THE REPUBLIC OF TURKEY
BAHCESEHİR UNIVERSITY

OPTIMAL ALLOCATION OF ASSETS OF TURKISH BANKS UNDER BASEL II REGULATION

Master's Thesis

LÜTFİYE TUĞÇE GÖNÜL

İSTANBUL, 2014

THE REPUBLIC OF TURKEY
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This is to certify that we have read this thesis and we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Sciences.

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ABSTRACT

OPTIMAL ALLOCATION OF ASSETS OF TURKISH BANKS
UNDER BASEL II REGULATION

Lütfiye Tuğçe Gönül

Industrial Engineering

Thesis Supervisor: Assist. Prof. Dr. Ethem Çanakoğlu

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In the aftermath of the crucial disturbances in global currency and banking markets, Basel II was introduced by the Basel Committee in consideration of the need for risk management in banking. Basel II has been developed in order to ensure financial stabilization and banks are required to assess capital adequacy themselves with this regulation.

This thesis deals with risks in banking sector, Basel Accords in risk management and the implication of Basel II on capital requirement and risk-weighted assets to maximize expected returns of Turkish banks' portfolio of assets under risk constraints with Basel II requirements. Banks' risk-weighted assets which constitute the basis for Banks' capital adequacy ratios and Banks'equity calculations return rates of each credit, distribution of maturity risk factors according to their outstanding maturities, Banks' average rates, average maturities and liabilities are taken into consideration as constraints using Banks' data in order to formulate optimization model. After solving the model with Excel Solver, computational results are provided for each Bank.

Keywords: Basel II, Risks, Capital Adequacy, Optimization Model

ÖZET

TÜRK BANKALARININ VARLIKLARININ BASEL II DÜZENLEMESİ KAPSAMINDA OPTİMAL TAHSİSİ

Lütfiye Tuğçe Gönül

Endüstri Mühendisliği

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Yabancı para ve bankacılık piyasalarındaki önemli çalkalanmalar sonrasında, bankaların risk yönetimi ihtiyaçların sebebiyle Basel II Uzlaşıları Basel Komitesi tarafından tanıtıldı. Basel II, finansal istikrarı sağlamak için geliştirilmiştir ve bankalar bu düzenleme ile sermaye yeterliliğini belirleyebilir.

Tezde, bankacılık sektöründeki riskler, risk yönetiminde Basel Uzlaşıları, Basel II'nin sermaye gereksinimi ve Basel II gereksinimleri ile risk kısıtları dahilinde risk ağırlıklı varlıkları, Türk bankalarının portföyünün beklenen getirilerini maksimize etmek üzerinde durulmuştur. Bankaların verileri kullanılarak optimizasyon modelini formüle etmek için bankaların sermaye yeterlilik oranları ve özsermaye hesaplamalarının temelini oluşturan risk ağırlıklı varlıkları, kredilerin faiz oranları, risk sınıflarının vade risk faktörlerinin kalan vadelerine göre dağılımı, bankaların ortalama faiz oranları, ortalama vadeleri ve yükümlülükleri risk kısıtları olarak dikkate alınmıştır. Optimizasyon modeli Excel Solver ile çözülerek her banka için ideal portfoy dağılımı bulunmuştur.

Anahtar Kelimeler: Basel II, Riskler, Sermaye Yeterliliği, Optimizasyon Modeli

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ABBREVIATIONS

A-IRB	:	Advanced Internal Ratings Based
AMA	:	Advanced Measurement Approach
BIA	:	Basic Indicator Approach
BIS	:	Bank for International Settlements
BRSA	:	Banking Regulation and Supervision Agency
EAD	:	Exposure at Default
F-IRB	:	Foundations Internal Ratings Based
FIs	:	Financial Institutions
IRB	:	Internal Ratings Based
IRR	:	Internal Rate of Return
LGD	:	Loss Given Default
M	:	Effective Maturity
NCAF	:	New Capital Adequacy Framework
OECD	:	Organization for Economic Cooperation and Development
ORMF	:	Operational Risk Management Framework
ORMS	:	Operational Risk Measurement System
PD	:	Probability of Default
RC	:	Regulatory Capital
RWA	:	Risk Weighted Asset
RWAs	:	Risk Weighted Assets
SA	:	Standardized Approach
TL	:	Turkish Lira
YKB	:	Yapı ve Kredi Bankası

SYMBOLS

Maturity rate of amount of assets of each risk class i and outstanding maturities k: r_{ik}

Return rate of amount of receivables of each risk class i and risk weight j : r_{ij}

The amount of assets of each risk class i and outstanding maturities k : x_{ik}

The amount of liabilities : l_i

The amount of receivables of each risk class i and risk weight j : x_{ij}

The average maturity of bank for eack risk classification : m_i

The average maturity of each amount of liability : m_l

The maximum possible weight of risk class i : max_i

The minimum possible weight of risk class i : min_i

The number of maturities : K

Total expected return : E(R)

1. INTRODUCTION

Banking sector is one of the crucial aspects of the economics. Banks are faced with several risks while they maintain their banking transactions. Hence, crisis of the banking sector has an important influence on the economy. Banks necessitate taking precautions to face with risks and getting over the crisis. Due to the need for risk management Basel Committee has been developed Basel regulations to secure financial stabilization and capital adequacy has become very significant for banks. With Basel regulations, banks are required to assess capital adequacy themselves and it is revealed that profitability in the banking sector has become important.

This thesis aims to describe risks in banking sector, Basel regulations and the implications of Basel II accord on capital requirement and risk-weighted assets to maximize expected returns of Banks' portfolio of assets under risk constraints with Basel II requirements for profitability.

The thesis consists of six chapters and is structured as follows:

Chapter 1 involves the introduction to the research and gives details the importance of this thesis.

Chapter 2 concerns literature review about understanding of Basel accords in risk management, importance of the reason that banks have to hold capital, importance of the optimization of return and explains optimization problem with using the Excel Solver tool.

Chapter 3 is about background data which is relevant for the analysis. It gives explanation about risks in banking sector, Basel accords in risk management and comparison of Basel I and Basel II accords.

Chapter 4 describes problem definition which includes data gathering and analyzing, formulation of optimization model under risk constraints considering Basel II requirements.

Chapter 5 discusses the solving the optimization model to find optimal allocation of assets, computational results, analyzing profitability and observing the changes of expected return.

Chapter 6 gives the discussion and conclusion based on the findings of the research.

2. LITERATURE REVIEW

Banks are confronted with various risks while they sustain their activities. Hence, they need adequate capital to be protected from exposure of unpredictable risks. Banking sector is one of the vital aspects of the economics. Thus, crisis of the banking sector can damage country's economy that is why banks need to take cautions against risks in order to prevent the spread of crisis and to protect investor's savings.

