PRODUCTIVITY AND EFFICIENCY OF SUGAR INDUSTRY IN INDIA

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DECLARATION

I hereby declare that the research work embodied in this dissertation entitled **"Productivity and Efficiency of Sugar Industry in India"** has been carried out by me at the department of Economics Central University of Haryana for the partial fulfillment of the requirement for the award of the degree of Master of Philosophy in Economics, is a record of original research work done by me under the supervision of Dr. Ranjan Aneja, Department of Economics, Central University of Haryana. The Manuscript has been subjected to Plagiarism check and the work is submitted for consideration of award of M.Phil Economics. The content of this dissertation has not been submitted so far in part or in full for any degree or diploma in any other institution.

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CHAPTER 1

INTRODUCTION

1.1 Background

Every industrialist is very much concern about the theory of firm in order to make correct decision regarding what items, how much and how to produce them. All these decisions are directly related with the cost consideration and market situation. Every industrialist tries to produce goods with maximum profits with minimum cost. In this regard, industrialist needs various inputs such as labour, capital, raw material etc and their optimum combination is equally important for maximum profitability.

In this modern era, economy cannot grow without technological improvement. Technology is changing as per second in this era and this has compelled most of the economy to undertake the appropriate strategies and policies to gear up the technological change and to reap its results, benefits for the economic growth which is derived from the productivity growth. Technological progress is the base of many developed economies rather than they don't have abundant in natural resources, Japan is the great example in this context. Scumpter (1911) said that "Innovations are the engine of growth in any economy."

Productivity is an economic measure of output per unit of input like labour and capital. Generally it is measured by the marginal productivity of capital and labour. Labour productivity measures the amount of goods and services produced by one hour of labour. Real GDP by an hour of labour has been measured by labour productivity. Capital productivity means the amount of goods and services produced by per unit of capital. It means that real GDP by a unit of Capital measured by capital productivity. Productivity can be increased by the efficiency improvement in the production. Technology plays an important role to increase the productivity. Technology allows more to be done in less time and empowering the workers that helps increase productivity of labours. Technique or technology is the method of production which helps to select combination of inputs for better output. But there is problem of choice of technology which type of combination used for production. Amritya Sen said that planning is important and its success is depends on the choice of technique more than the investment size and type of planning. There are mainly two type of technology discussed by the economists, first is lobour intensive technique (embodied technique) and second is capital intensive technique (disembodied). Technology would be adopted as per the availability of resources and according to the aims. In the developed countries there is availability of cheap labour so labour intensive technology should be adopted which helps to reduce the unemployment and on the other hand also helps to produce goods with less inputs costs. Generally developed countries adopted capital intensive technology.

Total factor productivity is the part of output which can't be explained by the inputs. It is the impact o output because of technological factors which may be new machines, innovations and new technique. Technology has two parts technological progress and technological change.

In 1956 Abramowitz wrote the first paper followed by Solow and Kendrick is an attempt to measure the contribution of technical change to economic growth. They treated it as disembodied. Disembodied technical change is purely organizational which permits more output to be produced from unchanged inputs, without any new investment. Disembodied technological change refers to any kind of shift in the production function that leaves the balance between capital labours undisturbed in the long-run. Technical progress is organizational in the sense that its effect on the productivity does not require any change in the quantity of inputs, existing inputs are improved or used more effectively. Embodied technical change improved technology which is exploited by investing new equipments.

What is technical efficiency?

Today, efficiency is a buzzword not only in economics but also in various areas and in daily life. We can take efficiency means as the optimum solution for any problem. Generally it is categorized in two types first is technical efficiency and second is economical efficiency. Technical efficiency happens, inputs used in best way when there is no possibility to increase the output without that how the maximum output is gotten from the input resources. Economic efficiency happens when the production cost output is as low as possible. So we can say that it depends upon the prices of the factors of production.

Technical efficiency is helpful to change the natural resources into goods and services without much waste. And economy can't imagine the economic efficiency in our production without achieved the technical efficiency. Technological change always increases the productivity of labour and capital also, which helps to produce cheaper goods and services. A rational producer always wants to achieve more profit by using less input. In this globalization and technological word which is full of perfect competition, technological efficiency is how much important for a country or producer. Because it helps them to produce goods at cheaper rate and establish them as a good competitor. Last few years economists and many other socialists attract the world mind at the scarcity of resources so the use of these resources should at their best level.

Total factor productivity is told about the unexplained part of output that's not explained by inputs like labour and capital. It's also known as Solow residual then many advanced techniques and definitions put forward by economists and try to explained the technological effect on output. Further, total factor productivity decomposed in pure technological efficiency change scale efficiency change and managerial efficiency change.

A higher growth path on the account of higher productivity is considered to be preferable alternative as compared to that due to increased application of inputs. But India is a labour abundant economy and increased productivity is always decreased the level of employment in the economy which is a big concern before the policymakers as it is a barrier of social welfare. World has certain natural resources and there is need of sustainable development and Pareto optimality situation is possible only by efficient use of technology.

1.2 Definitions of Technical efficiency

There are several definitions regarding technical efficiency. The two most famous definitions are discussed below:

The first definition is the radial definition given by **Debreu (1951)** and further developed by **Farrell (1957).** The input reducing radial measure of technical efficiency for a unit is defined as the difference between unity (100% efficiency) and the maximum equi-proportional reduction in inputs (while maintaining the production of originally specified output levels). If this difference is zero then the unit is efficient else it is inefficient. The output-increasing radial measure of technical efficiency is defined as the difference between unity (100% efficiency) and the maximum augmentation of outputs (while still utilizing the originally specified input levels). Again, the unit is efficient if this difference is zero else it is inefficient.

Koopmans (1951) formally defined technical efficiency as "If a producer needs to decrease one of the output or increase one of the inputs in order to increase in output, the situation is technical efficient." which is also known as the Parato –Koopmans Optimum or Koopmans technical efficiency. It is based upon the Parato optimality situation of welfare economics.

In simple words, the technical efficiency is the effectiveness with which a collection of inputs is used to produce an output. A firm or industry is said to be technically efficient if a firm or industry is producing the maximum output from the minimum quantity of inputs. For example, a firm or industry would be technically inefficient if a firm employed too many workers than was necessary or used outdated capital.

1.3 Need to study the Productivity and Technical Efficiency

Technical progress we mean inventing a new technology and improving it through innovation and diffusion in the society. Total factor productivity is a crucial measure of efficiency and thus an important indicator of policymakers. There will be strong relation between output and technological change in the sugar industry. As output and export increasing day by day, it can be expect that the technology adoption also shows changing pattern in sugar industry.

Technology and Economic growth

Significant fractions of innovation help to increase in the production. Innovations create new demand in the economy and on another innovation increasing the efficiency of production. Demand and profit motivates the investment in the economy. Innovations are necessary for an economy to move at a sustained path of growth.

Economic Fluctuations and Technology

Large portion of TFP growth is recognized by endogenous innovation decisions has significant implications for the business cycle. This study is likely to be an important research topic in future. Comin and Gertler (2006) examines that low-persistence, non-technological shocks generate pro-cyclical fluctuations in the market value of innovations. **Kydland and Prescott (1982)** came with the real business cycle (RBC) concept in their study with the title of ‘Time to Build and Aggregate Fluctuations’. In this standard model (RBC model) which is based on US labour market, focuses on productivity shocks and explains how they are responsible for fluctuations in economic activity. Existing models of business cycle have been incapable of explaining many of stylized facts that characterize the US labour market. The standard real business cycle model is modified by introducing two sided search in the labour market as an economic mechanism that propagates technology shocks. This new analytical environment can explain many phenomena of the business cycle that the standard model either has resolved is an unsatisfactory manner or has been able to address at all. When a technology advance leads to boom, MPL increases and there is increase in employment and real wages. According to this study the only driving force behind cyclical fluctuations is technological shocks or disturbances.

Barro and King (1982) conducted a study entitled Time-Separable preferences and inter temporal-substitution models of business cycles. And found that an initial shock in the form of a technological advance shifts the production function upwards. And this leads to increase in the resources by their better utilization and its increase in investment and investment followed by more output. To business cycles technology is responsible.

Technological efficiency and international trade

Technological difference is the base of international trade because it is technical difference which helps countries to make cheaper goods rather than other countries. And make their exports cheaper and stable them as efficient producer of international market and make their goods more valuable. And this shows surplus in current account. This study helps to understand the technological difference between countries and adoption of best technology in their production. **Comin, Hobijn and Rovito (2006)** put together direct measures of technology adoption for approximately 75 different technologies. Increase the number of theories regarding the adoption of technologies such as the role of policies **(Holmes and**

Schmitz, 2001). Burnside et al. (1995) and King and Rebelo (1999) has introduced pro-cyclical fluctuations in measured TFP by incorporating unmeasured labour capacity utilization in standard the standard framework. **Kelnow and Rodriguez-Clare (1997) and Hall and Jones (1999)** have confirmed that a majority of the gap in income per capita between rich and poor countries is associated to large cross country differences in TFP. Difference in TFP occurs because of difference in physical technology. **Squires and Reid (2004)** expressed that technological change us the development of the new technologies or new products to improve and shift production frontier upward.

1.4 Industrial sector of India

In an economy there are three basic sectors i.e. primary sector also known as agricultural, secondary sector and which is also known as industrial sector or manufacturing sector and territory or service sector. As economists told about the relationship between development of economy and change the occupation of people. At first stage of economy which is traditional stage, mostly people of economy depend on primary sector and it plays an important role in GDP. With the growth of an economy, the share of manufacturing sector and service sector also increase in GDP. This trend shows that the development in the economy due to transformation of unskilled labour force into skilled labour force. India also passing out from these stages, since independence Indian economy was mainly agro-based economy but as time passes manufacturing and service sector's share in GDP increased. The share of industrial sector in India's real GDP has been risen over the years. But its share is less than as the share of territory sector in GDP. Finally, we show that the mix of skilled and unskilled labor in manufacturing and services is increasingly similar. It is concluded that sustaining economic growth and rising living standards will require shifting labor into both manufacturing and services. Manufacturing sector has more potential to generate the employment rather than territory sector. Manufacturing sector is the path to increase service sector of an economy. It provides inputs and market for the other sectors of the economy. India is likely to be one of the few countries to witness a disproportionate expansion in its working age population by 2020. In India approximate 60% of the population was within the working age group (20-50 years) in 2007. An abundant supply of people in the working age group has the potential to boost manufacturing growth. It absorbs much of the force there is need to lay large emphasis on building strong human capital. Robust the growth in manufacturing sector can be a potential panacea for providing employment to vast majority of the population. To boost manufacturing sector govt. launched a new scheme 'Make in India' and there is target to increase the share of manufacturing Sector in GDP up to 25% by 2025 and create employment in manufacturing sector. Manufacturing sector of India can be classified into two parts: organized manufacturing sector and unorganized manufacturing sector

1.4.1 Contribution of manufacturing sector in real GDP: The average share of manufacturing sector in real GDP has marginally increased from about 13 per cent during 1970-75 to about 15.6 per cent in 2007-08 etc. approximately by about 2.6 percentage points over a period of almost four decades. In 2008-09 manufacturing sector's share in GDP is just about 16.1%. Share of manufacturing GVA at current prices is 14.8% in 2010-11, 18.1 % in 2011-12, 17.9 % in 2012-13, 17.3 % in 2013-14 and 17.2% in 2014-15.

