Performance Evaluation of After Sale Service in Automotive Industry by Data Envelopment Analysis

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ABSTRACT

In this decade, automotive industry has become second big industry in Iran after oil while more than 1 million and 350 thousand cars are produced yearly by different companies and have influenced in most of Iranian's living and has been considered by government due to sanction against Iran, appreciation of prices and dissatisfaction of customers in after sale services. This study will investigate 88 after sale service dealers belong to Kerman Motor Co. in all over Iran as a sample of the entire automotive industry in Iran. All data (number of customers, human resources, education, equipment, providing pieces and process as 6 inputs and stopped cars more than 48 hours in the repair shop, reworked cars, and customer satisfaction as 3 outputs) has been gathered during 2016-2017 observation of all dealers.

Data Envelopment Analysis (DEA) has been applied as one of the most common evaluation methods for measuring the efficiency of performance of each dealer. Contrary to Iran Standard Quality Institute (ISQI) which sends inspectors to all dealers from all companies to evaluate them yearly by a solid framework and without considering the differences in facilities and population in various regions of Iran, DEA has been utilized in this study to evaluate the dealer's efficiencies and rank them by their own capacities and potentials. CCR model as one of the basic models of DEA has been used in this study due to its more rigid and inflexible essence in comparison to other models. All weights assigned to inputs/outputs will be analyzed to find out most significant index which is effects inefficiency, also inefficient dealers are compared to efficient dealers with most similar for recognizing the weakness and an improvement plan will be presented for giving insight for inefficient units to be improved at the end.

Keywords: Automotive industry, Data Envelopment Analysis (DEA), Performance, Efficiency, Significant index

ÖZ

Son on yıl içerisinde İran'da yılda 1 milyon 350 bin araç farklı şirketler tarafından üretiliyor ve bu esnada otomotiv endüstrisi petrol'den sonra İran'da ikinci büyük endüstri haline gelmiştir. Fakat, Dünya'nın İran devletine uyguladığı yaptırımlar yüzünden satış sonrası servislerde (parça değişimi, tamirat, vs.) bir çok İran'lı vatandaşın yüksek fiyatlar karşısında memuniyetsiz olduğu gözlemlenmiştir. Bu çalışma İran'ın otomotiv endüstrisini örneklemek amacıyla İran'da bulunan Kerman Motor's şirketine ait olan 88 araç servisinde yapılmıştır. Toplanan veri (müşteri sayısı, insan kaynakları, eğitim, ekipman, parça temini ve işlem süresi olarak 6 girdi verisi ve 48 saatir tamirhanede bulunan durmuş araçlar, yeniden çalıştırılmış araçlar ve müşteri memnuniyeti olarak 3 çıktı verisi) 2016-2017 yılları arasında araç servislerini gözlemleyerek toplanmıştır. Her araç servisindeki verimilik performansını ölçmek için oldukça yayın bir metod olan Veri Zarflama Analizi (VZA) kullanılmıştır. İran Stadart Kalite Denetleme Enstitüsü (İSKD) İran'da bulunan bütün araç şirketlerine ait araç servislerine tesis farkı, bölgelerindeki nüfüsların yoğunluğunu gözetmeksizin denetim yapmak amacıyla gözetmen göndermektir buna karşın, VZA araç servislerinin verimliğini ölçerken araç servislerini kapasitelerini ve potansiyellerini göz önüne alarak sınıflandırma yapmaktadır. Daha sabit ve kararlı sonuç almak ve literatürde kullanılmış diğer modellerle kıyas yapabilmek adına VZA ait olan CCR modeli bu çalışmada kullanılmıştır. Girdi/Çıktılara atanan bütün ağırlıklar verimliliği etkilyen en dikkate değer endeksi bulmak için analiz edilecektir. Ayrıca, verimsiz araç servislerinin zayıf noktalarını teşhis etmek için verimli araç servisleri ile karşılaştırılacak ve verimsiz

olan araç servisleri için bir iyileştirme planı yapılarak daha sonra nasıl verimli hale gelebilcekleri gösterilecektir.

Anahtar Kelimeler: Otomotiv Endüstrisi, Veri Zarflama Analizi (VZA), Performans Verimliliği, Dikkata Değer Endeks

To my family

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LIST OF ABBREVIATIONS

CRS	Constant Return to Scale
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
DRS	Decreasing Return to Scale
IRS	Increasing Return to Scale
ISQI	Iran Standard and Quality Inspection
PPS	Production Possibility Set
VRS	Variable Return to Scale

Chapter 1

INTRODUCTION

1.1 Problem Description

The automotive industry is the second biggest industry after the oil industry in Iran where five hundred thousand people (almost 2.3% of human resource) are involved directly or indirectly. Two giant automotive companies named, Iran Khodro and Saipa are related to the governmental organization with more than 87 percent of market share, and the rest belongs to importing and private corporation companies in Iran.

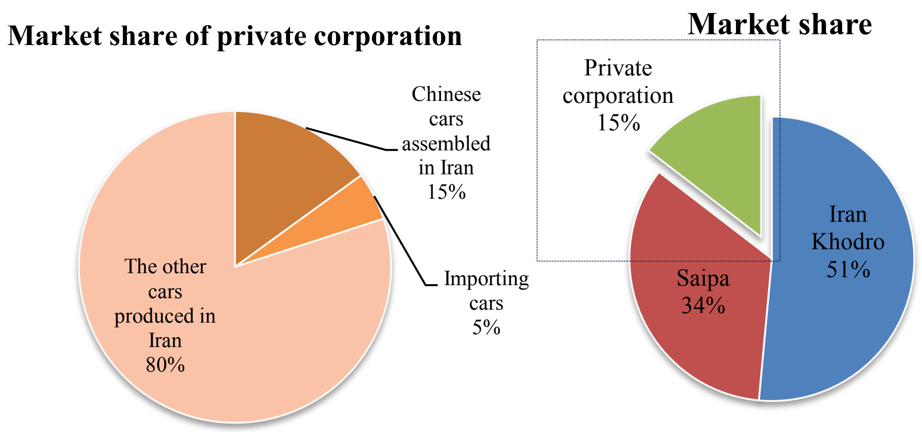

Figure 1. Market share of automotive companies in Iran between 2016-2018

Kerman Motor Co., founded in 1994, is managed by the private sector, however, unlike most of the companies related to vehicle is not supported by the government.

The article of association of the company is based on product, assembly, selling cars and after-sales services.

The most important strategy of the company was to contract with one of the biggest automotive companies in China, called JAC, in 2009 to import parts and spare pieces for three kinds of cars with manual and automatic gears. JAC is an automotive company located in Hefei in the southeast of China was founded in 1999, the company established China's first R&D center in Italy in 2005 and then in Tokyo in 2006. By now JAC has exported products to South America, Europe, Africa, and Asia and has made friendly relationship with more than 130 countries around the world and involved in producing both commercial vehicles and passenger cars.

Kerman Motor Co. has more than 80 dealers all around the country. In addition to cars selling, they are responsible for after-sale services, such as periodic services and repairing for customers who have bought the cars. Most of the car dealers follow a similar service process in that, the customers are guided to stop in a specific area to fill in a form with a receptionist to inform any physical features such as corrosion in the body of car or technical items like driven distance by the owner and the gas gauge and then are asked if they noticed or felt any defects of car. According to the rules, customers are not allowed to enter the fixing room area and have to wait in the waiting room until the end of the operation. The car will be transferred to the related station to be repaired or get changed if required. All of the activities of car repairing and piece change are recorded in a list which will be presented to the customers to sign and pay (if the guarantee is not included).

All car dealers are inspected by the head company weekly. They are also inspected and evaluated yearly by Iran Standard and Quality Inspection organization (ISQI), founded in 1989, to improve the quality and support the consumers' rights. The agents of ISQI co. consider many factors, examine all documents about dealers' activities and the head company and fill some questionnaire by asking the workers and the costumers randomly to evaluate and rank the dealers. If a dealer cannot reach the third grade out of four levels they will be banned and suspended from all activities.

Unfortunately, inspectors consider an equal criterion to evaluate all dealers in different cities and population with a different number of customers. However, the initial investment of establishing and running this kind of business in various states and regions of Iran is not the same. In other word, general inspectors compare the dealers without considering the differences with a solid inflexible framework.

In this thesis, it is supposed to measure all dealers' performance efficiency by considering the combination of some factors which are important for the head company as inputs or outputs, to verify the significant factors in efficiency values and to define an improving process for modifying the performance of inefficient dealers. For this purpose, all of the after sale services dealers have been considered as a homogeneous decision-making unit's (DMU) with same inputs and outputs, and are compared by each other to find out the performance efficiency of each dealer. Schematic figure of a DMU has been attached as Appendix 1. The following formula is the common simplest way to evaluate the efficiency value of a decision maker.

Efficiency = Output ÷ Input

By this formula, some problems might occur while trying to evaluate the efficiency with multiple inputs and multiple outputs. In this study Data Envelopment Analysis (DEA) as a non-parametric method based on linear programming and proposed by Charnes, Cooper, and Rhodes in 1978 for evaluating the relative efficiency of the decision making unit's is applied [1]. Using DEA approach for efficiency provides multiple dimensions for efficiency and makes it possible to rank the DMUs and manage them to find out the weaknesses and the inefficient factors to increase the usage of dealer's capacity.

DEA can be used as a decision analysis tool in several areas because it does not focus on finding universal relationships among all the units under assessment in the sample. Rather, DEA allows every unit in the dataset to have its own production function and then it evaluates the efficiency of that single unit by comparing it with the efficiency of the other units in the dataset. More specifically, DEA classifies all units into two groups: efficient with a 100% efficiency score and inefficient with a less than 100% efficiency score. Also, it can lead the decision maker to define the improvement project for increasing the efficiency of the performance for inefficient DMUs. This is done by introducing the suitable reference set and suggesting the expected input consumption or output production for having an efficient performance for an under evaluate inefficient DMU. This DMU can compare its performance by the performance of the efficient DMUs in the given reference set and modify its function to achieve the proposed input consumption or output production levels.

In order to form a corporate memory for the efficiency values for each dealer, input/output data is obtained during 2016-2017. Efficiency values for each dealer are calculated to seek for any improvement in the inefficient items. Weights of the input/output values are calculated to make suggestions on the types of enhancements. It is expected from this study to gain considerable insight into the compare and rank the dealers. As can be seen in the literature section, numerous studies have been performed in a different type of industries to analyze its efficiency.

1.2 Structure of the Thesis

After chapter 1 which is the introduction, the thesis will follow the literature review related to the study in chapter 2 then chapter 3 is continued by the presentation of methodology and basic data envelopment models also this chapter contains the procedure of data definition and collection as input or output. Chapter 4 goes on an explanation of the result obtained from data by mentioned models in methodology. Then finally in chapter 5 the entire of the study will be concluded and presenting the suggestions for the future studies in this case as it is illustrated by Figure 2.

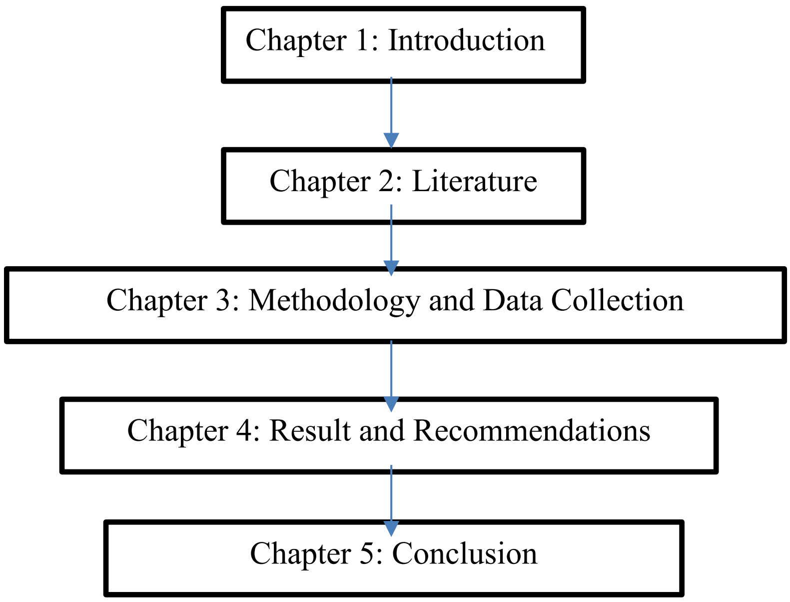

Figure 2. Structure of the thesis

Chapter 2

LITERATURE REVIEW

This chapter has three sections. The first one contains literature about the standard DEA models, and the definition of returns to scale concept in these models. Also, it discussed the articles which apply the DEA models for finding the most significant inputs and outputs in the efficiency evaluation of DMUs. In the second section, the brief literature is brought for the application of DEA in efficiency and performance verification of DMUs in different industries and the final section contains the literature about the application of DEA in auto manufacturing or after sell service companies.

2.1 Literature Review on Standard Models of DEA

The basic model for measuring efficiency is the ratio of output to input, but this model is not applicable for multi inputs and multi-outputs. In 1957, Farrell developed this basic concept to the efficiency frontier analysis, this method requires two variables data where all DMUs are plotted on a two-axis graph and on the efficient frontier line or below. All DMUs which lie on the efficient frontier are called as an efficient unit with 100% efficient score and all those are below of efficient frontier line called as inefficient units, their distance from the efficient frontier line is used for calculating their efficiency scores [2].

Twenty years later in 1978, Charnes, Cooper and Rhodes introduced a ratio definition of efficiency called CCR model which generalizes the single-output to single-input classical definition to multi-outputs and multi-inputs by proposing a nonlinear (non-convex) programming model for evaluating activities of units without pre-assigning the weights of inputs and outputs [1]. This model is constant returns to scale (CRS) which means by increasing (decreasing) the inputs, the outputs increase (decrease) with constant scale. Banker, Charnes and Cooper (1984) introduced a variable return to scale version of the CCR model, namely the BCC model which makes it possible to determine whether operations were conducted in regions of increasing, constant or decreasing returns to scale [3]. All of the above models can be presented by two aspects of input-oriented and output-oriented which means how much the outputs (inputs) should be increased (decreased) by making the inputs (outputs) constant. The more detailed of both models will be explained in the following chapter of the study.

The additive model presented by Charnes et al. in 1985. This model is neither input-oriented nor output-oriented while focusing on the increasing inputs and decreasing outputs at the same time [4].

Jati et al. (1996) presented a dynamic system for analysis of efficiency while inputs and outputs change by the time [5]. Another DEA model, labeled the SBM model (slack based model), was designed by Tone (1999). In contrast to the CCR and BCC measures, which are based on the proportional reduction (enlargement) of inputs (outputs) and which do not pay attention to the slacks, SBM deals directly with input excess and output shortfall. This model serves as the basis for the definition of super-efficiency [6]. In order to review efficient units, we can use super-efficiency models. Unlike the CCR and BCC model, they can also evaluate the efficiency rate of efficient units.

The selection of inputs and outputs in the study reflect the aim of the study. They can vary from indicators related to techniques, researches done by companies and other internal and external factors based on the aims of the study. The main focus of the abovementioned studies was on the overall efficiency of the Kerman motors dealers. Evaluating efficiency in smaller scale was conducted in a research study by Montoneri, Lin b, Lee c, & Huang c (2012), who apply data envelopment analysis (DEA) to explore the quantitative relative efficiency in a University of Taiwan. A diagram of teaching performance improvement mechanism is designed to identify key performance indicators for evaluation in order to help teachers concentrate their efforts on the formulated teaching suggestions [7].

Cooper, Seiford & Zhu (2000) emphasize on the advantages of applying DEA they also mentioned that DEA has also been used to supply new insights into activities (and entities) that have previously been evaluated by another method [8]. However, there is no need to explicitly specify a mathematical form for the production function. Furthermore, it is proven to be useful in uncovering relationships that remain hidden in other methodologies. Since it is capable of handling multiple inputs and outputs and capable of being used with any input-output measurement. The sources of inefficiency can be analyzed and quantified for every evaluated unit. Formally, DEA is a methodology directed towards efficiency frontiers rather than central tendencies. Instead of trying to fit a regression plane through the center of the data as in statistical regression, for example, one floats a piecewise linear surface to rest on top of the observations. Because of this perspective, DEA proves particularly adept at identifying new relationships that might be invisible from other methodologies. Finally, this approach can also provide analysis of inputs/outputs contributions in calculating efficiencies.

2.2 Literature Review on Application of DEA in Different Areas

DEA has been used by several researchers to show relative efficiencies of organizations or decision-making units (DMUs). In this section, we would see some articles showing how researchers have applied DEA in different areas. Some of these areas include as follows.

2.2.1 Telecommunication Industry

Telecommunication is very important to us today because of its undeniable impact on us and society. Some obvious benefits of telecommunication include: making distant communication easier, socialization, entertainment, customer service for the banking system, integrated voice response for the banking system, mobile bank transactions for the banking system, communication logistics and business meetings for business. Calculating the efficiencies of various telecommunication companies is seen as one of the most vital issues amongst researchers.

Roma Mitra Debnath and Ravi Shankar (2006) used DEA to compare the relative efficiency of mobile service providers in India. They used various inputs and outputs contributing towards the number of subscribers for different service providers. They discovered that the operating performance was the primary cause of insufficiency among service providers and Government policies need to be fine-tuned so that a better competitive environment emerges to meet customer expectations [9].

Soung-Hie Kim, Choong-Gyoo Park and Kyung-Sam Park (1999) used DEA to find the efficiency of thirty-three telephone offices with three inputs and five outputs. Nineteen out of the thirty-three offices were found efficient [10].

Hsu-Hao Yang and Cheng-Yu Chang (2009) using DEA revealed that firms can improve scale efficiency through acquisitions but will possibly encounter poor efficiency stemming from integrating resources of two existing units in the short run [11].

S.J. Sadjadi and H. Omrani (2010) used DEA to find the efficiency for twenty-four telecommunication companies and five of them were discovered to be efficient [12].

