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TECHNICAL EFFICIENCY OF POWER SECTOR IN INDIA: DATA ENVELOPMENT ANALYSIS

Manita Yadav*
*Research Scholar, Department of Economics, Central university of Haryana, Jant-Pali (Mahendragarh), E-mail-nitumom26@gmail.com

Abstract

This study intends to measure Productivity change of Power sector in India during the period of 2000-01 to 2013-14. To fulfill the objectives of the study secondary data has been collected from GOI, Indiastat.com and Ministry of Power. In this study the nature of efficiency and productivity change is investigated through the Malmquist Productivity Index (MPI).The Malmquist productivity index has the components which are used in performance measurement; such as changes in technical efficiency, change in technological change, change in pure technical efficiency, change in scale efficiency as well as change in Total factor productivity. This study has taken two highest power generating sources – thermal and hydro. Symbols here listed as DMU1 and DMU2 respectively. The results of the study show that DMU1 (thermal) is efficient than DMU2 (Hydro).

Keywords: Power Sector, Hydro Sector, Thermal Sector, Total Factor Productivity, Scale change, Technical Efficiency, Technological change and DEA.

1. Introduction

The most important sector in infrastructure is power sector. Power is an essential requirement for all fact of our life and recognized as a basic human need. It is an infrastructure on which the socio- economic development of any country depends to boost up growth of the economy and global competitiveness. Power is the key deriver for India. Electricity is a key element of power sector, prime mover of growth and a very important for the nutrition of modern economy. The projected growth of Indian economy depends heavily on the performance and growth of electricity and power sector.

Power Sector in India: History and Overview

Energy is considered as the most important commercial good. After the industrial revolution and formation of machine industry, energy was considered at the first and most applied factor of production. Electricity is considered to be the most convenient form of energy. It is classified as a secondary source of energy because anyone of the primary sources like coal, gas, petroleum, hydro-power, wind and solar energies may be used to produce electricity. Due to its better adaptable nature, it is a preferred source of energy at the consumer's ends.

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However, energy being a scarce and valuable resource, a great emphasis is laid on its optimal use. Given the chacterstic of 'no-storable nature', requirement of continuous connection between suppliers and consumers and economies of scale; the electricity supply industry was treated as a natural monopoly, all over the worlds.

The power sector has significant progress after independence. At time of independence in 1947, the country had power generating capacity of 1,362mw. Hydro and coal base have been main sources of generating electricity. Distribution of electrical power was carried out by private utility companies. After 1947 the state and the center government started generating electricity in India. There was a big gap between supply and demand. Only urban areas were electrified. In rural areas was a lack of electricity. The national electricity policy 2005 gives the concept of universal services that all villages should be electrified by 2007-08. The *Rajiv Gandhi Grameen Vidyutikiran Yojna* (RGHVY) lunched in 2005, aims to electrifying all villages and providing access to electricity to all rural households over a period of four year.

Power is central not only to household activities but to economic development as well. In fact, it is the fuel of economic progress in all sectors not only agriculture and industrial but in all other allied areas. Economic progress depends very much upon how a country manages in power sector successfully. Agriculture, industry and other core areas of economy ultimately depends for their development and success on the availability of adequate power constantly. If power consumption by all sectors is seen to increase, then the index of economic development as a measure of its progress is also found to increase.

The development of power sector was a high priority area for the overall rapid development of the economy after India's independence. Financial support was provided by to boost up the power sector. Power was listed as a concurrent subject in the constitution of India. It implies that center as well as state government have jurisdiction to make rules to govern the power sector. During the British period, Electricity Act 1910 was enacted to regulate the electric power sector. After independence, Electricity (Supply) Act 1948 was enacted to reshape the power industry in the public sector. It constitutionalized Central Electricity Authority (CEA) at the central level and State Electricity Board (SEBs) at the state levels. The CEA was made responsible for overall coordination and planning of the power sector. Where the State Electricity Boards are were constituted to operate the generation, transmission and distribution activities at state level.

1.1 Rationale of the study:

Most of the issues are much related to inefficiencies that come out in inflated proportion in the cost of electricity supply. Major dimension in the power sector are availability of finance, lack of efficiency to install and produce, supply the produced power to the required destination. These circumstances prompt to examine the problem at all dimensions for efficient allocation of resources. Thus, it is vibrant to study the technical efficiency and technological change of the power sector in India.

1.2. Objectives of the study:

1) To examine the Total Factor Production of power sector in India.
2) To examine the Technical Efficiency of power sector in India.