Ayan (2007) describes the Basel accords in risk management. Association in terms of the need for risk management in banking by providing both the conceptual and the implementation of risk management is very significant that contribute to the institutionalization of banking Basel accords, is the result of extensive studies carried out by the Basel Committee. In 1988, a report known as Basel I accord has been presented and accepted by the member country's central banks' presidents. By starting from 1999 Basel I accord transformed fundamentally and its name became Basel II accord. After that, there were some problems with the Basel II accord and when people looked from the outside, this report seemed inadequate because of the big financial crisis that the world faced. Hence, Basel III accord has come to order and considered.

Asarkaya and Özcan (2007) analyzes the determinants of capital structure in Turkish banking sector and propose an empirical model with the purpose of recognizing the factors which explain the reason that banks have to hold capital beyond the amount necessitated by the regulation. Factors such as technological alter, raised competition, and alterations in customer demand obliged financial institutions to enlarge the range of products they offer and develop their institutional structures. Consequently, banks' balance sheets have become more complicated and they are incured to a wider set of risk. Within this range, it is vitally crucial for stability of the banks.

With Basel II Accord, banks are required to assess capital adequacy themselves and it is necessitated that both capital adequacy and bank's self-evaluation process are

supervised and evaluated by the banking supervisory authority (Banking Regulation and Supervision Agency 2005).

Misra (2011) describes the portfolio optimization as the trade-off between risk and return to maximize income or return from the portfolio. Financial regulations are country specific and it relies on the current financial situations in the country. The portfolio of a commercial bank can be constrained by regulating instruction of exposure restrictions, risk weights and returns from each category of assets. As a result, optimization of return, in case of the loan portfolio, illustrates a demanding problem by cause of its large set of local extremes. In this context he uses Genetic Algorithm, that generates an optimal result for optimal allocation, as a reasonable result for optimizing the risk-return trade-off. The portfolio which is set up by the optimization model is mean-variance dictating for both worst and ideal cases than that of the existing market portfolio. Portfolio is formuated under Indian Banking Regulations and supervised to better the present portfolio of these banks. This optimization model can be further insight if optimization is also done inside each asset class taking into consideration all the credit class of each asset.

Puts (2012) explaines the bank balance sheet model which indicates how the optimization part confroms to the model and points out that the bank balance sheet optimization tool is built in Excel by using visual basic for applications which are the most accurate way for bank balance sheet optimization under Basel III. He describes that the optimization problem is classified as linear or nonlinear rely on whether the relationship in the problem is linear with respect to the variables and linear programming appears the most reasonable alternative. In this thesis, objective functions and constraints are denoted completely by linear equations then the model is regarded as a linear model. Since, the thesis is dealing with an optimization problem where I want to maximize the expected return and take into account the problem as linear programming problem.

Winston (2004) explains the optimization with using the Excel Solver tool which is an optimization add-in of Excel. Solver verifies that what happens with the result of

problem if one parameter is altered. The target cell, the changing cells and the constraints are the partials of an optimization model. Target cell denotes the objective. Target cell that measures the profitability will be maximized. In this thesis, expected returns of banks' portfolio of assets under Basel II regulation will be maximized. Changing variable cells are the spreadsheet cells which are altered or modified to optimize the target cell which is the amount of receivables of each risk classifications and risk weights. Constraints are limitations that are placed on the changing cells and determined as market risk, equality, retail portfolio and interest rate risk constraint. After all constraints and optimality conditions are satisfied, model is solved with Excel Solver and computational results are obtained.

Puts (2012) considers the problem as a non-linear programming problem. Because, there is a penalty function that affects the optimization such, that it loses the properties of a linear programming problem and consists of a quadratic component that implies the problem becomes a non-linear programming problem.

Hellemons (2012) aims to establish a model capable of optimizing the balance sheet of any type of bank. A balance sheet of a bank is a complicated statement that has to fulfill many necessitates described by the Basel accords. Thus, banks are looking for tools and models to be in conformity with the Basel III regulation, while maximizing their profits. He uses the proposed model which is a single-period portfolio optimization problem. In his study, a stylized balance sheet is presented, two different types of optimization objectives are presented for the model, an efficient frontier is created from composition of both optimization objectives. Efficient frontier provides the banks a chance to choose a portfolio allocation that fits its risk desire.The model proposed in his thesis can be used by every type of bank as a top-down strategic balance sheet management tool to get an optimal balance sheet optimization.

3. BACKGROUND

In this chapter, explanations about risks in banking sector, Basel accords in risk management and comparison of Basel I and Basel II accords are given.

3.1 RISKS IN BANKING SECTOR

In general, risk is defined as the probability of an event that will create loss or negativity. In other words, the risk is volatility in the amount of cash flow (Ayan 2007, p.8).

Banks are confronted with various risks while they sustain their activities. Hence, they need adequate capital to be protected from exposure of unpredictable risks. Banking sector is one of the vital aspects of the economics. Thus, crisis of the banking sector can damage country's economy that is why banks need to take cautions against risks in order to prevent the spread of crisis and to protect investor's savings.

3.1.1 Types of Risks in Banks

The risks that banks are faced and methods which are used by banks to describe, assess, observe and check the risks are significant determinants and market contributors take into consideration risks in their assessment of institute (Bank for International Settlements 2006).

The risks that banks are faced are divided in three groups which are market risk, credit risk and operational risks. Risks that can occur due to volatility in macro variables which can affect Banks' financial assets are under market risk category. Interest rate risk, exchange risk and liquidity risks can be given as examples of market risk. Credit risk is occurred when bank does not collect its receivables in due time and fully. Operational risks which are occurred resulting from people, process and system errors cover the risks out of market and credit risks (Bolgün and Akçay 2009).

3.1.1.1 Credit risk

Credit risk is the probable financial loss that the Bank might exposure owing to defaults or no implementation of the commitments of counterparties at the portfolio level that result from loan agreements. Foreign exchange agreements, currencies and also governments incur banks to credit risks (Hassan and Dicle 2007).

Banks should prepare the credit review assessment to manage credit risks and banks' credit analysis assessments of capital adequacy should include risk rating systems, portfolio examination/accumulation, securitization/complicated loan derivatives, and extensive exposures and risk concentrations at a minimum level. Internal risk ratings are a considerable instrument to observe credit risk and must be sufficient to sustain the determination and assessment of risk from all loan exposure. In addition, they should be consolidated into an institute's complete examinations of credit risk and capital adequacy. For all assets, specified ratings should be ensured and for capital adequacy credit loss free capital should be taken in the credit risk appraisal (BIS 2006).