1.4.2 Contribution of manufacturing sector in employment

Manufacturing sector's contribution was 13.8% in 1983. In 1999-2000 its contribution in employment creation was increased with 16.3% and in 2011-12 manufacturing sector contributed 24% and its contribution is increased with 33% today. The employment and output generation within the manufacturing sector exhibits a major imbalance. According to the latest available data, the unorganized sector accounts for about 80% of employment and only about 33 % of income of the manufacturing sector. 'Make in India' initiative a lion step to usher in increased manufacturing in the country, which will ultimately generate more employment opportunities for the poor and give greater purchasing power in their hands. The major expectation from this campaign is that it will create around 100 million job opportunities for youths in India over time.

1.5 Overview of world sugar industry regarding India

After Brazil, India is the largest sugar producer in the world and it leads in sugarcane production. However, if alternative sweeteners such as khandsari (sort of raw sugar) and gur (jaggery) are included in the fold, then India would be the largest overall producer of sugar. Brazil accounts for approximately 22 percent of the global sugar production and India contributes almost 14 percent. India stands at first place in consumption of sugar in the world but in per capita consumption India is so far from the highest per capita consumption countries.

1.5.1 Indian sugar industry

India is the world's largest producer of sugarcane and second largest producer of sugar after Cuba. This industry involves a total capital investment of Rs. 1,250 crore and provides employment to 2.86 lakh workers. In addition, 2.50 crore sugarcane growers also get benefit from this industry.

Indian Sugar industry is second biggest industry after cotton industry which is based upon agricultural products. India is the second biggest producer of world after Brazil and in consumption we stand at first place in the world. Sugar industry is basically rural area industry which plays an important role in the development of rural area to create direct and indirect employment. Sugar industry provides direct employment to 3.25lakh workers and also provides 450 lakh indirect employments to Farmers. India has 22% share in the world sugar production. Even we have enough surplus; our export of sugar is not as par expectations because price of our sugar is very high in world market. Recently in few years' sugar export of our country is increasing but not up to the mark. So there is need to study of their technological change. This study examines the effect of technological change on the output of sugar industry in a time period of 17 years i.e. from 1998-99 to 2014-15.

1.5.2 Background of Indian Sugar Industry

India is the traditional producer of sugar. India has a long tradition of manufacturing sugar from Vedic period. Many References of sugar making by the Indians are found even in the Atharva Veda. India is truly called the homeland of sugar. But in ancient times, only gur and khandsari were made and modern Sugar industry came on the Indian scene only in the middle of the 19th century, when it was introduced by the Dutch East India Company in north Bihar of India. Unfortunately, this mill was not working successfully. The first successful attempt was made by the indigo planters at the initiative of Britishers in 1903. In this attempt, Vaccum pan mills were started at Pursa, Pratabpur, Barachakia and Marhowrah and Rose in north-eastern U.P. and the adjoining Bihar. This happened when demand for indigo ceased to exist due to the introduction of synethic blue in the market. In the early years of the 20th century, the industry grew rather slowly and there were only 18 mills in 1920-21 and 29 mills in 1930-31. The industry got a great fillip after the fiscal protection in 1931 and the number of mills rose to 137 in 1936-37. The production also shot up from 1.58 lakh tonnes to 9.19 lakh tones during the same period. The industry passed through an uncertain phase during and after the World War II and some stability was experienced only after 1950-51. There were 139 mills producing 11.34 lakh tonnes of sugar in 1950-51. After that, the plan period started and the industry made rapid strides. In the year 1994-95, there were 420 mills producing 148 lakh tones of sugar.

1.5.3 Production trend of Indian sugar industry

In 1950-51 its production was 11 lakh ton and increasing year by year in 2007-08 its production was its highest stage with 263 lakh tons and its lowest production was in 2008-09. Then it again increased with 188 lakh tons in 2009-10 and then 274 lakh tons in 2011-12.

1.5.4 Indian sugar industry and international trade

Now, India has been a net exporter of sugar. However, it has been occasional net exporter of sugar depending upon demand and supply situation in the country. In 2005-06 India has been net exporter with 15.039 lakh tons exports and imports of sugar was 0.07 lakh tons. India export of sugar was highest in 2007-08 with 58.23 lakh tons and highest imports was in 2008-09 with 24.47 lakh tons imports. From last three years, India's export of sugar is higher than its import of sugar.

1.5.5 Major contributed states in the production of sugar in India

Sugar industry has two major areas of concentration. One comprises Uttar Pradesh, Bihar, Haryana and Punjab in the north and the other that of Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh in the south.

Maharashtra

Maharashtra has progressed a lot and comes at first position from U.P. to emerge as the largest producer of sugar in India. Large production of sugarcane, higher rate of recovery and longer crushing period are some of the factors which have helped the state to occupy this enviable position.

The state has one-fourth of the total sugar mills and produces a little more than one third of the total sugar of India. Sugar mills of Maharashtra are much larger as compared to the mills in other parts of the country. The major numbers of sugar mills is found in the river valleys in the western part of the Maharashtra Plateau.

Uttar Pradesh

Uttar Pradesh is the traditional producer of sugar and has been standing at the first rank among the major sugar producing states of India. However, its relative importance has been reduced during the last few years and the state has conceded the top position to Maharashtra and now occupies the second position. Maharashtra has fewer mills than Uttar Pradesh but they are of comparatively Large in size and yield more production. In Uttar Pradesh traditional techniques used for sugar production rather than Maharashtra. Huge part of sugar is used in the making of gur which is not use the sugarcane at optimum level.

Presently, the state records about 24 % of the total production of sugar in India. There are two distinct regions of sugar production in this state. One region consists of Gorakhpur, Deoria, Basti and Gonda in eastern Uttar Pradesh and the other lies in the upper Ganga Plain consisting of Meerut, Saharanpur, Muzaffar nagar, Bijnore and Moradabad.

Tamil Nadu

Tamil Nadu has shown extraordinary progress regarding to sugar production during the last years. High yield per hectare of sugarcane, higher sucrose content, high recovery rate and long crushing season have enabled Tamil Nadu to obtain highest yield of 9.53 tonnes of sugar per hectare in the whole of India.

As a result of these qualities, the state has emerged as the third largest producer of sugar in India and it contributing more than nine percent of the total sugar production of India. Most of the 32 mills of the state are located near to Coimbatore, North Arcot Ambedkar, South Arcot Vallalur and Tiruchchirapalli.

Karnataka

Karnataka has 30 mills producing 1,151 thousand tonnes or over 6 per cent of the total sugar of India. Belgaum and Mandya districts have the highest concentration of sugar mills. Bijapur, Bellary, Shimoga and Chittradurga are the other districts where sugar mills are scattered.

Andhra Pradesh

Andhra has 35 mills which are more than its neighbouring state Karnataka but it contributes only 6.01 percent in the production of India’s Sugar. The reason is that mills are smaller comparatively the mills of Karnataka. Mostly sugar mills are situated in the East and West of Godavari, Krishna Vishakhapatnam, Medak, Vishakhapatnam and Chittoor Districts.

Gujarat

Mills in Gujarat are scattered in Surat, Amreli, Bhavnagar, Junagarh, Rajkot, Banaskantha and Jamnagar districts. With the 16 mills state produced about 5.56 percent sugar of total sugar produced in India.

Haryana

Haryana has only 8 mills but their large size enables the state to contribute 1.91 per cent of the total sugar production. Sugar mills are located in Rohtak, Ambala, Panipat, Sonipat, Kamal, Faridabad and Hissar districts.

Punjab

Punjab has a total of 13 mills which are located in Amritsar, Jalandhar, Gurdaspur, Sangrur, Patiala and Rupnagar districts.

Bihar

Bihar was the second largest sugar producing state next only to Uttar Pradesh till mid- 1960s. Since then the state has been experiencing slow growth and as a result lost its prestigious position to the peninsular states like Maharashtra, Tamil Nadu etc...

Karnataka and Andhra Pradesh

These states have 28 mills and make an insignificant contribution to the production of sugar. The belt of eastern Uttar Pradesh extends further east in Bihar and the districts of Darbhanga, Saran, Champaran and Muzaffarpur are included in this belt.

Other states of India

Among the other producers are Madhya Pradesh has 8 mills in Morena, Gwalior and Shivpuri districts, Rajasthan has 5 mills in Ganganagar, Udaipur, Chittaurgarh and Bundi districts and Kerala, Orissa, West Bengal and Assam also contributed in the production of sugar in India

1.5.6 By-Products of Sugar Industry

Mainly, Sugar industry has two by-products

Baggase

Basic use of baggase continues as a fuel which is a traditional use of baggase. Now it is also used as a row material for paper industry requirement. Paper prepared by the use of baggase has high quality. However, since the mills are scattered all over the country, collection of surplus baggase becomes problem. Huge garbage collected around the mills and it creates pollution. Now makes paper units uneconomical. Efficient utilization yet to come up which increase the efficiency of the industry and it is used in the electrical. Through the cogeneration processes bagasse and molasses can be utilized to generate electricity for the use of industry itself and to distribute the same in near areas.

Molasses

Molasses can be used in the production of ethyl which can be utilized in the making of chemicals, liquor and ethanol. Ethanol can be used as the energy sources as it is bending with the petrol. . It can be utilized in the manufacturing of feed for cattle. There are total 283 distilleries and 108 sugar mills having distilleries attached total installed capacity is 2700 Mn liters. In india, mostly part of ethyl used as row material in alcohol.

1.6 Area of the study

In the present study overall sugar industry of India has been taken as the study area. Presently there are 763 sugar mills in operation. Details of the required variables have been taken from the ASI annual survey of India. In this site industries' data has been collected with their by products.

1.7 Rationale of the study

Indian sugar industry is third largest agro-based industry in its share in Gross Value Added (GVA) of Indian economy. Importance of the industry is increased as it is employment potential or labour intensive industry and direct linkage with the rural economy. This made essential to analyze the status of the sugar industry of India. The following reasons attract the researchers to select this industry for evaluate the productivity and technical efficiency in this industry.

- India is not only among the largest producers of sugar in the world but it is also stands at first place in overall production of sugar with khandsari and Gur. Sugar industry uses the huge amount of resources of Indian economy. This means the country has huge stake in efficient operation of the industry.

- Indian sugar industry is a great source of income; generate huge employment and great share in tax revenue of country.
- Sugar industry of India is one of the most highly regulating industries by government as it is an essential good of consumption so there is need to fulfill the demand of consumers at reasonable cost. But from the producer's side its partially decontrolled by the govt. as per time needed to improve the health of the sugar industry. So there is need to check the productivity changes in the industry after these decisions of the govt.
- Now India becomes net exporter from last three years but we have more surplus to export. But high cost of Indian sugar becomes barrier to sale it in the international market. To enjoy comparative advantages there must to adopt sufficient efficiency which capable us to compete in the international market.
- Another great issue that sugar industry is the most fluctuating industry of Indian economy. In the present study we use the most advance technique to estimate productivity and technical efficiency which is Malmquist productivity index.

