CHAPTER -6

TECHNICAL EFFICIENCY OF POWER SECTOR IN INDIA: DATA ENVELOPMENT ANALYSIS (DEA)

6.1. Introduction

This chapter concerns to measure productivity change of power sector in India. This study has examined the efficiency change through DEA Malmquist Productivity Index (MPI). The components of MPI which are used in performance measurement are change in technical efficiency, change in technological change, change in pure technical efficiency, change in scale efficiency and change in total factor productivity.

6.2. Data Envelopment Analysis (DEA)

This study attempts to provide current evidence of productivity change of Indian power sector. Through the application of non-parametric DEA based MPI, the study covers the period of fourteen years from 2000-01 to 2013-14. Applying this approach, we separate the efforts to catch up to the frontier which is referred to efficiency change from shift of frontier which is referred to technological change. This study has taken two highest power generating sources – thermal and hydro, symbolized here as DMU1 and DMU2 respectively. DEA evolves to use the linear programming methods to construct a non-parametric frontier over the data to calculate the efficiency of the concerning DMUs. It is in-put, out-put efficient technique to measure the efficiency of DMUs on the basis of linear programming model. This technique does not require the assumptions of the weights of the underlying production function. This technique was proposed by Charnes et.al (1978). The technique of DEA provides the efficiency scores for individual units as their technical efficiency measure with a score assigned to the frontier or efficient units.Other model of DEA analysis is useful for the analysis of efficiency for a specific period of time for concerning DMUs. Efficiency measurement of DMUs for a specific time period is important but the change in the efficiency during the several time periods are also crucial to examine for the firm or DMU. To access the change (decrease or increase) of efficiency of a firm during the any period of time, it is necessary to check the change of efficiency of such time period. In the efficiency change, a

DMU is reaches to the production frontier and in the technical change the DMU shifts to the production frontier (Renuka, 2002).

6.3. Malmquist Productivity Index

In this study, the measurement of total factor productivity and its corresponding change in its constituents between the study periods from 1999-00 to 2013-14. The study has employed the panel data of the two DMUs with one input and output. The MPI has been used to measure the performance of the DMUs. The constituents of MPI are change in efficiency (effch), change in technical efficiency (techch), change in pure technical efficiency (pech), change in scale efficiency (sech) and finally change in total factor productivity (tfpch). The MPI also gives an opportunity to compare the productivity change within the DMUs.

Total factor productivity (TFP) is defined as the ratio of weighted sum of output to the weighted sum of inputs. It can be increased due to technical change or due to increase in technical efficiency or both. The MPI is based on the distance function approach, which is defined in terms of input and output. If MPI > 1, it indicates the positive TFP or increasing productivity trend. If MPI = 1, it reflects no change in productivity. If MPI < 1, it tells negative TFP or decreasing productivity trend.

Table 6.3.1 Presents MPI score of the power sector taking both DMUs (Thermal and Hydro) together-

Table 6.3.1. MPI Summary of Annual Means					
Year	**effech**	**techch**	**pech**	**sech**	**Tfpch**
2000-01	0.926	1.023	1.000	0.926	0.947
2001-02	0.97	1.006	1.000	0.97	0.976
2002-03	0.912	1.027	1.000	0.912	0.936
2003-04	1.021	1.024	1.000	1.021	1.045
2004-05	1.046	0.978	1.000	1.046	1.023
2005-06	1.093	0.978	1.000	1.093	1.069
2006-07	1.025	1.002	1.000	1.025	1.028
2007-08	1.052	0.964	1.000	1.052	1.015
2008-09	0.941	1.017	1.000	0.941	0.957
2009-10	0.978	0.985	1.000	0.978	0.963
2010-11	1.087	0.932	1.000	1.087	1.014
2011-12	1.077	0.896	1.000	1.077	0.965
2012-13	0.96	0.936	1.000	0.96	0.898
2013-14	1.112	0.933	1.000	1.112	1.038
MEAN	**1.014286**	**0.978643**	**1**	**1.014286**	**0.991**
COMPARISON	**effch<1=06** **effch>1=08** **effch=1=00**	**techch<1=08** **techch>1=06** **techch=1=00**	**pech<1=00** **pech>1=00** **pech=1=14**	**sech<1=06** **sech>1=08** **sech=1=00**	**tfpch<1=07** **tfpch>1=07** **tfpch=1=00**

Abbreviations: Efficiency Change (effch),Technical Efficiency Change (techch), Pure Technical Efficiency Change (pech), Scale Efficiency Change (sech) and Total Factor Productivity Change (tfpch).

