PRODUCTIVITY MODELING IN THE APPAREL INDUSTRY OF BANGLADESH: AN APPLICATION OF DATA ENVELOPMENT ANALYSIS (DEA) TECHNIQUE

by

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CERTIFICATE OF APPROVAL

The thesis titled "**PRODUCTIVITY MODELING IN THE APPAREL INDUSTRY OF BANGLADESH: AN APPLICATION OF DATA ENVELOPMENT ANALYSIS (DEA) TECHNIQUE**" submitted by Syed Nadeem Ahmed, Roll No. P04040812 (P), Session: April 2004, to the Department of Industrial and Production Engineering, Bangladesh University of Engineering and Technology, Dhaka -1000, Bangladesh, has been accepted as satisfactory in partial fulfillment of the requirements for the degree of Doctor of Philosophy on 18 April 2009

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ABSTRACT

Although labor productivity or capital productivity are popular measures for any production system, it portrays only a partial picture of its performance. Comparison of performances of production systems is a must for subsequent improvement effort. However, performance measurement, especially in complex production environment, has remained a much sought about topic among researchers over the decades. Several indices have been proposed under varied circumstances, but none gained unanimous acceptability. Several models have also been proposed under different conditions and environment. Data Envelopment Analysis (DEA) is a non parametric analytical model, which can measure the performances of production, as well as service systems, taking into account multiple variables Researches reveal that DEA has been applied by researchers in different types of production systems. As reports reveal, although ratio analysis of productivity has been applied to analyze productivity and its weak linkages in textile industry of Bangladesh, the DEA, a much better analytical technique, has not been applied to analyze the performances of any production system.

The apparel factories in Bangladesh suffer from poor productivity due to several factors, or variables. On many occasions, these variables are not only complex in nature by itself, but interacting too, thereby multiplying the complexity further. These factors or variables have never been analyzed econometrically. As a result, accurate performance, in terms of productivity, could never be known. This impedes subsequent improvement drive. This research aimed at analyzing the performances, finding out the weak variable linkages and identifying the efficient frontier of apparel industry of Bangladesh.

Utilization of input quantity and efficiency of the production system to maximize output need serious consideration. Nevertheless, this has not gained due attention from the researchers. In this research, the input and output oriented models for both constant returns to scale as well as variable returns to scale have been analyzed to find the relative scores of the productive efficiency of several apparel factories. From the scores of efficiency measurement, the most efficient production periods (months) have been obtained. The rest of the inefficient periods have the scope to elevate their scores either by decreasing their input or by increasing their output, in order to become productive periods. The next step of analysis has been performed by applying the slack based model. In this model, both the input and output quantities have been dealt with simultaneously, i.e. to decrease the input and at the same time to increase the output. This type of analysis is expected to provide results better in the sense that unlike the previous model, both the input and output treatments have been possible simultaneously. The sensitivity analysis indicates the efficiency zones between which the firms can be operated without losing their productive efficiency values. In other

words, the maximum possible contraction or expansion of the input or output quantities may become possible within this safe range. Scale efficiency is an important parameter to judge from its value when under unity, there exists a scope to increase quantity of production. Malmquist Productivity Index with greater value of unity shows that there is growth in productivity compared to its earlier period. In this research. fifteen parameters have been considered in order to determine their influences upon the output of the workers as a whole. Five among them have been found to be influencing the output produced, which are: Gender, Age Group, Work Experiences, Satisfactions and Qualifications of the workers.

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LIST OF ABBREVIATIONS

AR	Assurance Region
BCC	Variable Returns to scale named after Banker and Others
BBS	Bangladesh Bureau of Statistics
BEPZA	Bangladesh Export Processing Zones Authority
BKMEA	Bangladesh Knitwear Manufacturers and Exporters Association
BGMEA	Bangladesh Garments Manufacturers and Exporters Association
CCR	Constant Returns to Scale model named after Charnes, Cooper and Edwardo
C-M	Cut and Make
CMI	Census of Manufacturing Industries
CAGR	Compounded Annual Growth Rate
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EU	European Union
FDH	Free Disposable Hull
GDP	Gross Domestic Product
GSP	Generalized System of Preferences
LDC	Least Developed Country
LMDEA	Long Memory Data Envelopment Analysis
MCDA	Multi-Criteria Decision Analysis/Aiding

MFA	Multi Fibre Agreement
NGO	Non Government Organization
OECD	Organization for Economic and Development
OLS	Ordinary Least Square
R & D	Research and Development
PE	Productive Efficiency
ROA	Return to Asset
RMG	Ready Made Garments
SSC	Super colliding Super Conductor
SOE	State Owned Enterprises
TFP	Total Factor Productivity
UNDP	United Nations Development Program

LIST OF NOTATIONS

λ	weight applied to firm
$\sum$	Summation
j	firm
n	number
x	input
y	output
μ	input weight
v	output weight
ε	non-Archimedean
k	capital
l	labor
β	vector of unknown parameters
$\forall$	belongs to

CHAPTER I

INTRODUCTION

1.1 PRODUCTIVITY AS A METRIC FOR THE APPAREL INDUSTRY

The Apparel industry off late has become the number one export contributor to the economy of Bangladesh and at the same time opened a new avenue for the employment generation for the idle people specially the neglected women of the rural area. Although agriculture sector is the backbone of Bangladesh economy, with the increase in price of seeds, pesticides and fertilizer. rural working people are finding it hard to generate enough income for their rural livelihood. With this situation prevailing one miracle scenario has emerged: finding of cheaper cost of cutting and sewing activities in this part of the world by the western buyers, rapidly setting up of garments industries has taken place by the local entrepreneurs with the collaboration of foreign partners. This created huge demand of labor forces and triggered migration of the rural poor to the urban areas resulting in establishment of this type of industries. Census of Manufacturing Industries (CMI). Bangladesh data shows that female employment as percentage of total employment in all industries covered by the CMI increased from 3.04% in 1985-86 to 15.29% in 1991-'92. As is well known, this increase is due to the growth of the readymade garments (RMG) and apparels industry, which according to the CMI data accounted for approximately 68% of total female employment in those industries covered by the CMI in 1985-'86, rising to over 69% by 1991-'92 According to BGMEA (Bangladesh Garments Manufacturers and Exporters Association) statistics, the RMG industry employed 1.5 million workers in 1997-98, 90 percent of whom were women. Incentives provided by the government such as "back-to-back" letters of credit extended by commercial banks, and bonded warehouse facilities were key factors in promoting the fast growth of this industry. Under the back to back letters of credit, the exporters are able to import fabrics and accessories against export orders, easing the working capital needs of entrepreneurs. Under the bonded warehouse arrangement, the entrepreneurs can have the access of importing at zero-tariff. Gradually the traditional export items. jute, tea, leather, frozen fish, etc. has fallen behind to keep pace with the apparel. Another important advantage is the quota free system Bangladesh had fixed target market in the USA and EU upto 2005. Although in a few years of time a number of apparel industry has created, but not all are producing good quality products. The main reason behind this is the low productivity of the unskilled and semi- skilled workers, who starts their jobs without any formal training or knowledge beforehand. With the abolishment of the free quota system Bangladesh has now to compete with other countries having the same advantages of the cheap labor.

As reported in the Business Sector Round Table discussion on Product Profile: Textiles & Garments in Third United Nations Conference On The Least Developed Countries on 16 May 2001 in Brussels, "So far as more differentiated products are concerned, Bangladesh has shown that it is possible to move successfully up the value chain by exporting finished products. In 1999, it was by far the largest single LDC exporter of other finished, woven fabrics with 85% cotton or more, weighing up to 200 g/m², having provided 58% of the total 3 LDC exports between 1995 and 1999." The report adds that in order to remove some of the critical constraints to export development of textiles from LDCs, efforts should be focused on: *increasing productivity in the garment industry.*

Thus here comes the need for considering the productivity enhancement of the abundant labor force of the country. With the increase in the productivity per unit cost of the product is reduced which leads the company to remain competitive in both the inside and outside markets of the country. The unproductive workers are burdensome to the company and in the long run destroy the organization. Productivity provides information about the performance, quality of individuals, work groups and processes. It presents current operational results and comparisons to past history. According to Janet S. Cuenca[24] productivity can be defined as the combination of efficiency and effectiveness of a production process that aims to maximize output while minimizing the use of inputs. Furthermore, at the macro-level, it is the overall measure of how well a country utilizes its resources to produce goods and services. In both cases, improving productivity involves changing how things are done by investing in new machinery and technology, and by advancing the knowledge of the labor force through education and training,.

1.2 DEA AS A PRODUCTIVITY TOOL

Although productivity is an age old concept in manufacturing industries and partial productivity measures such as labor, capital etc. are found to be very popular measures but those are not able to handle multiple input and outputs simultaneously. These drawbacks have led us to choose the Data Envelopment Analysis as a tool to evaluate the relative performance of the apparel industries of Bangladesh. Although DEA is a useful productivity assessing tool. widely used for non-profit organizations, an attempt has been made in the study of production performance of apparel industries mainly to take into account as much as possible the inputs and outputs of the firm. According to Coopers et.el. [23] DEA was accorded this name because of the way it 'envelops' observations in order to identify a 'frontier' that is used to evaluate observations representing the performances of all of the entities that are to be evaluated. The DEA method was first introduced by Charnes et el.[15]. Their paper re-presented and operational zed the work of Farrell using linear programming techniques. Compared to the other productivity measures DEA is a strong analytical tool for multi-input or multi-output case. In most of the cases labor productivity has been used as the single measure for determining the performance of labor intensive industry. Although labor productivity is a very popular measure. it had certain drawbacks. It ignores all inputs except labor. The overall productivity cannot be evaluated simply based on a single parameter; rather it should be judged based on all the output produced and all the input it has consumed in producing those outputs.

To eliminate the above mentioned drawbacks associated with traditional efficiency measures, Farrell [33] introduced a new measure of efficiency, which he termed as technical efficiency which employs the concept of the *efficient production function*. An *efficient frontier* is a description of the correspondence between input and output bundles when a firm is operating at the "best" productivity level. This method of measuring technical efficiency of a firm consists in comparing it with a hypothetically perfect efficient firm represented by the production function. The efficient production function is some postulated standard of perfect efficiency and is defined as the output that a perfectly efficient firm could obtain from any given combination of inputs. The first step in calculating the technical efficiency by this method is determining the efficient production function. There are two ways in which the production function can be determined. It could either be a theoretical function or an empirical one. Example could be the well known empirical Cobb-Douglas production function.

$$Y = AK^a L^b \tag{1.1}$$

where Y is the maximum output for given quantities of two inputs, capital (K), labor (L),a and b are the productivities of capital and labor respectively. Usually, the above function is simplified by taking log on both the sides and adding an error term on the right side of the equation. The problem with using a theoretical function is that it is very difficult to define a realistic theoretical function for a complex process. The empirical efficient production function, on the other hand, is estimated from observations of inputs and outputs of a number of firms. Therefore, it is far easier to compare performances with the best actually achieved (the empirical production function) than to compare with some unattainable ideal (the theoretical function).

DEA production frontier is not determined by some specific equation like that of production function, instead it is generated from the actual data for the evaluated firms. DEA assumes that all firms face the same unspecified technology which defines their production possibilities set. The objective of DEA is to determine which firms operate on their efficiency frontier and which firms do not. That is DEA partitions the inputs and outputs of all firms into efficient and inefficient combinations. The efficient input-output combinations yield an implicit production frontier against which each firm's input-output combination is evaluated. If the firm's input-output combination lies inside the DEA frontier, the firm is considered inefficient. An advantage of DEA is that it uses actual sample data to derive the efficiency frontier against which each firm in the sample can be evaluated. As a result no explicit functional form for the production function has to be specified in advance. Instead, the production frontier is generated by a mathematical programming algorithm which also calculates the optimum DEA efficiency score for each firm.

Certain inherent advantages lead to the use of DEA in analyzing the productivity of firms. It is non-statistical, which means that estimates are not based on any statistical distribution (e.g., the normal) and noise is not explicitly considered in the estimation.

It is non-parametric, which refers to the fact that it is not needed to assume a particular functional relationship between the inputs and outputs. Data points are enveloped with linear segments, and technical efficiency scores are calculated relative to the frontier technology.

1.3 BANGLADESH ECONOMY

From a mainly feudal agrarian base, the economy of Bangladesh has undergone rapid structural transformation towards manufacturing and services. The contribution of the agriculture sector to GDP has dwindled from 50 percent in 1972-73 to around 20 percent in 1999-2000. The agricultural sector is, however, still the main employment provider. The staple crop is rice, with paddy fields accounting for nearly 70% of all agricultural land. Industrial production growth has averaged more than 6% over the last 5 years. The export sector has been the engine of industrial growth, with ready-made garments leading the way, having grown at an average of 30% over the last 5 years. Primary products (tea, jute, leather, etc.) constitute less than 10 percent of the country's exports; the bulk of exports are manufactured/processed products, ready-made garments and knit wears in particular (Bangladesh Bank's website).

1.4 HISTORY OF GARMENTS INDUSTRY OF BANGLADESH

The garment industry has been classified in the International Standard Classification of the United Nations as "those establishments which cut and/or stitch/make up garments out of woven or knitted fabrics without being involved in the manufacture of fabrics". The term "garment" is used interchangeably with "apparel: and "clothing." The "garment" includes readymade woven garment as well as knitwear and hosiery. The products of the garment industry are very diverse, ranging from industrial work-wear or basic shirt which provides protection to the wearer's body to luxury fashion products which are worn more to create an image or to demonstrate the wearer's status than for their capacity to protect the wearer from the hazards of climate [107]. Since the late 1970s, the Ready Made Garments (RMG) industry started developing in Bangladesh primarily as an export-oriented industry although the domestic market for RMG has been increasing fast due to increase in personal disposable income and change in life style. The sector rapidly attained high importance in terms of employment, foreign exchange earnings and its contribution to GDP. In 1999, the industry employed directly more than 1.4 million workers, about 80% of whom were female. With the growth of RMG industry, linkage industries supplying fabrics, yarns, accessories, packaging materials, etc. have also expanded.

The RMG industry is highly dependent on imported raw materials and accessories because Bangladesh does not have enough capacity to produce export quality fabrics and accessories. About 90% of woven fabrics and 60% of knit fabrics are imported to make garments for export. The industry is based primarily on sub-contracting, under which Bangladeshi entrepreneurs work as sub-contractors of foreign buyers It has grown by responding to orders placed by foreign buyers on C-M (Cut and Make) basis.

The apparel industry of Bangladesh has started growing from a mall tailoring shop sometime around 1960. With the foreign buyers finding this place as a cheap source of cutting and making the fabrics to its desired fashions, gradually few entrepreneurs begin to enter into this business. In the year 1978 there were very few numbers of garment manufacturing units, which generated export earnings of hardly one million dollar. Some of these units were very small and produced garments for both domestic and export markets. Four such small and old units were Reaz Garments, Paris Garments, Jewel Garments and Baishakhi Garments; Reaz Garments being the pioneer. It served only domestic markets for about 15 years. In 1973 it changed its name to M/s Reaz Garments Ltd. and expanded its operations into export market by selling 10,000 pieces of men's shirts worth French Franc 13 million to a Paris-based firm in 1978. It was the first direct exporter of garments from Bangladesh. Desh Garments Ltd, the first non-equity joint-venture in the garment industry was established in 1979. Desh had technical and marketing collaboration with Daewoo Corporation of South Korea. It was also the first hundred percent export-oriented company. Increasingly, the foreign buyers found Bangladesh an increasingly attractive sourcing place. To take advantage of this cheap source, foreign buyers extended, in many cases, suppliers' credit under special arrangements.

Till the end of 1982, there were only 47 garment manufacturing units. The breakthrough occurred in 1984-85, when the number of garment factories stood at 587. The number of RMG factories shot up to around 2,900 in 1999. In 1983-84, RMG exports earned only $0.9 billion, which was 3.89% of the total export earnings of Bangladesh. In 1998-99, the export earnings of the RMG sector were $5.51 billion, which was 75.67% of the total export earnings of the country. The net foreign exchange earnings were, however, only about 30% of the figures quoted above because approximately 70% of foreign exchanges earned were spent in importing the raw materials and accessories to produce the garments exported.

There are several weaknesses of the RMG industry of Bangladesh. Labor productivity in the RMG sector of Bangladesh is lower than many of its competitors. Bangladeshi workers are not as efficient as those of Hong Kong, South Korea and some other countries and in most factories, technologies used are not the latest.

In addition to the fact that the industry is vulnerable because it is highly dependent on the imported raw materials, the infrastructure in the country is deplorably underdeveloped. Problems in power supply, transportation and communication create serious bottlenecks. Inadequate port facilities result in frequent port congestion, which delays shipment. All these increase the lead-time to process an order, i.e. the time from the date of receiving an order to the date of shipment.

For RMG sector, the backward linkages are weaving the fabric, spinning the yarn, and dyeing, printing and finishing operations. These operations can be combined into one composite mill or they can be established as separate units. There are 1,126 weaving and spinning mills including 142 ring spinning mills and 15 open-end spinning units in Bangladesh. These units produce mostly for the domestic markets. Of the total production of fabric, only 25% are supplied by the modern mills, the rest of the domestically produced fabrics are supplied by the specialized units, power looms and handloom sub-sectors. The RMG industry uses a small quantity of fabric woven in the handloom sub-sector. The domestic capacity meets less than 8% of the demand for woven fabrics of the export-oriented RMG industry. The domestic production can meet about 40% of the demand for export quality knit fabrics.

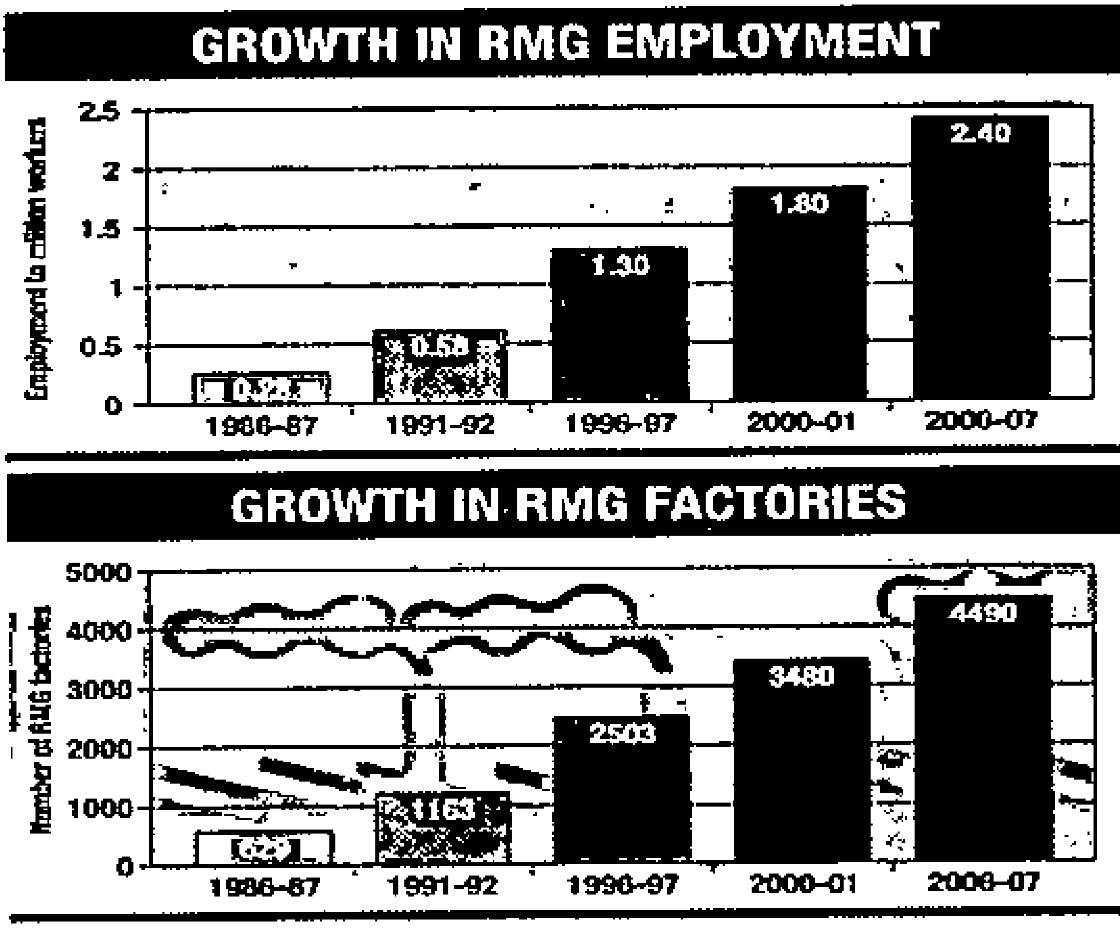
1.4.1 Product wise structural change

In the following table the year wise export performances of different products are shown. It can be easily seen that woven garments and knitwear have gradually taken place of jute items which have been dominating for long.

Table 1.1: Export data for four financial years.

Items	Year wise export(Percentage)			
	1972-73	1982-83	2004-15	2006-07
Jute Goods	51.4	46.5	3.6	2.63
Raw Jutes	8.5	16.3	1.1	1.21
Leather	4.6	10.1	2.6	2.18
Tea	2.9	6.1	0.2	0.06
Frozen Foods	0.9	8.5	4.9	4.23
Chemical Products	0.9	1.1	2.3	1.77
Woven Garments	0	1.1	41.6	38.25
Knitwear	0	0	32.6	37.39
Others	0.9	10.4	11.3	12.28
Totals	100	100	100	100

Source: www.epb.gov.bd



Source: www.cpb.gov.bd

Figure 1.1 RMG Employment and factories growth.

1.5 OBJECTIVES OF THE STUDY

The broad goal of this study is to evaluate the relative productive efficiencies of the different value adding production units of the largest export earning apparel sector of Bangladesh and to determine the possible contributing factors which play important roles in augmenting the productivity of the apparel industry.

In order to fulfill the above broad goals the following specific objectives have been identified:

- To assess and identify the most efficient period by carrying out window analysis for a certain period of time.

- To find out the best performing unit in a particular region of factories taken as the Decision Making Unit and in order to refer it for benchmarking.
- To relate various factors contributing to the increase in productivity, e.g. factory conditions, socio-economic parameters of the workers, product designs, environmental conditions, firms financial performances etc.
- To calculate the returns to scale.
- To calculate the growth/decay of productive efficiency for different periods of time.
- To study the application of concept of weight restriction and value judgment including fuzzy theory in the DEA technique.

1.6 METHODOLOGY AND DATA COLLECTION

The various steps involved in the experimental design/methodology can be summarized as follows:

1. To identify the various inputs and outputs involved in the production process of the apparels.
2. To apply the technique of the Data Envelopment Analysis in order to carry out the window analysis.
3. To find the productive efficiency scores of the various production units for constant and variable returns to scale for both input and output oriented models.
4. To draw the efficient frontier in a 2-D plane. The points those representing the efficient units falls in the frontier and the rest are enveloped by the frontier.
5. To apply the slack based model on various units of knitting, sweater and woven factory.
6. To calculate the returns to scale, scale efficiency and stability regions.
7. To identify and analyze the various factors those who are responsible for influencing the output of the production units after running the SPSS software.
8. To analyze the productive efficiency growth using Malmquist productivity Index.

9. To identify and analyze the constraint(s) that may occur in the form of weight restrictions and causes which may be removed utilizing value judgment based on Assurance Region Analysis technique

In Bangladesh, here are a number of organizations responsible for collecting and maintaining the records of production and exports of apparels. Bangladesh Export Promotion Bureau, Bangladesh Bank, Bangladesh Bureau of Statistics, Bangladesh Garments Manufacturers and Exporters Association, Bangladesh Knitwear Manufacturers and Exporters Association etc. publish only aggregate data, and none of them preserve those data systematically. National Productivity Organization (NPO) collects only textile data and are yet to start collecting and compiling data systematically. NPO usually collects input and output data and calculates the indices of productivity for a limited number of small industries. Secondary data have been collected from these sources.

In drawing a sample from a defined set of industries, the sample should be representative one, which means the sample must yield a valid estimate or in other words it infers as much accurate as possible the population estimate. For convenience the data set, both primary and secondary, at first have been collected utilizing the cluster sampling technique. In order to include the ultimate set of elements the total number of industries have been divided into a large grouping i.e. clusters. It has been observed that almost all the ready made garments and knitwear industries are located primarily in different parts of the Dhaka city i.e. Savar, Malibagh, Narayanganj, Green Road, Mohamadpur, Mirpur, Kanchpur etc. These areas have been taken to be the clusters. In the later stages giving equal chances of obtaining the primary data and secondary data of individual industries the simple random sampling technique has been used so that there remains every chances of industries to be included in the representative sample. A questionnaire survey has been carried out to find the data those may fit in the formula correlating the efficiency criteria. A number of software is used to run the model to find and analyze the data, e.g. customized spreadsheet as DEA and special statistical software such as SPPS etc.

1.7 ORGANIZATION OF THE THESIS

Chapter I provides the introduction and the need assessment of productivity as a metric for the apparel industry, Data Envelopment Analysis as a productivity tool, Economy of Bangladesh, History of the industry, Objectives of the study, Organization of the Thesis, Methodology and Collection of data, Scope and Limitations of the study, etc.

Chapter II provides the concepts of productive efficiency, returns to scale, mathematical framework of DEA.

Chapter III provides an overview of the techniques/methodology on various measurements available in the literature on productivity, applications of DEA in different sectors.

Chapter IV provides the technical description of Apparel industry, Development of the model for productivity assessment, further extensions in terms of growth estimation and scale efficiency, Input and output stability region, capacity utilization in terms of optimum number of production lines, sources of inefficiency, etc.

Chapter V the analysis is carried out for estimation of productive efficiency i.e. window analysis for 12 month period and the results and analysis has been carried out for both input and output oriented types of models.

In Chapter VI slack based model analysis for knitting, sweater and woven factory has been carried out in order to maximize the output(s) and/or minimize the input(s).

In Chapter VII Returns to scale, scale efficiency, Input and Output Stability Region have been calculated and discussed.

In Chapter VIII the factors which are thought to be affecting the productive efficiency has been analyzed and discussed in details using the SPSS software.

In Chapter IX the growth of productive efficiency is calculated and elaborated.

In Chapter X the model discussed in Chapter V has been extended to include weight restrictions and value judgment.

In Chapter XI the Summary and Conclusion and Recommendations are elaborated.

The Bibliography is shown in Chapter XII.

Finally, Appendix A contains the questionnaire and the data set in Appendix B

1.8 SCOPE AND LIMITATIONS

Basically, the apparel industry consists of Ready Made Garments. knitwear, sweater factories and thus it has been tried to cover the industries as much as possible. Although there exists two separate associations but it has been observed that there are some overlapping of industries in the both the associations. But due to the lack of published data it is concentrated only on the BGMEA data sets. It would very much interesting analysis if there be systematic publish data on the apparel industries. Access to the workers without intervention of the management people is almost to impossible which somewhat is a great hindrance for collecting the required data Also the workers are not that much alert and responsible to cooperate for carrying out an extensive research analysis. Secondary data are also not available either to the factory people or to the statistical agencies. Time and cost is also barrier for such a comprehensive work like thesis preparation.

CHAPTER II

BASIC CONCEPTS AND MATHEMATICAL FRAMEWORK.

2.1 CONCEPTS OF PRODUCTIVE EFFICIENCY

In evaluating the performance of any production system productivity measures an index number. which is a ratio between the output(s) produced and the input(s) consumed. The measurement refers to partial productivity, when it measures one output over total inputs and in case of measuring all the inputs and all the outputs, it refers to as total factor productivity. Efficiency, on the other hand is a broader term which measures the productivity relative to some reference value.

Actually, productive efficiency is a more suitable term which covers the total coverage and which occurs when the firm is operating at its efficient frontier . It is the case when highest possible output of one good is produced, given the production level of the other good(s). In long-run equilibrium for perfectly competitive markets, this occurs when the average cost is at the lowest point on the Average Cost Curve. An efficient frontier is a description of the correspondence between input and output bundles when a firm is operating at the best productivity level. In dealing with the concepts of the productive efficiency for any particular production system it is to concentrate on the efficient allocations of the inputs and to maximized the outputs produced in that particular production system.

Similar thoughts are found in the research papers of Debrau[27], Farrell[33], Koopmans[57], Lovell [65], etc.

Debrea[27] writes: If we impose on the economic system the constraints defined by (1) the set of possibilities of each production unit and (2) the limitation of physical resources, we cannot indefinitely increase the m satisfactions. In trying to do so we would find situations where it is impossible to increase any satisfaction without making at least one other one decrease In any one of these situations all the resources are fully exploited and it can be considered optimal. When a situation is non-optimal is it possible to find some measure of the loss involved, indicating how far it is from being optimal? The money value of the "dead loss" associated with a non-optimal situation can be derived from p. and the inefficiency of the economy is now described by a certain number of dollars representing the value of the physical resources which could be thrown away without preventing the achievement of the prescribed levels of satisfaction. We call p defined in the preceding way the coefficient of resource utilization of the economic system. To be precise, it is the smallest fraction of the actually available physical resources that would permit the achievement. This number is equal to 1 if the situation is optimal, smaller than 1 if it is non-optimal, measures the efficiency of the economy and summarizes:

(1) the underemployment of physical resources
(2) the technical inefficiency of production units and
(3) the inefficiency of economic organization(due, for example, to monopolies or a system of indirect taxes or tariffs.

Debreu[27] says that efficiency can also be achieved if all managers of individual plants or industries respond to a price system applicable to the whole economy, in a manner prescribed by the following rules: The manager of any plant should produce any output or output combination at minimum cost, and the manager of any plant or industry should arrange for production at such a level as to equate price and marginal cost. An attainable set of commodity flows, as well as any set of activity levels giving rise to it, is called efficient if there is no other attainable set of commodity flows in which all flows are at least as large as the corresponding flows in the original set, while at least one is actually larger. Efficiency for the economy as a whole, once attained, will be maintained if each process manager behaves according to the following rules: Choose only from those sets of activity levels that correspond to an efficient point within your process. If for all such points the profit on the entire process is negative, discontinue all activity. If you are in a point of nonnegative profit on the process, attempt to raise your profit-at-the-given-prices by varying the composition of the process. If you are in a point of zero profit and there is no increase in profit possible by variation of activity levels, continue all activities at the same level If your attempt to raise profit-at-given-prices leads to a rise in the prices of certain input commodities, determine your further action in the light of the new price situation.

Farrell [33] was the first to define specifically the concept of technical and allocative efficiency. The origin of the modern discussion of efficiency measurement dates back to Farell[33] , who identified two different ways in which productive agents could be inefficient: one, they could use more inputs than technically required to obtain a given level of output, or two, they could use a sub-optimal input combination given the input prices and their marginal productivities. The first type of inefficiency is termed technical inefficiency while the second one is known as allocative inefficiency.

Koopmans[57] provided a formal definition of technical efficiency: a producer is technically efficient if an increase in any output requires a reduction in at least one other output, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Efficiency in general is defined as the absence of waste. An efficient unit utilizes all of its available inputs and produces the maximum amount of output, given present technological knowledge. Equivalently, the Pareto-Koopmans notion of efficiency states that a decrease in any input must require an increase in at least one other input or a reduction in at least one output. Debreu[27] and Farrell[33] both introduced a measure known to be as technical efficiency. This measure is defined as one minus the maximum equi-proportionate reduction in all inputs that still allows continued production of given outputs. A score of unity means a firm is technically efficient since no equi proportionate input reduction is feasible, and a score less than unity indicates the extent of a firm's technical inefficiency.

Lovell [65] relates the efficiency of the firm to a comparison between observed and optimal values of its outputs and inputs. If the optimum is defined in terms of production possibilities, the resulting comparison measures technical efficiency. If the optimum is defined in terms of behavioral goals of the firm (e.g., profit or revenue maximization and cost minimization), then efficiency is economic and is measured by comparing a firm's observed and optimum achievement of goals (e.g., profit, revenue, and cost) subject to the appropriate consideration of technology and prices. Thus, technical efficiency depicts the ability of a firm to produce on the production frontier.

It can be seen that the concept of productive efficiency as explained by Debreu[27],Farrell[33] and Koopman[57] are quite similar but varies from the idea developed by Lovell.

2.2 RETURNS TO SCALE

Alfred Marshall [71] used the concept of returns to scale to define the state of the firms involved in production. The firms may be in the advantageous position in respect of sizes indicating "economies of scale" or may be in disadvantageous position in respect to the sizes indicating "diseconomies of scale". Although any particular production function can exhibit increasing, constant or diminishing returns throughout, it used to be a common proposition that a single production function would have different returns to scale at different levels of output. Specifically, it was natural to assume that when a firm is producing at a very small scale, it often faces increasing returns because by increasing its size, it can make more efficient use of resources by division of labor and specialization of skills. However, if a firm is already producing at a very large scale, it will face decreasing returns because it is already quite unwieldy for the entrepreneur to manage properly, thus any increase in size will probably make his job even more complicated. In economics this is denoted by the term elasticity means that the measurement concept i.e. the relative changes of output with respect to the relative changes of output.

The economics concept of returns to scale is extremely important in analyzing the productivity based on DEA. Initially Charnes et el[15] introduced the analysis assuming constant return to scale, Banker and Thrall [8]have shown that the constant returns to scale model can also be extended to determine whether returns to scale is increasing or decreasing. They postulated that if the optimal solutions are λ_1^*, λ_2^* ------, λ_n^* the then returns to scale at any point on the efficient frontier can be determined from the following conditions:

(i) If $\sum_{j=1}^{n} \lambda_j^*$ =1 in any alternate optimum then constant returns to scale prevails.

(ii) If $\sum_{j=1}^{n} \lambda_j^*$ >1 in any alternate optimum then decreasing returns to scale prevails.

(iii) If $\sum_{j=1}^{n} \lambda_j^*$ <1 in any alternate optimum then increasing returns to scale prevails.

Also to investigate the sources of efficiency it is necessary to investigate whether the unit inefficiency is caused by its inefficient operation or it is operating under internal or external disadvantageous environment. Since the constant returns too scale is capable of dealing with the radial expansion and reduction of all observed units under considerations its productive efficiency scored can be termed as global efficiency. On the other hand the variable returns to scale as postulated by Banker et el. [6] as BCC model assumes that convex combinations of the observed units form the production possibility set and the BCC efficiency score is called local pure efficiency. Based on the ideas developed so far inference can be drawn about the scale efficiency of any production unit. It is therefore easy to calculate the highest achievable scale of the production unit when the two efficiency measures are of fully efficient i e. 100% efficient and this is the most productive scale size. On the other hand if a unit under consideration has full efficiency assuming variable returns to scale but not when assuming constant returns to scale then it is operating locally efficient but not globally efficient due to the scale size of the unit. Thus it is reasonable to characterize the scale efficiency by the ratio on the two scores.

2.3 MATHEMATICAL FRAMEWORK OF DEA.

In carrying out the productive efficiency analysis for a certain number of production units applying the techniques of Data Envelopment Analysis one linear program needs to be generated and solved to calculate the efficiency score of each production unit. The production units are identified for which no other unit or linear combination of firms can produce as much or more of every output (given an input level for all inputs) or use as little or less of every input (given an output level for all outputs). The DEA efficient frontier is composed of these firms and the piecewise linear segments which connect the set of input/output combinations of these firms, yielding a convex production possibilities set. The efficient frontier is thus can be defined by certain convex combinations of these firms; since these composite firms do not have an observable instance, they create composite unit with composite levels of input and output. These composite units are called maximum virtual producers. The linear program decides the weighting of the efficient units to construct a virtual unit for the purposes of determining the efficiency of the unit under evaluation If the virtual unit is better than the unit being evaluated by either making more output with the same or less input or making the same output with less input, then the evaluated unit is inefficient.

Let us take the case where a virtual producer can make the same output with less input than a certain production unit. It is then said a proportional contraction of all resources, also called an equa proportional contraction, can occur. The size of this contraction (call this b) relative to the distance function measured to the point representing that unit (say a), can be used to calculate the efficiency of that particular unit by the equation 1 – b/ a. A fundamental assumption behind DEA and the use of virtual producers is a composite producer can be constructed by operating parts of a new producer unit in the manner of observed producers. If this is not true, then the virtual unit does not correspond to unit that could exist. Also a necessary assumption is that, if a given unit, is capable of producing output level y with input level x, then other producers in the data set should also be able to do the same if they were to operate efficiently. If this assumption does not hold, then the set of producers under evaluation may not truly be peers. It is very simple to evaluate the productive efficiency of a certain separate and individual production unit by the ratio of their out divided by the input. But in case when there are multiple units of inputs and outputs the process of evaluation becomes more and more complex.

To calculate the combined productivity of all the production units is to take the weighted averages of all the outputs and inputs, which is nothing but to construct a virtual unit utilizing and producing equivalent quantity of input and output.

In case of three firms producing four inputs and three outputs the following table has been formulated:

Table 2.1: Data set for 3 Inputs and 3 Outputs

Firm	Input(1)	Input(2)	Input(3)	Input(4)	Output(1)	Output(2)	Output(3)
1	x_{11}	x_{21}	x_{31}	x_{41}	y_{11}	y_{21}	y_{31}
2	x_{12}	x_{22}	x_{32}	x_{42}	y_{12}	y_{22}	y_{32}
3	x_{13}	x_{23}	x_{33}	x_{43}	y_{13}	y_{22}	y_{33}

If it is assumed that the weights a are applied to the outputs and b weights are applied to the inputs y, then the following equation can be produced to evaluate the

Combined Efficiency

$$= \frac{a_1 y_{11} + a_2 y_{21} + a_3 y_{31} + a_1 y_{12} + a_2 y_{22} + a_3 y_{32} + a_1 y_{13} + a_2 y_{22} + a_3 y_{33}}{b_1 x_{11} + b_2 x_{21} + b_3 x_{31} + b_4 x_{41} + b_1 x_{12} + b_2 x_{22} + b_3 x_{32} + b_4 x_{42} + b_1 x_{13} + b_2 x_{23} + b_3 x_{33} + b_4 x_{43}} \quad (2.1)$$

But it is obvious that , it is difficult to justify the common weights to be applied, whereas the firms may take inputs and outputs differently.

The equation (2.1) may be written as

$$\text{Combined Efficiency} = \frac{\sum_{r=1}^{s} \mu_r y_{rj}}{\sum_{i=1}^{m} v_r x_{ij}} \quad (2.2)$$

where x and y are inputs and outputs, respectively, r = 1 to s inputs, i= 1 to m outputs and μ and v are the common weights assigned to outputs and inputs, respectively.