Roma Mitra Debnath and Dr. Ravi Shankar (2008) used DEA to find the efficiency of thirteen telecommunication service providers. Eleven of them were found efficient and two of them inefficient. They revealed that for more efficiency and customer satisfaction, customer complaints should be resolved within four weeks or less [13].

2.2.2 Energy Industry

Electricity is very important in our society today. It is the backbone of a country. Its huge distribution and uninterrupted quality advancement are the basis for national economic development. In 2008, the high energy cost caused global concern and serious pressure in the management of power distribution. The articles below show how DEA has been applied in the energy distribution industry.

Alexander Vaninsky (2006) used DEA to estimate the efficiency of electric power generation in the US for the years 1991 to 2004. The inputs include operating expenses and energy loss while utilization of net capacity is used as the output. The results show that there was stability in efficiency from 1994 till 2000 and the efficiency decreased in the following years. The cause of the decrease in efficiency was due to the decrease in capacity maximization and the mixed dynamics of energy loss were not fully offset by only a moderate decrease in operating expenses [14].

Pun-Lee Lam and Alice Shiu (2001) used the DEA approach to measure the technical efficiency of China's thermal power generation for 1995 and 1996. The results show little increment in efficiency within the two years of study. Generally, areas with good supplies of coal and provinces along the eastern coast had higher levels of efficiency [15].

C.H. Liu, Sue J. Lin and Charles Lewis (2010) used DEA to evaluate the power-generation efficiency of major thermal power plants in Taiwan during 2004–2006. The inputs used were Electricity used, the Heating value of total fuels and Installed capacity while the output was the Net electricity produced. It was discovered that all power plants were efficient during through the years of study, with the range of average CCR efficiency from 0.737 to 1.000. The combined cycle power plants are found to be more efficient than steam and gas turbine power plants. Reduction in electricity use was discovered as the most effective way of improving the operation of inefficient utilities [16].

Beyzanur Cayir Ervurala, Bilal Ervuralb and Selim Zaimc (2016) used DEA to calculate the efficiency of renewable energy in 81 cities in Turkey. 11 out of 81 were efficient. It was discovered that the main reason for the efficiency of these regions is having high renewable energy potential and utilization of the potential [17].

Sabuj Kumar Mandal & S. Madheswaran (2010) makes an attempt to measure energy use efficiency of the Indian cement companies over the period 1989–1990 to 2006–2007 by using DEA models. DEA results state that firm size is the most effective items for being an efficient unit, on the other hand, there is no significant effect in efficiency for the firm age. This paper also presented two models for those firms are motivated to reduce all the inputs proportionately, or those which are considered the only minimization of cost input. It is suggested that if an Indian cement company is motivated to reduce all the inputs, they can reduce the energy input by 28.68% and still produce the given level of outputs without using more of any inputs than was actually used [18].

S.J. Sadjadi et al. (2011) used a stochastic super-efficiency DEA model is proposed for ranking 27 gas companies which are located in different regions of Iran in 2008. The kilometer of networks and the number of employees are considered as inputs and delivered volumes and number of customers, are observed as outputs in this study. Five gas companies are evaluated with efficiency equal to 1 which they served as a reference set to the others in terms of technical efficiency as a conclusion [19].

Mehmet Erturk, Serap Turut-Asık (2011) analyzes the performance of 38 Turkish natural gas distribution companies which was set up before 2003, The firms are compared in terms of type of ownership (public versus private), maturity level (new versus old), licensing process (tender versus non-tender), scale (small versus large) by using CRS and VRS model, they found out public sectors operate more efficient in Turkey but generally most companies are immature and it is too early to reach a conclusion about the inefficiency [20].

George E. Halkos, Nickolaos G. Tzeremes (2012) paper applies a bootstrapped Data Envelopment Analysis (DEA) formulation aiming to evaluate the financial performance of the firms operating in the Greek renewable energy sector like solar, hydropower, wind and biomass from 78 firms for the period 2006-2008 and led the Greek government to invest in solar energy [21].

Shen Yuzh, Zhangna (2012) applied standard DEA models and Malmquist indexes analysis for 5 power distribution systems. Also, they mentioned some noticeable factors should be considered for selecting reliable inputs and outputs [22].

Yunna Wu, Yong Hu, Xinli Xiao and Chunyu Mao (2016) took 42 large-scale wind farms in China as DMUs and analyzed the productive efficiency through the two-stage (DEA & Tobit) analysis. The results of DEA reveal that the wind farms studied have high-efficiency levels. The location of wind farms was seen to be a factor that affects the productive efficiency. The wind farms located in high-density wind resource areas tend to be more efficient than those located in low-density areas. They gave a few suggestions which include that developers ought to strengthen the quality of the development phase, select the optimal rich-wind site and properly design the installed capacity considering existing capacity, structure and maximum capacity of the local power grid when developing new wind power projects. They also suggested that for existing wind farms, operators should develop a good operational plan and replace old equipment in time so as to enhance the operational quality and reduce the electricity consumption and finally, a series of policies should be introduced to strictly control the approval of wind power projects and encourage the technical innovation of wind farms. The government should also narrow the gap between the development of wind farms and electricity grids to reduce the wind curtailment rate [23].

2.2.3 Health Care Systems

The Health sector is one of the most significant sectors in society today. A sufficient level of health of the people is necessary for them in order for them to lead a happy and very productive life and thus help in economic growth. As a result of this, a lot of public funds are allocated to the health sector in several nations. Given the increasing costs of health care worldwide, efficient provision of health care to patients has become important. Efficiency in this situation can be seen as the provision of sufficient health care by ensuring proper usage of available resources. Efforts have been made to assess the efficiency with which hospitals provide health care to patients, many of which are reported in the health care and operational management literature. Some of this literature can be seen below.

Ramakrishnan Ramanathan (2005) used the DEA method to analyze the efficiencies of operation of 20 hospitals in the Sultanate of Oman. Three inputs which were bed days, physicians and other medical personnel were used and Four outputs which are total out-patient visits Number of in-patients Major surgical procedures Minor surgical procedures were used. 10 out of 20 of the hospitals were found efficient [24].

Korkut Ersoy, Sahin Kavuncubasi, Yasar A. Ozcan and James M. Harris (1997) used Data Envelopment Analysis to examine the technical efficiencies of 573 Turkish acute general hospitals. Results show that less than ten percent of Turkish acute general hospitals were efficient. Comparing the inefficient hospitals to the efficient hospitals, it was seen that the efficient hospitals use 32% more specialists, 47% more primary care physicians, and have 119% more staffed bed capacity [25].

Joses M. Kirigia, Ali Emrouznejad and Luis G. Sambo (2002) used DEA to measure relative technical efficiencies of 54 public hospitals in Kenya. The 11 inputs used include medical officers, clinic officers, nurses, administrative staff, technicians, other staff, subordinate staff, pharmaceuticals, non-pharmaceutical supplies, maintenance of equipment, vehicles, and buildings, and food and rations. The 8 outputs used include Outpatient Department casualty visits, special clinic visits, MCH/FP visits, dental care visits, general medical admissions, pediatric admissions, maternity admissions, and amenity ward admissions. It was discovered that 14 of the public hospitals were inefficient and 40 of the hospitals were found efficient. It was seen that efficient hospitals were using less inputs to produce more outputs. Inefficient hospitals were seen to have used larger numbers of inputs and with their large inputs, they produced less outputs than their relatively efficient counterparts [26].

Jeffrey P. Harrison and LT Richard J. Ogniewski (2005) used DEA to analyze data for 131 VHA hospitals in 1998 and 121 in 2001. The results indicated that efficiency in VHA hospitals improved efficiency by 1% between 1998 and 2001. It was seen that they made use of opportunities for improved management and they utilized resources more to meet demands better. They also provided access to critical health care services [27].

2.2.4 Touristic Sectors and Hotels

Since the end of the cold war, reconciliation has gradually replaced confrontation. Barriers to international travel have gradually been removed. With the increasing popularity of free trade, the international exchange has gained tremendous increase which is seen in the relaxation of visa arrangements around the world. This has prompted the rapid growth of tourism industries (Shiuh-Nan Hwang & Te-Yi Chang, 2003) [28]. Tourism hasn't just become one of the major sources of income for many countries but also has the potential to bring about a huge influence in worldwide economic growth. The articles below show ways that DEA has been applied in the hotel sector.

Nick Johns, Barry Howcroft and Leigh Drake (1997) used Data envelopment analysis (DEA) to monitor and benchmark productivity in a chain of 15 hotels over a 12-month period. Factors like refurbishments, over-use of labor and resources, location and managerial effectiveness were seen as the cause of certain inefficiencies [29].

Shiuh-Nan Hwang and Te-Yi Chang (2003) used DEA to measure the managerial performance of 45 hotels in 1998 and the efficiency change of 45 Hotels from 1994 to 1998. The results show that due to the difference in sources of customers and management styles there was a notable difference in the change of efficiency [28].

Ali Ashrafi, Hsin-Vonn Seow, Lai Soon Lee and Chew Ging Lee (2013) used DEA to identify the efficient years for the hotel industry in Singapore from 1995 to 2010. The results show that the years of 1995-2000, 2004-2007 and 2008 as efficient DMUs. 2001-2003, 2009 and 2010 are inefficient DMUs. The inefficient years were caused by the happenings around that period, such as September 11 attacks in the year 2001, the outbreak of SARS between November 2002 and July 2003, and the global financial crisis [30].

Carlos Pestana Barros and Peter U.C. Dieke (2008) used data envelopment analysis (DEA) to estimate the technical efficiency of 12 hotels in Luanda, Angola. It was discovered that the efficiency decreased over the studied period, they discovered that a hotel's membership in a group increases efficiency and finally it was seen that hotels with international strategies have better efficiencies [31].

Carlos Alberto Pestana Barros and Carla Almeida Santos (2006) used DEA to show the economic efficiency of a sample of Portuguese hotels for the period 1998-2002. It was suggested that an organizational governance environment, with accountability, transparency, and efficiency incentives that explicitly oblige the hotels to achieve efficiency in their operational activities, should be provided to overcome the deficits inefficiency [32].

Joao C. Neves and Sofia Lourenco (2009) used DEA for strategic analysis and performance management of a worldwide sample of hotel companies. The results show that most hotel companies, the scale efficiency is higher than the technical efficiency, therefore hotel managers should concentrate on productivity improvements and not on scale issues. It was also discovered that a reduction in the size of the hotel companies would have a positive effect on the average efficiency level of the industry [33].

2.2.5 Transportation Systems

Transportation has an enormous impact on the world today. The world we live in today almost can't do without transportation systems because of its irreplaceable contribution towards everyone. Transportation has helped in mobilizing humans from one place to the other, transportation has helped in mobilizing labor and it has also helped agricultural and industrial development. Transportation has also helped in increasing national wealth as it's a source of income for the government.

Over the last 20 years, a large amount of work and resources have been spent in developing measures of performance for carriers in the various means of transportation. This has been kindled by both deregulation and privatization initiatives. Measures of performance and efficiency are now present for all forms of transportation firms. Below are some articles showing how DEA has been applied in the transportation industry.

Yu-Chun Chang, Ming-Miin Yu and Po-Chi Chen (2013) used DEA to examine the technical efficiency of 41 Chinese airports in 2008. The results show that airports located in cities with populations of more than two million are more efficient than those in cities with lesser population. Airports that are able to accommodate A380 or Boeing 747 aircraft are operationally more efficient than other airports [34].

Jose Tongzon (2001) used DEA to provide an efficiency measurement for four Australian and twelve other international container ports. 4 out of the 16 ports studied are found to be the most inefficient, based on constant and variable returns to scale assumptions, mainly due to the enormous slack in their container berths, terminal area and labor inputs [35].

Dan Liu (2017) used the multi-period Network Data Envelopment Analysis to evaluate the efficiencies and efficiency changes for East Asia airport companies. The results indicate that the overall efficiencies of airport companies were affected by the system efficiency and the sub-processes efficiencies. According to the operating decision analysis matrix, managers can discover inefficient sub-processes and create measures that will bring about improvement [36].

David Gillen and Ashish Lall (1997) applied Data Envelopment Analysis to assess the performance of 21 U.S. airports over a five-year period. Results show that having hub airlines and expanding gate capacity improves efficiency. Reducing the number of GA movements has a dramatic impact on improving efficiency as well. Market discipline is also an important feature that contributes to efficiency [37].

2.2.6 Financial Institutions

Financial institutions are very important in the economy today because they provide a major source of financial intermediation and their checkable deposit liabilities represent the bulk of the nation's money stock. Evaluating their overall performance and monitoring their financial condition is important to depositors, owners, potential investors, managers and, of course, regulators (Piyu Yue, 1992) [38]. Below are some articles that show how data envelopment analysis has been applied in financial institutions for evaluating their efficiency.

M. Vassiloglou and D. Giokas (1990) applied DEA to 20 bank branches of which 9 were efficient. The location of the branch was seen as one of the possible causes of inefficiencies [39].

David A. Grigorian and Vlad Manole (2002) applied DEA to assess the efficiency of commercial bank operations. The results show that foreign ownership with controlling power and enterprise restructuring enhance commercial bank efficiency [40].

Yang and Hsian-Ming Liu (2012) used DEA to calculate the managerial efficiency of bank branches in Taiwan. The results show that the mixed ownership bank branches are more efficient than the state-owned bank branches. This shows that banking privatization has some remedial effects for improving the managerial inefficiency of state-owned banks [41].

Carlo A. Favero and Luca Papi (1995) used data envelopment analysis to calculate the efficiencies of 174 Italian banks. It was seen that efficiencies and inefficiencies are caused by productive specialization, size and to a lesser extent, by location [42].

2.2.7 Educational Sector

"Educational institutions that shape today's information society are an important actor in providing economic development and growth, and competitive advantage to countries in the international arena, as well as in providing prestige and high level of income to individuals. Higher education contributes significantly to the development and economic growth of a country by training and providing a required quantity of required specialists in various fields of the national economy. In this case, investigating the factors that determine the efficiency of higher education institutions and research activities are important." (Sibel Selim & Sibel Aybarç Bursalıoğlu, 2015) [43].

M. Abbott and C. Doucouliagos (2003) used to DEA to estimate the technical and scale efficiency of individual Australian universities. The results reveal that all the Australian universities are operating at a fairly high level of efficiency, although there is room for improvement [44].

Sibel Selima and Sibel Aybarc Bursalioglu (2013) used a two-stage Data Envelopment Analysis to determine factors on the efficiency of universities in Turkey in 2006-2010. Results show that the number of students per academic has a positive effect on the relative efficiency of universities in Turkey. Employment and number of publications affect efficiency in a positive way. Since the government budget appropriations don't contribute to the efficiency of the universities, it was suggested that the universities search for alternative financing such as Triple Spiral model in co-operation with the private sector, R&D support, project support, counseling, within the framework of university-industry-government [45].

Adrian Sirbu, Dragos Cimpoies and Anatol Racul (2016) used DEA to measure the relative efficiency of academic departments of the faculty of economics. The results show that for a department to be more efficient, research and teaching activities must be intensified [46].

Ying Chu Ng and Sung Ko Li (2000) used DEA to calculate the efficiency of the research performance of 84 Chinese higher education institutions. Results show that the research performance of higher education institutions across regions has improved. It was discovered that Institutions located in the East region appeared to have performed better than the institutions located in the Central and the West regions [47].

2.2.8 Industry Sector

The application of DEA models in the industry considers the last subsection since auto manufacturing is one of its most important and effective subsectors.

Chung-Jen Chen et al (2005) evaluated the efficiency of 6 high-tech industries (semiconductor, computer, communications, photo-electronics, precision equipment, and biotech) in Taiwan during 1991-1999, number of employees, working capital, R&D expenditure, and land area are considered as inputs and annual sales and the number of patents observed as outputs. The technical efficiency and pure technical efficiency is calculated by standard CRS and VRS models [48].

J. Baran et al. (2016) investigated 9 metallurgical industries in Poland and calculated the relative efficiency, it is concluded that the majority of metal and metal products manufacture industry branches are characterized by increasing returns to scale (IRS), which means that if they decide to increase production, it should grow faster than the engaged inputs [49].

In Lam Weng Hoe et al. (2017) 18 huge Malaysian technology companies are ranked by CCR model and also the weights of inputs/outputs are analyzed, a practical recommendation for potential improvement is recommended for each input/outputs of inefficient companies by comparing them with efficient companies [50].

Teerawat Charoenrat, Charles Harvie (2017) applied CRS, DRS and IRS DEA model to measure the technical efficiency of Thai manufacturing small and medium enterprises (SMEs), it is illustrated skilled labor ratio has a significant role more than firm size and firm age for efficiency. The empirical evidence from DEA emphasizes that the average technical efficiency of all categories of Thai manufacturing SMEs in both 1997 and 2007 are relatively low. It was also indicated that Thai manufacturing SMEs experienced no technical efficiency improvement in the period [51].

Chienta Chen et al. (2018) aims to analyze and find out key factors in customer relationship management in the shipping industry; 12 Chinese shipping enterprises has been investigated by cost and manpower as inputs and response performance and financial performance as outputs. Cost input appears higher importance to all DMUs [52].

The above shows why many researchers have attracted DEA models. It is because of DEA's strength to measure the efficiency of multiple inputs and multiple outputs of DMUs without considering prior weight for the inputs and outputs.

2.3 Literature Review on the Application of DEA in Automobile Industries

According to our case study, some of the recent researches in automobile industries with different dimensions related to automotive fields such as (cost, produce, service quality and customer satisfaction) by using DEA application bring in the following.

R.Paramesh-waran et al. (2009) propose an integrated fuzzy AHP and DEA approach for the service performance measurement. The main advantage of this study is the consideration of both qualitative and quantitative criteria for performance evaluation of automobile repair shops, 8 DMUs are observed and one input (operating cost per day) and two outputs (revenue generated and productive service time per day) have been issued to approach in input-oriented CRS model. The overall result of this study shows that the combination of AHP and fuzzy expert method is a useful tool for service quality evaluation [53].

