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Review Article

MEASURING FINANCIAL PRODUCTIVITY OF ENERGY SECTOR IN UTTAR PRADESH: MALMQUIST TOTAL FACTOR PRODUCTIVITY

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Abstract.
This research examines the level and trend in financial productivity in four energy sector enterprises in Uttar Pradesh, India using the Data Envelopment Analysis. The paper mainly focuses on Total Factor Productivity (TFP) growth in these energy enterprises over the year 2008-09 to 2015-16. The present study attempts to examine Malmquist Total Factor Productivity Index as a tool and also has been used to quantify the productivity variations in the said enterprises. The finding suggests that enterprises have shown an increase in overall TFP changes.

Keywords: Data Envelopment Analysis, Total Factor Productivity, Energy, Uttar Pradesh, Malmquist Index.

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INTRODUCTION

Energy is a vital building bedrock for human development and acts as a key factor for the economic development of Uttar Pradesh. According to the International Energy Agency (IEC) projections, the demand for energy between 2011 and 2030 is poised to increase by 1.5 % per year. India is a developing economy, where it places enormous demand for energy resources, however, a gradual increase in demand is causing an imbalance between demand and supply of energy to the concerned States. To cope up with the substantial rise in demand over time, the government is augmenting the energy supply by improving the productivity of its units. Though the government has implemented various measures to improve the efficiency of the energy enterprises still most of them are loss-making or underperforming. Establishment of State level Public Sector Enterprises was envisaged with Industrial Policy Resolution 1948 and 1956 for the rapid development of the state, Industrial revolution helped in creating the road map of Public Sector Enterprises developed to make country self-reliance in overall economic development. Earlier, there existed only two names – Uttar Pradesh State Electricity Board (UPSEB) and Uttar Pradesh Alparthak Evan Laghu Jal Vidyut Nigam Limited (UPAELJVNL). UPSEB was established on April 1, 1959, under the provision of electricity supply Act 1948 with the interest to promote fully coordinated development in generation, transmission, distribution, and supply within the state in the most economical and efficient manner. Whereas, UPAELJVNL or Uttar Pradesh Micro-mini Hydroelectricity Corporation Limited was established on April 15, 1985. Currently, it has four units operational namely, Uttar Pradesh Power Corporation Limited (UPPCL) DMU1, Uttar Pradesh Jal Vidyut Nigam Limited (UPJVNL) DMU2, Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited (UPRVUNL) DMU3 and Uttar Pradesh Power Transmission Corporation Limited (UPPTCL) DMU4. Energy Sector is currently facing several complications due to which the financial profitability has been badly affected. Measurement of productivity of the enterprises is an important issue that encompasses all allied business entities, State government, Central government, shareholders and investors. Productivity assessment demonstrates how the interest of state government is affected, it also informs whether the enterprises using the resources effectively and efficiently, through which government motivates the units or enterprises to new strategies to improve their performance. A financial ratio analysis is appropriate when the firm manages single input to produce a single output, while, it needs univariate nature data to predict and estimate firm efficiency. DEA was introduced to measure multiple input and multiple outputs i.e. it measures the comparative efficiency of NGOs *viz*. educational institutions, hospitals, and State level public enterprises etc. DEA is a non-parametric linear programming-based technique applied to estimate Decision Making Units efficiency, where it does not necessitate any assumption about the weights of underlying production function (Liu *et al.,* 2008). The exclusivity with the Farrels work, 1957 was further developed by Charnes, Cooper and Rhodes 1978, often called Frontier Analysis. DEA used to quantify DMU efficacies of a single time period, whereas the Malmquist TFP index can measure single-period, multi-period, and cross-period changes.

REVIEW OF LITERATURE

Most of the studies were conducted on Public Sector enterprises based on ratio techniques, whereas the few studies were conducted taking State Level Public Enterprises. Ratio analysis is found unsuccessful in order to do prediction because of its univariate nature. It becomes difficult to measure the performance of enterprises that produces multiple inputs and outputs through ratio analysis (Ludwin and Guthrie, 1989). According to Smith, (1990) earlier ratio has been the main tool of performing analysis on the financials of the companies. The limitation of the ratio tool was it's being univariate in nature as it considers only one numerator and one denominator. An attempt to apply the principles of DEA on financial statements was made, whereas DEA itself has various peculiar difficulties including determining the inputs and output and that too when the firms are working under the different unusual mix of inputs and outputs. DEA offers insights into the performance of the firms to make judgment amongst the industries. The application concentrated on identifying the efficiency of the firms from its financial statements, which is seen from the end of investors, shareholders or proprietors. Thore *et. al.* (1994) used DEA technique to gauge the efficiency frontier to input and output of individual computer corporations in the U.S. The inputs were the