Charnes, Cooper and Rhodes [13] proposed the following ratio form to allow for difference in weights across all production units, which establishes the foundation of data envelopment analysis.

$$\text{Maximize} \quad \frac{\sum_{r=1}^{s} \mu_r y_{r0}}{\sum_{i=1}^{s} v_i x_{i0}} \tag{2.3}$$

$$\text{subject to} \quad \frac{\sum_{r=1}^{s} \mu_r y_{rj}}{\sum_{i=1}^{m} v_i x_{i0}} \text{-----------------} \leq 1 \text{ , j = 1,---------------,n}$$

$\mu r \geq \varepsilon$, r= 1,-------,s ; vi = $\geq \varepsilon$. i = 1,----------,m ; $\varepsilon > 0$

In the model, there are j=1, n observed units which employ i =1, ----,m inputs to produce r =1,..., s outputs. One unit is singled out each time, designating by suffix O as, to be evaluated against the observed performance of all units. The objective of model is to find the most favorable weights, μ_r and v_i , for the units under consideration to maximize the relative efficiency. The constraints are that the same weights will make ratio for every DMU be less than or equal to unity. One problem with the ratio formulation is that there are an infinite number of solutions: if μ_r and v_i are solutions to, so are $\alpha\mu_r$ and αv_i ,□α>0. It is worth observing one important feature of model. In maximizing the objective function it is the relative magnitude of the numerator and the denominator that really matters and not their individual values. It is thus equivalent to setting the denominator to a constant, say 1, and maximizing the numerator.

This transformation will not only lead to the uniqueness of solution but also convert the fractional formulation of model into a linear programming problem in model.

Maximize $\sum_{r=1}^{s} \mu_r y_{r0}$ (2.4)

Subject to:

$$\sum_{i=1}^{m} v_i x_{i0} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{r0} - \sum_{i=1}^{m} v_i x_{i0} \leq 0, j= 1, \text{------------}, n$$

$$-\mu r \leq - \varepsilon, r= 1, \text{----------------}, s \; ; - vi \leq \varepsilon , i= 1, \text{-------------}, m$$

where, $\varepsilon > 0$ is a non-Archimedean element defined to be smaller than any positive real number. (An algebraic structure in which any two non-zero elements are comparable, in the sense that neither of them is infinitesimal with respect to the other, is called Archimedean. A structure which has a pair of non-zero elements, one of which is infinitesimal with respect to the other. is called non-Archimedean).

The above model facilitates straightforward interpretation. The objective is now to maximize the weighted output per unit weighted input under various conditions, the most critical one of which is that the virtual output does not exceed the virtual input for any unit.

Since model is a linear programming, it can be converted the maximization problem into a minimization problem, e.g. a dual problem, by assigning a dual variable to each constraint in the primal.

Specifically, dual variables + − θ, λ j .sr , si are assigned as follows.

Max $\sum_{r=1}^{s} \mu_r y_{r0}$ (2.5)

Subject to:

Dual Variable

$$\sum_{i=0}^{m} v_i x_{i0} = 1 \qquad o$$

$$\sum_{r=1}^{s} \mu_r y_{r0} - \sum_{i=1}^{m} v_i x_{i0} \leq 0, j = 1, \text{-----------}, n \qquad \gamma$$

$$-\mu r \leq -c, r = 1, \text{-----------------}, s \qquad s + r$$

$$-vi \leq \varepsilon, i = 1, \text{--------------}, m \qquad s - i$$

where s + r and s - I are slack variables used to convert the inequalities.

A dual minimization problem is thus derived as model. It is clear that model has m+s constraints while model has n+m+s+1 constraint. Since n is usually considerably larger than m+s, the dual DEA significantly reduces the computational burden and is easier to solve than the primal.

CHAPTER III

LITERATURE REVIEW

The technique of applying Data Envelopment Analysis (DEA) has been applied in various occasions to evaluate the relative productive performance of profit and non-profit production and service units. The non-parametric method has also been used along with other parametric methods. In this chapter the literature review part is discussed and presented briefly based on applications to the following broad sectors:

3.1 TECHNIQUES FOR PRODUCTIVITY MEASUREMENT

The methods available for estimating productivity and productivity growth are discussed below as Discussed by Mawson et el.[86].

3.1.1 Growth accounting framework

In the year 1928 Charles W. Cobb & P.H. Douglas in the article 'A theory of Production' pioneered the relationship between output and input quantities through a production function approach i.e. Output $Q^t = A_t L^a K^b$ where L refers to Labor, K refers to capital, a & b are the productive capacities of labor and capital.

In the later stages Professor Jan Tinbergen used the Cobb-Douglas production function and incorporated an exponential term ent and has asserted that production function can obtain higher volumes output with the same volume of labor and capital, the variable t is the time trend and n is the represents the rate of technological change.

In the year 1957 Robert Martin Solow in this article 'Technical change and Aggregate Production Function' has shown that for a competitive market and the production showing constant returns to scale the physical factors of production is limited to capital and labor i.e. the output can be entirely distributed between labor and capital. In the production function Solow has shown that the constant term which connects the input and output quantities is endogenous in nature i.e. unaffected by the way the labor and capital are employed. This term is linked to technological progress. may raise from improvement in the production process and management techniques ----and has been named as the Solow's residual and later stages more often refers to as Total Factor Productivity or TFP. Total Factor Productivity gains have a cumulative impact on economic growth because the productive skills and knowledge whose expansion leads to higher income and a rising material standard of living

By totally differentiating both sides of the equation $Q = A\ F\ (K_t, L_t)$ with respect to time we have

$$\frac{dQ}{dt} = \frac{dA}{dt} F(K_t, L_t) + A_t \frac{\partial F}{\partial K}\frac{dK}{dt} + A_t \frac{\partial F}{\partial L}\frac{dL}{dt}$$

Dividing both sides by Q_t. we have

$$\frac{dQ}{dt} / Q_t = \frac{dA}{dt} / A_t + \frac{\partial F}{\partial K}\frac{dK}{dt} / F(K_t, L_t) + A_t \frac{\partial F}{\partial L}\frac{dl}{dt} /(K_t, L_t)$$

Replacing the marginal productivities by factor prices, we have

Qtg= TFPG+(rK_t/Qt)Ktg+(wLt/Qt) Ltg=TFPG +SkKtg+ slLtg

where TFPG is Total Factor Productivity growth, r and w are unit service prices of capital and labor, respectively, Sk and Sl are relative shares of income of capital and labor, respectively, and Qtg, Ktg and Ltg are the growth rate of output, capital and labor respectively.

Since, the growth rate terms in the above equations are for an instantaneous rate of change, for the discrete time we take the average of two consecutive periods:

$TFPG_t^* = (\ln TFPt - \ln TFPt-1)$

$$= (\ln Q_t - \ln Q_{t-1}) - \tfrac{1}{2}(S_{kt} - S_{t-1})(\ln K_t - \ln K_{t-1}) -$$

$$1/2(S_{kt} - S_{t-1})(\ln L_t - \ln L_{t-1}) - Q_t^* - 1/2(S_{kt} - S_{t-1})K_t^* -$$

$$1/2(S_{kt} - S_{t-1})L_t^* \quad (3.1)$$

The above equation is used in the estimation of TFP growth rate. The above form has been developed by Dr. Noroyoshi Oguchi,Professor of Commerce at the Sensei University, Japan. Based on the formula developed Asian Productivity Organization undertook a survey and has carried out the study to calculate the total factor productivity in its 10 member countries.

3.1.2 Value added or ratio method

Productivity is usually measured as a quantity index of output over a quantity index of inputs. Indices are required because the heterogeneity of goods and services does not permit simply adding up units of different types of commodities. However, results of index aggregation are in general sensitive to the choice of a specific index number formula and formulae should therefore be chosen on conceptual and on practical grounds. The Value Added is an efficiency analysis of any enterprise is based on two concepts:

Production of wealth and distribution of created wealth to those who have contributed to its creation. The productivity and efficiency of any organization can be evaluated through certain performance indices. These indices may be of different orders and from different perspectives. Number of pieces produced is a measure of worker's productivity. It is not the same as value added per employee, which is a hybrid labor performance measure. On the other hand Return on investment, which is dimensionless, a higher level measurement criteria. All economic activities can be broadly categorized into the broad headings of inputs and outputs.

The following index numbers are found to be of importance in evaluating productivity.

1. Value added per employee
2. Sales per Employee
3. Value added per unit of fixed capital utilized
4. Value added per unit of working/operating capital utilized
5. Value added to sales ratio
6. Sales per capital
7. Capital utilized per employee
8. Labor cost per employee (Labor cost/No. of employees)
9. Labor cost competitiveness (Value added/Labor cost)
10. Profitability (Operating profit/Operating capital)

It is to be noted here that each of the productivity measure may be of uniquely important for any particular sector.

$$\text{Labor Productivity} = \frac{\text{Pieces produced}}{\text{No. of workers}} \quad \text{for factory}$$

$$\text{Materials productivity} = \frac{\text{No. of Burgers produced}}{\text{kg of meats utilized}} \quad \text{Restaurant}$$

$$\text{Energy productivity} = \frac{\text{Kilo-meters run}}{\text{Fuel used}} \quad \text{Transport sector}$$

$$\text{Capital productivity} = \frac{\text{Taka sold}}{\text{Bank loan utilized}} \quad \text{Firm}$$

3.1.3 Distance function approach

In carrying out the productivity analysis it has been greatly relied on two important assumptions about firms' behavior and technology:

i) firms are economically efficient; and

ii) Technologies exhibit constant returns to scale.

It is plausible that there are inefficiencies in firms' operations and dealing with analysis of these inefficiencies, however, requires introduction of the concept of "distance functions". Distance functions are an important tool in index number theory, and form the basis for Malmquist indices of prices, quantities and productivity. The Malmquist (1953) quantity index is based on the concept of a distance function. An output distance function describes the factor by which the production of all output quantities could be increased while still remaining within the feasible production possibility set for a given input level. Similarly, an input distance function indicates by how much input use can be reduced for a given output level and within the production possibilities. In this general formulation, a distance function is very much an engineering-type relationship In its most general form, it requires neither assumption about efficient producer behavior nor about constant returns to scale technology. This property makes it a very versatile tool that is also suited for the measurement of non-market input, output and productivity.

Economic efficiency has two distinct components, "allocative" efficiency and "technical" efficiency (Farrell, 1957). Technical efficiency is the ability of a firm to obtain maximum output from a given set of inputs (output technical efficiency) or to use minimum inputs for a given set of outputs (input technical efficiency). Allocative efficiency relates to a firm's ability to use inputs in optimal proportions, given a set of input prices, or to produce outputs in optimal proportions, given a set of input prices, or to produce outputs in optimal proportions, given a set of output prices. Constant returns to scale occur when a proportional increase in all inputs results in the same proportional increase in output.

Malmquist (1953) defined an output quantity index as

$$Q_O^t = \frac{D_O^t(Q^t, X)}{D(Q^{t-1}, X)} \tag{3.2}$$

where D_O^t = Output distance function at t period of time

Q_O^t = vector of output quantity at t period of time

Q_O^{t-1} = vector of output quantity at t-1 period of time

X is an arbitrary reference vector of inputs.

It is a measure of the "distance" between Q^t and Q^{t-1} and reduces to the ratio one when there is only one output. Note that the specific form of the distance function is generally unknown. Also, the Malmquist quantity index as presented here depends on the reference technology in year t and on the vector of inputs.

An assumption can be made about the functional form of the distance function. One common functional form is the translog output distance function.

$$\frac{D_0^t(Q^t, X^t)}{D_0^{t-1}(Q^{t-1}, X^{t-1})} \times \frac{D_0^{t-1}(Q^{t-1}, X^{t-1})}{D_0^t(Q^{t-1}, X^{t-1})} \tag{3.3}$$

The first part of this expression shows changes in efficiency between the two periods. the second part shows technical change (for a given set of inputs and outputs, what is the maximum production achievable in period t as opposed to period t-1). Other combinations are possible, for example a measure of technical change with respect to the reference period t, rather than t-1. It is equally justifiable to define productivity measures with respect to input distance functions, and, without further restrictions on technology, there is no guarantee that input-related productivity measures yield the same result as output-related ones. The equivalence of input and output-related measures is only ensured under constant returns to scale of the production technology, and herein lies much of the attractiveness of this simplifying assumption.

3.1.4 Econometric method

The econometric approach to productivity measurement is based on observations of volume outputs and inputs. It involves estimating the parameters of a specified production function i.e. cost, revenue, profit; etc. It avoids postulating a relationship between production elastic ties and income shares, which may or may not correspond to reality, and indeed puts researchers in a position of testing these relationships Further possibilities arise with econometric techniques: allowance can be made for adjustment cost (the possibility that changes in factor inputs are increasingly costly the faster they are implemented) and variations in capacity utilization. Furthermore, it is possible to investigate forms of technical change implied by the index number based approach; and there is no a priori requirement to assume constant returns to scale of production functions. One advantage of this method is that it possess the ability to gain information on the full representation of the specified production technology, which may not be not possible to generate by other methods. The literature about the econometric approach is large. and examples of integrated, general models can be found in Morrison (1986) or Nadiri and Prucha (2001). All these possibilities come at a cost. however. Fully-fledged models raise complex econometric issues and sometimes put a question mark on the robustness of results. Often, researchers are constrained by the sample size of observations, and have again to revert to a priori restrictions (for example constant returns to scale) to increase the degrees of freedom for estimation. From the point of view of statistical offices concerned with the publication of regular productivity statistics, complex econometric approaches bear little attractiveness because:

i) updating involves full re-estimation of (systems of) equations;
ii) methodologies are often difficult to communicate to a broad spectrum of users of productivity statistics; and
iii) Significant data requirements tend to reduce the timeliness of results.

In summary it can be concluded that the econometric approaches are a tool that is best suited for academic purposes and is possible to explain the theoretical considerations of the problems related to productivity analysis or growth.

3.1.5 Data envelopment analysis

The two prominent field of studies i.e economics and operational research have common interests as to several research area, one being the analyses of the production possibilities of industries or micro units of production. The specific research strand of efficiency measurement for production units in the field of Operational Research took off with "Measuring the efficiency of decision making units" by Abraham Charnes, William.W. Cooper and Edwardo Rhodes in the year 1978 as the seminal paper [15]. The increasingly popular empirical use of linear programming techniques for calculating efficiency scores is due to the Data Envelopment Analysis or simply DEA model introduced to the general research public in popularly known as CCR. C for Charnes, C for Cooper and R for Rhodes, after the name of the three inventor of the method.

Data Envelopment Analysis or DEA provides a measure of efficiency for one option to a set of alternatives. This linear programming-based measure has its origin in linear production theory by Farrell but its evolution went down a path somewhat different from economic theory. In the DEA tradition, alternative choices of units are called decision making units (DMUs) which is characterized by a vector of outputs and a vector of inputs. Given a population of systems that consumes inputs to generate outputs. production theory can be used to develop basic postulates about the production possibility space and to construct an efficient frontier which is used to quantify efficiency for individual systems. Input of a DMU is human, financial, or physical resources put into a system in order to achieve a result. The result is any form of product, or service that a system produces.

3.2 DEA APPLICATIONS IN DIFFERENT SECTORS

3.2.1 Financial institutions.

There are a number of papers available [9, 18, 35, 55, 66, 97, 98,110] that dealt with the evaluation of relative productive efficiencies of financial institutions in different countries like USA, Turkey, Greece, Portugal, Brazil, etc. The findings and analysis of the papers have been briefly outlined as follows:

Barr et el.[9] in their paper have used a constrained-multiplier, input-oriented data envelopment analysis (DEA) model to quantifiably benchmark the productive efficiency of U.S. commercial banks. The DEA model offers numerous benefits, including the ability to target areas of relative efficiency between banks. Perhaps most importantly, it allows analysis of multiple aspects of a financial institution's performance, unlike more common benchmarking methodologies that focus on only one of many interrelated measures at a time. DEA creates an analysis that is broader without sacrificing depth of insight, an analysis that is more pertinent and hence applicable to the real-world operations of complex financial institutions.

Choudhari et el.[18] have studied the relative performance of public sector banks in India. They have evaluated the banks on five indicators-Profitability, Financial Management, Growth, Productivity and Liquidity. The Corporation Bank was found to be in efficient frontier in all indicators which followed by Oriental Bank of Commerce .The results of analysis the analysis shows that most of the banks from efficient frontier in profitability and financial indicators compared to productivity, growth and liquidity as compared to profitability and financial management.

Fethi et el.[35] investigated the determinants of efficiency in the Turkish commercial banks using censored regression techniques. First, the technical efficiency of individual banks in 1998 was evaluated using the non-parametric frontier methodology, the Data Envelopment Analysis (DEA). Then, the determinants of efficiency of commercial banks are investigated using the censored regression technique, the Tobit model. This aims to explain the variation in calculated efficiencies to a set of explanatory variables. The number of employees, and the sum of non-labor operating expense, direct expenditure on buildings and amortization expenses, are specified as the two inputs whereas the outputs are loans, demand deposits, and time deposits. The study is based on two samples: the sample consisting of 48 banks and the sample excluding 4 state-owned banks. The DEA efficiency scores can then be interpreted to show how much each bank could reduce its input usage without reducing output if it were as technical efficient as the best practice banks For example, if bank A has an efficiency score of 75%, this implies that that particular bank needs to reduce its inputs by 25% in order to achieve 100% efficiency The linear programs were solved to measure the technical efficiency of each observation. The computations were conducted by the OnFront Software. Both bank size and bank profitability have significant positive effects on efficiency, indicating that the larger and more profitable banks have higher technical efficiency. On the other hand, the capital adequacy variable is significantly negatively related to the technical efficiency.

Kisielewska et el. [55] have examined the growth performances of Polish Banks using various methods and techniques ranging from traditional ratio analysis to more complex tools based on efficiency frontier approach. Ratio analysis, which encompasses key performance indicators, is commonly used by all market participants. However, the approach brings only one dimensional measure through a set of indicators that may add confusion and inconsistencies, which is increasingly pushing the industry to choose more robust approaches. This limitation gave rise to development of more sophisticated methods known as frontier efficiency techniques. Unlike ratio analysis, these techniques allow for the identification of strengths and weaknesses as well as report on the overall value of efficiency. In this context, Data Envelopment Analysis (DEA), representing non-parametric approach in production frontier analyses, could be used as a complement to ratio analysis and could potentially yield a more comprehensive appraisal of business performance. Six production models were developed in which banks are mainly considered as producers of deposit accounts and loans services to examine the performance of the banks. To assess productivity changes over time, the Malmquist Index approach has been used. Calculating Malmquist indices from DEA window analysis scores raises the problem of definition of the same period frontier.

Laeven, Luc [66] has used Data Envelopment Analysis to estimate the inefficiencies of banks in Indonesia, Korea, Malaysia, the Philippines and Thailand of the pre-crisis period from 1992 to 1996. The study find that foreign-owned banks took little risk relative to other banks in the East Asian region, and that family-owned banks were among the most risky banks, together with company-owned banks. The results of the risk-taking model indicate that family and company ownership of banks should be discouraged, and that foreigners should be encouraged to become core group of investors of banks. In particular, the analysis might have overlooked that some banks operated under more restrictions than others. It is, however, likely that foreign banks were not favored by any of these rules and restrictions. It is therefore argued that banking regulation should be such that all banks, including foreign banks, can compete on an arms-length bases and that foreign ownership of East Asian banks should be encouraged. Since it is impossible to separate efficiency improvements from excessive risk taking, it was assumed that efficiency is constant during 1992-96 in order to construct our measure of risk taking. Of course, bank efficiency is not constant over time, even for a relatively short period of 5 years with no significant changes in bank management and bank regulation.

Rebelo et el.[97] evaluated the index numbers using nonparametric methods They have adopted the latter because it does not require the imposition of a possibly unwarranted functional form on the structure of production technology as required by the econometric approach. According to the authors there are two basic approaches to the measurement of productivity change: the econometric estimation of a production, cost, or some other function, and the construction of index numbers using nonparametric methods. They mentioned that three different indices are frequently used to evaluate technological changes: the Fischer [1922], Tornqvist [1936], and Malmquist [1953] indexes. They have cited Grifell-Tatjé Lovell [1996], where it is mentioned that the Malmquist index has three main advantages relative to the Fischer and Tornqvist indexes. First, it does not require the profit maximization, or cost minimization, assumption. Second, it does not require information on the input and output prices. Finally, if the researcher has panel data, it allows the decomposition of productivity changes into two components (technical efficiency change, or catching up, and technical change, or changes in the best practice). Its main disadvantage is the necessity to compute distance functions. However, the data envelopment analysis

(DEA) technique can be used to solve this problem The authors consider that the banking firm as a multi product organization produces three outputs (loans, financial applications, and other banking services) with three different inputs (deposits, labor, and capital). The final solution depends upon the concept of what banks do, the stated problem, and the availability of data. They have used the intermediation approach, and variables are defined as follows. For outputs. are loans outstanding (loans to clients, net of provisions); financial applications (loans to credit institutions plus bonds plus other financial applications, net of provisions); and are other bank services (commissions received plus net profit from financial operations). For inputs, are deposits (deposits from clients plus deposits from the public sector plus certificates of deposit plus deposits from other banks); are number of employees; and are fixed assets (net of depreciation). Data from the banks' annual balance sheets and income statements for 1990 to 1997 are used in this study. The sample includes almost all banks operating in Portugal during this period. The results showed that old banks exhibit better scores in all indicators. This could be partly explained by the fact that older institutions, having been in the market for a long time, are already known to the public and are now rationalizing their input usage and getting closer to the best practice.

Reztis [98] examines the productivity growth and technical efficiency in the Greek banking industry for the period 1982-1997. Furthermore, he compares productivity growth before and after 1992, since after 1992 the Greek banking industry has experienced a rapid acceleration of liberalization and deregulation. He uses the Malmquist productivity index to measure and decompose the total factor productivity growth, as well as the DEA method to measure technical efficiency. As mentioned that one of the main limitations of the DEA method is the presence of outliers which may influence the empirical results, especially in the present study, since the sample used consists of only six banks. However, the results of the present study, in terms of bank level efficiency and productivity measures, do not show big discrepancies among banks This indicates an absence of outliers in the sample. The results indicate that productivity growth increased on average by 2.4% per year over the entire period. The empirical finding that total factor productivity growth, which originates exclusively from technical change, is higher in the second sub-period than in the first is attributed to the rapid adoption of new information technology by Greek banks. The deterioration in efficiency observed during the second sub-period could be attributed to the presence of adjustment costs related to the use of this new technology. As for the first sub-period, given the empirical finding of technical regress, banks used the existing technology as efficiently as possible and, for this reason, total factor productivity growth during this sub-period resulted solely from improvements in efficiency.

Souza et el. [110] uses output oriented Data Envelopment Analysis (DEA) to measure the technical efficiency to assess the significance of technical effects for Brazilian banks. The three input sources are labor, capital and loanable funds and securities, loans, and demand deposits are combined measure of output. The factors or technical effects of interest in the analysis are bank nature (multiple and commercial), bank type (credit, business, bursary and retail), bank size (large, medium, small and micro), bank control (private and public), bank origin (domestic and foreign), and nonperforming loans. Bank origin and bank type are the only significant effects.

3.2.2 Health sectors

The application of DEA methodology to determine the efficiency of the health sectors has been found in a number of papers [1, 40, 72, 121] as outlined below:

Afonso et el. [1] computes the DEA efficiency scores and Malmquist indexes for a panel data set comprising 68 Portuguese public hospitals belonging to the National Health System (NHS) in the period 2000-2005. With data on hospital services' and resource quantities an output distance function was constructed, and was assessed by how much output quantities can be proportionally expanded without changing input quantities. The results show that, on average, the NHS hospital sector revealed positive but small productivity growth between 2000 and 2004. The mean TFP indices vary between 0.917 and 1.109, implying some differences in the Malmquist indices across specifications. Furthermore, there are significant fluctuations among NHS hospitals in terms of individual efficiency scores from one year to the other.

Friesner et el. [40] presents an empirical study that looks for evidence of seasonal inefficiency. Using a quarterly panel of general, acute-care hospitals from Washington

State, it was observed that hospital efficiency does vary over time, however, the nature of this dynamic inefficiency depends on the type of efficiency being measured. The results suggest that technical and cost efficiency vary by quarter. Allocative and scale efficiency also vary on a quarterly basis, but only if the data are jointly disaggregated by quarter and another, firm-specific factor such as size or operating status. The authors investigate the short-term effect of the new national health insurance known as Universal Coverage on hospital efficiency by comparing the technical efficiencies of public hospitals before and after the transition period during which universal coverage was implemented. The study was made for calculating the efficiency differences among 92 Thai provincial public hospitals using a two-stage analysis, including the Data Envelopment Analysis, bootstrapping DEA, and a censored Tobit model. In all, the DEA results indicate that UC improved efficiency across the country. Regional hospitals, in particular, improved their efficiency the most. On average, small general hospitals were the most efficient hospitals, followed by large general hospitals and regional hospitals. Because access of care, especially by those with lower incomes and the uninsured improved, an increase in the number of UC patients per enrollees increased hospital efficiency. This also implies that the capitation budget system which has replaced the incremental financing supply-sided cost, improved efficiency. Finally, it has been found that the efficiency change depends on geographical locations. Hospitals in the East become the least efficient instead of hospitals in the West after the reform started. These are very preliminary results, analyzing only at the short-term immediate effects of UC on the efficiency of regional and general hospitals in Thailand.

Masiye [72] analyzed to find the technical efficiency of a sample of hospitals in Zambia, in order to evaluate the ambitious national health program designed to meeting health-related MDGs. Although the lack of adequate resources presents the most important constraint, the efficiency with which available resources are being utilized is another challenge that cannot be overlooked. Inefficiency in producing health care undermines the service coverage potential of the health system. Here the efficiency is measured using a DEA model. Vectors of hospital inputs and outputs, representing hospital expended resources and output profiles respectively, were specified and measured. The data were gathered from a sample of 30 hospitals throughout Zambia. The model estimates an efficiency score for each hospital. A decomposition of technical efficiency into scale and congestion is also provided. Results show that overall Zambian hospitals are operating at 67% level of efficiency, implying that significant resources are being wasted. Only 40% of hospitals were efficient in relative terms The study further reveals that the size of hospitals is a major source of inefficiency. Input congestion is also found to be a source of hospital inefficiency. This study has demonstrated that inefficiency of resource use in hospitals is significant.

Webster et el. [121] applies a range of firm-level efficiency-measurement techniques to a unit record dataset for the Australian private hospital industry. Firm-level analyses of this kind are being applied by influential members of the ABS user community. This private hospitals study has three aims: to explore the differences in assumptions made by the various techniques and the differences in results they yield; to test the assumptions (relating to homogeneity of the industry, economies of scale, etc.) that underlie ABS standard methods for analyzing aggregate productivity; and to understand the ways in which the characteristics of a dataset can affect the application of these analytical techniques. Two types of techniques are used in the analyses: a non-parametric technique known as Data Envelopment Analysis (DEA), and two parametric techniques — Stochastic Frontier Analysis (SFA) and Ordinary Least Squares (OLS) regression. The benefits and shortcomings of each technique are discussed in general terms. and then each is applied to a number of model specifications using different combinations of input and output variables drawn from the private hospitals dataset. The purposes of this study were twofold; firstly to evaluate the robustness of a productivity analysis technique in the light of different model specifications, and secondly to draw some conclusions about the nature and pattern of efficiency within the Australian private hospital industry. Using the results presented in the previous section, a number of important observations can be made about the application and operation of the DEA methodology: The results presented for a range of model (input-output) specifications are not particularly robust to specification changes, where even minor variable definitional changes can produce different results. The comparison of mean efficiency by major ownership type (FP or NFP) showed a wide range of results from significant differences in either direction to insignificant differences. The comparison of rank correlations for each model with model 1 indicated that all were positive and significantly different from zero, with correlation coefficients ranging from 0.49 to 0.95. The lack of robustness is perhaps not surprising given the large sample size (301 observations) and the relatively small number of variables (a maximum of 16) when compared with previous studies of this type.

3.2.3 Education

In the education sector some papers have been found [2. 6, 119. 128] the technique of DEA has been applied as outlined below:

Afonso et el.[2] in their dissertation have shown five separate empirical papers based on panel data from Kenyan manufacturing firms in the food, wood, textile and metal sectors, collected during the early 1990s. The principal tools of analysis are the microeconomic theory of production and econometrics. Although the main thrust is empirical, the papers may also be of some independent methodological interest. The first two papers investigate whether technical efficiency is increasing in firm size and age. The evidence supports this claim with respect to firm size, but not age, which is consistent with previous evidence reviewed. These results, obtained using a stochastic frontier production function model in paper 1, are confirmed in paper 2 using data envelopment analysis combined with second-step regression models. Paper 3 addresses factor intensities and substitution. There exists a positive relationship between firm size and capital intensity. The evidence suggests this is due to non-homothetic technologies and to different input factor prices for small and large firms. Paper 4 is a broad analysis of the performance of the sub sectors in terms of technical efficiency and productivity. Small and informal firms are comparably inefficient. Food, followed by metals, is the most productive sector. Growing firms are more productive than contracting ones, suggesting that high turnover may increase overall sector productivity. Several variables do not explain the variation in productivity, including exporting, credit and foreign ownership. Textiles regressed after the trade liberalization. Paper 5 addresses the debate on the usefulness of the informal sector concept by conducting a comparative analysis of formal and informal small firms. Informal firms are younger, less capital-intensive, almost never run by Asians, pay less skilled wages and no taxes, have poor access to credit and have less educated managers. They invest more often and are less efficient than Asian-managed formal firms, but more efficient than those managed by Africans This suggests that formality status, independent of size, matters.

Banker et el [6] focuses in their study on how efficiency in public education is affected by competition from private schools The Swedish educational system is used, since the Swedish large scale voucher program implies that private and public schools compete on similar terms. Public school efficiency is estimated using Data Envelopment Analysis (DEA) A number of approaches have been proposed concerning how to model this in a DEA setting In this study, four different approaches are used and compared. Special focus is put on a second stage regression, where the efficiency estimates are regressed on competition and other explanatory variables.

Waldo [119] in his paper evaluates the efficiencies of secondary education across countries by assessing outputs (student performance) against inputs directly used in the education system (teachers, student time) and environment variables (wealth and parents' education). Firstly, output efficiency scores were estimated by solving a standard DEA problem with countries as DMUs. Secondly, these scores were explained in a regression with the environmental variables as independent variables. Results from the first-stage imply that inefficiencies may be quite high. On average and as a conservative estimate, countries could have increased their results by 11.6 percent using the same resources, with a country like Indonesia displaying a waste of 44.7 percent. The fact that a country is seen as far away from the efficiency frontier is not necessarily a result of inefficiencies engendered within the education system. Our second stage procedures show that GDP per head and parents' educational attainment are highly and significantly correlated to output scores – a wealthier and more cultivated environment are important conditions for a better student performance. Moreover, it becomes possible to correct output scores by considering the harshness of the environment where the education system operates. Country rankings and output scores derived from this correction are substantially different from standard DEA results. Non-discretionary outputs considered here cannot be changed in the short run. For example, parental educational attainment is essentially given when considering students performance in the coming year. However, contemporaneous educational and social policy will have an impact on future parents' educational attainment. Finally, it has been applied both the usual DEA/Tobit procedure and two very recently proposed bootstrap algorithms. Results were strikingly similar with these three different estimation processes, which bring increased confidence to obtained conclusions

Zheng et el. [128] in their paper presents a new DEA based method to analyze efficiency trends over time and differences across subgroups in a panel data setting. It was employed that the aggregate technical and allocative inefficiency score equals the technical inefficiency when input quantities are aggregated into a single total input cost variable, and develop test procedures to evaluate the presence of allocative inefficiency. These methods are used to test for the presence of allocative inefficiency in Texas school districts over 1993–99, and analyze shifts and trends in both technical and allocative inefficiencies over time for different regions The empirical results indicate the existence of statistically significant allocative inefficiencies. While technical inefficiency increased over the six year sample period. allocative inefficiency remained relatively stable during this period. These results for the full sample obtain also when the analysis was repeated for different regions.

3.2.4 Agriculture

Bosetti et el. in their paper [13] discusses a data-based, quantitative methodology to assess the relative performances of different climate policies, when long term economic, social and environmental impacts of the policy are considered. In the first, DEA is applied coupled with Cost-Benefit Analysis in order to evaluate the comparative advantages of policies when accounting for social and environmental impacts, as well as net economic benefits. In the second, DEA is applied to compute a relative efficiency score, which accounts for environmental and social benefits and costs interpreted as outputs and inputs. Although the choice of the model used to simulate future economic and environmental implications of each policy, as well as the choice of indicators for costs and benefits, represent both arbitrary decisions, the methodology presented is shown to represent a practical tool to be flexibly adopted by decision makers in the phase of policy design.

Dutta et el. in their paper [29] discusses two methods that are viable and widely-used approaches to the measurement of technical efficiency – how efficient a firm, or unit of a firm; is at using its inputs to produce a given set of outputs. These measures are also useful for comparing the efficiency of different units in a firm, such as salespeople, sales districts, retail outlets, divisions or subsidiaries of a firm. Which of the two approaches would be preferred in a given situation depends on the characteristics of the data at hand. DEA more readily incorporates multiple outputs, and requires only minimal assumptions about the shape of the efficiency frontier. These factors make DEA a good choice for cases where measurement errors are likely to be small, and outliers are unlikely to exist in the data. On the other hand, if measurement errors are likely to be large, the stochastic frontier method may be a better choice, especially if one is comfortable about making assumptions about functional form and the distribution of error terms. The viability of alternatives that fell well below the frontier would be questionable. This approach could have value for obtaining a preliminary determination of the viability of product concepts: if a concept were very inefficient at prices required making it profitable, its viability would be questionable; on the other hand, if a concept could be priced so that it shifted the efficiency frontier outward its viability would be promising. In this case the efficiency analysis would also permit determining which existing products are rendered inefficient by the new concept, and therefore most likely to be affected by its introduction. Here the discussion refers to the unit's ability to produce its current levels of outputs with the most economical use of inputs. Because it eliminates the confounding effect of differences in output and input prices, a technical efficiency measure is generally superior for efficiency comparisons between units or firms to standard profit measures

Krasachat in his paper [59] carry out the study is to measure and investigate technical efficiency in rice farms in Thailand. This study decomposes technical efficiency into its technical and scale components. In past studies, efficiency analyses have involved econometric methods. In this study, the data-envelopment analysis (DEA) approach and farm-level cross-sectional survey data of Thai rice farms in 1999 are used. A Tobit regression is used to explain the likelihood of changes in inefficiencies by farm-specific factors. The empirical findings indicate a wide diversity of efficiencies from farm-to farm and also suggest that the diversity of natural resources has had an influence on technical efficiency in Thai rice farms. An input-oriented DEA model was used for estimating overall technical, scale and pure technical, efficiencies in the rice farms of Thailand. Tobit regression was employed to investigate factors affecting technical efficiency of rice production at farm level in Thailand. The empirical results indicate that there are significant possibilities to increase efficiency levels in Thai rice farms. The average overall technical inefficiency could be reduced by 29 per cent, on average, by operating at optimal scales and by eliminating pure technical inefficiencies through the application of the best practices of efficient rice farms. In addition, the results also indicate that pure technical inefficiency for Thai rice farms provides a greater contribution to overall inefficiency. Thus, extension services should be used to increase the technical efficiencies of these inefficient farms in Thailand. The analysis presented in this paper can be improved in a number of areas. Some areas of further research should be considered. These include: comparing stochastic and DEA frontier analyses; and investigating the determinants of cost inefficiency in Thai rice farms.

Madlener et el. in their paper [67] compares multi-criteria decision aiding (MCDA) and data envelopment analysis (DEA) approaches for assessing renewable energy plants, in order to determine their performance in terms of economic, environmental, and social criteria and indicators. The case is for a dataset of 41 agricultural biogas plants in Austria using anaerobic digestion. The results indicate that MCDA constitutes an insightful approach, to be used alternatively or in a complementary way to DEA, namely in situations requiring a meaningful expression of managerial preferences regarding the relative importance of evaluation aspects to be considered in performance assessment.

Otsuki in his paper [83] examines the effects of the Brazilian governments' title granting policies on the efficiency of agricultural and timber production in the Brazilian Amazon. Data Envelopment Analysis (DEA) is used to develop multiple-output efficiency measures. These measures then are regressed on a set of predetermined variables that can affect efficiency measures but that do not fit the input-output structure of the first stage analysis. Two of these variables, the area share of land with titles and the expenditure on government services (a proxy for title security), measure the property rights situation of a county. The analysis includes timber and agricultural outputs to allow for potential interaction between these two land-based industries. Provision of private land title is found to positively affect the technical efficiency scores of agricultural and joint agricultural-timber production This effect is persistent: it can be observed years after the title granting policies are phased out. While the initial purpose of the granting of land titles was to encourage immigration into the Amazon, these policies also have evidently caused a long run increase in the technical efficiency scores of production. Governmental expenditures, including expenditures to secure property rights, also are found to increase technical efficiency scores in the agricultural industry. Policies that encourage private ownership of cleared land do not necessarily increase revenue efficiency scores. Counties with higher shares of privately titled land tend to produce too much agricultural output and too little timber output to maximize county revenues. Much of the revenue inefficiency found in the analysis is not directly related to land ownership. It exists in counties with high and with low share of privately titled land. Revenue and allocative efficiency scores are low in the Amazon counties, with only 32 percent of the potential revenue being realized on average at the given 1995 prices, and only thirteen of the 255 counties exhibiting both allocative and technical efficiency scores of one Increased shares of land under private ownership do increase revenue efficiency scores when revenue efficiency is measured for agricultural products alone. They do not increase revenue efficiency scores when both agricultural and timber products are considered. Results from the analysis suggest that land title policies may ultimately increase agricultural yields and reduce the amount of cleared land needed to produce a given quantity of agricultural output. Thus the land-titling policies can negatively affect the economic development of the counties. If the Amazon region is representative, policies that promote private ownership of public land in a region where all of the land is initially in the public domain will increase technical efficiency scores.

Pushpangadan in his paper [91] carries out a study to examine the use of Data Envelopment Analysis (DEA) for the estimation of the well being from drinking water using 'commodities and capabilities' approach. DEA uses the general purpose linear program version of the input oriented multi-input multi-output model for the estimation taking state as the decision-making unit. The transformation efficiency of the water characteristics into achieved capabilities (free from morbidity rates of water borne diseases) shows that Punjab has the least efficiency while Kerala and Orissa as the Pareto efficient Peer states. The major reason for the input use efficiency in Kerala may be due to the cultural practice of boiling drinking water before consumption. In the case of Orissa, it can be attributed to better hygienic water handling practices. One such indicator, taking water from the storage containers using vessels with handles, is very high among the households in Orissa.

Rao et el. in their paper [95] have examined the levels and trends in agricultural output and productivity in 97 developed and developing countries that account for a major portion of the world population and agricultural output. The data was drawn from the Food and Agriculture Organization of the United Nations and covers the period 1980-1995. Due to the non-availability of reliable input price data, the study uses data envelopment analysis (DEA) to derive Malmquist productivity indexes. The study examines trends in agricultural productivity over the period. Issues of catch- up and convergence. or in some cases possible divergence, in productivity in agriculture are examined within a global framework.

Rios et el. in their paper [97] evaluates the efficiency of small holder coffee farms in Vietnam. Data from a 2004 survey of farms in two districts in Dak Lak Province are used in a two-step analysis In the first step, technical and cost efficiency measures are calculated using DEA. In the second step, Tobit regressions are used to identify factors correlated with technical and cost inefficiency. Results indicate that small farms were less efficient than large farms. Inefficiencies observed on small farms appear to be related, in part, to the scale of investments in irrigation infrastructure.