Source: Calculated by researcher using DEAP 2.1

The above table reveals efficiency change (effch), technical efficiency change (techch), pure technical efficiency change (pech), scale efficiency change (sech) and total factor productivity change (tfpch) during 2000-01 to 2013-14. During the study period, there are eight years (57.14%) in which the both DMUs has recorded the improvement in the

efficiency change. Here, its value is more than 1.00 which is the indicator of progression. In the technical change, it is found that there are six years (42.85%) in which the technical change has improved with its value more than 1. The DMUs show no improvement in pure efficiency throughout the study period whereas scale efficiency has shown improvement in eight years (57.14%). The total factor productivity change has recorded in half of the study periodas improvement while half of the study periodhas produced evidence of no improvement.

Therefore, Malmquist summary of annual means shows change of efficiency and change in productivity during the period of study. The individual mean productivity change for thermal (DMU1) and hydro (DMU2) has been depicted in the Table 6.3.2.

Table 6.3.2. Malmquist Index Summary of Firm Means

Firm	effech	techch	pech	sech	tfpch
DMU1	**1.000**	**0.979**	**1.000**	**1.000**	**0.968**
DMU2	**1.033**	**0.979**	**1.000**	**1.033**	**1.007**

Source: Calculated by researcher using DEAP 2.1

The above table 6.3.2 shows that out of five parameters, three parameters (effech, pech and sech) are equal to one and no parameter is more than one for DMU1 whereas only one parameter (pech) is equal to one and four parameters are more than one for DMU2. Therefore, it can be inferred that DMU1 (thermal) is efficient than DMU2 (hydro) as DMU1 shows steadiness in its productivity over the time while DMU2 has shown some improvement.

6.4. Productivity Change by Group Categories

The key objective of this section is to compare the productivity of the power sectors within the groups. It will help to summarize and compare the performance of the power sectors-thermal (DMU1) and hydro (DMU2) for the electricity generation in India. It also helps to show the improvement or deteriorations in productivity in the DMUs.

Table 6.4.1. Malmquist Index Summary of Firms							
Firms	**Year**	**effech**	**techch**	**pech**	**sech**	**tfpch**	**agr tfpch**
Thermal (DMU1)	2000-01	1	1.023	1	0.857	0.876	~
	2001-02	1	1.006	1	1	1.006	0.148402
	2002-03	1	1.027	1	1	1.027	0.020875
	2003-04	1	1.024	1	1	1.024	-0.00292
	2004-05	1	0.978	1	1	0.978	-0.04492
	2005-06	1	0.978	1	1	0.978	0
	2006-07	1	1.002	1	1	1.002	0.02454
	2007-08	1	0.964	1	1	0.964	-0.03792
	2008-09	1	1.017	1	1	1.017	0.054979
	2009-10	1	0.985	1	1	0.985	-0.03147
	2010-11	1	0.932	1	1	0.932	-0.05381
	2011-12	1	0.896	1	1	0.896	-0.03863
	2012-13	1	0.936	1	1	0.936	0.044643
	2013-14	1	0.933	1	1	0.933	-0.00321
	Mean	**1.000**	**0.979**	**1.000**	**0.990**	**0.968**	**0.0062**
Hydro (DMU2)	2000-01	0.857	1.023	1	0.857	0.876	~
	2001-02	0.946	1.006	1	0.94	0.946	7.990868
	2002-03	0.831	1.027	1	0.831	0.854	-9.72516
	2003-04	1.042	1.024	1	1.042	1.066	24.82436
	2004-05	1.095	0.978	1	1.095	1.071	0.469043
	2005-06	1.194	0.978	1	1.194	1.167	8.963585
	2006-07	1.051	1.002	1	1.051	1.053	-9.76864
	2007-08	1.107	0.964	1	1.107	1.067	1.329535
	2008-09	0.885	1.017	1	0.885	0.9	-15.6514
	2009-10	0.957	0.985	1	0.957	0.942	4.666667
	2010-11	1.182	0.932	1	1.182	1.103	17.0913
	2011-12	1.159	0.896	1	1.159	1.039	-5.80236
	2012-13	0.921	0.936	1	0.921	0.862	-17.0356
	2013-14	1.238	0.933	1	1.238	1.155	33.99072
	Mean	**1.033**	**0.979**	**1.000**	**1.033**	**1.007**	**3.18023**
Source: Calculated by researcher using DEAP 2.1							