3.1.1.2 Market risk

Banks operate in founded financial environments with numerous types of financial entities. Parts of the whole monetary system are the assets and liabilities of banks. Market risk is the probable financial loss which might be exposed because of undesirable fluctuations on the capital markets.

Market risk can be divided into two sub groups which are systematic and unsystematic. While systematic market risk for banks is occurred by overall alterations in market conditions, unsystematic risk is caused by movement in particular assets. Interest rate risk, foreign exchange risk and liquidity risk are main types of market risks (Hassan and Dicle 2007).

3.1.1.2.1 *Interest rate risk*

Interest rate risk is the risk of loss owing to an adverse change in interest rates. Changes in interest rates influence a bank's earnings by altering its net interest income and the level of other interest-sensible revenue and operating expenditures. Fundamental value of the bank's assets, liabilities and off-balance sheet instruments are influenced by the alterations in interest rates since the present value of future cash flows change when interest rates alter. Consequently, an effectual risk management process that sustains interest rate risk within sensible levels is vital to the security and reliability of banks.

Interest rate risk is decomposed into repricing risk, yield curve risk, basis risk and optionality. Repricing risk is identified as financial mediators; banks meet interest rate risk in numerous methods. Timing dissimilarities in the maturity for fixed rate and repricing for floating rate of bank assets, liabilities and off-balance-sheet positions are the main argued form of interest rate risk that occurs from timing dissimilarities. As financial mediators, banks come up against internal rate of return (IRR) in numerous ways. Dissimilarities in the liabilities, timing of the repricing of bank assets, off-balance-sheet, and instruments are the main argued source of IRR. Moreover repricing disparities are essential to the banking business and commonly emerge from either having a loan of short-term to fund longer-term assets or having a loan of long-term to fund shorter term assets. Such diversities can initiate an institution to undesirable alterations in both the relative level of ratios across the yield curve (nonparallel shifts in the yield curve), and the overall level of interest rates (parallel shifts in the yield curve). Repricing diversities can also trigger off a bank to alterations in the slope and shape of the yield curve. Yield curve risk appears when unexpected shifts of the yield curve have unfavorable outcomes on a bank's profits or fundamental economical value. Basis risk emerges when the modification of the rates earned and paid on different instruments is improperly associated with alternatively similar repricing distinctiveness. When interest rates modify, these dissimilarites can give increase to unpredicted alterations in the cash flows and income extend between assets, liabilities and off-balance-sheet instruments of same maturities or repricing frequencies.

In addition, optionality means a supplementary and increasingly significant resource of interest rate risk occurs from the selections inserted in many bank liabilities, off-balance-sheet portfolios and assets. Officially, a selection makes possible the holder the right, but not the commitment, sell, to buy or in some manner change the cash flow of an instrument or financial agreement (BIS 2001a).

3.1.1.2.2 *Foreign exchange risk*

Foreign exchange risk is the risk of loss that the banks are exposed owing to exchange rates alterations due to currency of assets and liabilities.

When individuals or companies connect themselves in an action requiring cash flows specified in different currencies, the value relationship between those currencies becomes more crucial than before. This relationship is articulated as a foreign exchange rate (Gorvett 2001).

Exposure to foreign exchange risk can take several different forms. Transaction exposure emerges from transactions requiring future cash flows which are specified in a currency different from the home currency. This type of risk arises when the relevant exchange rate alters between the date a transaction agreement is gone into and the date the transaction is financially accomplished. Translation exposure is an accounting-based exposure ensuing from a company's having to renovate liability and/or asset items from one currency to another for financial statement aims. Operating exposure is an exposure related with the potential impact of alterations in exchange rates on the future cash flows of the firm. In other words, this can indicated as economic exposure, since the economic value of a firm is a purpose of the company’s future cash flows. The alteration in demand for holidays and the resulting reduced revenue stream due to the reinforced dollar is an example of this type of exposure (Gorvett 2001).

3.1.1.2.3 *Liquidity risk*

Liquidity is vital to the continuing sustainability of any banking institution. Banks' capital conditions affect their capability to get liquidity especially when the crisis is occurred (BIS 2006).

Banks have daily cash requirements rising from activities that include withdrawals, paying cheques, regulatory and credit payments. To assume these payment commitments on time is the duty of banks. If the banks don't fulfill these, liquidity risk is occurred. In other words, liquidity risk is the risk that the Bank will have insufficient funds in order to comply with its contractual commitments.

Every bank should have sufficient techniques to assess, observe and control liquidity risk and they must control liquidity risk through cash flow management (Hassan and Dicle 2007).

Every financial commitment has some impact for a bank's liquidity. Efficient liquidity risk management assists to make sure a bank's ability to encounter cash flow obligations, which are doubtful as they are influenced by exterior events and other negotiator's behavior. Liquidity risk management is of supreme significance because a liquidity deficit at a single institution can have system-wide consequences.

3.1.1.3. Operational risk

Operational risk is the venture of financial losses as a result of unsuitable or ineffective interior methods, individuals, systems or from exterior occurences. Part of operating risk is legal risk, that refers to risk of financial loss due to penalties and fines arising from Bank's omission to conform with legal or contractual provisions (Chorafas 2004).

3.2 BASEL ACCORDS IN RISK MANAGEMENT

Association in terms of the need for risk management in banking by providing both the conceptual and the implementation of risk management is very significant that contribute to the institutionalization of banking Basel Accords, is the result of extensive studies carried out by the Basel Committee.

Basel Accords have a significant importance in international markets to ensure stabilization. Basel Accords which are structured in accordance with the emergent requirements are not only well-prepared comprehensive work but also perform important achievements in practice. Moreover, Basel Accords provide for flexibility. Applicability of Basel has increased with providing its flexibility (Ayan 2007, p.26).

3.2.1 Institution and Historical Development of Basel Committee

Basel Committee, which has an importance place in finance literature especially since 1990s with regulations that have been put in the field of banking sector, was established within the bank for international settlements (BIS) after the banking crisis occurred in Federal Germany in 1974 [BIS no date].

3.2.1.1 Institution of BIS

The Bank for International Settlements which is the world's oldest global financial establishment and stays the major center for international central bank collaboration was found on 17 May 1930 in the background of the Young Plan which managed the concern of the compensation payments enforced on Germany by the Treaty of Versailles following the First World War. The new bank was to take over the functions before executed by the Agent General for Reparations in Berlin. Functions that are taken over are collection, management and distribution of the annuities payable as reparations.

The reparations concern was weakened rapidly, concentrating transactions of banks completely on collaboration between central banks and organizations in terms of monetary stabilization.

To operate central banks in their pursuit of monetary and financial stability, to encourage international collaboration and to perform as a bank for central banks are the duty of the Bank for International Settlements.