Ali Yousefi, Abdollah Hadi-Vencheh (2010) An integrated model from the most important and usable Multi-Criteria Decision Making (MCDM) techniques, means Analytic Hierarchy Process (AHP) and Technique for Ordering Preference by Similarity to Ideal Solution (TOPSIS) is proposed in order to examine the improvement fields of Iran automobile industry. They defined 6 main criteria (technical features, beauty, manufacture, tools availability, economical aspect, and social aspects) for choosing the most desirable automobile among 8 automobile models and expanded them to exact sub-criteria by paying attention to automobile markets of Iran. The most important criteria are: Technical features and Economical Factors, furthermore, the most important sub-criteria are: safety, price, spare parts availability, comfortableness, and relaxation in the automobile [54].

Shiuh-Nan Hwang et al. (2013) developed a new DEA model for evaluating the design for the environmental performance where a simultaneous increase of desirable outputs and decrease of undesirable outputs are considered. 35 automakers from Asia, Europe, Africa, and America has been evaluated to be eco-efficient from 1998 to 2009 [55].

Youchao Tan et al. (2016) compares 10 automobile dealers from different areas by using data envelopment with 5 inputs (physical aspects, reliability, customer relationship, problem solving and policy) and 5 outputs (Customer perception towards service, Number of customers, Profit, Order processing time, Complaints handled) through customer point of view then balance scorecard (BSC) is applied based on four perspectives like as; customers, financial, internal business process and learning and growth for inefficient units to guide them have a better performance [56].

In Amir Shabani et al. (2016) a new methodology based on the non-parametric DEA technique was presented to measure productivity. The proposed approach can compute efficiency, input effectiveness, and output effectiveness, simultaneously. The data set from 27 after sales service of SAIPA Company (as it was introduced in the introduction as a second biggest automotive company in Iran) is obtained. Personnel cost, liabilities, and frequency of financial facility utilization are defined as inputs and personnel experience, sales growth and delivered services are considered as outputs [57].

In Inha Oh et al. (2016) a conceptual and methodological framework is described to measure technical and allocative efficiency at the product level while The technical efficiency refers to the distance between the position of a product and the frontier in the price-quality space. The allocative efficiency refers to the degree of match of quality mix with the preference structure. It is shown technical efficiency is correlated marginally with sales, whereas allocative efficiency and overall efficiency evidence a strong correlation with sales [58].

Chapter 3

METHODOLOGY

As mentioned before there are two basic models for data envelopment analysis, firstly, the Standard CCR model presented by Charnes, Cooper, and Rhodes in 1978 which is commonly used by analyzers, secondly, Standard BCC model proposed by Banker, Charnes, and Cooper in 1984. The former model is based on the assumption of constant return to scale, unlike the latest model which is the generalized CCR model for variable return to scale.

Let there be *n* decision making units *DMUj* for $j = 1,...,n$ that convert m inputs x_{ij} $(i = 1,...,m)$ into s outputs y_{rj} $(r = 1,..., s)$. Consider DMU_O as under evaluation DMU. Suppose that all input and output elements are non-negative deterministic numbers where;

o= the DMU being observed in the set of $j=1,2,...,n$ DMUs

θ_o= the measure of the efficiency of *DMU o*

y_{ro}= the amount of output r produced by *DMU o*

x_{io}= the amount of input i used by *DMU o*

y_{rj}= the amount of output r produced by *DMU j*

x_{ij}= the amount of input i used by *DMU j*

u_r= the weights to be determined for output *r*

v_i= the weights to be determined for input *i*

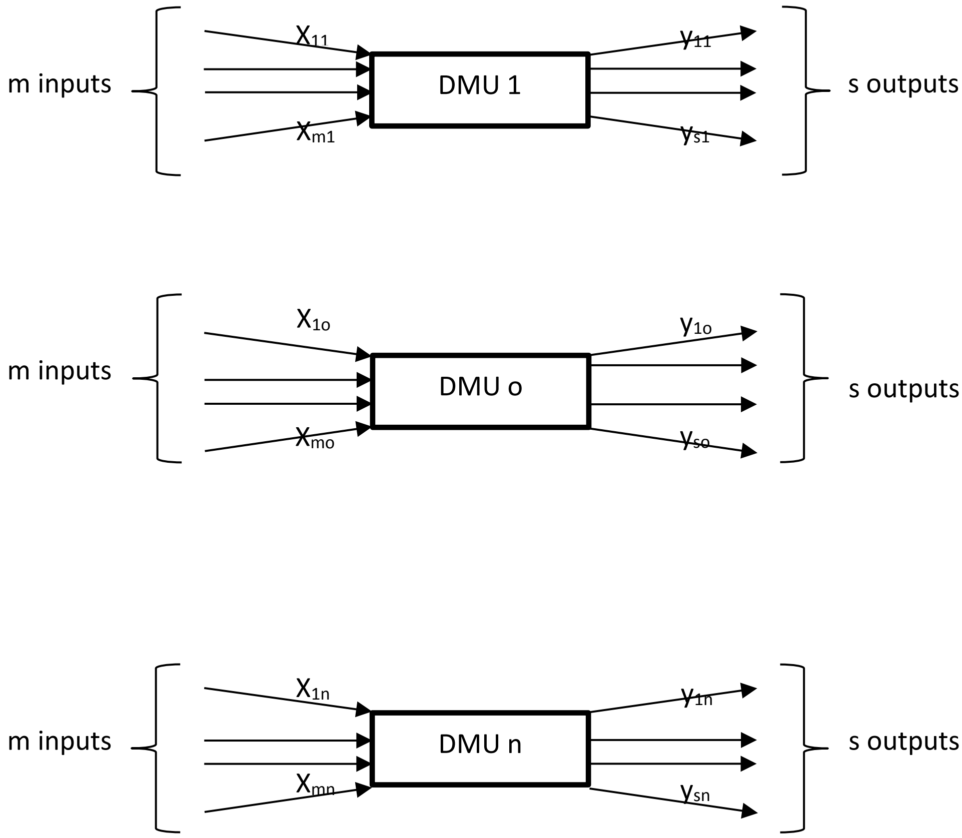

Figure 3. Efficiency evaluation structure regarding n homogenous DMUs

All of the inputs and outputs of each DMU must follow the following five rules which lead us to have a production possibility set (PPS):

1. "PPS" is the set including observed activities (X_j, Y_j) where $j= 1, 2... n$ and "*m*" inputs and *"s"* outputs. Semi-positive *"n"* DMUs are under concern meaning all the data assumed to be non-negative but at least one input and one output are positive;

2. If an activity *(X, Y)* belongs to PPS then the activity *(tX, tY)* also belongs to PPS for any positive scalar *t* (constant return to scale);
3. For any activity *(X, Y)* in PPS with input no less than *X* and any activity with output no greater than *Y* is feasible;
4. Any semi-positive linear combination of activities in PPS belongs to PPS;
5. "λ" a semi-positive linear vector in R^n is also defined as follow;

$$PPS_C = \{(X,Y) \mid X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \lambda_j \geq 0,\ j = 1,2,...,n\ \}$$

3.1 Mathematical CCR Model

For evaluation of DMU_O we try to find θ_o (the efficiency of DMU_O) by input oriented CCR model:

Min θ_o

S.t. $(\theta_o, X_o, Y_o) \in PPS_c$

$$PPS_C = \{(X,Y) \mid X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \lambda_j \geq 0,\ j = 1,2,...,n\ \}$$

The primal form of CCR model will be as following:

$$\begin{aligned}
& Min \quad \theta_o \\
& S.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_o x_{io} \quad i = 1,...,m \\
& \qquad \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \quad r = 1,...,s \\
& \qquad \lambda_j \geq 0 \quad j = 1,...,n
\end{aligned}$$

Also, we can transform the above model to its dual version as following:

$$\begin{aligned}
& Max \sum_{r=1}^{s} u_{ro} y_{ro} \\
& S.t. \ \sum_{i=1}^{m} v_{io} x_{io} = \mathbf{1} \\
& \qquad \sum_{r=1}^{s} u_{ro} y_{rj} - \sum_{i=1}^{m} v_{io} x_{ij} \leq 0 \quad j = 1,2,...,n \\
& \qquad u_{ro}, v_{io} \geq 0 \quad r = 1,2,...,s \quad i = 1,2,...,m
\end{aligned}$$

By solving the primal CCR model we can find efficiency of each DMU (θ_o) where obviously $0 \leq \theta_o \leq 1$ and the amount of λ_j will be equal to zero for all fully efficient DMUs otherwise, there is at least one $\lambda_j > 0$ for inefficient DMUs that lead us to refer the DMU with highest amount of correspondent λ_j to improve the inefficient DMU as it will briefly be explained in the next chapter after calculating by software, by solving dual form we can obtain the weights of inputs (u_{ro}) and outputs (v_{io}) for each DMUs but we must consider that it is possible the amount of u_{ro} and v_{io} could be equal to zero means that the related inputs and outputs have not to effect on efficiency of the DMU under observation, so to avoid this possibility the infinitesimal positive number ε should be defined and the last constraint will be transformed to:

$$u_{ro} , v_{io} \geq \varepsilon \qquad r = 1,2,\ldots,s \qquad i = 1,2,\ldots,m$$

For evaluating of DMU_O in output orientation, we try to find ϕ_o in a manner of that:

$$Max\ \phi_o$$
$$S.t.\ \ (X_o, \phi_o Y_o) \in PPS_c$$

The primal form of output-oriented CCR model is as follow:

$$\begin{aligned} Max\quad & \phi_o \\ S.t.\quad & \sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} && i = 1,\ldots,m \\ & \sum_{j=1}^{n} \lambda_j y_{rj} \geq \phi_o y_{ro} && r = 1,\ldots,s \\ & \lambda_j \geq 0 && j = 1,\ldots,n \end{aligned}$$

For any under evaluation, DMU says DMU_0, simply we can show that $\phi_o = \dfrac{1}{\theta_o}$.

3.2 Mathematical BCC Model

The BCC model assumed production possibility sets as a convex combination of the observed DMUs where $\sum \lambda_j = 1$ means, unlike the CCR model which is based on the constant return to scale (CRS), the BCC model can be a variable return to scale (VRS). The CCR production frontier is a shaped linear line passing through origin coordinates and efficient DMUs, on the other hand, the BCC production frontier is formed piecewise and concave.

Production possibility set (PPS) for BCC model will be redefined by eliminating the rule number 2 (If an activity *(X, Y)* belongs to PPS then the activity *(tX, tY)* also belongs to PPS for any positive scalar *t*) which is related to assumption of constant return to scale and adding $\sum\lambda_j = 1$ as convexity constraint, then;

$$PPS_B = \{(X,Y) \mid X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \sum_{j=1}^{n} \lambda_j = 1,\ \lambda_j \geq 0,\ j = 1,2,\dots,n \}$$

The primal form of BCC model (input oriented) will be as following:

$$\begin{aligned}
&Min \quad \theta_o \\
&S.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_o x_{io} \qquad i = 1,\dots,m \\
&\qquad \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \qquad r = 1,\dots,s \\
&\qquad \sum_{j=1}^{n} \lambda_j = 1 \\
&\qquad\qquad \lambda_j \geq 0 \qquad j = 1,\dots,n
\end{aligned}$$

Also, we can transform the above model to its dual version as following:

$$\begin{aligned}
&Max \sum_{r=1}^{s} u_{ro} y_{ro} + u_0 \\
&S.t. \ \sum_{i=1}^{m} v_{io} x_{io} = 1 \\
&\qquad \sum_{r=1}^{s} u_{ro} y_{rj} - \sum_{i=1}^{m} v_{io} x_{ij} + u_0 \leq 0 \qquad j = 1,2,\dots,n \\
&\qquad u_{ro}, v_{io} \geq 0 \quad u_0 \ free \qquad r = 1,2,\dots,s \quad i = 1,2,\dots,m
\end{aligned}$$

In primal BBC model, λ_j means as same as CCR primal model and dual BCC model is used for calculating the weights of inputs (u_{ro}) and outputs (v_{io}) and u_0 for observed DMU where;

If; $u_0 > 0$ then DMU_o has increased the return to scale

$u_0 < 0$ then DMU_o has decreasing return to scale

$u_0 = 0$ then DMU_o has constant return to scale

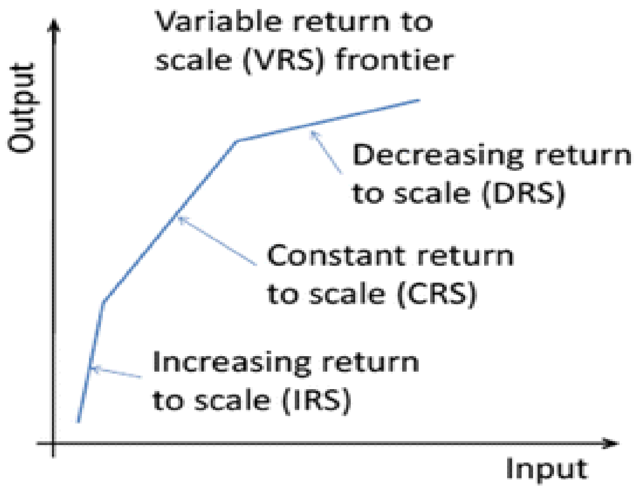

Figure 4. Increasing, Decreasing and constant return to scale

In both CCR and BCC model we assumed the summation of multiplication of inputs by their weights ($\sum v_{io} x_{io}$) is equal to one (maximum) that is why it is named input-oriented model which it means by forcing the summation of multiplication of inputs by their weights to be maximum, it is aimed to maximize the summation of multiplication of outputs by their weights as an objective function on the other hand both models can be rewritten in a manner of output oriental version by adding the constraint ($\sum u_{ro}y_{ro}= 1$) instead of ($\sum v_{io}x_{io}= 1$) and minimizing the summation of multiplication of inputs by their weights as an objective function.

In this study we will apply the CCR model due to its more rigid and inflexible feature in comparison to the BCC model as it is noticeable in figure 4 there are more efficient DMUs lie on the production frontier line, in other words if a DMU is found 100% efficient in the CCR model it will be fully efficient in the BCC model definitely but not vice versa.

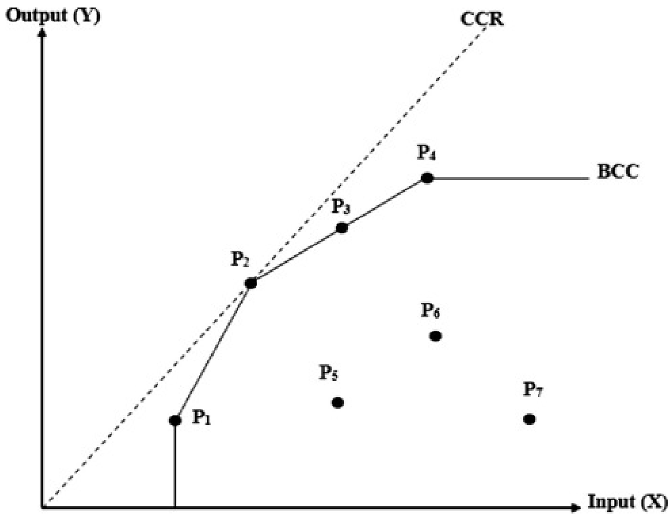

Figure 5. CCR and BCC frontiers for one input one output case

The summation of the resulted weights for each input and output in the multiplayer side of both CCR and BCC models, specially CCR model, can consider verifying the most significant factors (inputs/outputs) in the efficiency value of the under evaluation DMUs. It is clear that when the summation of the weights for one factor (input or output) is more than another one the effect of that factor in the efficiency value of the DMUs is more than another one.

Another method to verify the significant factor of efficiency value of the under evaluation DMUs is computing the efficiency of observed DMUs after removing each of the factors form the current set of inputs and outputs one by one. This effect on the efficiency values the DMUs (in most of the cases the efficiency values decrease). Now if the average of resulted efficiency values and original efficiency values are calculated, obviously the factor which its elimination has the biggest difference with the average of the efficiency value with original data is the most significant factor.

In this study, PIM DEA software is used for the calculation to attain the capacity to assess efficiency and productivity, to set targets, to identify benchmarks and even, to provide to truly manage the performance of organizational units. Furthermore, this software is able to solve complex mathematical DEA models and draw charts. Its graphical facilities include an illustration of production possibility set and its frontier as the model specification is modified and histogram of efficiencies and trend of efficiencies over time all basic DEA models and different types of return to scale is included and also it can be linked to EXCEL for importing the huge data sets.

3.3 Defining the Input/output Variable and Factors

In this study, 88 car dealers of Kerman Motor Co. are observed as the DMUs, all of which are involved in after sale service activities all over Iran. All data are obtained during 2017-2108 by using the documents of the head company, field observation, evaluation of inspectors of Iran Standard and Quality Inspection organization (ISQI) and filling the questioners by the customers. In general car dealers are evaluated and ranked by ISQI inspectors considering the following four criteria. As shown in figure 6, all criteria are pre-weighted before with a solid and inflexible framework unlike the evaluation by the DEA model.

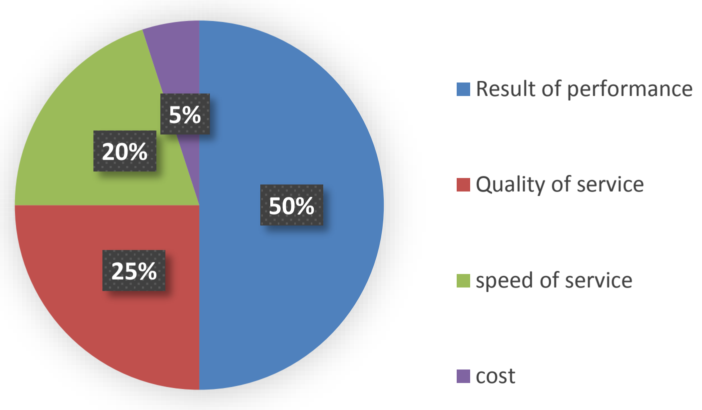

Figure 6. ISQI evaluation criteria

ISQI organization, rank and classify all dealers into 5 levels based on the total obtained score from inspectors as shown in table 1. If any dealers could not reach the fourth level, all of its activities will be suspended temporarily until the whole deficiencies are removed, otherwise, it will be banned permanently.