2. Review of Literature:

Power sector and its role in infrastructure development have been a subject of discussion and debate both in academia and policy making bodies. The main reason for this is that the power sector has been undergoing radical structural and policy changes for the last two

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decades all over the world. As a result, there has been lot of formal discussion and scholarly research on the various aspects of reform and performance of power sector across the globe. Though, there are a large number of studies available to review the power sector reforms across various countries, it is useful to make references of some studies which are highly relevant to the study area. Therefore, an extensive review of the relevant studies is under taken.

Charnes et. al. (1978) applied a nonlinear programming model which provides a new definition of efficiency for the purpose of evaluating activities of not-for-profit entities participating in public programs. A scalar measure of the efficiency of each participating unit is thereby provided. It provides the methods for determining weights by reference to the observational data for the multiple outputs and multiple inputs that characterize such programs. Equivalences are established to ordinary linear programming models for effecting computations. The duals to these linear programming models provide a new way for estimating extreme relations from empirical data. Connections between engineering and economic approaches to efficiency are delineated along with new interpretations and ways of using them in evaluating and controlling managerial behavior in public programs.**Bjurek (1996)** applied the definitions of the Malmquist output and input quantity indexes specified by Caves et al. (1982) in his study. Based on these indexes, a Malmquist total factor productivity index is derived for general production structures. The definition maintains the fundamental characteristic of a productivity index as a ratio between an output quantity change index and an input quantity change index. This index provides a remedy for the shortcoming of the traditional definition of the Malmquist productivity index in that the latter does not correctly measure changes in productivity in the presence of changes in returns to scale. The Malmquist productivity index has become the standard approach in productivity measurement, especially when nonparametric specifications are applied. Furthermore, the Malmquist input and output quantity indexes provide important information that can be used to explain the aspects of productivity changes caused by underlying economic decisions and activities.**Fare et. al. (1997)** analyzed the rates of productivity growth over the period 1979- 1988 in 17 OECD countries. They used DEA to measure Malmquist productivity indices for the individual countries by the ratio of the values of the output distance functions for a reference technology exhibiting constant returns to scale (CRS) at the input-output bundles of the same country observed in adjacent years. The Malmquist index is first decomposed into two factors: one showing technical change and the other, changes in technical efficiency, which can be interpreted as "catching up." The "catching up" term is further factored into two terms: one representing pure technical efficiency change and the other, changes in scale efficiency. This extended decomposition conceptualizes a technology characterized by variable returns to scale (VRS). Their use of CRS and VRS within the same decomposition of the Malmquist index raises a problem of internal consistency. Their technical change (TECHCH) measure corresponds to shifts over time in the CRS frontier. The other factors-pure efficiency change (PEFFCH) and scale efficiency change (SCH) are derived from VRS frontiers from two different periods, however. If CRS is assumed to hold, the TECHCH term correctly shows the shift in the frontier. But, under CRS no scale effect exists at all. Hence, the extended decomposition is misleading. On the other hand, if the VRS assumption is correct, TECHCH does not show how the maximum producible output changes due to technical change holding the input bundle constant. **Singh (1998)** examined economic efficiency level in the consumption of power. The study analysed that State Electricity Boards followed an inefficient and inconsistent pricing policy. It