The BIS follows its duty by encouraging argument and easing cooperation between central banks, providing for dialogue with other dominations that are accountable for encouraging financial stabilization, managing search on procedures concerns faces central banks and financial supervisory dominations, performing as a prime counterparty for central banks in their monetary operations, and operating as a trustee or representative in association with global financial transactions.

The head office of BIS is in Basel, Switzerland and also there are two representative offices which are in the Hong Kong Special Administrative Region of the People's Republic of China and in Mexico City.

The Bank's administrative and budgetary rules execute to the committees embraced by the BIS. The BIS currently has 60 member central banks, all members are given the right to be signified and vote in the General Meetings. Voting power is impartial to the number of BIS shares that is presented in the country of each member signified at the meeting [BIS no date].

3.2.1.2 Institution and development of Basel committee

The Basel Committee on Banking Supervision was set up as the Committee on Banking Regulations and Supervisory Practices by Group of Ten Countries' central bank administrators under the support of the BIS at the end of 1974 in the aftermath of crucial disturbances in global currency and banking markets.

Committee has published a report in 1975 to prevent unfair competition among banks and to prevent spread the financial crisis to other countries. This report includes the relationship between the international banks' home country and its branches in other countries. Therefore, by considering the market conditions, this report has been expanded and published again in 1983.

In the next few years, there were some problems because of the different international capital adequacy arrangements and to eliminate unfair competition. To solidify international banking system and to make it more stable, a new and wider report has been published. In 1988, this report has been presented and accepted by the member country's central banks' presidents. This report also known as Basel I Accord and because of the uncontrollable and changing conditions and emerging needs, it has been enriched. By starting from 1999 Basel I Accord transformed fundamentally and its name became Basel II Accord. After that, there were some problems with the Basel II Accord and when people looked from the outside, this report seemed inadequate because of the big financial crisis that the world faced. Hence, Basel III Accord has come to order and considered (Ayan 2007, p.27).

In addition, a forum for usual collaboration on banking supervisory subjects is enabled by Basel Committee on Banking Supervision. Its aim is to improve the comprehension of main supervisory subjects, develop the quality of banking supervision universal and enabling financial stability. Furthermore, the Committee is best well-known for its global standards on capital adequacy which are the Core Principles for Effective Banking Supervision and the Concordat on cross-border banking supervision.

The Committee's members are from Argentina, Australia, Belgium, Brazil, Canada, China, France, Germany, Hong Kong SAR, India, Indonesia, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Russia, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. Communications and collaborations among Committee's members and other banking supervisory authorities are supported by the Committee [BIS no date].

3.2.2 Basel I Accord

Basel I Accord was aranged by the Basel Committee in 1988 and the banks' working criteria was determined for the first time with Basel I Accord (Technology Development Foundation of Turkey 2007).

Basel I Accord was capital adequacy regulation emphasized on only risk measurements and Basel I capital adequacy ratio of 8% as the lower limit was determined to increase endurance against the crisis of banks. The main weakness of Basel I Accord was that while capital requirement for credit and market risks were taken into consideration, capital requirement for operational risk was not considered (Ayan 2007, p.40).

3.2.3 Basel II Accord

Basel II is the second Basel Accord. Due to significant improvements in the banking sector, Basel I, which has the simplest calculation method, is started to become interrogated and Basel I was inadequate to manage banking risks. Just because of this reason, Basel II was occurred in 2004. Basel II Accord's intend is to get over 1988 Basel Accord (Basel I) drawback by improving a structure that would reinforce the reliability and the constancy of the global banking system and Basel II supplies range of alternatives/regulations to conclude the capital entailed to obscure failure in case of unpredicted occasions to notify market on banks limelight to vital risks (Ernst and Young 2009).

The main features of Basel II Accord are:

1. Having the liability to monitor, manage and setup the financial regulations,
2. Endeavoring for customer protection, advisory supervision and perform of businesses,
3. Improving competitive equality,
4. Forming more comprehensive approach for risk,
5. Focusing on globally active banks (Paudel 2007).

Thereby, with Basel II the World and Turkish Banking sector will change. The probability of the credits not being paid is about whom to be given. Therefore, firm evaluation will be more crucial with Basel II. Generally, capital quantities that banks should reserve will depend on the risk of credit. Moreover, risk of management and decisions making process will depend on evaluation and it will be mandatory. Hence, banks have to be more selective when giving credits. Also, limit, indemnification and pricing decisions will be affected (Technology Development Foundation of Turkey 2007).

Basel II is based on three pillars which are capital requirements depending on the actual risk (Pillar 1), supervisory review process (Pillar 2) and market discipline (Pillar 3) (Paudel 2007, p.5).

3.2.3.1 Pillar 1: Minimum capital requirement

Trench (2009, p.6) states, "Capital performs as a buffer to keep banks solvent when losses exceed those experienced under normal market and operating conditions".

Minimum capital requirement is the amount to be hold by banks for business taking into consideration the public costs of bank failure. This amount is set up by the regulatory authorities and supervisors. The major aim of minimum capital requirement is to provide enhanced risk sensitivity. Furthermore, capital requirements are computed consisting of three most important risk components which are credit risk, market risk and operational risk. Basel II capital requirement necessitates banks to take all these risks into consideration while managing their credit risk. These risks are calculated by using several approaches as value at risk and loss functions. Basel I that banks that hold a minimum reserve of 8% of risky assets remains the same in Basel II Accord. Capital requirement only for credit and market risks are existent in Basel I. Besides credit and market risks, operational risk capital requirement is added on Basel II. When the capital requirements for a specific risk do not contain risk weighted assets (RWAs), it is multiplied by 12.5 to turn it into RWA-equivalent (Hull 2012, p.146).

Total capital = 0.08 * (credit risk RWA + market risk RWA
+ operational risk RWA) **(3.1)**

However, the capital requirement under Basel II is more complex because it considers different type of assets in a distinctive way depending on their risk profiles and type. Moreover, the supervisory committee necessitates banks to ensure minimum capital necessities for market, credit and operational risk. For this reason, the committee has identified different approaches in the management and measurement of banking risks.

3.2.3.1.1 *Credit risk capital under Basel II*

The Basel II introduced 3 approaches to compute the credit risk capital necessities. These three approaches which are supposed by committee for credit risk assessment are standardized approach (SA), foundations internal ratings based (F-IRB) approach and advanced internal ratings based (A-IRB) approach (Trench 2009, p.6).

SA is the minimum requirement which is obliged by the Basel committee on the banks and other financial institutions (FIs). Banks approve this method to assess their credit risk. SA takes into consideration the credit risk profile of the debt raiser. All the derivatives and assets from numerous classes are assigned weights depending on the risk profile (Trench 2009, p.6).

