CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research methodology

This section presents the methods of research to be applied in this research work. Research methodology has been adopted as per the problems and objectives are concerned. It explained the structure of the study like that techniques of estimation, data sources, and defined variables of the study and data type and it also considers the logic behind the adopted methods in the present study. This section helps to create a structure or a systematic frame for research which helps to conduct research smoothly and solve the research problem.

3.1.1 Research design

Present study is empirical in nature. Usually research has a certain theory regarding the research topic of investigation under empirical research design. Present study is based upon theory of productivity and efficiency. We try to find out the pattern of productivity and technical efficiency of sugar industry.

3.2 Data collection

As per study needed macro level secondary data has been used in the present study to analyses productivity and efficiency performance at the industry level. There are approximate 900 factories/firms under Indian sugar Industry in 2011-2012. And in 2002-03 there are 420 firms under this industry, which shows that industry is growing day by day. The study covered 17 years of data i.e. from 1998-1999 to 2014-2015. The Data has been collected from Annual Survey of Industries (ASI). Semi-Panel data has been used in this study which is collected at annual regular interval.

3.3 Variables used in the study

In the present study used variables are defined below:

Total inputs: In the total inputs the gross value of fuel materials consumed by the industry and also included other inputs like cost of non-industrial services received from others, cost of materials consumed for repair and maintenance of factory's fixed assets including cost of work done by others to the factory's fixed assets, cost of contract and commission work done by others on materials supplied by the factory, cost of office supplies and products reported for sale during last year & used for further manufacture during the financial year.(As ASI defined).

Gross output/ total output or value of output: total output is defined to include the ex-factory value, (i.e., exclusive of taxes, duties, etc. on sale and inclusive of subsidies etc., if any) of products and by-products manufactured during the accounting year, and the net value of the semi-finished goods, work-in process, (represents the excess/deficit of value of semi-finished goods or work-in-process at the end of the accounting year over that of the beginning of the year plus net balance of semi-finished fixed assets on factory's capital account) and also the receipts for industrial and non-industrial services rendered to others, value of semi-finished goods of last year sold in the current year, sale value of goods sold in the same condition as purchased and value of electricity generated and sold. Value of gross output and total output has been used in the text interchangeable to mean the same thing. (As ASI defined)

MALM: Malmquist index

TFP: Total factor Productivity is the unexplained part of output by the input and output variables. Generally TFP is denoted by A in the production function identity. It shows the impact of technological change on the output.

EFFCH: Technical Efficiency (catch up) just shows the Pure Efficiency Change and Scale change impact on output.

SECH: So far we have discussed the efficiency of operations of a firm with respect to the production technology frontier and at a given level of input and output prices. It is possible that a firm is both technically and allocatively efficient but the scale of operation of the firm may not be optimal. Suppose the firm is using a variable retums- to-scale (VRS) technology. Then, the firm involved may be too small in its scale of operation, which might fall within the increasing returns to scale (IRS) part of the production function. Similarly, a firm may be too large and it may operate within the decreasing returns to scale part of the production function. In both of these cases, efficiency of the firms might be improved by changing their scale of operations, i.e., to keep the same input mix but change the size of operations. If the underlying production technology is a globally constant returns to scale technology then the firm is automatically scale efficient. There have been several attempts to measure scale efficiency and its influence on productivity change over time.

TECHTC: Technical Change shows the technological progress. Which estimate the effect of innovations? Research and development's contribution in output.

3.4 Modeling Criterion

Total factor productivity is the part of output which is not explained by the inputs (labour and capital). Change in total factor productivity which is also known as multifactor productivity shows the dynamic technology and its level is determined by how efficiently the inputs are utilized in production. Then technical efficiency measured in this study by the help of non- parametric approach.

3.4.1 Total factor productivity

There are five methods of measuring total factor productivity i.e Solow residual index, translog index, Data envelopment analysis (DEA) and DEA with Malmquist productivity index etc. Two are growth accounting techniques and other three are econometric tools. Total factor productivity can be measured in two ways: Parametric approach and second is Non Parametric approach. when econometric techniques is used to estimate the productivity growth known as Parametric approach rather than if the index methods used to estimate productivity known as Non-Parametric approach. The present study is based upon DEA with MPI Non-Parametric approach.