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contributed to inflate the demand for electricity and resulted into irrational use of power. The tariff needs to be linked with the level of economic efficiency in consumption. There was a need to discourage the farmers form making unnecessary and uneconomical use of power.**McMullen and Okuyama (2000)** conducted a study on "Productivity Changes in the U.S Motor Carrier Industry Following Deregulation: a Malmquist Index Approach". This paper uses Malmquist productivity indices to examine motor carrier productivity in the U.S. both before and after the Motor Carrier Act of 1980. Although overall productivity did not appear to change following regulatory reform, decomposition of the Malmquist Index shows significant gains in technical efficiency (firms moving closer to their production frontiers) following 1980. However, these efficiency gains were offset by what appears to be simultaneous technological regression, resulting in no net change in productivity. In particular, Surviving firms have concentrated on increases in service quality which Malmquist technique interprets as technological regress. Also considered is the possibility that exogenous factors such as the deterioration highway system and increases in congestion may have played a role negative effect of technology on productivity. Further research is to explore these issues further. **Jarm et al. (2002)** analyzed the benchmarking results of electricity Distribution companies in Finland. The study used a DEA approach to measure the efficiency of 95 companies and also completed sensitivity analysis for the period of 1999-2000. The sensitivity analysis showed that the present efficiency benchmarking method treat the network companies unequally. The effects of the changes in operational costs are different for efficient and inefficient companies. For efficient companies, the changes effect slowly or they do not affect at all. For inefficient companies the effects of changes in operational costs are logical because they behave according to DEA approach. They also argue that the effect of the changes in interruption times of customers affect the efficiency scores. The reason is that the more interruption in the electricity supplies decreases the quality of the service. According to the authors, DEA technique was found as a good base for the efficiency benchmarking of the distribution companies but it has to be further developed by taking into account the special nature of the electricity distribution business.**Azadesh et. al. (2007)** Banker Charnes Cooper (BCC) input-oriented model of DEA (Data Envelopment Analysis) has been used as methodology in the study. This model has been followed for the assessment and optimization traditional thermal power plants such that gas, steam and combined cycles. As input parameters, this study had used Installed capacity, fuel consumption, labor cost, internal power, forced outage hours and operating hours whereas total power generation had been used as output parameter. Most of the power plants in Iran were used DEA-BCC model and decision-making units (DMUs) to evaluate their efficiency and productivity rank during 1997-2000.**Jha (2007)** conducted a study to estimate the relatively operational efficiency performance in hydropower plants owned by Nepal Electricity Authority (NEA), using DEA model of weight restricted during the financial year 2004-05. Nepal Electricity Authority (NEA) covers more than 95% of the total electricity generation of the country. The average of overall efficiency of the NEA hydropower plants was 51.4 per cent in the modified DEA model and 66.67 per cent hydropower plants are found efficient under CCR model of DEA. 60 per cent hydropower plants showed poor efficiency scores. Sensitivity analysis was carried out on DEA results to highlight the weakness and strength of individual power plants so that improving steps can be taken to improve their overall efficiency.**Jain and Thakur (2010)** conducted a study to measure the efficiency of State owned electricity generation companies in India during the period of 2006-07. Data Envelopment Analysis (DEA) has been used to evaluate the performance of

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30 State owned generation companies. Installed capacity, auxiliary consumption, energy losses has been taken as input parameters and total energy generated as output parameter. An input-oriented approach of DEA was chosen for analysis of these generation companies which helps to increase efficiency by minimizing the input. Results of the study revealed that companies still on an average can improve their performance by 24%. Nine companies turned out to be efficient as well benchmark for others too. This study has also analyzed that majority of the companies are working at the inefficient scale. **Chen and Yang (2011)** conducted a study on "A cross-country comparison of productivity growth using the generalized met a frontier Malmquist productivity index: with application to banking industries in Taiwan and China". This paper is an extension of the met a frontier Malmquist productivity index, which takes into account the effect of scale efficiency change in its decomposition for both the non-parametric and parametric frameworks. An empirical application that uses unbalanced panel data of the Taiwanese and Chinese commercial banking industry is also conducted under a parametric framework. The results reveal that the adverse scale efficiency change is the key factor to inducing the inferior productivity growth seen in Chinese banks compared with Taiwanese banks.

3. Research methodology:

3.1 Data Collection:

The study is based on secondary data type. The study covers the period of fourteen years from 2000-01 to 2013-14. The data has been collected from the various authentic sites such as GOI (Government of India), Ministry of power, Indiastat.com etc.

3.2 Data Analysis Tools:

The analysis of collected data has been carried out by using DEAP 2.1.

3.2.1 Data Envelopment Analysis (DEA)

DEA is a non-parametric mathematical programming approach for frontier estimation. It involves the use of linear programming methods to examine the relative efficiency of decision making units (DMUs). This non- parametric technique was originally proposed by (Charnes, W.W, & E, Measuring the Efficiency of Decision Making Units, 1978) and referred as a CCR model (Liu & Zhang, 2011). This technique has several varieties of models. Among them following three models are utilized in various studies:

i) Standard CRS, VRS and DEA Model.
ii) Cost and Allocative Efficiencies Analysis Model.
iii) Malmquist DEA Method.

The standard CRS, VRS and DEA model consist the calculation of technical and scale efficiencies. This model was extended and further developed as the technique for the analysis of cost and allocative efficiencies. The CRS, VRS and DEA model Cost and Allocative efficiencies analysis models are outlined by Fare, Grosskopf and Lovell (1994). While the Malmquist DEA method was discussed in Fare, Grosskopf, Norris and Zhang (1994). This method mainly used for panel data to calculate the indices of total factor productivity (TFP) change, technological change, technical efficiency change and scale efficiency change.