It is the continuation of the text that has been published in 1988. Risk sensitivity is taken more broadly. Risk weights are determined by the independent evaluation institutions. RWA is calculated by multiplying risk weight and risk amount and regulatory capital is calculated by multiplying RWA and percentage of eight. Formulas are shown below:

$$\sum_i^n RW_i x\, A_i = RWA \quad \textbf{(3.2)}$$

$$RWA*0.08 = RC \quad \textbf{(3.3)}$$

where, RW_i is the risk weight to asset I, A_i is the assets, RWA is the risk-weighted assets, RC is the regulatory capital and n denotes the number of asset.

Credits' risk weights assigned to country, banks and corporations are shown in Table 3.1 and AAA to AA-, A+ to A-, BBB+ to BBB-, BB+ to BB-, B+ to B-, Below B- and unrated denote the credit assessments of banks, country and corporations.

Table 3.1: Risk weights depending on the assets characteristics

	AAA to AA-	A+ to A-	BBB+ to BBB-	BB+ to BB-	B+ to B-	Below B-	Unrated
Country	0%	20%	50%	100%	100%	150%	100%
Banks	20%	50%	50%	100%	100%	150%	50%
Corporations	20%	50%	100%	100%	150%	150%	100%

Source: BIS, 2001b

Banks' capital requirements will be increased. Compared to Basel I, due to the risk sensitivity structure of SA of Basel II, additional capital requirements could arise for banks. Banks will be more selective when loans are issued to customers and there could be contraction in loan volume in the short run (Technology Development Foundation of Turkey 2007).

Internal ratings based (IRB) approach is used to estimate credit risk by banks. Under IRB approach banks are allowed to use their own estimations of risk components to assess capital requirement. The measures of expected loss and unexpected loss are taken into consideration with IRB approach. Capital requirements are obtained by subtracting expected losses from total losses.

The risk components consist of the measurements of the probability of default (PD), loss given default (LGD), the exposure at default (EAD), and effective maturity (M) (BIS 2004).

Banks enable their own approximation of the PD, LGD, EAD and valuable maturity for sovereign, retail and corporate bank experienced. PD can be reduced by credit mitigants as credit triggers. The seniority of the debt and the reciprocal bonds has an effect on the LGD. In computing EAD, banks can use their own approximation of credit adaptation aspects with rigid authorization (Hull 2012, p.146)**.**

In addition, IRB methods for computing the risk weights are an effort to familiar with an individual bank's risk profile in the computation of capital necessities. IRB attitudes to use a bank's own interior approximations of creditworthiness to decide the risk weightings in the capital computation. The IRB attitudes are a crucial feature of the Basel II Accord, as they are an effort to permit more modified/ exact risk profiles. This method can be very useful for banks since it has the possible to decrease the capital requirement because a bank's own approximations of risk may be inferior than those computed using the standardized method (BIS 2004).

There are three situations to direct in the IRB framework such as risk components, which are risk parameter approximations, either flourished internally or got from administrative approximations, risk weight functions, which take the risk parts and convert them in to RWAs and minimum requirements, which are standards that must be encountered before a banks is qualified to use an IRB method. The IRB method has much more dependence on administrative approximations, because of the fact that only PD is predicted by the bank (BIS 2004).

The IRB approach is found in two forms which are F-IRB approach and A-IRB approach. With IRB approach, banks supply their own estimations of PD and depend on supervisor's estimations for risk components to decide the risk weight that is used to compute capital amount to be kept against the loan. With A-IRB approach, banks provide their own estimation of all risk parameters to decide the risk weight and capital

charge against a loan. The advanced IRB approach is more or less indistinguishable to the normal IRB approach. The advanced method permits banks to predict not only PD, but also EAD, M, and LGD. Both approaches obtain the bank to use the risk weight functions to gain capital requirements (BIS 2004).

The IRB approaches needs the measurability of expected loss and unexpected loss for each of the credit. Since public data will be used, it is not possible to use this method. Hence, SA will be used in this thesis.

3.2.3.1.2 *Operational risk capital under Basel II*

Because of inadequate or ineffective interior methods, people, systems or from exterior occurences, operational risk is the risk of financial losses. The Basel II Framework necessitates banks to flourish an operational risk management framework (ORMF). The ORMF engages a bank's risk organizational and governance formation, rules, practices and methods and systems utilized by a bank in classify, determining, observing, managing, alleviate operational risk and operational risk measuring system (BIS 2011).

A bank's operational risk measurement system (ORMS) entails the systems and data managed for assessing operational risk to predict the capital charge of operational risk. The ORMS must be intimately combined into the day-to-day risk management methods of the bank (BIS 2011).

Three approaches for computing operational risk capital charges in continuum of raising complexity and risk sensitivity are enabled under the New Capital Adequacy Framework (NCAF). Approaches are:

1. The Basic Indicator Approach (BIA),
2. The Standardized Approach, and
3. Advanced Measurement Approach (AMA).

The simplest method, the BIA, connects the capital expense for operational risk to a single risk indicator for the entire bank. The SA is a more sophisticated variation of the BIA that make use of integration of monetary determiners and institutional working ways to measure the capital expense. Both methods are pre-measure by regulators. Under the AMA, banks can utilize its own determination method for operational risk. AMA endeavors to fit in, within a supervisory-indicated framework, an individual bank's interior loss data into the computation of its necessitated capital. Like SA, AMA demands a putrefaction of the bank's activities into denoted business lines (BIS 2001c).

3.2.3.1.3 *Market risk capital under Basel II*

Market risk is the possible monetary failure which might be acquired due to undesirable variations in the capital marketplaces.

Indications of market risk determinants has a crucial part of a bank's interior market risk measuring system which is the identification of a suitable set of market risk determinants. The risk factors included in a market risk measuring system should be adequate to incarcerate the risks which are existent in the bank's portfolio of on-balance sheet and off-balance sheet trading positions.

Even though banks have prudence in identifying the risk issues for their interior designs, the some principles should be accomplished which are issues considered appropriate for quoting a price should be contained as risk issues in the value-at-risk model. Where a risk issue is integrated in a quoting a price model but not in the value-at-risk model, the bank should substantiate this disregard to the fulfillments of its administrator. For interest rates, there must be a set of risk factors in relation to interest rates in all currency in which the bank has interest-rate-sensible on- or off-balance sheet positions. For exchange rates (which might contain gold), risk factors should be incorporated with the risk identifying method relating to the particular foreign currencies in which the bank's positions are disclosed. Since the value-at-risk figure which is worked out by the risk measurement system will be expressed in the bank's local currency, any net position specified in a foreign currency will trigger off a foreign

exchange risk. Thus, there must be risk factors in relation to the exchange rate between the local currency and each foreign currency in which the bank has a vital disclosures. For equity prices, there should be risk factors in relation to all equity marketplaces in which the bank hold important positions (BIS 2011).