Research on productivity growth is very important because economic growth cannot be sustainable without improvement in the Total Factor Productivity. From a policy point of view, the assessment of TFP growth is important as it serves as a guide for resource allocation and investment decisions.

1.8 Objectives of the study

These are main objectives of present study:-

1. To estimate the Productivity trend in sugar Industry of India.
2. To estimate the Labour Productivity and Capital productivity trend in the sugar industry of India.

3. To estimate the Total Factor Productivity with technical efficiency and technical change in Sugar Industry of India.

1.9 Hypotheses of the study

To fulfill the objectives and aim of the present study two hypotheses were framed. The hypotheses are as follows:

H0: There is no significant change in productivity of Indian sugar industry.

H1: There is significant change in productivity of Indian sugar industry.

H0: There is no significant relation between productivity growth and technological change.

H1: There is significant relation between productivity growth and technological change.

CHAPTER 2

THEORITICAL FRAMEWORK OF MODELS REAGRDING PRODUCTIVITY AND TECHNICAL EFFICIENCY AND LITERATURE REVIEW

2.1 Introduction of Literature Review

This section of the study is talking about the review of literature. Literature review plays a very important role in research work. It creates a gap between current study and past knowledge of the related subject. Increase the knowledge of researcher which makes roadmap for new research. And it also helps to discover research methods and tools for the study. This chapter deals with the existing literatures regarding the study. The reviewed literature is divided in three major parts:

2.2 Theoretical literature review

2.3 Empirical literature review

2.4 Methodological literature review

2.2 Theoretical literature review:

The concept of neutral progress was given by the following economists:

Hicks' Neutral Technical Progress (1932) in his book 'Theory of Wages' propounded the neutral technical progress concept. Under this, efficiency of all factors increases in the same proportion and the ratio of marginal productivities of the factors, that is, MP_K/MP_L is constant for a given K/L ratio.

$$y = t.f\,(K, L) \text{ where } t = \text{technology index}$$

Harrod's Neutral Technical Progress (1948) 'Towards a Dynamic Economy' Harrod's Neutral Technical Progress is labour augmenting, that is, the labour efficiency improves. As a result, marginal productivity of labour (MP_L) increases with a given constant K/L ratio. Relative input shares remain the same for a given Capital-Output (K/O) ratio.

$$y = f(K, T(t) L)$$

Solow's Neutral Technical Progress (1957) in his study with the title of 'Technical change and the aggregate production function' presents the concept of technical progress. It is capital augmenting. As a result, marginal productivity of capital (MPK) will increase with a given K/L ratio. Relative input shares remain the same for a given labour-output (L/O) ratio.

$$y = F(T(t) K, L)$$

These models are mainly known as exogenous models of Technical progress. Modern economists came with the concept of endogenous technological progress.

Classical views on Productivity:

Although technological progress did not get importance in the work of classical economists like Malthus, Ricardo and Mills, it is considered to be a major determinant of economic growth today. Subsequently, in the works of Marx and Schumpeter it got some importance with varied degrees. Later on, the concept came to the fore after the works of Tinbergen (1942), Schmookler (1952), Kendrick (1956), Fabricant (1954), Abramowitz (1956) and Solow (1957).

Index numbers (TFP): In this approach, under a number of assumptions, it is possible to calculate A, the technology coefficient or TFP coefficient without a specified exact production function or rigidity assuming it to be uniform across observations. There are two indices: Solow index (developed by Solow in 1957) and Translog index (developed by Diewert in 1976).

Solow index: Solow index assumes that elasticity of substitution between labour and capital to equal to one.

In A = lnY – (1-α.)lnL – α lnK

Translog index: the translog index of TFP is equals to-

$$\Delta \ln \quad TFPt = \Delta \ln \quad Yt - \frac{[(SLt + SLt - 1)}{2} * \Delta \ln \quad Lt] - [\frac{SKt + SKt - 1}{2} * \Delta \ln \quad Kt]$$

Solow factor productivity:

Solow (1956) also demonstrated that cross country differences in technology may generate important cross country differences in income per capita. Technology is positively correlated with income per capita. To find out the technical change there are many methods available. One of them is Solow residual; a very popular method. Let the growth rate of aggregate output **(g_y)**, the growth rate of aggregate capital **(g_k)**, the growth rate of aggregate labour **(g_L)** and α as the capital share. The Solow residual is defined as **$g_y - \alpha * g_k - (1-\alpha) * g_L$**. To find accuracy in Solow residual there are following assumptions:

1. The production function is neoclassical means constant return to scale.

2. There is perfect competition in factor market.

3. The growth rates of the inputs are measured accurately.

An increase in either A, K, L will lead to increase in output while lobour and capital inputs are tangible, total factor productivity appears to be more intangible as it is depends on the knowledge of workers we can say that on human capital. Technological capability is closely related to capability in research and development. Economic change, including technological change, is evolutionary process. Much technological change is cumulative within firms and within economies. The analysis explains some reasons behind this phenomenon. It then focuses on the internal organization of research and development within firms. Research and development is necessary for competitiveness but it is almost depend on human skill or human capital. Technical skills and information are key components in the process of technological change and competitions are the major sets of influences on the innovativeness and competitiveness of firms. As we know that resources are limited just like capital and lobour, we have to create efficient technology for proper utilization of these resources because this utilization of resource fulfills the needs of huge population.

Endogenous growth models:

The Endogenous theories are the result of reaction against the deficiencies in the Solow-swan model. In these models long run growth of an economy depends on the endogenous factors not on the exogenous factors like population growth and rate of technological progress which depends on saving rate. Endogenous growth models does not criticized neoclassical theories of growth, as these models are the extended version of neoclassical theories. Endogenous models, also known as new growth theory. Endogenous growth models focus on: Human capital, Knowledge, Innovation, Research and development, and investment etc. these theories consider the spillover effect or externalities of investment in technology. Some endogenous models are explained below:

Arrow (1962) in his paper entitled ‘The Economic Implication of Learning by Doing’ introduce the concept of learning by doing by regarding it as endogenous growth model. The theory focused upon how you gain by learning by doing which helps in decreasing the average cost. In other words, firms always increase in its efficiency to produce more. Stock of knowledge change in increasing trend and workers become more familiar with the work as volume of output increase.

Romer (1986) presented a paper on endogenous growth entitled 'Increasing Returns and Long-run Growth' and told that creation of knowledge is sub product of investment so the model is also known as learning by investment model. Knowledge is considered to be a non – rival good. Romer focuses on research and development which helps in creating more knowledge. According to him there is possibility of externalities that is returns to investment helps in creating more knowledge and it is quite possible that knowledge may show decreasing returns.

Lucas (1988) in his paper with the title of 'On the Mechanics of Economic Development' focused upon investment in human capital. According to this model growth rate is the combination of growth rate of labour and growth rate of per capita investment in human capital.

Romer (1990) in his study with the title of 'Endogenous Technological Change' Growth in this model is driven by technological change that arises from intentional investment decisions made by profit maximizing agents. According to this model technology treated as input or we can say that as endogenous factor and other feature of technology is that it is a non-rival, partially excludable good. Because of the non-convexity introduced by a non-rival good, price-taking competition cannot be supported, and instead, the equilibrium is one with monopolistic competition. The main conclusions are that the stock of human capital determines the rate of growth, that too little human capital is devoted to research in equilibrium, that integration into world markets will increase growth rates, and that having a large population is not sufficient to generate growth. Output per hour worked in the United States today is ten times as valuable as output per hour worked 100 years ago. (Maddison, 1982). Since the 1950s, economists have attributed much of the change in output per hour worked either directly or indirectly to technological change. (Abromowitz (1956), Kendrick (1956), Solow (1957). From a native point of view this seems right. The raw materials that we use have not changed, but as a result of trial and error, experimentation, refinement, and scientific investigation, the instructions that we follow for combining raw materials have become vastly more sophisticated. One hundred years ago, all we could do to get visual stimulation from iron oxide was to use it as pigment. Now we put it on plastic tape and use it to make video cassette recordings. The argument presented in this paper is based on three premises. The first is that technological change—improvement in the instructions for mixing together raw materials— lies at the heart of economic growth. As a result, the model presented here resembles the Solow (1956) model with technological change. Technological change provides the incentive for continued capital accumulation, and together, capital accumulation and technological change account for much of the increase in output per hour worked. The second premise is that technological change arises in large part because of intentional actions taken by people who respond to market incentives. Thus, the model is one of endogenous rather than exogenous technological change. This does not mean that everyone who contributes to technological change is motivated by market incentives. An academic scientist who is supported by government grants may be totally insulated from them. The premise here is that market incentives nonetheless play an essential role in the process whereby new knowledge is translated into goods with practical value. The third and most fundamental premise is that instructions for working with raw materials are inherently different from other economic goods. Once the cost of creating a new set of instructions has been incurred, the instructions can be used over and over again at no additional cost. Developing new and better instructions is equivalent to incurring a fixed cost. This property is taken to be the defining characteristic of technology.

2.3 Empirical literature review:

Singh (2015) in his study entitled 'Technical Change and Productivity Growth in the Indian Sugar Industry' examines the technical change and productivity growth in 40 Indian sugar companies with the help of MPI approach. The study time period is 2004-05 to 2013-14. The study is based on secondary company level panel data the results of the study showed 0.7%negative growth rate of TFP. And technical regress is the reason behind to make TFP growth negative. In this study five variables were used as input namely Capital Cost (CA), Employee Cost (EMP), Row Material (RM), Energy and Fuel (E&F) and Other Manufacturing Expenses (OME) at constant price level 2004-05 and Value of Output (VOP) taken as output variable.

Khavi et al. (2012) in his study entitled 'Analysis of Total Factor Productivity Growth of Sugar Beet in Iran Using Malmquist Approach' analyzed total factor productivity growth of sugar beet industry in Iran with the time series data taken during 1989-90 through 2007-08, was examined with the help of one of the latest non-parametric approach MPI. In their study amount of seeds, fertilizers, insecticides, herbicides, labour, water and acreage in one hand were taken as inputs and output of sugar beet production were taken as output. In their study they found that sugar beet production TFP growth increases with 6% in their study period. In this study first total factor productivity growth was calculated and the effective factors in changing the growth of total factors were determined through MPI. Results showed that changes in efficiency, technology and productivity of total factors during the study period have had positive growth in productivity of total factors of production. As the average productivity growth of total factors was 6% and average technological growth of sugar beet was 6.2%. But average productivity growth was showing negative trend and scale growth is estimated to zero which showed that there was lack of efficiency.

Hossain et. al (2012) conducted a study titled An Application of Non-Linear Cobb-Douglas Production Function to Selected Manufacturing Industries in Bangladesh. The study considers Cobb-Douglas production function with Additive and Multiplicative error term. The main purpose of this study is to select the appropriate C-D production function for some selected manufacturing industries in Bangladesh. Logarithmic transforming regression method and Newton Raphson method used to find the gradient of C-D production function .results of the study shows that there are economies of scale in the manufacturing of Drugs & Pharmaceuticals, Furniture & Fixtures, Iron & steel basic, Leather & Footwear, Fabricated Metal Products, Plastic products, Printing & Publications, Tobacco since $\gamma<1$ for the industries. And other industries like Beverage, Chemical, Glass & glass products, Leather & Leather products, Paper & Paper products, Textile, Wood & Crock products shows diseconomies of scale with $\gamma>1$.