The above table 6.4.1 shows that productivity change separately for both- thermal (DMU1) and hydro (DMU2).As far as DMU1 is concerned, improvement in technical efficiency change and total factor productivity change is seen for six years (42.85%) and five years (35.71%) respectively. But, for DMU2, improvements in efficiency change is seen for eight years (57.14%), in technical change for six years (42.85%); and, in scale efficiency for eight years (57.14%). This led to improvement in total factor productivity change for eight years (57.14%).

Table 6.4.1 and Figure 6.4.1 & Figure 6.4.2 represent the growth rate of total factor productivity change (tfpch). It can easily be inferred that the mean growth rate of total factor productivity change (tfpch) for DMU1 (thermal) during the study period is 0.0066 which is insignificant. This reveals thermal units of India are working at full efficiency. But, in the case of DMU2 (hydro), the mean growth rate of total factor productivity change (tfpch) is 3.18 during the study. This positive mean growth rate for DMU3 (hydro) exposes that there is improvement occurring. This further infers that hydro units are not fully efficient, and therefore, there is a great scope of innovation in hydro units.

Figure 6.4.1. Productivity Change (DMU1 & DMU2)

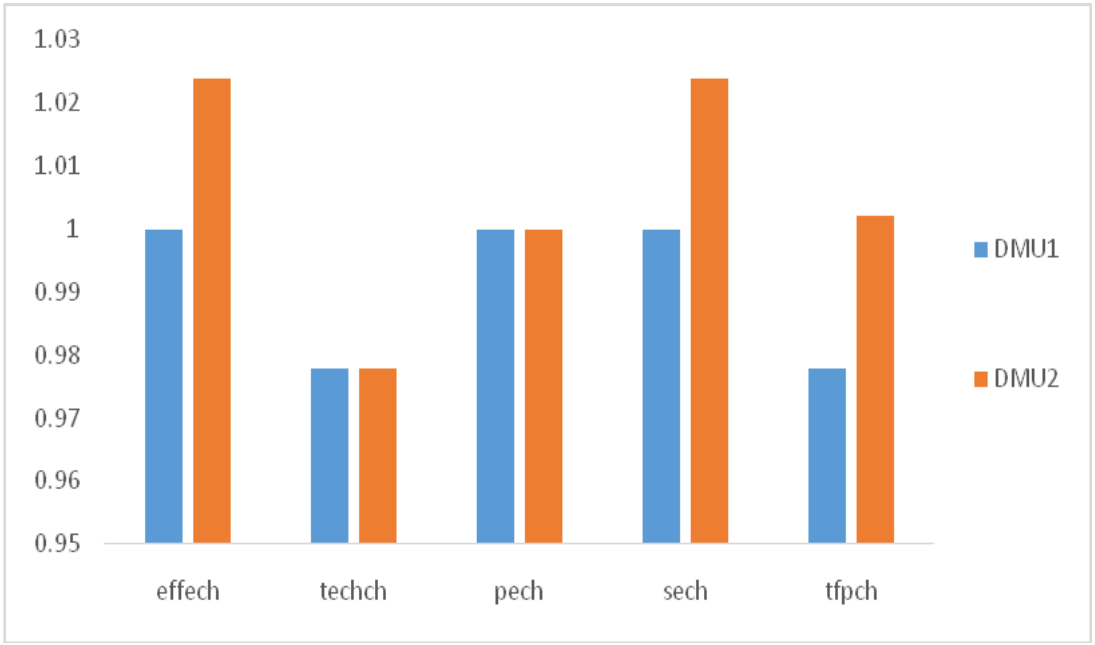

Figure 6.4.2. Annual Growth Rate in Total Factor Productivity Change (DMU1 & DMU2)