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IMPROVEMENT OF CREDIT EVALUATION PROCESS IN COMMERCIAL BANKING

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Abstract

Loans constitute the largest sources of revenue in banking industry thus effecting the Turkish economical environment extensively. Credits in the banking sector can be categorized as corporate, medium and large scale, and individual loans. Commercial loans constitute a high importance within the total loans granted as the economical size and risks are extreme. Importance of these loans can also be highlighted by the political role they play. Volatility and risk factors affecting the interest rates have direct effect on real sector as well. As a result, evaluation of such credits is a major task for the banks that involves objective and subjective criteria.

A typical evaluation process of loans, provided to the real sector, is carried out by educated and experienced human resources with high subjectivity depending on the personnel and daily macroeconomic conditions. This study aims to reduce the economic losses and variability that banks are facing in credit evaluation processes. We propose a decision making and support mechanism by using the Data Envelopment Analysis (DEA) methodology with an effective operations management perspective. At this point, our goal is to systematize the process which is controlled by credit analyst thus minimizing the subjectivity in credit decisions. This mechanism will also help us in the identification of the weaknesses of underperforming credit applicants.

Keywords: Credit Risk, DEA Methodology, Loan Allocation Process, Banking

TİCARİ BANKACILIKTA KREDİ DEĞERLENDİRME SÜRECİNİN İYİLEŞTİRİLMESİ

Özet

Krediler, bankacılık sektöründeki en büyük gelir kaynağıdır ve ulusal ekonomiyi kapsamlı bir şekilde etkiler. Bankacılık sektöründeki krediler, kurumsal, orta ve büyük ölçekli ve bireysel krediler olarak sınıflandırılabilir. Ekonomik büyüklük ve riskler aşırı olduğu için ticari krediler verilen kredilerde yüksek bir önem teşkil etmektedir. Bu kredilerin önemi, oynadıkları siyasi rol ile de vurgulanabilir. Faiz oranlarını etkileyen dalgalanma ve risk faktörleri reel sektör üzerinde de doğrudan etkiye sahiptir. Sonuç olarak, kredilerin değerlendirilmesi, bankalar için objektif ve öznel ölçütleri içeren büyük bir görevdir.

Reel sektöre sağlanan kredilerin tipik bir değerlendirme süreci, personel ve günlük makroekonomik koşullara bağlı olarak yüksek öznellik içeren, eğitimli ve tecrübeli insan kaynakları tarafından gerçekleştirilmektedir. Bu çalışma bankaların kredi değerlendirme süreçlerinde karşılaştıkları ekonomik kayıpları ve değişkenliği azaltmayı amaçlamaktadır. Etkin bir operasyon yönetim perspektifi ile veri zarflama analizini kullanarak karar verme ve destek mekanizması önermekteyiz. Bu noktada amacımız, kredi değerlendiricisi tarafından kontrol edilen süreci sistematize etmek ve böylelikle kredi kararlarında öznelliği en aza indirmektir. Bu mekanizma, kredi başvuru sahiplerinin performansının zayıf yönlerinin belirlenmesine de yardımcı olacaktır.

Anahtar kelimeler: Kredi Riski, Veri Zarflama Analizi, Kredi Tahsis Süreci, Bankacılık

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To my dear family and friends...

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List of Abbreviations

CBRT	**C**entral **B**ank of the **R**epublic of **T**urkey
DEA	**D**ata **E**nvelopment **A**nalysis
CCR	**C**harnes **C**ooper **R**hodes
DMU	**D**ecision **M**aking **U**nit
LP	**L**inear **P**rogramming
FDIC	**F**ederal **D**eposite **I**nsuarence
ROE	**R**eturn on **E**quitiy
ROA	**R**eturn on **A**sset
NPL	**N**on **P**erforming **L**oan
CAR	**C**apital **A**dequacy **R**atio
GDP	**G**ross **D**omestic **P**roduct
ADF	**A**utomated **D**ata **F**low
ANN	**A**rtificial **N**eural **N**etworks
EBITDA	**E**arnings **B**efore **I**nterest **T**axes **D**epreciation and **A**mortization
MSE	**M**ean **S**quared **E**rror
SD	**S**tandart **D**eviation
BCG	**B**oston **C**onsulting **G**roup
ERP	**E**nterprise **R**esource **P**lanning

Chapter 1

Introduction

1.1 The Importance Of Banking Terms of Sectoral Markets

Today, many people need cash money for their home or needs. For this reason, the banking sector is facing a challenge as a reality. Economic revitalization occur by affordable and low-cost loans hence this situation provides using credit card or cash money for shopping and low cost for investment. From this point of view, the banking sector is one of the major sectors in our country and in the whole world. Firms and people have a certain economic power to invest, buy or provide services. Institutions or people want to invest but they can not find cash money, for this reason, they delay or give up investments. In order to avoid such situation, it is crucial to provide loans to the rapidly growing firms and economy that are to be created by making an appropriate repayment plan in the banks.

When you think about the global economy, the banking sector will continue to grow rapidly. For the state, too, the banking sector are seen as a major source of revenue, where hot money flow. For this reason, today's banking sector is too big to compare with other sectors. There are a few factors that directly affect the banking sector such as interest and exchange rates, growth rates of loans, composition and quality of loans, the proportion of future receivables and other risk measures, funding sources and costs, sector profitability ratios, growth rate of the economy and other macroeconomic data etc.

1.2 Commercial Banking

In the global economic sense, the banking sector within financial system is the largest and most important actor in fulfilling financial intermediation. For this reason, banks are profit-making institutions which the continuous regulation is made by the states and are operating under these regulations.

The banking sector is extremely sensitive to change in supply and demand conditions and rapidly affected by developments. In addition to the available arrangements made by the public authority, financial innovations enable the creation of a market that offers very different alternatives to borrowers at the world level. Rapid developments in information technology have led to the emergence of new financial products and services. In addition to traditional financial instruments, banks offer financial innovations in diversified product and service offerings. Banks have become more profitable by lowering the cost of financial transactions. Thus, new financial products and services were offered to customers.

In Turkey, the banking sector is a major sector that affects the economy and it is most important cornerstone of the entire financial sector. The banking sector constitutes an important part of the financial system that acts as an intermediary for resource transfer in the economy. The share of the banking sector in the system differs from country to country depending on the economic and social developments. In parallel with social and economic development, the share of the banking sector in financial system is decreasing but in Turkey, the share of the banking sector in the financial system is still very high and has been increasing over time too.

The balance sheet size distribution of the financial sector for 2009 is given in Figure 1.1. In Turkey, the financial system includes insurance companies, securities investment funds, financial leasing companies, pension funds, securities brokerage houses, consumer finance companies, real estate investment trusts and securities

investment trusts outside the banks. As seen in Figure 1.1, banks in Turkey constitute account for 88.3 % of the balance sheet size of the financial system. Despite negative or positive developments in the financial sector, banking sector continues to weigh within the system since in 2001.

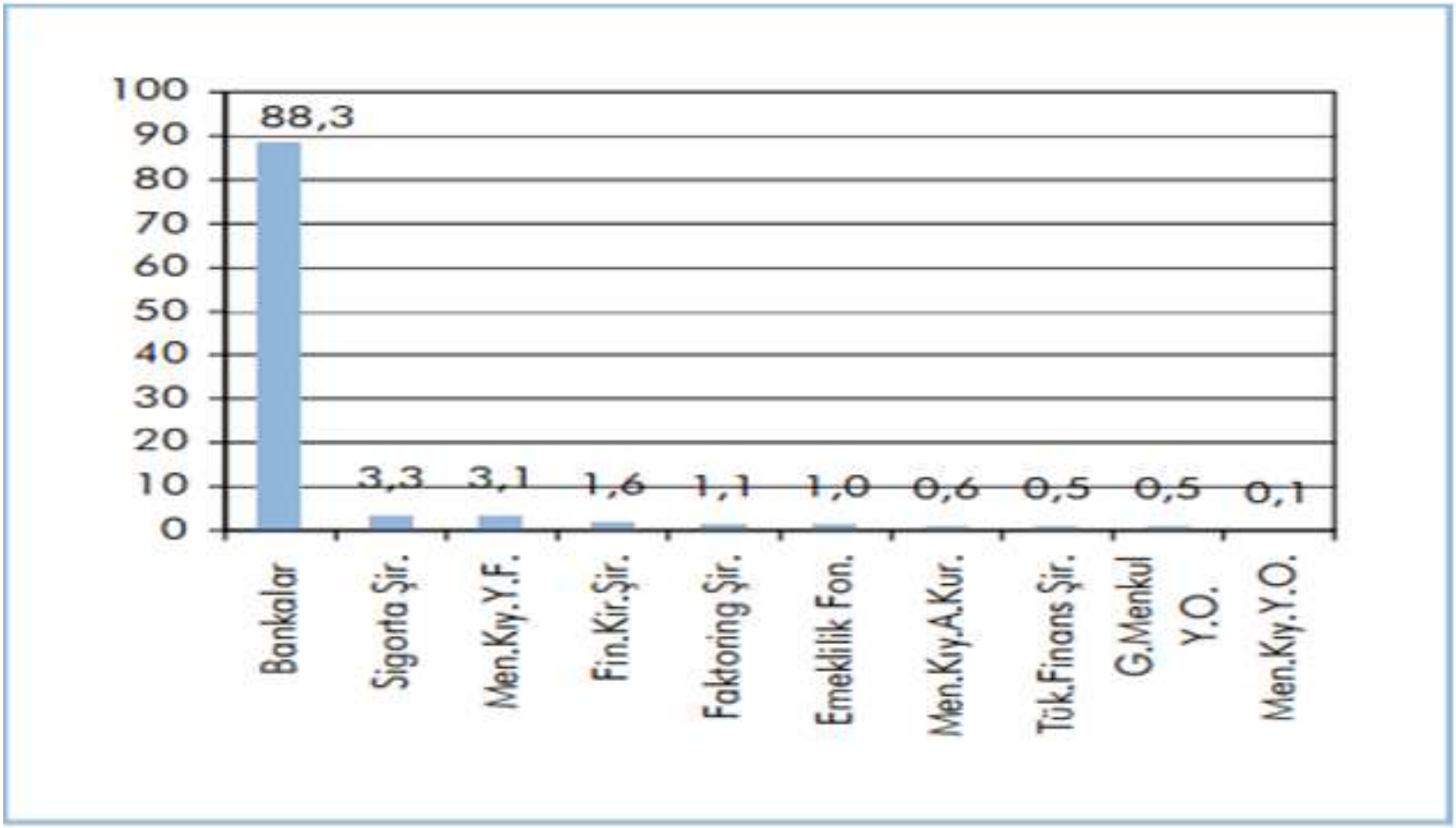

Figure 1.1: Balance sheet size distribution of the financial sector(2009-CBRT [1])%

As of February 2012, there are 51 banks in the banking sector, including deposit, development and investment and participation banks. The progress of economic activities and the monetary regime of the country is usually the responsibility of central banks as well as commercial banks. Commercial banks; collects all kinds of deposits and gives various services to its customers. In this way, they make both profit and also satisfy the needs of the customers. The other name of such banks is "deposit banks" because they have collected deposits which carry out from their transactions. Commercial banks are required to allocate some of the funds they collect to their customers in return for the central bank. The purpose of leaving the counterpart of the deposit determined by the central bank is the protection of the bank customers' money. Such banks have a close relationship with their customers because the needs of a customer demand like credit receives from other customers with the savings. In doing so, it also aims to earn income and charges with commissions in the form of interest.