Mandal and Madheswaran (2012) in their study entitled with Productivity Growth in Indian Cement Industry: A Panel Estimation of Stochastic Production Frontier, to estimate total factor productivity growth in the Indian cement industry. Applying stochastic frontier approach to estimate TFP growth and then decomposed it into technical progress and technical efficiency. The time period of the study is from 1989-90 to 2006-07. Empirical results show that TFP growth is driven by technological progress not by the technical efficiency. Total Factor Productivity growth found 5.37% of output growth and 94.63% of output growth has been achieved through input growth. So there is needed to take steps by government to improve productivity efficiency.

Saliola and Seker (2011) in their study entitled Total Factor Productivity across the Developing World observed TFP performance of developing countries of world with the help of micro level data from manufacturing countries in 80 developed countries. The data source of the study was surveys' of World Bank Enterprises survey in 2006. Solow residual method used to estimate the TFP which is the residual part of Cobb-Douglas production function not defined by inputs like labour, capital and intermediates as the study defines. Indonesia has the highest aggregate productivity among the countries that were surveyed in 2008-09 and second position covered by Turkey while Brazil has the highest average productivity among countries that were surveyed in 2006-07 and Peru has the highest aggregate productivity among these countries and in average productivity Peru stands at lowest place. In 2008-09 Brazil stands out for having the highest average productivity in the garment and chemicals industries and also performed well in food industry. And in the 2006-07 surveyed, Mexico comes relatively good performance in garment and chemicals. Regional analysis

Kumar and Arora (2011) conducted a study with the title of 'Assessing Technical Efficiency of Sugar Industry in Uttar Pradesh: An Application of Data Envelopment Analysis. The study examines the technological efficiency in sugar industry of Uttar Pradesh commonly known as the sugar bowl of India. Using firm level data of 86 sugar mills operating in UP during the time period of 2003-04. Total technical inefficiency is about to 19% and pure technical and scale efficiency contributed the same share.

Rahmen (2010) conducted a study with the title of 'Efficiency Dynamic of Sugar Industry of Pakistan' applied DEA approach to estimate the total factor productivity growth , technical efficiency change and technological progress in Pakistan sugar industry using panel data for 20 sugar firms from 1998 to 2007.and MPI was used to measure the productivity Growth. The empirical estimates on the performance of sugar industry fielded serval striking results. The Malmquist TFP Result rejects a tormenting picture for the sugar industry. Overall sugar industry improved. Technological progress by 0.8% while managerial efficiency change put a negative effect on the productivity by a same percentage as result the overall total factor productivity during 1998-2007 remained almost static with a decline of 0.1%. If we see the

TFP and its components in individual year for overall sugar industry, it presents divergent trend.

Fogarasi (2006) in his study entitled Efficiency and Total Factor Productivity in post-EU accession Hungarian Sugar Beet Production examines the efficiency and total factor productivity in Hungarian beet sugar production applying non parametric approach of DEA is used to calculated the TFP growth and then Malmquist productivity index is used to decompose the technical progress and technical efficiency. During study years 2004 and 2005, TFP increased by 9%. The major reason increment in TFP was Technical Progress of 8% while technical efficiency played a limited role in improving the performance of sugar beet production.

Miller and Upadhyay (2000) analysis in his study the effects of openness, trade orientation, and human capital on total factor productivity for a pooled (time series + cross sectional data) sample of developed and developing countries. Total factor productivity depends upon economical (cost effective) specification of the aggregate production function. Potential determinants of total factor productivity include measures of openness, trade Orientation and human capital. Higher openness benefits total factor productivity. Outward-oriented countries experience higher total factor productivity, over and above the positive effect of openness. Generally, total factor productivity positively affected by Human Capital. In poor countries, however, human capital interacts with openness to achieve a positive effect. In this study to estimate total factor productivity from a cost effective specification of the aggregate production function involving output per worker, capital per worker, and the labor force, both with and without the stock of human capital. Then, try to search for possible determinants of total factor productivity, with special emphasis on trade variables. Results show that open economy generally benefits total factor productivity it helps to increasing exports to GDP and it also helpful to improve the terms of trade and depricate the value of currency in world market. Moreover, the stock of human capital contributes positively to total factor productivity in many, but not all, specifications. That is, human capital has a negative effect on total factor productivity in high-income countries and a positive effect in middle-income countries and low-income countries as result of opening of economies.

Fare et al (1994) in their paper titled with Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries. This study examines the productivity growth in 17 OECD countries over the period 1979-1988 which is the time of nine years. A non-parametric programming method is used to calculate Malmquist productivity indexes. These are decomposed into two component measures, namely, technical change and efficiency change. The study finds that U.S. productivity growth is slightly higher than average, all of which is due to technical change. Japan's productivity growth is the highest in the sample, with almost half due to efficiency change. In this paper we apply recently developed techniques to the analysis of productivity growth for a sample of OECD countries. The technique we use allows us to decompose productivity growth into two mutually exclusive and exhaustive components: changes in technical efficiency over time and shifts in technology over time. These components lend themselves in a natural way to the identification of catching up and the identification of innovation, respectively.

Jha and Sahni (1993) analyzed the technical efficiency of Indian Sugar industry. Study is based on secondary data with the period time period of 1960-61 to 1986-87 which is taken from the two authentic sites first is Census of Indian manufacturers (CMI) and second is Annual survey of Industries (ASI). The results of the study show the downward trend in the pattern of allocative inefficiency in the Indian sugar industry. Translog index method is used to calculate TFP.

Acharya and Nair (1978) examined empirical issue in Total Factor Productivity Growth of Cement industry in India over the time period of 1959-60 to 1970-71. Data source was Annual Survey of Industries. Solow index has been used to estimate the Total factor productivity growth. Results of the study analysis that the given increasing returns to scale the industry can reap the benefits of scale expansion. Moreover, the analysis of TFP growth using Solow index exhibits no monotonic trend in TFP growth.

Gupta and Patel (1976) in their study entitled with 'Production Function in Indian Sugar Industry' estimated Different forms of Production functions for Indian sugar industry. The study was confined the time period of 1946-1966 and further divided the study period in two parts: 1946-1958 and 1959-66. The data used in this study taken from Census Manufacturing Industries (CMI) and the Annual Survey of Industries (ASI). The study revealed zero neutral technical progress and results showed the increasing returns of Scale for the industry. And there was unit elasticity of substation between labour and capital. In terms of factor elasticity of output labour become more powerful factor than capital to find out the parameters of production function ordinary least square method (OLS) used after transforming the production function in Logarithmic form.

Sastry (1966) in his study entitled 'Measurement of Productivity and Production Function in Sugar Industry in India: 1951-1961' calculated the growth of output and trends in labour Productivity within the time period of 1951-1961, which is the time of 10 years. The main purpose of this study is towards measuring of productivity change in the sugar industry of india during the study period. This attempts at analyzing separately at aggregate and regional level because of its heterogeneous characteristic. Productivity change is measured through the total factor productivity indices and average productivity ratios. These indices are estimated by the output per unit of input per unit approach. The growth in labour productivity is purely attributed to the capital available per labour. And all other residual factors effect was negatively because of old machinery and technology used in sugar industry of India. Labour of Andhra Pradesh, Bombay and Madras have been found more efficient than capital and on the other side Bihar and Uttar Pradesh showed inverse situation. Productivity showed the negative value at both aggregate and regional level.

2.4 Methodological literature review:

The literature reports three approaches to measure technical efficiency:

(i) The index numbers approach

(ii) The econometric approach

(iii) The mathematical programming approach.

The index numbers approach includes multi-factor productivity models, financial and operational ratios. The econometric approach presupposes a theoretical production function to serve as the standard of technical efficiency. The Cobb-Douglas, Translog, and Leontief type functions are most commonly used to approximate the production function as they are easily transformed into linear forms. Econometric models are further divided into Stochastic and non-Stochastic models. The mathematical programming approach does not require the use of a specified functional form for the production data. This approach was pioneered by Charnes, Cooper and Rhodes (1978) and is called Data Envelopment Analysis (DEA).

While econometric methods (e.g. regression analysis) employ "average observations" mathematical programming methods (e.g. DEA) use "production frontiers" or "best practice observations" for efficiency analysis. A detailed discussion of input-reducing and output-increasing orientations of technical efficiency and DEA is provided in the subsequent sections. In this section of study we explains the DEA approach related review and try to explain the history of DEA till its present.

2.4.1 Data Envelop Analysis related review

According to classical economists, labor productivity was considered as an overall measure of efficiency. According to **Farrell (1957),** this ratio (units produced divided by labor hours) was not appropriate as a measure of technical efficiency (TE) as it included only labor and ignored other important factors such as materials, energy, and capital. Thus he proposed a measure of technical efficiency that incorporated all inputs in an aggregated scalar form and also overcame the difficulty of converting multi-component input vectors into scalars. Thus the technical efficiency formulation for multiple input-output configurations is:

Technical Efficiency = Aggregate Output Measure/ Aggregate Input Measure

The inputs are all resources that are consumed to generate the outputs. From equation the above equation, it can be seen that technical efficiency for a firm relates to its ability to:

(i) O**utput-increasing efficiency**: Produce maximum output with the use of constant use of inputs.

(ii) **Input reducing efficiency:** Use minimum inputs to produce a constant output.

Charnes, Cooper, and Rhodes (1978) extended **Farrell's (1957)** work in the measurement of technical efficiency and developed Data Envelopment Analysis (DEA). It is a non parametric approach which is originally propounded by Charnes, Cooper and Rhodes to making relative efficiency in organizations or in Decision Making Units. The CCR model is based on linear programming approach. Data of output and inputs of relative Decision Making units needed to find technical efficiency in this approach.

Banker, Charnes, and Cooper (1984) In DEA an inefficient DMU can be made efficient by projection onto the efficient frontier or the envelopment surface. However, the DEA model used determines the actual point of projection that is chosen on the envelopment surface. The CCR model assumes constant returns to scale *i.e.,* if all inputs are increased proportionally by a certain amount then the outputs will also increase proportionally by the same amount. However, Banker, Charnes, and Cooper (1984) noted that the constant returns to scale assumption skewed the results when making comparisons among DMUs differing significantly in size. In such situations it would be pertinent to know how the scale of operation of a DMU impacts it's (in) efficiency. Thus, **Banker et al (1984)** developed a new formulation of data envelopment analysis that is commonly known as the BCC model. The BCC model enables the use of a new empirical production function and is used to compute efficiency under the assumption of variable returns to scale *i.e.,* a proportional increase in inputs need not necessarily yield a proportional increase in outputs.

Whereas the CCR model addresses aggregate (technical and scale) efficiency, the BCC model addresses pure technical and Scale efficiency. Efficiency is made up of technical (physical) efficiency and scale efficiency. Scale efficiency is explained through (Boussofiane *et al.* (1991)).