3.2.2 Malmquist DEA Method

If a researcher is dealing with a panel data one may utilize the DEA like programme and a (in-put or out-put) Malmquist total factor productivity (TFP) index are used to measure productivity change, and to decompose this productivity changes into technical change and technical efficiency change. Fare et. al. (1994) constructed the DEA based Malmquist Productivity Index which is the geometric mean of two Malmquist Productivity Indices of Caves et al (1982). Among these two indices one measures the change in efficiency and other

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measures the changes in frontier technology. It is estimated by using DEA for a set of DMUs (Fare, Grosskop, Mary , & Zhang, 1994); (Caves, Christensen, & Diewert, 1982).

There are n DMUs under the examination of their performance. Let x_{ij} and y_{rj} denote the value of the i^{th} in-put (i= 1,2,3,......, m) and the r^{th} out-put (r=1,2,3,....., s), of DMU_j (j=1,2,3,.....,n), respectively. The slack variables for the i^{th} in-put and r^{th} out-put are represented by s_i^- and s_r^+ respectively which indicate the input excess and the output short fall respectively. The variable λ_j denotes the weight of DMU_j at the time of examining the performance θ_0 of object DMU_0.

According to Fare et. al. (1982), out-put based Malmquist Productivity Change Index can be obtained from the formula given as follows:

$M_0^{t+1}(y_{t+1}, x_{t+1} y_t, x_t)$ =[]$^{1/2}$.....................(4.5)

Where,

M_0 = Represents the productivity of production point (x_{t+1}, y_{t+1}) relative to the production point (x_t, y_t)

d (t) = Relative efficiency of particular DMU in period t against the performance of those DMUs in period (t+1).

x(t) = The In-put of particular DMUs in time period (t) against the performance of those DMUs in time period (t+1).

y (t) = The relative out-put of particular DMUs in time period (t) against the performance of those DMUs in time period (t+1).

When, $M_0^{t+1} > 1$, signifies a productivity gain,

$M_0^{t+1} < 1$, signifies a productivity loss,

$M_0^{t+1} = 1$, signifies there is no change in productivity (Coelli, 1996), (Liu & Wang, 2007).

The objective of this study is to examine the efficiency of two power unit in India which are thermal power unit and Hydro power unit. These are called as DMUs. Thermal power denoted as DMU1 while hydro power sector is denoted as DMU2. One In-put and one output are taken in this study and the time period is fifteen years. The installed capacity in Mega Watt (MW) and gross generation in (MU units) is taken as the In-put and out-put for thermal power unit. For hydro power sector installed generating capacity (in MU) and gross generation of power in (MU units) are taken as in-put and out-put respectively.

Assuming constant returns to scale (CRS), Malmquist DEA method has been applied to check the efficiency of these two power sectors. Productivity at different time period has been calculated on the basis of the equation (4.5) which reveals the efficiency of these DMUs.

4. DATA ANALYSIS AND DATA INTERPRETION

4.1 Technical efficiency of power sector in India:

This study has examined the efficiency change through Malmquist Productivity Index (MPI). The components of MPI which are used in performance measurement; such as changes in technical efficiency, change in technological change, change in pure technical efficiency, change in scale efficiency as well as change in total factor productivity.

This study attempts to provide current evidence of productivity change of Indian power sector. Through the application of Non Parametric MPI, the study covers the period of fourteen years from 2000-01 to 2013-14. Through 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. Symbols here listed as DMU1 and DMU2 respectively.

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4.2 Malmquist Productivity Index DEA Analysis

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) and so this model is named as CCR model. In this model DEA provides the efficiency scores for individual units as their technical efficiency measure with a score of one assigned to the frontier or efficient units (Charnes, W.W, & E, Measuring the Efficiency of Decision Making Units, 1978).

4.3 Malmquist Productivity Index

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 analysis purpose of the firm or DMU. To access the 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.

According to Mahadevan (2002), Deliktas, (2002) states that the efficiency change is the caching up effect and technical change is the technical change frontier effect. In other words in the efficiency change a DMU is reaching to the production frontier and in the technical change the DMU is shifting to the production frontier (Renuka, 2002).

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 changes in efficiency, changes in technical efficiency changes in pure technical efficiency, the changes in scale efficiency and finally the changes in total factor productivity. The MPI gives an opportunity to compare the productivity change within the DMUs.