3.2.5 Service sectors

DEA methods have been applied in many papers [17, 34, 45, 47, 70, 88] of service sectors which have been outlined below:

Cheong et el. in their paper evaluates [17] the advertising practices of top U.S. advertisers, using Data Envelopment Analysis. The goal is to identify best practices and to test the efficiency of the adverrising in each of three media types: print, broadcast, and the Internet. The results reveal inefficiencies in each area, relative to the money spent by the advertisers, and also show that the efficiency of Internet advertising for these advertisers is less than that for print or broadcast expenditures.

Consequently, it is vital to measure, maximize, and benchmark the efficiency of advertising media expenditures. The pioneering retailer, John Wanamaker, is famous for the saying attributed to him: "Half of every dollar spent on advertising is wasted; the problem is I just don't know which half." Given the huge amounts of money spent on advertising, practitioners are concerned about possible inefficiency in their use of advertising money, about how to uncover such inefficiency, and how to improve the efficiency. A firm undertakes advertising to improve its sales and/or profits. Nonetheless, numerous marketing scholars have theorized the possibility of inefficiency in advertising expenditures. The present study offers DEA – Data Envelopment Analysis – a widely accepted management technique, to calculate and benchmark the efficiency (or lack thereof) in advertising spending. The special merits of the DEA technique are that it is capable of handling multiple inputs and multiple outputs, and that it calculates the efficiency of advertisers relative to each other. The current study analyzes the advertising expenditures of top U.S. advertisers in the three areas of print, broadcast, and the Internet, and determines the capability of each of the advertisers to generate sales and profits, relative to their expenditures. The overarching results indicate that some inefficiency is indeed present. Overall, the Internet advertising efficiency of the top advertisers is lower than that for either print or broadcast advertising. This study incorporated two recent innovations in DEA – input congestion and slack analysis. Since the most important consideration in DEA application is the selection of input and related output variables, the choice of which advertising channel is the input variable is important to DEA analysis. So far, however, no media study has adopted the DEA model to address the efficiency of advertising in the Internet medium environment. However, there has been a lack of attempts to empirically investigate the efficiency of Internet advertising through application of the method employed in this study. This study finds that the selected top 47 advertisers were less efficient on Internet advertising than on other media – print and broadcast. The outcomes of this DEA analysis provide useful information on how the media spending and sales/earnings should be adjusted to transform inefficient advertisers into efficient advertisers for the Internet medium as well as traditional media.

Fethi et el. in their paper [34] discusses that the liberalization movement in European airlines industry was initiated in the late 1980s to create a more competitive environment. This has aimed to result in an increase in efficiency and productivity of the industry. The radical changes which have occurred since then have given risen to the need to evaluate the efficiency in the early phases of the liberalization process. This study utilizes Data Envelopment Analysis (DEA) to assess the efficiency of airlines. The Tobit model applied to the second stage is conducted in an effort to identify the effects of various explanatory variables on efficiency. Applying DEA with Tobit models to detect the efficiency and the determinants of (in) efficiency serves a variety of policy purposes and aimed at improving performance. Our analysis is based on a panel data set of 17 airlines European airlines over the period of 1991-1995. The empirical findings confirm the detrimental effects of concentration and subsidy policies. Airlines confronting competition may seek to exploit economies of scope and of density. In recent years, it has been strongly argued by the EC that all state aids for the state -owned carriers be eliminated except in very rare circumstances. Moreover, the empirical findings reveal that the state ownership did not provide an impediment for being efficient in this sample. Further, in order to remain competitive and efficient, the European airlines need to maintain their service quality – increase the load factors. This analysis, however, is the first attempt to investigate Tobit analysis in the airline efficiency literature. Therefore additional studies are imperative to confirm or falsify the detected determinants in this study. The empirical work here suggests that future research may need to concentrate on the dynamic factors, i.e. the R&D facilities and innovation which could play a significant role in an industry's performance.

Herrera et el. in their paper [45] comments that the Governments of developing countries typically spend between 15 and 30 percent of GDP. Hence, small changes in the efficiency of public spending could have a major impact on GDP and on the attainment of the government's objectives. Thus evaluation of efficiency is vital, thus an attempt has been made for evaluation base on DEA The basic philosophy estimates efficiency by calculating the distance between observed input-output bundles and an efficiency frontier (defined as the maximum attainable output for a given level of inputs) estimated for several health and education output indicators. The frontier is estimated by means of the Free Disposable Hull (FDH) and Data Envelopment Analysis (DEA) techniques. Both input-inefficiency (excess input consumption to achieve a level of output) and output-inefficiency (output shortfall for a given level of inputs) are scored in a sample of 140 countries using data from 1996 to 2002. The second part of the paper seeks to explain the cross-country variation in efficiency score, controlling for environmental variables. Results show that countries with higher expenditure levels register lower efficiency scores. Other variables that explain cross-country differences are the share of total service provision that is publicly financed (negatively associated with efficiency), the degree of urbanization (positively correlated with efficiency), the prevalence of the HIV/AIDS epidemic (negatively associated with efficiency scores), income inequality (higher inequality associated with lower efficiency), and the degree of external aid financing (negatively associated with efficiency) .

Holvad in his paper [47] presents the results of an analysis of efficiency patterns for Norwegian bus companies using the non-parametric techniques DEA and FDH. Overall, the paper has demonstrated that it is feasible to use these techniques to examine the productive performance of bus companies. In particular, the application has shown that DEA and FDH can provide useful information regarding the efficiency patterns. This information relates both to the industry as well as to the individual companies. In the Norwegian bus industry a relative high inefficiency level was detected. Obviously, the efficiency results depend on the technology assumption used. However, the difference between DEA-C and DEA-V was relatively small indicating a high level of scale efficiency. In contrast, the change from a DEA to a FDH model resulted in significant changes in efficiency level demonstrating the importance of the convexity assumption. In the paper it was also shown the significance of slacks in the inputs and/or outputs emphasizing the need for careful analysis of observations with efficiency scores equal to one. The scope for providing valid explanations of the efficiency patterns was examined, where the research revealed that a relative simple model with four variables could explain around 85 per cent of the variation in efficiency. Future research could consider the extent to which it is possible to develop alternative output measures in order to allow for consideration to the quality of the bus service provision in the measurement of efficiency. Furthermore, at a more theoretic level it could of importance to examine the scope for converging non-parametric approaches towards parametric approaches and vice versa. Indeed, it could be of importance to develop nonparametric efficiency measurement techniques with a stronger statistical basis. Similarly, possible improvements in the parametric approach could accommodate for more flexible functional forms concerning the linkage between inputs and outputs.

Maria et el. in their paper [70] estimates the DEA technical efficiency for 4796 Brazilian municipalities by applying a "jackstrap" method. which combines Bootstrap and Jackknife re-sampling techniques to eliminate the effect of outliers and measurement errors in the data set. For that purpose a two-step procedure is used: first, leverage value is calculated for each municipality in order to identify potential outliers; second, CCR and BCC efficiency scores was computed by excluding (using different probability schemes) those communes which presented the highest leverage. The computed efficiency scores, as well as their rank, proved to be very robust for both variants, thus increasing the credibility of the estimated frontiers. Corroborating previous results. efficiency results for the Brazilian municipalities show a clear relationship between the size of the municipality and its efficiency scores. Indeed, under both DEA variants, smaller cities tend to be less efficient than larger ones hence indicating that the quality of the frontier adjustment improves significantly as the size of the municipality increases. There has been an argument that may explain to some extent these findings, such as economies of scale, the excess spending due to substantial royalties. and underestimate of population due to tourism. However, such effects require further, more careful examination. It should also be noted that inefficiency of some municipalities may be due do exogenous factors that cannot be controlled, such as natural and climatic factors, political issues, demographic and socio-economic characteristics that have not been taken into account in our analysis. Therefore, the natural extension of our current investigation would be to separate the effects of the exogenous factors from those related to the technical aspects of the productive process, in order to obtain a "pure" measure of technical efficiency for the Brazilian municipalities. Finally, because of the shear size of the data set, it is impossible to include here a table with our final efficiency results for all the municipalities.

Poitras et el. in their paper [88] narrates that available studies have not provided a satisfactory answer to the problem of making international comparisons of port efficiency. This study applies data envelopment analysis (DEA) to provide an efficiency ranking for five Australian and eighteen other international container ports.

While DEA has been applied to a wide number of different situations where efficiency comparisons are required, this technique has not previously been applied to ports. The DEA technique is useful in resolving the measurement of port efficiency because the calculations are nonparametric and do not require specification or knowledge of a priori weights for the inputs or outputs, as is required for estimation of efficiency using production functions. One Australian port, Fremantle, is found to be the most inefficient port in the sample using both constant and variable returns to scale assumptions. Two Australian ports, Sydney and Brisbane were found to be efficient independent of the returns to scale assumption, indicating that port size alone is not the primary determinant of port efficiency. Adelaide was found to be efficient with variable returns to scale, but had one of the lowest efficiency scores with CCR. The remaining Australian port, Melbourne, also exhibited a sizable change in efficiency score, being efficient with variable returns to scale and having an efficiency score of .5778 under CCR. The primary contribution of this study is methodological. It demonstrates that DEA provides a viable method of evaluating relative port efficiency. DEA has recently been successfully applied to a number of different economic efficiency measurement situations. The technique offers a significant alternative to classical econometric approaches to extracting efficiency information from sample observations, such as the use of stochastic frontier production functions. Important features of DEA are that the technique is nonparametric and that more than one output measure can be specified. In the case of port efficiency, the ability to handle more than one output is particularly appealing because a number of different measures of port output are available, depending on which features of port operation are being evaluated. In addition to providing relative efficiency rankings, DEA also provides results on the sources of input and output inefficiency, as well as the ports which were used for the efficiency comparison. The ability to identify the sources of inefficiency could be useful to port authority managers in inefficient ports, acting as a guide to focusing efforts at improving port performance.

3.2.6 Manufacturing Firms.

Some of the works based on DEA have been also found in the manufacturing sectors [31, 36, 41,46, 64, 76, 79, 81, 89, 99, 102, 104, 108. 112, 124, 127].

Fanchon in his study[31] establishes two points : (1) it is inappropriate to include the lagged values of the variables for measuring efficiency, and (2) expenditures on R&D on advertising have only a short-term effect on sales. These findings can be explained by the rapid duplication of innovations in computer design, which does not seem to give any firm a lasting competitive edge. The absence of lagged variables can also be explained by the fact that most of the innovations occur in chips or components design and computer manufacturers simply benefit from advances in other industries. Only two firms do not benefit directly from the Intel-Microsoft alliance: Apple and Sun. Most of the companies who entered the PC market after 1990 did not survive (ALR, AST, Northgate, and ZEOS). Many firms were bought, merged, or went bankrupt. However, the recent market consolidation cannot be explained only by the demise of inefficient firms. Only a few of the 43 original firms from the Standard Industrial Classifications 3570 and 3571 were able to maintain productive efficiency throughout the time-period 1979-2000. Many of the other firms gradually shifted their production away from personal computers. These firms, who now produce very specialized computers for inventory management or animation services, have assets and advertising strategies that are too specialized to be compared with that of other major manufacturers. Because their market share is minuscule, they were excluded from this study. In addition, several data points for the major manufacturers could not be used for lack of relevant or reliable data. Six of the surviving personal computer manufacturers with a market share consistently greater than one percent have maintained a high level of technical efficiency, with the exception of Apple. Successful firms were not all efficient in the use of the three inputs selected. Their sub efficiency can be caused by periods of intense advertising campaigns or by a major investment in capital (for example, elimination of sockets on the mother-boards and the rapid trend to miniaturization induced major investments in specialized machines). Such is the case for Apple, who developed the i-Mac and Titanium notebook, and Dell5 who had to establish itself through strong advertising. It is unclear whether these short-term inefficiencies will generate to long-term benefits through economies of scale.

Forstner in his paper [36] has argued that DEA is an acceptable tool for analyzing economic performance at country level when compared with the growth accounting and stochastic-frontier approaches. One drawback of the standard DEA is that the method allows countries to lose knowledge about production techniques. This kind of memory loss is implausible and causes inaccurate measurement of technological change and technical-efficiency change. As a consequence, a country appears as performing exceptionally well in technical efficiency without actually having improved at all. This bias occurs when the country is located in a region where the world technology frontier is receding. The amendment to DEA proposed here and called Long-Memory DEA (LMDEA) imposes on countries infinite technological memory in concordance with the nature of knowledge. The virtues of this amendment are twofold: First, LMDEA, by retaining all previous frontier points, prevents the technology frontier from moving inwards and thus preserves knowledge about production techniques. Second. it avoids overestimation of technical-efficiency change due to memory loss. The figures for TFP-change are in principle identical for DEA and LMDEA with occasional small differences. The view taken here is that if the focus is on productivity alone, standard DEA is viable. In order to illustrate the risks of using standard DEA. and the virtues of using LMDEA for the purpose of evaluating various countries' growth performance. TFP change and changes in technology and technical efficiency were computed using both methods. Among the most striking results of this comparison is the fact that for African countries technical-efficiency change is grossly exaggerated in DEA estimates. And for countries like Kenya or Zimbabwe an improvement in technical efficiency suggested by DEA figures is actually turned into deterioration when using LMDEA. Similar examples are found among 'other' developing countries, where several instances of positive technical-efficiency change assessed by DEA turn negative with LMDEA The results of the present paper also largely corroborate the findings of Färe et al (1994) that for OECD countries TFP growth were based on innovation. Finally, as an important by-product, the paper refutes the idea that the Asian 'Tiger' economies grew only by means of factor accumulation. It shows that, to the contrary, there was considerable

TFP growth involved in the growth of these economies, and that this component was mainly the result of improvements in technical efficiency.

Gavirneni presents a case study [41] in the name of Applichem about a multinational chemical company, with six manufacturing plants located all over the world. The manufacturing plants' efficiencies are highly varied and in the presence of excessive capacity, management is having a difficult time determining which plants must be shut down. This case is often studied from an optimization perspective. with the objective of matching customer demands with plant capacities at the lowest possible cost. The case involves multiple measures of performance (e g. labor cost, material cost, etc.). which makes it ideal for introducing and demonstrating DEA from a practical perspective. This paper details how such an analysis can be presented in a business classroom.

Ho et el [46] in their study discusses five approaches that were widely used for performance measurement and decision analysis. They are: 1)Data Envelopment Analysis; 2) Analytic Hierarchy Process: 3) Grey Relation Analysis; 4) Balanced Score Card; and 5) Financial Statement Analysis. Each of the five approaches has its limitation in application. Yet, each of them has its strength. This study aims at finding out the difference of the five approaches in application on performance measurement, their respective" characteristics and "appropriateness in application". Based on the result of this study, the owners of small and medium enterprises in Taiwan may be able to find out an approach appropriate for their respective diagnosis and measuring of performance of the firms. Basing on the result of this study, the owners of small and medium enterprises may not be easy to choose an effective method for performance measurement for their respective diagnosis of the firms. In summary, no single approach is perfect. There is a saying that "whenever there is an advantage. it entails a drawback". Only when the approaches can complement each other over time, so as to avoid the shortcomings, can the evaluation of performance over specific issues be done appropriately.

Los et el in their study [64] provides an empirical framework to study the labor productivity growth performance of countries. Innovations for capital-intensive technologies will not affect the performance of capital-extensive technologies, and the other way round. The model has been used by relaxing the assumption of immediate spillovers. As a result, many countries perform well below the best practice at similar technologies. A decomposition framework suggested by the augmented BW-model was implemented by estimating a global production frontier, which indicates for each technology the maximum labor productivity level at which it can be operated, given the knowledge available at that time. Actual labor productivity growth was decomposed into the effects of assimilating knowledge pertaining to particular technologies, creating potential to benefit from more productive technologies, and localized innovation. Analysis of convergence processes suggests that localized innovation causes a tendency towards divergence. At low levels of capital intensity, hardly any innovation was found, whereas the frontier was steadily pushed at high capital intensities.

Mohammad in his paper [76] analyzes the changes in productivity of Malaysian mobile telecommunications industry from 1996 to 2001. The data consist of a panel of five mobile service providers in Malaysia, namely Celcom, DiGi, Maxis, TimeCel and TM Cellular. Productivity is measured by the Malmquist index, using a Data Envelopment Analysis (DEA) technique. The Malmquist productivity measures are decomposed into two components: efficiency change and technical change index. The results showed that Total Factor Productivity (TFP) has increased significantly for the whole industry in which technical change has been the most important source of productivity growth to the mobile telecommunications industry. A low level of efficiency change in the industry indicates a great potential for the industry to increase its productivity through higher utilization of technology as well as technological knowledge dissemination. Continuous training programs to familiarize and improve technical expertise appear to offer better prospects for the mobile telecommunications industry to achieve greater productivity growth.

Mukherjee et el. in their paper [79] evaluates the performance of firms, efficiency in particular, in the framework of resource-based view of the firm, increasingly important school of thought in strategic management field, to address the question of why some firms are performing better than others. As a research setting the study compromises the sample of firms in textile and clothing industry for the time period 1998-2001, across two distinct countries – Poland and Spain. In particular, this paper is analytically linking three important concepts of resource-based view, meaning intangible assets, tangible assets and firms' age with efficiency. In addition, the results were compared when applying another measure of performance, used very often in RBV studies – return on assets (ROA). The results obtained with efficiency as dependent variable seem to be more relevant than the ones when ROA was applied. The study opens a wide area for future research.

Nguyen et el in his paper [81] uses both parametric and non-parametric approaches to estimate technical efficiency for 2,298 construction firms in Vietnam in the database of the 2002 Economic Census for Enterprises by the General Statistics Office of Vietnam. It is found that results from both approaches are consistent, and they could help explain the performance efficiency of these firms. Estimates from the nonparametric approach data envelopment analysis and the parametric approach stochastic frontier production function indicate that the average pure technical efficiency of these firms was about 60 percent (58.6% and 57.8% for DEA and SFPF, respectively). Models to test the factors influencing efficiency scores in both approaches show relatively similar results that state firms were more efficient than non-state ones, and location in Hanoi and Ho Chi Minh city did have impacts on efficiency scores. However, exploration of the net capital-labor ratio variable show that it did not influence efficiency scores in the DEA model, while it had clear influence in the SFPF model.

In a dissertation of Preston University [89] the study identified those factors perceived by Wyoming state government employees as most important to their overall productivity. In April 1996 and in May 1998 three hundred thirty two state government workers responded to a survey containing four open-ended questions related to their perceptions of the best and most limiting aspects of their work. The same survey was administered to 91 state government supervisors in November 1998. The surveys produced consistent results. State employees identify their jobs, the people they work with, helping others, making a difference and the opportunity to learn as the best aspects of their work. State workers say they are limited in their ability to perform the most productive work by poor management, uncertain policies and priorities, poor communications, bureaucracy and politics Lack of training, lack of rewards and recognition, and high workloads were also cited as limiting factors to their productivity. Supervisors identify politics and bureaucracy, inadequate pay and benefits for workers, poor leadership, lack of trust in upper-level leaders and inadequate staffing as most limiting to productivity in state government. To improve productivity, the work force would improve communications, provide incentives and rewards, train more, build teamwork and set clear goals and objectives. The supervisors would increase pay and benefits, support and respect state employees, improve leadership and communication, give managers more flexibility with fewer controls, improve the performance appraisal system and make it easier to remove non-performers. The factors affecting workplace productivity in Wyoming state government are congruent with the classic motivation theories of Maslow and Herzberg, as well as with the principles of management described by Mintzberg, Peters, House and Dressler. The nature of these findings indicates a strong potential for increased productivity within Wyoming State Government: that increase could be achieved with minimal financial investment. Systematic application of time-tested motivation principles, together with highly focused implementation of true managerial activities would result in significant improvements in overall output from state government employees.

Rimkuvienë in his paper [99] carry out a study in order to investigate the current status of operation management for companies in free trade zone, to evaluate the operation performance for each company, to obtain an insight of how each company performs, and to provide a guideline of improvement direction for each company and the free trade zone. In this study, it was surveyed and collected management data from companies in free trade zone in Taiwan. The results obtained include potential improvement, peer contribution, input-output contributions for each company, and total potential improvement. The obtained results suggest that there exists a great potential of improvement for many companies.

Rocha in his paper [102] discusses the benefits of integration companies-suppliers top the strategic agendas of managers. Developing a system showing which suppliers merit continuing and deepening the partnership is difficult because of the large quantity of variables to be analyzed. The internationalized petroleum industry, requiring a large variety of materials, is no different. In this context, the Brazilian company PETROBRAS S.A. has a system to evaluate its suppliers based on a consensus panel formed by its managers. This paper shows a two phase methodology for classifying and awarding suppliers using the DEA model. Firstly, the suppliers are classified according to their efficiency based on commercial transactions realized. Secondly they are classified according to the opinions of the managers, using a DEA model for calculating votes, with the assurance regions and super efficiency defining the best suppliers. The paper presents a case study in the E&P segment of PETROBRAS and the results obtained with the methodology.

Saranga et el in their paper [104] applies Data Envelopment Analysis on a sample of 44 listed companies that have survived the past one-decade, to determine the best practices if any in the Indian Pharmaceutical Industry. The results of DEA have been analyzed along with their Compounded Annual Growth Rate (CAGR) to see if internal efficiencies and growth rate are related in the Indian Pharmaceutical Industry. Regression analysis is used to see the correlations between various inputs/outputs and the growth rates. Various models of DEA like Constant Returns to Scale (CCR), Variable Returns to Scale (BCC) and Assurance Region (AR) are used to substantiate the results obtained.

Sirasoontorn [108] in his paper aims to evaluate the technical efficiency of Thai electricity generation under public ownership. Technical efficiency is measured employing a comparative application of nonparametric and parametric approaches, namely Data Envelopment Analysis and Stochastic Frontier Analysis respectively in two separate cases: Thai and Australian power plants and electricity suppliers in various countries. The results from inter-country comparison show that the Thai state owned electricity generating company is on the frontier and performs better than other electricity suppliers in OECD and non-OECD countries on average. Implications for the analysis of privatization are discussed.

Stokes et el. in their paper [112] uses the Data envelopment analysis (DEA) to examine the efficiency of 74 front wheel assist agricultural tractors from three U.S. manufacturers. The outputs of drawbar horsepower and power takeoff horsepower are modeled in a constant returns-to-scale framework using three productive performance inputs (fuel consumption, slip, and center of gravity), and one price input, namely, retail tractor price. The results suggest that by and large, John Deere tractors are more

DEA efficient than their competitor's tractors. However, competitor's tractors that are DEA efficient are most often the top benchmarks for DEA inefficient tractors. These results suggest that while John Deere appears to produce many quality tractors, competitor's like CNH and AGCO produce a few tractors that may be of even higher quality. It is often said that the green paint on John Deere tractors adds price/value. An analysis of tractor data from various U.S. manufacturers reveals that John Deere tractors are generally more DEA efficient that their competitor's tractors in using productive and price inputs to generate horsepower output. This result seems to suggest that while John Deere tractors may have brand appeal, on average, they are of high enough quality to justify a higher price. However, this is not to say that AGCO and CNH tractors are inferior across the board. In fact, a Massey Ferguson tractor (made by AGCO) and two CNH tractors (a New Holland and Case-IH tractor) are top benchmarks for the majority of DEA inefficient tractors. Despite the generally high quality of John Deere's product as measured by DEA efficiency, competitor tractors are often times the industry standard. Preliminary results suggest that the DEA methodology could be used as a product planning tool, particularly when interfaced to computer-aided engineering methodologies. For agricultural tractor development, therefore the DEA could serve as a guide to optimize future prototype tractor model development, particularly in terms of tractor architecture to evaluate form and function considerations.

The objective of the thesis of Wu et el. [124] is not to determine the optimal measure of economic efficiency, but rather to use Data Envelopment Analysis (DEA) to obtain efficient solutions for multi-objective linear programs by separating efficient from inefficient organizations. This is a convenient way for decision makers to choose within complex environments. The thesis develops a three-stage algorithm to generate a company competitor list and then evaluates 50 companies selected from the Taiwan stock market (TAIEX). 17 efficient companies are selected through DEA Model, while 33 companies are defined as inefficient units based upon their relative angle of profitability. All companies are treated as independent Decision-Making Units (DMU's). DEA is used to evaluate the performance of 50 listing companies in Taiwan stock market in 1999. Using the Banker, Charnes and Cooper (1984) model in DEA, the results are obtained of efficiency scores and returns to scale of 50 samples. Empirical results generated from this study compare both profitability and marketability between "hi-tech" and traditional companies in Taiwan. These empirical results indicate that there is still some deviation within Taiwan stock market performance (i.e. relatively more efficient hi-tech industries tend to exhibit superior profitability, while traditional industries nevertheless demonstrate superior marketability even at the end of 1999)

Zheng et cl [127] their study says that with respect to technical efficiency, relatively large TVEs(Town-Village Enterprises) surpassed SOEs(State Owned Enterprises) by a large margin during the study period (1986 –1990); urban COEs were less efficient than TVEs, but more efficient than SOEs. However, these results should be interpreted with caution, because there are other factors (such as the differences in product quality and in input and output pricing across ownership types) that were not accounted for in the study. The scale of production was also positively correlated with technical efficiency. Coastal provinces were preponderant among the most efficient. The proportion of nonproductive labor was not highly correlated with technical efficiency, but the proportion of nonproductive capital was positively correlated with technical efficiency at a high level of statistical significance and with considerable magnitude. Some important explanatory variables in the regression analysis were not statistically significant, including the one related to nonproductive labor and those for types of management system. Thus, investigation on the impact of management reforms is thus inconclusive, partly because of data problems but mainly because of limitations of the methods used. Beyond that, comparative static and even dynamic studies of management reforms are required. To obtain more significant parameter estimates, the entire data-set for the 39 two-digit industries (covering 148 three-digit industries) could be utilized by forming a DEA frontier for each industry (three-digit or two-digit) and then by pooling the efficiency scores from all industries to perform a regression analysis as in this study. The difference in technical efficiency between SOEs and COEs is interesting. Given that larger size has no negative effect on technical efficiency, small scale COEs are still more efficient than small-scale SOEs because small SOEs are larger than small COEs, on average. Further analysis of the impact of management reforms on small SOEs should be conducted.

CHAPTER IV

PRODUCTIVITY MODELING IN THE APPAREL INDUSTRY

4.1 TECHNICAL DESCRIPTION OF APPAREL INDUSTRY

Apparel is simply clothing or dresses meant for mainly covering outer body or wearing under the main dress also for the purpose of enhancing beauty or fashion. Apparel may be broadly classified into three categories: woven, knitting and sweater. Traditionally, in these three categories have been merged into two associations: one is the Bangladesh Garments Manufacturers and Exporters Association (BGMEA), whose members are the woven and sweater manufacturers and the other is the Bangladesh Knitwear Exporters Associations (BKMEA), whose members are the knitting manufacturers. The term garments usually covers two types i.e. the woven fabrics and the sweaters. Due to the advantage of cheap labors forces of the country the cutting and making process has gained popularity. Thus the garments industry may be defined as an establishment where fabrics are cut and sewn to the desired shapes and sizes and converted to garments as per requirement of the buyer. Further, BGMEA has categorized its member organizations based on the number of machine utilized to carry out its production processes as the following:

Table 4.1: Annual Fees based on number of machines.

Sl #	Number of Machines	Annual Fees
1.	1 to 100	Tk.5000/-
2.	101 to 200	Tk.7000/-
3.	201 or more	Tk.12000/-

Also the factories may also be classified based on number of production lines. There should be at least three production lines. Large factories usually have ten or more production lines.

The garments industry is basically a cutting, making and sewing factory, utilizing a great number of labors and very simple machineries. The sewing section is the heart of the factory and the whole production is largely dependent upon the utilization of skilled and semi-skilled labors and thus the productivity of the whole factory happens to be largely dependent on the productivity of that section. In some cases more value additions are made when fabrics are produced in house through the processing of yarns, using the knitting machines.

The various activities may be termed as under:

1. **Knitting section:** Different sizes of yarns are the input (raw material), where circular knitting machines are used to convert the yarns into the desired width and colors of fabrics of various textures. A few numbers of skilled workers are needed to operate the machines.

2. **Inspection and cutting section:** Here the fabrics are checked for various defects and the fabrics which are found to be within the allowable limits are cut to specified shapes. In a large table fabrics are laid down and fine cutters are used by workers to cut those fabrics into desired shapes and required number of pieces.

Table 4.2: **Layout of Inspection and cutting section.**

Man	Operation	Machine and Tools
Sample master	Sample making	Electric Cutting
Marker man	Marker making	machines
Layer	Laying of Fabrics	Clippers
	Clipping fabrics with table	Chalks
Cutter	Cutting	Art Sheet for patterns
Worker for	Numbering	News paper
numbering the parts		Marker Pencil
Bundling	Bundling and sorting	
Storing and		
Transportation		

3. **Sewing section:** This section is the heart for any garments industry. Here the production processes are channeled through different production lines as per the installed capacity of the factory. In each line the cut pieces are sewn together to make the product (e.g. shirts, trousers, etc.). Various stitches are applied through sewing machines. Helpers are arranged to seat beside the main workers so that the total required work could be accomplished without any hindrance. Sequentially one after another part is completed and accordingly after completion of prior fixed of one set of stitches the output is pass on to the next upper stream. The total process for making the desired shape of product is completed in each line. There may be rework which is fed back to the line. The main works are sewing the garments parts, attaching accessories such as elastic, draw cord, zipper, button, eye lets, labels by machines etc.

Table 4.3: Layout sewing section.

Man	Operations	Machine and Tools
Floor-in-charge Line Chief Supervisor Quality checker Machine Operator Operator's helper Marking man	Sewing Bar-Taking Over Locking(Lock Stitch) Button Fixing	Single Needle machine/ Plain Machine Double needle machine Bar tak Machine

In each production line the distance between the machines should be 36 inches and the distance between the production lines should be 36 to 42 inches. In this way the total floor area can be divided into required number of production lines or the required amount of floor space needed can be obtained by multiplying with number of production lines.

4. **Finishing and packing:** The final product is then ironed, packed into poly bags and put inside a carton of required number of pieces, which is now ready for delivery.

Table 4.4: Layout of Finishing and Packing.

Man	Operation	Machine and Tools
Floor-in-charge	Bar Taking	Iron
Line Chief	Over locking	Single needle machine
Supervisor	Button fixing	Double needle machine
Quality Checker		
Marking Man		

There are many factors or constraints which are beyond the control of the factory authority. Some examples could be the weather condition, market volatility, supply of raw materials. But the most critical among these are supply of skilled manpower. An estimate is given below which has been obtained enquiring relevant persons from various factories.

Table 4.5: Plan for making basic shirt for hourly 100 pieces of production.

Name of the Machine	Quantity
P.M: Plane Machine (sewing)	23
OVA: Over lock (sewing)	3
Button Hole (hole making)	1
TOTAL MACHINES:	27
Designation of the person	Required Number
Line In charge	1
No. of Supervisor	2
No. of workers	27
No. of Helpers	27
TOTAL MANPOWER:	57

	OUTPUT TABLE	
	HEM(PM)	
COLLAR TOP(PM)	INSPECTION TABLE	
COLLAR TOP(PM)	COLLAR JOINT(PM)	
SIDE JOINT(OVA)	SIDE JOINT(OVA)	
ARM HOLE TOP STITCH(PM)	ARM HOLE TOP STITCH(PM)	
FRONT TOP STITCH(PM)	SLEEVE JOINT(OVA)	
FRONT JOINT(PM)	FRONT JOINT(PM)	
POCKET ATTACH(PM)	POCKET ATTACH(PM)	BAND JOINT(PM)
POCKET ROLLING(PM)	INSPECTION TABLE	BAND JOINT(PM)
BACK TAKEN(PM)	FRONT ROLLING(PM)	COLLAR TOP(PM)
BACK YOKE TOP STITCH(PM)	BACH YOKE JOINT(PM)	COLLAR JOINT(PM)
LABEL ATTACH(PM)	LABEL HOLE ATAACH (PM)	BAND ROLLING(PM)
BOX PLATE(KANSAI)		

Figure 4.1: Sequences showing production flow chart for one production line to manufacture basic shirts.

4.2 DEVELOPING THE MODEL FOR ASSESSING THE PRODUCTIVITY

In this study the DEA technique is applied to evaluate the efficiency of a number of garment producers. A typical statistical approach is characterized as a central tendency approach and it evaluates producers relative to an average producer. In contrast, DEA compares each producer with only the "best producer". In the DEA literature, a producer is usually referred to as a decision making unit (DMU). The production process for each producer is to take a set of inputs and produce a set of outputs. Each producer has a varying level of inputs and gives a varying level of outputs. Each factory has a certain number of workers, a certain square footage of space, and a certain number of managers (the inputs) There are a number of measures of the output, including number of basic shirts, polo shirts, T-shirts, etc. The objective is to determine which industries are most efficient, and to point out the relative efficiencies of the other industries. Throughout the study the term as productive efficiency has been used

A fundamental assumption behind this method is that if a given producer. **A**, is capable of producing **Y (A)** units of output with **X** (A) inputs, then other producers should also be able to do the same if they were to operate efficiently. Similarly, if producer **B** is capable of producing **Y (B)** units of output with **X (B)** inputs, then other producers should also be capable of the same production schedule. Producers A, B and others can then be combined to form a composite producer with composite inputs and composite outputs. Since this composite producer does not necessarily exist, it is typically called a **virtual producer.** The heart of the analysis lies in finding the "best" virtual producer for each real producer. If the virtual producer is better than the original producer by either making more output with the same input or making the same output with less input then the original producer is inefficient. The subtleties of DEA are introduced in the various ways that producers A and B can be scaled up or down and combined.

This study consists of two-step analysis. In the first step, productive efficiency is calculated for a certain period of time using the DEA techniques and in the second step, regression analysis was carried out on a set of firm and firm-specific characteristics that includes age of the workers, sex of the workers, level of satisfactions, qualifications of the workers. labor productivity, capital productivity, social, and economic characteristics of fixed- and variable-input employed on the firm.

4.2.1 Basic Formulations:

Here, different types of models have been discussed in order to determine the productive efficiency for different firms.

Model A:

Table 4.6: Three inputs and one output.

Firm	Input(1) salary	Input(2) Factory cost	Input(3) Employees	Output(1) Production Qty
1	x_{11}	x_{21}	x_{31}	y_{11}
2	x_{12}	x_{22}	x_{32}	y_{12}
3	x_{13}	x_{23}	x_{33}	y_{13}
4	x_{14}	x_{24}	x_{34}	y_{14}
5	x_{15}	x_{25}	x_{35}	y_{15}
6	x_{16}	x_{26}	x_{36}	y_{16}
7	x_{17}	x_{27}	x_{37}	y_{17}
8	x_{18}	x_{28}	x_{38}	y_{18}

Therefore, the **Combined or Overall Productive Efficiency**

$$= \frac{\sum_{r=1}^{1} a_r y_{rj}}{\sum_{i=1}^{3} b_i x_{ij}} \qquad (4.1)$$

where,

x_1 refers to salary and overtime expenses in taka

x_2 refers to factory costs in taka

x_3 refers to number of employees

y_1 refers to output produced in a month in taka

j refers to the number of months, i.e. from January to August

a and b are the common weights given to outputs and inputs respectively.

r refers to the number of outputs

i refers to the number of inputs

Model B:

In the above model it is difficult to justify putting common weights to the inputs and outputs, whereas each factory may value its inputs and outputs differently. This form of equation may be simplified by finding separately the productivity of each of the factory and then obtaining the maximal value among those factories. The mathematical form appears to be as follows:

For factory 1, the Productive Efficiency is = $$\frac{\sum_{r=1}^{1} a_r y_{r1}}{\sum_{i=1}^{3} b_i x_{i1}} \quad (4.2)$$

For factory 2, the Productive Efficiency is = $$\frac{\sum_{r=1}^{1} a_r y_{r2}}{\sum_{i=1}^{3} b_i x_{i2}} \quad (4.3)$$

For factory 3, the Productive Efficiency is = $$\frac{\sum_{r=1}^{1} a_r y_{r3}}{\sum_{i=1}^{3} b_i x_{i3}} \quad (4.4)$$

and so on.

where a, b,x, y, r,i have the usual notations.

Using the above model one can easily determine the maximum value of the productive efficiency among a number of production units.

Model C:

The above ratio form model can further be simplified and to reduce the cumbersome calculation is to set the denominator equal to unity, thus leaving the calculation only to maximize the linear mathematical form of the numerator. The objective now becomes to maximize the weighted output under the condition that virtual output does not exceed the virtual input for any industry.

Mathematically, which can be written as

to maximize the aggregate output $\sum_{r=1}^{1} a_r y_{r1}$

subject to $\sum_{i=1}^{3} b_i x_{i1} = 1$

and $\sum_{r=1}^{1} a_r y_{r1} - \sum_{i=1}^{3} b_i x_{i1} \leq 0$ (4.5)

where, a, b, x, y are non-negative.

Model D:

The main idea behind to maximize the productive efficiency is to decrease the amount of input and still produce the same output, also to increase the output keeping the value of input as before. It is to be noted here that the output slacks will be equal to zero only if $Y\lambda - y_j = 0$ and the input slacks will be equal to zero only if $\theta x_j - X\lambda = 0$.

Considering equation 4.5 as the multiplier form of the linear problem and based on the above concepts of input and output slacks an equivalent envelopment form of this problem can be written as

Min θ

subject to $Y\lambda - y_j \geq 0$

$$\theta x_j - X\lambda \geq 0$$

$$\lambda \geq 0 \quad (4.6)$$

Where θ is a scalar quantity and refers top the value of the efficiency score for the j-th production unit and λ is Nx1 vector of constants. The value obtained will satisfy $\theta \leq 1$, with a value of unity indicating a point on the frontier and hence an efficient production unit. It is mentioned here that the mathematical equation have to be solved N times, one for each unit and the θ is then obtained for each unit. This envelopment form has fewer constants than the multiplier form and hence is easy to solve.

Referring to the same data as shown in the Table 4.2 two simultaneous equations for maximization of inputs and minimization of inputs can be used to solve to find the value of the productive efficiency.