***i.e.*, Aggregate Efficiency** = Scale Efficiency * Technical Efficiency

Fare and Lovell (1978) Non- Radial measures used to put side by side DMUs to the efficient frontier or isoquant and not the efficient subset of the isoquant. This sometimes results in a DMU using excess inputs also being termed efficient as compared to a DMU on the efficient subset. Secondly, the radial measure of technical efficiency is mainly based on Farrell's (1957) assumptions of the production function which limits its application to production technologies that satisfy those assumptions. And lastly, radial measures involve proportional reduction/augmentation of input/output mixes respectively which is not always feasible in real world scenarios. Fare and Lovell (1978) developed a non-radial measure that addresses these shortcomings for the production function by terming only DMUs on the efficient subset as efficient and by scaling input factors by different proportions to define the path of projection onto the efficient subset.

2.4.2 Malmquist Productivity Index related reviews

Fare et al (1994) this paper decomposed the MPI into technical efficiency and technical change component. This helped us to identify improvement in efficiency and contribution of technological progress and innovation to productivity growth in sugar industry.

Coelli (1994) in his working paper entitled ‘A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program explained the DEA (Data Envelopment Analysis) approach with MPI. In his paper with the help of three examples which are based on these approaches told that how the application of DEAP version 2.1 can be used to measure the cost efficiency between DMUs, comparison of between them and also MPI approach with DEA to measure the productivity and its sources with Panel data. The study is the full explanation of productivity change and its sources. It explained the both input oriented and output oriented approaches of the DEA and also taking about the assumptions and condition to use the approaches of MPI. Basically his study is based upon how to use the computer application DEAP Version 2.1 and hoe it is useful for the study of productivity and technological change and its efficiency parameters of any firm.

Alithin (2001) in his study entitled ‘Measurement of Productivity Changes: Two Malmquist index approaches’ he took comparison between the basic period of MPI which is developed by the **Caves Christensen** and **Diewert (1982)** and adjacent malmquist productivity index which is developed by **Fare, Grosskopt, Lindegren** and **Rooj (1989).** Both of the Versions Measures efficiency Changes between two time periods similarly. But technical change is measure by them differently. The adjacent version primarily a two period notion and measure the shift in the Technology frontier as the shift at the time t and t+1. To measure technological changes it uses adjacent time period. So, two shifts are averaged geometrically. The shift in the frontier measured by the base period index is given as the ratio in the shift in the frontier at time t and t+1. Both shifts are related to the technology in the base fixed year and and the shift in the frontier is always measured in relation to the technology of the fixed period. thus base period index is also a two period notion. But it uses an additional period to uses to measure the productivity change.

Balk (2001) in his study with the title 'Scale Efficiency and Productivity Change' tried to develop a generic measure of scale efficiency for a multiple inputs and multiple outputs of firms using modern approach of production relate theories. To measure the technological change, technical efficiency and scale efficiency is the second purpose of the study. Malmquist productivity index is well known approach to measure productivity, technological change and technical efficiency but in this study three other approaches were introduced to measure the scale change. This study told the sticky difference between the different modern approaches of the productivity change and its sources. The study has main focused on the scale efficiency.

Tohidi (2012) in his paper entitled 'A global cost Malmquist productivity index using data envelopment analysis' new cost Malmquist productivity index which is the measure of single measure of productivity, it is circular. This study is mainly based on the input oriented approach of the MPI. This approach of the MPI with DEA is mainly used for the comparison of the DMU (Decision Making Units) efficiency or cost efficiency.

This section of the study is concluded that the MPI (Malmquist Productivity index) is between the modern approaches it is one of the most well known approach to estimate the

Productivity change and technological progress. It is the attracted the researchers and also the firms to analyses the efficiency of their production function.

2.5 Research Gap

There are several study have been conducted on the productivity and efficiency of sugar industry. But in other studies, there are number of tools used in order to estimate the total factor productivity such as Solow index, translog index, Data Envelopment Analysis. In the present tools used MPI with a non parametric approach of DEA that is out-put oriented approach. And the tool used in the present study is totally differ from the tools used in earlier study. MPI used in few earlier studies but it was input oriented.

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)

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

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.

CHAPTER 4

LABOUR PRODUCTIVITY AND CAPITAL PRODUCTIVITY IN SUGAR INDUSTRY OF INDIA

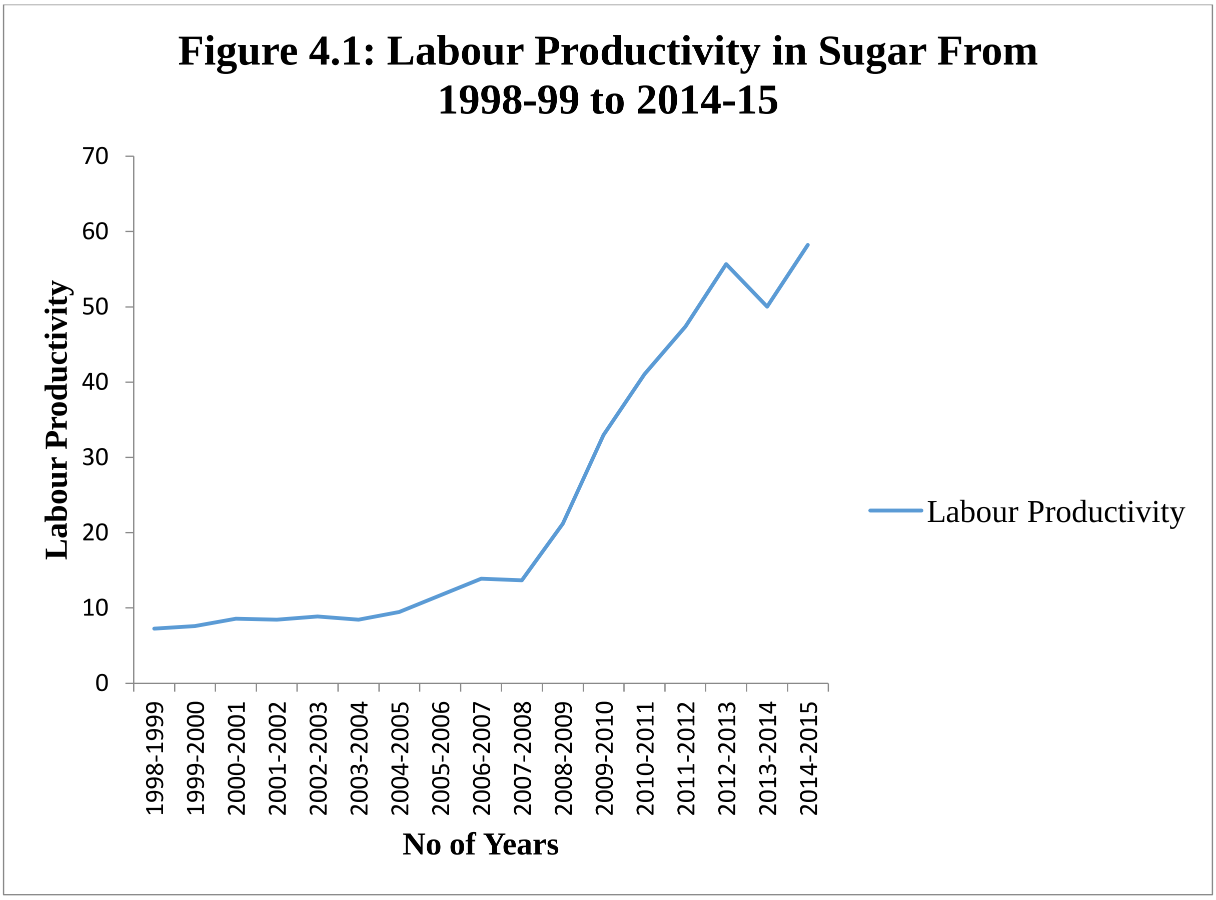
This section of the study estimates the labour and capital productivity in the sugar industry of India. Initially, Labour productivity is considered to be one of the oldest and widely used measures of productivity (Trivedi, *et al.* 2000). "The wide usage of labour productivity is due to the fact that it can be used as proxy for the amount of goods available for consumption per labourer. Hence increase in labour productivity is very often regarded as an end in itself and in such a situation the role of capital gets reduced merely to that of enabling labour productivity to rise." The Labour productivity is the ratio of aggregate total output and total number of labours. Labour Productivity measures the amount of goods and services produced by one hour of labour. Real GDP by an hour of labour has been measured by labour productivity. Capital output ratio is the second measure of productivity which measures real GDP at per unit of capital.

Table 5.1 Labour Productivity in Sugar Industry of India

Sr. No	Years	Total Outputs	No of Labours	Labour Productivity
1	1998-1999	4012781	553338	7.25
2	1999-2000	4321322	569730	7.58
3	2000-2001	4820613	562026	8.57
4	2001-2002	4623798	547950	8.43
5	2002-2003	4758598	536574	8.86

6	2003-2004	4544405	538184	8.44
7	2004-2005	5051133	533508	9.46
8	2005-2006	6561793	562891	11.65
9	2006-2007	8147044	585980	13.90
10	2007-2008	8139956	595029	13.67
11	2008-2009	3863937	182418	21.18
12	2009-2010	6008971	182110	32.99
13	2010-2011	7585384	184758	41.05
14	2011-2012	8681154	183236	47.37
15	2012-2013	10016728	179887	55.68
16	2013-2014	8588392	171620	50.04
17	2014-2015	9739559	167298	58.21
			CAGR	**14%**

Table 4.1 depicted the Labour productivity in the sugar industry of India during the study period from 1998-99 to 2014-15. During the study years, the labour productivity is gradually increased. In 1998-99 it was 7.25 and it increased up-to 13.90 in 2006-07. In 2007-08 there is little decline shown in the above table. From 2008-09 it again look up at the increasing path which stopped in 2013-14 when a little decline noticed in the labour productivity of labour. In 2014-15 labour productivity is 58.21. The Compound Annual Growth is 14% in the Sugar Industry of India, which is showing increasing trend in the labour productivity of Indian sugar industry.



The above figure 4.1 revealed the Labour Productivity trend in the Sugar Industry of India during the study period. In this diagram on the Horizontal-Axis shows number of Years and on Vertical-Axis shows labour productivity. We can analyzed that it predicted the increasing trend in the labour productivity of sugar industry during the study period excepted it shows little decline in 2007-08 and 2012-13.

Table 4.2: Capital Productivity in Sugar Industry of India

Sr. No	Years	Total Outputs	Productive Capital	Capital Productivity
1	1998-1999	4012781	1544263	2.59
2	1999-2000	4321322	1673673	2.58

3	2000-2001	4820613	1899301	2.53
4	2001-2002	4623798	1947399	2.37
5	2002-2003	4758598	1960585	2.42
6	2003-2004	4544405	2101437	2.16
7	2004-2005	5051133	2284461	2.21
8	2005-2006	6561793	2695787	2.43
9	2006-2007	8147044	3168931	2.57
10	2007-2008	8139956	3799520	2.14
11	2008-2009	3863937	3257294	1.18
12	2009-2010	6008971	3904003	1.53
13	2010-2011	7585384	4516943	1.67
14	2011-2012	8681154	4895754	1.77
15	2012-2013	10016728	4984284	2.00
16	2013-2014	8588392	4753911	1.80
17	2014-2015	9739559	4618134	2.10
			CAGR	**-1%**
Calculated by Researcher				

The Table 4.2 revealed the capital productivity growth in the sugar industry of India. The capital productivity was highest in 1998-99 with the value of 2.59. Then capital productivity continuously declined from 1998-99 to 2004-05. In 2005-06 there is little increment shown in capital productivity (2.43) and again it was declined after 2006-07. In 2008-09 capital productivity is the lowest during the study period and reached at the 1.18. Capital productivity increased up-to 2.00 in 2012-13. Again it is declined in 2013-14, capital productivity comes at 1.80. In 2014-15 capital productivity reached at 2.10. The compound annual growth rate is -1%, which shown negative growth rate of capital productivity.