1.2.1 Duties of Commercial Banking

Another name for commercial banking is deposit banking and there are many activities with competence of laws. The deposit which is the priority is the sum. Another area of activity is presentation of these deposits to other customers as both cash and non-cash. Commercial banks operate investment consulting, portfolio management, buying and selling in the markets, insurance transactions. Looking at all these transactions, the most active type among banks is deposit banks. There is a constant competition between the banks in this kind because of purpose is profit. Therefore, they compete with each other to offer credit limits to good customers.

1.2.2 Functions of Commercial Banking

Commercial banks have a big role about short and medium term financial requirements of industries. As a general, people or firms have deposits in commercial

banks and they can be used at short term therefore, commercial banks prefer to provide credit for a short period of time by backed tangible and easily marketable securities. Commercial Banks consider various factors like nature of business and size, financial status and profitability of the business and its ability to repay loans while they providing loans to business.

1.2.3 Needed Requirements for Credit Demand

There are loan requests from banks in line with the money needs of commercial or personal customers. Realization of this money claim can be realized in different forms as much as possible. This situation causes formation of loans. In order to approved customers' credits, firms or personal customers need to be from a good group of customers. A good group of customers means that should pay early on their credit or pay credit card debt on time. For commercial customers should have a strong capital structure either a low level of debt or a good debt coverage ratio. Credit facility means that customers who are commercial or personal have power of purchasing. If they provide terms, conditions, calculated interest rates, credits can be given to customers required amount by banks. Credits vary both cash and non-cash. A certain amount is requested from the bank for cash loans. Non-cash loans are monetary but it is not cash money. This type of companies use generally letter of guarantee, credit by way of guarantee, leasing, reference letters, checks, bills, bonds.

1.2.4 Loans by Structural Qualities

We have mentioned above that the credits do not only include cash money. For this reason, we need to examine the loans under two main headings as cash and non-cash loans. The basis of this distinction is that cash loan put the account as cash money. Non-cash loan is to use of different products that can be used in place of money.

Cash Loan: Generally, kind of credit is as monetary. The person or firm who needed credit will repay by including specific interest rate with planned payment schedule. It can be used currency or Turkish Liras. It can be different kinds of forms.

Non-Cash Loan: The type of credit used to fulfill the contractual provisions or conduct a business. the most widely used types are letter of guarantee, letter of credit, acceptance loans. In other words, this type of credit covers money, it is not cash money.

1.2.5 Loans When Changing to Expiry

There are credits that vary according to their expiry. For this reason, credits are referred to by different names. They are called short term, medium term and long term loans.

- *Short-term Loans*: This kind of loans expiry is maximum 1 year to repay the bank according to this loan plan.
- *Medium Term Loans*: This loan's period must be between 1 year to 2 years.
- *Long Term Loans*: If the loan is over 2 years, long term loan will be the loan. Its period can be protracted until 10 years or more.

1.2.6 Loans Varying According To Authorization Status

Branch Authorized Loans:

These credits can be used by branches when General Directorate approves them. Small amounts loans do not approve by General Directorate. For example; There is no need to approved by the General Directorate for a loan of TL 15 thousand because this is a waste of time and can also mean loss of customers for the

banks at the same time. In general, this is a quick way to find a solution for customers who need loans are in a hurry. Because of the possibility of customer loss when they are kept waiting too long, the banks have given a authority the credit limits of branch managers to certain amounts. With the approval of the branch manager, customers can withdraw their money from branches without approval of the center.

Headquarters Authorized Loans:

Credit limits send to General Directorate with the increasing of demanded credit amount or over branch approval authorization credit limits. As a result of General Directorate examinations, credit is approved or not depends on customers income. The inspections are carried out separately for real and legal persons.

1.2.7 Changes in Loans According to the Activity

Loans vary according to the purpose of use as legal and real persons. According to their intended usage are consumer, investment and business loans. If we examine them;

- *Consumer Loan*: This loan is used in case of needs. Consumer loans are the most requested by personal customers. Consumer loan is used to supply customers' needed service and goods.
- *Investment Loan*: These are cash and non-cash loans for the amount of businesses required by new investments. Banks provide financial resources to the project.
- *Business Loan*: A type of loan that businesses use to maintain their business.

1.2.8 Loan Tools

The expansion of service networks has also led to differences in the credit instruments of banks. As mentioned above about loan types, there are a lot of credit instruments that banks sometimes use. These instruments which defined in banking literature are surety, guarantee letter, counter guarantee, credit by way of guarantee , check, letter of credit, futures. As an example, commercial customers are benefiting from credit instruments such as counter-guarantees, letters of credit and letter of guarantee, personal customers tend to cash loans. Credit usage for personal customers is made within the scope of credit note and credit usage is limited within the limit for this customers. If customers has a problem with pay back their loans, some procedures become a part of an activity such as "credit tracking process and its derivatives" for them.

1.2.9 Credit Tracking Process

This process is considering as a credit operation which can be realized under certain conditions and contracts. At this process that commercial or personal customer can demand loan as cash or noncash from the banks or financial institutions. Commercial or personal customer apply to banks or lenders. After this application, if commercial or personal customer has a financial history that can fulfill all the requirements, it deserves to receive a loan after the examinations. Then, a contract is signed for the repayment of the credits within certain dates. Loan payments can usually be made on a monthly basis or in different periods determined by the banks.If customers (commercial firms and persons) get late for installment time will be reminded by the bank for their debts with a reminder phone within the first 10 days. If the debt is not paid at the end of the first month, the bank will continue to call you at intervals and remind you to pay your debt. If the debts are not paid until the end of 3 months, they can be restructured or the administrative tracking process is applied by the bank. In all the delays,

customers who have a credit note decreases when they are considered on the basis of banks.

1.2.10 The Route Watching Credit Delays

Banks communicate with their customers who want to delay their credit payments within 5-10 days following their delay. In this process, credit payments are reminded. If they made a partial payment, the remaining amount is reported. In the following process, a call is made again for delayed credits that have completed one month. In this period, they will be reminded that have delayed their loan and if possible banks will give a due date for these customers. Within 90 days, customers will be asked to call and inform for their decreasing credibility scores that vary according to their bank. Following the legal period of 90 days expires, customer's credit administrative tracking is initiated.

1.2.11 Administrative Tracking Process

Administrative tracking is the process performed by bank if customers have delayed their debts such as loan or credit cards. If customer's delays are in a two-month period, this will only affect their credit score. When the 90 days pass, bank that they have credit with will start legal action for them. During administrative tracking, banks meet with customers and offer to construct their debt. These reconstruction usually extends over a 12 month period. This interest rate applied during the credit administrative tracking is higher than normal interest rates.

1.2.12 Law Tracking

If customers do not negotiate with the bank during the administrative tracking period after the 90 day delay period, they will receive a notice which is telling to pay your debt within 7 days. If the customers do not pay their debts within

7 days or they do not object to justifiable grounds, the bank will initiate legal action against them. In this notice, bank will ask them for all of their debts, not the part customers did not pay. Since customers have not paid for 90 days and they have violated contractual rules which they have signed, their contract will not have any validity anymore. After this process, bank will depute a lawyer. The lawyer can demand a payment for the loan. If they do not meet this demand, they will start the foreclosure and enforcement proceedings.

1.2.13 Difference Between Administrative Tracking And Law Tracking

Administrative tracking is an attempt by the bank to restructure your debt by committing without initiating a legal process. In this process, you do not have any lawsuits filed against you or a notice issued by your bank. This application which is done by some banks, is applied for the definition of an additional period of payment. Following this process, if you can not agree with bank, legal tracking will begin.

1.3 Problem Statement

The realization of economic growth which is among basic objectives of any country's economy and sustainability of growth are quite a difficult task. There are many economic factors that will influence growth and one of the factors that stands out is banking sector.

It can be said that financial markets are very important for today's economies and this situation can be showed us clearly that difference between developed and underdeveloped countries. The financial system of developing countries such as Turkey is largely based on the banking sector. Technological development of modern communication networks in the global world make access opportunities of market which has led the banking sector to take part in a continuous development.

Along with these developments, sector has become more professional and business departments have been established on basis of the general directorate, regional and branch offices. These units have been established as marketing-sales teams, operation teams, credit allocation units, foreign trade, treasury, close monitoring, information technologies, inspections, and so on. This rapid development has helped to make the human resource within bank's field. Development occurs specializing in banking industry for every business unit. It is mean that different business units require several profession for own department. For instance, credit is analyzed in loan allocation department and marketing is done in the branch etc. With professionalisation, it is seen that the banking sector plays a big role in the development of the industry and the economy of the country with its developed human resources. The banking sector provides recovery of the deposits and funds necessary for growth and enables projects of the companies to be realized economically and improve their business.

Collected deposits provide loans in banking sector and this loans constitute vital point in whole sector. The banking sector is more prominent than the other sectors in terms of given loans in support of the economy. Banks provide loans for customers and it makes possible for firm's investing in fields such as researching and development, innovation to improve their business, increasing their production quality, using branding, contemporary finance resources. Corporate, commercial, medium-sized firms and personal customers who play an important role to form loan volumes of the banks, have an active part. When we considered personal loans which used in terms of country's economy, volume of personal loans is 425 billion 809 million TL as of 2017/02. In terms of the Central Bank of the Republic of Turkey (CBRT) reports on June/2017, credit debt has reached to level of USD 210.9 billion together with provided loans from abroad.

When you consider banks which provide loans to firms to invest and trade, this situation proves that banks take big risk for their position. Although personal banking has a large sector in terms of banking, it will not be included our study

because we do not have necessary data and information about it. Credit limits and preparation of the credit are made by the branches for the requests of the firms. If we summarize financial analysis in a simple way, necessary information and documents send to loan allocation department in the bank and then these documents and information are examined by loan allocation department. Documents which will be examined include financial statements of the company, income tables for the 1st, 2nd, 3rd and 4th period, detailed balance sheet, credit record bureau data and findeks documents that will reveal the performance of the companies, limit occupancy rates at banks. When examining these requests which come from branches, credit department decide on it by keeping risk perception at the highest level by take advantage of systematic data and trained people. Loans demand are evaluated by carrying out a wide range of aspects such as debt coverage rate, activity cycle, number of days of activity qualification. Loan analysts prepare a report which includes company's history, activity, working conditions in the bank (conditions such as collateral, total limit and risk), and import and export conditions. Loan decisions are taken by authorization of managers or refer to top management. While these analyzes are carried out, the systems that banks have developed in themselves, help to make credit decisions but most of the time, control and decision making is realize by educated human factor. On the other hand, some of the important credit issues that need to mention are sometimes lacking because of this process. This situation increases likelihood of inspecting firm and making mistakes in correct credit decision making process. Such situations may make it difficult for the firm to determine firm credit limit requirement ratio by making a credit decision above or below the actual credit limit requirement. If decision is above demanded credit limit by the company and firm has not risk perception, this situation causes that usage of entire credit limit has worsen the company's balance sheet by periods and years and increased its debt. In terms of banks, this possibility of increasing risk of submerged credit can be seen as a margin of error in managing risk perception. A limit which is approved under demanded credit limit can create a bad picture on the balance sheet due to possibility of causing the wrong usage of credit because firm can not

provide necessary growth.

Our aim is to contribute decision support system in banking sector which is lack of systematic when evaluating to the firms' loan demand. Therefore, we want to eliminate some shortcomings or mistakes in the credit decisions that evaluated with the credit system and human factor. Thus, development of a decision support system will ensure that we make the least amount of mistakes and decide correct credit decisions when evaluating credit decisions. Our aim is to develop this system, taking fast credit decisions will provide to be one step ahead of competition in banking sector.