For each firm the following LP formulations are required i.e. for firm 3(say) the equation will be as follow:

Minimize θ

Subject to $-y_3 + (y_{11}\lambda_1 + y_{12}\lambda_2 + y_{13}\lambda_3 + y_{14}\lambda_4 + y_{15}\lambda_5 + y_{16}\lambda_6 + y_{17}\lambda_7 + y_{18}\lambda_8) \geq 0$

$$\theta x_{13} - (x_{11}\lambda_1 + x_{12}\lambda_2 + x_{13}\lambda_3 + x_{14}\lambda_4 + x_{15}\lambda_5 + x_{16}\lambda_6 + x_{17}\lambda_7 + x_{18}\lambda_8) \geq 0$$

$$\theta x_{23} - (x_{21}\lambda_1 + x_{22}\lambda_2 + x_{23}\lambda_3 + x_{24}\lambda_4 + x_{25}\lambda_5 + x_{26}\lambda_6 + x_{27}\lambda_7 + x_{28}\lambda_8)) \geq 0$$

$$\theta x_{13} - (x_{31}\lambda_1 + x_{32}\lambda_2 + x_{33}\lambda_3 + x_{34}\lambda_4 + x_{35}\lambda_5 + x_{36}\lambda_6 + x_{37}\lambda_7 + x_{38}\lambda_8)) \geq 0$$

$$\lambda \geq 0 \qquad (4.7)$$

There are two variations in analyzing the above situations. One is the constant return to scale and other is the variable return to scale. Constant Return to Scale or CRS assumption is only appropriate when all firms are operating at an optimal scale. Imperfect competition, constraint on finance, etc, may cause a firm to be not operating at optimal scale. At this stage an important consideration is needed to be given emphasis, i.e. about the input or output orientation. In input oriented models the aim or process is to seek to identify productive inefficiency as a proportional reduction in input usage, while satisfying the given level of output. It is also possible to measure productive inefficiency as a proportional increase in output production. The two measures provide the same value under constraint return to scale. Actually, the selection of orientation essentially lies on the judicious choice of the input or output over which the manager's most control over. One point that should be stressed is that the output and input-oriented models will estimate exactly the same frontier and therefore by definition identify the same set of firms as being efficient.

Model E:

The input oriented approach considers the possible and proportional input reductions while maintaining the current level of outputs. On the other hand output oriented approach considers the possible and proportional increase in outputs at the same time maintaining the current level of inputs. Thus an additive model can be useful where reduction of the values of output slacks and simultaneously increasing the values of the input slacks can be performed together.

With user specified input weight w_i^+ and w_o^- a formula is devised by Ali et el.[3] in the following form:

$$\max \sum_{i=1}^{m} w_i^- s_i^- + \sum_{r=1}^{s} w_r^+ s_r^+ \tag{4.8}$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io} \qquad i= 1,2.\text{-------------},m;$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro} \qquad r= 1,2,\text{-------------},s;$$

$$\lambda_j, s_i^-, s_r^+ \geq 0$$

4.3 FURTHER EXTENSIONS IN TERMS OF GROWTH ESTIMATION AND SCALE EFFICIENCY.

4.3.1 Growth Estimation

After having the values of productive efficiencies in hand one might BE interested to calculate the changes i.e. growth/decay of the productivity of the firms under consideration. Due to its inherent advantages, i.e. similar to DEA techniques the Malmquist total factor productivity (TFP) indexes has been found to be a suitable tool for evaluation. The index is based on the concept of distance functions, which provide a very general description of the technology. Malmquist productivity index allows decomposition of estimated productivity growth into technological change and efficiency improvement with further decomposition of the latter component into technical efficiency and scale efficiency components. Grosskopf characterizes productivity growth as "the net change in output due to change in efficiency and technical change, where the former is understood to be the change in how far an observation is from the frontier of technology and the latter is understood to be shifts in the production frontier".

Given the fact that the output distance function is the reciprocal of the Farrell output-based measure of technical efficiency, the output distance function is computed for each farm k' at time t under the assumption of CRS, given the production possibility set St, as a solution to the following linear programming problem:

$$(D_o^t(x^{k',t}, y^{k',t}))^{-1} = \text{Maximize } \theta k \tag{4.9}$$

$$\text{subject to } \theta k \; y_m^{k',t} \leq \sum_{k=1}^{K} \lambda^{k,t} y_m^{k,t}$$

$$\sum_{k=1}^{K} \lambda^{k,t} y_m^{k,t} \leq x_n^{k',t} \quad \lambda^{k,t} \geq 0$$

which is identical to BCC model and follows that θk' is the DEA measurement of the $D_o^t(x^t, y^t)$. Caves et al. (1982) define an output-based Malmquist productivity index with reference technology in time period t as

$$M_0^t = \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \tag{4.10}$$

and an output-based Malmquist productivity index with reference technology in time period t+1 as

$$M_0^{t+1} = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \tag{4.11}$$

To calculate the change in productivity for two different time periods due to the upward shift in the production frontier and/or change in the technology Faré et. al specifies the modified Malmquist productivity index as follows:

$$\text{Productivity change}\ (y^{t+1},x^{t+1};y^{t},xt) = \left[\frac{D_o^{t}(x^{t+1},y^{t+1})}{D_o^{t}(x^{t},y^{t})} \times \frac{D_o^{t+1}(x^{t+1},y^{t+1})}{D_o^{t+1}(x^{t},y^{t})}\right]^{1/2} \qquad (4.12)$$

which represents the productivity of the production point(xt+1,yt+1) relative to the production point (x^t,y^t). A value greater than unity indicate positive growth from period t to t+1. This index is basically the geometric mean of the two output based Malmquist TFP indices. One index uses period t technology and the other period t+1 technology. To calculate the above equation we have to calculate four LP problems.

The CRS output oriented LP used to calculate $D_o^{t}(x^t,y^t)$ is calculated as follows:

$$D_o^{t}(x^t,y^t) = \max \theta \qquad (4.13)$$

subject to $-\theta y_i^t + Y_t\lambda \geq 0\ ;\ x_i^t - X_t\lambda \geq 0\ ;\ \lambda \geq 0$

Like productivity estimation there are also two approaches for measurement of productivity changes between the two consecutive periods of time. One is parametric and the other is non-parametric. In this chapter it is concentrated on the same principle of avoiding the cumbersome statistical/functional relationship between the inputs and outputs of the production quantities.

Basically, there are three different indices available for evaluating the technological changes: the Fischer [1922], Tornqvist [1936], and Malmquist [1953] indexes. According to and Grifell-Tatjé Lovell [1996], the Malmquist index has three main advantages relative to the Fischer and Tornqvist indexes. First, it does not require the profit maximization. or cost minimization, assumption. Second, it does not require information on the input and output prices. Also, if there are panel data, it allows the decomposition of productivity changes into two components (technical efficiency change, or catching up, and technical change. or changes in the best practice). The necessity to compute distance functions is being solved by applying the data envelopment analysis.(DEA) technique.

4.3.2 Scale efficiency

The nature of return to scale i.e. increasing, decreasing or constant can be found by calculating the scale efficiency. Scale Efficiency refers to the amount by which productivity can be increased by moving to the most productive scale size. The concept is useful when there are multiple optima and does not require information on weight age values μ, v, or λ

Mathematically this can be written as

$$\textbf{Scale Efficiency} = \frac{\theta^*_{CCR}}{\theta^*_{BCC}} \quad (4.14)$$

The above formula can be further modified when the two concepts are incorporated as follows. When a unit is operating as BCC efficient with constant returns to scale i.e in the most productive scale size, its scale efficiency is unity. This constant return to scale efficiency score is called the global efficiency, since it takes no account of scale effect as distinguished from pure technical efficiency under variable returns to scale. Using the above concepts, the scale efficiency relationship demonstrate a decomposition of efficiency as

Global Efficiency = Pure Technical Efficiency x Scale Efficiency

In abbreviated form this can be written as

$$\textbf{GE = PTE X SE} \quad (4.15)$$

This decomposition depicts the sources of inefficiency. i.e. whether it is caused by inefficient operations PTE or by disadvantageous conditions displaced by scale efficiency or by both.

4.3.3 Input and Output Stability Region.

Two paths may be followed in treating returns to scale (RTS) in DEA. The first path, developed by Färe et el [30] determines RTS by a use of ratios of radial measures. These ratios are developed from model pairs which differ only in whether conditions of convexity and sub-convexity are satisfied. The second path stems from work by Banker et el[7]. This path, includes, but is not restricted to, radial measure models. It extends to additive and multiplicative models as well. and does so in ways that provide opportunities for added insight into the nature of RTS and its treatment by the methods and concepts of DEA. As per the concept of most productive scale size developed by Banker[7] linear programming models can be designed to set the scale efficient input or output targets Zhu [127].

$$\text{Min} \sum_{j=1}^{n} \lambda_j \tag{4.16}$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le \theta^* x_{i0} \qquad i=1,1,\text{----------}m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{r0} \qquad r=1,2,\text{----------}s$$

$$\lambda_j \ge 0 \qquad j=1,2,\text{----------}n$$

where θ^* is the input -oriented CRS efficiency score.

Based upon the optimal values from the above equation i.e. $\sum \lambda_j{}^*$ the MPSS concept yields the following scale- efficient target for DMU_0 corresponding to the largest

$$MPSS_{max} : \begin{cases} \tilde{x}_{i0} = \theta^* x_{i0} / \sum \lambda_j^* \\ \tilde{y}_{r0} = y_{r0} / \sum \lambda_j^* \end{cases}$$ where ~ represents the target value.

If we change the minimization objective to a case of maximization the objective changes to

$$\text{Max} \sum_{j=1}^{n} \lambda_j \qquad (4.17)$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le \theta^* x_{i0} \qquad i=1, 1, \text{----------} m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{r0} \qquad r=1, 2, \text{-----------} s$$

$\lambda_j \ge 0$ j= 1,2,-----------n

Then we have the scale efficient target corresponding to the smallest MPSS

$$MPSS_{min} : \begin{cases} \tilde{x}_{i0} = \theta^* x_{i0} / \sum \lambda_j^* \\ \tilde{y}_{r0} = y_{r0} / \sum \lambda_j^* \end{cases} \qquad (4.18)$$

The above form of input oriented can be changed to calculate the model for output oriented also.

4.3.4 Capacity Utilization in terms of optimum number of production lines.

In order to address the optimum space utilization criteria first of all we have to think about fixing the number of production lines in the existing floor space based on the production output per day. The management usually thinks or plans to set up the production lines based on the number of quantities to be produced and /or number of workers available for utilizing them for production.

We are of the opinion that based on the factory cost the number of production lines are needed to be fix up

Total Expense for any factory = Direct Labor Cost + Factory Overhead+ Administrative Overhead cost

Total Expected earning =Total Expense+30 %(say) expected profit*Total Expense=B

Total Production Line (say) = C (say);

Working day= 26 days per month

Therefore, Earning Per Line Day = B/ (26*C) (4.19)

4.3.5 Style of products in terms of Standard Allowable Minutes

Factory Efficiency based on SAM:

$$\text{Factory efficiency} = \frac{\text{Actual Output}}{\text{Targeted Output}}$$

$$= \frac{\text{Actual production rate per hour}}{\text{At 100\% efficiency, production rate per hour}}$$

At 100% efficiency, Production rate per hour

=Available machine minute/SAM

=Number of machines*60/SAM(4.20) (4.20)

To get a particular style of product order from the buyer, it is essential to analyze the production cost of that particular product. In doing so the SAM is calculated in the pre-production meeting held with production people in the factory premises. SAM is basically the time needed to produce that particular type of garments. The overall process of production is to break down into its individual components and then time is calculated to derive the total time needed to complete the product. An example may be as follows:

Table 4.7: SAM Calculation.

Sl #	Name of the Operations	Time needed to complete the work (Minute)
1.	Shoulder Att	T_1
2.	Neck Binding Att	T_2
3.	Armhole Binding Att	T_3
4.	Side Seam	T_4
5.	Bottom Hem	T_5
6.	Tack at Arm hole, Shoulder	T_6
	Total Time (SAM)	$(T_1+T_2+T_3+T_4+T_5+T_6)$

There are also other ways to calculate the factory efficiency based on the value obtained from work sampling procedure as follows:

$$\text{Factory Efficiency} = \frac{\text{Total number of working observed}}{\text{Total number of observations}} \times 100\% \qquad (4.21)$$

Where, Total number of observations= Total Observations - number of idle time-Workers not in position.

4.4 SOURCES OF INEFFICIENCY

In order to calculate the sources of productive inefficiency, output and input efficiency indexes obtained using DEA can be separately regressed on firm specific characteristics in order to identify sources of inefficiency in the utilization of input resources and maximization of outputs respectively. Among those the prominent factors which appear to be needed in order to improve the productivity of any firm the following parameters has been identified those which might be responsible for positively or negatively affecting it.

Based on the discussion with the factory people a number of factors listed below assumed to be affecting the productive efficiency as potential ones:

1. Floor space utilized in the production process.
2. No. of workers employed.
3. Age of the workers
4. Sex of the workers
5. Productive rating or skill-ness of the workers
6. Absenteeism
7. Labor Turnover
8. No. of machines used in the production process
9. Age of the plant
10. SAM of individual designs
11. Experiences of the Manager
12. Experiences of the workers.
13. Factory Conditions.
14. Family conditions of the workers.
15. Level of satisfactions of the workers.
16. Workload of the individual workers.
17. Compensation package of the workers.
18. Training needs.
19. Mode of learning skills and techniques.
20. Owners style of leadership
21. Size of the enterprise.

It is to be mention here that for any apparel industry size is measured in three ways:

1. the total output in terms of number of pieces produced or the value in taka of the output produced
2. the total number of manpower employed.
3. the number of machines utilized.

Because efficiency measures range between 0 and 1, it is better to employ a two-tailed Tobit model in place of OLS regression.

The Tobit model takes the following form:

$$\text{Efficiency Index} = \beta X_k + U_k; \qquad (4.22)$$

Where the efficiency index is obtained from DEA, β is a vector of unknown parameters, vector X contains independent variables hypothesized to be correlated with efficiency, and U is an error term that is independently and normally distributed with mean zero and common variance σ.

The Tobit Model is an econometric, biometric model proposed by James Tobin to describe the relationship between a non-negative dependent variable y_i and an independent variable (or vector) x_i The model supposes that there is a latent (i.e. unobservable) variable y_i^*. This variable linearly depends on x_i via a parameter (vector) β which determines the relationship between the independent variable (or vector) x_i and the latent variable y (just as in a linear model).

In addition, there is a normally distributed error term u_i to capture random influences on this relationship. The observable variable y_i is defined to be equal to the latent variable whenever the latent variable is above zero and zero otherwise.

$$Y = \begin{cases} y_i^* \text{ if } y_i^* > 0 \\ 0 \text{ if } y_i^* \leq 0 \end{cases} \quad (4.23)$$

where y_i^* is a latent variable · $y_i^* = \beta x_i + u_i$

CHAPTER V

ESTIMATION OF PRODUCTIVE EFFICIENCY

5.1 WINDOW ANALYSIS FOR 12 MONTH PERIOD.

The analysis was carried out based in four types of models:

a) Constant Returns to Scale and Input Orientation.
b) Constant Returns to Scale and Output Orientation.
c) Variable Returns to Scale and Input Orientation.
d) Variable Returns to Scale and Output Orientation.

Productive Efficiency Scores, Ranking and References. slacks, graphical presentations of efficiency scores and overall projections for each type are calculated. These calculations are carried out using the software developed by Coopers, Seiford and Tone [20].

The software runs in the Excel worksheet. In the first column there should be the name of the DMU and the successive columns will contain the input and output quantities respectively. To identify the inputs and outputs every input should be marked as I and every output should be marked as O within the parenthesis. A data set should be bordered by at least one blank column at right and at least one blank row at the bottom. This is necessary for knowing the scope of the data domain. The data set should start from the top-left cell (A1). A preferable sheet name is "DAT" (not Sheet 1). It should be noted here that Score, Rank, Projection, Weight, WeightedData, Slack, RTS, Window, Graph1, Graph2 should not be used because these are reserved for the software.

The values of three input quantities are further combined to make it one input. With this single input and single output the efficient frontier is drawn.

For the efficient months the values of slacks are found to be zero. From the values of slacks it can also be seen that except for the month April and May, most of the values has come to a zero values. In order to address the above issue the weight restrictions and value judgment concepts are introduced and discussed in Chapter X.

The data were collected for a period from January to December for a particular factory to carry out window analysis in order to evaluate the relative productive efficiencies of these eight months. Three inputs and one output were chosen for determining the productive efficiency. The data set is shown in the Table 5.1, the Input and Output statistics and the correlation matrix are shown in the Table 5.2 and Table 5.3 respectively.

Table 5.1: Data set for twelve months.

Sl #	Months	Inputs			Output
		(I) Salary and overtime expenses in taka	(I) Factory cost in taka	(I) No. of Employees	(O) Production Qty in pieces
1	January	1841091	2629881	520	900050
2	February	1897942	2625892	528	850002
3	March	1867703	2658963	523	880500
4	April	1804071	2625101	516	880005
5	May	1884775	2636582	527	850000
6	June	1836728	2653422	524	880005
7	July	1898292	2630301	529	980000
8	August	1839901	2614431	525	900088
9	September	1892231	2658972	527	998000
10	October	1800012	2670322	513	905600
11	November	1852061	2602561	524	950888
12	December	1848022	2635862	520	945862

Table 5.2: Input –Output Statistics of twelve months.

	Salary in taka	Factory cost in taka	No. of Employees	Production Qty in pieces
Max	1898292	2670322	529	998000
Min	1800012	2602561	513	850000
Average	1855236	2636858	523	910083
SD	32380.15	19153.64	4.70	46267

Table 5.3: Correlations.

	Salary in taka	Factory cost in taka	No. of Employees	Production Qty in pieces
Salary	1	-0.088	0.907	0.211
Factory cost	-0.088	1	-0.275	0.006
Employees	0.907	-0.275	1	0.152
Production Qty	0.211	0.006	0.152	1

5.1.1 Analysis: Constant return to scale and Input oriented model (CCR –I).

The productive efficiency and the ranking values of twelve month period have been calculated and shown in Table 5.3. It can be seen that the productive efficiency (PE) scores of only one month i.e. September is found to have the maximum value of unity. This month's PE lies in the frontier and the rest lies beyond the frontier. Thus there exists a scope for the rest of the months to increase their productivity either by increasing the output quantity or by lowering the values of their one or more input quantity(s), where the values of input and output slacks shown to be lower or to increase with respect to month September. It is to be noted that the score of the six months i.e. January, July, August, October, November and December are very close to the unity and therefore will lye on the efficient frontier.

Table 5.4: PE Scores and Ranking (CCR-I).

No.	Month	Scores	Ranking	Proposed Wt.	
1	January	0.927	7	September	0.902
2	February	0.862	11	September	0.852
3	March	0.894	10	September	0.882
4	April	0.925	8	September	0.882
5	May	0.859	12	September	0.852
6	June	0.908	9	September	0.882
7	July	0.993	2	September	0.982
8	August	0.928	6	September	0.902
9	September	1.000	1	September	1.000
10	October	0.954	5	September	0.907
11	November	0.973	3	September	0.953
12	December	0.970	4	September	0.948

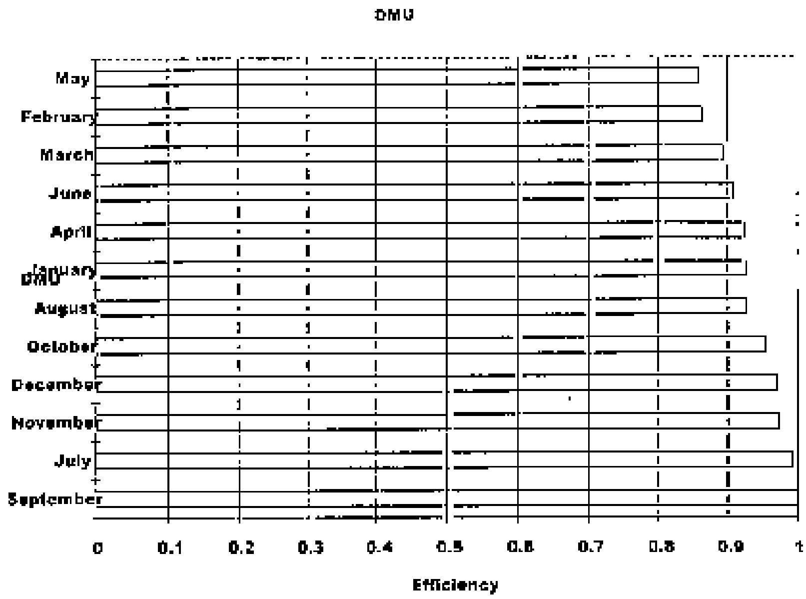


Figure 5.1: PE scores-month wise in ascending order (CCR-I).

Table 5.5: Various Projections (CCR-I).

No.	Months	Scores			
	I/O	Data	Projections	Difference	%
1	January	0.927			
	Salary	1841091	1706516	-134575	-7.31
	Factory cost	2629881	2398004	-231877	-8.82
	Employees	520	475	-45	-8.60
	Production Qty	900050	900050	0	0
2	February	0.862			
	Salary	1897942	1611623	-286319	-15
	Factory cost	2625892	2264661	-361231	-13.76
	Employees	528	449	-79	-14.99
	Production Qty	850002	850002	0	0
3	March	0.894			
	Salary	1867703	1669448	-198255	-10.61
	Factory cost	2658963	2345917	-313046	-11.77
	Employees	523	465	-58	-11.10
	Production Qty	880500	880500	0	0
4	April	0.925			
	Salary	1804071	1668510	-135561	-7.51
	Factory cost	2625101	2344598	-280503	-10.69
	Employees	516	465	-51	-9.94
	Production Qty	880005	880005	0	0
5	May	0.859			
	Salary	1884775	1611620	-273155	-14.49
	Factory cost	2636582	2264656	-371926	-14.11
	Employees	527	449	-78	-14.83
	Production Qty	850000	850000	0	0

6	June	0.908			
	Salary	1836728	1668510	-168218	-9.16
	Factory cost	2653422	2344598	-308824	-11.64
	Employees	524	465	-59	-11 32
	Production Qty	880005	880005	0	0
7	July	0.993			
	Salary	1898292	1858103	-40189	-2.12
	Factory cost	2630301	2611015	-19286	-0.73
	Employees	529	518	-11	-2.17
	Production Qty	980000	980000	0	0
8	August	0.928	.		
	Salary	1839901	1706588	-133313	-7.25
	Factory cost	2614431	2398105	-216326	-8.27
	Employees	525	475	-50	-9.47
	Production Qty	900088	900088	0	0
9	September	1			
	Salary	1892231	1892231	0	0
	Factory cost	2658972	2658972	0	0
	Employees	527	527	0	0
	Production Qty	998000	998000	0	0
10	October	0.954			
	Salary	1800012	1717038	-82973.5	-4.61
	Factory cost	2670322	2412791	-257531	-9.64
	Employees	513	478	-35	-6.78
	Production Qty	905600	905600	0	0
11	November	0.973			
	Salary	1852061	1802906	-49155.4	-2.65
	Factory cost	2602561	2533451	-69109.5	-2.66
	Employees	524	502.1222	-21.8778	-4.18
	Production Qty	950888	950888	0	0
12	December	0.970			
	Salary	1848022	1793376	-54645.8	-2.96
	Factory cost	2635862	2520061	-115801	-4.39
	Employees	520	500	-20	-3.95
	Production Qty	945862	945862	0	0

Table 5.6: Slacks (CCR-I).

No.	Months	Scores	Excess Salary	Excess Factory cost	Excess Employees	Shortage Production Qty
			S-(1)	S-(2)	S-(3)	S+(1)
1	January	0.927	0	39645	7	0
2	February	0.862	25228	0	7	0
3	March	0.894	0	30800	3	0
4	April	0.925	0	83248	13	0
5	May	0.859	7282	0	4	0

6	June	0 908	0	65808	11	0
7	July	0.993	26270	0	8	0
8	August	0.928	0	26893	12	0
9	September	1.000	0	0	0	0
10	October	0.954	0	134440	11	0
11	November	0.973	0	35	8	0
12	December	0 970	0	37859	5	0

5.1.2 Analysis: Constant Return to Scale and Output oriented model (CCR –O).

The twelve month data set has now been used to calculate using the constant return to scale and input oriented model. From the Table 5.7 it can be seen that similar results have been found like that of input oriented cases. But the projected values found to differ in both the model as can be seen from Table 5.8.

Table 5.7: PE Scores and the Ranking (CCR-O).

No.	DMU	Score	Rank	Proposed Wt.	
1	January	0.926	7	September	0.973
2	February	0.862	11	September	0.988
3	March	0.893	10	September	0.987
4	April	0.924	8	September	0.953
5	May	0.858	12	September	0.992
6	June	0.908	9	September	0.971
7	July	0.992	2	September	0.989
8	August	0.927	6	September	0.972
9	September	1.000	1	September	1.000
10	October	0.953	5	September	0.951
11	November	0.973	3	September	0.979
12	December	0.970	4	September	0.977

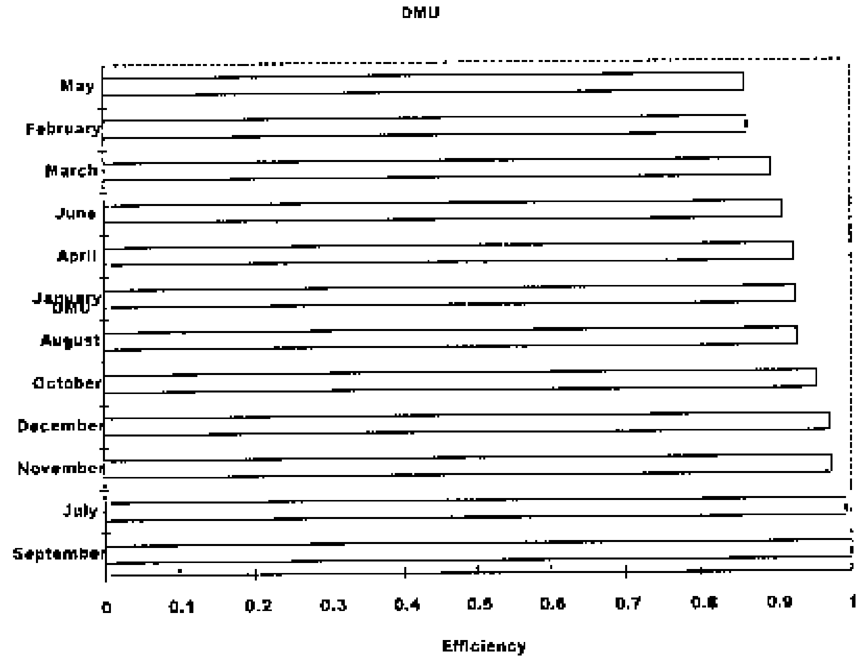


Figure 5.2: PE scores-month wise in ascending order (CCR-O).

Table 5.8: Various Projections (CCR-O).

No.	Months	1/Scores			
	I/O	Data	Projection	Difference	%
1	January	1.078			
	Salary	1841091	1841091	0	0
	Factory cost	2629881	2587109.829	-42771.171	-1.63
	Employees	520	512	-8	-1.39
	Production Qty	900050	971028	70978	7.89
2	February	1.159			
	Salary	1897942	1868690	-29252	-1.54
	Factory cost	2625892	2625892	0	0
	Employees	528	520	-7	-1.43
	Production Qty	850002	985584	135582	15.95
3	March	1.118			
	Salary	1867703	1867703	0	0
	Factory cost	2658963	2624505	-34458	-1.30
	Employees	523	520	-3	-0.54
	Production Qty	880500	985063	104563	11.88
4	April	1.081			
	Salary	1804071	1804071	0	0
	Factory cost	2625101	2535089	-90012	-3.43

	Employees	516	502	-13	-2.63
	Production Qty	880005	951503	71498	8.12
5	May	1.164			
	Salary	1884775	1876297	-8478	-0.45
	Factory cost	2636582	2636582	0	0
	Employees	527	522	-4	-0.84
	Production Qty	850000	989596	139596	16.42
6	June	1 100			
	Salary	1836728	1836728	0	0
	Factory cost	2653422	2580979	-72443	-2 73
	Employees	524	511	-12	-2.38
	Production Qty	880005	968727	88722	10.08
7	July	1.007			
	Salary	1898292	1871828	-26464	-1.39
	Factory cost	2630301	2630301	0	0
	Employees	529	521	-8	-1.45
	Production Qty	980000	987239	7239	0.74
8	August	1.078			
	Salary	1839901	1839901	0	0
	Factory cost	2614431	2585438	-28993	-1.11
	Employees	525	512	-13	-2.40
	Production Qty	900088	970400	70312	7.81
9	September	1			
	Salary	1892231	1892231	0	0
	Factory cost	2658972	2658972	0	0
	Employees	527	527	0	0
	Production Qty	998000	998000	0	0
10	October	1.048			
	Salary	1800012	1800012	0	0
	Factory cost	2670322	2529385	-140937	-5.28
	Employees	513	501	-12	-2.28
	Production Qty	905600	949362	43762	4.83
11	November	1.027			
	Salary	1852061	1852061	0	0
	Factory cost	2602561	2602525	-36	0
	Employees	524	515.8123649	-8	-1.56
	Production Qty	950888	976813	25926	2.73

12	December	1.030			
	Salary	1848022	1848022	0	0
	Factory cost	2635862	2596849	-39013	-1.48
	Employees	520	515	-5	-1.02
	Production Qty	945862	974683	28821	3.05

Table 5.9: Slacks (CCR-O).

No.	Months	Score	Excess Salary	Excess Factory cost	Excess Employees	Shortage Production Qty
			S-(1)	S-(2)	S-(3)	S+(1)
1	January	0.927	0	42771	7	0
2	February	0.862	29252	0	8	0
3	March	0.894	0	34458	3	0
4	April	0.925	0	90012	14	0
5	May	0.859	8478	0	4	0
6	June	0.908	0	72443	12	0
7	July	0.993	26464	0	8	0
8	August	0.928	0	28993	13	0
9	September	1.000	0	0	0	0
10	October	0.954	0	140937	12	0
11	November	0.973	0	36	8	0
12	December	0.970	0	39013	5	0

5.1.3 Analysis: Variable returns to scale and input oriented model (BCC –I).

The twelve month data set has been used to calculate PE scores. As can be seen from Table 5.10 the month April, July, September, October, November and December came out to be efficient production months. Unlike constant returns to scale here the efficient months have been found to be more than one. Various projections have also been found to be different from constant returns to scale as shown in Table 5.11 and also the slacks values can be seen from Table 5.12.

Table 5.10: PE Scores and Ranking (BCC-I).

No.	Months	Score	Rank	Proposed Wt.	
1	January	0.996	8	April	0.699
2	February	0.992	9	April	0.055
3	March	0.987	12	April	0.973
4	April	1.000	1	April	1.000
5	May	0.990	10	April	0.304
6	June	0.988	11	April	0.807
7	July	1.000	1	July	1.000
8	August	0.998	7	April	0.321
9	September	1	1	September	1.000
10	October	1	1	October	1.000
11	November	1	1	November	1.000
12	December	1	1	December	1.000

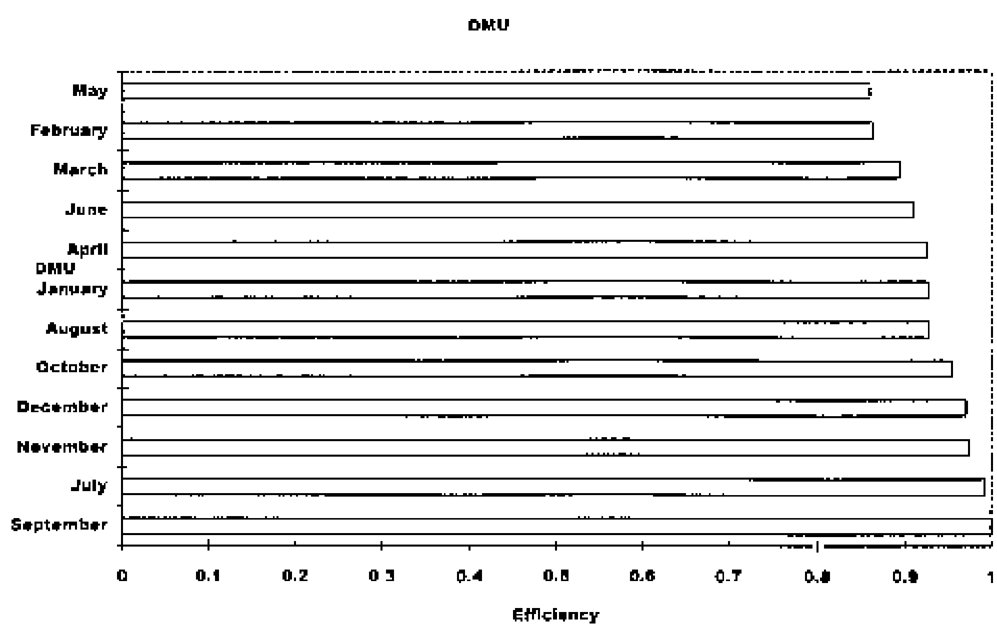


Figure 5.3: PE scores-month wise in ascending order (BCC-I).

Table 5.11: Various Projections (BCC-I).

No.	Months	1/Scores			
	I/O	Data	Projection	Difference	%
1	January	1.00			
	Salary	1841091	1817019	-24072	-1.31
	Factory cost	2629881	2620221	-9660	-0.37
	Employees	520	518	-2	-0.37
	Production Qty	900050	900050	0	0
2	February	0.99			
	Salary	1897942	1849395	-48547	-2.56
	Factory cost	2625892	2603778	-22114	-0.84
	Employees	528	524	-4	-0.84
	Production Qty	850002	946969	96967	11 41
3	March	0.99			
	Salary	1867703	1805364	-62339	-3.34
	Factory cost	2658963	2624459	-34504	-1.30
	Employees	523	516	-7	-1.30
	Production Qty	880500	881932	1432	0.16
4	April	1.00			
	Salary	1804071	1804071	0	0
	Factory cost	2625101	2625101	0	0
	Employees	516	516	0	0
	Production Qty	880005	880005	0	0
5	May	0.99			
	Salary	1884775	1837459	-47315	-2.51
	Factory cost	2636582	2609384	-27198	-1.03
	Employees	527	522	-5	-1.03
	Production Qty	850000	929339	79339	9.33
6	June	0.99			
	Salary	1836728	1813331	-23397	-1.27
	Factory cost	2653422	2620717	-32705	-1.23
	Employees	524	518	-6	-1.23
	Production Qty	880005	893700	13695	1.56
7	July	1.00			
	Salary	1898292	1898292	0	0
	Factory cost	2630301	2630301	0	0
	Employees	529	529	0	0
	Production Qty	980000	980000	0	0
8	August	1.00			
	Salary	1839901	1836625	-3276	-0.18
	Factory cost	2614431	2609776	-4655	-0.18

	Employees	525	521	-4	-0.68
	Production Qty	900088	928107	28019	3.11
9	September	1.00			
	Salary	1892231	1892231	0	0
	Factory cost	2658972	2658972	0	0
	Employees	527	527	0	0
	Production Qty	998000	998000	0	0
10	October	1.00			
	Salary	1800012	1800012	0	0
	Factory cost	2670322	2670322	0	0
	Employees	513	513	0	0
	Production Qty	905600	905600	0	0
11	November	1.00			
	Salary	1852061	1852061	0	0
	Factory cost	2602561	2602561	0	0
	Employees	524	524	0	0
	Production Qty	950888	950888	0	0
12	December	1.00			
	Salary	1848022	1848022	0	0
	Factory cost	2635862	2635862	0	0
	Employees	520	520	0	0
	Production Qty	945862	945862	0	0

Table 5.12: Slacks (BCC-I).

No.	Month Name	Score	Excess Salary	Excess Factory cost	Excess Employees	Shortage Production Qty
			S-(1)	S-(2)	S-(3)	S+(1)
1	January	0.927	0	42771	7	0
2	February	0.862	29252	0	8	0
3	March	0.894	0	34458	3	0
4	April	0.925	0	90012	14	0
5	May	0.859	8478	0	4	0
6	June	0.908	0	72443	12	0
7	July	0.993	26464	0	8	0
8	August	0.928	0	28993	13	0
9	September	1.000	0	0	0	0
10	October	0.954	0	140937	12	0
11	November	0.973	0	36	8	0
12	December	0.970	0	39013	5	0

5.1.4 Analysis: Variable returns to scale and Input oriented model (BCC –O).

In the following analysis using variable returns to scale and output oriented scale model has been used to calculate to find the productive Efficiency scores. The results of the PE obtained are very much similar to the PE values those obtained after running the variable returns to scale model as shown in Table 5.13 But the projected values as shown in Table 5.14 and slack values as shown in Table 5.15 found to vary significantly.

Table 5.13: PE Scores and Ranking (BCC-O).

No.	Months	Scores	Ranking	Proposed Wt.	
1.	January	0.959	8	October	0.248
2.	February	0.872	11	July	0.784
3.	March	0.907	10	September	0.659
4.	April	1.000	1	April	1.000
5.	May	0.866	12	July	0.321
6	June	0.935	9	September	0.285
7.	July	1.000	1	July	1.000
8.	August	0.960	7	April	0.098
9.	September	1.000	1	September	1.000
10.	October	1.000	1	October	1.000
11.	November	1.000	1	November	1.000
12	December	1.000	1	December	1.000

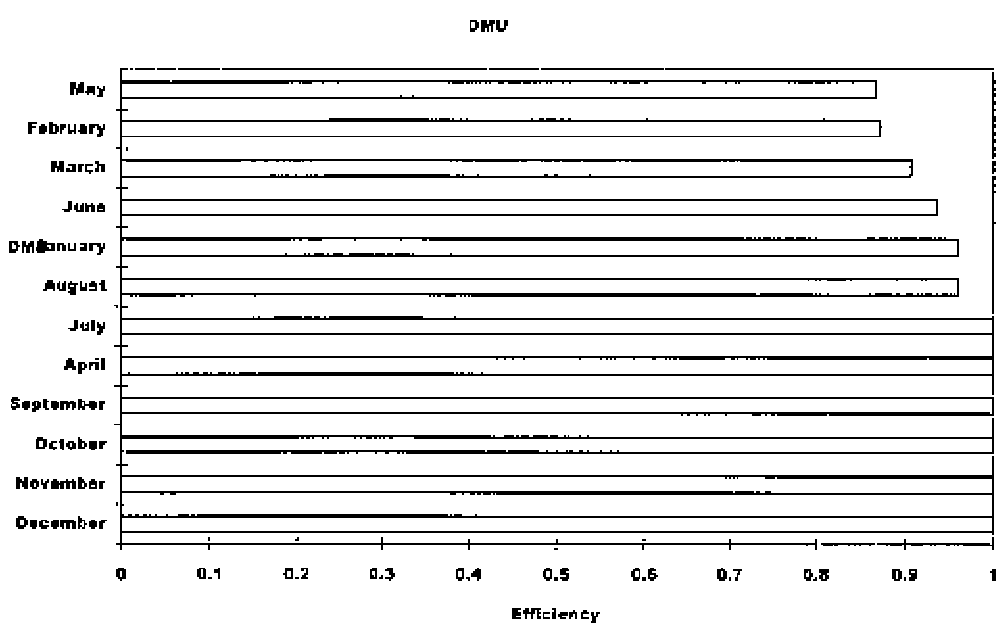


Figure 5.4: PE scores-month wise in ascending order (BCC-O).

Table 5.14: Various Projections (BCC-O).