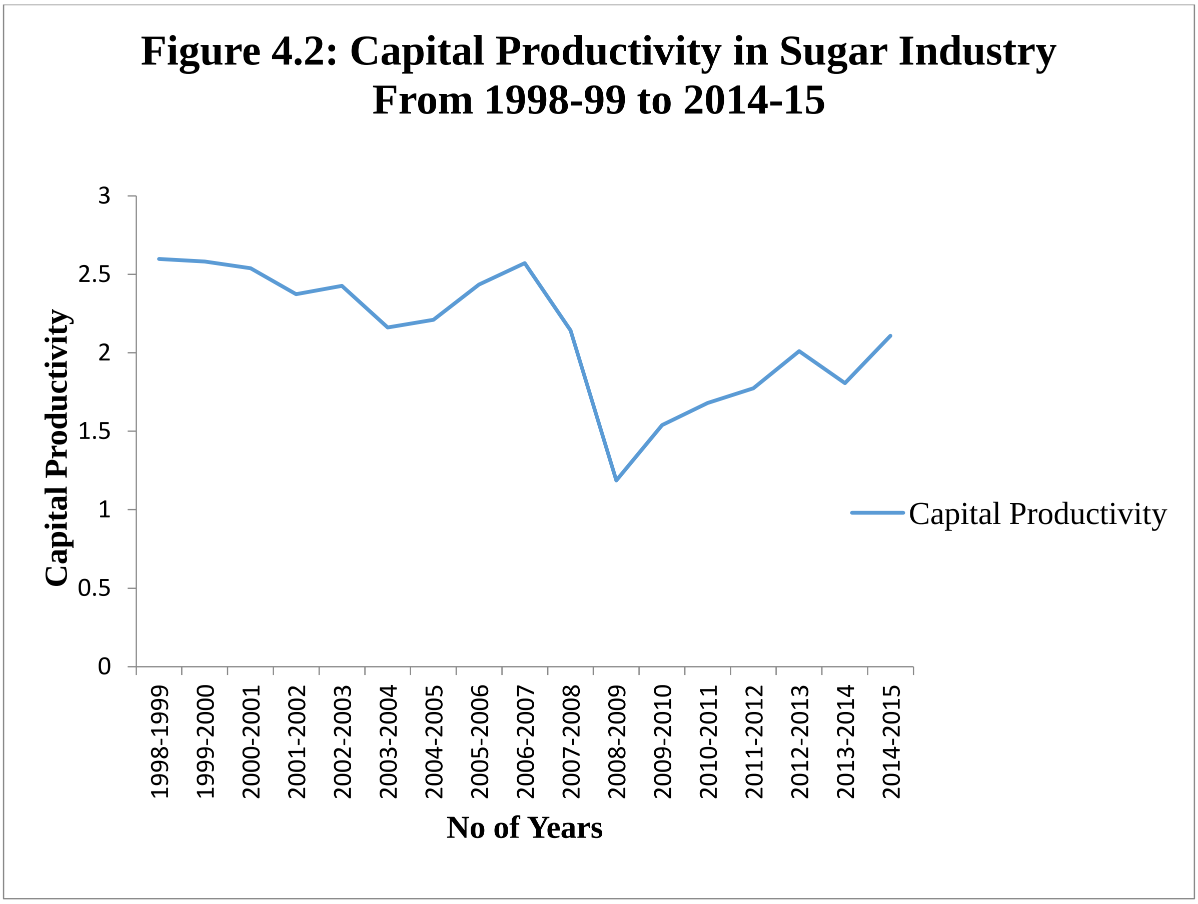


Figure 4.2 revealed the capital productivity in sugar industry of India during the study period. Horizontal axis shown number of years and vertical axis told the capital productivity line. The Fig predicted the decreasing growth in the Capital output ratio of sugar industry of India. In 2008-2009 capital productivity is at its lowest point. Again it is increasing after 2008-09. The highest point is of capital productivity is 2.59 in the 1998-99.

Conclusion

labour productivity showed increasing trend and compound annual growth is about 14%. Capital productivity showing decreasing trend and compound annual growth is negative one. Labour productivity and employment generated in the industry has negative relation. Generally there is negative relation between the Capital productivity and invested capital if the output is constant. So as per the results, there is increasing investment in the sugar industry of India. It is followed by labour productivity. Profitability and efficiency should increase in the industry.

CHAPTER 5

PRODUCTIVITY CHANGE WITH DECOMPOSITION OF TECHNICAL CHANGE, EFFICIENCY CHANGE, SCALE CHANGE AND PURE EFFICENCY CHANGE

In this study we calculate productivity change as the geometric mean of two Malmquist productivity indexes. The Malmquist index was introduced by Caves et al. (1982) who dubbed it the (output-based) Malmquist productivity index after Sten Malmquist, who earlier proposed constructing quantity indexes as ratios of distance functions (Malmquist, 1953). Distance functions are function representations of multiple-output, multiple-input technology which require data only on input and output quantities. Consequently, our Malmquist index is a "primal" index of productivity, productivity change that, in contrast to the Tornqvist index, does not require cost or revenue shares to aggregate inputs and out-puts, yet is capable of measuring total factor productivity growth in a multiple-output setting.

In this study, Malmquist productivity index (MPI) a non parametric DEA based approach is used to estimate Total Factor Productivity and its sources. TFP is defined as the ratio of weighted sum of output to the weighted sum of inputs. It can be increased either due to technical change or due to increase in technical efficiency or due to both. The MPI is based on the distance function approach, which is defined in terms of inputs and outputs. With the given input vector, an output distance function maximize the proportional expansion of the output vector, while an input distance function minimize the input vector, given the output vector. In present study we apply output oriented MPI approach, which maximize the output at a given level of inputs. MPI>1 indicates the positive TFPG or increasing productivity trend. MPI<1 indicates the decline in productivity. If MPI is equal to 1 it indicates the no change in productivity. Total Factor Productivity Change (TFPCH) is a geometric mean of

Technical Efficiency Change (EFFCH) and Technical Change (TECHCH). The EFFCH index measures changes in technical efficiency between period t and t+1, which compares to closeness of a firm in each period to that period's efficient boundary. The TECHCH index measures the technology frontier shift between time period t to t+1. These indices can be interpreted as progress when a value is greater than 1, no change when value is equal to 1 and regress when value is less than 1.

Table No 5.1: MALMQUIST PRODUCTIVITY INDEX SUMMARY

Sr. No	**Years**	**EFFCH**	**TECHCH**	**PECH**	**SECH**	**TFPCH**	**TFPGR**
1	1998-1999	-	-	-	-	-	-
2	1999-2000	1.000	0.983	1.000	1.000	0.983	-
3	2000-2001	1.000	0.982	1.000	1.000	0.982	-1.8
4	2001-2002	1.000	1.018	1.000	1.000	1.018	1.8
5	2002-2003	1.000	0.976	1.000	1.000	0.976	-2.4
6	2003-2004	1.000	0.986	1.000	1.000	0.986	-1.4
7	2004-2005	1.000	1.025	1.000	1.000	1.025	2.5
8	2005-2006	1.000	0.988	1.000	1.000	0.988	-1.2
9	2006-2007	1.000	1.022	1.000	1.000	1.022	2.2
10	2007-2008	1.000	0.938	1.000	1.000	0.938	-6.2

11	2008-2009	1.000	0.962	1.000	1.000	0.962	-3.8
12	2009-2010	1.000	1.017	1.000	1.000	1.017	1.7
13	2010-2011	1.000	1.019	1.000	1.000	1.019	1.9
14	2011-2012	1.000	0.973	1.000	1.000	0.973	-2.7
15	2012-2013	1.000	0.989	1.000	1.000	0.989	-1.1
16	2013-2014	1.000	0.995	1.000	1.000	0.995	0.5
17	2014-2015	1.000	1.007	1.000	1.000	1.007	0.7
Calculated by the Researcher in DEAP 2.1							

In above table 5.1 depicts the summary total factor productivity change (TFPCH), technical change (TECHCH) and efficiency change (EFFCH) indices during the period from 1998-99 to 2014-15. In the study period technical efficiency is equal to one which showing that there is efficiency in sugar industry of India. Pure change (PECH) and Scale change (SECH) also equals to 1 which showing that there is no change in the scale and pure efficiency of the industry. Total Factor productivity change (TFPCH) changed during the study period because of only the change in technical change (TECHCH). In 1999-2000 TFPCH value 0.9383 which is less than 1 so the productivity is declined during the year. And technological change also shows the same value. In 2000-01 TFPCH value is 0.982 which again showed the declined productivity condition in the industry and same change shown in TECHCH. In 2001-02 TFPCH growth is increased with the 1.8% and its value was 1.018 and there was increasing productivity shown during that year. In 2002-03 and 2003-04 TFPCH shows again negative or decreasing productivity and TECHCH trend. In 2004-05 TFPCH is increased with 2.5% and it shows the value 1.025 which shows increasing productivity trend. In 2004-05 TFPG rate is highest during the study period. In 2005-06 productivity trend is declined with the TFPCH value is 0.988. In 2006-07 TFPCH is 1.022 which is again greater than one and shows the increasing productivity growth. In 2007-08 noticed a high declined in the TFPG rate with -6.2% and TFPCH value is 0.938 in 2007-08 and 0.962 in 2008-09, just showed the declined in the productivity. In 2009-10 and 2010-11 TFPCH is again showed the value greater than one. From 2011-12 to 2013-14 productivity decreasing trend. In 2014-15 TFPCH showed the value 1.007 and again increasing trend in productivity. So we can conclude that there is fluctuation in Total factor productivity of sugar industry in India.

In the study we see that there is change in productivity is effected only by the change in technological change and both consist the same values and trend. So there is direct relation with TFPCH and TECHCH in the study area.