We can sort out gains what we will achieve after this study;

- With this decision support system, we will develop a kind of system which employees will receive fast credit decisions and it will help increase efficiency in the bank by using it efficiently time.
- Another benefit of the decision support system is that it is an important factor in speeding up credit decision-making process and preventing loss of time. This situation provides accessing to information, accelerating and developing to fast decision to analysts.
- The system which will be developed can help to automate to decision-making process. It will provide quick and reliable preparation of concrete data which approved by more than one person, such as in the credit department. The decision support system will help us to develop innovative loans applications for performance improvement which is a systematic benefit to the bank.
- Another advantage of this system is that semi-regular or irregular information is collected in one system to help decision-making process. There can be disagreement before credit decision is submitted to approval to manager

because analysts can evaluate to firms differently from managers so it can be caused loss of time and decreasing efficient of examination. The decision support system will provide to support for common decisions in the decision-making process.

- It is known that credit limit decision process in the credit allocation department has a sequence which can be given as following: These are steps of requesting a credit limit from company, sending information and documentation to the credit allocation department, writing reports by examining all the information and documents of credit analysts and deciding according to credit limit authority level. The decision support system that we will do in such a multiple-stage situation will help to pass some stages and connect to the result at the decision level. In this sense, data enveloping analysis has an important place to determine efficiency of customers credibility and doing to systematize evaluation of loans allocation. Efficiency and productivity analyzes are significant management tools to determine which customers can be workable for banks. For this reason, an analysis of efficiency is required for credit performance analysis.

1.4 Research Objective

Data Envelopment Analysis (DEA) was preferred for our study because it is a linear programming based technique and it is one of the best way to measure efficiency to multiple input and output with different scales which in difficult situation. One of the important features of the method is that it can be measured in a rich data environment where more than one output is obtained by using more than one input without requiring existence of any predetermined analytical production function as in parametric methods. Amount and sources of inefficiency in each decision can be defined by using Data Envelopment Analysis (DEA). In this way, this study can be guide for banks. It can be possible that managers/-credit analysts can be measure customer credibility by checking their inputs and

outputs thus they can eliminate poor customers or data which include bad input and output factors.

We are studying on credit decision model to measure credit efficiency. It will provide us to elimination of firms which have weak or strong financial data using inputs and outputs by controlling their balance sheet. In the formation of non-paying loan, many inputs in the firm's balance sheet can be caused. Comparison of current credit evaluation process (which involves subjective stages) with a Data Envelopment Analysis (DEA) will show us which one is more efficient for banks. This comparison will be illustrated with our study.

Chapter 2

Literature Review

2.1 Risk Management in Banking Sector

In the most general sense, credit risk is the sum of the probable risks until the fulfillment of commitments until customer debt is collected. These risks are defined as non-repayment of the loan on time, non-fulfillment of business or service commitment and non-compliance with the terms of the loan agreement. It is necessary to closely monitor credit demanded companies which has strong collateral and loan portfolio although loans are being used for business purpose. There is a study made by Tokel *et al.* [2] on evaluation of loan claims. He utilized artificial neural network model while evaluating loan claims. Needed data for artificial neural network application are Credit Risk Note, expiry and credit amount. In terms of sector wealth, determined 5 sectors which are manufacturing sector, wholesale and retail, construction sector, transportation, storage and communication sector and hotel -restaurant sector. In our study, loan claims evaluation which used some important data from firm's financial balance examined by using Data Envelopment Analysis (DEA) methodology. In this study, model based on estimation or new loan claims can be evaluate current credit data by utilizing artificial neural network . This situation is one of the basic features that distinguishes this study from our study.

If refer to our study, we utilize to data from one of the five largest bank in Turkey. It means that big banks bring big responsibility about risks.There are a lot of studies about this field, one of the studies on this fields mention the importance of credit risk which have done Stan *et al.* [3].Their study researches between bank size and risk whether positive or negative relationship. In this study, data consist public and private banks which are smallest to largest. These data had taken wide variety of 7,369 banks' data from Federal Deposit Insurance (FDIC)'s database that biggest one is JP Morgan Chase Bank with an asset size of 962 billion dollars, the smallest being the Oakwood State Bank with an asset size of 3 million dollars. In this context, this article shows us that data which we used in our study create big risk management for banks. Study is noting that "It is an increasing risk trend when an asset of over 250 million dollars goes out". banks' risks grow as their assets grow and this risk should be managed well. In this sense, the fact that larger banks have higher risk levels than small banks has been confirmed by the article.

There are some study under Risk Management concept. One of them which is how credit risk management is investigating the impact of performance on commercial banks in Nigeria, study made by Abiola *et al.* [4]. They had studied relation between bank's non performing loan and capital adequacy basen on performance. The article makes an analysis according to the rates that like parallel to our work, and develop a model with credit risk management. In this article, financial data of seven commercial banking companies were used between 2005 and 2011. For this model, a panel regression model is used and the performance indicators are Return on Equity (ROE) and Return on Asset (ROA). Non-Performing Loans (NPL) and Capital Adequacy Ratio (CAR) were used as Credit risk management indicators. A total of 49 observations were made for the analysis with 7 year financial reports and 7 bank accounts and the collected data were analyzed using the panel regression model.

Another studies about risk management by using artificial neural network. This

study worked by Ghodrati *et al.* [5].Research is a study aimed at finding the lowest risk of credit risk and showing that some data have a high effect on credit risk. Also this research uses past data to implement a countdown paradigm and provide predictions. Study used certain data to estimate the credit risk of two banks, Saderat and Sermayeh, located in Iran. These are Gross Domestic Product (GDP), exchange rate, inflation rate, stock price index, and M2. It contains the data of the period between 2007 and 2011. In the research model, research data enters the Automated Data Flow (ADF) and Causality Granger Test before entering the artificial neural network analysis in order to achieve the best lag. The Mean Squared Error (MSE) and R values for the Artificial Neural Networks(ANN) developed in this study were 123 and 0.9885, respectively. The study shows that Artificial Neural Networks (ANN) can predict banks' credit risk with low error. In the sensitivity analyzes made with artificial neural networks, it is seen that M2 has the most influence on the credit risk. In this case, Iran is confirming that it is shown as an additional leading indicator by banking authorities. This confirms that Iran maintains the validity of macroeconomic concepts in the risk of the credit system.It is preferred because the data used in our study and the data used in this article are parallelling and can be predicted in terms of credit risk. By using artificial neural networks at this point, we can distinguish study from our work and introduce a different way of risk management into different analyzes, thus providing us with a light on risk management.

2.2 Credit Risk Management by DEA

One of the studies on credit risk management by Data Envelopment Analysis (DEA) methodology made by Ahmet Burak Emel *et al.* [6] that sheds light to our study in terms of other angle. They used 82 firm's data from Industrial/manufacturing sector by applying based Data Envelopment Analysis (DEA) methodology. This paper aimed to apply quantitative analysis used in the financial performance modules of state-of-the-art credit scoring methodologies. The

study determine whether customers can repay loan by evaluating their risks. It seems to our study but leaving at one point it is defining credibility score.

Chiu *et al.* [7], applies Data Envelopment Analysis (DEA) on Taiwan's Banks (43 banks). They selected period of 1998-2002 and number of bank employees, assets, deposits, risk and they define one risk indicator which incorporating non performing loans as an input in the Data Envelopment Analysis (DEA) analysis. Study uses Data Envelopment Analysis (DEA) by including BCC and SBM methodology to investigate outcomes of banks' technical efficiency whether account risks. Inputs which used their study are parallel to our data in terms of some inputs and outputs. However, This study is separated from our work about Data Envelopment Analysis (DEA) model. It shows us non performing loans play an important and negative role in bank productivity therefore, banks need to investigate the financial controls of firms, previous banking work and business loans when lending.

The study was made Cielen *et al.* [8] which enables bankruptcy prediction using Data Envelopment Analysis (DEA) methodology int the banking sector. They compared the classification performance of a linear programming model by using Data Envelopment Analysis (DEA) Methodology and rule induction (C5.0) model. They used Data Envelopment Analysis (DEA) methodology because accuracy and employment the Data Envelopment Analysis (DEA) model outperforms the other models. They selected 11 ratios in according to proved to be efficient to predict in prior research. Their paper includes some ratios that they used their study seem to our study in terms of our selected ratios.However, There are some different process and vision from our study such as working on bankruptcy and more ratios to effect firm's balance.

Chapter 3

A Review on Credit Banking

In this chapter, we summarized about loan allocation process and useable data for our study. Loan allocation process is comprised of 4 step. This steps constitute evaluation of loan allocation which is done by experts. This process requires to be careful and rigorous for banking and experts. If experts find a mistake or deficient document in this period, all process can return to beginning or reject. We illustrated this important period figure 3.1. In our study, our goal is to systematize this process so we use some of data from firms' balance sheet as inputs or outputs. We decided to use most important data for our study as inputs and outputs.This inputs and outputs were defined by firms' financial condition to checking their each years(2014,2015 and 2016).

3.1 Functioning of the Credit Allocation Process

Credit Allocation process can be evaluated as the credit allocation applications created by the banks for the legal entities. The Positioning process can be viewed as a 4-step whole;

1- Marketing and Data Collection Function

2- Intelligence Process

3- Financial Analysis Function

4- Finalization - Credit Allocation

We can characterize the first stage as the marketing of the loan and then the data collection process. This process is carried out by the portfolio managers within the bank's branch offices. According to the needs of the existing or new client, the company prepares the limit preparation in the direction of the demands. All the processes related to the credit allocation are shaped by the branch manager and the portfolio managers in the first stage. According to the credit limit authority, the credit package to be submitted to the headquarters or the regional allocation management shall include financial statements (balance sheet-income table), detailed trial balance, information and documents to reveal the company's moral status, and property assets. At the end of the credit allocation period, the credit limit amount requested for the business is reported to the higher evaluation authority with sub-contracts. (The distinctions between cash, non-cash, leasing, checks, etc. are specified).

Institutional-commercial and medium and large-scale enterprises credit allocation in the bank's headquarters or regional allocation begin to consider credit limit requests from branches. The first point to note at this stage is; intelligence process. The credit performance of the firms in the past periods is investigated with the help of sources such as check-bond payments, credibility at other banks and limit-risk situation, market intelligence (in terms of reliability). The intelligence units in the banks' own structures work in coordination with other banks to share information. In this way, it is possible to obtain information about which bank has been granted the credit limit on how long it is held and on the security.

In addition, the company's previous performance of the credit request can be tracked with a survey called a note. In this context, the Central Bank collects information on the loans they use from all the banks in Turkey on a monthly

basis. The information will then be posted on a common platform that will be open to the entire bank. This table, called "The Consolidated", contains the limit risk of the bank and how many banks are working for the company. In a study conducted by the Credit Registrar in Turkey with the participation of nine leading banks, we are able to see the borrowing of companies, limit / risk and credit rating at banks with the report called findeks. The difference between findeks and The Consolidated is that bank names can be seen.

Credit allocation unit; branch marketing, intelligence, financial analysis units, and provides an integrated report to the credit committee. However, depending on the size of the credit limit, these reports can be concluded by examining the reports in the credit committee or in the authority of the credit officers. This report; financial data analysis of the company's history, company and partners' moralities, memorandum information, limit and risk information in other banks, balance sheet and income table and there are opinions regarding limits and guarantee conditions of the loan that can be given to the company. The credit committee evaluates and makes decisions based on requests from sub-units, the bank's policy and current economic conditions.