Table4.3.1. 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

Source: Calculated by researcher

Note: Technical efficiency change (TECHCH), Efficiency Change (EFFCH), Pure Technical efficiency change (PECH) Scale efficiency change (SECH) and Total factor productivity change (TFPCH).

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The total factor productivity indicates all the concerning factors of productivity in the production unit. In nutshell the changes in the total factor productivity needs the changes in the constituents like changes in efficiency, changes in technology. At the time of interpretation of the Malmquist total factor productivity, all such factors are required to be considered.

The above table 4.1 reveals that during the study period there are eight such years (57.14%) of the total in which the both DMUs has recorded the improvement in the efficiency change. Here the value of theta (ɵ) is more than 1.00 which the indicator of efficiency. In the technical change it is found that there are six such years (42.85%) in which the technical change has improved with theta value more than 1.00. the DMUs got improvement in pure efficiency change and total factor productivity change also in the study period. The total factor productivity change has recorded in the 50 percent of the study period as improvement while half of the study period has produced evidence for lagging behind the improvement. The results of efficiency change and technological change shows the improvements in the thermal and hydro electricity generation. In terms of efficiency and technical change they are 57.14 percent and 42.85 percent. The Malmquist summary of annual means is the evidence, shows technological progress, gain of efficiency during the period of study.

Table 4.3.2. Malmquist Index Summary of Firm Means

FIRM	EFFECH	TECHCH	PECH	SECH	TFPCH
DMU1	1.000	0.978	1.000	1.000	0.978
DMU2	1.024	0.978	1.000	1.024	1.002

Source: calculated by the researcher

The above table 4.3.2 shows that in the efficiency change the dmu1 has recorded stagnant while the dmu2 has recorded improvement during the study. In the technical change there is deterioration in both of the DMUs. But in the total factor productivity change the DMU2 is performing well in the study period.

4.4. Productivity Change by Group Categories

The prime 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 for the electricity generation in India. It also helps to show the deteriorations in productivity in the DMUs.

Table 4.4.1. Malmquist Index Summary of Firms

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Firms	Year	EFFECH	TECHCH	PECH	SECH	TFPCH
Thermal	2000-01	1	1.023	1	0.857	0.876
	2001-02	1	1.006	1	1	1.006
	2002-03	1	1.027	1	1	1.027
	2003-04	1	1.024	1	1	1.024
	2004-05	1	0.978	1	1	0.978
	2005-06	1	0.978	1	1	0.978
	2006-07	1	1.002	1	1	1.002
	2007-08	1	0.964	1	1	0.964
	2008-09	1	1.017	1	1	1.017
	2009-10	1	0.985	1	1	0.985
	2010-11	1	0.932	1	1	0.932
	2011-12	1	0.896	1	1	0.896
	2012-13	1	0.936	1	1	0.936
	2013-14	1	0.933	1	1	0.933
	Mean	1.000	0.979	1.000	0.990	0.968
Hydro	2000-01	0.857	1.023	1	0.857	0.876
	2001-02	0.946	1.006	1	0.94	0.946
	2002-03	0.831	1.027	1	0.831	0.854
	2003-04	1.042	1.024	1	1.042	1.066
	2004-05	1.095	0.978	1	1.095	1.071
	2005-06	1.194	0.978	1	1.194	1.167
	2006-07	1.051	1.002	1	1.051	1.053
	2007-08	1.107	0.964	1	1.107	1.067
	2008-09	0.885	1.017	1	0.885	0.9
	2009-10	0.957	0.985	1	0.957	0.942
	2010-11	1.182	0.932	1	1.182	1.103
	2011-12	1.159	0.896	1	1.159	1.039
	2012-13	0.921	0.936	1	0.921	0.862
	2013-14	1.238	0.933	1	1.238	1.155
	Mean	1.033	0979	1.000	1.033	1.007

Source: Calculated by researcher

The above table 4.4.1 shows that productivity change in all DMUs and improvements in both major constituents such as efficiency change, technical change and total factor productivity change. In the thermal power sector the total factor productivity change has been recorded as 6.51 percent improvement during the year 1999-00 to 2013-14. While in this sector the scale efficiency change was recorded as 16.69 percent improvement in the same period of time.

In the hydro power sector the change in efficiency has been recorded in the table 4.4.1, it says that there is 44.46 percent improvement and the scale efficiency has also recorded as the same efficiency improvement during the study period from 1999-00 to 2013-14. This power sector has got 31.85 percent improvement in the total factor productivity during the same time period. But the technical efficiency change has recorded as the deterioration in the study period and pure efficiency change has shown the constant performance in this power sector during the study period.