3.2.3.2 Pillar 2: Supervisory review

Supervisory review copes with the regulatory responses to minimum capital requirement and recognizes the requirement of practicing valuable managerial analysis of banks' internal evaluations of their overall risks to make sure that bank management has put aside enough capital for risks (BIS 2004).

The Committee has identified four main basis of supervisory review.

1. The banks have suitable process for estimating their capital adequacy entirely to maintain their capital levels.
2. Banks' capital adequacy assessments should be overviewed and assessed by supervisors. If they are not sufficed, supervisors take corrective precautions.
3. Observers predict banks to perform above the minimal capital requirement.
4. Supervisors interfere with banks if the minimum capital requirement is not maintained (BIS 2004).

3.2.3.3 Pillar 3: Market discipline

The third main aspect of the Committee's approach to capital adequacy is market discipline. The accord underlines the potential for market discipline to strengthen capital regulations and other supervisory attempts in encouraging protection and reliability in banks and monetary systems (Bessis 2009).

Market discipline necessitates revelation of data respect to the computation of bank capital positions and risk administration methods that are planned to secure the capacity of safety marketplace to reply to alteration of risk profiles of bank (Terry 2008).

In addition, pillar 3 copes with providing information for the customers and mentioned organization by the banks to generate open market. This is intended to create surroundings fairly for rivalry among the banks in the market and to secure the customers (Paudel 2007).

3.2.4 Comparison of the Basel I and Basel II accords

Basel I was inadequate to manage banking risks. For this reason, Basel II was occurred. As a result of Committee's intensive studies, Basel II was taken the final version. Basel II does not only maintain the basic characteristics of Basel I but also has fundamental revisions (Ayan 2007, p.40).

3.2.4.1 Similarities of Basel I and Basel II accords

Basel II brought significant differences compared to Basel I. Unchanging issues of Basel II or issues of sustaining the Basel I's characteristics extensively are:

1. Basel I capital adequacy ratio of 8% as the lower limit was determined similarly in Basel II.
2. Method of capital base calculation that was formed in Basel I was considerably adopted in Basel II.
3. There has not been a significant change in Basel II relevant to market risk measurement methods that were renewed in 1996 (Ayan 2007, p.40).

3.2.4.2 Differences of Basel I and Basel II accords

Basel II includes crucial alterations. While Basel I Accord is capital adequacy regulation focused on only risk measurements, Basel II Accord is management philosophy that includes both capital adequacy measurement and audit and market discipline issues (Ayan 2007, p.41).

Differences between Basel I and Basel II Accords are as follows:

1. With Basel I Accord, while standard risk coefficients are determined, countries are classified according to whether they are members of the OECD (Organization for Economic Cooperation and Development) or not and more advantageous risk coefficients are determined for members of the OECD. With Basel II Accord, this criterion is removed while credit risk is calculated.
2. Credit risk is determined in accordance with credit rating notes of the loan creditors in Basel II.
3. Capital requirement only for credit and market risks are existent in Basel I. In addition to these risks, operational risk capital requirement is added on Basel II. In Basel II, operational risk is described as the risk that caused by unsuitable or failing interior methods, people or the system and banks need to have enough funds for these risks.
4. With Basel II Accord, banks are required to assess capital adequacy themselves and it is necessitated that both capital adequacy and bank's self-evaluation process are supervised and evaluated by the banking supervisory authority (BRSA 2005).

4. PROBLEM DEFINITION

Banks are required to assess capital adequacy themselves with Basel II regulation and the implication of Basel II on capital requirement and risk-weighted assets is taken into account by banks for risk management in this thesis.

In this chapter, banks' data is analyzed, optimization model is formulated and solved with appropriate optimization tool to find optimal allocation of assets of Turkish banks under risk constraints with Basel II requirements.

4.1 DATA

Turkish banks which are Vakıfbank, Akbank and Yapı ve Kredi Bankası (YKB) are chosen for optimization problem to maximize expected returns of these banks' portfolio of assets under Basel II regulation. Data that is used in the model is taken from from unconsolidated financial statements as at and for the year ended 31 December 2012. Amounts of the tables are indicated in thousands of Turkish Lira (TL) in this thesis.

There are sixteen risk classifications c_1 to c_{16} in all these banks and these are shown below:

c_1 = conditional and unconditional receivables from central governments and Central Banks
c_2 = conditional and unconditional receivables from regional or local governments
c_3 = conditional and unconditional receivables from administrative bodies and non-commercial enterprises
c_4 = conditional and unconditional receivables from multilateral development banks
c_5 = conditional and unconditional receivables from international organizations
c_6 = conditional and unconditional receivables from banks and brokerage houses
c_7 = conditional and unconditional receivables from corporates
c_8 = conditional and unconditional receivables from retail portfolios

c_9= conditional and unconditional receivables secured by mortgages

c_{10} = past due receivables

c_{11} = receivables defined under high risk category by BRSA

c_{12} = securities collateralized by mortgages

c_{13} = securitization positions

c_{14} = short-term receivables from banks brokerage houses and corporate

c_{15} = investments similar to collective investment funds

c_{16} = other receivables

Risk weights are classified into seven groups which are zero percent, twenty percent, fifty percent, seventy five percent, one hundred percent, one hundred and fifty percent and two hundred percent and used for assessing capital required on the basis of credit rating and type of assets.

x_{ij} = the amount of receivables of each risk classes i and risk weight j

Table 4.1, Table 4.2 and Table 4.3 show the details of RWAs which constitute the basis for banks' capital adequacy ratios and banks' equity calculations end of 31 December 2012.

Table 4.1: Information on unconsolidated capital adequacy ratio of Vakıfbank

	0%	20%	50%	75%	100%	150%	200%	
x_{ij}	1	2	3	4	5	6	7	**TOTAL**
1	28,558,222	0	3,969,804	0	0	0	0	**32,528,026**
2	9,128	955,396	137,598	0	0	0	0	**1,102,122**
3	13,080	0	248	0	22,627	0	0	**35,955**
4	82,169	0	0	0	0	0	0	**82,169**
5	0	0	0	0	0	0	0	**0**
6	5,449,874	1,133,933	2,302,272	0	590,020	0	0	**9,476,099**
7	541,951	0	0		30,050,423	0	0	**30,592,374**
8	87,961	0	0	19,064,767	0	0	0	**19,152,728**
9	0	0	18,334,707	0	1,849,410	0	0	**20,184,117**
10	0	0	0	0	265,394	0	0	**265,394**
11	0	0	0	0	0	1,979,962	4,851,957	**6,831,919**
12	0	0	0	0	0	0	0	**0**
13	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	**0**
16	1,119,644	4,449	0	0	3,321,294	0	0	**4,445,387**
TOTAL	**35,862,029**	**2,093,778**	**24,744,629**	**19,064,767**	**36,099,168**	**1,979,962**	**4,851,957**	**124,696,290**

Source: Unconsolidated financial statements as at and for the year ended 31 December 2012, February 2013, p: 23.