Cost of Goods Sold, Sales, Administrative expenditures, labour (*in thousand*), and retaining of factory, property and equipment, gross at beginning of the year; whereas output components were Gross Sales Revenue, Income Before Taxes (EBT). This study was carried out for 44 large computer manufacturers. Whereas in the study Malmquist type index measured the intra-period total productivity change arises during the respective duration of each individual corporation. It was found that the companies demonstrated no outcome shift over the entire duration, therefore, the decision related to how much and what to do at various points of time, when choice at one time influences the possibilities available at other points of time, remains unchanged. Zain *et al.,* (1997) have provided the estimates of Turkish manufacturing enterprises during 1974-91 using the Malmquist productivity index. Where in the measurement three inputs were used the real values of the raw materials, electricity and fuels, and the aggregate capacity of the power equipment installed (horsepower) in the closing of the year and the output was the cumulative output of subsectors in the actual worth of the industry. The study was performed to do compare the performance between public and private for various sub-sectors of manufacturing sectors. Feroz *et al.,* (2003) demonstrated that DEA can augment the traditional ratio method. Where the authors stated that DEA provides a reliable measure for operational efficiency for any firm. It was also noticed that ratio analysis provides ad-hoc and partial evaluation, whereas DEA measures efficiency especially meaningful for stakeholders and analyzers. Chen and Ali, (2004) used a new extension to the DEA Malmquist productivity index to evaluate the productivity of computer industries. The inputs were the valuables or economic value (assets), stakeholder's equity and the total person employed; whereas the result output was money received by the government. The new approach measures productivity change and also identifies the strategy shift of each industry based on isoquant changes. Abbott (2006) measured the TFP using the DEA Malmquist approach of the electricity supply industry in the different states of Australia over the past 30 years. Where the study includes four inputs: Capital Stock, Fuel, number of labours, other material services and output was GWH of electricity supplied. A substantial improvement in the performance was noticed in early of the study duration. Fu *et al.,* (2008) examined the dissimilarities in State-owned enterprise's efficiency and productivity. Efficiency was measured using Data Envelopment Analysis, whereas productivity change was measured using the Malmquist Index. Aggregate data were used to represent each firm average data, in which the number of employees, net fixed capital and working capital is taken as input variables and value-added represents the output variable. The conclusion of the analysis approach shows that the efficiency and productivity of State-owned enterprises exhibit improvement during the systematic reform periods. Reyes and Tovar, (2009) has examined the competencies and output produced per employee of electricity disseminating corporates of Peru with input-oriented DEA and Malmquist TFP index in which two models were used, in Model 1 four inputs namely number of employees, distribution power loss, medium-voltage and low-voltage network kilometers and numeral of substations, whereas two outputs were used Sales and customers numbers. Model 2, number of workers, distribution power loss, the financial value of active capital during the time frame with output as sales and number of customers. Under the study, considerable progress was noticed in the total output of Peruvian electricity distribution companies. The case study of 10 papers provided by Emrouznejad *et al.,* (2014) contributed towards the theory and application of DEA in public sectors. The papers included the application of DEA on areas including school performance, education assessment, University efficiency, health care system, Public sector, public rail transit, energy network to name a few. The paper has contributed towards the recent research in different industries of non-parametric efficiency and productivity evaluation in the public sector. Smith, (1990) also advocated that the triumph of Data envelopment analysis in performing the analysis on Public Sector enterprises up-to some extent as the data wealth is not satisfactory. It can be concluded that the application of the DEA Malmquist TFP index has various processes. The studies vary on numbers and types of inputs and outputs included in the analysis, which means each study considers suitable and appropriate variable according to its choice and availability.

DATABASE AND RESEARCH METHODOLOGY

This study reviles measurement of the financial performance of energy sector operational enterprises in Uttar Pradesh, for the period of 8 years from 2008-09 to 2015-16. The data for research was obtained from the flash report of the Bureau of Public Enterprises, Government of Uttar Pradesh. The financial performance of the Energy Sector of Uttar Pradesh, to a substantial level and which depends on its physical performance and further determined by the efficiency of operations and policy-related variables. The data with plausibility to affect the financial efficiency of energy enterprises are used as an indicator in this study. Here methodology for analyzing the financial performance of four enterprises of the Government of Uttar Pradesh is elaborated. The study has specified the constraints on the input and output annual total employees (X_1), Total Assets (X_2), Operating expenses (X_3) as three-inputs, whereas the output is yearly Total revenue as (Y1), these all variables are measured in lakhs.