The Credit Allocation Process is shown Figure 3.1:

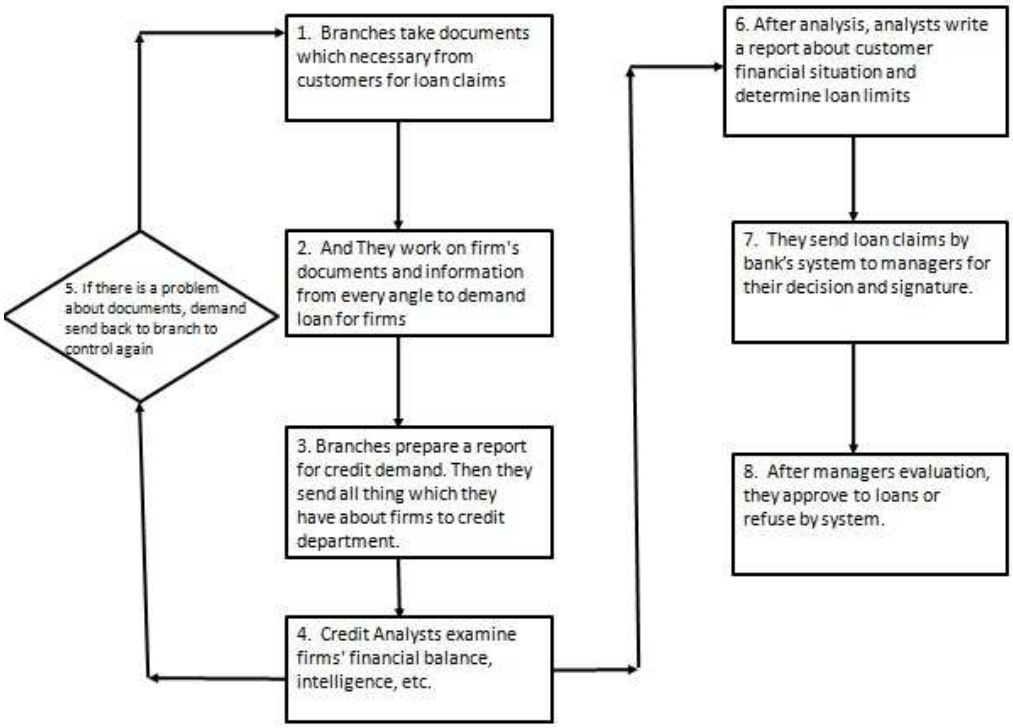

Figure 3.1: Flow Chart of Credit Allocation Process .

3.2 Defining of Possible Inputs and Outputs for Study

Some factors are used for credit evaluation in commercial banking with the help of human experienced and some computer system as mentioned before. However this evaluation technique is neither sufficient nor effective. So, avoiding the negative affects of this problems is the most basic aim of the this study. DEA gives an important opportunity to solve the problem with the perspective of Industrial Engineering. For this purpose, the most significant factors of credit evaluation in commercial banking was used as inputs and outputs in DEA and a much more effective system was created based on Industrial Engineering discipline for this sector. Some possible significant financial balance factors which can be used as input and output are following.

The possible balance sheet factors can be used as outputs:

Capital: Capital which is money, goods and labor put into by owners. Capital means that is total investment, production, ready to use cash money and total assets. This factor didn't use in DEA methodology because it was not weighted data for our study when we run DEA.

Deposit: Money which is deposited in bank in return with interest for a quite while or withdraw whenever customers want.

Due from shareholders: Account which is in debt to shareholders because of operation in out of main area of activity. This factor couldn't be used in our study because its value can not located in each year for some customers so we haven't used it.

Customer Advance: This account means that collect money about delivering goods and services in the future from receiver. Same situation is valid for customer advance such as due from shareholders. For some customers' balance sheet doesn't include this factor, for this reason DEA didn't run through lack of customer advance so we didn't prefer it.

Sales: This account means that is sum of Turkish Liras, Dollars, Euros within earned a certain period of time with including cost.

Ebitda (Earnings Before Interest, Taxes, Depreciation, And Amortization): This account means that exclude firm's all expenses from incomes with the exception of tax and interest.

Net Profit: Account which is net income after tax relating to firm's activity period. Another unchosen factor is net profit. Some poor customers can not

generate profit even losing money, in such cases this factor's can turned negative character. Same situation also was valid for our study such some of poor customers had negative value of net profit therefore we haven't used it in CCR model which didn't accept negative value.

Exchange Gain and Loss: Currency is difference of positive and negative which convert from their own money to Turkish Liras. Customers which have strong and poor balance sheet can have negative value of exchange gain and loss in their balance sheet. Some of customers had negative values of it so we didn't choose this factor in our study to run CCR model.

The possible balance sheet factors can be used as inputs:

Interest Expense: Occur expense due to borrower's quantity, risk and maturity. This account monitors about interest expense related to amounts borrowed.

Trade Payable: It is an account which short-term debentures and non-due debts are monitored due to the commercial relations of firm.

Cost of Sales: Total kind of costs which occur service or selling a product .

Bank Loans Payable: This account means that borrow amount from bank at specific interest in certain period with condition of repayment.

All of these factors mentioned above are the most important ones to evaluate credit approval of a firm.

Chapter 4

Methodology

Our methodology proceeds as follows. First of all we will use the most important data which effect's to financial statements that evaluate to firm's performance during 2014, 2015 and 2016 years. Therefore, we find efficiency in according to outputs which deteriorates to firm's financial statements about trade banking. We provide this by using Data Envelopment Analysis (DEA).

4.1 Data Envelopment Analysis (DEA)

Data Envelopment Analysis(DEA) methodology proceeds as follows. First of all, we find bank loans efficiency which approved by bank. These data that affect the customer's balance more than others took from a bank commercial customers. After approved customer's bank loans whether these credits are used efficiently for understanding firms's activity in case pay back and we predict which data are efficient in firm's balance. While we report results by utilizing Data Envelopment Analysis (DEA) methodology, any bankers can be used this model to compare their decision whether firm's balance sheet performances are efficient for requested loans.

Data Envelopment Analysis(DEA) introduced for the first time by Charnes. It is a technique which evaluate comparative efficiency Decision Making Unit(DMU). It is a linear programming based nonparametric method used to measure the relative

activity of multiple organizational units producing similar output by using similar inputs.

In this study as a methodology was used Charnes Cooper and Rhodes (CCR) input-oriented model Cooper *et al.* [9] for evaluating the efficiency of credit loans without human's evaluating by using Data Envelopment Analysis(DEA) methodology. We used some inputs and outputs which effect to firm's balance.Our inputs include interest expense, trade payable, cost of sales and bank loans payable. Outputs are deposit,sales and ebitda. We used this inputs and outputs because they are more efficient values which in firms' balance in terms of evaluation commercial bank loans. We could have used other data but these data don't have big impact to balance therefore we gave information about them in data set chapter to understand what these data are useful.

Based from here, Data envelopment analysis (DEA) model compares these inputs and outputs to determine which evaluating is more efficient for understanding human examining or Data Envelopment Analysis(DEA) methodology. Secondly, Data Envelopment Analysis(DEA)- Charnes, Cooper and Rhodes (CCR model) try to determine to best decision for firms which needed to loans. By comparing human examining and Data Envelopment Analysis(DEA) methodology, which one is more efficient than other.

Let define n be a number of customers(DMU),m be a number of inputs and s be the number of outputs. If we assume that have a data matrix containing the input and output values of Decision Making Unit(DMU)s with a size of n by $m+s$ thus fractional Charnes Cooper and Rhodes (CCR) model can be formulated as below.

$$\max \quad \theta = \frac{\sum_{r=1}^{s} u_r y_{r_0}}{\sum_{i=1}^{m} v_i x_{i_0}} \tag{4.1}$$

subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \quad j = 1, ..., n \tag{4.2}$$

$$u_r, v_i \geq 0 \quad r = 1, ..., s; i = 1, ..., m \tag{4.3}$$

Efficiency score can be evaluated by DEA model, θ,of DMU j_0. Theta is the relative input and output levels of DMU evaluated from the data matrix, x_{ij}(represents input for customer j) and y_{rj}(represents output for customer j), with reference to all other *n-1* DMUs. Decision variable can be defined the positive weights of inputs and outputs and they represented by u_r(weight for output r) and v_i(weight for input r).

Fractional model is difficult to solve so it was converted to a linear programming (LP) model by Charnes *et al.* [10]:

$$\max \quad \theta = \sum_{r=1}^{s} u_r y_{r_0} \tag{4.4}$$

subject to:

$$\sum_{i=1}^{m} v_i x_{i_0} = 1 \tag{4.5}$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \quad j = 1, ..., n \tag{4.6}$$

$$u_r, v_i \geq 0 \quad r = 1, ..., s; i = 1, ..., m \tag{4.7}$$

4.2 Applications of DEA on Banking Sector

DEA which can be applied in many problems of nearly all sectors, is often used to measure relevant efficiency of decision making units (DMU). Banking sector is also one of the usage area of DEA. It is applied in many banking areas such

as measuring the efficiency of the bank branches, measuring the performance efficiency of the bank personnel and to compare the productivity of the banking sector with other sectors. So many people who studies on DEA, carry out this methodology applied to banking sector.

The study of Nandkumar *et al.* [11] is one of the outstanding banking DEA study which works on a technical efficiency of banks in India by using DEA for 10 Indian banks and each year. Results of study show that mean technical efficiency increased from 2006 to 2008 but technical efficiency decreased between 2008-2010. While some banks were preserving their efficiency performance and some of them were not. It is mean that their efficiency scores are below sufficient level. The main factor of below sufficient level shows us that is huge amounts of deposits and operating expenses.

Another DEA approach on banking sector study had been developed by Oliveira *et al.* [12]. The study is based on international banking systems which included developed and emergent economies. It contains performance data of hoard of the banking systems in 41 countries between 1995 and 2002. Countries are from America, Asia and European continents. Result of DEA implementation, banking efficiency was not different between developed and emerging countries.In addition, Asia banking systems were more efficient from Latin American banking systems during Asian crisis (between 1997-1998)but rising Asian banking systems showed underperformed. With this study, they have aimed to increase comprehension of competitiveness all around the world.

There is an implementation of DEA methodology in measuring efficiency in the banking sector and Maletic *et al.* [13] had a study about this. Goal of study is that measuring banking sector operation efficiency by using DEA for 33 banks in Serbia. Two models of DEA was used with different input-output indicators and result were analyzed comparatively by using BCG matrix. Banks are arrayed in terms of their efficiency. As a result similarities and differences were examined

by DEA methodology in the study. Maletic *et al.* [13] deduced private banks of foreign owners are more efficient than state banks. Branches are not included this study because all banks have not branches in rural areas so it could be changed operation bank performance.

DEA methodology can be carried out to banking sector and it is popular measuring efficiency approach in banking. Every countries can be measured efficiency of banking implementation areas by using DEA methodology for themselves. There is a study about examine efficiency of Czech banking sector by Repkova [14]. The study contains Czech commercial banking sector's efficiency during period 2003-2012. They used DEA window analysis by utilizing input-oriented model. Result of analyzed period, group of large bank was less efficient than other banks. The reason of this, these banks have surplus of deposits in their balance sheet so it caused that interest income increases bank's cost. Thus, reflect of this situation is negatively to DEA results. As a different approach of implementation DEA methodology to banks, Othman *et al.* [15] investigated measuring relative efficiency of them. In this study they had aimed to define development in future about areas which is socio-economic, technology and management by measuring efficiency. They had utilized DEA methodology's two kind of basic model Charnes-Cooper-Rhodes model and Banker-Charnes-Cooper model. Banking sectors' effectiveness and efficiency are defined this study and they categorized the efficiency of 4 factors (technical, scale, price and allocative efficiency) to describe general productivity.