Figure 5.1: Productivity Change in Sugar industry (From 1998-99 to 2014-15)

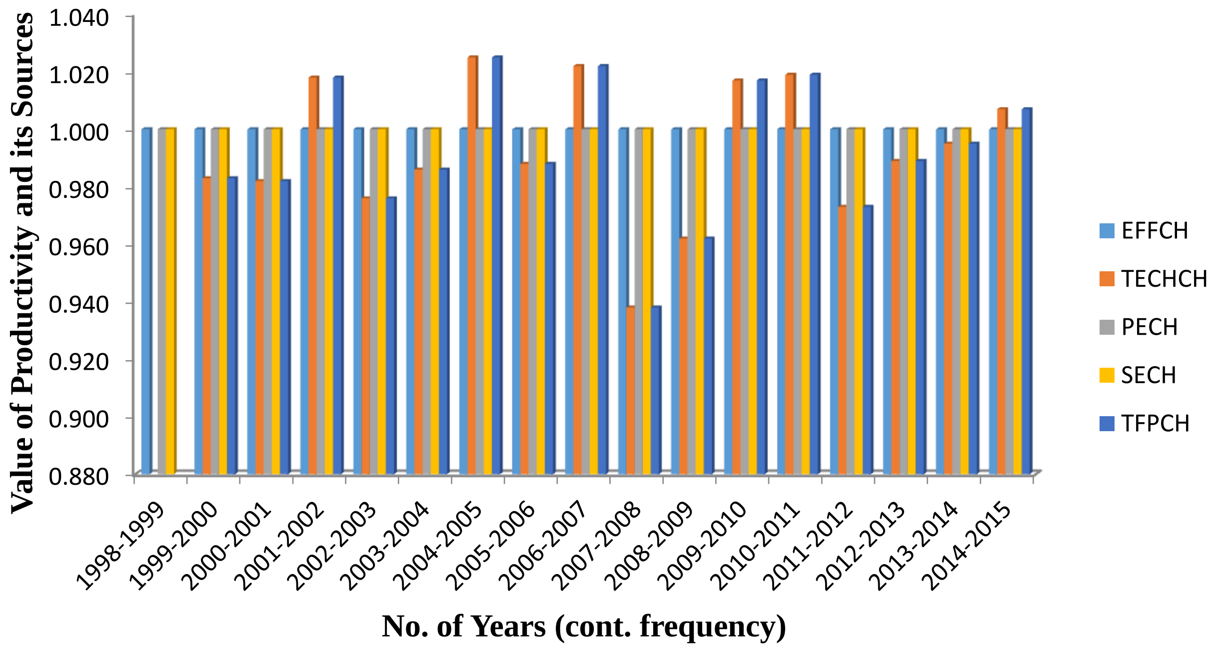


Figure 5.1 depicted the Productivity Change in the Sugar Industry of India from 1998-99 to 2014-15. On the Horizontal Axis no of Years and on the Vertical Axis value of Productivity and its sources showed in the above figure. We can analyze that there is no change in the efficiency change, Pure change and Scale change. All are at their efficient level and gives the value equal to 1. The total factor productivity change which is the productivity of total factors shows variation in the sugar industry and Technological change also fluctuation in the industry during the study Period.

Table 5.2: Malmquist Productivity index summary of Mean

EFFCH	TECHCH	PECH	SECH	TFPCH
1.00	0.992	1.00	1.00	0.992

Calculated by the Researcher in DEAP 2.1

Table 4.2 depicts the mean of Malmquist Productivity Index in the study period. Technical efficiency (EFFCH) mean of the study is equal to 1 which shows the efficiency in the industry. Mean of Pure change and scale change during the study period showing no change. Mean of Technical change (TECHCH) showing the regression in technological change which is the main cause in the decline of mean in Total Factor Productivity Change (TFPCH).

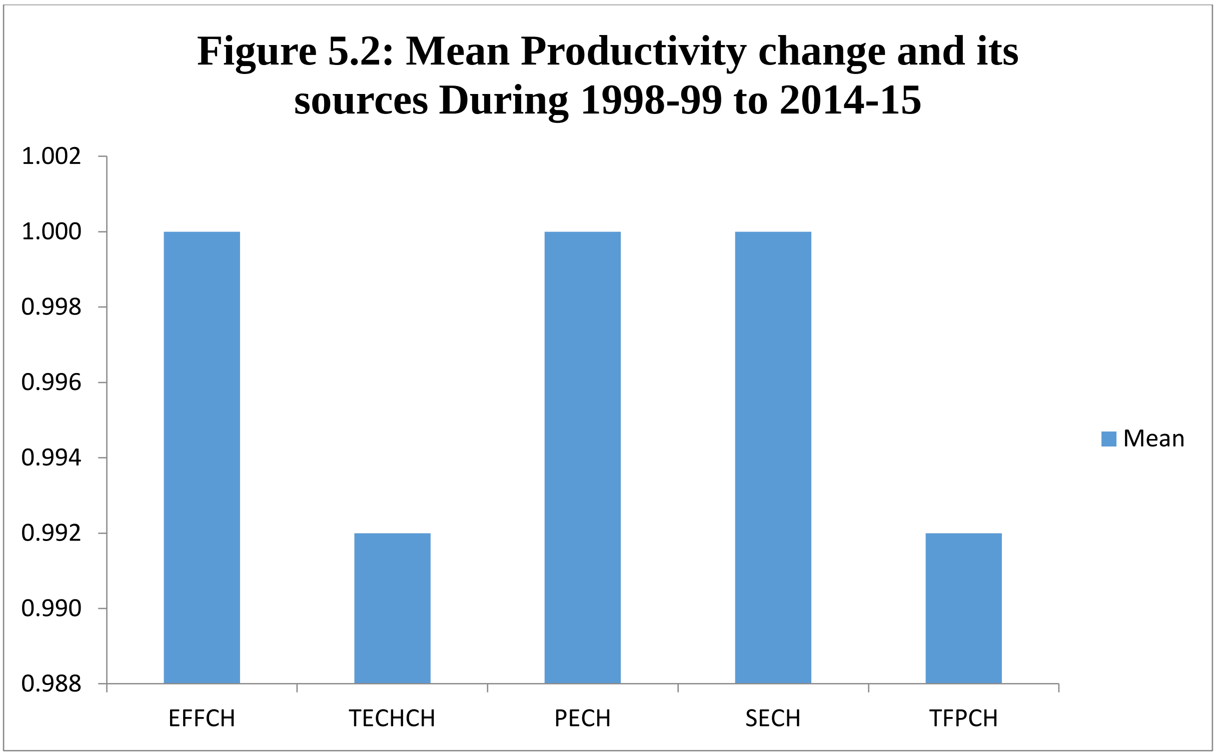


Figure 5.2 shows the average of Productivity trend during the study Period from 1998-99 to 2014-15. And we can that there is declined productivity trend showed in the sugar industry of India. And the Efficiency Change (Catching Up) which shows the efficiency level in the sugar industry. Pure Change and Scale Change does show no change during the study period Technological Change is less than 1 and just shows the regress trend in the sugar industry. Total Factor Productivity is also changed with same value and showed the declined trend in the productivity of sugar industry in India.

Conclusion

On the bases of above tables, we analyzed that there is found the regress in the productivity of sugar industry in India. And there is need to improve in TECHCH which is directly related with the innovation, research and development in the industry. There is no change in the efficiency of the sugar industry. Managerial efficiency (Pure efficiency) and Scale change is also shown no change. It means firms are working on Constant Return to Scale. By this chapter researcher fulfilled two Objectives of the study which are: the Productivity trend and

Total Factor Productivity with technical efficiency and technical change in Sugar Industry of India.

CHAPTER 6

MAJOR FINDINGS AND POLICY IMPLICATIONS OF THE STUDY OF THE STUDY

6.1 Major Findings of the Study

The study has been fond the following major results**:**

1. The productivity of Sugar industry is declined during the study period 1998-99 to 2014-15.
2. Regress in technological change declined the total factor productivity of sugar industry. Poor research and development is the factor behind the poor Total Factor productivity in the sugar industry of India.
3. The result comes from the analysis shown constant return to scale and pure efficiency also shown no change. Technical efficiency is near to efficient frontier during the whole study period industry.

6.2 Policy Implication of this study

The empirical study shows that on an average, sugar industry of India have registered a negative Total factor productivity growth rate during the study period. The growth is observed highest in 2004-05 (2.5%) and lowest in 2007-08 (-6.5%) and MPI average value is less than (<) 1 (0.992) which depicts the declined in TFPCH. The decomposition of TFPG into technical change (frontier shift) and technical efficiency change (catch up effect) reveals that the negative growth in the TFP is only due to technological regress, as the technical efficiency reveals a positive growth. On the bases of the study results there are some suggestion to improve the condition of Sugar firms in India.

1. In sugar industry, there is a need to improve both technical efficiency and Technological progress. Improvement in technical efficiency requires improvement in quality of input like capital and labor.
2. The management phase is also play a vital role in terms of capital. These strategies will improve the technical change as well which also relies on managing technology and adoption capability of firms.
3. The Research and Development (R & D) activities can play a vital role to bring technological progress. More qualitative research and development is required to improve the productivity and quality of sugarcane. To increase in the technical change there is need to increase in the productivity, efforts could be made to increase the research and development (R & D) activities in this industry. Therefore firms in the sugar industry need greater investment in (R & D) activities and adoption of new technologies.
4. Increase in skilled worker through human resource development reduces skills shortage which obstructs technological adoption. Good managerial skills are needed to take decisions regarding the investment in innovations in sugar industry.
5. The research and development activities are necessary to increase the productivity of by products which help to reduce the sugar market price internationally.
6. Ethanol attaining from the By-product of sugar firms Mossase can be blending up with petrol. So firms must tight-up with the petroleum companies to buy ethanol from them. One side which helps government to reduce the increasing BOP (Balance of Payment) due to high imports of petroleum products and on other side it helps to firms to make their profit.
7. High Quality transportation is required to attain maximum possible recovery of Sugarcane. Because after a sugar is reduced from sugarcane.

8. Sugar firms must invest in the machinery which helps to generate and distribute steam power for electricity which is attaining from its by-product bagasse. Firms can tight-up with other small industries to buy their surplus electricity and make their firms Profitable.
9. High quality paper mills established near the sugar mills to make high quality paper as per the quality of bagasse. There is two profit of this first is firms efficiency increased in cost and second is to save environment from the wastage of sugar industry.
10. Technique of attaining sugar per quintal of sugarcane should be improve, which make industry cost efficient.

All the above suggestions will be helpful to improve the sugar industry profitable and improve their productivity, efficiency and technological progress. It will have a positive effect on the international trade of country, consumers of country and also generates more employment in the industry. Without efficiency in any industry and economy sustainable development is not possible. It helps to best utilization of resources.

6.3 Limitations of the study

The Limitations of the study are as follow

1. There are certain other parameters and techniques to measure the performance of sugar industry in India. This study is limited up to the DEA (Data Envelopment Analysis) and MPI (Malmquist Productivity Index).
2. The time period is taken for the study is from 1998-99 to 2014-15. The result may vary if time frame is extended.

6.4 Further Research Directions

The present study is helpful for the further researchers. There are a lot of future scopes of the present study. Few are discussed below:-

1. Present study focuses on the sugar industry but in the modern economies there is need to take look up on the other sectors too. Various industries like Jute, cotton, paper, coal, electricity etc. can be included in study Area.
2. The study can be extended on the manufacturing sector of India and inter-state perspectives study can be done by the researchers.
3. The study can be extended on the international economics topics like comparison the total factor productivity and its sources on the economies, international organizations like BRICS, SAARC and other economic organization. Because it helps to find out the areas of a firm or industry which are becomes the barrier in the efficiency of any firm or an industry. Technological progress helps to make cheaper good by the optimum use of allocative resources which is the base of international trade.

Bibliography

Althin, R. (2001). Measurement of Productivity Changes: Two Malmquist Index Approaches. *Journal of Productivity Analysis, 16*(2), 107-128.