Sakar B., (2006) stated that Malmquist indices of TFP measure the change in output comparative to input, the Malmquist index is elucidated using a distance function. The distance function defines multiple inputs and multiple output production technology. An input distance function characterized the output technique by examining at the lowest proportionate reduction of input vector on the specified output vector. Whereas, output distance function where a maximal proportionate broadening output magnitude with the assumption of input magnitude. In the paper output distance function is considered. Here, the Total Factor Productivity (TFP) growth is assessed by the Malmquist TFP method which is explained by Fare *et al.* (1994). Malmquist TFP index measures Total Factor Productivity variation amongst the two data points by scheming ratios of the distance of each data point, relative to a common technology (Casu *et al.,* 2004). Total Factor Productivity is merely the multiplier effect of its efficiency change and technical indices. Fare was not the first one who explained the concept of TFP change measure which contained both technical change and technical efficiency change components before that translog production frontier was estimated by Nishimizu and Page (1982) using Aigner and Chu (1968) linear programming method, where they recommended as correct measure of TFP growth. The *Fare et al.* (1994) specifies an output-based

Malmquist productivity change index formulated as:

$$m_o(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)} \times \frac{d_o^{t+1}(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)} \right]^{1/2}$$

In the above equation, a, (X_{t+1}, Y_{t+1})= distance function is referred by d_o and is representing the productivity at the production point, (X_t, Y_t) represents relative production point of the productivity, t is period of benchmark technology, t+1 is the next period of technology. As explained the notations, mo greater than one indicates positive TFP change from period t and t+1, whereas a value less than one indicates a decline in TFP growth. Through the above equation is the geometric mean of two TFP indices. First evaluated with respect to period t technology and the

second is period t+1 technology. The decomposition of the Malmquist Productivity Index (MPI) into two factors.

MPI = Efficiency Change x Technical Change

Efficiency change (EC) (*catching-up effect*) and technical changes (TC) (*frontier-Shift effect*) dual factors of TFP (Nishimizu and Page, 1982; Färe *et al.,* 1994), the value of Malmquist Index equals to the product of EC and TC, where they can move in opposite directions *i.e* value of one increase and other will decrease. EC>1 indicates growth in comparative efficiency from time 't' to *'t+1'*, whereas EC=1 and EC<1, indicates that the lesser advanced efficiency remain stationary. The same in Technical efficiency TC greater than unity suggests advancements, TC equals to unity and TC less than unity, which indicates, indicates no-change and technical regress.

There are various methods of measuring distance function, but the legendary is the linear programming method. Färe *et al.,* 1992 empirical measure of Malmquist productivity index using DEA non-parametric linear programming technique made it popular amongst the researchers. According to Fare *et al.,* 1992, to calculate distance function for DMU 'h' from time t to t+1 four linear programming problems are solved to measure distance functions.

Malmquist TFP can be measured in two different modes i.e. the parametric and non-parametric methods. In the parametric approach, a distance function is measured by stochastic frontier analysis (SFA). Whereas, in the non-parametric approach, a distance function is calculated through Data Envelopment Analysis (DEA). Under the study, MPI with the constant return to scale (CRS) was measured, as it has been proved by Grifell-Tatje and Lovell, 1995 Malmquist TFP index cannot appropriately measure to predict wide TFP variations under VRS assumption. Hence it is important to impose the CRS assumption in order to measure the Malmquist Productivity index.

Table 1 is the descriptive presentation of the statistically employed variable in the present study as inputs and output. Where a large number of variation is observed in the distribution of variable in the study framework which is evidenced by large values of standard deviance.

Table 1: Descriptive Statistics for input and output

Input/ Output	Variables	Mean	Median	Standard Deviation	Minimum	Maximum
Inputs	*X1*	4300.94	4022.00	3301.64	546.00	9327.00
	X2	2381613.21	1743604.57	2342300.12	67651.54	7482472.00
	X3	150705.55	50353.65	342240.97	3706.30	1517369.00
Output	*Y1*	822688.50	293695.63	1146039.43	9744.30	3695139.00

Table 2 shows the TFP change in DMUs over the year. The analysis projected year-wise TFP change from 2008 to 2015, where 2008 taken as the base year. Mean of Total Factor Productivity Change (TFPCH) for an 8-years study was measured, where DMU2 achieved the highest TFPCH of (0.895), DMU1 scored TFPCH (0.823), DMU4 scored TFPCH (0.807) and DMU3 scored TFPCH of (0.764) over the years. It was observed that all the enterprises have shown average annual growth regress. DMU2 has attained highest TFP (0.976) in the year 2015-16, whereas DMU3 attained the lowest TFP (0.564) in 2009-10.

