH)and (ii) favourably influenced by social indicators 'percentage of Scheduled Tribe enrolment at H.S.' (PSTEH), 'percentage of Scheduled Caste enrolment at H.S.' (PSCEH) and 'Proportion of Female to Male Teacher' (PFTMTH).

For SCS&UT, the relationship between GEXPE and OUTTE is nonlinear U-shaped in nature, implying that initially OUTTE falls as GEXPE increases but up to a limit. There is a threshold level of GEXPE after which OUTTE increases with GEXPE. This result suggests that in order to get a positive relation between GEXPE and OUTTE, there must be a minimum level of GEXPE. Since the relation between GEXPE and OUTTE is nonlinear in nature, to get the effect of GEXPE on OUTTE, one needs to calculate marginal effect of GEXPE**.** The estimated figure for the marginal effect turns out to be negative. This result can be interpreted as follows. The sample mean value of GEXPE is 16.00 which is less than the threshold value of GEXPE, after which positive effect of GEXPE on OUTTE will be felt (16.75). Thus, the minimum value of GEXPE which will result in an increase in OUTTE has not been reached for the present sample of SCS&UT and the system is at the declining portion of the curve specifying the relation between OUTTE and GEXPE**.** Hence, in order to get a positive effect of GEXPE on OUTTE, government should emphasize more to increase GEXPE for SCS&UT.

4. Summary and policy suggestions

Output oriented technical efficiency of Indian higher secondary stage of education is estimated using state level data and non-parametric Data Envelopment Approach, creating two separate frontiers under variable returns to scale for: (i) 17 General Category States and (ii) 18 Special Category States & Union Territories , for 2010-11 to 2015-16, as these two groups are not homogeneous and operate under different economic and fiscal conditions. A second step regression analysis is resorted separately for theses two groups of states for finding out the determinants that can increase technical efficiency at higher secondary level.

The results reflect that not all the states under each of the two groups are perfectly efficient and hence the states with observed inefficiency can increase output of higher secondary level, given the existing inputs. Variation of output oriented technical efficiency within and between these two categories is observed. Breusch-Pagan Lagrange multiplier test suggested application of pooled model for both of these two groups of states. Further, Pesaran's cross-sectional dependence test confirms estimation of simple pooled model for both these two groups of states due to non-existence of cross-sectional dependence in residuals.

For General Category States, output oriented technical efficiency of the higher secondary level of education, *is (i) favourably influenced by* (a) infrastructural indicator like 'proportion of para teacher in higher secondary school', (b) social indicator i.e., 'proportion of girls' enrolment to boys' at higher secondary level' and (c) policy indicator such as 'government expenditure on education' (as a ratio to aggregate expenditure for the state); and *(ii) adversely affected by* poor infrastructure variables like 'percentage of higher secondary schools without building' and 'percentage of higher secondary schools without girl's toilet'.

Output oriented technical efficiency for Special Category States and Union Territories is *(i) favourably influenced by* social indicators namely, 'percentage of scheduled tribe enrolment', 'percentage of scheduled caste enrolment' and 'proportion of female to male teacher' at higher secondary level; and *(ii) adversely affected by* poor infrastructure variable like 'proportion of single classroom higher secondary school'. A non-linear U shaped relationship is evident between policy indicator variable i.e., 'government expenditure on education' and output oriented technical efficiency of higher secondary level, along with a negative marginal effect. This result can be interpreted by noting that the sample mean value of 'government expenditure on education' is less than the threshold value of 'government expenditure on education', after which positive effect of the same variable on output oriented technical efficiency will be felt. In other words, in order to get the positive effect of government expenditures on TE there must be a minimum level of it. Thus, the minimum value of 'government expenditure on education' which will result in an increase in output oriented technical efficiency has not been reached for the present sample of *Special Category States and Union Territories* and the system is at the declining portion of the curve specifying the relation between output oriented technical efficiency and 'government expenditure on education'. Hence, for obtaining favourable impact of this policy variable on output oriented technical efficiency, there is an urgent need to increase government expenditure on education so that the same can be put beyond the threshold level of government expenditure on education, after which its positive effect on technical efficiency is felt.

Since determinants of output oriented technical efficiency are different for two groups of states, it therefore justifies construction of two different frontiers.

The estimated results thus suggest that the policies that can increase output oriented technical efficiency are specific to (i) General Category States and (ii) Special Category States and Union Territories, respectively. For improving output oriented technical efficiency of higher secondary in General Category States, improvement in poor infrastructure, in the form of construction of more school buildings and girls' toilets, is needed. Government policy of incentivizing girl students to enroll higher secondary stage of education, increasing government expenditure on education and recruiting sufficient number of teachers can also increase output oriented technical efficiency of General Category States.

For Special Category States and Union Territories, improvement in school infrastructure in the form of constructing more classrooms in higher secondary schools can improve output oriented technical efficiency. Government policy of incentivizing socially backward Scheduled Caste and Scheduled Tribe students to enroll higher secondary stage of education and employing more female as compared to male teachers can also boost up output oriented technical efficiency of higher secondary level in Special Category States and Union Territories.