No.	Months	1/Scores			
	I/O	Data	Projection	Difference	%
1	January	1			
	Salary	1841091	1837847	-3244	0
	Factory cost	2629881	2629881	0	0
	Employees	520	520	0	0
	Production Qty	900050	938049	37999	0
2	February	1			
	Salary	1897942	1889431	-8511	0
	Factory cost	2625892	2625892	0	0
	Employees	528	528	0	0
	Production Qty	850002	975045	125043	0.147
3	March	1			
	Salary	1867703	1866111	-1592	-0.001
	Factory cost	2658963	2658963	0	0
	Employees	523	523	0	0
	Production Qty	880500	970960	90460	0.103
4	April	1			
	Salary	1804071	1804071	0	0
	Factory cost	2625101	2625101	0	0
	Employees	516	516	0	0
	Production Qty	880005	880005	0	0
5	May	1			
	Salary	1884775	1884775	0	0
	Factory cost	2636582	2636582	0	0
	Employees	527	527	-0.065	0
	Production Qty	850000	981219	131218.772	0.154
6	June	1			
	Salary	1836728	1836728	0	0
	Factory cost	2653422	2653422	0	0
	Employees	524	519	-5	0.009
	Production Qty	880005	941015	61010	0.069
7	July	1			
	Salary	1898292	1898267	-25	0
	Factory cost	2630301	2630301	0	0
	Employees	529	529	0	0
	Production Qty	980000	980000	0	0
8	August	1			
	Salary	1839901	1839901	0	0
	Factory cost	2614431	2614431	0	0
	Employees	525	522	-3	0
	Production Qty	900088	937462	37374	0
9	September	1			
	Salary	1892231	1892231	0	0
	Factory cost	2658972	2658972	0	0
	Employees	527	527	0	0

	Production Qty	998000	998000	0	0
10	October	1			
	Salary	1800012	1800012	0	0
	Factory cost	2670322	2670293	-29	0
	Employees	513	513	0	0
	Production Qty	905600	905600	0	0
11	November	1			
	Salary	1852061	1852061	0	0
	Factory cost	2602561	2602561	0	0
	Employees	524	524	0	0
	Production Qty	950888	950888	0	0
12	December	1			
	Salary	1848022	1848022	0	0
	Factory cost	2635862	2635862	0	0
	Employees	520	520	0	0
	Production Qty	945862	945862	0	0

It can be seen from the following table the months April, September, October, November and December have zero slacks and thereby can be termed as efficient months lying on the frontier

Table 5.15: Slacks (BCC-O).

Sl #	Months	Scores	Excess Salary S-(1)	Excess Factory cost S-(2)	Excess Employees S-(3)	Shortage Production Qty S+(1)
1	January	0.959	3244.03	0	0	0
2	February	0.872	8511.16	0	0	0
3	March	0.907	1591.83	0	0	0
4	April	1.000	0	0	0	0
5	May	0.866	0	0	0	0
6	June	0.935	0	0	5	0
7	July	1.000	24.54	0	0	0
8	August	0.960	0	0	3	0
9	September	1	0	0	0	0
10	October	1	0	28.92	0	0
11	November	1	0	0	0	0
12	December	1	0	0	0	0

In order to draw the efficient frontier in a 2-D plane the salary and overtime expenses have been added with the factory cost to find the total cost for twelve month period as shown in Table 5.16 Now these values have been further modified to find total cost per number of employees and production quantity per number of employees as shown in Table 5.17.

Table 5.16: Input and Output data set for twelve months.

Months	Total Cost in taka	No. of Employees	Production Qty. in pieces
January	4470972	520	900050
February	4523834	528	850002
March	4526666	523	880500
April	4429172	516	880005
May	4521357	527	850000
June	4490150	524	880005
July	4528593	529	980000
August	4454332	525	900088
September	4551203	527	998000
October	4470334	513	905600
November	4454622	524	950888
December	4483884	520	945862

Table 5.17: Data converted to single input and single output.

Months	Output/Cost	Output/Employees
1	0.20	1731
2	0.19	1610
3	0.19	1684
4	0.20	1705
5	0.19	1613
6	0.20	1679
7	0.22	1853
8	0.20	1714
9	0.22	1894
10	0.20	1765
11	0.21	1815
12	0.21	1819

By plotting the values of output/Employee in the abscissa and the values of Output/ total cost in the ordinate a scattered-diagram has been found as shown in the Figure 5.5. The slope of the line connecting each point with the origin represents the ratio between output/employee and output/cost. The highest value among all the points is the month September The line connecting the origin and the month of September is the efficient frontier for this set of data. It is to be noted here that this frontier touches only one pint and the rest lies below this line. According to the property of DEA this frontier envelops all the points.

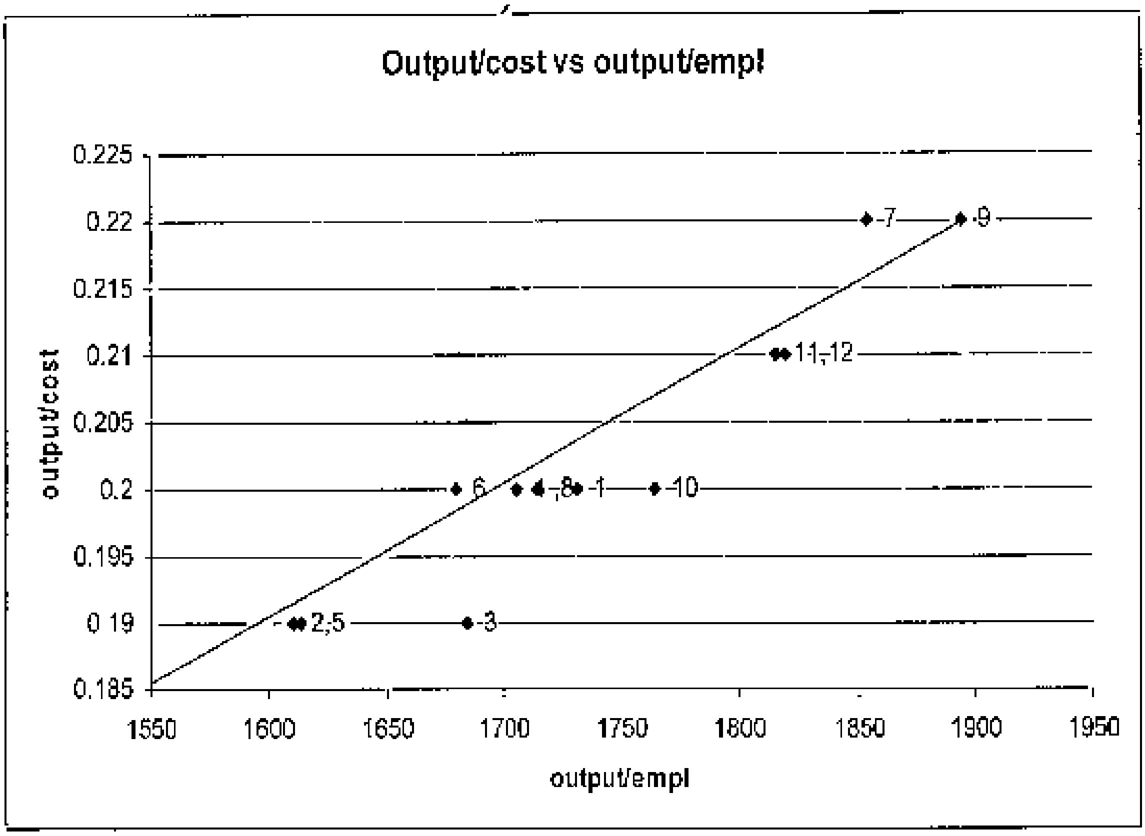


Figure 5.5: DEA drawn based on single input and single output.

At this stage the utilizing the following two parameters : (A) Space utilization in terms of optimum number of production lines and (B) Style of products in terms of Standard Allowable Minutes and with the available data in hand the Earning per line par day and the factory efficiency has been calculated and plotted in a 2-D plane, the efficient frontier is found to envelop the inefficient points.

Table 5.18: Earning per Line per Day and SAM.

Period	EPLD	Factory Efficiency (%)
1	32964	55
2	33250	58
3	31998	56
4	30568	58
5	33520	59

Here the efficient period is the Period 5 wit the highest factory efficiency, which has been found to lie on the frontier and the rest periods lies beneath the frontier indicating their inefficiency.

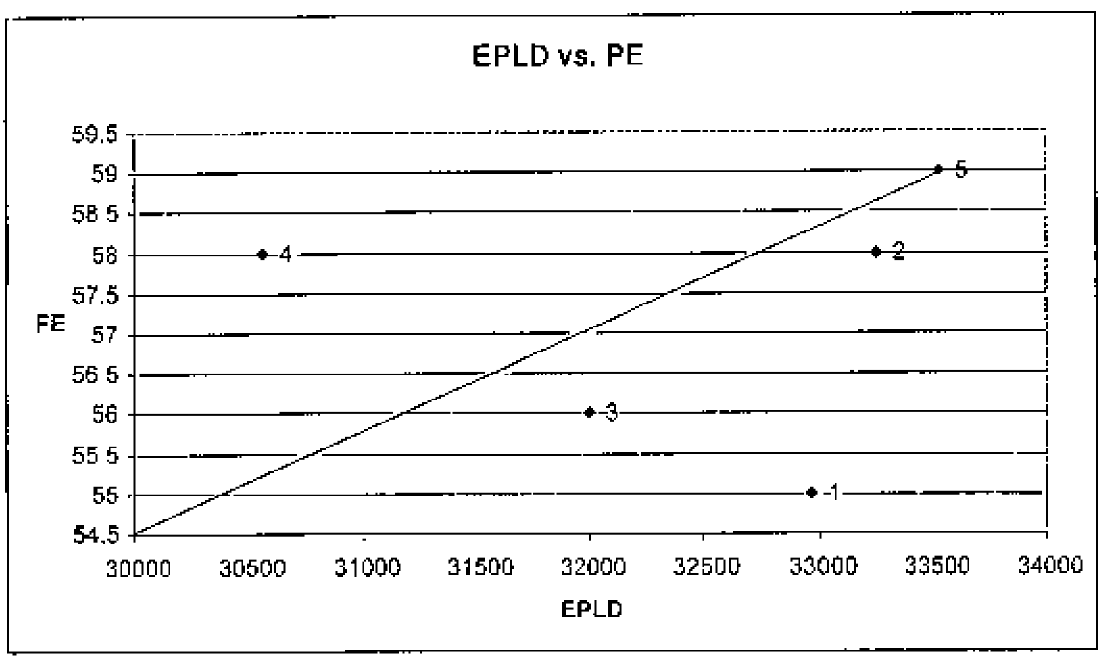


Figure 5.6: Efficient frontier based on EPLD.

CHAPTER VI

SLACK BASED MODEL

6.1 INTRODUCTION

The productive efficiency scores both for input and output orientations models were computed in Chapter V. In input oriented cases the input slacks are increased as much as possible to achieve the highest productive efficiency and in output oriented cases the output slacks are reduced as much as possible in order to achieve the highest possible efficiency. In this chapter both the slack values are treated simultaneously in order to maximize the input slack(s) and to minimize the output slack(s). The analysis has been carried out with the same twelve months data used in the analysis carried out in Chapter V. The month wise ranking. scores and weight results are shown in Table 6.1. After running the data set the efficient values for the input found are shown in Table 6.2. The efficient output values and proposed weights which can make the unit efficient are shown in Table 6.3.

Table 6.1: Month wise Ranking, scores and weight.

No.	Month Name	Score	Rank	Reference set	Monthly Weightage λ
1	January	0.918	6	September	0.902
2	February	0.854	12	September	0.852
3	March	0.888	10	September	0.882
4	April	0.906	8	September	0.882
5	May	0.855	11	September	0.852
6	June	0.893	9	September	0.882
7	July	0.983	2	September	0.982
8	August	0.917	7	September	0.902
9	September	1.000	1	September	1.000

10	October	0.930	5	September	0.907
11	November	0.968	3	September	0.953
12	December	0.962	4	September	0.948

Table 6.2: Month wise efficient input values.

Month Name	Efficient Input Target		(1) No. of Employees
	(I) Salary in taka	(I) Factory cost in taka	
January	1706516	2398004	475
February	1611623	2264661	449
March	1669448	2345917	465
April	1668510	2344598	465
May	1611620	2264656	449
June	1668510	2344598	465
July	1858103	2611015	517
August	1706588	2398105	475
September	1892231	2658972	527
October	1717038	2412791	478
November	1802906	2533451	502
December	1793376	2520061	499

Table 6.3: Month-wise efficient output.

Month Name	Efficient Output Target in pcs.
January	900050
February	850002
March	880500
April	880005
May	850000
June	880005
July	980000
August	900088
September	998000
October	905600
November	950888
December	945862

6.1.1 Type A: Knitting Factory

In carrying out the analysis unlike that of Chapter V none of the cost items have been considered as the input. The reason behind this is in most cases the factory people are reluctant to provide necessary data and but this analysis cannot be termed as incomplete, in the sense that from buyer point of view each of the firms used to judge from the two input factors. One is the number of machines and the other one is the number workers engaged in the production. But, nevertheless, there remains a scope for further extension of the model by incorporating the cost component in the analysis.

Small knitting Factory:

Based on the number of machines the data obtained from different knitting factories are classifies as small, medium and large types. The factories which have less than 100 machines fall under small types. With the data of 24 number of small knitting type factories data set, as shown in Table 6.4 the analysis have been carried out in order to find input and output slack values. These values are shown in Table 6.5. The efficient input and output values obtained are shown in Table 6.6.

Table 6.4: Small Scales knitting factory data.

Sl #	Registration number	No. of Employee	No. of Machine	Production quantity in dozen pcs
1	2190	120	78	60000
2	937	150	67	25000
3	2807	90	38	165000
4	2975	212	78	175000
5	4080	250	75	200000
6	3077	300	54	83000
7	3084	225	82	260000
8	3037	250	75	152000

9	3247	80	57	150000
10	1992	491	55	120000
11	2387	54	26	46800
12	3441	100	44	52000
13	4078	220	62	130000
14	821	130	66	120000
15	3367	200	80	100000
16	3590	275	38	75000
17	2976	200	64	72500
18	1551	50	6	150000
19	1857	150	46	150000
20	4006	200	96	150000
21	3294	225	90	175000
22	1334	460	87	182500
23	3307	280	49	4100
24	3489	150	67	50000

Table 6.5: Slack Values for small scale knitting factory.

VRS Results		Input Slacks		Output Slacks	
DMU No.	**Month Name**	**No. of Employees**	**No. of Machines**	**Production Qty in dozen pcs.**	**Optimal weights**
1	2190	0	42	134000	0.400
2	937	0	17	187857	0.571
3	2806	0	17	11428	0.286
4	3395	0	12	58286	0.257
5	2807	0	14	10143	0.229
6	2975	0	2	76828	0.926
7	4080	41	0	49868	0.908
8	3077	139	0	136474	0.632
9	**3084**	**0**	**0**	**0**	**1.000**
10	3037	41	0	97868	0.908
11	3247	0	38	18857	0.171
12	1992	328	0	100921	0.645
13	2387	0	18	105714	0.023
14	3441	0	16	129428	0.286
15	4078	41	0	101053	0.737
16	821	0	25	80286	0.457
17	3367	0	9	144286	0.857

18	3590	151	0	121316	0.421
19	2976	16	0	161447	0.763
20	**1551**	**0.**	**0**	**0**	**1.000**
21	1857	8	0	57895	0.526
22	4006	0	25	94286	0.857
23	**3294**	**0**	**8**	**85000**	**1.000**
24	**1334**	**235**	**5**	**77500**	**1.000**
25	3307	130	0	208137	0.566
26	3489	0	18	162857	0.571

Table 6.6: Efficient Inputs and Outputs for small scale knitting factory.

VRS Slack-based Model Efficient Target			**Efficient Input Target**	**Efficient Output Target**
DMU No.	**Month Name**	**Efficient Input Target**		
		No. of Employees	**No. of Machines**	**Production Qty in dozen of pcs.**
1	2190	120	36	194000
2	937	150	49	212857
3	2806	100	28	181428
4	3395	95	25	178285
5	2807	90	23	175143
6	2975	212	76	251828
7	4080	209	75	249868
8	3077	160	54	219474
9	3084	225	82	260000
10	3037	209	75	249868
11	3247	80	19	168857
12	1992	163	55	220921
13	2387	54	8	152514
14	3441	100	28	181428
15	4078	179	62	231052
16	821	130	41	200285
17	3367	200	71	244285
18	3590	124	38	196315
19	2976	183	64	233947
20	1551	50	6	150000
21	1857	142	46	207894
22	4006	200	71	244285
23	3294	225	82	260000
24	1334	225	82	260000
25	3307	149	49	212236
26	3489	150	49	212857

From the above table the data shows that the maximum output is 2. 60,000 and the minimum value show the output 4,100. Assuming the other factors remaining same the process tends to maximize all the output values with respect to the maximum value. The most efficient factories are found as follows:

Table 6.7: Findings- Small knitting.

		Efficient Input Target		Efficient Output Target
DMU No.	Month Name	No. of Employee	No. of Machine	Production Qty in dozen pcs
9	3084	225	82	260000
20	1551	50	6	150000
23	3294	225	82	260000
24	1334	225	82	260000

Medium type knitting Factory:

Medium type of knitting factories fall under the category those which has more than 100 but not more than 200 machines. Twenty numbers of such types of factories data have been considered for the analysis. The data set for those factories is shown in Table 6.8 and the input and output slack values obtained are shown in Table 6.9. Also the efficient input and output values are shown in Table 6.10.

Table 6. 8: Medium Scale knitting factory data set.

Sl #	Reg #	No. of Employee	No. of Machine	Production Qty in dozen of pcs.
1	3837	284	110	100000
2	4045	250	120	180000
3	2500	340	109	150000
4	1216	350	160	165000
5	2417	915	110	645000
6	2431	200	150	78000
7	855	450	200	250000
8	2317	275	170	131250

9	2266	300	120	240000
10	3937	315	105	350000
11	3384	321	170	300000
12	1390	285	127	100000
13	520	343	155	75000
14	3485	500	108	200000
15	3797	555	200	393750
16	2222	230	187	200000
17	2158	200	145	200000
18	1703	390	170	250000
19	4052	460	198	300000
20	248	300	130	70000

Table 6.9: Slack Values for medium scale knitting factory.

VRS Results		Input Slacks		Output Slacks	
DMU No.	Month Name	No. of Employees	No. of Machine	Production Qty in dozen of pcs.	Optimal Lambdas with Benchmarks
1	**3837**	**0**	**0**	0	**1.0**
2	**4045**	**0**	**0**	0	**1.0**
3	2500	17	0	203868	0.013
4	1216	0	37	202208	0.058
5	**2417**	**0**	**0**	**0**	**1.0**
6	2431	0	5	121999	1.00
7	855	0	26	166375	0.225
8	2317	0	51	166576	0.652
9	2266	0	10	90434	0.870
10	**3937**	**0**	**0**	0	**1.0**
11	3384	0	62	52950	0.010
12	1390	0	11	210869	0.739
13	520	0	36	288767	0.047
14	3485	179	0	152901	0.010
15	3797	53	0	48135	0.311
16	2222	0	52	39130	0.261
17	**2158**	**0**	**0**	**0**	**1.0**
18	1703	0	27	136875	0.125
19	4052	0	19	121292	0.242
20	248	0	20	260435	0.870

Table 6.10: Efficient Inputs and Outputs for medium scale knitting.

VRS Slack-based Model Efficient Target				
		Efficient Input Target		**Efficient Output Target**
DMU No.	**Month Name**	**No. of Employee**	**No. of Machine**	**Production Qty in dozen of pcs.**
1	3837	284	110	100000
2	4045	250	120	180000
3	2500	323	109	353869
4	1216	350	122	367208
5	2417	915	410	645000
6	2431	200	145	199999
7	855	450	173	416375
8	2317	275	118	297826
9	2266	300	110	330435
10	3937	315	105	350000
11	3384	321	108	352950
12	1390	285	115	310869
13	520	343	119	363767
14	3485	321	108	352902
15	3797	502	200	441885
16	2222	230	134	239130
17	2158	200	145	200000
18	1703	390.	143	386875
19	4052	460	178	421291
20	248	300	110	330435

Table 6.11: Findings- Medium knitting.

The most efficient factories are found as follows:

		Efficient Input Target		**Efficient Output Target**
DMU No.	**Month Name**	**No. of Employee**	**No. of Machine**	**Production Qty in dozen of pcs.**
1	3837	284	110	100000
2	4045	250	120	180000
5	2417	915	410	645000
10	3937	315	105	350000
17	2158	200	145	200000

Large knitting Factories.

The factories having more than 200 machines fall under this category. Twenty number of large knitting factories data have been taken for analysis. The data set are shown in Table 6.12 and the input and out put slack values are shown n table 6.13.

Table 6.12: Data set for large scale knitting factory.

Sl #	Reg #	No. of Employee	No. of Machine	Production Qty in dozen of pcs.
1	3922	700	560	20000
2	1276	2250	796	10000000
3	3583	500	350	100000
4	1252	600	500	360000
5	2096	850	390	650000
6	3368	900	500	12000
7	3465	919	305	130000
8	2016	1150	750	1200000
9	1603	800	450	600000
10	3729	1500	400	120000
11	2533	600	550	325000
12	3966	800	350	650000
13	3696	730	441	250000
14	3732	350	299	312500
15	2312	2200	500	1019620
16	762	425	282	350000
17	3676	1200	417	5000000
18	1939	400	240	240000
19	1812	500	300	250000
20	2329	750	370	400000

Table 6.13: Slack values large scale knitting factory.

VRS Results		Input Slacks		Output Slacks	Optimal Lambdas with Benchmarks
DMU No.	Month Name	No. of Employee	No. of Machine	Production Qty in dozen of pcs.	
1	3922	0	212	2222647	0.588
2	**1276**	**0**	**0**	**0**	**1.0**
3	3583	0	30	1040	0.824
4	1252	0	166	1331176	0.706
5	2096	0	22	2419853	0.412
6	3368	0	125	3333588	0.353
7	3465	225	0	1858023	0.367
8	2016	0	340	3524265	0.059
9	1603	0	88	2194118	0.471
10	3729	377	0	4422825	0.904
11	2533	0	216	1366176	0.706
12	3966	0	0	2083541	0.307
13	3696	0	89	2158088	0.553
14	**3732**	**0**	**0**	**0**	**1.0**
15	2312	770	0	5075367	0.219
16	762	0	0	231341	0.521
17	**3676**	**0**	**0**	**0**	**1.0**
18	**1939**	**0**	**0**	**0**	**1.0**
19	1812	0	0	785017	0.541
20	2329	0	15	2118382	0.529

Table 6.14: Efficient Inputs and outputs for large scale knitting.

VRS Slack-based Model Efficient Target			No. of Machine	Efficient Output Target
Sl #	Reg.	Efficient Input Target		
		No. of Employee		Production Qty in dozen of pcs.
1	3922	700	347	2242647
2	1276	2250	796	10000000
3	3583	500	320	1139706
4	1252	600	334	1691176
5	2096	850	368	3069853
6	3368	900	375	3345588
7	3465	694	305	1988023
8	2016	1150	410	4724265
9	1603	800	361	2794117
10	3729	1123	400	4542825
11	2533	600	334	1691176

12	3966	800	350	2733541
13	3696	730	352	2408088.
14	3732	350	299	312500
15	2312	1430	500	6094987
16	762	425	282	581341
17	3676	1200	417	5000000
18	1939	400	240	240000
19	1812	500	300	1035018
20	2329	750	354	2518382

Table 6.15: Findings- Large Knitting.

The most efficient factories are found as follows:

		Efficient Input Target		Efficient Output Target
DMU No.	Month Name	No. of Employee	No. of Machine	Production Qty in dozen of pcs.
2	1276	2250	796	10000000
14	3732	350	299	312500
17	3676	1200	417	5000000
18	1939	400	240	240000

6.1.2 Type B: Sweater Factory

Data for twenty four sweater factories have been taken for the analysis to find out the slacks values and thereby to find those efficient sweater firms. The data set have been shown in Table 6.16, VRS efficient input and output targets in Table 6.17 and slacks values for individual units in Table 6.18.

Table 6.16: Data set for twenty four sweater factories.

Sl #	Reg	(I)No. of Employee	(I) No. of Machine	(O)Production Qty in dozen of pcs.
1	3968	700	300	72000
2	1983	307	180	30000
3	2730	150	100	10000
4	3949	350	204	47000
5	3183	700	427	60000
6	2204	500	310	75000
7	3792	105	117	16000
8	1925	600	300	41000
9	3504	850	730	250000
10	3493	240	220	45000

11	3431	365	129	32000
12	1554	245	110	25000
13	2085	250	161	36000
14	3898	650	470	75400
15	2978	850	602	60000
16	2866	650	526	220000
17	3828	1525	513	1000000
18	3687	495	442	50000
19	2074	300	200	48000
20	3501	826	513	78000
21	3316	550	381	60000
22	3231	1200	866	100000
23	3843	1244	1203	140000
24	3989	756	612	65000

Table 6.17: VRS Slack-based Efficient Target for sweater factories.

Sl #	Reg.	Efficient Input Target		Efficient Output Target
		(I)No. of Employee	(I) No. Of machines	(O)Production Qty in dozen of pcs.
1	3968	700	283	428310
2	1983	307	173	155977
3	2730	150	100	10000
4	3949	350	185	185774
5	3183	700	283	428310
6	2204	500	227	289718
7	3792	105	117	16000
8	1925	600	255	359014
9	3504	850	325	532253
10	3493	240	155	109549
11	3431	246	129	79516
12	1554	183	110	33971
13	2085	250	157	116479
14	3898	650	269	393662
15	2978	850	325	532253
16	2866	650	269	393662
17	3828	1525	513	1000000
18	3687	495	226	286253
19	2074	300	171	151127
20	3501	826	318	515622
21	3316	550	241	324366
22	3231	1200	422	774789
23	3843	1244	435	805279
24	3989	756	298	467115

Table 6.18: Slack for sweater factories.

VRS Results	Reg	Input Slacks		Output Slacks	Optimal weights
Sl #		(I)No. of Employee	(I)No. of Machine	(O)Production Qty in dozen of pcs.	with Benchmarks
1	3968	0	17	356310	0.581
2	1983	0	7	125977	0.858
3	**2730**	**0**	**0**	**0**	**1.0**
4	3949	0	19	138775	0.827
5	3183	0	144	368310	0.581
6	2204	0	83	214718	0.722
7	**3792**	**0**	**0**	**0**	**1.0**
8	1925	0	45	318014	0.651
9	3504	0	405	282253	0.475
10	3493	0	65	64549	0.905
11	3431	118	0	47516	0.930
12	1554	62	0	8971	0.976
13	2085	0	3	80479	0.898
14	3898	0	201	318262	0.616
15	2978	0	277	472253	0.475
16	2866	0	257	173662	0.616
17	**3828**	**0**	**0**	**0**	**1.0**
18	3687	0	216	236253	0.725
19	2074	0	29	103127	0.863
20	3501	0	194	437622	0.492
21	3316	0	140	264366	0.687
22	3231	0	444	674789	0.229
23	3843	0	768	665279	0.198
24	3989	0	313	402115	0.542

Table 6.19: Findings- Sweater.

Sl #	Reg	Efficient Input Target		Efficient Output Target
		(I)No. of Employee	(I)No. of Machine	(O)Production Qty in dozen of pcs.
3	2730	150	100	10000
7	3792	105	117	16000
17	3828	1525	513	1000000

6.1.3 Type C: Woven Factory.

Finally, twenty seven woven factories data have been taken for carrying out the analysis to find the slack values applying the slack based model. The data set for twenty seven industries have been shown in Table 6.20, CRS efficient input and output targets shown in Table 6.21 and the slack values in Table 6.22

Table 6.20: Data set for twenty seven woven factories.

Sl #	Registration number	(I)No. of Employee	(I)No. of Machine	(O) Production Qty in dozen of pcs.
1	1375	415	175	29
2	2914	450	200	130000
3	3236	587	110	30000
4	937	150	67	25000
5	1192	240	90	45000
6	1283	325	105	30000
7	1095	525	289	200000
8	1259	145	90	24000
9	2276	505	219	100000
10	700	150	164	15000
11	2181	431	174	96000
12	4116	250	83	60000
13	3420	425	200	120000
14	4018	1200	878	2400000
15	213	204	104	36000
16	114	540	255	150000
17	1548	330	108	336000
18	2152	250	120	150000
19	1631	225	125	25000
20	78	255	200	112000
21	3195	430	168	30000
22	4130	900	432	150000
23	1144	300	152	25000
24	3016	588	271	120000
25	1404	938	396	210000
26	60	450	223	75000
27	1721	700	358	72000

Table 6.21: CRS Slack-based Efficient Target for woven factories.

		Efficient Input Target		Efficient Output Target
Sl #	Reg.	(I)No. of Employee	(I) No. of Machine	(O)Production Qty in dozen of pcs.
1	1375	415	175	517674
2	2914	450	200	586197
3	3236	336	110	342222
4	937	150	67	196208
5	1192	240	90	272174
6	1283	321	105	326667
7	1095	525	289	819048
8	1259	145	90	250931
9	2276	505	219	644625
10	700	150	110	300000
11	2181	431	174	518824
12	4116	250	83	257415
13	3420	425	200	580607
14	4018	1200	878	2400000
15	213	204	104	298114
16	114	540	255	739855
17	1548	330	108	336000
18	2152	250	120	347246
19	1631	225	125	353795
20	78	255	186	510000
21	3195	430	168	504033
22	4130	900	432	1250086
23	1144	300	152	436119
24	3016	588	271	789434
25	1404	938	396	1171180
26	60	450	223	642038
27	1721	700	358	1025702

Table 6.22: Slacks for woven factories.

CRS Results		Input Slacks		Output Slacks	Optimal weight
Sl #	Reg	(I)No. of Employee	(I) No. of Machine	(O)Production Qty in dozen of pcs.	with Benchmarks
1	1375	0	0	517645	0.081
2	2914	0	0	456197	0.109
3	**3236**	**251**	**0**	**312222**	**1.019**
4	937	0	0	171208	0.037

5	1192	0	0	227174	0.024
6	1283	4	0	296667	0.972
7	1095	0	0	619048	0.241
8	1259	0	0	226931	0.088
9	2276	0	0	544625	0.111
10	700	0	54	285000	0.125
11	2181	0	0	422824	0.068
12	4116	0	0	197415	0.002
13	3420	0	0	460607	0.126
14	**4018**	**0**	**0**	**0**	**1.0**
15	213	0	0	262114	0.077
16	114	0	0	589854	0.161
17	**1548**	**0**	**0**	**0**	**1.0**
18	2152	0	0	197246	0.079
19	1631	0	0	328795	0.106
20	78	0	13	398000	0.212
21	3195	0	0	474033	0.056
22	4130	0	0	1100086	0.283
23	1144	0	0	411118	0.111
24	3016	0	0	669434	0.162
25	1404	0	0	961180	0.183
26	60	0	0	567038	0.156
27	1721	0	0	953702	0.266

Table 6.23: Findings- Efficient woven factories.

		Efficient Input Target		**Efficient Output Target**
Sl #	**Reg**	**(I)No. of Employee**	**(I) No. of Machine**	**(O)Production Qty indozen of pcs.**
3	3236	336	110	342222
14	4018	1200	878	2400000
17	1548	330	108	336000

Analysis of results:

In using the additive model our focus is to give attention in analyzing the amount of slacks present in the inputs and outputs, unlike the cases where we our interest is to find the units which are efficient. It is clearly evident that the analysis is revolved with respect to the maximum value of the production quantity, used in the calculation.

CHAPTER VII

RETURNS TO SCALE

7.1 SCALE EFFICIENCY

The concept of scale efficiency is important to determine the nature of scale to returns. The same sets of data used in the Chapter V have been used in this chapter to find out the scale efficiency for twelve month period. In order to calculate the scale efficiency the first thing is to find out the input oriented productive efficiencies for both constant returns to scale and variable return to scale. The scale efficiency is nothing but the ratio between constant return to variable return values found for each firms. The productive efficiency values for constant returns to scale are shown in Table 7.1 and variable returns to scale are shown in Table 7.2. Both have been calculated for input oriented cases. The scale efficiency values, thus, found are shown in Table 7.3. The increasing returns to scale prevail as long as the value of scale efficiency remains below one. From the table 7.3 it can easily be seen that there exist increasing returns to scale except for the month of September and December, which has achieved the higher score for efficiency. The value of unity indicates that there exist constant returns to scale.

Table 7.1: PE Scores for constant return to scale.

No.	Months	Score
1	January	0.927
2	February	0.862
3	March	0.894
4	April	0.925
5	May	0.859
6	June	0.908

7	July	0.993
8	August	0.928
9	September	1.000
10	October	0.954
11	November	0.973
12	December	0.970

From the table 7.2 it can be analyzed that except for the months April, July, September, October and November the overall efficiency is low due to the inefficient operation. Thus there exists the scope for increasing the efficiency by scaling up their activities.

Table 7.2: Productive scores for variable returns to scale.

No.	DMU	Score
1	January	0.959
2	February	0.872
3	March	0.907
4	April	1.000
5	May	0.866
6	June	0.935
7	July	1.000
8	August	0.960
9	September	1.000
10	October	1.000
11	November	1.000
12	December	0.970

Based on the data of the above tables the scale efficiencies have been calculated as follows:

Table 7.3: Scale Efficiency or SE.

No.	Months	SE
1	January	0.967
2	February	0.989
3	March	0.986
4	April	0.925
5	May	0.992
6	June	0.971
7	July	0.993
8	August	0.967
9	September	1.000
10	October	0.954
11	November	0.973
12	December	1.000

7.2 INPUT AND OUTPUT STABILITY REGION

As defined by Zhu [129] input stability region is that region where the input quantities can be increased where such allowable input increases does not affect the efficiency of that firm. Likewise a region of allowable output decreases is denoted as output stability region if that firm remains efficient after such decreases occur.

With the same set of data of twelve months the input oriented and output oriented returns to scale is calculated.

The CRS efficiency score is equal to VRS efficiency only if there exists an optimal solution so that $\sum\lambda = 1$.

In other cases when VRS efficiency scores are greater than CRS efficiency scores and $\sum\lambda < 1$ then there is the case for increasing returns to scale.

Table 7.4 Data set

Month	(I) Salary	(I) Factory cost	(I) Employees	(O) Production Qty
January	1841091	2629881	520	900050
February	1897942	2625892	528	850002
March	1867703	2658963	523	880500
April	1804071	2625101	516	880005
May	1884775	2636582	527	850000
June	1836728	2653422	524	880005
July	1898292	2630301	529	980000
August	1839901	2614431	525	900088
September	1892231	2658972	527	998000
October	1800012	2670322	513	905600
November	1852061	2602561	524	950888
December	1848022	2635862	520	945862

Table 7.5 Input Oriented RTS

Sl No.	Months	Input-Oriented VRS Efficiency	Input-Oriented CRS Efficiency	$\sum\lambda$	Input-Oriented RTS
1	January	0.996	0.926	0.9018	Increasing
2	February	0.991	0.862	0.8517	Increasing
3	March	0.987	0.893	0.8822	Increasing
4	April	1.000	0.924	0.8817	Increasing
5	May	0.989	0.858	0.8517	Increasing
6	June	0.987	0.908	0.8817	Increasing
7	July	1.000	0.992	0.9819	Increasing
8	August	0.998	0.927	0.901	Increasing
9	September	1.000	1.000	1.000	Constant
10	October	1.000	0.953	0.907	Increasing
11	November	1.000	0.973	0.952	Increasing
12	December	1.000	0.970	0.947	Increasing

Table 7.6 Smallest Input

Sl No.	Months	Smallest Input MPSS Target			Smallest Output
		(I) Salary	(I) Factory cost	(I) Employees	(O) Prodn Qty
1	January	1892231	2658972	527	998000
2	February	1892231	2658972	527	998000
3	March	1892231	2658972	527	998000
4	April	1892231	2658972	527	998000
5	May	1892231	2658972	527	998000
6	June	1892231	2658972	527	998000
7	July	1892231	2658972	527	998000
8	August	1892231	2658972	527	998000
9	September	1892231	2658972	527	998000
10	October	1892231	2658972	527	998000
11	November	1892231	2658972	527	998000
12	December	1892231	2658972	527	998000

Table 7.7 Largest Input

Sl. No.	Month	Largest Input MPSS Targets			Largest Output
		(I) Salary	(I) Factory cost	(I) Employees	(O) Production Qty
1	January	1892231	2658972	527	998000
2	February	1892231	2658972	527	998000
3	March	1892231	2658972	527	998000
4	April	1892231	2658972	527	998000
5	May	1892231	2658972	527	998000
6	June	1892231	2658972	527	998000
7	July	1892231	2658972	527	998000
8	August	1892231	2658972	527	998000
9	September	1892231	2658972	527	998000
10	October	1892231	2658972	527	998000
11	November	1892231	2658972	527	998000
12	December	1892231	2658972	527	998000

Table 7.8: Output Oriented RTS for small knitting.

Sl No.	Reg. No.	Output-Oriented VRS Efficiency	Output-Oriented CRS Efficiency	$\sum\lambda$	Output-Oriented RTS
1	2190	3.23	6.00	2 40	Decreasing
2	937	8.51	18.00	3.00	Decreasing
3	2806	1.06	1.761	2.00	Decreasing
4	3395	1.48	2.37	1.90	Decreasing
5	2807	1.06	1.63	1.800	Decreasing
6	2975	1.43	3.63	4.24	Decreasing
7	4080	1 24	3.75	5.00	Decreasing
8	3077	2.64	10.84	6.00	Decreasing
9	3084	1.000	2.59	4.50	Decreasing
10	3037	1.64	4.93	5.00	Decreasing
11	3247	1.12	1.60	1.60	Decreasing
12	1992	1.84	11.45	9.16	Decreasing
13	2387	3.25	3.46	1.08	Decreasing
14	3441	3.481	5.76	2 00	Decreasing
15	4078	1.77	5.07	4.40	Decreasing
16	821	1.665	3.25	2.60	Decreasing
17	3367	2.44	6.00	4.00	Decreasing
18	3590	2.61	11.00	5.50	Decreasing
19	2976	3.22	8.27	4.00	Decreasing
20	1551	1.00	1.00	1.00	Constant
21	1857	1.38	3.00	3.00	Decreasing
22	4006	1.62	4.00	4.00	Decreasing
23	3294	1.48	3.85	4.50	Decreasing
24	1334	1.42	7.56	9 20	Decreasing
25	3307	51.76	204.87	5.60	Decreasing
26	3489	4.25	9.00	3.00	Decreasing

Table: 7.9: Largest MPSS (Output Oriented).

Sl. No.	Reg. No.	Largest Input MPSS Targets		Largest Output MPSS Targets
		Employee	Machine	
1	2190	50	6	150000
2	937	50	6	150000
3	2806	50	6	150000
4	3395	50	6	150000
5	2807	50	6	150000
6	2975	50	6	150000

7	4080	50	6	150000
8	3077	50	6	150000
9	3084	50	6	150000
10	3037	50	6	150000
11	3247	50	6	150000
12	1992	50	6	150000
13	2387	50	6	150000
14	3441	50	6	150000
15	4078	50	6	150000
16	821	50	6	150000
17	3367	50	6	150000
18	3590	50	6	150000
19	2976	50	6	150000
20	1551	50	6	150000
21	1857	50	6	150000
22	4006	50	6	150000
23	3294	50	6	150000
24	1334	50	6	150000
25	3307	50	6	150000
26	3489	50	6	150000

Table 7.10: Smallest MPSS (Output Oriented).