Table 4.2: Information related to capital adequacy ratio of Akbank

	0%	20%	50%	75%	100%	150%	200%	
x_{ij}	1	2	3	4	5	6	7	**TOTAL**
1	48,259,649	149,185	10,858,032	0	0	0	0	**59,266,866**
2	0	0	44	0	0	0	0	**44**
3	0	0	0	0	23,908	0	0	**23,908**
4	0	0	0	0	0	0	0	**0**
5	0	0	0	0	0	0	0	**0**
6	808,257	7,595,811	5,965,422	0	247,156	0	0	**14,616,646**
7	6,462	0	0	0	50,771,605	0	0	**50,778,067**
8	0	0	0	29,475,426	0	0	0	**29,475,426**
9	0	0	9,581,766	0	777,034	0	0	**10,358,800**
10	0	0	0	0	92,850	0	0	**92,850**
11	0	0	0	0	0	2,665,161	6,441,595	**9,106,756**
12	0	0	0	0	0	0	0	**0**
13	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	**0**
15	0	0	0	0	239,123	0	0	**239,123**
16	1,420,117	723	0	0	2,030,896	0	0	**3,451,736**
TOTAL	**50,494,485**	**7,745,719**	**26,405,264**	**29,475,426**	**54,182,572**	**2,665,161**	**6,441,595**	**177,410,222**

Source: Unconsolidated financial report as of 31 December 2012, February 2013, p: 23.

Table 4.3: Information related to capital adequacy ratio of YKB

	0%	20%	50%	75%	100%	150%	200%	
x_{ij}	1	2	3	4	5	6	7	**TOTAL**
1	20,699,166	0	10,878,578	0	0	0	0	**31,577,744**
2	0	148	0	0	0	0	0	**148**
3	0	0	0	0	4,437	0	0	**4,437**
4	2,766	0	0	0	0	0	0	**2,766**
5	0	0	0	0	0	0	0	**0**
6	0	6,183,231	3,614,933	0	1,968,498	0	0	**11,766,662**
7	0	0	0	0	49,984,498	0	0	**49,984,498**
8	0	0	0	30,262,517	0	0	0	**30,262,517**
9	0	0	8,548,065	0	0	0	0	**8,548,065**
10	0	0	0	0	628,879	404,520	0	**1,033,399**
11	0	0	0	0	0	3,166,614	3,902,915	**7,069,529**
12	0	0	0	0	0	0	0	**0**
13	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	**0**
16	1,687,075	155	0	0	6,787,517	0	0	**8,474,747**
TOTAL	**22,389,007**	**6,183,534**	**23,041,576**	**30,262,517**	**59,373,829**	**3,571,134**	**3,902,915**	**148,724,512**

Source: Unconsolidated financial statements as of 31 December 2012, February 2013, p: 77.

4.2 CONSTRAINTS

The information related to capital adequacy ratio of bank is used in order to find risk weighted assets. In order to find risk weighted assets, the risk weight of each asset is multiplied by summation of each asset as shown below formula:

$$RWA=\sum_{i=1}^{n} x_{i1}*0\%+\sum_{i=1}^{n} x_{i2}*20\%+\sum_{i=1}^{n} x_{i3}*50\%+\sum_{i=1}^{n} x_{i4}*75\%+ \quad \textbf{(4.1)}$$
$$\sum_{i=1}^{n} x_{i5}*100\%+\sum_{i=1}^{n} x_{i6}*150\%+\sum_{i=1}^{n} x_{i7}*200\%,\ n = 1,2,3,...,16$$

Minimum capital requirement that banks have to hold is the 8% of its risk weighted assets in terms of Basel II Acord.

$$RC = RWA*0.08 \quad \textbf{(4.2)}$$

where, RC is the regulatory capital.

RC should be equal to or smaller than the summation of assets of first risk classification that is conditional and unconditional receivables from central governments and Central Banks. Total market risk capital requirement is found by the formula below:

$$\text{RWA} * 0.08 \leq \sum_{j=1}^{7} x_{1j} \quad \textbf{(4.3)}$$

Bank's past data is analyzed. According to past data, bank will want to maintain its investments in specific asset classifications. Therefore, minimum and maximum possible weights are assumed for every risk classification. These are determined by bank's risk attitudes.

$$\sum_{j=1}^{J} x_{ij} / \text{total asset, for all } i=1,\ldots,16 \quad \textbf{(4.4)}$$

$$\text{total asset} = \sum_{i=1}^{16} \sum_{j=1}^{7} x_{ij} \quad \textbf{(4.5)}$$

While minimum and maximum possible weights are assumed, the amount of assets of each risk class is taken into consideration. Total asset of each bank is calculated by using risk-weighted assets with the formula above.

$$\sum_{j=1}^{J} x_{ij} / \text{total asset} \leq \max_i, \text{ for all } i = 1,2,\ldots,16 \quad \textbf{(4.6)}$$

$$\sum_{j=1}^{J} x_{ij} / \text{total asset} \geq \min_i, \text{ for all } i = 1,2,\ldots,16 \quad \textbf{(4.7)}$$

where, $\min_i$ is the minimum possible weight and $\max_i$ is the maximum possible weight of risk class i.

Table 4.4: Minimum and maximum possible weights of Vakıfbank

minimum possible weight	maximum possible weight
10%	40%
1%	100%
0%	100%
0%	100%
0%	100%
5%	30%
10%	40%
5%	30%
5%	30%
0%	100%
1%	100%
0%	100%
0%	100%
0%	100%
0%	100%
1%	100%

Table 4.5: Minimum and maximum possible weights of Akbank

minimum possible weight	maximum possible weight
10%	40%
0%	100%
0%	100%
0%	100%
0%	100%
5%	30%
10%	40%
5%	30%
5%	30%
0%	100%
1%	100%
0%	100%
0%	100%
0%	100%
0%	100%
0%	100%

Table 4.6: Minimum and maximum possible weights of YKB

minimum possible weight	maximum possible weight
10%	40%
0%	100%
0%	100%
0%	100%
0%	100%
5%	30%
10%	40%
5%	30%
5%	30%
1%	100%
1%	100%
0%	100%
0%	100%
0%	100%
0%	100%
0%	100%

Minimum and maximum possible weights are identified for each bank in the Table 4.4, Table 4.5 and Table 4.6 as shown above.