It is evident that 'government expenditure on education' significantly affects output oriented technical efficiency for General Category States; and also for Special Category States and Union Territories. For General Category States, there is a direct positive relation between 'government expenditure on education' and output oriented technical efficiency. For Special Category States and Union Territories, the relation between 'government expenditure on education' and output oriented technical efficiency is nonlinear U-shapped in nature; indicating an increase in education expenditure beyond a threshold level is required to have a favorable impact of the variable on output oriented technical efficiency for this group of states at higher Secondary level. The marginal effect of this policy variable at its mean value on output oriented technical efficiency is negative for Special Category States and Union Territories. As argued above, the negative marginal effect arises because the mean value of 'government expenditure on education' for the present sample is less than the threshold value of 'government expenditure on education', after which the positive effect will be felt. The implication of this result is that government should put more emphasis and attention to increase expenditure on education for Special Category States and Union Territories, so that the positive effect of this policy variable on output oriented technical efficiency is felt.

References:

Arshad, M.N.M. (2014). Efficiency of secondary education in selected OIC countries. *Global Education Review, 1*(4),53-75.

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science, 30*(9), 1078-1092.

Barro, R.J. (1991). Economic growth in a cross section of countries. *The Quarterly Journal of Economics, 106*(2), 407-443.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*(6), 429-444.

Charnes, A., Cooper, W. W., & Rhodes, E. (1981). Evaluating program and managerial efficiency: an application of data envelopment analysis to program follow through. *Management science, 27*(6), 668-697.

Ciro, A. J., & Torres García, A. (2018). Economic efficiency of public secondary education expenditure: how different are developed and developing countries?. *Desarrollo y Sociedad*, (80), 119-154.

Gavurova, B., Kocisova, K., Belas, L., & Krajcik, V. (2017). Relative efficiency of government expenditure on secondary education. *Journal of International Studies*, *10*(2), 329-343.

Ghose, A. (2017). Efficiency of elementary education in India, empirical evidence using a nonparametric data envelopment approach. *Springer*.

Haug, A. A., & Blackburn, V. C. (2017). Government secondary school finances in New South Wales: accounting for students' prior achievements in a two-stage DEA at the school level. *Journal of Productivity Analysis*, *48*(1), 69-83.

Hulten, C. R. (1996). Infrastructure capital and economic growth: How well you use it may be more important than how much you have, *NBER Working paper*, 5847.

Lucas Jr, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22*(1), 3-42.

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, *107*(2), 407-437.

Masci, C., De Witte, K., & Agasisti, T. (2018). The influence of school size, principal characteristics and school management practices on educational performance: An efficiency analysis of Italian students attending middle schools. *Socio-Economic Planning Sciences*, *61*, 52-69.

Mohapatra, R. (2015). Ranking of efficient states of India on the basis of performances in secondary education: An application of super efficiency models. *Asian Journal of Research in Social Sciences and Humanities*, *5*(12), 1-15.

Planning Commission Government of India, 2012.Report of the working group on state's financial resources for the twelfth five year plan. https://niti.gov.in/planningcommission.gov.in/docs/aboutus/committee/wrkgrp12/wg_state_finan0106.pdf

Ray, S. C. (1991). Resource-use efficiency in public schools: A study of Connecticut data. *Management Science*, *37*(12), 1620-1628.

Ray, S. C. (2004). *Data envelopment analysis: theory and techniques for economics and operations research*. Cambridge University Press.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, *94*(5), 1002-1037.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*(5), S71-S102.

Sankar, D. (2007). Education system performance among Indian states: A public expenditure efficiency analysis using Linear Programming Methods. *South Asia Human Development Unit (SASHD) of the World Bank, Washington DC*.

Singh, N., & Pant, M. (2017, December). Evaluating the efficiency of higher secondary education state boards in India: a DEA-ANN approach. In *International conference on intelligent systems design and applications* (pp. 942-951). Springer, Cham.

Sotiriadis, D., Menexes, G., & Tsamadias, C. (2018). Investigating the efficiency of senior secondary schools: Evidence from schools in the Greek region of Central Macedonia. *International Journal of Business and Economic Sciences Applied Research (IJBESAR)*, *11*(2), 36-43.

Sengupta, A., & Pal, N. P. (2010). Primary education in India: delivery and outcome-a district level analysis based on DISE data. *Journal of Educational Planning and Administration*, *24*(1), 5-21.

Sengupta, A., & Pal, N. P. (2012). Assessing the primary schools—A multi-dimensional approach: A school level analysis based on Indian data. *International Journal of Educational Development*, *32*(2), 264-272.

Tyagi, P., Yadav, S. P., & Singh, S. P. (2009). Efficiency analysis of schools using DEA: A case study of Uttar Pradesh state in India. https://www.researchgate.net/.../254871435