Sl No.	Reg. No.	Smallest Input MPSS Target		Smallest Output MPSS Target
		Employee	Machine	Production
1	2190	50	6	150000
2	937	50	6	150000
3	2806	50	6	150000
4	3395	50	6	150000
5	2807	50	6	150000
6	2975	50	6	150000
7	4080	50	6	150000
8	3077	50	6	150000
9	3084	50	6	150000
10	3037	50	6	150000
11	3247	50	6	150000
12	1992	50	6	150000
13	2387	50	6	150000
14	3441	50	6	150000
15	4078	50	6	150000
16	821	50	6	150000
17	3367	50	6	150000
18	3590	50	6	150000
19	2976	50	6	150000

20	1551	50	6	150000
21	1857	50	60	150000
22	4006	50	6	150000
23	3294	50	6	150000
24	1334	50	6	150000
25	3307	50	6	150000
26	3489	50	6	150000

Table 7.11: Stability Region (Output Oriented).

Sl No.	Reg. No.	Output-Oriented RTS	Stability Region	
			Lower Bound	Upper Bound
1	2190	Decreasing	0.42	1.00
2	937	Decreasing	0.33	1.00
3	2806	Decreasing	0.50	1.00
4	3395	Decreasing	0.53	1.00
5	2807	Decreasing	0.56	1.00
6	2975	Decreasing	0.24	1.00
7	4080	Decreasing	0.20	1.00
8	3077	Decreasing	0.17	1.00
9	3084	Decreasing	0.22	1.00
10	3037	Decreasing	0.20	1.00
11	3247	Decreasing	0.63	1.00
12	1992	Decreasing	0.11	1.00
13	2387	Decreasing	0.93	1.00
14	3441	Decreasing	0.50	1.00
15	4078	Decreasing	0.23	1.00
16	821	Decreasing	0.38	1.00
17	3367	Decreasing	0.25	1.00
18	3590	Decreasing	0.18	1.00
19	2976	Decreasing	0.25	1.00
20	1551	Constant	1.00	1.00
21	1857	Decreasing	0.33	1.00
22	4006	Decreasing	0.25	1.00
23	3294	Decreasing	0.22	1.00
24	1334	Decreasing	0.11	1.00
25	3307	Decreasing	0.18	1.00
26	3489	Decreasing	0.33	1.00

Table 7.12: Input Oriented RTS.

Sl No.	Reg. No.	Input-Oriented VRS Efficiency	Input-Oriented CRS Efficiency	∑λ	Input-Oriented RTS
1	2190	0.41	0.16	0.40	Increasing
2	937	0.33	0.05	0.16	Increasing
3	2806	0.81	0.56	1.13	Decreasing
4	3395	0.52	0.42	0.80	Increasing
5	2807	0.82	0.61	1.10	Decreasing
6	2975	0.42	0.27	1.16	Decreasing
7	4080	0.54	0.26	1.33	Decreasing
8	3077	0.16	0.09	0.55	Increasing
9	3084	1.00	0.38	1.73	Decreasing
10	3037	0.21	0.20	1.01	Decreasing
11	3247	0.62	0.62	1.00	Constant
12	1992	0.10	0.08	0.80	Increasing
13	2387	0.92	0.28	0.31	Increasing
14	3441	0.50	0.17	0.34	Increasing
15	4078	0.22	0.19	0.86	Increasing
16	821	0.38	0.30	0.80	Increasing
17	3367	0.25	0.16	0.66	Increasing
18	3590	0.18	0.09	0.50	Increasing
19	2976	0.25	0.12	0.48	Increasing
20	1551	1.00	1.00	1.00	Constant
21	1857	0.33	0.33	1.00	Constant
22	4006	0.25	0.25	1.00	Constant
23	3294	0.39	0.25	1.16	Decreasing
24	1334	0.32	0.13	1.21	Decreasing
25	3307	0.17	0.00	0.02	Increasing
26	3489	0.33	0.11	0.33	Increasing

Table 7.13: Stability Region (Input Oriented).

		Output-Oriented	Stability Region	
Sl No.	Reg. No.	RTS	Lower Bound	Upper Bound
1	2190	Decreasing	0.41667	1.00000
2	937	Decreasing	0.33333	1.00000
3	2806	Decreasing	0.50000	1.00000
4	3395	Decreasing	0.52632	1.00000

5	2807	Decreasing	0.55556	1.00000
6	2975	Decreasing	0.23585	1.00000
7	4080	Decreasing	0.20000	1.00000
8	3077	Decreasing	0.16667	1.00000
9	3084	Decreasing	0.22222	1.00000
10	3037	Decreasing	0.20000	1.00000
11	3247	Decreasing	0.62500	1.00000
12	1992	Decreasing	0.10909	1.00000
13	2387	Decreasing	0.92593	1.00000
14	3441	Decreasing	0.50000	1.00000
15	4078	Decreasing	0.22727	1.00000
16	821	Decreasing	0.38462	1.00000
17	3367	Decreasing	0.25000	1.00000
18	3590	Decreasing	0.18182	1.00000
19	2976	Decreasing	0.25000	1.00000
20	1551	Constant	1.00000	1.00000
21	1857	Decreasing	0.33333	1.00000
22	4006	Decreasing	0.25000	1.00000
23	3294	Decreasing	0.22222	1.00000
24	1334	Decreasing	0.10870	1.00000
25	3307	Decreasing	0.17857	1.00000
26	3489	Decreasing	0.33333	1.00000

In the Table 7.14 the most productive scale size for input oriented largest values and the smallest values in Table 7.15 have been shown. Actually it is a condition where the firm has been operating within the constant returns to scale and all the slacks has the zero values. Thus there are two values of input and outputs: largest and smallest.

Table 7.14: Largest MPSS (Input Oriented).

		Largest Input MPSS Targets		Largest Output MPSS Targets
Sl No.	**Reg. No.**	**Employee**	**Machine**	**Production**
1	2190	50	6	150000
2	937	50	6	150000
3	2806	50	6	150000
4	3395	50	6	150000
5	2807	50	6	150000
6	2975	50	6	150000
7	4080	50	6	150000
8	3077	50	6	150000

9	3084	50	6	150000
10	3037	50	6	150000
11	3247	50	6	150000
12	1992	50	6	150000
13	2387	50	6	150000
14	3441	50	6	150000
15	4078	50	6	150000
16	821	50	6	150000
17	3367	50	6	150000
18	3590	50	6	150000
19	2976	50	6	150000
20	1551	50	6	150000
21	1857	50	6	150000
22	4006	50	6	150000
23	3294	50	6	150000
24	1334	50	6	150000
25	3307	50	6	150000
26	3489	50	6	150000

Table 7.15: Smallest MPSS (Input Oriented).

Sl No.	Reg No.	Smallest Input MPSS Target		Smallest Output MPSS Target
		Employee	Machine	Production
1	2190	50	6	150000
2	937	50	6	150000
3	2806	50	6	150000
4	3395	50	6	150000
5	2807	50	6	150000
6	2975	50	6	150000
7	4080	50	6	150000
8	3077	50	6	150000
9	3084	50	6	150000
10	3037	50	6	150000
11	3247	50	6	150000
12	1992	50	6	150000
13	2387	50	6	150000
14	3441	50	6	150000
15	4078	50	6	150000
16	821	50	6	150000
17	3367	50	6	150000
18	3590	50	6	150000
19	2976	50	6	150000

20	1551	50	6	150000
21	1857	50	6	150000
22	4006	50	6	150000
23	3294	50	6	150000
24	1334	50	6	150000
25	3307	50	6	150000
26	3489	50	6	150000

It is clearly evident from the analysis that it is not wise to go for increasing the output. It is also worthy to mention here that the return to scale exercise is equally useful to derive the input and output stability regions.

CHAPTER VIII

FACTORS AFFECTING THE PRODUCTIVE EFFICIENCY

8.1 INFLUENCING PARAMETERS

In this chapter an attempt is being made to explain the affects of various parameters which positively or negatively influence the productive efficiency of any apparel industry. A questionnaire incorporating as much as factors shown in Appendix A elaborated and analyzed in a sequential manner After obtaining detail answers analysis was carried out to find which factors are significant contributors to the productive efficiency. The analysis was done using the software SPSS 11.5 version.

Fifteen factors such as: Gender, Age Group, Work Experiences, Level of satisfactions, Fatigue, Relation with Fatigue, Number of hours worked, Compensation, Comfort, Skillness improvement, Nonpayment, Deferred payment, Qualifications, Need for training, Mode of learning, were analyzed against the output produced. It has been found that the following factors have positive influences to the output produced: Gender, Age Group, Work Experiences, Satisfactions of the workers and Qualifications of the workers.

8.1.1 Gender

Gender plays a major role in the factory environment. The percentage of male and female and their individual contribution is necessarily big issue for augmenting the productivity. In Table 8.1 the number and percentage of male and female working in the factory are shown. In Table 8.2 the p-value shows that the relationship found between outputs produced in number of pieces and gender is significant.

Table 8.1: Gender distribution.

	Number	Percent
Male	120	29.6
Female	285	70.4
Total	405	100.0

Table 8.2: Output related to gender.

Gender	pieces produced per hour			p-value
	60-79	80-99	100+	
Male	10.0	24.4	36 3	0.013
Female	90.0	75.6	63.7	
Total	100.0	100.0	100.0	

Here the outputs produced have been divided into three groups and analyzed accordingly. From the above table it can be seen that in the higher producing categories the percentage of male workers are increasing proportionately i.e. the male workers are performing better than their counterpart.

Gender Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Gender	0.185	0.034	0.032	0.53631

The R Square value of 0.034 indicates approximately 3.4 percent of the variation in output is explained by the gender factor. Also it is understood that there are other factors besides gender which have influences on the output produced. The differences between R Square and Adjusted R Square is very small along with the error quantity indicates that the misspecification is very small.

8.1.2 Age group

In considering the age of the workers as have been shown in the Table 8.3 the total numbers of workers are divided against four age groups (19-24, 25-30, 31-36 and 37+) and three output producing groups (60-79, 80-99 and 100+). In Table 8.4 the p-value shows that the relation between output produced in number of pieces and the different age groups are significant.

Table 8.3: Output distribution.

PCSPHR GROUP	Age Group				Total
	19-24	25-30	31-36	37+	
	Number of workers				
60-79	8	2	0	0	10
80-99	55	123	18	9	205
100+	12	159	7	12	190
Total	75	284	25	21	405

Table 8.4: Output related to age group.

Age Group	% Output			p-value
	pieces produced per hour			
	60-79	80-99	100+	
19-24	80.0	26.8	6 3	0.0
25-30	20.0	60.0	83.7	
31-36	.0	8 8	3 7	
37+	0	4.4	6.3	
Total	100.0	100.0	100.0	

From the above Table it can be seen that the better performing group is

Age Group Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Age Group	0.206	0.042	0.040	0.53401

The R Square value of 0.042 indicates approximately 4.2 percent of the variation in output is explained by the age group factor. Also it is understood that there are other factors besides age group which have influences on the output produced. The differences between R Square and Adjusted R Square is very small along with error quantity indicates that the misspecification is very small.

8.1.3 Work experiences

In a factory undoubtedly work experiences of the workers augments the output of the factory as whole. This has also found true in this case. The work experiences of the workers are divided into three groups (leas than 3 years, 3 to 10 years and more than 10 years) against output produced in pieces into three groups (60 to 79, 80 to 99 and more than 100) as shown in Table 8.5. The patterns of workers following into different groups are analyzed and when these data are run has been found to have very significant relationship, which can be seen from the p values in the Table 8.6.

The fourth factor has been analyzed is the level of satisfactions of the workers, which is divided into five levels (Very satisfied, Satisfied, Neither satisfied nor dissatisfied, Dissatisfied and Very dissatisfied) against the three output produced in pieces in hour(60 to 79, 80 to 99 and more than 100) as shown in Table 8.7. When these levels of satisfactions of the workers are analyzed against the output produced it was found to have no significant relationship as shown in Table 8.8.

Table 8.5: Distribution of Work Experiences of the workers.

Work Exp. Group		**Number of workers**			**Total**
		<3	3-10	10+	
PCSP HR GROUP	60-79	1	0	9	10
	80-99	45	25	135	205
	100+	26	103	61	190
Total		72	128	205	405

Table 8.6: **Output related to Work Experiences.**

WEXPGR	pieces produced per hour			Total	p-value
	60-79	80-99	100+		
<3	10.0%	22.0%	13.7%	17.8%	0.0
3-10	0	12.2%	54.2%	31.6%	
10 and above	90.0%	65.9%	32.1%	50.6%	
Total	100.0	100 0	100.0	100.0	

Work Experiences Group Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Work Experiences Group	0.192	0.037	0.034	0.535

The R Square value of 0.037 indicates approximately 3.7 percent of the variation in output is explained by the age group factor. Also it is understood that there are other factors which have influences on the output produced. The differences between R Square and Adjusted R Square is very small along with the error quantity indicates that the misspecification is very small.

8.1.4 Level of satisfactions

The fourth factor has been analyzed is the level of satisfactions of the workers, which is divided into five levels (Very satisfied. Satisfied, Neither satisfied nor dissatisfied, Dissatisfied and Very dissatisfied) against the three output produced in pieces in hour(60 to 79, 80 to 99 and more than 100) as shown in Table 8.7 When these levels of satisfactions of the workers are analyzed against the output produced it was found to have no significant relationship as shown in Table 8.8.

Table 8.7: Satisfaction distribution.

PCSPHRGR		Numbers of workers			Total
		60-79	80-99	100+	
SATIS GROUP	Very much satisfied 81%>	8	178	165	351
	Satisfied 61%-80%	1	15	9	25
	Neither satisfied nor dissatisfied 51%-60%	1	5	5	11
	Dissatisfied 30%-50%	0	2	5	7
	Very much dissatisfied <30%	0	5	6	11
Total		10	205	190	405

Table 8.8: Output related to satisfactions.

SATISFACTION GROUP	PCSPHRGR	% workers			p-value
		60-79	80-99	100+	
	Very much satisfied 81%>	2.3	50.7	47.0	0.001
	Satisfied 61%-80%	4.0	60.0	36.0	
	Neither Satisfied nor Dissatisfied 51%-60%	9.1	45.5	45.5	
	Dissatisfied 30%-50%	0	45.5	54.5	
	Very much Dissatisfied <30%	2.5	50.6	46.9	

Satisfaction Model Summary

Mode	R	R Square	Adjusted R Square	Std. Error of the Estimate
Satisfaction	0.074	0.005	0.003	0.54418

The R Square value of 0.005 indicates approximately 05 percent of the variation in output is explained by the age group factor. Also it is understood that there are other factors besides age group which have influences on the output produced. The differences between R Square and Adjusted R Square is very small along with error quantity indicates that the misspecification is very small.

8.1.5 Fatigue

The fifth factor of interest is the tiredness of the workers faced by the workers after working continuously or a stress. The total number of the worker's pattern of distribution of the fatigue has been shown in Table 8.9. Fatigue is divided into two answers: yes and no. Then these two replies have been analyzed against the output produced in pieces into three groups (60 to 79, 80 to 99 and more than 100 pieces). The result found is not much important since it ahs no significant relationship as shown in the Table 8.10.

Table 8.9: Fatigue distribution.

Parameter	Percent
YES	17
NO	388
Total	405

Table 8.10: Output related to Fatigue.

Fatigue	pieces produced per hour				p-value
	60-79	80-99	100+	Total	
	Percent of workers				
YES	10.0%	4.4%	3.7%	4.2%	0.612
NO	90.0%	95.6%	96.3%	95.8%	
Total	100.0	100.0	100.0	100.0	

8.1.6 Relationship with Fatigue

The sixth factor relationship to Fatigue whether it is related to health or any other external factors has been analyzed as the sixth factor and has been found not to have any significant role. Since, this parameter is a qualitative one and thus exhibits no relationship with output produced. The distribution pattern fatigue is shown in Table 8.11 and its relationship to fatigue is shown in Table 8.12.

Table 8.11: Relationship to Fatigue distribution.

	Number	Percent
Fatigue to Health condition	405	100.0

Table 8.12: Output related to relationship to Fatigue.

Relationship to Fatigue	pieces produced per hour				p-value
	60-79	80-99	100+	Total	
WITHIN HEALTH	2.5%	50.6%	46.9%	100.0%	No statistics are computed because REL_FAT is a constant.
	100.0%	100.0%	100.0%	100 0%	

8.1.7 Hours worked

The relationship to number of hours worked whether it is related to health or any other external factors of the factory has been analyzed as the seventh factor and was found not to have any significant role. Since, this parameter is a qualitative one and exhibits no relationship with output produced. Here continues period of work has been taken as three and half hours time of work. The breakdown of the number and percent of workers working continuously are shown in Table 8.13

Table 8.13: Hours worked distribution.

Continuous Period of work in hours	Number	Percent
3.5	405	100.0

Table 8.14: Output related to relationship to hours worked.

Hours Worked	pieces produced per hour				p-value
	60-79	80-99	100+	Total	
WITHIN HEALTH	2.5%	50.6%	46.9%	100.0%	No statistics are computed because hours of worked is a constant.
	100.0%	100.0%	100.0%	100.0%	

8.1.8 Compensation

It is assumed in the factory environment that the increased monetary reward or compensation package motivates the worker and its productivity increases which in turn increase the output of the factory. Keeping this view in mind the output relationship with compensation is analyzed as eighth contributing factor. The pattern distribution compensation is shown in Table 8.15. It can be seen that there exists no relationship with output which is shown in Table 8.16.

Table 8.15: Compensation distribution.

Compensation	Number	Percent
YES	394	97.3
NO	11	2.7
Total	405	100.0

Table 8.16: Output related to relationship to compensation.

Compensation		pieces produced per hour				p-value
		60-79	80-99	100+	Total	
	WITHIN	2.5%	50.8%	46.7%	100.0%	
YES		100.0%	97 6%	96.8%	97.3%	0 787
	WITHIN	.0%	45.5%	54 5%	100 0%	1 cell (16.7%) has expected count less than 5.The minimum expected count is 27.
NO		.0%	2.4%	3.2%	2.7%	

8.1.9 Comfort

Similarly, the ninth factor taken Comfort and is assumed that in the inside the factory with the increased comfort the job becomes attractive and thus the individual worker's productivity increases which in turn increase the output of the factory. With this view the output's relationship with Comfort is analyzed. The pattern distribution of comfort is shown in Table 8.17. It can be seen that there exists no relationship with output which is shown in Table 8.18.

Table 8.17: Comfort distribution.

COMFORT	Frequency	Percent
YES	390	96.3
NO	15	3.7
Total	405	100.0

Table 8.18: Output related to relationship to comfort.

Compensation		pieces produced per hour				p-value
		60-79	80-99	100+	Total	
	WITHIN	2.3%	50 5%	47.2%	100.0%	
YES		90 0%	96 1%	96.8%	96.3%	0.524 1cell (16.7%) has expected count less than 5 The minimum expected count is .37.
	WITHIN	6.7%	53.3%	40.0%	100.0%	
NO		10.0%	3.9%	3.2%	3.7%	

8.1.10 Skillness improvement

In order to increase the productivity of workers the individual skillness of the workers are needed to be improved. To look into the extent of the skillness of the workers the skillness improvement parameter is analyzed as the ninth factor. It can be seen that all of the workers responded positively. The skillness improvement distribution is shown in Table 8.19. No relationship is found as shown in Table 8.20.

Table 8.19: Skill ness improvement distribution.

	Number	Percent
YES	405	100.0

Table 8.20: Output related to relationship to skillness improvement.

IMP_SKIL	pieces produced per hour					p-value
		60-79	80-99	100+	Total	
YES	WITHIN	2.5%	50.6%	46.9%	100.0%	No statistics are computed because IMP_SKIL is a constant.
		100.0%	100.0%	100.0%	100.0%	

8.1.11 Non payment

To find views of the workers for improving their skillness and withholding their payment for a certain period of payment with their consent. The nonpayment issue has been analyzed as the eleventh factor. It can be seen that all of the workers responded positively. The nonpayment and deferred payment distribution and relationship is shown in the Table 8.21, Table 8.22, Table 8.23 and Table 8.24. No relationship is found as shown in Table 8.22 and Table 8.24. No statistics can be computed because the factor Nonpayment is found to be a constant.

Table 8.21: Nonpayment distribution.

	Number	Percent
No	405	100.0

Table 8.22: Output related to relationship to nonpayment.

NONPAY	%Output pieces produced per hour					p-value
		60-79	80-99	100+	Total	
NO	WITHIN	2.5%	50.6%	46.9%	100.0%	No statistics are computed because NONPAY is a constant.
		100.0%	100.0%	100.0%	100.0%	

8.1.12 Deferred payment

Deferred payment is the twelfth factor which has been analyzed and was found not to contribute to the increase in the output of the workers.

Table 8.23: Deferred payment distribution.

	Number	Percent
YES	405	100.0

Table 8.24: Output related to relationship deferred payment.

Deferred Payment		% Output pieces produced per hour				p-value
		60-79	80-99	100+	Total	
YES	WITHIN	2.5%	50.6%	46.9%	100.0%	No statistics are computed because deferred payment is a constant.
		100 0%	100.0%	100.0%	100.0%	

8.1.13 Qualifications

The qualification of the workers plays an important role, since uneducated person are able to learn the skills and techniques very slowly, which in turn lead the overall performance of the factory to remain in a low level. The qualifications of the workers have been classified into three tiers: below Class V, Class VI to VIII and above Class VIII. The pattern distributions are shown in Table 8.25. When the values of the output are analyzed against the qualifications it is found that there exists a significant relationship as shown in Table 8.26.

Table 8.25: Qualifications distribution.

Class interval	Number	Percent
Below class V	243	60.0
Class VI to VIII	121	29.9
Above class VIII	41	10.1
Total	405	100.0

Table 8.26: Output related to relationship to qualifications.

Qualification	% Output pieces produced per hour				p value
	60-79	80-99	100+	Total	0
Below class V	90.0%	74.1%	43.2%	60.0%	2 cells (22.2%) have expected count less than 5.The minimum expected count is 1.01.
Up to Class VIII	10.0%	13.7%	48.4%	29.9%	
Above Class VIII	.0%	12.2%	8.4%	10.1%	

Qualifications Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Qualifications	0.221	0.049	0.046	0.53218

The R Square value of 0.049 indicates approximately 4.9 percent of the variation in output is explained by the qualifications factor. Also it is understood that there are other factors besides gender which have influences on the output produced. The differences between R Square and Adjusted R Square is very small along with the error quantity indicates that the misspecification is very small.

8.1.14 Need for training

The relationship to need for training is supposed to play a key role in the improvement of the productive efficiency. Keeping this view in mind the analysis is carried out whether it is related to the overall productivity of the factory as the fourteenth factor and was found not to have any significant role. Since, this parameter is a qualitative one and exhibits no relationship with output produced No statistics can be computed because the factor of training is a constant

Table 8.27: Training needs distribution.

	Number	Percent
NO	405	100.0

Table 8.28: Output related to relationship to training.

		% Output				
Training		Pieces Produced per hour				p-value
		60-79	80-99	100+	Total	
NO	WITHIN	2.5%	50.6%	46.9%	100.0%	No statistics are computed because TRAINING is a constant
		100.0%	100.0%	100.0%	100.0%	

8.1.15 Mode of learning

The fifteenth contributory factor is the relationship of mode of learning is also supposed to play a key role in the improvement of the productive efficiency. Keeping this view in mind similar analysis is carried out whether it is related to the overall productivity of the factory and was found not to have any significant role. Since, this parameter is a qualitative one and exhibits no relationship with output produced. No statistics can be computed because the factor of training is a constant.

Table 8.29: Mode of learning distribution.

	Number	Percent
From management	5	1.2
From supervisor	306	75.6
From fellow worker	48	11.9
Self made	46	11.4
Total	405	100.0

Table 8.30: Output related to relationship mode of learning.

	% Output				
Learning	**pieces produced per hour**				**p-value**
	60-79	80-99	100+	Total	
From Management	.0%	1.0%	1.6%	1.2%	0 .973 5 cells (41.7%) have expected count less than 5. The minimum expected count is .12.
From Supervisor	70.0%	76.1%	75.3%	75.6%	
From fellow Worker	10.0%	12.2%	11.6%	11.9%	
Self made	20.0%	10.7%	11.6%	11.4%	

CHAPTER IX

PRODUCTIVE EFFICIENCY GROWTH

9.1 GROWTH ESTIMATION

To run the factories efficiently, besides knowing the productivity indices, sometimes it may also be useful to get ideas about the changes in the productivity, which is, whether the productive efficiency is increasing or decreasing over a period of time, so that the performance of the overall follow up process can be tracked accurately.

The data for the month of January and February are shown in Table 9.1 and the productivity growth is shown in Table 9.2. Like wise in the following tables from 9.1 to 9.22 from growth estimation has been carried out considering the values of two months at a time from January to December and growth estimation for the successive two month period are shown accordingly. The values Malmquist Index, Efficiency Change and Frontier Shift has been calculated for both input and output oriented constant return to scale, using the software developed by Zhu[129]. The value(s) of Malmquist Index greater than unity indicates the growth and equal value no change in efficiency and less than value(s) of Index presents decay in the growth process.

Table 9.1: Data set for period January- February.

Name of the period	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
January	1841091	2629881	520	900050
February	1897942	2625892	528	850002

Table 9.2: Malmquist Index for January-February.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	1.074	1.000	1.074
Output Oriented CRS	0.931	1.000	0.931

Table 9.3: Data set for period February-March.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
February	1897942	2625892	528	850002
March	1867703	2658963	523	880500

Table 9.4: Malmquist Index for February-March.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	0.964	1.000	0.964
Output Oriented CRS	1.038	1.000	1.038

Table 9.5: Data set for period March-April.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
March	1897942	2625892	528	850002
April	1804071	2625101	516	880005

Table 9.6: Malmquist Index for March-April.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	0.977	1.000	0 977
Output Oriented CRS	1.023	1.000	1.023

Table 9.7: Data set for period April-May.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
April	1804071	2625101	516	880005
May	1884775	2636582	527	850000

Table 9.8: Malmquist Index for April-May.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	1.061	1.000	1.061
Output Oriented CRS	0.943	1.000	0.943

Table 9.9: Data set for period May-June.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
May	1884775	2636582	527	850000
June	1836728	2653422	524	880005

Table 9.10: Malmquist Index for May-June.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	0.957	1.000	0.957
Output Oriented CRS	1.045	1.000	1.045

Table 9.11: Data set for period June-July.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
June	1836728	2653422	524	880005
July	1898292	2630301	529	980000

Table 9.12: Malmquist Index for June-July.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	0.909	1.000	0.909
Output Oriented CRS	1.100	1.000	1.100

Table 9.13: Data set for period July-Aug.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
July	1898292	2630301	529	980000
August	1839901	2614431	525	900088

Table 9.14: Malmquist Index for July-Aug.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	1.069	1.000	1.069
Output Oriented CRS	0.936	1.000	0.936

Table 9.15: Data set for period Aug-Sep.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
August	1839901	2614431	525	900088
September	1892231	2658972	527	998000

Table 9.16: Malmquist Index for Aug-Sep.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	0.961	1.000	0.961
Output Oriented CRS	1.091	1.000	1.091

Table 9.17: Data set for period Sep-Oct.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
September	1892231	2658972	527	998000
October	1800012	2670322	513	905600

Table 9.18: Malmquist Index for Sep-Oct.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	1.077	1.000	1.077
Output Oriented CRS	0.928	1.000	0.928

Table 9.19: Data set for period Oct-Nov.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
October	1800012	2670322	513	905600
November	1852061	2602561	524	950888

Table 9.20: Malmquist Index for Oct-Nov.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	0.954	1.000	0.954
Output Oriented CRS	1.049	1.000	1.049

Table 9.21: Data set for period Nov-Dec.

Name	(I) Salary	(I) Factory cost	(I) Employees	(O) Prod Qty
November	1852061	2602561	524	950888
December	1848022	2635862	520	945862

Table 9.22: Malmquist Index for Nov-Dec.

	Malmquist Index	Efficiency Change	Frontier Shift
Input Oriented CRS	1.008	1.000	1.008
Output Oriented CRS	0.992	1.000	0.992

In the Table 9.23 four firms Year 1 data have been shown and in Table 9.24 the same firms' data for the next year have been shown.

Table 9.23: Data set for period 1.

Name	(I) Factory expenses	(I)Employees	(I)Fixed Asset	(O) Sales
Ibrahim Cotton	604.86	683	940	960.78
PaharTali Textille	3833.01	1587	368.68	4561.97
Ashraf Textile	3662.93	2163	4948.3	5239.21
Anlima Yarn	47.815673	230	309.367	149.196

Table 9.24: Data set for period 2.

Name	(I)Factory expenses	(I)Employees	(I)Fixed Asset	(O) Sales
Ibrahim Cotton	751.76	673	939.75	897.98
PaharTali Textile	4149.83	1595	365.47	5138.83
Ashraf Textile	3199.7	2118	4583.97	5078.03
Anlima Yarn	49.34	229	322.34	151.58

The Output oriented Malmquist Index values for two consecutive years have been shown in Table 9.25.

Table 9.25: Malmquist index for productivity changes.

Sl #	Name of the Firms	Output-Oriented CRS Malmquist Index	Efficiency Change	Frontier Shift
1	Ibrahim Cotton	0.799	0.768	1.040
2	Pahar'l ali Textile	1.088	1.00	1.088
3	Ashraf Textile	1.067	1.00	1.067
4	Anlima Yarn	0.992	1.00	0.992

RESULTS AND ANALYSIS:

In case of input oriented cases and compared between two consecutive months of input-output data the following months have been found to exhibit growth in the productivity:

a) January -February

b) April-May

c) July-August

d) September-October

e) November-December

In case of output oriented cases and compared between two consecutive months of input-output data the following months have been found to exhibit decay in the productivity:

a) February-March

b) March-April

c) May-June

d) June-July

e) August-September

f) October-November

Also the efficiencies and frontier shifts are shown accordingly. It can also be seen that only when the Malmquist Index number is greater than unity then only there is a growth in the overall productivity.

CHAPTER X

WEIGHT RESTRICTIONS AND VALUE JUDGEMENT

10.1 EXPERT OPINIONS

A set of production unit in which a production unit (say A) is inefficient if a composite unit (linear combination of units in the set) can be identified which utilizes less input than the A unit while maintaining at least the same output levels. The units involved in the construction of the composite unit can be utilized as benchmarks for improving the inefficient A unit. DEA also allows for computing the necessary improvements required in the inefficient unit's inputs and outputs to make it efficient. It should be noted that DEA is primarily a diagnostic tool and does not prescribe any reengineering strategies to make inefficient units efficient. Such improvement strategies must be studied and implemented by managers by understanding the operations of the efficient units [113].

In this chapter it has been tried to discuss the concept of employing weight restrictions to the linear equations, so that the weights could not take arbitrary zero or absurd values. Data Envelopment Analysis is basically a technique for choosing the coefficients of the inputs and outputs under consideration so that the individual production unit maximizes its productivity. Thus in calculating the relative productive efficiency of a production unit, the unit under consideration automatically adopts arbitrary such weights to the individual inputs and outputs so that the ratio of its weighted output to weighted input is maximized. In earlier analysis the process was fully flexible to allow the units to achieve relatively high efficiency scores by taking sometimes infeasible input and output factor weights. Based on the previous analysis it is observed that up to certain extent imposing factor restrictions may be needed through integration of managerial preferences in terms of relative importance levels of various inputs and outputs. When formulating the linear equations two constraints are usually applied. One is that the weights should be nonzero and the other is that the productive efficiency of none of the units should exceed unity. This allows each unit to achieve the maximum feasible efficiency rating with its existing levels of inputs and outputs. An argument in favor of total weight flexibility is that if a unit is identified as inefficient in spite of using a favorable set of weights, it is a strong statement about the inefficiency of that unit. Another argument in favor of total flexibility is that the efficiency of different unit is evaluated using different sets of weights allowing the unit to express their different circumstances and different objectives.

In carrying out the analysis it has been observed that weight flexibility allows different units to assign vastly different weights to the same factor. Thus, some degree of weight flexibility may be desirable to allow units to reflect their particular circumstances. However, complete flexibility becomes unacceptable as most of the units employ similar technologies. pay similar prices for inputs, produce the same kind of outputs and have the same overall objectives. The intention of incorporating value judgments is to incorporate prior views or information regarding the assessment of efficiency of the units.

However. total flexibility for the weights has been criticized on several grounds:

1) Factors of secondary importance may dominate a DMU's efficiency assessment. If the inputs and outputs included in the analysis are not equally important, it is not sensible to claim that a DMU is relatively efficient if the weights assigned to the important inputs and outputs are zero. The total flexibility of the unbounded model may lead to an unfounded emphasis on efficient use of relatively unimportant inputs or the production of relative unimportant outputs, concealing inefficiencies in the most important activities undertaken by the unit.

2) Important factors may be all but ignored in the analysis. Some inputs and output measures may not be considered when assessing the relative efficiency of some DMUs. As a result, the relative efficiency of a DMU may not really reflect its performance on the inputs and outputs taken as a whole.

3) The implicit assumption made when allowing weight flexibility in DEA is that the DMUs analyzed may have individual objectives and particular circumstances that should be considered when assessing them. Since the DMUs compared using

DEA are homogeneous units, in the sense that they produce the same kind of outputs and have the same overall objectives, it may be unacceptable to assume that the relative importance attached to the different inputs and outputs by each unit should differ greatly. Although some degree of flexibility on the weights may be desirable for the DMUs to reflect their particular circumstances, it may often be unacceptable that the weights should vary substantially from one DMU to another.

4) In some cases, a certain amount of information regarding the importance of inputs and outputs might be available. In this case, it would seem sensible to take advantage of the information in deriving estimates of relative efficiency. Therefore, there is a dilemma. On one hand, some degree of flexibility is desirable, since variations in factor weights may reflect different circumstances and different objectives of the DMUs being assessed, and because there is imperfect information about the values to assign to weights. On the other hand, total flexibility can disguise serious price inefficiencies in some units [14].

The most important is that the complete lack of flexibility, which converts the problem to that of ratio analysis and obviates the need for DEA. Therefore the aim is to be such that to set the upper and lower bounds within which factor weights are allowed to vary. The imposition of restrictions on the weights implies the formulation of value judgments about the relative importance of the different outputs and about the relative opportunity costs of the inputs that produce these outputs. By assigning specific values to weight bounds, the decision-maker can express his/her opinion about the relative importance of the factors. In this way weight restriction models. overcome the drawback of unbounded models of not allowing a priori information to be incorporated in the analysis.

To assess the relative productive efficiency of various firms is basically calculating the weights needed to be put before the different inputs and outputs so that to maximize the individual productivity of the firms. This could be done based on two broad classifications. On is subjective approach and the other is objective approach. The subjective approaches include the Analytic Hierarchy Process, Delphi method, Weighted least square method etc. The objective approaches include Date Envelopment Analysis , Principal Component Analysis, Entropy

Method and Multiple Objective Programming. Subjective approaches determine weights that reflect subjective judgment. but those weights can be influenced by the individual firms Objective approaches determine weights by making use of mathematical models, but they neglect subjective judgment]. Although weight restrictions effectively discriminate between efficient and inefficient units, ranking DMUs can still be an issue.

In the following discussion the objective is to analyze various methods that can be exercise in the adoption of weight application:

10.1.1 Approach A: setting upper and lower bounds.

This approach was initially developed by Dyson and Thanassoulis[1998] and generalized by Roll, Cook and Golany [101]. In this approach the restrictions are of the type:

$$\alpha_i \leq v_i \leq \beta_i \quad \text{for input i}$$

$$\alpha_r \leq \mu_r \leq \beta_r \quad \text{for output r}$$

As can be seen, the restrictions impose numerical limits on the weights. The purpose of these limits is to ensure that some or all variable inputs and outputs would not be overestimated or ignored in the analysis. The values of the bounds depend on the context and on the information provided by an expert. Such bounds could be established only after analyses of the resulting weights of the original DEA problem, i.e., the problem was performed without restrictions. It is important to note that these models produce different efficiency scores depending on the orientation (input or output) of the model, even when using constant returns to scale. To apply this type of weight restrictions, we must run the DEA classic model to determine the weight dimensions for each variable (because it depends on the magnitude of the variable). Only after the analysis of the weights for all variables and all DMUs, are the restrictions introduced. If the model results are unfeasible, we can relax the restrictions until the unfeasibility disappears. Weight restrictions allow for the integration of managerial preferences in terms of relative importance levels of various inputs and outputs For example, if output 1 is at least twice as important as output 2 then this can be incorporated into the DEA model by using the linear constraint $v_1 > 2v_2$.

i) Maximum and minimum values are known beforehand :

When the maximum and minimum weights are known beforehand to the production managers, these values can be applied as constraints to the DEA model, so that the input and output values could not take any of the extreme or inappropriate values i.e. these constraints may prevent the inputs or outputs from being over or under emphasized.

ii) Maximum and minimum values are not known beforehand:

The maximum, minimum and average values which have been obtained by running the model may be used by applying proper judgments to determine the range for the weights [14].

10.1.2 Approach B: Assurance Region concept

The Assurance Region or AR method was developed by Thompson et.el.[115]. They used DEA to analyze six Texas sites for location of a high energy Physics lab called Super colliding Super Conductor or simply SSC which was directed to advancing fundamental knowledge in Physics. Five of the six sites were DEA efficient. This was not satisfactory so they then used survey data and expert opinion to specify bounds for the virtual multipliers or the constraints. The AR method identified only one efficient DMU for the location of SSC and this site was selected by Texas and won in a national competition award,-conducted by the US Department of Energy in 1988 as the location for the SSC.

In choosing the optimal weights for the inefficient units there are many zero values as the coefficients of the inputs and outputs. The AR comes from the concept of limiting the regions of weights to some special regions based on a number of calculations carried out by the experts in the relevant field The AR model can be mathematically expressed as follows:

$$\text{Max} \quad \sum_{r=1}^{s} \mu_r y_{r0} \tag{10.1}$$

Subject to:

$$\sum_{i=0}^{m} v_i x_{i0} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{r0} - \sum_{i=1}^{m} v_i x_{i0} \leq 0, \; j = 1, \text{------------}, n$$

$$A_i \leq \frac{v_i}{v_t} \leq B_i \qquad i < k, \; i,k = 1, \text{-----} m$$

$$a_r \leq \frac{\mu_r}{\mu_t} \leq b_r \qquad r < t, \quad r, t = 1, \text{----} s$$

$$v_i, \mu_r \leq -\varepsilon \qquad i = 1, \text{------} m \; ; \; r = i, \text{----} s$$

where A_i and B_i are the lower and upper bounds on the ratios of input weights and a_r and b_r are the lower and upper bounds on the ratios of output weights.

Rearranging the terms in the above model we get the following most commonly used form of AR constraints:

$$a_r \mu_1 \leq \mu_r \leq b_r \mu_1 \qquad r = 2, \text{-----}, s$$

$$A_i v_1 \leq v_i \leq B_i v_1 \qquad i = 2, \text{---}, m$$

where the value for a, b, A and B be provided by the expert.