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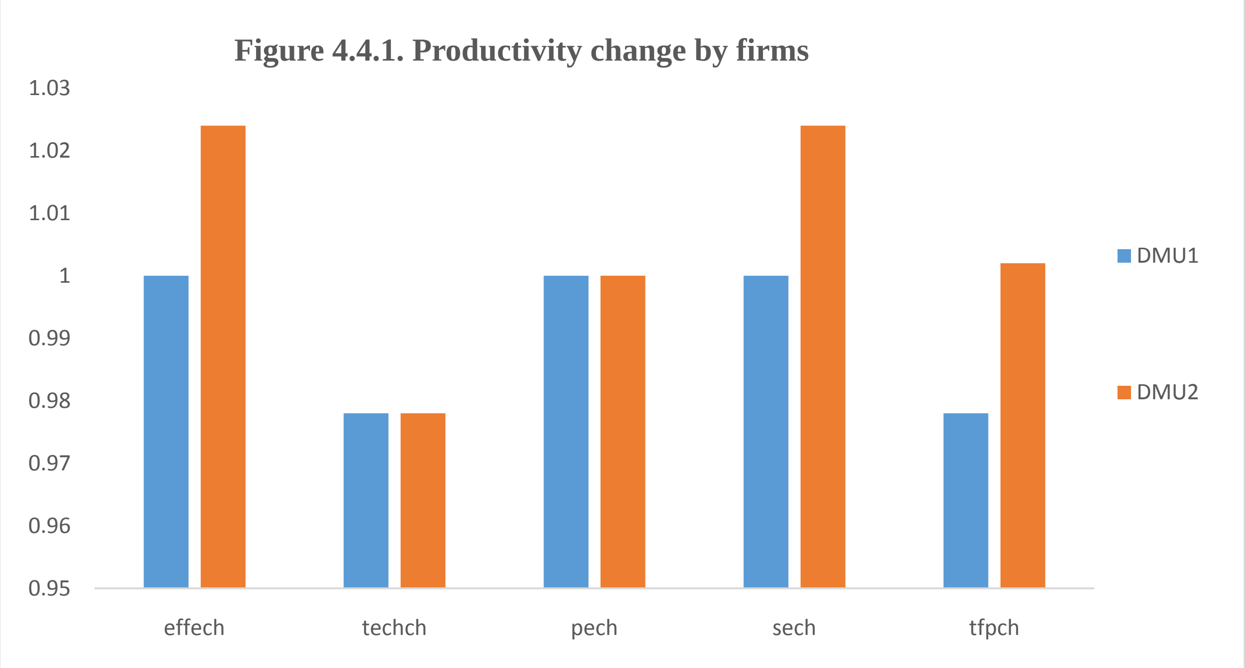

Note: DMU1= Thermal Power, DMU2 = Hydro Power, Technical Efficiency Change (TECHCH), Efficiency Change (EFFCH), Pure Technical Efficiency Change (PECH) Scale Efficiency Change (SECH) and Total Factor Productivity Change (TFPCH).

The mean efficiency of DMU2 is higher than that of the DMU1 for efficiency change, scale efficiency change and total factor productivity change. There is equal performance in technical efficiency change and pure efficiency change in both of the DMUs during the study period. In this analysis thermal power and hydro power are denoted as decision making units (DMUs). Among these two thermal powers is denoted as DMI1 and hydro power is denoted as DMU2. Here there is one input and one output for such analysis. In technical efficiency investigation it is found that the thermal power unit is more efficient than the hydro power unit.

5. Conclusion of the study:

In this analysis, thermal power units and hydro power units were taken as decision making units (DMUs). Thermal power units were denoted as DMU1 whereas hydro power units were denoted as DMU2. In technical efficiency investigation, at first, Malmquist index of annual means is calculated jointly for both the DMUs. Secondly, Malmquist index of firm mean is calculated separately for thermal and hydro. it is found that the thermal power unit is more efficient than the hydro power unit. Finally, the productivity of the power sector is compared within the groups- thermal and hydro applying the same technique. This examination of technical efficiency of power sector in India disclosed that DMU1 (thermal) is efficient than DMU2 as DMU1 shows no change in its productivity over the time while DMU2 has shown some improvement. Since hydro units are not fully efficient, there is a great scope of innovation in hydro units.

***Corresponding author**:* Manita Yadav
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