Thagunna *et al.* [16] had consist a study which measure productivity and performance by using known as DEA and its two models to achieve their goal. They had analyzed and measured efficiency level to 21 Nepali banks for 2007-2008 and 2010-2011. 9 out of 21 banks were analyzed and found that 43% percentage of them is more efficient than 2010-2011. Result showed that kind of ownership and total of assets did not affect efficiency. It means that foreign banks have not better efficiency. For this reason, there were no relationship between total

asset and size.This situation reflected that there were area for large and small investment. It means that more competition for investments. This study refer that more investment competition can be if banking sector release.

Chapter 5

Analysis

The study deals with the identification and reduction of risk factors in commercial loans which are mainly human-based, detailed in the previous chapters and it is a serious problem in the banking sector. The use of real sector data for this purpose is great importance in terms of being more productive and useful.

5.1 Data Set

In our study, 2014, 2015 and 2016 balance sheet data of large and small scale commercial customers of a bank with added value in commercial banking in Turkey were used. In accordance with to privacy of corporation's agreement, we keep secret the customers's names and bank's name. For this purpose, we designated to bank's name as X and customers name's are C1,C2,....,etc.

The bank, which its data were used is one of the 10 biggest banks in Turkey. Such as, its sales is approximately 1.5 billion dollars in third quarter in 2017 [17]. Moreover, the bank increased credit volume by %26 in 2017 [18] and its deposit amounts got close about 65 billion TL in same quarter. The bank give nearly 65 billion TL of average loans the previous years. Recently, the bank focuses on trade firm customers because new legal obligations decreased profitability of given personal services. Thus, profitability of trade firm customers are higher

and their data are more useful and smooth. So, we have decided to work on this customer group. We worked on 72 trade firm customers in this study and these set of customers reflects nearly all of the economic sectors such as; trade, building, several manufacture sectors etc. The data of customers have sometimes financial differences since selected customers and their data are homogeneous. Such that, some sectors works with small values and the others seriously big values in financial balance. In other words, numbers or data change from sector to sector. This situation provided that our study is homogenous as well and it reflects real life banking issue.

According to the periods and customers we have specified in our study, we used some factors mentioned in Chapter 3 as inputs in DEA. These input factors are Interest Expense, Trade Payable, Bank Loans Payable, Cost of Sales and output factors are Deposit, Sales, EBITDA. We have data all of these factors and we thought to use all of them as input or output in DEA. However, it was not possible to use all of them. The reasons of this, firstly we did not have data of some factors for every year which we work on, secondly we could not process some data in DEA because they have negative values and finally when we processed some data in DEA, we faced that they were not significant for these study (such as data has difficult increase or decrease arrangement based on sector economic situation). Table 5.1 consists factors whether they were used in DEA and their usage types (as input or output).

	FACTOR	**USAGE**	**USAGE TYPE**
1.	capital		
2.	deposit	✓	output
3.	due from shareholders		
4.	customer advance		
5.	sales	✓	output
6.	ebitda	✓	output
7.	net profit		
8.	exchange gain and loss		

Continued on next page

Table 5.1 – *Continued from previous page*

	FACTOR	**USAGE**	**USAGE TYPE**
9.	interest expense	✓	input
10.	trade payable	✓	input
11.	cost of sales	✓	input
12.	bank loans payable	✓	input

TABLE 5.1: Table of factors.

5.1.1 Descriptive Statistics of the Data Set

As is seen from Table 5.2, standard deviations of all factors for every years are very big because of difference between maximum and minimum values. As mentioned before, the customer sample consists customer from great in number different sectors and trade amounts of customers are very different from each other's based on economic conditions. For different customers, a factor can set to be zero or be a high number. The other reason is that financial data of some customers had a bad pattern in some years because of national or global economic conditions.

2014	**Interest Expense 14**	**Trade Payable 14**	**Bank Loans Payable 14**	**Cost of Sales 14**	**Deposit14**	**Sales14**	**EBITDA14**
Max	30104389	109131185	207444748	1461433266	65390484	1536270570	40135341
Min	0	0	0	0	0	0	133
Average	1757685,639	10905481,99	17326261,92	73138293,49	1971438,986	82361092,08	4351249,139
SD	3892589,679	19528626,75	32940123,29	183969121,5	7735448,262	196214652,5	8172913,307
2015	**Interest Expense 15**	**Trade Payable 15**	**Bank Loans Payable 15**	**Cost of Sales 15**	**Deposit15**	**Sales15**	**EBITDA15**
Max	35245949	117162395	358048717	1626026134	16694446	1725134525	54366667
Min	0	0	0	0	1017	0	0
Average	2462509,083	11909394,35	22987428,74	80784132,86	1622658,694	91683947,58	5063073,082
SD	5573116,175	20688902,29	48896226,79	206768332,3	3097778,185	222514421,7	10118276,87
2016	**Interest Expense 16**	**Trade Payable 16**	**Bank Loans Payable 16**	**Cost of Sales 16**	**Deposit16**	**Sales16**	**EBITDA16**
Max	43333567	130865819	198977604	1621225022	29575616	1740662585	69504240
Min	0	0	0	0	1591	0	0
Average	2659820,817	13869174,33	23936336,58	89295164,24	2312005,153	100875984,9	5464585,033
SD	6315727,886	23741748,83	41957794,42	217030281,2	5269508,602	237768346,8	12169375,2

Table 5.2: Table of statistics on Input/Output Data for years 2014, 2015 and 2016

Correlation between factors is an important elimination reason. If a correlation exist between two factors, that means one of them is redundant. As mentioned before, we have eliminated some data because of this reason. Table 5.3 shows correlation of factors' for base years. For each year, there are some high correlations to be observed. Although high correlations exist in data, we have not eliminated any factor. One of the reason of this, some correlations were not between same data types (in other words, like both of them used as input or both of them used as output), the other reason is that different correlations exist in different years.

We did not eliminate factors each year separately to make a effective comparison based on base years.

2014	**Interest Expense 14**	**Trade Payable 14**	**Bank Loans Payable 14**	**Cost of Sales 14**	**Deposit14**	**Sales14**	**EBITDA14**
Interest Expense 14	1	0,501412673	0,634494779	0,403743148	0,229698415	0,438024525	0,807270326
Trade Payable 14	0,501412673	1	0,342321176	0,345982801	0,131569451	0,357922859	0,479911207
Bank Loans Payable14	0,634494779	0,342321176	1	**0,860423169**	0,316400637	0,874411755	0,837377398
Cost of Sales 14	0,403743148	0,345982801	**0,860423169**	1	0,204864738	0,996792576	0,65338244
Deposit14	0,229698415	0,131569451	0,316400637	0,204864738	1	0,224823902	0,442638861
Sales14	0,438024525	0,357922859	0,874411755	0,996792576	0,224823902	1	0,689272779
EBITDA14	0,807270326	0,479911207	0,837377398	0,65338244	0,442638861	0,689272779	1
2015	**Interest Expense 15**	**Trade Payable 15**	**Bank Loans Payable 15**	**Cost of Sales 15**	**Deposit15**	**Sales15**	**EBITDA15**
Interest Expense 15	1	0,320629018	**0,858230354**	**0,822128817**	0,542880429	0,832078442	0,821693408
Trade Payable 15	0,320629018	1	0,3002363	0,356079831	0,167119577	0,365796761	0,445010676
Bank Loans Payable15	**0,858230354**	0,3002363	1	**0,932980855**	0,471763818	0,940657499	0,873627451
Cost of Sales 15	**0,822128817**	0,356079831	**0,932980855**	1	0,421335786	0,997149015	0,807066501
Deposit15	0,542880429	0,167119577	0,471763818	0,421335786	1	0,435237136	0,431839537
Sales15	0,832078442	0,365796761	0,940657499	0,997149015	0,435237136	1	**0,835599437**
EBITDA15	0,821693408	0,445010676	0,873627451	0,807066501	0,431839537	**0,835599437**	1
2016	**Interest Expense 16**	**Trade Payable 16**	**Bank Loans Payable 16**	**Cost of Sales 16**	**Deposit16**	**Sales16**	**EBITDA16**
Interest Expense 16	1	0,422978613	0,77356614	**0,923516994**	0,423444917	0,923987727	0,039209615
Trade Payable 16	0,422978613	1	0,458067961	0,457542483	0,384304848	0,46474357	0,099736716
Bank Loans Payable16	0,77356614	0,458067961	1	0,725894171	0,458690248	0,735511127	-0,001460089
Cost of Sales 16	0,923516994	0,457542483	0,725894171	1	0,416141935	0,998663917	0,076998085
Deposit 16	0,423444917	0,384304848	0,458690248	0,416141935	1	0,426931703	0,003615128
Sales 16	0,923987727	0,46474357	0,735511127	0,998663917	0,426931703	1	0,076869747
EBITDA 16	0,039209615	0,099736716	-0,001460089	0,076998085	0,003615128	0,076869747	1

Table 5.3: Correlation tables for years 2014,2015 and 2016

5.2 Scenario Analysis

Benefits of the proposed decision support system can best be illustrated through a series of real life scenarios. These are the cases that illustrate the challenges faced in a typical evaluation process. Elimination of subjective criteria is the underlying benefit.

5.2.1 Scenario 1: The Comparison within Human Experts vs. DEA

To illustrate the inconsistency between experts, we will use DEA data. Five experts selected and our DEA data is evaluated by all this experts based on their experience. The following table consists experts' and also DEA results.

	DEA Score	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**S.D.**	**AVERAGE**
C70	0.13	0	0	0	0	0	0	0
C16	0.17	0	0	0	0	0	0	0
C58	0.22	2	0	0	0	5	1987,46	1
C34	0.24	0	0	0	5	0	2236,06	1
C39	0.31	0	5	0	0	0	2236,06	1
C36	0.34	0	0	0	3	0	1118,03	1
C72	0.35	0	5	0	5	5	2738,61	3
C47	0.39	0	0	0	0	4	1787,06	1
C51	0.41	0	0	2,000	1,000	2,000	1000000	1.000
C13	0.43	0	0	0	1,000	1,000	547722,55	400
C49	0.45	0	800	1,000	1,000	1,147	458215,88	789
C66	0.46	0	0	0	250	300	151657,50	110
C27	0.47	5,000	0	2,500	5,000	2,000	2133072,90	2.900
C71	0.48	1,100	0	750	1,000	500	441021,54	670
C35	0.48	1,000	600	1,000	1,000	1,500	319374,38	1.020
C50	0.48	1,000	1,000	1,200	750	1,500	279284,80	1.090
C7	0.49	7,500	0	0	3,000	5,000	3248076,35	3.100
C1	0.49	5,000	1,000	5,000	6,000	5,000	1949358,86	4.400
C53	0.49	6,000	2,500	4,000	3,000	5,000	1431782,10	4.100
C62	0.50	0	0	2,500	4,000	7,500	3134485,60	2.800
C19	0.50	0	0	0	1,000	1,500	707106,78	500
C28	0.51	20,000	15,000	15,000	25,000	10,000	5700877,12	17.000
C65	0.52	0	0	50	75	0	35355,33	25
C68	0.52	2,000	1,000	3,000	2,500	4,000	1118033,98	2.500
C59	0.52	1,250	2,400	2,500	2,500	5,000	1374590,84	2.730
C26	0.53	5,000	3,000	3,000	6,000	3,500	1341640,78	4.100
C52	0.56	1,500	1,000	1,000	2,500	1,500	612372,43	1.500