10.1.3 Approach C: Cone Ratio model

The cone-ratio model is a method involves generating a cone spanned by the optimal virtual multipliers of efficient DMUs which satisfy certain conditions specified by the decision-maker. The following example may be useful to illustrate the concept of convex cones graphically. The situation of apparel industry in Bangladesh could be analyzed when two inputs are considered- the labor and the automation. In the areas such as the export processing zones where foreign investment are allowed with certain benefits to the investors, e.g. tax holiday, etc. In such zones due to employment of huge capitals by the foreign investors auto machineries gets the priorities over the labor intensive processes. Thus the management founds it more advantageous to use more and more machine hours compared to the labor hours. On the contrary most of the local industries that have the shortage of capitals generally depend more upon using labors. There is another class of industries those want to use more labor hours utilizing less quantity of machine hours. Thus different combinations are possible with two inputs----one is labor hours and other is machine hours. Usually we have the apparel industries situated in Savar EPZ, in an around Savar and Ashulia areas, in the heart of the capital city Dhaka, Narayanganj, Chiattagong, and very few are placed in the other parts of the country.

In the Figure 10.1 the scatter plot of the industries is shown with the production possibility set identifying efficient and inefficient factories using two types' inputs- labor hours and machine hours. The convex cones have been used to linearly partition the management styles based on certain possible combinations of labor and machine hours. For example, the line connecting the origin and the point A represents all points that use the two inputs in the same ratio as A. Similarly, the line connecting the origin and the point B represents all points that use the inputs in the same proportion as B. Therefore, a factory lying inside the "F2" cone will have a ratio of machine hours to labor hours that lies between the corresponding ratios for factories A and B. Similar other styles can be drawn, such as C, etc. Thus, although all factories on the efficiency frontier are technically efficient, not all of them have same management styles that would satisfy the company management. This points out the weakness of using unbounded DEA models when decision-makers have certain preferences or when information about prices exists. Cone-ratio constraints eliminate this drawback of standard models by allowing cones of virtual multipliers to be defined so that decision makers can incorporate qualitative or price information into the analysis.

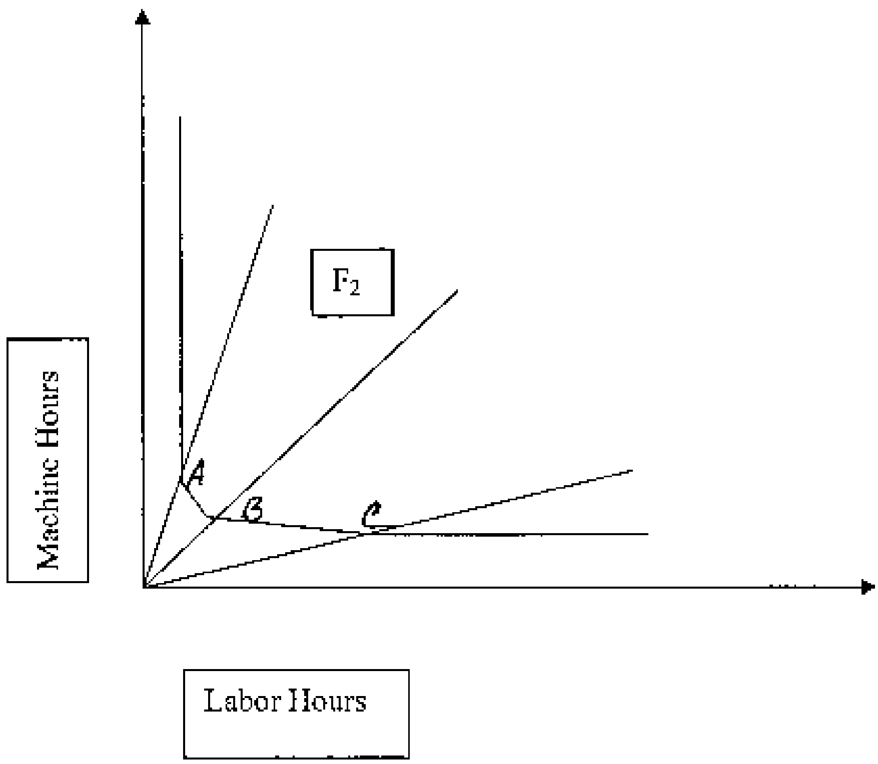


Figure 10.1: Assurance Region (Geometric Representation of Convex Cones).

Suppose that v_1 and v_2 are input coefficients and let the management of the particular company sets the following limits as $c_1 \leq \frac{v_1}{v_2} \leq c_2$, where $c_2 \geq c_1 > 0$.

Then we have,

$-v_1 + c_1 v_2 \leq 0$ and $v_1 - c_2 v_2 \leq 0$.

When the input-output weights are enclosed in cones. the resulting cone- ratio DEA model is as follows:

Maximize $\mu^T Y_0$ (10.2)

subject to $v^T X_0 = 1$

$-v^T X + \mu^T Y \leq 0$

$v \in v$, $\mu \in \mu$

where X(mxn) and Y(sxn) are input and output vectors respectively and μ(s x j) and v(m x j) are the output and input weights respectively.

10.1.4 Approach D: Fuzziness

To deal with uncertainty of the weights in the models it appears that the concept of fuzzy sets is needed to be introduced. Fuzzy sets are the sets with boundaries that are not precise. "The membership in a fuzzy set is not a matter of affirmation or denial, but rather a matter of degree." Fuzzy sets may be defined in the following manner: When A is a fuzzy set and x is a relevant object, the proposition "x is a member of A" is not necessarily either true or false, as required by two-valued logic, but it may be true only to some degree - the degree to which x is actually a member of A.

The degrees of membership in fuzzy sets are most commonly expressed by numbers in the closed unit interval [0, 1]. Thus fuzzy sets express gradual transitions from membership (membership value of 1) to non-membership (membership value of 0) and vice versa. A membership function is a function which assigns to each element x of X a number, μA(x), in the closed unit interval [0,1] that characterizes the degree of membership of x in A. The closer the value of μ□(x) is to one, the greater the membership of x in A. Thus, a fuzzy set A can be defined precisely by associating with each element x, a number between 0 and 1, which represents its grade of membership in A. The membership function of a fuzzy set A can also be represented as A(x).

To completely describe triangular membership functions we need to specify the following:

The most desirable value, which gets a membership grade of 1;

Two least desirable values - one on either side of the most desirable value which are assigned membership grades of 0, and the form of the membership function as it varies between the most desirable and the least desirable values.

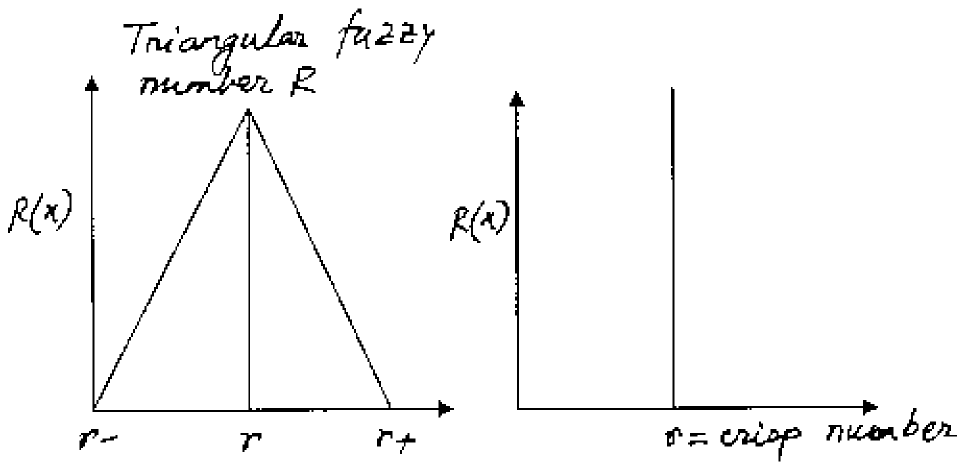


Figure 10.2: Membership function.

The most commonly used shapes for fuzzy numbers are the triangular. The triangular functions express the proposition close to real number r. Both the fuzzy number and crisp numbers are shown graphically in Figure 10.2.

When the concept of fuzziness in introduced in the existing Data Envelopment Analysis model the model then is not a uniquely defined type of model rather the model might take many possible variations, depending on the assumptions or features of the real situation being modeled.

In developing the DEA model it have been considered that all the coefficients of the objective function and constraints are crisp numbers, but introducing the fuzzy concepts Zimmerman [130] has suggested the following possible variations:

Firstly, the decision-maker might not want to actually maximize or minimize the objective function. He/she might just be interested in "improving the present cost situation." Therefore, he/she might end up specifying some aspiration levels for the objective function that may not be definable crisply.

Depending upon whether the objective function is crisp or fuzzy and according to the thought developed by Zimmerman [130] the Fuzzy DFA can be classified into two types as follows:

a) when both the objective function and the constraints are fuzzy.

b) when the constraints are fuzzy but the objective function is crisp.

a) In this model, it is assumed that the decision maker can establish an aspiration level. z, for the value of the objective function and that each of the constraints is modeled as a fuzzy set. The fuzzy LP then becomes:

$c^T x \geq z$

$Ax \leq b$

$x \geq 0$

Zimmerman [130] assumes $\mu A(x)$ to take a value 0 if the constraints (or the objective function) are strongly violated and a value 1 if they are very well satisfied i.e. satisfied in the crisp sense. The values between 0 and 1 represent the "in between" satisfaction.

$$\text{maximize} \quad \frac{\mu^T Y_0}{\nu^T X_0} \qquad (10.3)$$

$$\text{subject to} \quad \frac{\mu^T Y}{\nu^T X} \leq 1$$

$LB_r \leq \mu_r \leq UB_r \qquad \forall_r$

$LB_i \leq v_i \leq UB_i \qquad \forall_i$

where

Y = set of output values

X= set of input values and LB and UB stands for lower bound and upper bounds respectively.

10.1.5 Approach E: Absolute Weight Restriction DEA.

The implementation of the fuzzy model has the following steps [98a]:

Step 1: To collect and place the raw data in a tabular form.

Step 2. To run the unbounded model and determine the most and least desirable bounds.

The data presented in table are plugged into a CCR model without weight restrictions. The optimal input/output weights and efficiency scores for all DMUs calculated by the CCR model are presented in a table. Looking at the table it can be seen that on numerous occasions, some inputs and/or outputs took zero weights.

Step 3: To eliminate the extreme values. In the table the values marked with a * are the ones that are eliminated.

Step 4: To take the average of the remaining values. The averages r u and i v of the remaining values of all weights are taken. The averages are also presented in the table in the row titled "Average after Truncation."

Step 5: Choose the desirable ratio between the largest and the smallest weight values. This will be the same as the ratio between the upper and lower bounds and will be used to determine the bound values based on the averages. Roll and Golany [98a] use two different ratios, 2:1 and 3:1 to determine two different sets of bounds and produce two different sets of efficiency scores.

Step 6: To determine the values of the bounds. Using a value of d=2 and using the formulas.

Step 7: To Solve the fuzzy model.

10.1.6 Proposed method for finding upper and lower limits.

As usual the linear equations are solved and the efficient unit or units are determined. If there is one efficient unit then we may follow the same weights for the remaining inefficient units or production.

If the number of efficient units are greater than or equal to 2, then we may use the mean values of the all the input weights and mean values and the standard deviations of the output weights of all the output weights separately.

Thus in the above model the upper and lower limits for may be fixed as follows:

Let us say,

Input mean = u_m

Input standard = s_i

Output mean= v_m

Output standard = s_m

Then the

Input lower limit will be $A_i = v_m - s_m$

Input upper limit $Bi = v_m + s_i$

Output lower limit will be $a_r = u_m - s_i$

Output upper limit $br = u_m + s_i$

In the table below the two inputs and one output values have been taken data from twelve factories. The productive efficiency scores and ranking are calculated and shown in Table 10.2 and 10.3. In Figure 10.1 graphically the productive efficiency scores have been shown.

Table 10.1: Data for twelve factories.

Factory	(I)Input-1	(I)Input-2	(O)Output-1
A	20	151	100
B	19	131	150
C	25	160	160
D	27	168	180
E	22	158	94
F	55	255	230
G	33	235	220
H	31	206	152
I	30	244	190
J	50	268	250
K	53	306	260
L	38	284	250

Table 10.2: Productive efficiency scores.

No.	DMU	Score	Rank
1	A	0.94	7
2	B	1	1
3	C	0.89	9
4	D	1	1
5	E	0.86	11
6	F	0.93	8
7	G	1	1
8	H	0.64	12
9	I	0.88	10

10	J	1	1
11	K	1	1
12	L	1	1

Table 10.3: Rank

Rank	DMU	Score
1	L	1
1	K	1
1	B	1
1	J	1
1	D	1
1	G	1
7	A	0.94
8	F	0.93
9	C	0.89
10	I	0.88
11	F	0.86
12	H	0.64

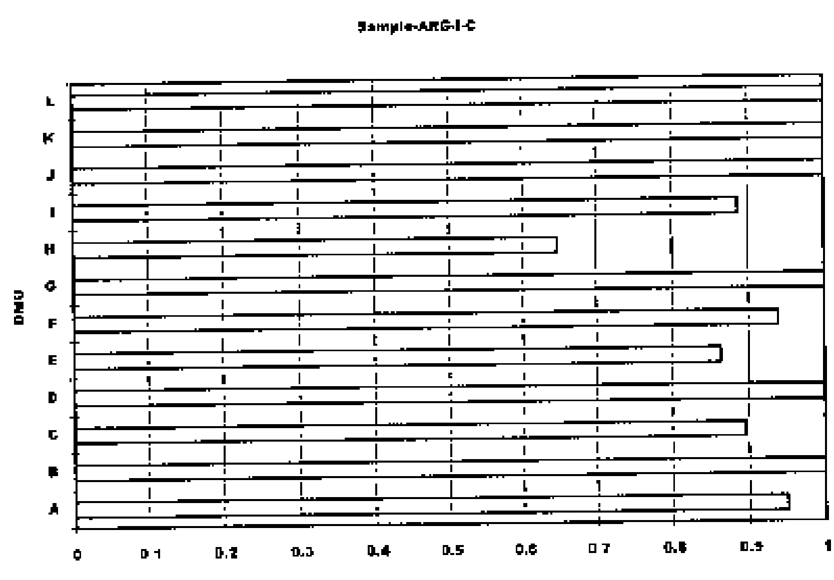


Figure: 10.3: Bar graph Score in descending order.

In Table 10.4 the same set of data have been shown after incorporating Assurance Region in the two input quantities values i.e. for Input 1 the region is 0.5 to 0.8 and for Input 2 the region is 0.2 to 0.3. After running with this value the productive efficiency scores and the ranking is shown in Table 10.5 and Table 10.6.

Table 10.4: Data with AR.

DMU	(I)Input-1	(I)Input-2	(O)Output-1
A	20	151	100
B	19	131	150
C	25	160	160
D	27	168	180
E	22	158	94
F	55	255	230
G	33	235	220
H	31	206	152
I	30	244	190
J	50	268	250
K	53	306	260
L	38	284	250
0.5	(I) Input-1	0.8	
0.2	(I) Input-2	0.3	

Table 10.5: Score with AR.

Sl. No.	DMU	Score	Rank
1	A	0.93	6
2	B	1	1
3	C	0.85	8

4	D	0.95	5
5	E	0.85	9
6	F	0.73	11
7	G	0.98	4
8	H	0 63	12
9	I	0 86	7
10	J	0.84	10
11	K	1	1
12	L	1	1

Table 10.6: Rank with AR.

Rank	DMU	Score
1	L	1
1	K	1
1	B	1
4	G	0.98
5	D	0.95
6	A	0.93
7	I	0.86
8	C	0.85
9	E	0.85
10	J	0.84
11	F	0.73
12	H	0.63

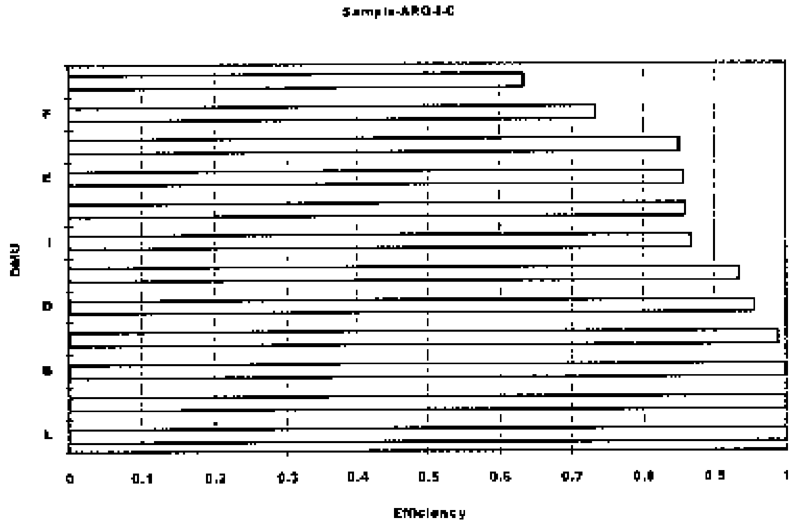


Figure 10.4: Bar graph Score with AR.

CHAPTER XI

CONCLUSIONS AND RECOMMENDATIONS

11.1 CONCLUSIONS

The study has been carried out with a view to develop a productive efficiency model for the apparel industry by employing a two step methodology to investigate the performance of individual unit and assess the determinants of factors which positively or negatively influence the productivity of the factory------ both in terms of manpower and technology utilized and the maximum possible quantity of pieces, which can be produced. Thus the defective items remain at an acceptable level and rework of the items falls gradually. Window analysis has been carried out with twelve months data with four types of model: constant and variable returns to scale, and input and output oriented models. Three inputs: salary and overtime expenses, factory cost and number of employees and single output: production quantity produced in pieces have been taken into account. For both the cases of input oriented and output oriented constant returns to scale, the production month of September came out as the most efficient production month. But in case of variable returns to scale, out of twelve months, six months: April, July, September, October, November and December came out as the most efficient production months.

The explanation of the scores of the productive efficiencies using correlations and regressions exhibit the role played or efficiency of management. This also interprets the significance of various factors affecting the productivity as an indication of higher profitability. In order to find which factors influence the productive efficiency of any apparel industry, a questionnaire incorporating multiple factors (shown in Appendix A) has been developed and the factory workers have been interviewed. After obtaining detail answers, Chi-Square test has been done and correlations have been calculated. The important parameters which are significant contributors to the productive efficiency have been identified. The analysis was done running the software SPSS 11.5 version.

Fifteen factors such as: Gender, Age Group, Work Experiences, Level of satisfactions, Fatigue, Relation with Fatigue, Number of hours worked, Compensation, Comfort, Skill improvement, Nonpayment, Deferred payment, Qualifications, Need for training, Mode of learning, were analyzed against the output produced. It has been found that the following factors have positive influences on the output produced: Gender, Age Group, Work Experiences, Satisfactions of the workers and Qualifications of the workers. From the values after conducting individual linear regressions it has been found that approximately 3.4 percent of the variation in output is explained by the gender factor, approximately 4.2 percent of the variation in output is explained by the age group factor, approximately 3 7 percent of the variation in output is explained by the work experiences, approximately 0 05 percent of the variation in output is explained by the satisfactions, 4.9 percent of the variation in output is explained by the qualifications factor. Also it is understood that there are other factors besides these contributing factors which have influences on the output produced. The differences between R Square and Adjusted R Square are very small. The error quantity indicates that the misspecification is very small. It can be seen that in the higher producing categories, the percentage of male workers are increasing proportionately i.e. the male workers are performing better than their counterpart.

Once the efficient unit is known, it could be referred to as benchmark for other units. At the same time, the inefficient units could elevate their efficiencies with respect to this benchmark. The DEA is basically a process of attaching necessary coefficients to the inputs and outputs. But when the factors' weights came as zero or absurd values, this indicates imposing careful restrictions. Thus this study could be extended to fix this problem through incorporating judgmental values which may be obtained from the experts in this field or data collected from the markets. Also knowing various factors, which affect the efficiencies, finding the relationship might be helpful, which in turns contributes towards raising the productive efficiency of the individual units of production. Also there remains the scope for further study relating to the Health and other environmental conditions. The model developed and utilized in this study is quite a helpful tool in comparing the productive efficiency of the units to be evaluated. With the data set in hand, the window analysis is carried out i.e. the twelve months input and output data of the same factory were analyzed, and performance of each of the time period is obtained. The most efficient period thus obtained may be referred to the remaining periods as the benchmark. Customized software has been used here to evaluate the efficiency scores. Productive efficiency scores have been calculated both for input and output orientation and constant and variable returns to scale; thereafter scale efficiency has been calculated. After combining the input and output models into an additive model, the slack based model has been used decreasing the output slack values simultaneously increasing the input slack values. For these calculations, the data from knitting, woven and sweater factories have been used. In most of the cases, the results show that input and output values take arbitrary weights in finding the efficiency scores indicating the need for imposing restrictions through careful judgments.

11.2 RECOMMENDATIONS

The apparel industry is considered to be the number one foreign exchange earning sector, thus more emphasis needs to be given by the policy makers as well as the producers. Usually, the Time and Motion study is used to evaluate the individual performance of the worker and the time needed to complete the required activities. Based on this information the producers set the standard time needed to complete a particular design of apparel, workers skill rating and overall productivity of the production process. But as has been observed, this technique is very much tedious and at the same time involves human error. This study recommends using the DEA model, which is very much flexible. The analysis can be carried out with the existing input and output data available to the management. With this model, the overall performance can be evaluated with less complexity.

Therefore, the following recommendations are made:

1. In the analysis of constant and variable returns to scale, three inputs and a single output have been considered. This analysis can be carried out using different number of input and output combinations, e.g. delivery time can be considered as an output quantity.

2. The efficient frontier can be drawn adding the salary cost with factory cost to become total cost considering two different inputs producing one single output, and the outcome of the analysis can be discussed.

3. The data set considered have been collected from around the greater Dhaka city. The analysis may be carried out collecting the data from outside the Dhaka city e.g. Chittagong and other parts of the country.

4. In finding the factors, responsible for augmenting the productive efficiency of the Apparel factories, fifteen factors have been considered, mostly related to labor productivity of the workers and working conditions of the factory. Other factors such as style of leadership, management quality etc. may be incorporated.

5. Multiple Regression Analysis may also be applied taking into account all the parameters which may influence the output of the factory.

6. In order to relate the productive efficiency scores with the factors which are supposed to contribute towards their augmentation, a censored regression analysis may be carried out, since the PE values are discrete in nature and can vary from zero to unity.

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APPENDIX A

1. The purpose of this questionnaire is to find the information that affect positively or negatively the productivity of the factory.

2. Nowhere in the questionnaire space is kept for name, address, signature of the persons answering these questions. Thus the personal identity of those persons could not be established through this information. Moreover, it is thus assured that assure that these information in no way would reach the management/owner of the factory and thus no probability exists which might harm the job of the individuals or the groups.

3. I gratefully acknowledge the receipt of the contributions of the persons those who have answered these questions and assure them that these data would be used only for my PhD dissertation/research purpose and subsequently to the publications thereafter.

****

Factory Code:

Person ID:

Please put tick mark as you find appropriate or filled in the box as asked:

1. Gender: Male ☐ Female ☐

Contd.

2. Age: below 18 [ ] 18-25 [ ] 26-30 [ ]

31-40 [ ] 41 and above [ ]

3. How long you are working in these factory days/months/years? [ ]

4. How many pieces of products you are able to produce/finish/inspect as per your job description ? [ ] per hour

5. Name the factors which directly affects your work?

(a) Electricity
(b) Water
(c) Proper lighting.
(d) Machine condition
(e) Supervisor's control
(f) Salary
(g) Family conditions
(h) Distance of house from factory i.e. factory reaching
(i) In-house fellow workers influences
(j) Outside environment
(k) overall factory working conditions

Contd.

6. Are you satisfied with the present condition

- [ ] 0% - 30%
- [ ] 31% - 50%
- [ ] 51%- 60%
- [ ] 61% - 80%
- [ ] 81% - and above

7. Do you think the workload in heavy for your? [ ] Yes [ ] No

8. Do you get easily tried and fatigue? [ ] Yes [ ] No

9. If yes do you think your tiredness is related to factory conditions or your health [ ] Health [ ] Factory Con

10. How many hours do you think you could work without being stopped

[ ] 1 hr [ ] 1 hr. 30 m

[ ] 2 hrs. [ ] 2 hrs. 30 m

Contd.

☐ 3 hrs ☐ 3 hrs 30 m

☐ 4 hrs ☐ 4 hrs 30 m

☐ 5 hrs ☐ 5 hrs 30 m

☐ 6 hrs ☐ 6 hrs or more

11. Do you think the compensation provided by this factory is at par with the average industry payment? ☐ Yes ☐ No

12. Do you think you are quite comfortable with your present rank/category of your job? ☐ Yes ☐ No

13. Do you think you need to improve your Skillness/capacity? ☐ Yes ☐ No

14. If yes, what is your suggestion for improvement of your skillness/capacity?

a) Through working in the present rank for few weeks and not receiving any payment ☐ Yes ☐ No

Contd

b) Ready to receive training and agree to deduct from your future salary ☐ Yes ☐ No

15. State your qualifications

☐ Never been to school

☐ Below class V

☐ Class VI/Class VIII

☐ Class X/SSC/HSC/Higher

16. Have you received any formal training ? ☐ Yes ☐ No

17. From whom did you learn in this type of work?

☐ From factory owner

☐ From Management people

☐ From Supervisor

☐ From worker

☐ From Outside people

☐ Self made

Thanking you for your kind co-operations.

APPENDIX B

personid	gender	age	workexp	prod	elec	water
1001	2	19	12.0	80	1	1
1002	2	20	12.5	85	1	1
1003	2	22	13.0	120	1	1
1004	2	20	14.0	75	1	1
1005	2	20	14.0	100	1	1
1006	2	25	14.0	101	1	1
1007	2	24	14.0	125	1	1
1008	2	25	13.5	85	1	1
1009	2	19	13.5	85	1	1
1010	2	20	12.5	86	1	1
1011	2	21	11.5	84	1	1
1012	2	22	11.5	87	1	1
1013	2	23	10.5	65	1	1
1014	2	22	10.5	65	1	1
1015	2	22	10.5	63	1	1
1016	2	21	11.3	64	1	1
1017	2	25	14.0	78	1	1
1018	2	21	14.0	79	1	1
1019	2	21	14.0	89	1	1
1020	2	22	10.5	85	1	1
1021	2	22	11.0	65	1	1
1022	2	23	11.0	76	1	1
1023	2	23	12.0	97	1	1
1024	2	23	12.0	96	1	1
1025	2	23	12.0	97	1	1
1026	2	23	11.0	97	1	1
1027	2	25	11.5	98	1	1
1028	2	25	13.5	99	1	1
1029	2	25	13.5	100	1	1
1030	2	25	13.5	102	1	1
1031	2	25	14.0	104	1	1
1032	2	25	14.0	105	1	1
1033	2	25	14.0	106	1	1
1034	2	25	14.0	85	1	1
1035	2	25	14.0	85	1	1
1036	2	25	14.0	88	1	1
1037	2	25	14.0	88	1	1
1038	2	25	14.0	88	1	1
1039	2	24	14.0	89	1	1
1040	2	24	14.0	85	1	1
1041	2	24	14.0	86	1	1
1042	2	24	13.5	87	1	1
1043	2	24	13.5	84	1	1
1044	2	24	13.5	81	1	1
1045	2	24	13.5	82	1	1

personid	gender	age	workexp	prod	elec	water
1046	2	24	14.0	88	1	1
1047	2	24	14.0	89	1	1
1048	2	24	12.5	86	1	1
1049	2	24	12.5	85	1	1
1050	2	24	12.5	82	1	1
1051	2	23	12.5	83	1	1
1052	2	23	12.5	86	1	1
1053	2	23	12.5	89	1	1
1054	2	23	12.5	82	1	1
1055	2	23	13.0	85	1	1
1056	2	23	13.0	81	1	1
1057	2	23	13.0	80	1	1
1058	2	24	13.0	80	1	1
1059	2	24	12.5	85	1	1
1060	2	24	12.5	89	1	1
1061	2	24	12.5	100	1	1
1062	2	25	12.5	102	1	1
1063	2	25	12.5	104	1	1
1064	2	25	14.0	105	1	1
1065	2	25	14.0	107	1	1
1066	2	25	12.0	105	1	1
1067	2	24	12.0	108	1	1
1068	2	24	12.2	88	1	1
1069	2	24	12.3	89	1	1
1070	2	24	13.3	90	1	1
1071	2	24	13.3	96	1	1
1072	2	24	10.5	93	1	1
1073	2	22	10.5	96	1	1
1074	2	22	10.5	98	1	1
1075	2	23	10.5	97	1	1
1076	2	22	10.5	96	1	1
1077	2	22	10.5	93	1	1
1078	2	23	10.5	92	1	1
1079	2	24	10.5	92	1	1
1080	2	23	10.5	99	1	1
1081	2	23	10.5	102	1	1
1082	2	22	10.5	105	1	1
1083	2	23	10.5	104	1	1
1084	2	21	10.5	105	1	1
1085	2	24	10.5	105	1	1
1086	2	23	10.5	105	1	1
1087	2	23	10.5	106	1	1
1088	2	25	11.5	100	1	1
1089	2	24	11.5	98	1	1
1090	2	25	11.5	97	1	1
1091	2	25	12.5	98	1	1
1092	2	23	10.0	97	1	1
1093	2	25	11.2	96	1	1
1094	2	26	11.2	98	1	1

personid	gender	age	workexp	prod	elec	water
1095	2	24	10.5	97	1	1
1096	2	24	10.5	96	1	1
1097	2	24	10.3	98	1	1
1098	2	22	10.3	98	1	1
1099	2	23	11.3	99	1	1
1100	2	24	11.0	96	1	1
1101	2	26	5.0	93	1	1
1102	2	26	14.0	96	1	1
1103	2	28	14.0	96	1	1
1104	2	29	14.0	96	1	1
1105	2	29	14.0	93	1	1
1106	2	29	13.5	95	1	1
1107	2	30	13.5	98	1	1
1108	2	30	13.5	95	1	1
1109	2	30	13.5	98	1	1
1110	2	30	14.0	99	1	1
1111	2	30	14.0	94	1	1
1112	2	30	14.0	96	1	1
1113	2	30	14.0	96	1	1
1114	2	30	13.0	98	1	1
1115	2	30	13.0	95	1	1
1116	2	30	9.0	92	1	1
1117	2	30	12.0	98	1	1
1118	2	30	9.5	96	1	1
1119	2	30	9.5	98	1	1
1120	2	30	8.5	95	1	1
1121	2	30	8.5	98	1	1
1122	2	29	9.0	97	1	1
1123	2	29	9.0	99	1	1
1124	2	29	9.0	96	1	1
1125	2	29	9.0	98	1	1
1126	2	29	9.0	92	1	1
1127	2	29	9.0	99	1	1
1128	2	29	9.0	104	1	1
1129	2	29	9.0	105	1	1
1130	2	29	9.0	108	1	1
1131	2	29	9.0	109	1	1
1132	2	29	9.0	108	1	1
1133	2	28	9.0	107	1	1
1134	2	28	10.0	104	1	1
1135	2	28	10.0	125	1	1
1136	2	27	10.0	125	1	1
1137	2	28	10.0	122	1	1
1138	2	28	11.0	105	1	1
1139	2	27	12.0	104	1	1
1140	2	28	12 0	100	1	1
1141	2	28	12.0	100	1	1
1142	2	28	13.0	125	1	1
1143	2	28	12.0	125	1	1

personid	gender	age	workexp	prod	elec	water
1144	2	29	1 0	126	1	1
1145	2	28	4.0	123	1	1
1146	2	29	14.0	124	1	1
1147	2	29	14.0	128	1	1
1148	2	29	14.0	100	1	1
1149	2	29	14.0	99	1	1
1150	2	29	13.0	95	1	1
1151	2	28	13.0	98	1	1
1152	2	28	13.0	97	1	1
1153	2	28	13.0	95	1	1
1154	2	28	13.0	95	1	1
1155	2	28	12.5	96	1	1
1156	2	28	12.5	95	1	1
1157	2	29	12.5	96	1	1
1158	2	29	12.5	99	1	1
1159	2	30	12.5	85	1	1
1160	2	30	13.5	96	1	1
1161	2	30	13.5	99	1	1
1162	2	29	13.5	100	1	1
1163	2	29	13.5	102	1	1
1164	2	29	12.0	105	1	1
1165	2	30	12.0	108	1	1
1166	2	30	12.0	88	1	1
1167	2	29	12.0	89	1	1
1168	2	28	13.0	89	1	1
1169	2	28	13.0	87	1	1
1170	2	28	13.5	89	1	1
1171	2	29	13.5	87	1	1
1172	2	29	13.5	85	1	1
1173	2	30	13.5	85	1	1
1174	2	30	12.0	85	1	1
1175	2	29	12.0	82	1	1
1176	2	29	12.0	82	1	1
1177	2	29	12.0	81	1	1
1178	2	28	13.0	84	1	1
1179	2	29	13.0	85	1	1
1180	2	30	13.0	99	1	1
1181	2	30	13 0	101	1	1
1182	2	29	12.5	125	1	1
1183	2	28	12.5	104	1	1
1184	2	28	12.5	104	1	1
1185	2	29	12.5	105	1	1
1186	2	29	13.0	102	1	1
1187	2	29	14.0	111	1	1
1188	2	30	14.0	125	1	1
1189	2	29	14.0	147	1	1
1190	2	30	14.0	148	1	1
1191	2	29	14.0	132	1	1
1192	2	30	13.0	100	1	1

personid	gender	age	workexp	prod	elec	water
1193	2	29	13.0	100	1	1
1194	2	30	12.0	102	1	1
1195	2	30	12.5	85	1	1
1196	2	29	12.5	89	1	1
1197	2	28	12.5	87	1	1
1198	2	29	12.5	87	1	1
1199	2	29	12.5	87	1	1
1200	2	28	12.5	85	1	1
1201	2	29	12.5	87	1	1
1202	2	29	13.0	84	1	1
1203	2	30	13.0	85	1	1
1204	2	29	13.0	86	1	1
1205	2	29	14.0	89	1	1
1206	2	28	14.0	85	1	1
1207	2	27	14.0	84	1	1
1208	2	27	13.5	85	1	1
1209	2	27	13.5	125	1	1
1210	2	27	13.5	126	1	1
1211	2	27	12.6	128	1	1
1212	2	27	12.8	129	1	1
1213	2	27	12.8	125	1	1
1214	2	26	8.0	148	1	1
1215	2	26	4.0	147	1	1
1216	2	26	6.5	126	1	1
1217	2	28	6.5	126	1	1
1218	2	27	7.5	123	1	1
1219	2	27	7.8	100	1	1
1220	2	27	7.8	125	1	1
1221	2	26	7.5	100	1	1
1222	2	26	7.5	100	1	1
1223	2	26	14.0	100	1	1
1224	2	27	13.5	100	1	1
1225	2	27	13.5	100	1	1
1226	2	27	12.6	112	1	1
1227	2	28	12.6	99	1	1
1228	2	29	12.5	99	1	1
1229	2	30	12.5	99	1	1
1230	2	30	12.5	99	1	1
1231	2	30	12.5	99	1	1
1232	2	30	12.4	98	1	1
1233	2	30	12.5	99	1	1
1234	2	30	12.5	96	1	1
1235	2	30	13.5	96	1	1
1236	2	30	13.5	98	1	1
1237	2	30	13.5	95	1	1
1238	2	30	12.3	98	1	1
1239	2	30	12.3	97	1	1
1240	2	30	5.0	98	1	1
1241	2	30	4.5	94	1	1

personid	gender	age	workexp	prod	elec	water
1242	2	30	4.5	98	1	1
1243	2	30	4.8	96	1	1
1244	2	30	4.0	99	1	1
1245	2	30	4.2	102	1	1
1246	2	30	4.2	102	1	1
1247	2	29	4.3	101	1	1
1248	2	29	3.5	101	1	1
1249	2	29	3.6	101	1	1
1250	2	29	3.4	102	1	1
1251	2	29	3.4	105	1	1
1252	2	29	3.5	105	1	1
1253	2	29	3.4	105	1	1
1254	2	29	3.6	110	1	1
1255	2	30	3.4	111	1	1
1256	2	30	3.1	100	1	1
1257	2	30	3.2	110	1	1
1258	2	30	3.2	121	1	1
1259	2	30	3.3	110	1	1
1260	2	30	3.2	100	1	1
1261	2	30	3.1	100	1	1
1262	2	30	3.0	100	1	1
1263	2	30	3.1	121	1	1
1264	2	30	3.1	131	1	1
1265	2	30	3.1	100	1	1
1266	2	30	3.1	125	1	1
1267	2	30	3.1	104	1	1
1268	2	30	3.0	100	1	1
1269	2	30	3.2	100	1	1
1270	2	30	3.3	121	1	1
1271	2	30	3.2	122	1	1
1272	2	30	4.5	102	1	1
1273	2	30	4.5	102	1	1
1274	2	29	4.0	104	1	1
1275	2	29	4.0	107	1	1
1276	2	28	4.0	108	1	1
1277	2	29	4.1	107	1	1
1278	2	29	3.5	108	1	1
1279	2	29	3.6	105	1	1
1280	2	30	3.9	101	1	1
1281	2	30	3.8	120	1	1
1282	2	30	3.9	121	1	1
1283	2	29	3.9	100	1	1
1284	2	29	3.7	89	1	1
1285	2	29	3.6	98	1	1
1286	1	30	3.5	98	1	1
1287	1	30	3.4	99	1	1
1288	1	30	3.0	99	1	1
1289	1	30	2.9	100	1	1
1290	1	30	2.9	96	1	1

personid	gender	age	workexp	prod	elec	water
1291	1	30	2.9	96	1	1
1292	1	30	2.8	93	1	1
1293	1	30	2.5	93	1	1
1294	1	29	2.5	98	1	1
1295	1	29	2.6	97	1	1
1296	1	28	2.4	97	1	1
1297	1	28	2.4	97	1	1
1298	1	28	2.5	99	1	1
1299	1	28	2.5	97	1	1
1300	1	28	2.6	98	1	1
1301	1	28	2.3	97	1	1
1302	1	28	2.1	97	1	1
1303	1	28	2.2	98	1	1
1304	1	28	2.2	98	1	1
1305	1	29	2.3	97	1	1
1306	1	28	2.3	97	1	1
1307	1	28	2.6	95	1	1
1308	1	28	2.2	96	1	1
1309	1	28	2.5	99	1	1
1310	1	28	2.8	69	1	1
1311	1	28	2.9	140	1	1
1312	1	28	2.7	120	1	1
1313	1	29	2.8	100	1	1
1314	1	30	2.9	100	1	1
1315	1	30	4.5	100	1	1
1316	1	29	4.8	100	1	1
1317	1	29	5.0	100	1	1
1318	1	29	4.8	100	1	1
1319	1	29	4.8	100	1	1
1320	1	29	4.8	101	1	1
1321	1	30	5.0	120	1	1
1322	1	30	4.8	121	1	1
1323	1	30	4.9	121	1	1
1324	1	30	3.9	122	1	1
1325	1	30	3.9	145	1	1
1326	1	30	4.9	125	1	1
1327	1	29	5.0	125	1	1
1328	1	28	4.5	122	1	1
1329	1	27	4.6	147	1	1
1330	1	27	4.9	100	1	1
1331	1	26	4.7	100	1	1
1332	1	26	4.8	101	1	1
1333	1	26	4.8	121	1	1
1334	1	26	5.0	112	1	1
1335	1	25	5.0	125	1	1
1336	1	25	5.0	125	1	1
1337	1	26	5.0	100	1	1
1338	1	26	5.0	100	1	1
1339	1	28	5.0	121	1	1