Table 1. ISQI ranking scores

Grade	**Total score(A)**
Premium	$95 < A < 100$
1	$85 < A < 95$
2	$70 < A < 85$
3	$55 < A < 77$
Fail	$A < 55$

We consider 6 inputs including the number of customers, human resource, equipment, providing pieces and process and 3 outputs including the stopped cars (more than 48 hours), reworked cars and customer satisfaction for evaluation of car dealer’s repair shops. The definition and identification of inputs and output along and a brief explanation of how they were collected is presented as follows.

3.3.1 Inputs

The number of customers

All of Kerman Motor car dealers are connected to unique software named “SEVEN” to insert all activities including after sale service activity with details and submit them online to the head company. Each dealer is linked to an expert whom observes its activities from head company whose wage is paid by the customers (if the guarantee is not included). In case of finding any infringement or activity which is not registered in the software, this may cause suspension or cancellation of dealer that is the reason of why the data, such as customer number, collected from software SEVEN, is reliable. In this study, the number of customers is collected for all of the dealers from SEVEN data sets during one-year activity from 2016-2017.

This is noticeable that some dealers are established during the above-mentioned period that is why there is a significant difference in the number of customers in comparison to the other old and experienced dealers. On the other hand, there is various population dispersion in different parts of Iran which affects the number of customers that are served by car dealers.

Human resources

According to the ISQI instruction, every single car dealer should follow united and organized chart for the recruited personnel as below in figure 7.

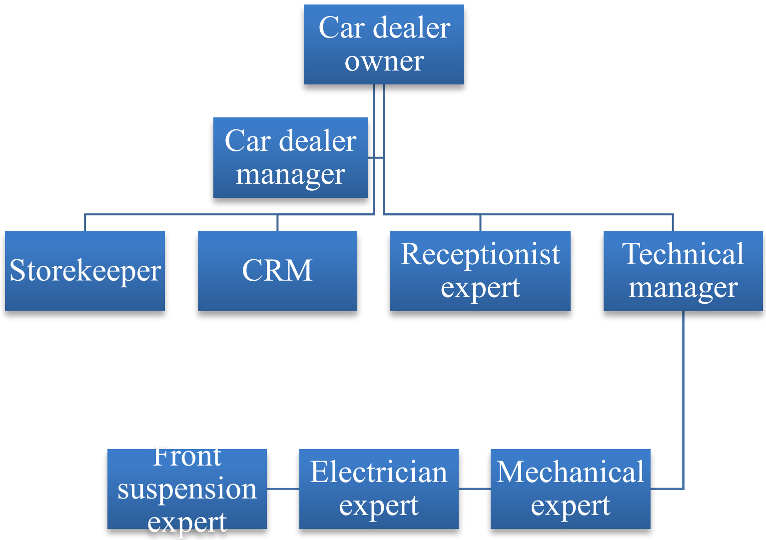

Figure 7. Organization chart of car dealers

Inspectors consider the number of employees according to the instruction rules for scoring the human resource item. Furthermore, they control if all of the employees are over 18 years old, have at least one-month experience, and officially are recruited in the car dealer.

The number of employees who are involved in different positions in car dealer should follow the following rules based on the demand of customers during a day.

Table 2. The number of managerial employees needed

<table>
<tr><th>Position</th><th>0< D < 10</th><th>10< D < 20</th><th>20< D < 30</th><th>D > 30</th></tr>
<tr><td>Car dealer manager</td><td colspan="4">1</td></tr>
<tr><td>Receptionist expert</td><td colspan="2" rowspan="2">1</td><td>1</td><td>2</td></tr>
<tr><td>CRM</td><td>1</td><td>1</td></tr>
<tr><td>Storekeeper</td><td colspan="4">1</td></tr>
</table>

*D= demand of customers during a day

It is clear that in order to calculate the number of operational experts (mechanical, electrical and front suspension experts); the demand of each station should be estimated separately during the working time in a day.

Table 3. Calculation of the number of operational experts

Position	**Mechanical expert**	**Electrical expert**	**Front suspension expert**
Symbol	T_M	T_E	T_F
Formula	$\left\lceil \frac{D_M \times 2.5}{t} \right\rceil$	$\left\lceil \frac{D_E \times 1}{t} \right\rceil$	$\left\lceil \frac{D_F \times 1.5}{t} \right\rceil$

*D= The average demand of position i per day
*t= Working time per day (8 hours)

The first formula shows that every mechanical repairing activity lasts 2.5 hours on average, so total mechanical activity time divided to working time in a day (in this case 8 hours) will give us the number of mechanical experts. It is considerable that formula should be calculated by roundup.

The technical manager plays a vital rule in the car dealers, commonly this position is directly responsible for everything related to all of the activities happen inside repair area, and for instance, deciding the number of required technical manager which is calculated based on the number of technical personnel (mechanical, electrical and front suspension experts).

Table 4. The number of technical managers needed

Amount					
Technical experts	**$0 < T < 5$**	**$5 < T < 10$**	**$10 < T < 15$**	**$15 < T < 20$**	**$20 < T$**
Technical manager	**1**	**2**	**3**	**4**	**5**

*$T = T_M + T_E + T_F$ (Total number of mechanical, electrical and front suspension experts)

Education

All personals should attend educational courses provided by head-office, some courses related to employee’s duties based on their position in a car dealer, some general customer-focused courses for all employees to improve the communication with clients, besides, more expert courses based on each repair station (mechanical, electrical and front suspension). For this purpose, residence and comforts for those who attend the courses in another city are provided by the head-office staff. The evaluation of educational scores is calculated as follows;

S = (total courses trained independently of car types) ÷ (total courses × number of personnel)

The aggregate of the above scores include 80% of educational scores, the rest is related to person’s job resume and educational documents, and therefore, there is a minimum educational and experience limitation for each position according to the ISQI instruction. On the other hand, there is a weight for each position based on the sensitivity and responsibility of their job according to the following table.

Table 5. The weights of educational points for each position

Position	Weight for education
Technical manager	3
Receptionist expert	2
Technical expert	2
Car dealer manager	1.5
CRM	1.5
Storekeeper	1.5

Equipment

There are 24 car repair equipment, the existence of each one is a must for car dealers, in other words, the lake or defectiveness of each item causes a big weakness for car dealers and have an irrecoverable effect on the repairing process. The equipment list is attached as Appendix 2. It is vital and necessary for all equipment to be calibrated and maintained. The point of equipment will be decreased up to 30% in case of not being calibrated; it can also be reduced up to 20% because of not being maintained.

Providing pieces

One of the most sensitive items which can have a very destructive effect in the repair process is the inappropriate providing pieces. After establishing a car dealer, a list including various car pieces and spare parts of all types of cars is given by the head office. The storekeeper is obligated to order and provide them from the head company. The number of car pieces and spare parts differs according to the location of the car dealer, the population and demands. During the car dealer’s activities, storekeeper should take care of the inventory and order pieces before it is finished by software SEVEN. Lack of any insignificant pieces may result in stopping the repair process for a long time and consequently the reduction of customer satisfaction. All pieces existing in store should match the SEVEN software data sets; inspectors commonly check 5 to 10 pieces randomly in terms of accordance to the amount, originality and the maintenance requirements quality.

Process

Four main processes during the repairing car should be applied according to the rules of ISQI instruction. The first process is related to all activities from reception till releasing the car which should be applied daily to cover all cars stopped from previous days to serve new customers. The customers' statement should be inserted in reception form honestly and fully matched. All customers should be informed about the approximate cost and duration of the repairing process of their cars. In case of finding any probable defectiveness in the car by experts, the extra cost and time should be announced. The final test before releasing the car should be done by the presence of the customer. According to the second main process, an official and systematic bill including the cost, repair activities description must be presented to customers while all guarantee instruction are should be considered. The next process is about the process of providing and ordering the pieces and maintenance condition of pieces in storage. The last process is related to filling the questioner by customers after finishing the repair process and handling the customer's complaints.

3.3.2 Outputs

Stopped cars

According to the SEVEN software reports, there are always a few percentages in the number of customers whose processes of repairing has been stopped more than 48 hours because of different reasons. Most of the times, the shortage of pieces in storage can cause delay for repairing. Unfortunately, sometimes the head office is not able to provide pieces for all car dealers due to sanction against Iran but there are significant number of stopped cars because of the lack of skill or knowledge of laborers and the other reason might occur in case of incorrect daily planning for acceptance of new customers and serving the stopped cars from previous working day.

Reworked cars

In many cases, some customers return again to car dealer because of the same previous deficiency in their cars. It illustrates that the first repair process was wrong or insufficient and the experts could not eliminate the main reason for the technical defects of the car. It is easily noticeable by SEVEN software to observe repetitive referrals of customers for the same reason.

Customer satisfaction

The most important output for all dealers is customer satisfaction, where the half of total scoring of car dealers by ISQI inspectors belongs to customer satisfaction. For the evaluation of customer satisfaction, inspectors choose a sample of total customers for each car dealer to get information about their satisfaction level. Choosing the sample size of customers is based on the number of customers in one month and three-month period as follow.

Table 6. Choosing sample size for customer satisfaction evaluation

Number of customers during three month	Three-month sample size	Monthly sample size
$100 < D < 200$	75	25
$200 < D < 500$	160	53
$500 < D < 1000$	195	65
$1000 < D < 5000$	230	77
$5000 < D$	250	83

After choosing proper sample size, inspectors access the customer's information to ask them to fill a questionnaire provided by ISQI organization which includes detailed information of customers and their cars and 19 questions about all of the repairing process which is as attached in Appendix 3. Commonly, the inspectors make phone calls with customers from the central branch of ISQI organization to get their help. All customer's statement and information will be kept safe and secure.

Finally, the table of all data gathered as inputs and outputs for all DMUs has been presented in Appendix 4. Similarly, inputs and outputs data of table 7 is shown for random five DMUs as below (DMU9, 25, 34, 58, 73).

Table 7. Input\Outputs data table for five random DMUs

DMU	Number of customers	Human resources (%)	Education (%)	Equipment (%)	Providing pieces (%)	Process (%)	Stopped cars (%)	Reworked cars (%)	Customer's satisfaction (%)
DMU9	8455	77.2	74.9	79.7	76	73.5	13	0	63.1
DMU25	4524	90.2	90.1	74.4	97	61.4	8	1.07	66.8
DMU34	3213	92.4	96.2	91.6	90	85.5	5	0.26	75.7
DMU58	784	61	79.3	65.4	57	57.3	9	0.25	64.9
DMU73	2244	92.4	71.4	85.6	125	81.8	9	0.99	74.8

Chapter 4

APPLYING DEA MODELS AND RESULTS

In this chapter, firstly the prepared input/output table is modified appropriately and imported to the PIM-DEA software. Secondly, the envelopment side and multiplier side of input-oriented CCR model is used to evaluate the branches as the DMUs. Finally, the results obtained from the software are interpreted.

4.1 DMUs Input\output Modification and Efficiency Results

The values related to the number of customers remain without any manipulation. The data for human resources, education, equipment, and the process has been normalized for importing to the software by identifying the biggest data in each column and dividing the other data to this value. Along with the above inputs, the absolute differences of 100 and providing piece percentage are also considered as an input.

As mentioned in the previous chapter, the good performance or efficient DMU is the DMU produces more outputs while consuming fewer inputs. Therefore, we applied the reversed form of data for the stopped cars and the reworked cars as outputs by dividing one over data in each column. Then increasing in the value of these data which practically is not desired, will give the smallest value for the considered outputs and decreasing in the value of them will increase these outputs. As customer satisfaction is stated as a percentage, this output also imported to the software without any changes.

It is noticeable that seven DMUs (DMU 1, 9, 37, 48, 53, 67 and 75) are scored infinite ∞ in their related reworked cars outputs because they did not have any reworked cars during the observed period.

The final inputs/outputs data table for random DMUs (DMU9, DMU25, DMU34, DMU58, DMU73) considered in Table 8.

Table 8. Final inputs/outputs table for five random DMUs.

DMU	**Number of customers**	**Human resources**	**Equipment**	**Education**	**Providing pieces**	**Process**	**Stopped cars**	**Reworked cars**	**Customers satisfaction**
DMU9	8455	0.0129	0.0125	0.0133	24	0.0136	0.0769	∞	63.1
DMU25	4524	0.0110	0.0134	0.0110	3	0.0162	0.125	0.9345	66.8
DMU34	3213	0.0108	0.0109	0.0103	10	0.0116	0.2	3.8461	75.7
DMU58	784	0.0163	0.0152	0.0126	43	0.0174	0.1111	4	64.9
DMU73	2244	0.0108	0.0116	0.0140	25	0.0122	0.1111	1.0101	74.8

The results of PIM-DEA software are shown in Appendix 5. The following table contains the efficiency value of selected random DMUs.

Table 9. The efficiency value for random DMUs

DMU	**Efficiency**
DMU9	70.36
DMU25	96.27
DMU34	100
DMU58	92.91
DMU73	92.71

In this case study, 31 DMUs out of 88 DMUs (35%) are recognized as fully efficient, the efficiency of 24 DMUs (27%) are ranked between 90 to 99 percent, which means more than half of the DMUs (62%) have an acceptable limit in their efficiency values for being as a good performance unit. On the other hands, just 6.8% of the branches perform under 70% efficiency and the lowest efficiency belongs to DMU84 with 61% efficiency while The average of efficiencies of all DMUs is obtained 90.62%. Therefore, it seems that the current average efficiency values can be increased rapidly by a small modification. All of the DMUs are classified by their efficiencies in a different interval as follow.

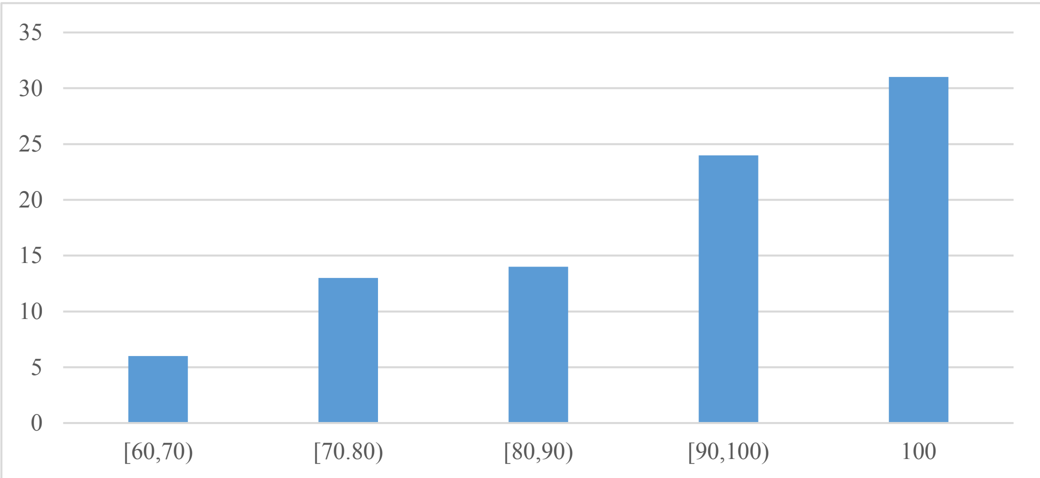

Figure 8. DMUs efficiency interval

Table 10. Classification of DMUs by their efficiency interval

Efficiency interval	Number of DMUs	Percentage
100	31	35.22%
[90,100)	24	27.27%
[80,90)	14	15.90%
[70.80)	13	14.77%
[60,70)	6	6.81%

Now, we are able to compare the total average of inputs and outputs for all DMUs with average of inputs and outputs for efficient DMUs as shown in Table 11. It is noticeable that fully efficient DMUs have better performance in all fields (except in the average number of customers with a minor difference) in comparison to the total average. This means that efficient DMUs provide good service for the less number of the customers. Clearly increasing the number of customers without enough basic equipment will result in a low level of customer satisfaction. Here the average for a number of customers for all DMUs is 3574.48 and this value for efficient DMUs is 3291.28.

Table 11. All DMUs inputs/outputs data versus efficient DMUs inputs/outputs data

DMU	**Number of customers**	**Human resources**	**Equipment**	**Education**	**Providing pieces**	**Process**	**Stopped cars**	**Reworked cars**	**Customers satisfaction**
All DMUs average	3574.48	79.82	83.38	77.63	100.94	71.97	11.22	0.85	67.94
Variance	13448987.91	310.59	91.59	239.144	1866.88	132.15	81.85	0.39	29.35
Range	31-17171	9.2-100	61-98.5	33.8-100	0-306	37.6-94.8	1-50	0-2.86	56.7-81.9
Efficient DMUs average	3291.28	83.65	85.38	78.78	101.25	74.19	9.61	0.74	70.16
Variance	15734293.9	301.30	95.61	310.13	2823.39	136.29	96.91	0.27	34.08
Range	31-15585	45.8-100	61.7-97.6	37.7-100	0-306	46.9-90.9	1-50	0.08-1.97	56.7-81.9

The third column implies that hiring skilled and experienced employees by efficient DMUs is more than all DMUs. Also, there is a significant difference (3.83%) between the average of the human resources of efficient DMUs and the average for all DMUs. Comparing the average values on the columns related to the Equipment, Education, Providing pieces and Process shows that inputs consumption of efficient DMUs is exceeding the average of all DMUs. The reason for this can be clarified by considering the rest of the Table 11 The efficient DMUs have performed much better in their outputs level with 14.35% less stopped car (9.61 versus 11.22) and 12.94% less reworked cars (0.74 versus 0.85) that caused 3.2% increase in customer satisfaction in comparison to all DMUs average (70.16 versus 67.94)

By considering the results obtained from the software in detail, the following items can be highlighted:

- The average number of customers for efficient DMUs is about 3300 customers per year which means the dealer owners need to get prepared to serve approximately this amount of customers per year. Moreover, the huge amount of variance illustrates that the customers have not been distributed equally even among the efficient DMUs;
- The range of human resources value for efficient DMUs indicated that at least half of the employees (45.8%) should be skilled and educated for an efficient DMU;
- There is no significant difference between the average and variance of the equipment index of all and efficient DMUs. Because all dealers should provide equipment, specified by the head office as discussed in the previous chapter in 3.3.1 section;

- The differences in education average and variance for all DMUs and efficient DMUs are negligible which shows that the educational facilities and comforts are provided equally to all DMUs by the head office;
- The average of providing pieces for efficient DMUs (101.25) shows that most of the efficient DMUs followed head office program for ordering and purchasing the pieces. However, the average of providing pieces for all DMUs (100.94) illustrates that most dealers have performed according to the head office plan as discussed in the previous chapter in section 3.3.1;
- In order to identify the general weak point of inefficient DMUs ignoring their location, Table 12 is provided to compare them with efficient DMUs. It is shown that most conflict belongs to human resources (77.74%) where the most difference with its correspondent index exists inefficient DMUs.