Balk, B. M. (2001). Scale Efficiency and Productivity Change. *Journal of Productivity Analysis, 15*(3), 159-183.

Charnes, A., Cooper, W., & Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operations Research, 2*, 429-444.

Coelli, T. J. (1996). A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program. *Centre for Efficiency and Productivity Analysis (CEPA) Working Paper 96/08*. Australia: NSW, Department of Econometrics, University of New England.

Farrell, M. (1957). The Measurement of productive Efficiency. *Journal of the Royal Statistical Society, 120*, 253-81.

Fogarasi, J. (2006). Efficiency and Total Factor Productivity in Post-EU Accession Hungarian Sugar Beet Production. *Studies in Agricultural Economics, 105*, 87-100.

Gupta, G., & Patel, K. (1976). Production Function in Indian Sugar Industry. *Indian Journal of Industrial Relations, 11*(3), 315-337.

Hellwing, M., & A., I. (2001). Endogenous Technical Change in a Competitive Economy. *Journal of Economic Theory*, 1-39.

Hossian, M. M., Majumder, A. K., & Basak, T. (2012). An Application of Non-Linear Cobb-Douglas Production Function to Selected Manufacturing Industries in Bangladesh. *Open Journal of Statistics, 2*, 460-468.

Khiavi, P. K., Moghaddasi, R., & Eskandarpour, B. (2012). Analysis of Total Factor Productivity of Sugar Beet in Iran Using Malmquist Approach. *Journal of Sugar Beet, 28*(1), 51-55.

King, R., & S., R. (1999). Resuscitating Real Business Cycles. *In Handbook of Macroeconomics*, 927-1007.

Kumar, S., & Arora, N. (2011). Assessing Technical Efficiency of Sugar Industry in Uttar Pradesh: An Application of Data Envelopment Analysis. *Indian Economic Review, 46*(2), 323-353.

Kydland, F., & E., P. (1982). Time to Build and Aggregate Fluctuations. *Econometrica*, 1345-1370.

Mandal, S. K., & Madheswaran, S. (2012). Productivity Growth in Indian Cement Industry: A Panel Estimation of Stochastic Rroduction Frontier. *The Journal of Developing Areas, 46*(1), 287-303.

Miller, S. M., & Upadhyay, M. P. (2000). The Effect of Openness, Trade Orientation, and Human Capital on Total Factor Productivity. *Journal of Development Economics, 63*, 399-423.

Murti, V., & Sastry, V. (1957). Production Functions for Indian Industry. *Econometrica, 25*(2), 205-221.

Romer, P. (1990). Endogenous Technological Change. *The Journal of Political Economy, 98*(5), 71-102.

Saliola, F., & Seker, M. (2011). Total Factor Productivity Across the Developing World. *World Bank Group*.

Sastry, V. (1966). Measurement of Productivity and Production Function in Sugar Industry in India: 1951-1961. *Indian Journal of Industrial Relations, 2*(1), 70-94.

Solow, R. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics, 70*(1), 65-94.

Solow, R. (1957). Technical Change and the Aggregate Production Function. *Review of Economics and Statistics*, 312-320.

APPENDICES

APPEDIX

```
Results from DEAP Version 2.1

Instruction file = eg4-ins.txt
Data file        = eg4-dta.txt

 Output orientated Malmquist DEA


 DISTANCES SUMMARY


 year =     1

   firm      crs te rel to tech in yr      vrs
    no.      ************************       te
              t-1         t       t+1

     1     0.000     1.000     1.017     1.000

 mean      0.000     1.000     1.017     1.000

 year =     2

   firm      crs te rel to tech in yr      vrs
    no.      ************************       te
              t-1         t       t+1

     1     0.983     1.000     1.018     1.000

 mean      0.983     1.000     1.018     1.000

 year =     3

   firm      crs te rel to tech in yr      vrs
    no.      ************************       te
              t-1         t       t+1

     1     0.982     1.000     0.982     1.000

 mean      0.982     1.000     0.982     1.000

 year =     4

   firm      crs te rel to tech in yr      vrs
    no.      ************************       te
              t-1         t       t+1

     1     1.018     1.000     1.025     1.000

 mean      1.018     1.000     1.025     1.000

 year =     5

   firm      crs te rel to tech in yr      vrs
    no.      ************************       te
```

```
                t-1         t        t+1

     1      0.976     1.000     1.014     1.000

mean        0.976     1.000     1.014     1.000

year =       6

  firm         crs te rel to tech in yr       vrs
   no.       ************************        te
                t-1         t        t+1

     1      0.986     1.000     0.975     1.000

mean        0.986     1.000     0.975     1.000

year =       7

  firm         crs te rel to tech in yr       vrs
   no.       ************************        te
                t-1         t        t+1

     1      1.025     1.000     1.012     1.000

mean        1.025     1.000     1.012     1.000

year =       8

  firm         crs te rel to tech in yr       vrs
   no.       ************************        te
                t-1         t        t+1

     1      0.988     1.000     0.978     1.000

mean        0.988     1.000     0.978     1.000

year =       9

  firm         crs te rel to tech in yr       vrs
   no.       ************************        te
                t-1         t        t+1

     1      1.022     1.000     1.067     1.000

mean        1.022     1.000     1.067     1.000

year =      10

  firm         crs te rel to tech in yr       vrs
   no.       ************************        te
                t-1         t        t+1

     1      0.938     1.000     1.039     1.000

mean        0.938     1.000     1.039     1.000

year =      11
```

```
  firm      crs te rel to tech in yr      vrs
   no.      ************************       te
             t-1         t       t+1

    1     0.962     1.000     0.983     1.000

mean      0.962     1.000     0.983     1.000

year =    12

  firm      crs te rel to tech in yr      vrs
   no.      ************************       te
             t-1         t       t+1

    1     1.017     1.000     0.981     1.000

mean      1.017     1.000     0.981     1.000

year =    13

  firm      crs te rel to tech in yr      vrs
   no.      ************************       te
             t-1         t       t+1

    1     1.019     1.000     1.028     1.000

mean      1.019     1.000     1.028     1.000

year =    14

  firm      crs te rel to tech in yr      vrs
   no.      ************************       te
             t-1         t       t+1

    1     0.973     1.000     1.011     1.000

mean      0.973     1.000     1.011     1.000

year =    15

  firm      crs te rel to tech in yr      vrs
   no.      ************************       te
             t-1         t       t+1

    1     0.989     1.000     1.006     1.000

mean      0.989     1.000     1.006     1.000

year =    16

  firm      crs te rel to tech in yr      vrs
   no.      ************************       te
             t-1         t       t+1

    1     0.995     1.000     0.993     1.000

mean      0.995     1.000     0.993     1.000
```

```
year =    17

  firm      crs te rel to tech in yr      vrs
   no.      ***********************        te
             t-1         t       t+1

    1     1.007     1.000     0.000     1.000

mean      1.007     1.000     0.000     1.000

[Note that t-1 in year 1 and t+1 in the final year are not defined]


MALMQUIST INDEX SUMMARY

year =     2

  firm   effch  techch    pech    sech   tfpch

    1   1.000   0.983   1.000   1.000   0.983

mean    1.000   0.983   1.000   1.000   0.983

year =     3

  firm   effch  techch    pech    sech   tfpch

    1   1.000   0.982   1.000   1.000   0.982

mean    1.000   0.982   1.000   1.000   0.982

year =     4

  firm   effch  techch    pech    sech   tfpch

    1   1.000   1.018   1.000   1.000   1.018

mean    1.000   1.018   1.000   1.000   1.018

year =     5

  firm   effch  techch    pech    sech   tfpch

    1   1.000   0.976   1.000   1.000   0.976

mean    1.000   0.976   1.000   1.000   0.976

year =     6

  firm   effch  techch    pech    sech   tfpch

    1   1.000   0.986   1.000   1.000   0.986

mean    1.000   0.986   1.000   1.000   0.986

year =     7

  firm   effch  techch    pech    sech   tfpch
```

1	1.000	1.025	1.000	1.000	1.025
mean	1.000	1.025	1.000	1.000	1.025

year = 8

firm	effch	techch	pech	sech	tfpch
1	1.000	0.988	1.000	1.000	0.988
mean	1.000	0.988	1.000	1.000	0.988

year = 9

firm	effch	techch	pech	sech	tfpch
1	1.000	1.022	1.000	1.000	1.022
mean	1.000	1.022	1.000	1.000	1.022

year = 10

firm	effch	techch	pech	sech	tfpch
1	1.000	0.938	1.000	1.000	0.938
mean	1.000	0.938	1.000	1.000	0.938

year = 11

firm	effch	techch	pech	sech	tfpch
1	1.000	0.962	1.000	1.000	0.962
mean	1.000	0.962	1.000	1.000	0.962

year = 12

firm	effch	techch	pech	sech	tfpch
1	1.000	1.017	1.000	1.000	1.017
mean	1.000	1.017	1.000	1.000	1.017

year = 13

firm	effch	techch	pech	sech	tfpch
1	1.000	1.019	1.000	1.000	1.019
mean	1.000	1.019	1.000	1.000	1.019

year = 14

firm	effch	techch	pech	sech	tfpch
1	1.000	0.973	1.000	1.000	0.973

```
mean     1.000   0.973   1.000   1.000   0.973

year =     15

  firm   effch  techch    pech    sech   tfpch

     1   1.000   0.989   1.000   1.000   0.989

mean     1.000   0.989   1.000   1.000   0.989

year =     16

  firm   effch  techch    pech    sech   tfpch

     1   1.000   0.995   1.000   1.000   0.995

mean     1.000   0.995   1.000   1.000   0.995

year =     17

  firm   effch  techch    pech    sech   tfpch

     1   1.000   1.007   1.000   1.000   1.007

mean     1.000   1.007   1.000   1.000   1.007


MALMQUIST INDEX SUMMARY OF ANNUAL MEANS

  year   effch  techch    pech    sech   tfpch

     2   1.000   0.983   1.000   1.000   0.983
     3   1.000   0.982   1.000   1.000   0.982
     4   1.000   1.018   1.000   1.000   1.018
     5   1.000   0.976   1.000   1.000   0.976
     6   1.000   0.986   1.000   1.000   0.986
     7   1.000   1.025   1.000   1.000   1.025
     8   1.000   0.988   1.000   1.000   0.988
     9   1.000   1.022   1.000   1.000   1.022
    10   1.000   0.938   1.000   1.000   0.938
    11   1.000   0.962   1.000   1.000   0.962
    12   1.000   1.017   1.000   1.000   1.017
    13   1.000   1.019   1.000   1.000   1.019
    14   1.000   0.973   1.000   1.000   0.973
    15   1.000   0.989   1.000   1.000   0.989
    16   1.000   0.995   1.000   1.000   0.995
    17   1.000   1.007   1.000   1.000   1.007

mean     1.000   0.992   1.000   1.000   0.992


MALMQUIST INDEX SUMMARY OF FIRM MEANS

  firm   effch  techch    pech    sech   tfpch

     1   1.000   0.992   1.000   1.000   0.992
```

```
mean    1.000   0.992   1.000   1.000   0.992
```

[Note that all Malmquist index averages are geometric means]