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Table 5.4 – *Continued from previous page*

	DEA Score	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**S.D.**	**AVERAGE**
C33	0.56	0	25	0	50	0	22360,67	15
C41	0.57	35,000	60,000	40,000	80,000	25,000	21965882,64	48.000
C54	0.57	18,000	10,000	5,000	10,000	15,000	5029910,53	11.600
C44	0.57	3,000	3,000	3,000	2,500	2,000	447213,59	2.700
C61	0.57	0	0	0	0	0	0	0
C69	0.58	0	0	0	0	150	67082,03	30
C9	0.58	20,000	10,000	12,500	20,000	15,000	4472135,95	15.500
C12	0.60	0	100	0	200	250	114017,54	110
C22	0.61	0	0	0	100	300	130384,04	80
C30	0.61	0	1,000	1,000	1,500	2,500	908295,10	1.200
C38	0.61	35,000	50,000	20,000	25,000	15,000	13874436,93	29.000
C48	0.63	0	750	0	1,000	1,502	652473,92	650
C23	0.64	2,000	200	0	250	300	818535,27	550
C60	0.64	0	100	250	50	0	103682,20	80
C63	0.64	0	800	400	750	0	387943,29	390
C43	0.65	0	0	0	0	0	0	0
C67	0.65	500	400	0	500	750	272946,88	430
C14	0.66	20,000	10,000	15,000	40,000	30,000	12041594,58	23.000
C18	0.66	15,000	60,000	20,000	100,000	20,000	36674241,64	43.000
C32	0.66	8,000	10,000	5,000	5,000	8,500	2224859,54	7.300
C37	0.67	10,000	5,000	5,000	6,500	10,000	2539685,02	7.300
C64	0.67	400	1,200	500	2,000	1,500	676017,75	1.120
C31	0.68	0	100	0	0	250	109544,51	70
C3	0.70	6,000	3,000	4,000	6,000	1,500	1949358,86	4.100
C10	0.70	25,000	20,000	12,000	25,000	20,000	5319774,43	20.400
C15	0.70	500	900	750	600	850	168077,36	720
C11	0.73	2,000	1,000	1,000	1,500	2,000	500000	1.500
C4	0.77	0	50	25	0	0	22360,67	15
C24	0.79	3,000	1,000	1,000	1,000	1,500	866025,40	1.500
C2	0.81	2,500	3,250	1,750	3,000	4,500	1015504,80	3.000
C45	0.90	1,000	1,400	1,850	1,500	1,650	317411,40	1.480
C57	0.95	7,000	5,500	4,500	6,000	7,000	1060660,17	6.000

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Table 5.4 – *Continued from previous page*

	DEA Score	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**S.D.**	**AVERAGE**
C56	0.97	3,500	2,000	3,250	5,000	2,230	1195127,60	3.196
C5	1.00	500	500	650	450	750	125499,00	570
C6	1.00	75	100	150	500	100	178185,29	185
C8	1.00	0	0	0	0	0	0	0
C17	1.00	800	500	600	350	600	164316,76	570
C20	1.00	4,000	1,500	5,000	2,500	1,500	1557241,15	2.900
C21	1.00	3,500	2,500	3,750	4,500	2,750	802340,32	3.400
C25	1.00	2,000	2,250	3,000	2,500	1,750	480884,60	2.300
C29	1.00	0	0	0	0	0	0	0
C40	1.00	1,000	500	1,250	1,100	1,000	281957,44	970
C42	1.00	3,000	1,000	5,000	10,000	5,000	3346640,10	4.800
C46	1.00	1,750	2,500	1,000	2,000	1,000	651920,24	1.650
C55	1.00	5,000	6,500	7,500	5,500	2,500	1884144,36	5.400

TABLE 5.4: The comparison of DEA scores with 5 different experts credit limit evaluation for year 2016 data(*1000 for all experts limits and average)

DEA scores has sorted from smaller to larger. Experts' experience levels are different from each other therefore they examined firms from different perspectives. Different levels experiences showed us that experts' evaluation were inconsistent with each other but on the other hand, it means that our study were valid and meaningful. While they have evaluated firms, they have considered raw and past data. As it is understood from standard deviation's big values, we could say experts were inconsistent between each other but consistent with DEA scores. Another examination was that from table 5.4 some good firms have not credit limits, situation told us that firms have not needed to any credit limits because of good DEA scores and some good factors from raw data in according to experts' evaluation.

5.2.2 Scenario 3: Time Horizon Evaluation

Current credit evaluation is carried out by the human experience. Only consider financial of the previous year. By carrying out such an evaluation through DEA allows us to include more historical data to the evaluation. This can either be done included all data, consequence years separately.

An example is carry out for 2014, 2015 and 2016 calendar years. Results illustrated in Figure 5.1.

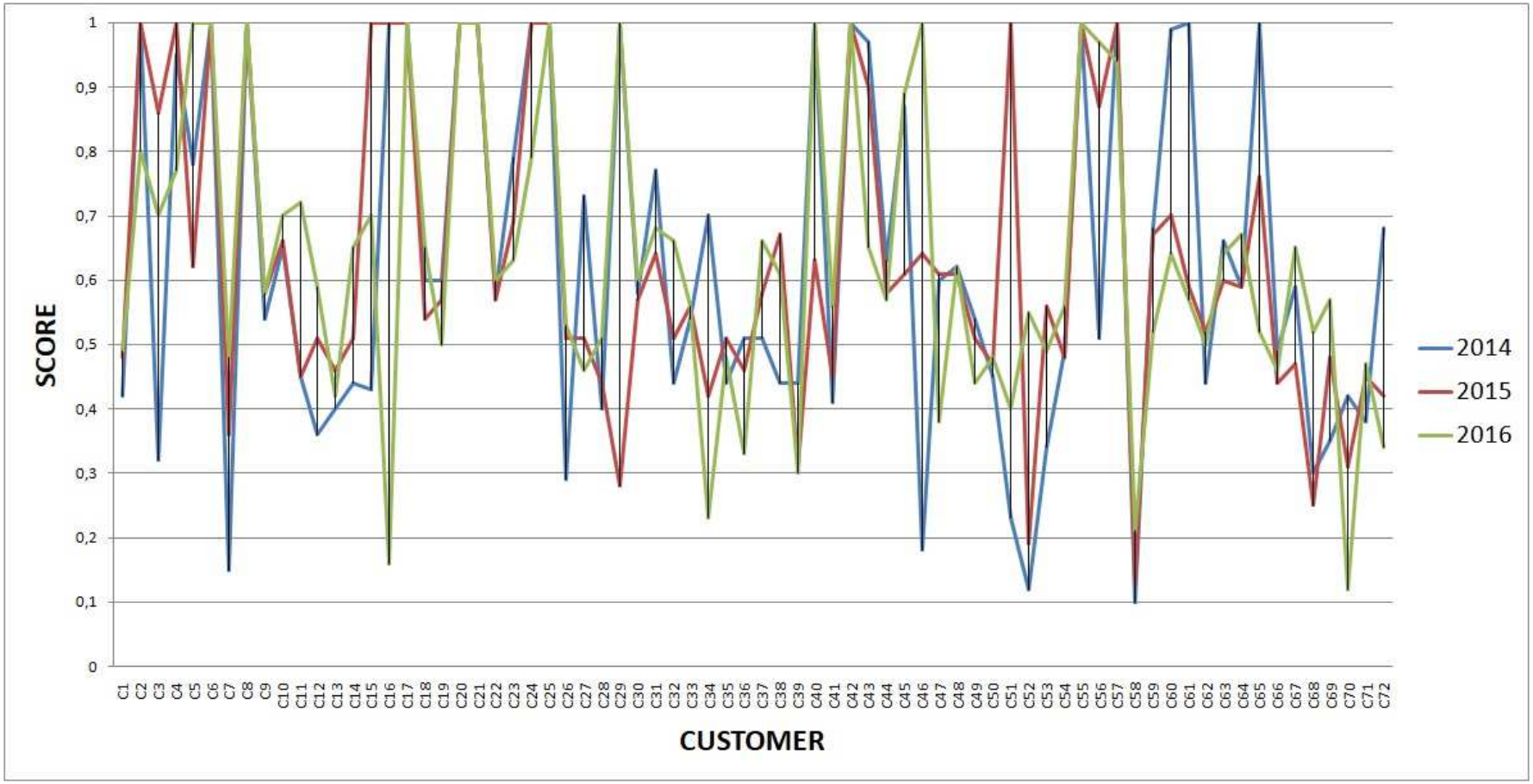

Figure 5.1: Line Chart of Customers' DEA Scores for each base years

As is seen from the Figure 5.1, yearly DEA scores of each customers can have big differences or can be nearly same level. It's clearly state that, these customers' scores highly depend on customers' trade volume factors which we used as data in DEA and these factors can be change highly or be same for a customer annually.

5.3 Discussion on Results

In this section, we will examine results of DEA using outputs of scenarios which we were done and comparing some evaluation factors currently used in banking sector.

5.3.1 Interpretation of DEA Scores without any Comparison

The DEA Scores of customers are the most important results of our study. Because, when we offer an innovation to banking sector, we commonly used these results. So, we added all scores for all customers, even if they all generated a very big table. Table 5.5 consists data scores for 72 customers in 3 base years. Moreover, the values of data scores are between 0 to 1. If a data score of a firm close to 0, that firms had a bad economic balance and it is evaluated that its credibility rating is too low (in other words that firm can not get loan from bank). As can be easily understood, If a data score of a firm close to 1, that firm is evaluated vice versa.

According to the evaluation of the experts, some firms have very low levels of balance sheet data therefore we have seen that no credit limits have been approved for some firms or have been approved very restricted. When we examined DEA scores, it has been seen that some companies had poor scores. Firms with had poor DEA scores showed parallelism with experts' evaluations. We have chosen 0,40 DEA scores because firms which have under this scores had high interest

expense, trade payable, cost of sales and bank loans payable. In this case, we evaluated under 0,40 DEA score firms were poor for loan allocation. Experts have considered some or all of these factors according to their experiments, almost all experts have not approved credit limits which had under 0,40 DEA scores from as seen table 5.4. In addition, we determined to offer a lower limit of data score as 0.40 to evaluate that a data score is acceptable so, we suggest not to need more discussion on a firm credit demand if its score is under 0.40. The reason of choosing 0,40 is that balance sheet had poor data than other firms and experts avoid approving to their credit limits in according to DEA results and experts examining. Experts' comments about poor firms which had under 0,40 DEA scores helped us to determine threshold(0,40).