Table 2: Year-wise TFP Change in DMUs

DMUs	Year 2 TFPCH	Year 3 TFPCH	Year 4 TFPCH	Year 5 TFPCH	Year 6 TFPCH	Year 7 TFPCH	Year 8 TFPCH	Annual Average
DMU1	0.640	0.776	0.805	0.878	0.870	0.919	0.908	0.823
DMU2	0.778	0.851	0.869	0.918	0.934	0.952	0.976	0.895
DMU3	0.564	0.702	0.770	0.801	0.833	0.857	0.875	0.764
DMU4	0.595	0.739	0.821	0.872	0.875	0.940	0.864	0.807
Mean	0.639	0.765	0.815	0.866	0.877	0.916	0.905	

**Note that year 2 refers to range between 2008 and 2009, etc.*

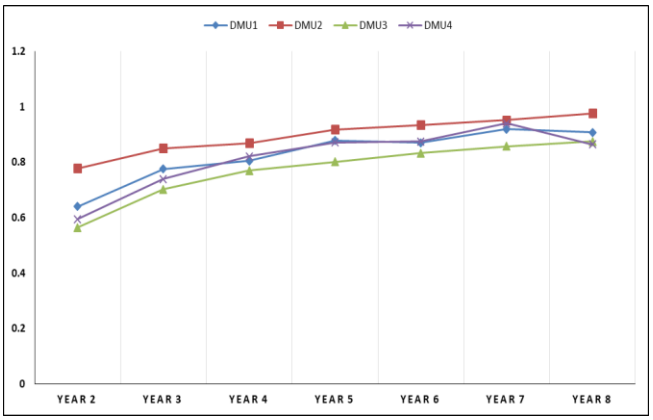

Figure 1: Year-wise TFP change over the years
Source: Author's elaboration

The technological change (TECH) or frontier-shift in DMUs over a period of time, this represents the innovation in the enterprises. Table 3 shows, the average annual technological change in enterprises, where technological regress was observed in all the DMUs, the DMU1 attained (0.811), DMU2 (0.895), DMU3 (0.764) and DMU4 (0.807). Highest TECH was recorded in DMU2 (0.976) in the year 2015-16 and lowest was recored in DMU3 (0.564) in the year 2009-10.

Table 3: Year-wise TE Change in DMUs

DMUs	Year 2 TECH	Year 3 TECH	Year 4 TECH	Year 5 TECH	Year 6 TECH	Year 7 TECH	Year 8 TECH	Annual Average
DMU1	0.625	0.742	0.814	0.867	0.885	0.896	0.891	0.811
DMU2	0.778	0.851	0.869	0.918	0.934	0.952	0.976	0.895
DMU3	0.564	0.702	0.770	0.801	0.833	0.857	0.875	0.764
DMU4	0.595	0.739	0.821	0.872	0.875	0.940	0.864	0.807
Mean	0.636	0.757	0.818	0.863	0.881	0.910	0.900	

**Note that year 2 refers to range between 2008 and 2009, etc.*

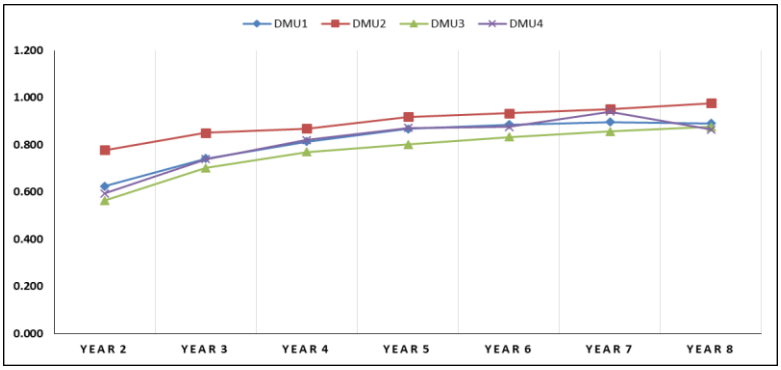

Figure 2 Year-wise TECH change in DMUs
Source: Author's elaboration

Table 4 shows efficiency change which is comprises of pure efficiency and scale efficiency. The table displays figures or scores above 1, which indicates efficiency progress. It was revealed that DMU1 has improved its efficiency over a period of time as its score is above 1 and remaining DMUs exhibited stationary picture. The figure 3 displays the several ups and downs in EFFCH, while remaining remains unchanged. Highest score of EFFCH attained by DMU1 (1.045) in year 2010-11 and the lowest was attained by same DMU (0.989) in the year 2011-12.