3.4.2 Data Envelopment Analysis (DEA)

This approach to productivity measurement is completely non parametric and makes use of linear programming. The Data Envelopment Analysis (DEA) is a non-parametric technique that converts Multiple input and output measures into a single comprehensive measure of productivity without imposing any functional form on data or making assumptions of inefficiency. This is done by linear programming which constructs the frontier technology from data. This technique was first used by **Farrell in 1957** and later it is operationalised by **Charnes, Cooper and Rhodes in 1978.** This approach compares the ratio of linear combination of outputs over linear combination of inputs. It defines that a firm is efficient which has highest output-input ratio for any combination of outputs and inputs. In some situation no firm may be efficient.

Output and Input Distance Functions

Distance functions are very useful technique for describing the technology in a way that makes it possible to measure efficiency and productivity. The concept of a distance function is directly related to production frontiers. The basic idea underlying distance functions is quite simple, involving radial contractions and expansions in defining these functions. The concept of a distance function was introduced independently by Sten Malmquist (1953) and Shephard (1953), but they have gained prominence only in the last three to four decades.

Distance functions allow one to depict a multi input, multi output production technology without the need to specify a behavioural purpose such as cost-minimization or profit-maximization. One may specify both input distance functions and output distance functions. An input distance function characterises the production technology by looking at a minimal proportional contraction of the input vector, given an output vector. An output distance function considers a maximal proportional expansion of the output vector, given an input vector. We first consider an output distance function.

3.4.3 Malmquist productivity index (MPI)

The MPI is based on the distance function approach, which is defined in terms of inputs or outputs. With the given input vector, an output distance function maximizes the proportional expansion of the output vector, while an input distance function minimizes the input vector (x), given the output vector (y). Etc. We have calculated Malmquist total factor productivity and efficiency change, technical change, pure technical efficiency and scale change component for all the sugar firms in the sample. Total Factor Productivity Growth is the geometric mean of efficiency change and technical change.

In this research we apply Malmquist Productivity index to find the pattern of technological change with a non parametric DEA based approach to estimate TFP growth and best optimum level of technological growth. Firstly Malmquist Index is introduced by Swedish statistician Malmquist as non parametric approach to measure the consumer behavior. It used to calculate productivity and known as Malmquist Productivity Index, which is propounded by **Cavez et al** in **1982**. As time passes many economists and statisticians used this method with some improvements. In the Present study based on MPI used by **Fare et. al.(1989,1992)** in to calculate technical efficiency and this also leads to our decompositions of the productivity in two parts first change in efficiency(catching up) and second is change in technology (innovations). Following index used by Fare et. al. (1989, 1992)

3.4.3.1 Malmquist Productivity Index/Total Factor Productivity Change (MPI/TFPCH)

$$M_0^{t+1}(y_{t+1,} x_{t+1} y_{t,} x_t) = [\frac{d(t)\ \{x(t+1),\ \ y(t+1)\}}{d(t)\ \{x(t),\ \ y(t)\}} \frac{d(t+1)\ \{x(\ t+1),\ \ y(t+1)\}}{d(t+1)\ \{x(t)\ ,y(t)\}}]^{1/2} \ldots\ldots 1.1$$

Where X and Y denotes inputs and outputs respectively. t and t+1 denotes the time period of production. The ratio measures the change in relative efficiency it tells that the change in how far observed production is from maximum potential production between the time period t and t+1.geometric mean of two ratios in brackets just shows the technical change. The value of M0 express that there is no change in the technology and there is constant returns to scale. If M0 >or < it is the symbol of technological change in production. And the value of M0 lies between -1 to +1.

3.4.3.2 Efficiency Change

$$\textbf{EFFCH} = \frac{d(t)\ \{x(t+1),\ \ y(t+1)\}}{d(t)\ \{x(t),\ \ y(t)\}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1.2$$

3.4.3.3 Technological Change

TECHCH = $\left[\frac{d(t+1)\{x(t+1),\ y(t+1)\}}{d(t+1)\{x(t),y(t)\}}\right]$^1/2………………….1.3

3.5 Data Analysis

The analysis of collected data will be carried out using DEAP 2.1.