CUSTOMER		**SCORE**	
	2014	**2015**	**2016**
C1	0,42	0,48	0,49
C2	1	1	0,8
C3	0,32	0,86	0,7
C4	0,95	1	0,77
C5	0,78	0,62	1
C6	1	1	1
C7	0,15	0,36	0,48
C8	1	1	1
C9	0,54	0,58	0,58
C10	0,65	0,66	0,7
C11	0,45	0,45	0,72
C12	0,36	0,51	0,59
C13	0,4	0,46	0,42
C14	0,44	0,51	0,65
C15	0,43	1	0,7
C16	1	1	0,16
C17	1	1	1
C18	0,6	0,54	0,65
C19	0,6	0,57	0,5

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Table 5.5 – *Continued from previous page*

CUSTOMER		**SCORE**	
	2014	**2015**	**2016**
C20	1	1	1
C21	1	1	1
C22	0,58	0,57	0,6
C23	0,79	0,69	0,63
C24	1	1	0,79
C25	1	1	1
C26	0,29	0,51	0,53
C27	0,73	0,51	0,46
C28	0,4	0,44	0,51
C29	1	0,28	1
C30	0,58	0,57	0,6
C31	0,77	0,64	0,68
C32	0,44	0,51	0,66
C33	0,54	0,56	0,56
C34	0,7	0,42	0,23
C35	0,44	0,51	0,48
C36	0,51	0,46	0,33
C37	0,51	0,58	0,66
C38	0,44	0,67	0,61
C39	0,44	0,31	0,3
C40	1	0,63	1
C41	0,41	0,45	0,56
C42	1	1	1
C43	0,97	0,9	0,65
C44	0,63	0,58	0,57
C45	0,87	0,61	0,89
C46	0,18	0,64	1
C47	0,6	0,61	0,38
C48	0,62	0,61	0,62
C49	0,54	0,51	0,44
C50	0,45	0,47	0,48
C51	0,23	1	0,4

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Table 5.5 – *Continued from previous page*

CUSTOMER		**SCORE**	
	2014	**2015**	**2016**
C52	0,12	0,19	0,55
C53	0,34	0,56	0,49
C54	0,49	0,48	0,56
C55	1	1	1
C56	0,51	0,87	0,97
C57	1	1	0,94
C58	0,1	0,13	0,21
C59	0,68	0,67	0,52
C60	0,99	0,7	0,64
C61	1	0,59	0,57
C62	0,44	0,52	0,5
C63	0,66	0,6	0,64
C64	0,59	0,59	0,67
C65	1	0,76	0,52
C66	0,49	0,44	0,46
C67	0,59	0,47	0,65
C68	0,3	0,25	0,52
C69	0,35	0,48	0,57
C70	0,42	0,31	0,12
C71	0,38	0,45	0,47
C72	0,68	0,42	0,34

TABLE 5.5: Table of data scores for each customer for years 2014, 2015 and 2016.

In the light of data scores in Table 5.5, some customers have a good credibility profile and the others do not have. In addition, while some customers keep their bad or good credibility profile in years, some others is going to worse or better in years. The reason of this, country's economic and political situation changes under global and national conditions in years. Depend on this situation, some of firms which have long established trade past and experience could save themselves. When they faced with a bad condition, these kind of firms knew to

getting precaution. Under this kind of conditions, they can preserve their trade and financial balance. So, this provided them credibility care of banks. We can say that customers which have good DEA scores show us this condition did not effect them. Some of them have bad DEA scores which show us their balance and trade volume did not resist economic conditions. It indicated that bad economic profile firms could not save themselves from bad global and national economic affects.

5.3.2 The Comparison of DEA Scores with Real Financial Rates

The comparison of DEA scores with real financial rate is one of the important processes to applicability of DEA application on banking sector. The real financial rates include basically 3 components which are most appropriate ones to compare with DEA scores. These 3 components are "Asit Test Rate", "Cash Ratio" and "Total liabilities/Total Assets". Before numerical comparison, some information about component would be beneficial.

Asit Test Rate means rate of coverage of short-term debits with cash convertible asset of a firm. With the results of this rate, we define whether a firm has assets to cover emergency short-term debit. In short, it is an important liquidity indicator. While this ratio is smaller than 1, it is interpreted that the firm can have liquidity problem, on the other hand 1 is enough level for this rate.

Cash Ratio indicates whether short-term external assets are covered, in case of stopping income providing fund and not to collect trade not to collect receivables. It is desired that, this ratio should be about 1 for a firm and if it is 1 for a firm, that firm can be cover its short-term liabilities with its own cash or cash-like.

Total Liabilities / Total Assets shows that a firm finances its assets with what amount liability. it is known as financial leverage rate or liability rate. When this ratio increases, the financial risk increases at the same time.

5.3.2.1 Worst DEA Scores Comparison

As is seen from Table 5.6, there are 12 firms' DEA scores in 2014 which are worst ones with their real financial rates. When the ratio of "Total Liabilities / Total Assets" is examined, almost all firms in table have this factor with high level. This ratio is an important factor to evaluate firms' credibility. As defined previously and its pattern on table, it effects a firm's credibility inverse proportionally (by the way the other two ratios effect direct proportionally). Comparing with DEA scores, the characteristics of these three ratio can be observed on nearly all worst firms consistently. But some firms go beyond the ordinary. One of the reason of this, these firms have very low ebitda and high bank loan payable (these two factors were used as inputs in DEA) and the other reason even if defined three ratios are important to evaluate a firm credibility, there are lots of ratios for this evaluation process. In addition, the reason of choosing these ratios is that only, they have values between 0 and 1. So, it provided us more effective DEA scores comparison with these ratios. When we check out the Table 5.6 again, we can see that our choices are not bad.

Customer	**DEA Data Score**	**Asit Test Rate**	**Cash Ratio**	**Total Liabilities / Total Assets**
C58	0,1	0,99	0,05	0,94
C52	0,12	0,24	0,02	0,75
C7	0,15	0,79	0,6	0,11
C46	0,18	0,35	0,22	0,89
C51	0,23	0,07	0,07	0,99
C26	0,29	0,91	0,5	0,06
C68	0,3	0,7	0,01	0,92
C3	0,32	0,76	0,5	0,18
C53	0,34	0,38	0,02	0,65
C69	0,35	0,5	0,1	1
C12	0,36	0,96	0,8	0,03
C71	0,38	0,7	0,1	0,9

Table 5.6: The comparison of worst DEA Data Scores provided by related customers with real financial rates for year 2014.

Table 5.7 and Table 5.8 represent the comparison of DEA scores with real financial rates in 2015 and 2016 separately. The interpretation of these tables are similar to interpretation of Table 5.6.

Customer	**DEA Data Score**	**Asit Test Rate**	**Cash Ratio**	**Total Liabilities / Total Assets**
C58	0,13	0,99	0,04	0,96
C52	0,19	0,99	0,29	0,81
C68	0,25	0,75	0,01	0,92
C29	0,28	0,89	0,3	0,71
C70	0,31	1	0,1	0,7
C39	0,31	0,9	0,7	0,14
C7	0,36	0,79	0,6	0,11

Table 5.7: The comparison of worst DEA Data Scores provided by related customers with real financial rates for year 2015.

Moreover, we did not attained success reflection of DEA scores with real financial rates for data in 2015 and 2016 not as much as 2014.

Customer	**DEA Data Score**	**Asit Test Rate**	**Cash Ratio**	**Total Liabilities / Total Assets**
C70	0,12	0,9	0,1	0,8
C16	0,16	0	0,01	0,01
C58	0,21	0,98	0,18	0,81
C34	0,23	0,98	0,9	0,06
C39	0,3	0,78	0,4	0,32
C36	0,33	0,93	0,8	0,06
C72	0,34	0,6	0,1	0,9
C47	0,38	0,23	0,01	0,99

Table 5.8: The comparison of worst DEA Data Scores provided by related customers with real financial rates for year 2016.

5.3.2.2 Best DEA Scores Comparison

This time, we compared best DEA scores with same real financial rates for each year. As we expected, financial rates generally indicated inverse pattern for best scores compared to worst scores. Such as, "Total Liabilities / Total Assets" rate close to 0 for almost all best scores and the other rates behave like nature of DEA. This means that their scores close to 1. However, there are some exceptions because of previously mentioned reasons. Tables 5.9, 5.10 and 5.11 represent the comparison of DEA scores with real financial rate for years 2014, 2015 and 2016.

Customer	**DEA Data Score**	**Asit Test Rate**	**Cash Ratio**	**Total Liabilities / Total Assets**
C16	1	0,00	0,01	0,01
C65	1	0,10	0,10	0,70
C61	1	0,90	0,10	0,20
C24	1	0,96	0,90	0,02
C2	1	0,86	0,40	0,04
C57	1	0,52	0,15	0,63
C29	1	0,99	0,90	0,00
C40	1	0,72	0,70	0,05
C6	1	0,98	0,50	0,03
C8	1	0,43	0,50	0,14
C17	1	0,99	0,80	0,01
C20	1	0,98	0,70	0,06
C21	1	0,84	0,50	0,09
C25	1	0,87	0,80	0,08
C42	1	0,87	0,25	0,73
C55	1	0,36	0,01	0,72

Table 5.9: The comparison of best DEA Data Scores provided by related customers with real financial rates for year 2014.

Customer	**DEA Data Score**	**Asit Test Rate**	**Cash Ratio**	**Total Liabilities / Total Assets**
C16	1	0	0,02	0,01
C24	1	0,78	0,6	0,09
C2	1	0,71	0,3	0,06
C57	1	0,65	0,12	0,79
C6	1	0,79	0,2	0,14
C8	1	0,2	0,9	0
C17	1	0,98	0,6	0,01
C20	1	0,97	0,7	0,06
C21	1	0,85	0,7	0,08
C25	1	0,91	0,5	0,05
C42	1	0,88	0,29	0,62
C55	1	0,53	0,02	0,82
C4	1	0,84	0,7	0,02
C15	1	0,95	0,8	0,17
C51	1	0,03	0,03	0,98

Table 5.10: The comparison of best DEA Data Scores provided by related customers with real financial rates for year 2015.

Customer	**DEA Data Score**	**Asit Test Rate**	**Cash Ratio**	**Total Liabilities / Total Assets**
C6	1	0,99	0,9	0
C8	1	0,28	0,9	0
C17	1	0,97	0,6	0,04
C20	1	0,99	0,6	0,06
C21	1	0,84	0,5	0,09
C25	1	0,92	0,4	0,04
C42	1	0,88	0,01	0,69
C55	1	0,69	0,03	0,86
C40	1	0,69	0,6	0,16
C29	1	0,99	0,9	0
C5	1	0,92	0,9	0
C46	1	0,78	0,04	0,74

Table 5.11: The comparison of best DEA Data Scores provided by related customers with real financial rates for year 2016.

5.3.3 Projection of Worst Firms

The one of the most useful result is projection. Projection of DEA provides proposition to increase DEA score of a firm. This propositions gets a form according to most significant inputs for a firm. In the light of these information, there are not any reason to examine projection of firms which have best DEA score because they do not need to any proposition. So, we decided to examine projection of some firms which has worst scores. Tables 5.12, 5.13 and 5.14 contain projection values of 5 firms which have worst DEA scores for every year separately.