Table 4: Year-wise EFF Change in DMUs

DMUs	Year 2 EFFCH	Year 3 EFFCH	Year 4 EFFCH	Year 5 EFFCH	Year 6 EFFCH	Year 7 EFFCH	Year 8 EFFCH	Annual Average
DMU1	1.024	1.045	0.989	1.012	0.984	1.025	1.019	1.014
DMU2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
DMU3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
DMU4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Mean	1.006	1.011	0.997	1.003	0.996	1.006	1.005	

**Note that year 2 refers to range between 2008 and 2009, etc.*

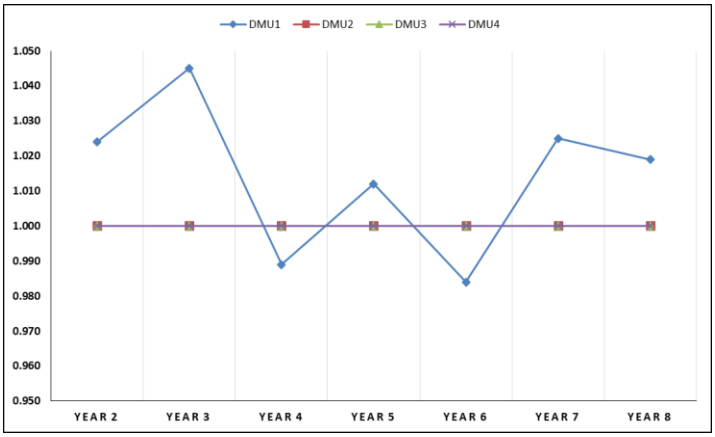

Figure 3: Year-wise EFF change over the years
Source: Author's elaboration

RESULT AND DISCUSSION

All the firms are surveyed and analyzed using the DEA Malmquist model to evaluate the TFP change over the period of time. TFP change, the percentage change in TFP over the duration and average annual growth or regress in TFP of each enterprise have been calculated. The financial records reveal that the enterprises are not working efficiently as the efficiency score is not satisfactory. The scores measured are below to unity, which shows regress in productivity, it was found that technological regress accountable for decline in TFP. The empirical result from the Table 2 and Figure 1 suggest that amongst four enterprises, Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited has exhibited the average annual TFP regress of 24 per cent where average annual technological regress was 24 per cent and efficiency change remains stationary. Similarly Uttar Pradesh Power Transmission Corporation Limited has average annual TFP regress of 19 per cent here average annual regress technological regress of 19 per cent and EFFCH remains unchanged. In Uttar Pradesh Power Corporation Limited the average annual TFP regress of 18 per cent where average annual regress technological regress of 19 per cent and EFFCH exhibited 1 per cent improvement. Lastly Uttar Pradesh Jal Vidyut Utpadan Nigam Limited average annual TFP regress of 11 per cent here average annual regress technological regress of 11 per cent and EFFCH remains unchanged. From the table it has been identified that major decline in TFP is due to reduction in technological change. There is possibility of improvement in enterprises by 18 per cent, means with better technological input in enterprises can improve their productivity.

CONCLUSION:

The empirical results of the DEA Malmquist Productivity Index (MPI) gave a new insight into the recent changes in productivity in energy enterprises, as found from table 2, 3 and 4 average annual TFPCH, TECH and EFCH for 4 energy enterprises of Uttar Pradesh government during the eight years. The average annual Total factor productivity have shown decline in TFP. Thus, it can be concluded that the majority of enterprises have shown regress in TFP, in which DMU1 and DMU2 are high-performing and DMU3 and DMU4 low-performing, out of all DMU3 can be denoted as low performing enterprise. The result based on average annual TFP change which indicates grade of in productivity level amongst high-performers and low-performers. Total Factor Productivity (TFP) growth in Energy SLPEs divulges that productivity performance recorded a moderate development. The innovative technological change is prerequisite and must be improved and implemented to attain better productivity growth with optimal utilization of resources. The management/Government must focus on investment in revenue generation assets, rather than investing in non-revenue

generation assets. This would help in the utilization of financial resources, which could improve the overall financial performance of the enterprises. Another major reason for low productivity is red-tapism involved in most of the projects, where government approval is required for every action, this causes a delay in decision making. Malmquist index is a very powerful technique for measuring variation in the productivity over a period of time. It has a varied extension with a wide application area and used for various other purposes. Despite it has many merits and many demerits. Future research is suggested for getting an advancement model, which would modestly claim the DEA Malmquist model can completely augment the traditional ratio analysis.

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