personid	gender	age	workexp	prod	elec	water
1340	1	29	5.0	100	1	1
1341	1	29	5.0	145	1	1
1342	1	30	5.0	125	1	1
1343	1	30	5.0	122	1	1
1344	1	30	5.0	100	1	1
1345	1	30	5.0	100	1	1
1346	1	30	5.0	100	1	1
1347	1	30	5.0	100	1	1
1348	1	30	5.0	100	1	1
1349	1	30	5.0	121	1	1
1350	1	30	5.0	101	1	1
1351	1	30	5.0	102	1	1
1352	1	30	5.0	100	1	1
1353	1	30	5.0	121	1	1
1354	1	30	5.0	100	1	1
1355	1	30	5.0	110	1	1
1356	1	30	5.0	121	1	1
1357	1	30	5.0	100	1	1
1358	1	30	5.0	100	1	1
1359	1	30	1.0	121	1	1
1360	1	32	1.2	121	1	1
1361	1	33	1.2	121	1	1
1362	1	39	1.5	100	1	1
1363	1	40	0.5	98	1	1
1364	1	40	1.3	98	1	1
1365	1	40	2.0	99	1	1
1366	1	40	2.0	98	1	1
1367	1	39	2.0	99	1	1
1368	1	39	1.3	98	1	1
1369	1	38	1.5	98	1	1
1370	1	39	1.4	98	1	1
1371	1	40	1.8	99	1	1
1372	1	40	1.9	102	1	1
1373	1	40	1.3	101	1	1
1374	1	40	1.6	101	1	1
1375	1	40	2.0	102	1	1
1376	1	39	2.0	102	1	1
1377	1	38	2.0	101	1	1
1378	1	38	2.0	102	1	1
1379	1	36	2.0	102	1	1
1380	1	37	2.0	101	1	1
1381	1	37	2.0	132	1	1
1382	1	37	2.0	125	1	1
1383	1	37	2.0	100	1	1
1384	1	35	2.0	125	1	1
1385	1	35	2.0	124	1	1
1386	1	35	2.0	102	1	1
1387	1	35	2.0	100	1	1
1388	1	35	2.0	99	1	1

personid	gender	age	workexp	prod	elec	water
1389	1	35	2.0	99	1	1
1390	1	35	2.0	98	1	1
1391	1	35	2.0	98	1	1
1392	1	35	2.0	96	1	1
1393	1	35	2.0	97	1	1
1394	1	35	2.0	96	1	1
1395	1	35	2.0	97	1	1
1396	1	35	2.3	97	1	1
1397	1	35	2.5	96	1	1
1398	1	35	2.4	97	1	1
1399	1	34	2.8	98	1	1
1400	1	32	3.0	99	1	1
1401	1	33	3.0	98	1	1
1402	1	36	2.5	98	1	1
1403	1	36	2.0	97	1	1
1404	1	35	2.2	98	1	1
1405	1	35	2.2	96	1	1

personid	light	m/c	super	sal	fam	facreac	ihfwi	env_out
1001	1	1	1	1	1	1	1	1
1002	1	1	1	1	1	1	1	1
1003	1	1	1	1	1	1	1	1
1004	1	1	1	1	1	1	1	1
1005	1	1	1	1	1	1	1	1
1006	1	1	1	1	1	1	1	1
1007	1	1	1	1	1	1	1	1
1008	1	1	1	1	1	1	1	1
1009	1	1	1	1	1	1	1	1
1010	1	1	1	1	1	1	1	1
1011	1	1	1	1	1	1	1	1
1012	1	1	1	1	1	1	1	1
1013	1	1	1	1	1	1	1	1
1014	1	1	1	1	1	1	1	1
1015	1	1	1	1	1	1	1	1
1016	1	1	1	1	1	1	1	1
1017	1	1	1	1	1	1	1	1
1018	1	1	1	1	1	1	1	1
1019	1	1	1	1	1	1	1	1
1020	1	1	1	1	1	1	1	1
1021	1	1	1	1	1	1	1	1
1022	1	1	1	1	1	1	1	1
1023	1	1	1	1	1	1	1	1
1024	1	1	1	1	1	1	1	1
1025	1	1	1	1	1	1	1	1
1026	1	1	1	1	1	1	1	1
1027	1	1	1	1	1	1	1	1
1028	1	1	1	1	1	1	1	1
1029	1	1	1	1	1	1	1	1

personid	light	m/c	super	sal	fam	facreac	ihfwi	env_out
1030	1	1	1	1	1	1	1	1
1031	1	1	1	1	1	1	1	1
1032	1	1	1	1	1	1	1	1
1033	1	1	1	1	1	1	1	1
1034	1	1	1	1	1	1	1	1
1035	1	1	1	1	1	1	1	1
1036	1	1	1	1	1	1	1	1
1037	1	1	1	1	1	1	1	1
1038	1	1	1	1	1	1	1	1
1039	1	1	1	1	1	1	1	1
1040	1	1	1	1	1	1	1	1
1041	1	1	1	1	1	1	1	1
1042	1	1	1	1	1	1	1	1
1043	1	1	1	1	1	1	1	1
1044	1	1	1	1	1	1	1	1
1045	1	1	1	1	1	1	1	1
1046	1	1	1	1	1	1	1	1
1047	1	1	1	1	1	1	1	1
1048	1	1	1	1	1	1	1	1
1049	1	1	1	1	1	1	1	1
1050	1	1	1	1	1	1	1	1
1051	1	1	1	1	1	1	1	1
1052	1	1	1	1	1	1	1	1
1053	1	1	1	1	1	1	1	1
1054	1	1	1	1	1	1	1	1
1055	1	1	1	1	1	1	1	1
1056	1	1	1	1	1	1	1	1
1057	1	1	1	1	1	1	1	1
1058	1	1	1	1	1	1	1	1
1059	1	1	1	1	1	1	1	1
1060	1	1	1	1	1	1	1	1
1061	1	1	1	1	1	1	1	1
1062	1	1	1	1	1	1	1	1
1063	1	1	1	1	1	1	1	1
1064	1	1	1	1	1	1	1	1
1065	1	1	1	1	1	1	1	1
1066	1	1	1	1	1	1	1	1
1067	1	1	1	1	1	1	1	1
1068	1	1	1	1	1	1	1	1
1069	1	1	1	1	1	1	1	1
1070	1	1	1	1	1	1	1	1
1071	1	1	1	1	1	1	1	1
1072	1	1	1	1	1	1	1	1
1073	1	1	1	1	1	1	1	1
1074	1	1	1	1	1	1	1	1
1075	1	1	1	1	1	1	1	1
1076	1	1	1	1	1	1	1	1
1077	1	1	1	1	1	1	1	1
1078	1	1	1	1	1	1	1	1

personid	light	m/c	super	sal	fam	facreac	ibfwi	env_out
1079	1	1	1	1	1	1	1	1
1080	1	1	1	1	1	1	1	1
1081	1	1	1	1	1	1	1	1
1082	1	1	1	1	1	1	1	1
1083	1	1	1	1	1	1	1	1
1084	1	1	1	1	1	1	1	1
1085	1	1	1	1	1	1	1	1
1086	1	1	1	1	1	1	1	1
1087	1	1	1	1	1	1	1	1
1088	1	1	1	1	1	1	1	1
1089	1	1	1	1	1	1	1	1
1090	1	1	1	1	1	1	1	1
1091	1	1	1	1	1	1	1	1
1092	1	1	1	1	1	1	1	1
1093	1	1	1	1	1	1	1	1
1094	1	1	1	1	1	1	1	1
1095	1	1	1	1	1	1	1	1
1096	1	1	1	1	1	1	1	1
1097	1	1	1	1	1	1	1	1
1098	1	1	1	1	1	1	1	1
1099	1	1	1	1	1	1	1	1
1100	1	1	1	1	1	1	1	1
1101	1	1	1	1	1	1	1	1
1102	1	1	1	1	1	1	1	1
1103	1	1	1	1	1	1	1	1
1104	1	1	1	1	1	1	1	1
1105	1	1	1	1	1	1	1	1
1106	1	1	1	1	1	1	1	1
1107	1	1	1	1	1	1	1	1
1108	1	1	1	1	1	1	1	1
1109	1	1	1	1	1	1	1	1
1110	1	1	1	1	1	1	1	1
1111	1	1	1	1	1	1	1	1
1112	1	1	1	1	1	1	1	1
1113	1	1	1	1	1	1	1	1
1114	1	1	1	1	1	1	1	1
1115	1	1	1	1	1	1	1	1
1116	1	1	1	1	1	1	1	1
1117	1	1	1	1	1	1	1	1
1118	1	1	1	1	1	1	1	1
1119	1	1	1	1	1	1	1	1
1120	1	1	1	1	1	1	1	1
1121	1	1	1	1	1	1	1	1
1122	1	1	1	1	1	1	1	1
1123	1	1	1	1	1	1	1	1
1124	1	1	1	1	1	1	1	1
1125	1	1	1	1	1	1	1	1
1126	1	1	1	1	1	1	1	1
1127	1	1	1	1	1	1	1	1

personid	light	m/c	super	sal	fam	facreac	ibfwi	env_out
1128	1	1	1	1	1	1	1	1
1129	1	1	1	1	1	1	1	1
1130	1	1	1	1	1	1	1	1
1131	1	1	1	1	1	1	1	1
1132	1	1	1	1	1	1	1	1
1133	1	1	1	1	1	1	1	1
1134	1	1	1	1	1	1	1	1
1135	1	1	1	1	1	1	1	1
1136	1	1	1	1	1	1	1	1
1137	1	1	1	1	1	1	1	1
1138	1	1	1	1	1	1	1	1
1139	1	1	1	1	1	1	1	1
1140	1	1	1	1	1	1	1	1
1141	1	1	1	1	1	1	1	1
1142	1	1	1	1	1	1	1	1
1143	1	1	1	1	1	1	1	1
1144	1	1	1	1	1	1	1	1
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1146	1	1	1	1	1	1	1	1
1147	1	1	1	1	1	1	1	1
1148	1	1	1	1	1	1	1	1
1149	1	1	1	1	1	1	1	1
1150	1	1	1	1	1	1	1	1
1151	1	1	1	1	1	1	1	1
1152	1	1	1	1	1	1	1	1
1153	1	1	1	1	1	1	1	1
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1155	1	1	1	1	1	1	1	1
1156	1	1	1	1	1	1	1	1
1157	1	1	1	1	1	1	1	1
1158	1	1	1	1	1	1	1	1
1159	1	1	1	1	1	1	1	1
1160	1	1	1	1	1	1	1	1
1161	1	1	1	1	1	1	1	1
1162	1	1	1	1	1	1	1	1
1163	1	1	1	1	1	1	1	1
1164	1	1	1	1	1	1	1	1
1165	1	1	1	1	1	1	1	1
1166	1	1	1	1	1	1	1	1
1167	1	1	1	1	1	1	1	1
1168	1	1	1	1	1	1	1	1
1169	1	1	1	1	1	1	1	1
1170	1	1	1	1	1	1	1	1
1171	1	1	1	1	1	1	1	1
1172	1	1	1	1	1	1	1	1
1173	1	1	1	1	1	1	1	1
1174	1	1	1	1	1	1	1	1
1175	1	1	1	1	1	1	1	1
1176	1	1	1	1	1	1	1	1

personid	light	m/c	super	sal	fam	facreac	ihfwi	env_out
1177	1	1	1	1	1	1	1	1
1178	1	1	1	1	1	1	1	1
1179	1	1	1	1	1	1	1	1
1180	1	1	1	1	1	1	1	1
1181	1	1	1	1	1	1	1	1
1182	1	1	1	1	1	1	1	1
1183	1	1	1	1	1	1	1	1
1184	1	1	1	1	1	1	1	1
1185	1	1	1	1	1	1	1	1
1186	1	1	1	1	1	1	1	1
1187	1	1	1	1	1	1	1	1
1188	1	1	1	1	1	1	1	1
1189	1	1	1	1	1	1	1	1
1190	1	1	1	1	1	1	1	1
1191	1	1	1	1	1	1	1	1
1192	1	1	1	1	1	1	1	1
1193	1	1	1	1	1	1	1	1
1194	1	1	1	1	1	1	1	1
1195	1	1	1	1	1	1	1	1
1196	1	1	1	1	1	1	1	1
1197	1	1	1	1	1	1	1	1
1198	1	1	1	1	1	1	1	1
1199	1	1	1	1	1	1	1	1
1200	1	1	1	1	1	1	1	1
1201	1	1	1	1	1	1	1	1
1202	1	1	1	1	1	1	1	1
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1206	1	1	1	1	1	1	1	1
1207	1	1	1	1	1	1	1	1
1208	1	1	1	1	1	1	1	1
1209	1	1	1	1	1	1	1	1
1210	1	1	1	1	1	1	1	1
1211	1	1	1	1	1	1	1	1
1212	1	1	1	1	1	1	1	1
1213	1	1	1	1	1	1	1	1
1214	1	1	1	1	1	1	1	1
1215	1	1	1	1	1	1	1	1
1216	1	1	1	1	1	1	1	1
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1221	1	1	1	1	1	1	1	1
1222	1	1	1	1	1	1	1	1
1223	1	1	1	1	1	1	1	1
1224	1	1	1	1	1	1	1	1
1225	1	1	1	1	1	1	1	1

personid	light	m/c	super	sal	fam	facreac	ihfwi	env_out
1226	1	1	1	1	1	1	1	1
1227	1	1	1	1	1	1	1	1
1228	1	1	1	1	1	1	1	1
1229	1	1	1	1	1	1	1	1
1230	1	1	1	1	1	1	1	1
1231	1	1	1	1	1	1	1	1
1232	1	1	1	1	1	1	1	1
1233	1	1	1	1	1	1	1	1
1234	1	1	1	1	1	1	1	1
1235	1	1	1	1	1	1	1	1
1236	1	1	1	1	1	1	1	1
1237	1	1	1	1	1	1	1	1
1238	1	1	1	1	1	1	1	1
1239	1	1	1	1	1	1	1	1
1240	1	1	1	1	1	1	1	1
1241	1	1	1	1	1	1	1	1
1242	1	1	1	1	1	1	1	1
1243	1	1	1	1	1	1	1	1
1244	1	1	1	1	1	1	1	1
1245	1	1	1	1	1	1	1	1
1246	1	1	1	1	1	1	1	1
1247	1	1	1	1	1	1	1	1
1248	1	1	1	1	1	1	1	1
1249	1	1	1	1	1	1	1	1
1250	1	1	1	1	1	1	1	1
1251	1	1	1	1	1	1	1	1
1252	1	1	1	1	1	1	1	1
1253	1	1	1	1	1	1	1	1
1254	1	1	1	1	1	1	1	1
1255	1	1	1	1	1	1	1	1
1256	1	1	1	1	1	1	1	1
1257	1	1	1	1	1	1	1	1
1258	1	1	1	1	1	1	1	1
1259	1	1	1	1	1	1	1	1
1260	1	1	1	1	1	1	1	1
1261	1	1	1	1	1	1	1	1
1262	1	1	1	1	1	1	1	1
1263	1	1	1	1	1	1	1	1
1264	1	1	1	1	1	1	1	1
1265	1	1	1	1	1	1	1	1
1266	1	1	1	1	1	1	1	1
1267	1	1	1	1	1	1	1	1
1268	1	1	1	1	1	1	1	1
1269	1	1	1	1	1	1	1	1
1270	1	1	1	1	1	1	1	1
1271	1	1	1	1	1	1	1	1
1272	1	1	1	1	1	1	1	1
1273	1	1	1	1	1	1	1	1
1274	1	1	1	1	1	1	1	1

personid	light	m/c	super	sal	fam	facreac	ihfwi	env_out
1275	1	1	1	1	1	1	1	1
1276	1	1	1	1	1	1	1	1
1277	1	1	1	1	1	1	1	1
1278	1	1	1	1	1	1	1	1
1279	1	1	1	1	1	1	1	1
1280	1	1	1	1	1	1	1	1
1281	1	1	1	1	1	1	1	1
1282	1	1	1	1	1	1	1	1
1283	1	1	1	1	1	1	1	1
1284	1	1	1	1	1	1	1	1
1285	1	1	1	1	1	1	1	1
1286	1	1	1	1	1	1	1	1
1287	1	1	1	1	1	1	1	1
1288	1	1	1	1	1	1	1	1
1289	1	1	1	1	1	1	1	1
1290	1	1	1	1	1	1	1	1
1291	1	1	1	1	1	1	1	1
1292	1	1	1	1	1	1	1	1
1293	1	1	1	1	1	1	1	1
1294	1	1	1	1	1	1	1	1
1295	1	1	1	1	1	1	1	1
1296	1	1	1	1	1	1	1	1
1297	1	1	1	1	1	1	1	1
1298	1	1	1	1	1	1	1	1
1299	1	1	1	1	1	1	1	1
1300	1	1	1	1	1	1	1	1
1301	1	1	1	1	1	1	1	1
1302	1	1	1	1	1	1	1	1
1303	1	1	1	1	1	1	1	1
1304	1	1	1	1	1	1	1	1
1305	1	1	1	1	1	1	1	1
1306	1	1	1	1	1	1	1	1
1307	1	1	1	1	1	1	1	1
1308	1	1	1	1	1	1	1	1
1309	1	1	1	1	1	1	1	1
1310	1	1	1	1	1	1	1	1
1311	1	1	1	1	1	1	1	1
1312	1	1	1	1	1	1	1	1
1313	1	1	1	1	1	1	1	1
1314	1	1	1	1	1	1	1	1
1315	1	1	1	1	1	1	1	1
1316	1	1	1	1	1	1	1	1
1317	1	1	1	1	1	1	1	1
1318	1	1	1	1	1	1	1	1
1319	1	1	1	1	1	1	1	1
1320	1	1	1	1	1	1	1	1
1321	1	1	1	1	1	1	1	1
1322	1	1	1	1	1	1	1	1
1323	1	1	1	1	1	1	1	1

personid	light	m/c	super	sal	fam	facreac	ihfwi	env_out
1324	1	1	1	1	1	1	1	1
1325	1	1	1	1	1	1	1	1
1326	1	1	1	1	1	1	1	1
1327	1	1	1	1	1	1	1	1
1328	1	1	1	1	1	1	1	1
1329	1	1	1	1	1	1	1	1
1330	1	1	1	1	1	1	1	1
1331	1	1	1	1	1	1	1	1
1332	1	1	1	1	1	1	1	1
1333	1	1	1	1	1	1	1	1
1334	1	1	1	1	1	1	1	1
1335	1	1	1	1	1	1	1	1
1336	1	1	1	1	1	1	1	1
1337	1	1	1	1	1	1	1	1
1338	1	1	1	1	1	1	1	1
1339	1	1	1	1	1	1	1	1
1340	1	1	1	1	1	1	1	1
1341	1	1	1	1	1	1	1	1
1342	1	1	1	1	1	1	1	1
1343	1	1	1	1	1	1	1	1
1344	1	1	1	1	1	1	1	1
1345	1	1	1	1	1	1	1	1
1346	1	1	1	1	1	1	1	1
1347	1	1	1	1	1	1	1	1
1348	1	1	1	1	1	1	1	1
1349	1	1	1	1	1	1	1	1
1350	1	1	1	1	1	1	1	1
1351	1	1	1	1	1	1	1	1
1352	1	1	1	1	1	1	1	1
1353	1	1	1	1	1	1	1	1
1354	1	1	1	1	1	1	1	1
1355	1	1	1	1	1	1	1	1
1356	1	1	1	1	1	1	1	1
1357	1	1	1	1	1	1	1	1
1358	1	1	1	1	1	1	1	1
1359	1	1	1	1	1	1	1	1
1360	1	1	1	1	1	1	1	1
1361	1	1	1	1	1	1	1	1
1362	1	1	1	1	1	1	1	1
1363	1	1	1	1	1	1	1	1
1364	1	1	1	1	1	1	1	1
1365	1	1	1	1	1	1	1	1
1366	1	1	1	1	1	1	1	1
1367	1	1	1	1	1	1	1	1
1368	1	1	1	1	1	1	1	1
1369	1	1	1	1	1	1	1	1
1370	1	1	1	1	1	1	1	1
1371	1	1	1	1	1	1	1	1
1372	1	1	1	1	1	1	1	1

personid	light	m/c	super	sal	fam	facreac	ihfwi	env_out
1373	1	1	1	1	1	1	1	1
1374	1	1	1	1	1	1	1	1
1375	1	1	1	1	1	1	1	1
1376	1	1	1	1	1	1	1	1
1377	1	1	1	1	1	1	1	1
1378	1	1	1	1	1	1	1	1
1379	1	1	1	1	1	1	1	1
1380	1	1	1	1	1	1	1	1
1381	1	1	1	1	1	1	1	1
1382	1	1	1	1	1	1	1	1
1383	1	1	1	1	1	1	1	1
1384	1	1	1	1	1	1	1	1
1385	1	1	1	1	1	1	1	1
1386	1	1	1	1	1	1	1	1
1387	1	1	1	1	1	1	1	1
1388	1	1	1	1	1	1	1	1
1389	1	1	1	1	1	1	1	1
1390	1	1	1	1	1	1	1	1
1391	1	1	1	1	1	1	1	1
1392	1	1	1	1	1	1	1	1
1393	1	1	1	1	1	1	1	1
1394	1	1	1	1	1	1	1	1
1395	1	1	1	1	1	1	1	1
1396	1	1	1	1	1	1	1	1
1397	1	1	1	1	1	1	1	1
1398	1	1	1	1	1	1	1	1
1399	1	1	1	1	1	1	1	1
1400	1	1	1	1	1	1	1	1
1401	1	1	1	1	1	1	1	1
1402	1	1	1	1	1	1	1	1
1403	1	1	1	1	1	1	1	1
1404	1	1	1	1	1	1	1	1
1405	1	1	1	1	1	1	1	1

personid	faccon	satis	Fat	relfat	hrswrk	comp	comf	impsk	nonpay
1001	1	81	2	1	3.5	1	1	1	2
1002	1	85	2	1	3.5	1	1	1	2
1003	1	78	1	1	3.5	1	1	1	2
1004	1	65	2	1	3.5	1	1	1	2
1005	1	66	2	1	3.5	1	1	1	2
1006	1	69	2	1	3.5	1	1	1	2
1007	1	70	2	1	3.5	2	1	1	2
1008	1	69	2	1	3.5	1	1	1	2
1009	1	69	2	1	3.5	1	1	1	2
1010	1	85	2	1	3.5	1	1	1	2
1011	1	88	1	1	3.5	1	1	1	2
1012	1	70	2	1	3.5	1	1	1	2
1013	1	74	2	1	3.5	1	1	1	2

personid	faccon	satis	Fat	relfat	hrswrk	comp	comf	impsk	nonpay
1014	1	62	2	1	3.5	1	1	1	2
1015	1	65	2	1	3.5	1	1	1	2
1016	1	65	2	1	3.5	1	1	1	2
1017	1	66	2	1	3.5	1	1	1	2
1018	1	60	2	1	3.5	1	1	1	2
1019	1	60	2	1	3.5	1	1	1	2
1020	1	60	2	1	3.5	1	1	1	2
1021	1	60	1	1	3.5	1	2	1	2
1022	1	60	2	1	3.5	1	1	1	2
1023	1	60	2	1	3.5	1	1	1	2
1024	1	60	2	1	3.5	1	1	1	2
1025	1	60	2	1	3.5	1	1	1	2
1026	1	60	2	1	3.5	1	1	1	2
1027	1	60	2	1	3 5	1	1	1	2
1028	1	60	2	1	3.5	1	1	1	2
1029	1	60	2	1	3.5	1	1	1	2
1030	1	60	2	1	3.5	1	1	1	2
1031	1	61	2	1	3.5	1	1	1	2
1032	1	60	2	1	3.5	1	1	1	2
1033	1	60	2	1	3.5	1	1	1	2
1034	1	60	2	1	3.5	1	1	1	2
1035	1	60	2	1	3.5	1	1	1	2
1036	1	60	1	1	3.5	1	1	1	2
1037	1	62	2	1	3.5	1	1	1	2
1038	1	60	2	1	3.5	1	1	1	2
1039	1	60	2	1	3.5	1	1	1	2
1040	1	60	2	1	3.5	1	1	1	2
1041	1	60	2	1	3.5	2	1	1	2
1042	1	62	2	1	3.5	1	1	1	2
1043	1	60	2	1	3.5	1	1	1	2
1044	1	60	2	1	3.5	1	1	1	2
1045	1	60	2	1	3.5	1	1	1	2
1046	1	60	2	1	3.5	1	1	1	2
1047	1	60	2	1	3.5	1	1	1	2
1048	1	61	2	1	3.5	1	1	1	2
1049	1	60	2	1	3.5	1	1	1	2
1050	1	60	1	1	3.5	1	1	1	2
1051	1	60	2	1	3.5	1	1	1	2
1052	1	61	2	1	3.5	1	1	1	2
1053	1	60	2	1	3.5	1	1	1	2
1054	1	60	2	1	3.5	1	1	1	2
1055	1	60	2	1	3.5	1	1	1	2
1056	1	60	2	1	3.5	1	2	1	2
1057	1	62	2	1	3.5	1	1	1	2
1058	1	60	2	1	3.5	1	1	1	2
1059	1	60	2	1	3.5	1	1	1	2
1060	1	60	2	1	3.5	1	1	1	2
1061	1	60	2	1	3.5	1	1	1	2
1062	1	62	2	1	3.5	1	1	1	2

personid	faccon	satis	Fat	relfat	hrswrk	comp	comf	impsk	nonpay
1063	1	60	2	1	3.5	1	1	1	2
1064	1	62	2	1	3.5	1	1	1	2
1065	1	60	2	1	3.5	1	1	1	2
1066	1	60	2	1	3.5	1	1	1	2
1067	1	60	2	1	3.5	1	1	1	2
1068	1	62	2	1	3.5	1	1	1	2
1069	1	60	1	1	3.5	1	1	1	2
1070	1	60	2	1	3.5	1	1	1	2
1071	1	60	2	1	3.5	1	1	1	2
1072	1	61	2	1	3.5	1	1	1	2
1073	1	60	2	1	3.5	1	1	1	2
1074	1	60	2	1	3.5	1	1	1	2
1075	1	62	2	1	3.5	1	1	1	2
1076	1	60	2	1	3.5	1	1	1	2
1077	1	60	2	1	3.5	1	1	1	2
1078	1	61	2	1	3.5	1	2	1	2
1079	1	60	2	1	3.5	1	1	1	2
1080	1	60	2	1	3.5	1	1	1	2
1081	1	62	1	1	3.5	2	1	1	2
1082	1	60	2	1	3.5	1	1	1	2
1083	1	60	2	1	3.5	1	1	1	2
1084	1	62	2	1	3.5	1	1	1	2
1085	1	60	2	1	3.5	1	1	1	2
1086	1	60	2	1	3.5	1	1	1	2
1087	1	61	2	1	3.5	1	1	1	2
1088	1	60	2	1	3.5	1	1	1	2
1089	1	60	2	1	3.5	1	1	1	2
1090	1	64	2	1	3.5	1	1	1	2
1091	1	60	2	1	3.5	1	1	1	2
1092	1	60	2	1	3.5	1	1	1	2
1093	1	65	2	1	3.5	1	1	1	2
1094	1	60	2	1	3.5	1	1	1	2
1095	1	60	2	1	3.5	1	1	1	2
1096	1	64	2	1	3.5	1	1	1	2
1097	1	60	2	1	3.5	1	1	1	2
1098	1	61	2	1	3.5	1	1	1	2
1099	1	60	2	1	3.5	1	1	1	2
1100	1	60	2	1	3.5	1	1	1	2
1101	1	62	2	1	3.5	1	1	1	2
1102	1	60	2	1	3.5	1	1	1	2
1103	1	60	2	1	3.5	1	1	1	2
1104	1	62	2	1	3.5	1	1	1	2
1105	1	60	2	1	3.5	1	2	1	2
1106	1	60	2	1	3.5	1	1	1	2
1107	1	65	2	1	3.5	1	1	1	2
1108	1	60	2	1	3.5	1	1	1	2
1109	1	60	2	1	3.5	1	1	1	2
1110	1	62	2	1	3.5	1	1	1	2
1111	1	60	2	1	3.5	1	1	1	2

personid	faccon	satis	Fat	relfat	hrswrk	comp	comf	impsk	nonpay
1112	1	60	2	1	3.5	1	1	1	2
1113	1	61	2	1	3.5	1	1	1	2
1114	1	60	2	1	3.5	1	1	1	2
1115	1	60	2	1	3.5	1	1	1	2
1116	1	61	2	1	3.5	1	1	1	2
1117	1	60	2	1	3.5	1	1	1	2
1118	1	60	2	1	3.5	1	1	1	2
1119	1	61	2	1	3.5	1	1	1	2
1120	1	60	1	1	3.5	1	1	1	2
1121	1	60	2	1	3.5	1	1	1	2
1122	1	61	2	1	3.5	1	1	1	2
1123	1	60	2	1	3.5	1	1	1	2
1124	1	60	2	1	3.5	1	1	1	2
1125	1	62	2	1	3.5	1	1	1	2
1126	1	60	2	1	3.5	1	1	1	2
1127	1	60	2	1	3.5	1	1	1	2
1128	1	63	2	1	3.5	1	1	1	2
1129	1	60	2	1	3.5	1	1	1	2
1130	1	69	2	1	3.5	2	1	1	2
1131	1	60	2	1	3.5	1	1	1	2
1132	1	60	2	1	3.5	1	1	1	2
1133	1	68	2	1	3.5	1	1	1	2
1134	1	60	2	1	3.5	1	1	1	2
1135	1	60	2	1	3.5	1	1	1	2
1136	1	64	2	1	3.5	1	1	1	2
1137	1	60	2	1	3.5	1	1	1	2
1138	1	60	2	1	3.5	1	2	1	2
1139	1	62	2	1	3.5	1	1	1	2
1140	1	60	2	1	3.5	1	1	1	2
1141	1	60	2	1	3.5	1	1	1	2
1142	1	65	2	1	3.5	1	1	1	2
1143	1	60	2	1	3.5	1	1	1	2
1144	1	60	2	1	3.5	1	1	1	2
1145	1	65	2	1	3.5	1	1	1	2
1146	1	60	2	1	3.5	1	1	1	2
1147	1	60	2	1	3.5	1	1	1	2
1148	1	65	2	1	3.5	1	1	1	2
1149	1	60	2	1	3.5	1	1	1	2
1150	1	60	2	1	3.5	1	1	1	2
1151	1	63	2	1	3.5	1	1	1	2
1152	1	60	2	1	3.5	1	1	1	2
1153	1	60	2	1	3.5	1	1	1	2
1154	1	62	2	1	3.5	1	1	1	2
1155	1	60	2	1	3.5	1	1	1	2
1156	1	60	2	1	3.5	1	1	1	2
1157	1	64	2	1	3.5	1	1	1	2
1158	1	60	2	1	3.5	1	1	1	2
1159	1	60	2	1	3.5	1	1	1	2
1160	1	65	2	1	3.5	1	1	1	2

personid	faccon	satis	Fat	relfat	hrswrk	comp	comf	impsk	nonpay
1210	1	65	2	1	3.5	1	1	1	2
1211	1	60	2	1	3.5	1	1	1	2
1212	1	60	2	1	3.5	1	1	1	2
1213	1	60	2	1	3.5	1	1	1	2
1214	1	60	2	1	3.5	1	1	1	2
1215	1	62	2	1	3.5	1	1	1	2
1216	1	60	2	1	3.5	1	1	1	2
1217	1	60	2	1	3.5	1	1	1	2
1218	1	60	2	1	3.5	1	1	1	2
1219	1	60	2	1	3.5	1	1	1	2
1220	1	60	2	1	3.5	1	1	1	2
1221	1	64	2	1	3.5	1	1	1	2
1222	1	60	2	1	3.5	1	1	1	2
1223	1	60	2	1	3.5	1	1	1	2
1224	1	60	2	1	3.5	1	1	1	2
1225	1	60	2	1	3.5	1	2	1	2
1226	1	62	2	1	3.5	1	1	1	2
1227	1	60	2	1	3.5	1	1	1	2
1228	1	60	2	1	3.5	1	1	1	2
1229	1	60	2	1	3.5	1	1	1	2
1230	1	65	2	1	3.5	1	1	1	2
1231	1	60	2	1	3.5	1	1	1	2
1232	1	60	2	1	3.5	1	1	1	2
1233	1	60	2	1	3.5	1	1	1	2
1234	1	60	2	1	3.5	1	1	1	2
1235	1	60	2	1	3.5	1	1	1	2
1236	1	60	2	1	3.5	1	1	1	2
1237	1	65	2	1	3.5	1	1	1	2
1238	1	60	1	1	3.5	1	1	1	2
1239	1	60	2	1	3.5	1	1	1	2
1240	1	60	2	1	3.5	1	1	1	2
1241	1	60	2	1	3.5	1	1	1	2
1242	1	60	2	1	3.5	1	1	1	2
1243	1	60	2	1	3.5	1	1	1	2
1244	1	70	2	1	3.5	1	1	1	2
1245	1	60	2	1	3.5	1	1	1	2
1246	1	65	2	1	3.5	1	1	1	2
1247	1	60	2	1	3.5	1	1	1	2
1248	1	60	2	1	3.5	1	1	1	2
1249	1	60	2	1	3.5	1	1	1	2
1250	1	60	2	1	3.5	2	1	1	2
1251	1	60	2	1	3.5	1	1	1	2
1252	1	62	2	1	3.5	1	1	1	2
1253	1	60	2	1	3.5	1	1	1	2
1254	1	60	2	1	3.5	1	1	1	2
1255	1	60	2	1	3.5	1	1	1	2
1256	1	60	2	1	3.5	1	1	1	2
1257	1	60	2	1	3.5	1	1	1	2
1258	1	62	2	1	3.5	1	2	1	2

personid	faccon	satis	Fat	relfat	hrswrk	comp	comf	impsk	nonpay
1259	1	60	2	1	3.5	1	1	1	2
1260	1	60	2	1	3.5	1	1	1	2
1261	1	60	2	1	3.5	1	1	1	2
1262	1	60	2	1	3.5	1	1	1	2
1263	1	64	2	1	3.5	1	1	1	2
1264	1	60	2	1	3.5	1	1	1	2
1265	1	60	2	1	3.5	1	1	1	2
1266	1	60	2	1	3.5	1	1	1	2
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1268	1	60	2	1	3.5	1	1	1	2
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1302	1	64	2	1	3.5	1	1	1	2
1303	1	60	2	1	3.5	1	1	1	2
1304	1	60	2	1	3.5	1	1	1	2
1305	1	60	2	1	3.5	1	1	1	2
1306	1	70	2	1	3.5	1	1	1	2
1307	1	60	2	1	3.5	1	1	1	2

personid	faccon	satis	Fat	relfat	hrswrk	comp	comf	impsk	nonpay
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1309	1	60	2	1	3.5	1	1	1	2
1310	1	60	2	1	3.5	1	1	1	2
1311	1	75	2	1	3.5	1	1	1	2
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1316	1	62	1	1	3.5	1	1	1	2
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1340	1	60	2	1	3.5	1	1	1	2
1341	1	64	2	1	3.5	1	1	1	2
1342	1	60	2	1	3.5	1	1	1	2
1343	1	60	2	1	3.5	1	1	1	2
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1355	1	60	2	1	3.5	1	1	1	2
1356	1	60	2	1	3.5	1	1	1	2

personid	faccon	satis	Fat	relfat	hrswrk	comp	comf	impsk	nonpay
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1358	1	60	2	1	3.5	1	1	1	2
1359	1	60	2	1	3.5	1	1	1	2
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1361	1	78	2	1	3.5	1	1	1	2
1362	1	60	2	1	3.5	1	1	1	2
1363	1	60	2	1	3.5	1	1	1	2
1364	1	60	2	1	3.5	1	1	1	2
1365	1	60	2	1	3.5	1	1	1	2
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1367	1	60	1	1	3.5	1	1	1	2
1368	1	60	2	1	3.5	1	1	1	2
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1371	1	60	2	1	3.5	1	1	1	2
1372	1	60	2	1	3.5	1	1	1	2
1373	1	84	2	1	3.5	1	1	1	2
1374	1	60	2	1	3.5	1	1	1	2
1375	1	60	2	1	3.5	1	1	1	2
1376	1	60	2	1	3.5	1	2	1	2
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1396	1	60	2	1	3.5	1	1	1	2
1397	1	65	2	1	3.5	1	1	1	2
1398	1	60	2	1	3.5	1	1	1	2
1399	1	60	2	1	3.5	1	1	1	2
1400	1	78	2	1	3.5	1	1	1	2
1401	1	60	2	1	3.5	1	1	1	2
1402	1	60	2	1	3.5	1	1	1	2
1403	1	61	2	1	3.5	1	2	1	2
1404	1	60	2	1	3.5	1	1	1	2
1405	1	69	2	1	3.5	2	1	1	2

personid	dpay	quali	train	learn
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1005	1	2	2	3
1006	1	2	2	3
1007	1	2	2	4
1008	1	2	2	3
1009	1	2	2	3
1010	1	2	2	6
1011	1	2	2	3
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1014	1	2	2	4
1015	1	2	2	3
1016	1	2	2	3
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1018	1	2	2	6
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personid	dpay	quali	train	learn
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personid	dpay	quali	train	learn
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1111	1	2	2	4
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1121	1	2	2	3
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1123	1	2	2	3
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1129	1	2	2	6
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personid	dpay	quali	train	learn
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1194	1	2	2	6
1195	1	2	2	3
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personid	dpay	quali	train	learn
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1199	1	2	2	3
1200	1	2	2	3
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personid	dpay	quali	train	learn
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personid	dpay	quali	train	learn
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personid	dpay	quali	train	learn
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1387	1	4	2	3
1388	1	4	2	3
1389	1	4	2	3
1390	1	4	2	3
1391	1	4	2	2
1392	1	4	2	3

personid	dpay	quali	train	learn
1393	1	4	2	3
1394	1	4	2	3
1395	1	4	2	3
1396	1	4	2	3
1397	1	4	2	3
1398	1	4	2	3
1399	1	4	2	3
1400	1	4	2	3
1401	1	4	2	3
1402	1	4	2	2
1403	1	4	2	3
1404	1	4	2	3
1405	1	4	2	3