Table 12. Comparison of efficient and inefficient DMUs

DMU	**Number of customers**	**Human resources**	**Equipment**	**Education**	**Providing pieces**	**Process**	**Stopped cars**	**Reworked cars**	**Customers satisfaction**
Inefficient DMUs data average	3728.50	77.74	82.30	77	100.77	70.76	12.10	0.91	66.73
Efficient DMUs data average	3291.28	83.65	85.38	78.78	101.25	74.19	9.61	0.74	70.16

- There are 13 DMUs in the capital city of Iran (Tehran) which contains more potential aspect for customers and facilities, with only five DMUs, are evaluated as efficient. Unfortunately, the majority of dealers in

Tehran concentrate on selling the car more than after sale services. As shown in Table 13 the average of their inputs is higher than the average of the rest of the DMUs, with an identical level of outputs.

Table 13. Comparison between DMUs in Tehran and other cities

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction
Average of DMUs data in Tehran	8959.69	86.65	86.86	84.86	101.61	75.37	11.15	0.89	68.43
Average of DMUs data in other cities	2641.05	78.64	82.78	76.38	100.82	71.38	11.24	0.84	67.85

- Since accessing the facilities and resources is easier for all DMUs in the capital city, we tried to compare efficient DMUs with all DMUs in Tehran. As it will be discussed briefly in section 4.2 (Identifying the significant inputs and outputs), the most effective indexes for DMUs in Tehran are human resources, providing pieces and customer satisfaction, respectively. Both human resources and customer satisfaction are higher for efficient DMUs in Tehran but providing pieces index has prominent diversity with all DMUs in Tehran. Probably it is because when some dealers prefer to provide some pieces from the black market in Tehran because of more reasonable price or faster accessibility which might cause penalty from the head office.

Table 14. Comparison of efficient DMUs and all DMUs in Tehran

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction
Average of efficient DMUs data in Tehran	8908.2	87.8	86.38	85.92	90	72.44	11.16	0.72	69.42
Average of all DMUs data in Tehran	8959.69	86.65	86.86	84.86	101.61	75.37	11.15	0.89	68.43

- DMU16 is evaluated as efficient by software, while this unit has served just 31 customers, but it is necessary to mention that this dealer has been established during the observation period. Table 15 shows the detailed data for this DMU in comparison with all DMUs data average.

Table 15. Comparison between DMU16 and all DMUs data average

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction
DMU16	31	58.1	89.1	83.3	0	87.4	7	1.07	66.5
All DMUs data average	3574.48	79.82	83.38	77.63	100.94	71.97	11.22	0.85	67.94

- The least customer satisfaction with 56.7% belongs to DMU39 which is evaluated as efficient by the software. This branch is located in Mashhad, the second large and populated city after Tehran, and contains only two after sale service dealers during the observation period that caused a huge number of customers with a low level of customer satisfaction but this unit could handle it with 100% efficiency, the data for DMU39 and comparison to the other DMUs is provided in table 16.

Table 16. Comparison between DMU39 and all DMUs data average

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction
DMU39	8830	75.6	77.4	87.9	67	46.9	1	0.51	56.7
All DMUs data average	3574.48	79.82	83.38	77.63	100.94	71.97	11.22	0.85	67.94

4.2 Identifying the Significant Inputs and Outputs

As mentioned before, the DEA method is able to assign the weights for inputs and outputs by solving the dual version of the CCR model for each DMUs. The values of these weights show the effect of each input and output inefficiency value of under evaluated DMU. Then they can use to show which one of the inputs or outputs have more effect on the efficiency value of specific DMU. The calculated weights by software for random DMUs (DMU9, 25, 34, 58, 73) are shown in Table 17, and the table of calculated weights for all DMUs attached as Appendix 6.

Table 17. The weights assigned for random DMUs

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction
DMU9	0	0	0.15	1.03	0.35	0.2	0	0	0.91
DMU25	0.07	8.18	0.16	0	6.1	0	0	0.39	1.14
DMU34	0.9	0	0.21	0.15	0.11	1.48	0.03	0.35	0.96
DMU58	7.59	2.33	0.55	0	0.31	0	0	0.76	0.87
DMU73	0.02	7.21	0.19	0	0.44	0.29	0.02	0	1.01

Clearly, the effect of the input or output with the largest related weight in the efficiency value of the under evaluated DMU is more than other inputs and outputs. By calculating the average weights for each input and outputs, we can find out which inputs/outputs have more effect in efficiency evaluation of DMUs. To find significant inputs and outputs, the average of weights for each input and outputs are shown as the following table.

Table 18. The average of inputs/outputs weights for all DMUs

Inputs and Outputs	**Number of customers**	**Human resources**	**Equipment**	**Education**	**Providing pieces**	**Process**	**Stopped cars**	**Reworked cars**	**Customers satisfaction**
Averages of the weights	1.40	1.68	0.49	0.35	1.11	0.46	0.18	0.20	0.95

Table 18 shows that human resource (1.68), number of customers (1.40) and providing pieces (1.11) as inputs and customer satisfaction (0.95) as output have the most effect in efficiency values of DMUs. On the other hands, equipment (0.49), Process (0.46) and education (0.35) as inputs and stopped cars (0.18) and reworked cars (0.20) as outputs have less impression and influence in the performance of the under evaluated DMUs.

According to unbalanced dispersion of facilities among the capital city and the other cities in Iran, Table 19 is provided to illustrate the most essential indexes in Tehran.

Table 19. The average of inputs/outputs weights for DMUs located in Tehran

Inputs and Outputs	**Number of customers**	**Human resources**	**Equipment**	**Education**	**Providing pieces**	**Process**	**Stopped cars**	**Reworked cars**	**Customers satisfaction**
Averages of the weights	0.17	2.05	0.47	0.39	1.47	0.57	0.59	0.16	1.02

Considering the population and convenient accessibility to facilities in Tehran, there is no intense sensitivity for the number of customers (0.17) and equipment (0.47), hiring skilled and experienced employees (2.05) should be the first priority of dealer's owners in Tehran.

Now, just fully-efficient DMUs are considered for the calculation of the weights average that have been given to them by software.

Table 20. The average of inputs/outputs weights for efficient DMUs

Inputs and Outputs	**Number of customers**	**Human resources**	**Equipment**	**Education**	**Providing pieces**	**Process**	**Stopped cars**	**Reworked cars**	**Customers satisfaction**
Averages of the weights	1.67	1.06	0.55	0.23	0.94	0.64	0.19	0.24	0.97

Table 20 shows that the most vital indexes for efficient DMUs are the number of customers (1.67), human resources (1.06) and customer satisfaction (0.97). That is why there is a hard competition among efficient DMUs to attract more customers by advertising and hiring skilled and experienced employees. All priorities for indexes are gathered as table 21 where they are made comparable by their rank.

Table 21. Comparison of significant indexes

Rank	Significant indices in All DMUs	Significant indices in DMUs located in Tehran	Significant indices in efficient DMUs
1	Human resources	Human resources	Number of customers
2	Number of customers	Providing pieces	Human resources
3	Providing pieces	Customers satisfaction	Customers satisfaction
4	Customers satisfaction	Stopped cars	Providing pieces
5	Equipment	Process	Process
6	Process	Equipment	Equipment
7	Education	Education	Reworked cars
8	Reworked cars	Reworked cars	Education
9	Stopped cars	Number of customers	Stopped cars

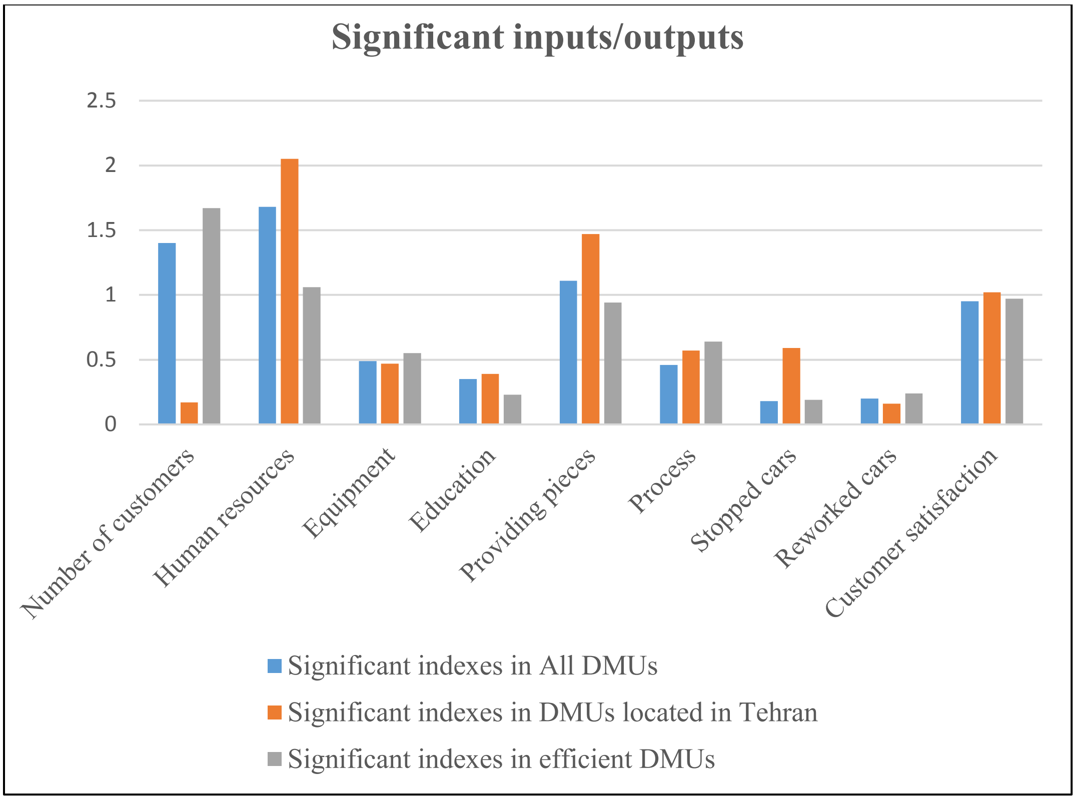

Figure 9. Significant inputs/outputs chart

The detailed verification of Table 13 and Figure 9 may lead us to the following facts: Commonly, for improving the performance of an inefficient branch or DMU, the performance improvement plan should pay more attention to hiring skilled and experienced employees instead unskilled and aged personnel to decrease their cost of the human resources. Also, it should focus to get a suitable customer number by providing enough spare pieces which can result in a high level of customer satisfaction. Modifying in the equipment, process and education indices to reduce the number of reworked and stopped cars should consider as next step in their performance improvement plan.

The good performance branches or efficient DMUs should consider approximately the above-mentioned priority in their performance plan to preserve their efficiency further.

But this priority is not the same for the Tehran branches. Because these DMUs already catch their favorable customer level, then it is not necessary to care about this issue. They should be careful about the skilled and young workforce and adjusting the spare pieces for increasing customer satisfaction. On the other hand, they should try to decrease the number of a stopped car in these branches. In the next step, they should catch a suitable level of equipment and education to decrease the reworked car's number and keep their current customers level.

4.3 Performance Improvement Plan for Inefficient DMUs

As mentioned in the previous chapter, solving the primal CCR model, the amount of λ for inefficient DMUs can be achieved to lead them to the most similar efficient DMU as a pattern to improve their inputs and outputs. Any convex combination of efficient DMUs which have positively associated λ value in the optimal solution of the envelopment side of the CCR model can be considered as a reference efficient DMU for under evaluated DMU. Also based on the amount of λ, the efficient DMU with biggest λ value should have more weights in this combination or it can directly consider as the most similar efficient DMU as the benchmark for under evaluated DMU. For example, the calculated amount of λ for sample DMUs (DMU9, 25, 34, 58, 73) and the related illustrations about their benchmarks are considered. As seen before DMU34 is an efficient DMU then this DMU is referenced to just itself in Table 22. This means that in the evaluation of DMU34 by the envelopment side of the CCR model the objective value is one also the value of λ for DMU36 is one and for other efficient DMUs is zero.

Table 22. The calculated λ for sample DMUs

Efficient DMUs	**DMU9**	**DMU25**	**DMU34**	**DMU58**	**DMU73**
DMU5	0	0	0	0.27	0
DMU6	0	0	0	0.02	0
DMU16	0	0	0	0.03	0
DMU19	0	0	0	0	0.12
DMU21	0	0	0	0	0
DMU34	0.19	0.1	**1**	0	0.07
DMU35	0	0.04	0	0	0
DMU41	0	0	0	0	0.07
DMU47	0	0	0	0.24	0
DMU50	**0.43**	0	0	0	0.15
DMU51	0	0.03	0	0	0
DMU54	0.1	0	0	0	**0.46**
DMU68	0	**0.81**	0	0	0
DMU71	0.11	0	0	**0.33**	0.11
DMU81	0	0.04	0	0	0

The efficient DMUs which have not any effect in the efficiency value of the above-considered DMUs are removed in Table 23 and also the table of calculated λ for all DMUs has been presented as Appendix 7.

According to this table for improving DMU9 we should refer to DMU50, 34 and 71. Any convex combination of these efficient DMUs can consider as the benchmark or pattern to improve the performance of DMU9. But because DMU50 has the greatest amount of λ in the evaluation of DMU9 by envelopment side of the CCR model, then DMU9 directly can compare itself with this DMU to improve its input/output level and performance. It means the best benchmarking option for DMU9 is DMU50. Table 23 shows inputs/outputs data for DMU9 and three referenced efficient DMUs with the highest amount of λ as an example. Then DMU9 should improve its performance in all inputs level except a number of customers and while the level of stopped and reworked cars are kept stable since there is no significant difference in these two outputs compared with DMU50. It is considered that improving any inputs or outputs can have a positive effect in other indexes, it means all inputs and outputs are dependent on each other. For example, a small improvement in education level can cause eye-catching progress in stopped cars, reworked cars, customer satisfaction or even number of the customers and there is no need to expend in each input/output level separately.

Table 23. Referenced efficient DMUs for DMU9

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction	Efficiency	Amount of λ
DMU9	8455	77.2	79.7	74.9	76	73.5	13	0	63.1	70.36	-
DMU34	3213	92.4	91.6	96.2	90	85.5	5	0.26	75.7	100	0.19
DMU50	2028	95.1	93.6	89.7	125	88.1	15	0.94	76.8	100	0.43
DMU71	954	93.2	92	100	119	79.8	10	1.16	77.2	100	0.11

In this order, let's consider DMU25. From Table 24, this DMU is compared by three efficient DMUs (DMU34, 35, 68, 81) which DMU68 has the highest amount of λ. The associated λ value for each of these efficient DMUs is summarized in Table 24.

Table 24. Referenced efficient DMUs for DMU25

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction	Efficiency	Amount of λ
DMU25	4524	90.2	74.4	90.1	97	61.4	8	1.07	66.8	96.27	-
DMU34	3213	92.4	91.6	96.2	90	85.5	5	0.26	75.7	100	0.1
DMU35	11526	98.9	92.84	90.0	102	80.7	16	1.97	65.1	100	0.04
DMU68	4274	95.3	87.7	97.4	98	68.8	4	1.93	64.7	100	0.81

Any convex combination of above-mentioned DMUs can be considered as a reference efficient DMU for DMU25. But based on the values of λ, DMU68 should have more weights in this combination, Therefore DMU25 should compare its inputs and outputs with inputs and outputs level of DMU68 for increasing the efficiency. In the next chapter, an improvement plan will be presented for these two above inefficient DMU based on their referenced efficient DMU and weights.

The referenced efficient DMUs table has been provided for DMU58 in Table 25 based on Table 22. Here three efficient DMUs with highest amounts of λ have been considered for further discussion. Since the λ value of DMU71 is greater than other efficient DMUs, the reference DMU for DMU58 is DMU71. But if this DMU wants to consider the effect of DMU5 and DMU47 it is better than a convex combination of mentioned efficient DMUs consider as a reference DMU.

Table 25. Referenced efficient DMUs for DMU58

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction	Efficiency	Amount of λ
DMU58	784	61	65.4	79.3	57	57.3	9	0.25	64.9	92.91	-
DMU5	656	45.8	64.9	63.2	204	48.4	12	0.13	70.5	100	0.27
DMU47	965	47.7	65.5	73.5	111	76.2	2	0.15	70.3	100	0.24
DMU71	954	93.2	92	100	119	79.8	10	1.16	77.2	100	0.33

Finally, the referenced efficient DMUs table for DMU73 is as below (Table 26). Again same as previous three efficient DMUs with highest amounts of λ has been considered. This DMU can compare itself with the convex combination of DMU19, DMU50, and DMU54 since the λ value for DMU54 is more than others, DMU73 should try to achieve the input/output level of DMU54 for increasing its efficiency value.