2014	Score Data	Projection	Differences	%
C58	0,109954804			
Interest Expense 14	2623170	288430,1419	-2334739,858	-89,00%
Trade Payable 14	29404537	3233170,088	-26171366,91	-89,00%
Bank Loans Payable 14	19845870	2182148,736	-17663721,26	-89,00%
Cost of Sales 14	80196750	8818017,888	-71378732,11	-89,00%
Deposit14	507134	2190929,876	1683795,876	332,02%
Sales14	21884517	21884517	0	0,00%
EBITDA14	2815887	2831820,988	15933,98784	0,57%
C52	0,129927791			
Interest Expense 14	1964494	249801,9143	-1714692,086	-87,28%
Trade Payable 14	225388	29284,16506	-196103,8349	-87,01%
Bank Loans Payable 14	14082290	1829680,838	-12252609,16	-87,01%
Cost of Sales 14	3596833	467328,5679	-3129504,432	-87,01%
Deposit14	61715	72757,5061	11042,5061	17,89%
Sales14	5185595	5185595	0	0,00%
EBITDA14	800626	811090,5187	10464,51869	1,31%
C7	0,156664001			
Interest Expense 14	960248	130372,5996	-829875,4004	-86,42%
Trade Payable 14	819595	128401,0317	-691193,9683	-84,33%
Bank Loans Payable 14	15061690	2359624,613	-12702065,39	-84,33%
Cost of Sales 14	8797730	1378287,579	-7419442,421	-84,33%
Deposit14	33145	202927,4353	169782,4353	512,24%
Sales14	8771186	8771186	0	0,00%
EBITDA14	615134	2160407,618	1545273,618	251,21%
C46	0,189294751			
Interest Expense 14	665455	48934,39633	-616520,6037	-92,65%
Trade Payable 14	99735	7291,968244	-92443,03176	-92,69%
Bank Loans Payable 14	7550000	1429175,367	-6120824,633	-81,07%
Cost of Sales 14	0	0	0	0,00%
Deposit14	135879	135879	0	0,00%
Sales14	663112	663112	0	0,00%
EBITDA14	114157	433187,6144	319030,6144	279,47%
C51	0,232755451			
Interest Expense 14	2884048	32504,5006	-2851543,499	-98,87%

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Table 5.12 – *Continued from previous page*

2014	**Score Data**	**Projection**	**Differences**	%
Trade Payable 14	1111606	258732,3557	-852873,6443	-76,72%
Bank Loans Payable 14	4267435	993268,7573	-3274166,243	-76,72%
Cost of Sales 14	3544882	825090,6081	-2719791,392	-76,72%
Deposit14	177358	177358	0	0,00%
Sales14	3629962	3913303,434	283341,4343	7,81%
EBITDA14	1728989	1728989	0	0,00%

TABLE 5.12: Table of worst result of DEA projection for year 2014.

The most significant and useful projection value is percentage propositions (%) where state most right columns of table. This component offers ways to increase DEA scores a firm based on most related inputs and outputs for that firm. Such as, Customer C58 has gained the worst DEA score in 2014 (Table 5.12). Percentage of Deposit output for this customer is about 332% and it means that deposit of C58 must be increased by 332% to gain higher DEA score. However, percentage of Bank Loan Payable input for same customer is -89%. So Bank Loan Payable input of C58 must be decreased by 89% to gain higher DEA score. This kind of interpretation is valid for all bad DEA score customer for every year with the help of DEA projection.

2015	**Score Data**	**Projection**	**Differences**	%
C58	0,139249862			
Interest Expense 15	1470479	204763,9976	-1265715,002	-86,08%
Trade Payable 15	32808706	4568607,778	-28240098,22	-86,08%
Bank Loans Payable15	15796756	1510384,87	-14286371,13	-90,44%
Cost of Sales 15	81345141	11327299,65	-70017841,35	-86,08%
Deposit15	167224	848485,2134	681261,2134	407,39%
Sales15	23671448	23671448	0	0,00%
EBITDA15	1668598	6806737,027	5138139,027	307,93%
C52	0,198792756			
Interest Expense 15	2582280	513338,5574	-2068941,443	-80,12%

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Table 5.13 – *Continued from previous page*

2015	**Score Data**	**Projection**	**Differences**	**%**
Trade Payable 15	2467607	490542,3957	-1977064,604	-80,12%
Bank Loans Payable15	11872615	2360189,854	-9512425,146	-80,12%
Cost of Sales 15	2339555	465086,5857	-1874468,414	-80,12%
Deposit15	175142	462596,0262	287454,0262	164,13%
Sales15	4755867	7061470,642	2305603,642	48,48%
EBITDA15	1265410	1265410	0	0,00%
C68	0,258050567			
Interest Expense 15	6064528	700522,3293	-5364005,671	-88,45%
Trade Payable 15	1212265	312825,6704	-899439,3296	-74,19%
Bank Loans Payable15	14519961	3746884,166	-10773076,83	-74,19%
Cost of Sales 15	11645888	3005228	-8640660	-74,19%
Deposit15	187797	713809,1746	526012,1746	280,10%
Sales15	15287320	15287320	0	0,00%
EBITDA15	1409159	2715519,188	1306360,188	92,70%
C29	0,287261197			
Interest Expense 15	77000	4,09E-09	-77000	-100,00%
Trade Payable 15	1057000	303635,0855	-753364,9145	-71,27%
Bank Loans Payable15	0	0	0	0,00%
Cost of Sales 15	247000	70953,51572	-176046,4843	-71,27%
Deposit15	5106	27204,35983	22098,35983	432,79%
Sales15	249000	249000	0	0,00%
EBITDA15	47000	132396,0027	85396,00273	181,69%
C70	0,312390951			
Interest Expense 15	7952	1641,99867	-6310,00133	-79,35%
Trade Payable 15	161872	50567,34796	-111304,652	-68,76%
Bank Loans Payable15	28114	8782,559185	-19331,44081	-68,76%
Cost of Sales 15	37000	11558,46517	-25441,53483	-68,76%
Deposit15	4087	6127,736242	2040,736242	49,93%
Sales15	65000	65000	0	0,00%
EBITDA15	15475	24504,66373	9029,663727	58,35%

TABLE 5.13: Table of worst result of DEA projection for year 2015.

There was an extraordinary situation was occurred in 2016, such as percentage of

ebitda output was too high for many customers. Because bank loan payable and interest expense of these customers were too high compared to ebitda in 2016. In banking sector, it is expected that ebitda is more important than these two inputs. Firstly, ebitda of a firm covers interest expense and then covers short-term bank loan payable, thus the firm can pay its debt.

2016	**Score Data**	**Projection**	**Differences**	**%**
C70	0,129261357			
Interest Expense 16	11455	1480,688845	-9974,311155	-87,07%
Trade Payable 16	247582	32002,78531	-215579,2147	-87,07%
Bank Loans Payable 16	27098	3502,724254	-23595,27575	-87,07%
Cost of Sales 16	59206	7653,047908	-51552,95209	-87,07%
Deposit 16	3106	246409,406	243303,406	999,90%
Sales 16	23000	23000	0	0,00%
EBITDA 16	1010562	1010562	0	0,00%
C16	0,169896103			
Interest Expense 16	17637	2996,457562	-14640,54244	-83,01%
Trade Payable 16	2603286	442288,1454	-2160997,855	-83,01%
Bank Loans Payable 16	22259400	3781785,307	-18477614,69	-83,01%
Cost of Sales 16	0	0	0	0,00%
Deposit 16	849385	849385	0	0,00%
Sales 16	0	271,6018691	271,6018691	999,90%
EBITDA 16	533,376	881167,8683	880634,4923	999,90%
C58	0,215767114			
Interest Expense 16	3381098	250678,8469	-3130419,153	-92,59%
Trade Payable 16	23442948	5058217,239	-18384730,76	-78,42%
Bank Loans Payable 16	17722208	3823869,678	-13898338,32	-78,42%
Cost of Sales 16	44329162	9564775,361	-34764386,64	-78,42%
Deposit 16	44062	2347638,182	2303576,182	999,90%
Sales 16	23529142	23529142	0	0,00%
EBITDA 16	79931	172684345,1	172604414,1	999,90%
C34	0,238086555			
Interest Expense 16	52032	12388,11961	-39643,88039	-76,19%
Trade Payable 16	13624525	3243816,216	-10380708,78	-76,19%

Continued on next page

Table 5.14 – *Continued from previous page*

2016	**Score Data**	**Projection**	**Differences**	**%**
Bank Loans Payable 16	15490511	3688082,394	-11802428,61	-76,19%
Cost of Sales 16	580115	138117,5817	-441997,4183	-76,19%
Deposit 16	1128062	1128062	0	0,00%
Sales 16	906664	906664	0	0,00%
EBITDA 16	1531192	51880423,71	50349231,71	999,90%
C39	0,308421115			
Interest Expense 16	331677	38158,68133	-293518,3187	-88,50%
Trade Payable 16	1759175	542566,7144	-1216608,286	-69,16%
Bank Loans Payable 16	2346750	723787,2509	-1622962,749	-69,16%
Cost of Sales 16	7058070	2176857,817	-4881212,183	-69,16%
Deposit 16	55682	1481174,473	1425492,473	999,90%
Sales 16	4713098	4713098	0	0,00%
EBITDA 16	448281	90049989,67	89601708,67	999,90%

TABLE 5.14: Table of worst result of DEA projection for year 2016.

We can say that ideal customers in terms of banks have capacity for a strong balance sheet. When credit analysts evaluate firms, they consider components of balance sheet. This components occur a lof of financial factors which like deposit, trade receivables, capital, ebitda, bank loan payable, trade payable etc. The main thing to evaluate firms as a ideal one is strong capital, minimum debt, cost of sales, interest expense and enough ebitda to cover interest expense and short-term bank loan payable. If firms have this all conditions which we mentioned before, we can say that they can be provided loan by banks. As we seen in projection of worst firms, almost all firms need to have enough level of ebitda, deposits in bank and minimum interest expense, trade payable, bank loan payable and cost of sales. This situation shows us that poor firms should provide conditions to be ideal firm by increasing or decreasing some factors. Thus, Projection can be signal for analysts when they evaluate poor firms about which factors should be increased or decreased.

Chapter 6

Conclusion

In this study, we aimed to improve credit process in commercial banking. Loan allocation is examined by human resources and banking own system. Credit limit demands which are evaluated with human experiences are time consuming and economically cumbersome for banks and economy. We have studied by using the DEA methodology with an industrial engineering perspective to reduce time and economic losses. The study, which was performed on one of Turkey's largest 5 banks with 72 commercial customers from different sectors. The most important indicators affects these customers' balance sheet were used as data. In our study, we also analyzed companies with different size of balance sheets from different sectors and firms which has bad and good balance sheets. The firm's final year data for 2014, 2015 and 2016 were used. By applying the DEA methodology to every year, we obtained different results and compared these results with 5 experts' evaluations who has different experienced. While making comparisons with DEA and experts, DEA evaluated that firms' most important data from balance sheet but experts evaluated the data with raw and wider indicators. We evaluated results of DEA with different analyzes. According to the results of DEA, we have seen that when we increase or decrease some factor levels, the balance sheet will get better. Thus, credit decision system made by expert evaluation can be reduced in terms of time, economic loss and margin of error. According to our analysis in Chapter 5, the results of DEA showed that firms which had bad balance sheet had low score and firms which had durable balance

sheet had a high score. When a ranking is made according to DEA scores, there were some firms which are under 0.40 scores because of high cost and borrowing. Because of these reasons, experts did not approve credit limits to these kind of firms so we deduced that DEA score was parallel to the experts. However, when we examined firms which had good scores, we have provided with standard deviation that experts were inconsistent among themselves. Although experts evaluation has been consist with DEA, inconsistencies among themselves were due to different experiences and different perspectives for evaluation.

6.1 Improvement Opportunities for Evaluation Process

There may be various improvement opportunities in the DEA evaluation process on the banking system. One of them is that DEA may be helpful as an early warning system for firms which behave different within years. DEA can be useful for firms which are inconsistent, thus advising evaluation by 2 experts. After DEA is used as an early warning signal in the banks, there may be a decrease in the number of non-performing loans and can be seen more precise results. An average expert's credit evaluation process can occur more quickly with DEA methodology thus banks can make a more profit from time, personnel and money.

6.2 Future Work

This study's content can be extendable with future work. It can be a guide to studies such as;

- There are more factors in personal loans so DEA can be implemented and measure efficiency on this kind of loans.
- DEA can be used in banking sector as a user friendly decision support system.

- DEA needs to be integrated into Enterprise Resource Planning (ERP) systems and investigated for big bank's data.
- The impact of alternative methodology such as systems dynamics or Artificial Neural Networks(ANN) should also be considered in the solutions.

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