Table 26. Referenced efficient DMUs for DMU73

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction	Efficiency	Amount of λ
DMU73	2244	92.4	85.6	71.4	125	81.8	9	0.99	74.8	92.71	-
DMU19	7001	95.8	89.4	84.6	66	90.9	5	0.63	78.3	100	0.12
DMU50	2028	95.1	93.6	89.7	125	88.1	15	0.94	76.8	100	0.15
DMU54	1151	100	97.6	62.5	77	86.4	25	0.9	76.4	100	0.46

4.4 Identifying the Most Referenced Efficient DMUs

For finding the most referenced efficient DMU Table 27 is provided. This table contains a number of times which each of the efficient DMUs are referenced by software as a pattern for other inefficient DMUs.

Table 27. Number of times which efficient DMUs are referenced

DMUs	Referenced times	DMUs	Referenced times
DMU5	8	DMU50	8
DMU6	12	DMU51	3
DMU16	7	DMU54	30
DMU19	10	DMU59	16
DMU21	1	DMU61	1
DMU26	6	DMU65	3
DMU31	1	DMU66	1
DMU34	36	DMU68	5
DMU35	4	DMU71	31
DMU36	4	DMU72	10
DMU39	2	DMU78	4
DMU40	2	DMU81	7
DMU41	17	DMU83	10
DMU44	2	DMU87	3
DMU47	18	DMU88	1
DMU49	3		

The last table shows three DMUs have been chosen as a referenced DMU more than the others, as the level of their inputs/outputs can be useful and noticeable, table 28 is presented to show data for these three premium DMUs.

Table 28. The three of most referenced DMUs

DMU	Referenced times	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction	Efficiency
DMU34	36	3213	92.4	91.6	96.2	90	85.5	5	0.26	75.7	100
DMU54	30	1151	100	97.6	62.5	77	86.4	25	0.9	76.4	100
DMU71	31	954	93.2	92	100	119	79.8	10	1.16	77.2	100

DMU34 is located in Tehran, this unit can be considered as an appropriate pattern for all dealers located in the capital city. In the same way, both DMU54 and DMU71 are located in small cities (Abadeh and Gonbad-e-Kavoos) and they also can be used for guiding inefficient DMUs in small cities. On the other hands, we can refer inefficient dealers located in the center of the province (except Tehran) to DMU47 which is located in Zanjan with 18 times elected as a reference for inefficient DMUs by software.

Table 29. The most referenced DMU located in the center of the province (Except Tehran)

DMU	Referenced times	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction	Efficiency
DMU47	18	965	47.7	65.5	73.5	111	76.2	2	0.15	70.3	100

In the next chapter, all of the above-mentioned results will be used to prepare useful suggestions to have some improvement in the individual efficiency values and total performance of all under evaluated branches or DMUs. Also, they used to forecast the acceptable input/output level to have an appropriate performance in the next inspection period or in the case which the branches want to decrease or increase their service based on the different economic or financial conditions.

Chapter 5

CONCLUSION

As discussed in previous chapters, the data for 88 car dealers of Kerman Motor Company are collected during one-year observation, classified as inputs and outputs and after some modifications, inserted in PIM-DEA software. The Performance efficiency of DMUs and some other useful information are computed by applying the envelopment and multiplayer sides of input-oriented CCR model. Then the significant inputs/outputs are verified for all of the DMUs, especially for DMUs which were identified as inefficient units. The best pattern or benchmark DMUs are introduced for inefficient DMUs from good performance or efficient DMUs. Finally, three DMUs were selected as general patterns for all inefficient DMUs based on the location of dealers for increasing their performances. In this chapter, three improvement plans have been introduced which can be applied for each inefficient DMU for being a fully efficient unit.

5.1 Inefficient DMUs Improvement

Automotive industries in Iran have faced numerous problems due to sanction against Iran, incorrect policy making by government and foreign currency frequencies. In this situation, convincing the dealer's owners to spend more efforts for improving their performances is a difficult job. On the other hand, most of the business owners in Iran are traditional people with a low level of academic education who insist on their old methods and resist against anything that may cause extra charges for them. Also, Iranian automotive industry giants are close to bankruptcy these days and recently decided to raise the final price of vehicles more than 5 times which caused disarray in the market, fake demands and customer's anxiety.

In this chapter we will discuss different ways to improve the performance of inefficient DMUs, considering all of the above-mentioned restrictions using the information gained from applying the DEA models.

5.1.1 Input Oriented Improvement Method

Here, we assume all outputs level constant as they were measured before, that is, there is no need to change the output levels and focus on decreasing the input levels due to the same output level with 100% efficiency. By reducing inputs, resulting from multiplication of the efficiency value to the input vector (θx), the costs will be dwindled and inefficient DMUs will move toward the efficient frontier and lie on it as discussed in chapter three. The following two tables include two sample DMUs (DMU9, DMU25) improved by this method.

Table 30. Improvement plan for DMU9 by input oriented method

DMU	Number of customers	Human resources (%)	Equipment (%)	Education (%)	Providing pieces (%)	Process (%)	Stopped cars (%)	Reworked cars (%)	Customer's satisfaction (%)	Efficiency
DMU9 (old)	8455	77.2	79.7	74.9	76	73.5	13	0	63.1	70.36
Changing percentage	-79.95	-32.84	-29.64	-29.64	-29.64	-29.64	0	0	0	
DMU9 (new)	1695	51.84	56.07	52.69	53.47	51.71	13	0	63.1	100

Table 31. Improvement plan for DMU25 by input oriented method

DMU	Number of customers	Human resources (%)	Equipment (%)	Education (%)	Providing pieces (%)	Process (%)	Stopped cars (%)	Reworked cars (%)	Customer's satisfaction (%)	Efficiency
DMU25 (old)	4524	90.2	74.4	90.1	97	61.4	8	1.07	66.8	96.27
Changing percentage	-3.73	-3.73	-14.55	-3.73	-3.73	-12.68	0	0	0	
DMU25 (new)	4355	86.83	63.57	86.73	93.38	53.61	8	1.07	66.8	100

As it is clear, all DMUs have to reduce their inputs and resources in order to be an efficient unit. This means that the inputs level such as customers, education, and equipment should be reduced for being an efficient unit which seems unrealistic. On the other hand, all of the indexes are dependent on each other. For example, by reducing human resources and education we cannot expect that the amount of stopped and reworked cars remain steady. So this method does not present a practical and applicable improvement plan but it can be advised for those DMUs whose efficiencies are close to 100%. For example, DMU25 can be ended up to 100% efficiency by reducing a small value of inputs.

5.1.2 Output Oriented Improvement Method

As mentioned in the third chapter, section 3.1.1, there is a formula which can be used for finding the optimal objective function value of output-oriented CCR method ($\varphi = 1/\theta$). In this case, all inputs level will remain steady and outputs level will be changed (increasing, decreasing or fixing based on output character and nature) for improving an inefficient DMU into an efficient DMU. This can be done by multiplying the inverse of the optimal objective function of input-oriented CCR model by output vector. Table 32 and 33 shows the improvement plan of DMU9 and DMU25.

Table 32. Improvement plan for DMU9 by output oriented method

DMU	**Number of customers**	**Human resources (%)**	**Equipment (%)**	**Education (%)**	**Providing pieces (%)**	**Process (%)**	**Stopped cars (%)**	**Reworked cars (%)**	**Customer's satisfaction (%)**	**Efficiency**
DMU9 (old)	8455	77.2	79.7	74.9	76	73.5	13	0	63.1	70.36
Changing percentage	0	0	0	0	0	0	-42.12(1)	0(2)	+42.12(3)	
DMU9 (new)	8455	77.2	79.7	74.9	76	73.5	7	0	89.68	100

(1): φ =1÷%70.36=1.4212 (42.12%) of the stopped car should be reduced for better performance;

(2): The current amount of stopped car is already optimized;

(3): φ =1÷%70.36=1.4212 (42.12%) of customer satisfaction should be increased for better performance.

Table 33. Improvement plan for DMU25 by output oriented method

DMU	Number of customers	Human resources (%)	Equipment (%)	Education (%)	Providing pieces (%)	Process (%)	Stopped cars (%)	Reworked cars (%)	Customer's satisfaction (%)	Efficiency
DMU25 (old)	4524	90.2	74.4	90.1	97	61.4	8	1.07	66.8	96.27
Changing percentage	0	0	0	0	0	0	-3.87	-3.87	+3.87	
DMU25 (new)	4524	90.2	74.4	90.1	97	61.4	7	0	69.38	100

This method can be used for those DMUs which do not accept more investment or spending money for improving the input levels, although increasing customer satisfaction without any changes in input levels seems illogical it can be reached easily in DMUs located in small cities by a few advertisements, respecting and serving the customers. On the other hands, decreasing stopped and reworked cars need more education or skilled human resources, however, it can sometimes be achieved only by smart scheduling and more accuracy.

5.1.3 Benchmarking Based Improvement Method

Both of the previous methods include some illogical changes and cannot be used for all DMUs practically, therefore a method will be introduced in this section based on the amount of (λ) which is the variable of envelopment side of the CCR model, for each inefficient DMU with consideration of input/output weights of related DMU.

In this method, each inefficient DMU is compared with its referenced efficient DMUs, as discussed in chapter 4.3 to present a future performance plan with respect to the weights as shown in the following table which contains the improvement plan for DMU9.

Table 34. Benchmark based improvement method for DMU9

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction	Efficiency
DMU9	8455	77.2	79.7	74.9	76	73.5	13	0	63.1	70.36
DMU50	2028	95.1	93.6	89.7	125	88.1	15	0.94	76.8	100
Difference (%)	+76	-17.9	-13.9	-14.8	-49	-14.6	+2	+0.94	-13.7	
Weights for DMU9	0	0	0.15	1.03	0.35	0.2	0	0	0.91	
Weights × Difference	-	-	-2.08	-15.24	-17.15	-2.92	-	-	-12.46	
Priority	9	6	5	2	1	4	8	7	3	

Here, we start from input/output with the most negative amount of (weights×difference) as our priority and then for those indexes whose weights are zero, we consider the most negative amount of differences to define improvement priority. Negative and positive signs in differences row explain the worse or better performance of inefficient DMU in comparison to the referenced efficient DMU.

After this calculation, it is possible to present an improvement plan for DMU9 based on priorities as mentioned in the following table.

Table 35. DMU9 improvement plan

<table>
<tr><th>Priorities</th><th>Indices</th><th>Plan</th></tr>
<tr><td>1</td><td>Providing pieces</td><td>Spending money on providing all items planned by head office for the dealer from the main store of the company.
Strengthening storekeeper's knowledge and skill in scheduling the ordering pieces at the right time by offering more education to the staff.</td></tr>
<tr><td>2</td><td>Education</td><td>Sending all employees to the academic center of head office to complete related courses weekly or hiring new high educated and skillful staff.</td></tr>
<tr><td>3</td><td>Customer satisfaction</td><td>Respecting and serving customers during the repairing process, contracting with customers by making call after services, washing cars after the repair process and etc.</td></tr>
<tr><td>4</td><td>Process</td><td>Reviewing the head office's instructions and observing the repairing process by technical manager.</td></tr>
<tr><td>5</td><td>Equipment</td><td>Providing and completing the remained items of equipment as attached in Appendix B and observing the calibration and maintenance by technical manager.</td></tr>
<tr><td>6</td><td>Human resources</td><td>Hiring skilled and fresh workers or improving the current employee's abilities by offering new educational courses.</td></tr>
<tr><td>7</td><td>Reworked cars</td><td>Both items can be kept without any change and abnegated because of a minor difference.</td></tr>
<tr><td>8</td><td>Stopped cars</td><td rowspan="2">Both items can be kept without any change and abnegated because of a minor difference. There is no need to spend more money to attract more customers.</td></tr>
<tr><td>9</td><td>Number of customers</td></tr>
</table>

The improvement plan for inefficient DMU25 is presented as follow in the same way.

Table 36. Benchmark based improvement method for DMU25

DMU	Number of customers	Human resources	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction	Efficiency
DMU25	4524	90.2	74.4	90.1	97	61.4	8	1.07	66.8	96.27
DMU68	4274	95.3	87.7	97.4	98	68.8	4	1.93	64.7	100
Difference (%)	+5.5	-5.1	-13.3	-7.3	-1	-7.4	-4	+0.86	+2.1	
Weights	0.07	8.18	0.16	0	6.1	0	0	0.39	1.14	
Weights × Difference	0.38	-41.71	-2.12	-	-6.1	-	-	0.33	2.39	
Priority	8	1	3	5	2	4	6	7	9	

After specifying the priorities, the improvement plan table for DMU25 is presented as the following table.

Table 37. DMU25 improvement plan

Priorities	Indices	Plan
1	Human resources	According to the high rate of weights and sensitivity for human resources, employee's skills should be improved by more education also hiring new skilled and experienced worker can be considered.
2	Providing pieces	Spend money on providing all items planned by head office for this unit from the main store of the company. Strengthen storekeeper's knowledge and skill about scheduling the ordering pieces at the right time by receiving more education.
3	Equipment	Provide and complete all remained items for equipment as attached in Appendix B and observe the calibration and maintenance by technical manager.
4	Process	Review head office's instructions and observe the repairing process by technical manager.
5	Education	Send all employees to the academic center of head office to complete their related courses weekly.
6	Stopped cars	This item can be done by smart scheduling, education of employees or rejecting the overload customers by considering the capacity.
7	Reworked cars	Both items can be kept without any changes and abnegated because of a minor difference.
8	Number of customers	
9	Customers satisfaction	Customer satisfaction will be increased automatically by doing the above-mentioned plans.

It is noticeable that there are many ideas about increasing customer satisfaction level and also improving other indexes which can influence customer satisfaction spontaneously. Moreover, increasing the customer satisfaction level can be considered as a separate topic for new studies in automotive industries considering that recently complaint and protest against automotive factories in Iran are increasing. These discontents turned into political issues which can be studied deeply by the government.

5.2 Input/output Forecasting for Preserving Efficiency

As mentioned before, all DMUs can be categorized into three groups based on their locations, DMUs in Tehran, province centers and small cities. In some cases when a dealer owner wants to increase or decrease capacity and facilities without considering the location and continue its performance in previous efficiency level or as the efficient DMU, it should follow second principle of PPS (production possibility set) which states If an activity *(X, Y)* belongs to PPS then the activity *(tX, tY)* also belongs to PPS for any positive scalar *t*. That is both inputs and outputs should be increased or decreased at the same time by the same scale.

This can be used for those who need to expand their business and spend money without considering the location for being one of the top dealers in that certain region or for those who want to reduce capacity and facility due to financial problems or saving money. This method can be recommended for those who have established a new dealer recently by expecting its inputs and outputs levels based on the inputs and outputs and performance of the nearest dealers and running the business by boosting the inputs level to attract customers and rip in this business field.

5.3 Future Study

This study can be expanded by mixing the other mathematical models such as fuzzy DEA where inputs/outputs are not crisp and stable or statistic DEA where each index follows its own distribution probability functions by referring the experts that can be useful due to the unstable economic and financial situations in Iran. An online monitoring system can be defined for customer satisfaction with a lower bound which does not allow the dealers to reduce customer satisfaction because of the late delivery.

Also, the main office can use the DEA based ranking methods for ranking the dealers or DMUs for making some strategic or long term decisions about the increasing or decreasing in the number of the dealers or have some considerations or modifications to define common characteristic for all of the dealers.

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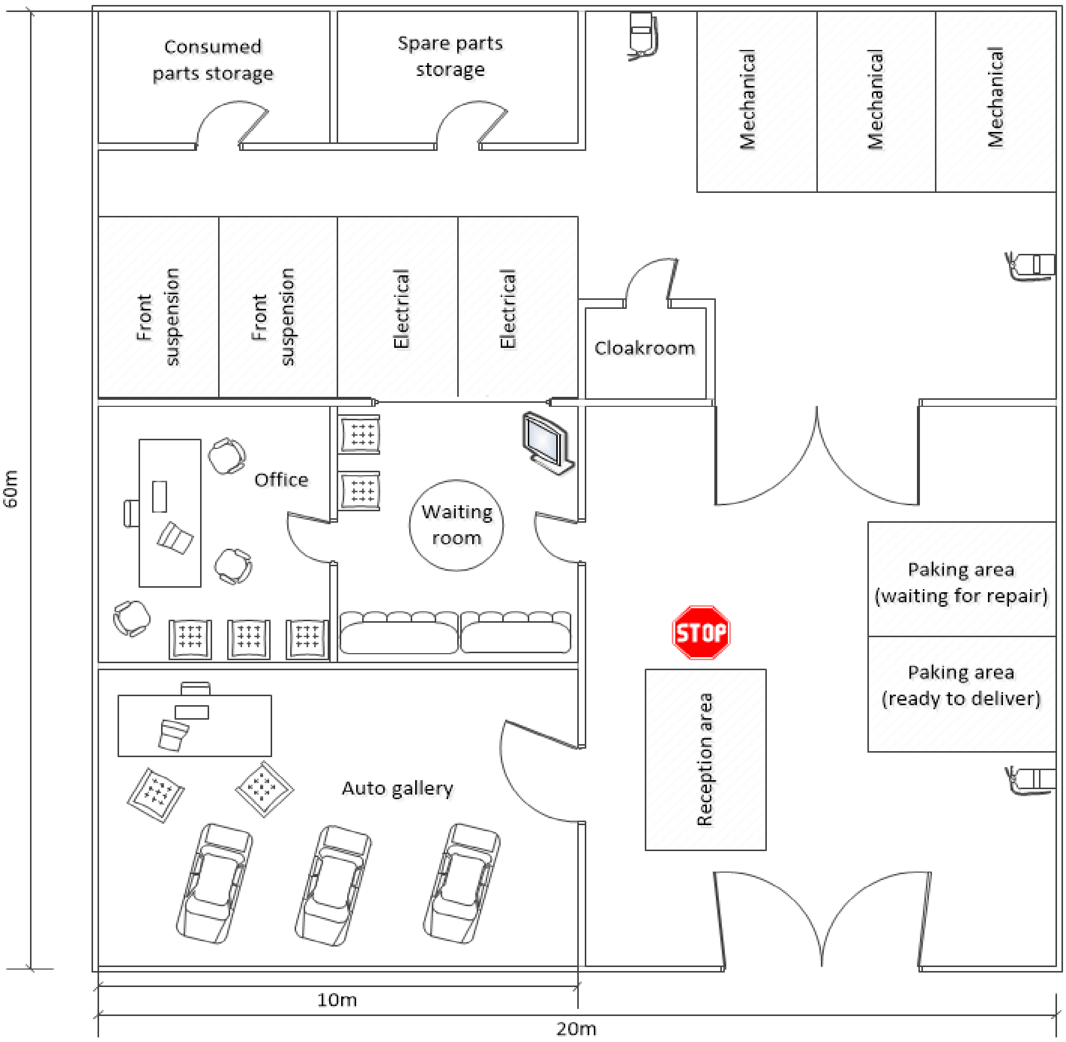
APPENDICES

Appendix A: Schematic Figure of a DMU



Appendix B: The Equipment List for Each Dealer

Item No.	Equipment	Points
1	Chain ceiling crane or portable jack for Engine yanking	10
2	Hydraulic press with minimum power 3 tons for (light car repair shops) Hydraulic Press with minimum power 20 tons for (heavy car repair shops)	10
3	Parts cleaning device (minimum dimensions according to the cylinder block of all the under licenses vehicles)	10
4	Pressure air compressor	10
5	Micrometer with measuring range 75-50, 50-25, 25-0 mm	5
6	Caliper with minimum measuring range 30 cm	5
7	Dial indicator with stand	5
8	Radiator thermometer (installed on the radiator cap of all the under licenses vehicles) or pyrometer	5
9	Engine oil suction device	10
10	Rotary table for engine and gearbox with the ability to install all of Engine and Gearbox under licenses vehicles	10
11	Crack-tester/meter	10
12	Battery charger device	10
13	Multi meter	5
14	Battery tester device (with the ability to display the charge status of the alternator)	5
15	Testing device for function and charge of cooler system	15
16	Adjusting device for car front lights	15
17	Computerized adjusting device for the car steering wheel	20
18	Car wheel balancer device	15

Item No.	Equipment	Points
19	Device for analyzing of four gases or five gases for (light car repair shops) car exhaust gas testing device for (heavy car repair shops)	15
20	Measurement gauge for motor compressor	5
21	Injector cleaning device on the car or out of the car	15
22	Testing device for brake Oil	10
23	Fault finding device (Diagnosis)	20
24	Exhaust fan for (half of the mechanical and electrical area)	15

Appendix C: Customer Satisfaction Questionnaire

Questions		Satisfaction					Comment
1	Have you used the queue system?	Yes					No
2	How much is your satisfaction with the queue system?	5	4	3	2	1	
3	How satisfied are you with the time spent in the reception area?	5	4	3	2	1	
4	How much are you satisfied with registering your car's defects by the receptionist?	5	4	3	2	1	
5	How satisfied are you with the duration of the repair?	5	4	3	2	1	
6	How much did it take to retrieve your car?	At the same day Tomorrow A few days later …..…Days					
7	Did they fix all the defects of your car?	Yes					No
8	How satisfied are you with the periodic services of this dealer?	5	4	3	2	1	
9	How satisfied are you with the quality of the repairs done by the dealer?	5	4	3	2	1	
10	Was there any need to change a part to repair your car?	Yes					No
11	How satisfied are you with providing pieces of your car on time?	5	4	3	2	1	
12	Have you received your repair bills?	Yes					No
13	Have you paid for this service?	Yes					No
14	For which item have you paid?	Wage Parts Both					
15	How satisfied are you with the payment (parts and wage) for services performed?	5	4	3	2	1	
16	How satisfied are you with the explanation given when releasing your car for replaced parts and services performed?	5	4	3	2	1	
17	How satisfied are you with the behavior of the dealer's staff?	5	4	3	2	1	
18	Have you visited the dealer in the past three months which have been prevented from accepting your car for repair?	Yes					No
19	How satisfied are you with access to the dealerships of this company?	5	4	3	2	1	

In total, how satisfied are you with the provided after-sales service? Too much much middle Little Very little
Suggestion and complaint:

Customer profile	
1	**Sex:** Female Male
2	**Age:** (1)Between 18 to 30 years (2)31 to 42 (3)46 to 60 (4) more than 61 years
3	**Education level:** (1)Under high School graduation (2) High School graduation (3)Associate degree (4) Bachelor (5) Master Degree /MA and Higher than MA
4	**City of residence/ Address:**
5	**Customer's first and surname:**
6	**Contact telephone-No.:**
Vehicle specifications	
7- Type of Vehicle: 8- Purchasing year: 9-Manufacturer: 10-Vehicle status: Guarantee Warranty (*out of guarantee*)	
Complete by the interviewer	
Province: City: Dealership's Code: Inspection's Code: Date of reception: Interview date: Interviewer Code:	

Appendix D: Input\Output Data for All Dealers

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction
1	5692	81.7	84.2	74.2	74	81.6	16	0	70.4
2	6402	73.1	88.7	65.3	89	70.6	31	1.33	63.2
3	954	90.5	78.8	98.9	122	61	14	0.53	68.9
4	3685	65.9	71.4	59	116	43.3	9	1.11	69
5	656	45.8	64.9	63.2	204	48.4	12	0.13	70.5
6	358	79.5	85.5	41.1	103	82.3	9	0.66	75.4
7	5092	80	90.1	86.5	130	70.5	5	1.25	77.1
8	938	65	67.9	79.8	71	59.8	18	0.29	65.8
9	8455	77.2	79.7	74.9	76	73.5	13	0	63.1
10	1459	95.2	94	91.1	77	74.8	17	2.24	73.2
11	1090	70.1	92.8	85	80	68	4	0.38	66.6
12	1443	73.8	86.8	74.3	115	54.4	8	1.53	75.7
13	1933	81.8	82	71.1	105	81.6	5	1.09	66.1
14	1920	93.4	83.8	96.6	81	73.4	8	2.86	73.2
15	1808	86.6	89.5	80.4	168	83.9	3	0.43	64.6
16	31	58.1	89.1	83.3	0	87.4	7	1.07	66.5
17	5153	97.5	73.2	86.7	142	70.7	12	0.73	68.6
18	4819	85.4	77.4	58.2	65	78.9	9	2.16	70
19	7001	95.8	89.4	84.6	66	90.9	5	0.63	78.3
20	1439	79.6	78.6	84.2	78	80.9	29	0.74	69.3
21	1880	97	72.5	88.6	88	57	4	0.3	67.1
22	2177	78.7	79.8	49.5	78	57.2	15	1.89	60.8
23	542	62.4	61.2	33.8	123	66.2	5	1.32	60.3
24	12797	97.7	98.5	85.3	207	80.3	9	0.56	68.4
25	4524	90.2	74.4	90.1	97	61.4	8	1.07	66.8
26	12622	96.3	91.8	79.8	69	59.7	14	0.08	70.8
27	9567	92.9	80.8	100	80	71.2	10	0.66	68.1
28	13142	96.6	97.8	94.5	85	94.8	9	0.84	65
29	17171	98.3	98.5	90.5	183	82	10	0.69	70.6
30	7328	79.2	73.1	57.6	72	69.1	9	1.3	62.7

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction
31	15585	94.4	94	87.5	90	75.2	8	0.18	65.8
32	4328	49.9	81.2	70.6	71	67.6	6	1.15	68.1
33	3078	82.7	93	85	76	91.3	26	1.7	72.8
34	3213	92.4	91.6	96.2	90	85.5	5	0.26	75.7
35	11526	98.9	92.8	90.9	102	80.7	16	1.97	65.1
36	1595	57	61.7	75.2	99	61.1	15	1.14	69.7
37	802	52.3	70.9	73.2	160	64.9	7	0	62
38	1441	42.6	80.8	56.3	132	52.1	17	0.53	64.4
39	8830	75.6	77.4	87.9	67	46.9	1	0.51	56.7
40	882	51.8	81.7	53.3	99	61	10	0.36	72.2
41	1531	99.6	90.4	96.4	71	84.6	2	0.61	74.3
42	1530	79.5	92	63.2	130	60.4	8	0.36	68.5
43	1801	62.7	87.7	62.1	64	71.7	8	1.89	66.6
44	311	75.4	85.9	66	62	74.1	3	0.83	59.3
45	508	84.1	92.9	79.4	48	78.1	9	0.49	58.2
46	4653	81.1	88.6	86.4	179	74.1	3	0.79	59.7
47	965	47.7	65.5	73.5	111	76.2	2	0.15	70.3
48	1491	86	84.1	88.3	76	73.5	32	0	72.3
49	1487	95.8	87.4	90.5	78	71.8	7	0.32	68
50	2028	95.1	93.6	89.7	125	88.1	15	0.94	76.8
51	3356	87.6	95.6	79	97	79.3	50	0.3	66.1
52	9317	77	63.8	81.6	77	63.8	14	0.27	65.2
53	10528	97.1	85.1	83.1	89	71.6	36	0	62.7
54	1151	100	97.6	62.5	77	86.4	25	0.9	76.4
55	988	94.5	84.6	65.3	110	81.8	8	1.5	66.1
56	1651	94.3	87.7	100	66	76.6	10	1.76	76.4
57	965	77.7	89	64.2	156	70.9	8	1.38	75.5
58	784	61	65.4	79.3	57	57.3	9	0.25	64.9
59	449	98.1	97.6	87.9	306	82.4	26	1.04	81.9
60	3554	72.1	83.8	76.7	94	66.8	3	0.71	62.1

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped cars	Reworked cars	Customers satisfaction
61	2541	88.1	91.4	93.8	66	64.5	2	0.29	62.9
62	2078	82.3	80.5	63.5	69	70.3	24	0.94	62.3
63	2218	44.5	74.7	75.8	92	61.1	5	0.62	61.3
64	5949	83.2	73.9	67.2	91	78	4	0.76	65.6
65	1087	78.1	85.2	37.7	139	83.4	10	0.26	70.3
66	327	54.2	75.2	42.2	102	64.4	8	0.9	69.3
67	1068	41.1	68.4	48.2	72	61.2	5	0	65.5
68	4274	95.3	87.7	97.4	98	68.8	4	1.93	64.7
69	2732	83.1	88.7	78.9	108	81.8	16	0.95	59.5
70	3458	87.5	81.6	92.5	112	59.8	8	0.99	70.7
71	954	93.2	92	100	119	79.8	10	1.16	77.2
72	2231	99.7	90.9	67.6	86	79	2	1.57	74
73	2244	92.4	85.6	71.4	125	81.8	9	0.99	74.8
74	2349	93.9	92.1	90.7	95	73.6	14	2.85	61.9
75	1059	81	92.3	78.7	211	89.1	13	0	65.4
76	693	73.2	87.5	85.5	77	71.2	40	0.45	65
77	2330	93.7	87.9	83.8	116	80	19	1.54	76.4
78	4208	79.8	79.1	93.6	96	73.7	3	0.33	63
79	5339	63.4	85.9	89.3	87	76.8	20	0.67	64
80	3820	93.4	85.2	95.7	68	80.9	2	0.73	68.1
81	907	94.6	82.1	68.2	103	79.9	7	1.45	67.5
82	3324	93.5	81.9	61.5	90	70.7	8	0.76	60.4
83	2243	77.5	96.4	91.5	191	86.9	2	0.96	75.6
84	1971	9.2	65.2	60.5	73	48.7	11	0.53	63
85	1681	50.4	61	75	86	37.6	8	0.77	64.5
86	3263	78.2	85.3	89	73	79.5	4	0.7	62.3
87	763	95.4	74.5	73.9	57	70.6	2	1.32	68.3
88	7038	95.4	86.3	99.3	78	70	12	0.5	75.5

Appendix E: The Result of PIM DEA for All DMUs Efficiency

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped car	Reworked car	Customers satisfaction	Efficiency
1	5692	0.0122	0.0122	0.0122	26	0.0123	0.0625	#DIV/0!	70.4	84.32
2	6402	0.0137	0.0113	0.0153	11	0.0142	0.0323	0.7519	63.2	80.57
3	954	0.0110	0.0127	0.0101	22	0.0164	0.0714	1.8868	68.9	99.85
4	3685	0.0152	0.0140	0.0169	16	0.0231	0.1111	0.9009	69	70.15
5	656	0.0218	0.0154	0.0158	104	0.0207	0.0833	7.6923	70.5	100
6	358	0.0126	0.0117	0.0243	3	0.0122	0.1111	1.5152	75.4	100
7	5092	0.0125	0.0111	0.0116	30	0.0142	0.2000	0.8000	77.1	97.57
8	938	0.0154	0.0147	0.0125	29	0.0167	0.0556	3.4483	65.8	90.23
9	8455	0.0130	0.0125	0.0134	24	0.0136	0.0769	#DIV/0!	63.1	70.36
10	1459	0.0105	0.0106	0.0110	23	0.0134	0.0588	0.4464	73.2	95.86
11	1090	0.0143	0.0108	0.0118	20	0.0147	0.2500	2.6316	66.6	99.8
12	1443	0.0136	0.0115	0.0135	15	0.0184	0.1250	0.6536	75.7	94.5
13	1933	0.0122	0.0122	0.0141	5	0.0123	0.2000	0.9174	66.1	97.19
14	1920	0.0107	0.0119	0.0104	19	0.0136	0.1250	0.3497	73.2	94.81
15	1808	0.0115	0.0112	0.0124	68	0.0119	0.3333	2.3256	64.6	87.91
16	31	0.0172	0.0112	0.0120	100	0.0114	0.1429	0.9346	66.5	100
17	5153	0.0103	0.0137	0.0115	42	0.0141	0.0833	1.3699	68.6	89.02
18	4819	0.0117	0.0129	0.0172	35	0.0127	0.1111	0.4630	70	80.03
19	7001	0.0104	0.0112	0.0118	34	0.0110	0.2000	1.5873	78.3	100
20	1439	0.0126	0.0127	0.0119	22	0.0124	0.0345	1.3514	69.3	88.15
21	1880	0.0103	0.0138	0.0113	12	0.0175	0.2500	3.3333	67.1	100
22	2177	0.0127	0.0125	0.0202	22	0.0175	0.0667	0.5291	60.8	66.82
23	542	0.0160	0.0163	0.0296	23	0.0151	0.2000	0.7576	60.3	70.9
24	12797	0.0102	0.0102	0.0117	107	0.0125	0.1111	1.7857	68.4	89.72
25	4524	0.0111	0.0134	0.0111	3	0.0163	0.1250	0.9346	66.8	96.27
26	12622	0.0104	0.0109	0.0125	31	0.0168	0.0714	12.5000	70.8	100
27	9567	0.0108	0.0124	0.0100	20	0.0140	0.1000	1.5152	68.1	89.69
28	13142	0.0104	0.0102	0.0106	15	0.0105	0.1111	1.1905	65	92.86
29	17171	0.0102	0.0102	0.0110	83	0.0122	0.1000	1.4493	70.6	93.67
30	7328	0.0126	0.0137	0.0174	28	0.0145	0.1111	0.7692	62.7	66.3

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped car	Reworked car	Customers satisfaction	Efficiency
31	15585	0.0106	0.0106	0.0114	10	0.0133	0.1250	5.5556	65.8	100
32	4328	0.0200	0.0123	0.0142	29	0.0148	0.1667	0.8696	68.1	77.4
33	3078	0.0121	0.0108	0.0118	24	0.0110	0.0385	0.5882	72.8	97.83
34	3213	0.0108	0.0109	0.0104	10	0.0117	0.2000	3.8462	75.7	100
35	11526	0.0101	0.0108	0.0110	2	0.0124	0.0625	0.5076	65.1	100
36	1595	0.0175	0.0162	0.0133	1	0.0164	0.0667	0.8772	69.7	100
37	802	0.0191	0.0141	0.0137	60	0.0154	0.1429	#DIV/0!	62	68.92
38	1441	0.0235	0.0124	0.0178	32	0.0192	0.0588	1.8868	64.4	75.82
39	8830	0.0132	0.0129	0.0114	33	0.0213	1.0000	1.9608	56.7	100
40	882	0.0193	0.0122	0.0188	1	0.0164	0.1000	2.7778	72.2	100
41	1531	0.0100	0.0111	0.0104	29	0.0118	0.5000	1.6393	74.3	100
42	1530	0.0126	0.0109	0.0158	30	0.0166	0.1250	2.7778	68.5	95.68
43	1801	0.0159	0.0114	0.0161	36	0.0139	0.1250	0.5291	66.6	79.4
44	311	0.0133	0.0116	0.0152	38	0.0135	0.3333	1.2048	59.3	100
45	508	0.0119	0.0108	0.0126	52	0.0128	0.1111	2.0408	58.2	93.32
46	4653	0.0123	0.0113	0.0116	79	0.0135	0.3333	1.2658	59.7	74.13
47	965	0.0210	0.0153	0.0136	11	0.0131	0.5000	6.6667	70.3	100
48	1491	0.0116	0.0119	0.0113	24	0.0136	0.0313	#DIV/0!	72.3	85.8
49	1487	0.0104	0.0114	0.0110	22	0.0139	0.1429	3.1250	68	100
50	2028	0.0105	0.0107	0.0111	25	0.0114	0.0667	1.0638	76.8	100
51	3356	0.0114	0.0105	0.0127	3	0.0126	0.0200	3.3333	66.1	100
52	9317	0.0130	0.0157	0.0123	23	0.0157	0.0714	3.7037	65.2	74.06
53	10528	0.0103	0.0118	0.0120	11	0.0140	0.0278	#DIV/0!	62.7	85.59
54	1151	0.0100	0.0102	0.0160	23	0.0116	0.0400	1.1111	76.4	100
55	988	0.0106	0.0118	0.0153	10	0.0122	0.1250	0.6667	66.1	92.47
56	1651	0.0106	0.0114	0.0100	34	0.0131	0.1000	0.5682	76.4	99.48
57	965	0.0129	0.0112	0.0156	56	0.0141	0.1250	0.7246	75.5	93.08
58	784	0.0164	0.0153	0.0126	43	0.0175	0.1111	4.0000	64.9	92.91
59	449	0.0102	0.0102	0.0114	206	0.0121	0.0385	0.9615	81.9	100
60	3554	0.0139	0.0119	0.0130	6	0.0150	0.3333	1.4085	62.1	94.63

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped car	Reworked car	Customers satisfaction	Efficiency
61	2541	0.0114	0.0109	0.0107	34	0.0155	0.5000	3.4483	62.9	100
62	2078	0.0122	0.0124	0.0157	31	0.0142	0.0417	1.0638	62.3	68.83
63	2218	0.0225	0.0134	0.0132	8	0.0164	0.2000	1.6129	61.3	79.91
64	5949	0.0120	0.0135	0.0149	9	0.0128	0.2500	1.3158	65.6	86.14
65	1087	0.0128	0.0117	0.0265	39	0.0120	0.1000	3.8462	70.3	100
66	327	0.0185	0.0133	0.0237	2	0.0155	0.1250	1.1111	69.3	100
67	1068	0.0243	0.0146	0.0207	28	0.0163	0.2000	#DIV/0!	65.5	67.53
68	4274	0.0105	0.0114	0.0103	2	0.0145	0.2500	0.5181	64.7	100
69	2732	0.0120	0.0113	0.0127	8	0.0122	0.0625	1.0526	59.5	79.14
70	3458	0.0114	0.0123	0.0108	12	0.0167	0.1250	1.0101	70.7	88.96
71	954	0.0107	0.0109	0.0100	19	0.0125	0.1000	0.8621	77.2	100
72	2231	0.0100	0.0110	0.0148	14	0.0127	0.5000	0.6369	74	100
73	2244	0.0108	0.0117	0.0140	25	0.0122	0.1111	1.0101	74.8	92.71
74	2349	0.0106	0.0109	0.0110	5	0.0136	0.0714	0.3509	61.9	95.65
75	1059	0.0123	0.0108	0.0127	111	0.0112	0.0769	#DIV/0!	65.4	86.96
76	693	0.0137	0.0114	0.0117	23	0.0140	0.0250	2.2222	65	97.51
77	2330	0.0107	0.0114	0.0119	16	0.0125	0.0526	0.6494	76.4	99.16
78	4208	0.0125	0.0126	0.0107	4	0.0136	0.3333	3.0303	63	100
79	5339	0.0158	0.0116	0.0112	13	0.0130	0.0500	1.4925	64	78.75
80	3820	0.0107	0.0117	0.0104	32	0.0124	0.5000	1.3699	68.1	94.23
81	907	0.0106	0.0122	0.0147	3	0.0125	0.1429	0.6897	67.5	100
82	3324	0.0107	0.0122	0.0163	10	0.0141	0.1250	1.3158	60.4	80.63
83	2243	0.0129	0.0104	0.0109	91	0.0115	0.5000	1.0417	75.6	100
84	1971	0.1087	0.0153	0.0165	27	0.0205	0.0909	1.8868	63	61.03
85	1681	0.0198	0.0164	0.0133	14	0.0266	0.1250	1.2987	64.5	74.01
86	3263	0.0128	0.0117	0.0112	27	0.0126	0.2500	1.4286	62.3	76.89
87	763	0.0105	0.0134	0.0135	43	0.0142	0.5000	0.7576	68.3	100
88	7038	0.0105	0.0116	0.0101	22	0.0143	0.0833	2.0000	75.5	100

Appendix F: The Calculated Weights for All DMU's Input\output by PIM DEA

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped car	Reworked car	Customers satisfaction
1	0	0	0.43	0	0.51	1.35	0	0	0.98
2	0	0	1.37	0	1.03	0	0	0	1.04
3	4.88	5.83	0	0.3	0.3	0	0	1.41	0.93
4	0.11	0	1.05	0	1.01	0	0	0	0.83
5	1.1	0	0.87	0.12	0.12	0.02	0	0.65	0.69
6	1.55	0	0	0.14	0.13	1.86	0.12	0	1.07
7	0	0	1.35	0.14	0.22	0	0.15	0	1.01
8	3.86	4.62	0	0.24	0.24	0	0	1.12	0.74
9	0	0	1.03	0.15	0.35	0.2	0	0	0.91
10	0	0	1.41	0.2	0.12	0	0	0	1.07
11	1.46	0	1.28	0.13	0.15	0	0.14	0.82	0.97
12	0.29	0	1.25	0.03	1.12	0	0.12	0	1.01
13	0.11	0	0	0.32	6.41	1.48	0.66	0	1.04
14	0	9.02	0	0.2	0.45	0	0.01	0	1.06
15	0.83	0	1.22	0	0	0.19	0.3	0.83	0.79
16	2.77	0	0	0.23	0.17	1.9	0.24	0	1.19
17	0.02	9.74	0	0.15	0.09	0	0	0.11	1.05
18	0.13	2.2	0	0	0.04	1.51	0	0	0.94
19	0.2	0	0	0	0.02	2.21	0.08	0	1.03
20	1.05	0	0	0.22	0.12	1.74	0	0.32	1
21	2.1	4.22	0.26	0.23	1.14	0	0.19	0.97	0.85
22	0.12	0	1.14	0	1.09	0	0	0	0.9
23	8	0.16	0	0	0.29	1.22	1.01	0	0.69
24	0	1.42	1.28	0.07	0.08	0	0.16	0.13	1.03
25	0.07	8.18	0	0.16	6.1	0	0	0.39	1.14
26	0	0	0.82	0	0	0.72	0.11	0.29	0.82
27	0	0	0	2.96	0	0	0	0.25	1.04
28	0	0	0	0	0.85	2.37	0	0	1.17
29	0	0	1.42	0.19	0.11	0	0.06	0.07	1.07
30	0	6.65	0	0.16	0.4	0.14	0.02	0	0.86

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped car	Reworked car	Customers satisfaction
31	0	0	1.24	0	4.01	0	0.26	0.71	0.81
32	0	0	1.21	0.13	0.19	0	0.13	0	0.9
33	0.07	0	0	0	0.66	2.21	0	0	1.1
34	0.9	0	0.15	0.21	0.11	1.48	0.03	0.35	0.96
35	0	10.43	0	0.02	2.44	0	0	0	1.26
36	1.23	0	0	1.19	4.16	0.54	0	0	1.18
37	5.22	0	0	1.47	0.26	0	0.59	0	0.8
38	1.25	0	1.12	0.04	0.18	0	0	0.84	0.8
39	0	0	1.21	0	0.28	0	0.53	0.28	0.61
40	1.51	0	1.08	0.17	0.85	0	0	0.77	0.94
41	0.49	0	0	0	0.05	2.14	0.11	0.15	1.02
42	1.35	0	1.27	0.04	0.12	0	0.07	0.89	0.9
43	0	0	1.29	0.11	0.22	0	0.16	0	0.95
44	5.27	0	1.24	0	0.12	0	0.88	0	0.98
45	9.46	3.09	0	0.68	0.36	0	0.03	0.96	1.09
46	0	1.29	1.16	0.06	0.08	0	0.15	0.12	0.93
47	0.55	0	0	0	0.04	1.96	0.09	0.3	0.93
48	0.02	7.09	0.2	0.21	0.1	0	0	0	0.97
49	1.77	1.84	0.85	0.15	0.16	0	0.03	1.03	0.89
50	0	0	1.39	0.2	0.12	0.01	0	0	1.07
51	0	0	1.5	0	3.08	0	0	0.54	1.06
52	0	0	0	2.41	0	0	0	0.32	0.81
53	0	9.27	0	0.01	2.17	0	0	0	1.12
54	0	0	1.41	0.2	0.12	0	0	0	1.07
55	1.19	7.9	0	0	1.46	0.2	0.12	0	1.13
56	0	4.44	0	1.68	0	0	0.08	0	1.06
57	1.65	0	1.26	0	0.15	0	0.28	0	0.97
58	7.59	2.33	0	0.55	0.31	0	0	0.76	0.87
59	0	0	1.31	0.19	0.11	0	0	0	1
60	0.66	0	0.74	0	11.04	0	2.02	0	0.36

DMU	Number of costumers	Human resource	Equipment	Education	Providing pieces	Process	Stopped car	Reworked car	Customers satisfaction
61	0.77	0	1.33	0	0	0	0.55	0.86	0.64
62	0.02	5.76	0.3	0.2	0.09	0	0	0.1	0.89
63	1.1	0	0.2	1.16	4.56	0	0.4	0	0.96
64	0	0.19	0	0.19	5.16	1.37	0.65	0	0.87
65	0.87	0.84	0	0	0.06	1.85	0	0.57	0.96
66	26.15	0	0	0.61	1.41	0	0.84	0	1.06
67	3.1	0	0.77	0.14	0.15	0	0.37	0	0.75
68	0.4	0	1.09	0.27	4.71	0	0.46	0	1.12
69	0.5	0	0.59	0.44	4.7	0.32	0	0	1.09
70	0	0	0	2.54	1.21	0	0	0	1.03
71	1.02	0	0	0.19	0.12	1.85	0.08	0	1.05
72	0.28	0	0.61	0	0.64	1.08	0.2	0	1
73	0.02	7.21	0	0.19	0.44	0.29	0.02	0	1.01
74	0.92	0	0.45	1.16	6.05	0	0	0	1.27
75	0.52	0	0	0	0.05	2.23	0.12	0	1.08
76	11.87	0	0	1.01	1.08	0	0	0.4	1.14
77	0	8.7	0	0.18	0.64	0.05	0	0	1.06
78	0.31	0	0.39	1.57	3.03	0	0.94	0.09	0.86
79	0	0	1.28	0.14	0.55	0	0	0	1.01
80	0	0	0	0	0.09	2.12	1.59	0	0.17
81	0.54	6.66	0	0.05	1.79	0.58	0.03	0	1.21
82	0.01	9.03	0	0	2.25	0	0	0	1.09
83	0.59	0	0	0	0.05	2.08	0.13	0	1.01
84	1.07	0	0.85	0.12	0.13	0	0	0.63	0.67
85	1.09	0	0	1.47	3.39	0	0.31	0	0.89
86	0	0	0	1.43	0	0.97	0.07	0	0.99
87	3.25	6.63	0	0	0.19	0.33	0.26	0	1.04
88	0	3.54	0	1.93	0	0	0	0.2	1.05

Appendix G: The Calculated Amount of λ for All DMUs

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU1	0	0	0	0.47	0	0	0	0.33	0	0	0	0	0	0	0	0	0	0	0.11	0	0	0	0	0	0	0	0	0	0	0	0
DMU2	0	0	0	0	0	0	0	0.79	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0	0	0	0	0	0	0
DMU3	0.05	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.06	0.18	0	0	0	0	0	0	0	0	0.63	0	0	0	0	0	0
DMU4	0	0	0	0	0	0	0	0.75	0	0	0	0	0	0	0	0	0	0	0.16	0	0	0	0	0	0	0	0	0	0	0	0
DMU5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU7	0	0	0	0	0	0	0	0.37	0	0	0	0	0	0	0	0	0	0	0.14	0	0	0	0	0	0.32	0	0	0	0.18	0	0
DMU8	0.14	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0.26	0.09	0	0	0	0	0	0	0	0	0.38	0	0	0	0	0	0
DMU9	0	0	0	0	0	0	0	0.19	0	0	0	0	0	0	0	0	0.43	0	0.1	0	0	0	0	0	0.11	0	0	0	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0.02	0	0	0	0	0.76	0	0	0	0	0	0
DMU11	0	0	0	0	0	0	0	0.04	0	0	0	0	0.17	0	0.27	0	0	0	0.29	0.01	0	0	0	0	0.12	0	0	0	0	0	0
DMU12	0	0.17	0	0	0	0	0	0.22	0	0	0	0	0	0	0	0	0	0	0.04	0	0	0	0	0	0.55	0.01	0	0	0	0	0
DMU13	0	0.15	0	0	0	0	0	0.19	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0	0	0	0	0	0.2	0.35	0	0	0
DMU14	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0.87	0.06	0	0	0	0	0
DMU15	0	0	0	0	0	0.03	0	0.09	0	0	0	0	0.52	0	0.1	0	0	0	0	0.13	0	0	0	0	0	0	0	0	0	0	0
DMU16	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU17	0	0	0	0.6	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0.03	0.05	0	0	0	0	0	0	0	0	0	0	0
DMU18	0	0	0	0.44	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0	0.17	0.01	0	0	0	0	0	0	0	0	0	0	0
DMU19	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08	0	0.35	0	0.12	0	0	0	0	0	0.36	0	0	0	0	0	0
DMU21	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU22	0	0.01	0	0	0	0	0	0.26	0	0	0	0	0	0	0	0	0	0	0.52	0	0	0	0	0	0	0	0	0	0	0	0
DMU23	0	0.49	0.05	0	0	0	0	0	0	0	0	0	0	0.11	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.12	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU24	0	0	0	0	0	0.04	0	0.17	0	0	0	0	0.03	0	0	0	0	0	0.17	0.4	0	0	0	0	0	0	0	0	0.08	0	0
DMU25	0	0	0	0	0	0	0	0.1	0.04	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0.81	0	0	0	0.04	0	0	0
DMU26	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU27	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.64	0	0	0	0	0	0
DMU28	0	0	0	0.23	0	0	0	0.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU29	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0.13	0.31	0	0	0	0	0.21	0	0	0	0.04	0	0
DMU30	0	0	0	0.04	0	0	0	0.1	0	0	0	0	0.12	0	0	0	0	0	0.52	0	0	0	0	0	0.05	0	0	0	0	0	0
DMU31	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU32	0	0	0	0	0	0	0	0.47	0	0	0	0	0	0	0	0	0	0	0.28	0	0	0	0	0	0.03	0	0	0	0.12	0	0
DMU33	0	0	0	0.19	0	0	0	0.13	0	0	0	0	0	0	0	0	0.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU34	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU35	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU36	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU37	0	0	0.28	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0.46	0	0	0	0	0.09	0
DMU38	0.07	0	0	0	0	0	0	0.07	0	0	0	0	0	0	0.04	0	0	0	0.65	0	0	0.03	0	0	0	0	0	0	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU39	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU40	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU41	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU42	0.02	0	0	0	0	0	0	0.23	0	0	0	0	0	0	0.09	0	0	0	0.35	0.04	0	0.2	0	0	0	0	0	0	0	0	0
DMU43	0	0	0	0	0	0	0	0.08	0	0	0	0	0	0	0	0	0	0	0.63	0	0	0	0	0	0	0.02	0	0	0.14	0	0
DMU44	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU45	0.1	0.19	0.06	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.13	0	0	0	0	0.2	0	0	0	0	0	0
DMU46	0	0	0	0	0	0.01	0	0.06	0	0	0	0	0.23	0	0	0	0	0	0.01	0.07	0	0	0	0	0	0	0	0	0.41	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU48	0	0	0	0.06	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0.03	0.01	0	0	0	0	0.78	0	0	0	0	0	0
DMU49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU52	0	0	0	0	0	0.04	0	0.82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU53	0	0	0	0	0	0	0	0.45	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.34	0	0	0	0	0
DMU54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU55	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.19	0	0	0	0	0	0.13	0.06	0	0.45	0	0	0
DMU56	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0.06	0	0	0	0	0.92	0	0	0	0	0	0
DMU57	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0.01	0.17	0	0	0	0	0.68	0	0	0	0	0	0
DMU58	0.27	0.02	0.03	0	0	0	0	0	0	0	0	0	0	0	0.24	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0	0
DMU59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
DMU60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0.27	0	0.21	0.4	0	0	0	0
DMU61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU62	0	0	0	0.03	0	0.02	0	0	0	0	0	0	0	0	0	0	0.16	0	0.4	0.01	0	0	0	0	0.19	0	0	0	0	0	0
DMU63	0	0	0	0	0	0	0	0.38	0	0.07	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0.02	0	0	0	0.22	0	0	0
DMU64	0	0.18	0	0	0	0	0	0.35	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0.2	0.13	0	0	0	0
DMU65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
DMU66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
DMU67	0	0.35	0.06	0	0	0	0	0	0	0	0	0	0.27	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0
DMU68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
DMU69	0	0.07	0	0	0	0	0	0.57	0	0	0	0.03	0	0	0	0	0	0.07	0	0	0	0	0	0	0	0	0	0.07	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU70	0	0	0	0	0	0	0	0.78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0	0	0	0	0	0
DMU71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
DMU72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
DMU73	0	0	0	0.12	0	0	0	0.07	0	0	0	0	0.07	0	0	0	0.15	0	0.46	0	0	0	0	0	0.11	0	0	0	0	0	0
DMU74	0	0	0	0	0	0	0	0.35	0	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0.18	0	0	0	0.29	0	0	0
DMU75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17	0	0.19	0.39	0	0	0	0	0	0	0	0	0.09	0	0
DMU76	0	0.1	0.11	0	0	0	0	0	0	0	0	0	0	0	0.24	0	0	0	0	0	0	0	0	0	0.42	0	0	0	0	0	0
DMU77	0	0	0	0	0	0	0	0.23	0	0	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0.44	0.28	0	0	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
DMU79	0	0	0	0	0	0	0	0.65	0	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0.17	0	0	0	0	0	0
DMU80	0	0	0	0	0	0	0	0	0	0	0.07	0	0.82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0
DMU81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
DMU82	0	0	0	0	0	0	0	0.73	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0
DMU83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
DMU84	0.02	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0.08	0	0	0	0.22	0	0	0	0	0	0.35	0	0	0	0	0	0
DMU85	0	0	0	0	0	0	0	0.11	0	0.25	0	0	0	0	0.09	0	0	0	0	0	0	0	0	0	0.42	0	0	0	0	0	0

Name	DMU5	DMU6	DMU16	DMU19	DMU21	DMU26	DMU31	DMU34	DMU35	DMU36	DMU39	DMU40	DMU41	DMU44	DMU47	DMU49	DMU50	DMU51	DMU54	DMU59	DMU61	DMU65	DMU66	DMU68	DMU71	DMU72	DMU78	DMU81	DMU83	DMU87	DMU88
DMU86	0	0	0	0	0	0	0	0.53	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0.11	0	0
DMU87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
DMU88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1