Receivables from Central Banks are easily converted to cash and 0% risk weight is applied for receivables from Central Banks. r_{11} corresponds to 0% risk weight and is the same for each bank (Resmi Gazete 2012). Its value is the overnight borrowing interest rate. Overnight borrowing interest rate was kept at 5% level as of 18 December. (P:2) Therefore, r_{11} is 5% (Türkiye Cumhuriyeti Merkez Bankası 2012).

r_{13} corresponds to 50% risk weight according to Resmi Gazete. It is bond interest rate and its rate is 6.16% for each bank as of December 2012.

20% risk weight is applied for conditional and unconditional receivables from regional or local governments. Conditional and unconditional receivables from administrative bodies and non-commercial enterprises are not subjected to more than 100% risk weight. 0% risk weight is applied for conditional and unconditional receivables from

multilateral development banks. No risk weght is applied for each bank for conditional and unconditional receivables from international organizations. 20%, 50% and 100% risk weights are applied for conditional and unconditional receivables from banks and brokerage houses. 100% risk weight is applied for conditional and unconditional receivables from corporates. 75% risk weight is applied for conditional and unconditional receivables from retail portfolios. 50% and 100% risk weigts are applied conditional and unconditional receivables secured by mortgages. 100% and 150% risk weights are applied for past due receivables. 150% and 200% risk weights are applied for receivables defined under high risk category by BRSA. No risk weights are applied for banks for securities collateralized by mortgage, securitization positions and short-term receivables from banks brokerage houses and corporate. 100% risk weight is applied for investments similar to collective investments funds. 100% risk weight is applied for tangible fixed assets for other receivables, cash and cash equivalents are applied for 0% risk weight, matured securities, cheques purchased are applied for 20% risk weight for other receivables. 75% risk weight is usually applied for conditional and unconditional receivables from retail portfolios, therefore, sum of amount of receivables for this risk classification is assumed as zero except for receivables correspond to 75% risk weight (Resmi Gazete 2012).

Retail portfolio constraint is found by formula below:

$$\sum_{j\neq 4} x_{8j} = 0 \qquad \textbf{(4.8)}$$

In order to find bank's total return, return rates of each credit are determined. Return rates of amount of receivables are determined in terms of Banks' returns rates which are announced by the banks from official websites of each bank as of December 2012.

r_{ij} = return rate of amount of receivables of each risk class i and risk weight j

Table 4.7, Table 4.8 and Table 4.9 show the details of return rates of amount of receivables of banks.

Table 4.7: Return rates of amount of receivables of Vakıfbank

r_{ij}	1	2	3	4	5	6	7
1	5.0%	0	6.16%	0	0	0	0
2	8.0%	8.5%	9%	0	0	0	0
3	8.0%	0	9%	0	10.0%	0	0
4	8.0%	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	7.8%	8.2%	8.6%	0	9.0%	0	0
7	6.5%	0	0	0	7.0%	0	0
8	9.0%	0	0	9.5%	0	0	0
9	0	0	11.28%	0	11.28%	0	0
10	0	0	0	0	13.0%	0	0
11	0	0	0	0	0	15.0%	15.5%
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
16	5.0%	5.0%	0	0	5.0%	0	0

Table 4.8: Return rates of amount of receivables of Akbank

r_{ij}	1	2	3	4	5	6	7
1	5.0%	5.0%	6.16%	0	0	0	0
2	0	0	8.5%	0	0	0	0
3	0	0	0	0	10.0%	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	8.0%	8.4%	8.8%	0	9.2%	0	0
7	7.0%	0	0	0	7.5%	0	0
8	0	0	0	9.8%	0	0	0
9	0	0	9.48%	0	9.48%	0	0
10	0	0	0	0	12.0%	0	0
11	0	0	0	0	0	15.0%	16.0%
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	5.0%	0	0
16	5.0%	5.0%	0	0	5.0%	0	0

Table 4.9: Return rates of amount of receivables of YKB

r_{ij}	1	2	3	4	5	6	7
1	5.0%	0	6.16%	0	0	0	0
2	0	8.5%	0	0	0	0	0
3	0	0	0	0	9.0%	0	0
4	7.0%	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	8.3%	8.7%	0	9.1%	0	0
7	0	0	0	0	7.4%	0	0
8	0	0	0	9.8%	0	0	0
9	0	0	11.16%	0	0	0	0
10	0	0	0	0	14.0%	15.0%	0
11	0	0	0	0	0	15.0%	15.0%
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
16	5.0%	5.0%	0	0	5.0%	0	0

After returns rates are determined, total return that will be maximized is found. In order to find Banks' total return, interest rates of each credit are averagely distributed considering the risk-weight assets and these interest rates are multiplied with risk-weighted assets.

$$E(R) = \sum_{i=1}^{16} \sum_{j=1}^{7} x_{ij}\, r_{ij} \qquad \textbf{(4.9)}$$

where, E(R) is the total expected return.

Equaility constraint is found by the formula below:

$$\sum_{i=1}^{16} \sum_{j=1}^{7} x_{ij} = \text{bank}'\text{s total asset} \qquad \textbf{(4.10)}$$

Distribution of maturity risk factors according to their outstanding maturities end of 31 December 2012 are used and Table 4.10, Table 4.11 and Table 4.12 show the details.

Table 4.10: Distribution of maturity risk factors according to their outstanding maturities of Vakıfbank

	DISTRIBUTION OF MATURITY RISK FACTORS ACCORDING TO THEIR OUTSTANDING MATURITIES					
x_{ik}	1 month	1-3 months	3-6 months	6-12 months	1 year and over	**TOTAL**
1	24,027	3,978	3,708	1,621	32,494,691	**32,528,025**
2	95,536	8,684	11,845	60,612	925,445	**1,102,122**
3	11,207	1,093	1,711	4,392	17,552	**35,955**
4	0	0	0	0	0	**0**
5	0	0	0	0	0	**0**
6	1,283,931	152,434	213,780	199,970	7,625,984	**9,476,099**
7	7,287,253	2,595,895	2,974,509	5,633,044	12,110,097	**30,600,798**
8	590,150	302,147	376,712	769,351	17,188,113	**19,226,473**
9	2,417,434	886,628	1,253,439	2,871,372	12,755,243	**20,184,116**
10	0	0	0	0	265,394	**265,394**
11	0	0	0	0	6,831,919	**6,831,919**
12	0	0	0	0	0	**0**
13	0	0	0	0	0	**0**
14	0	0	0	0	0	**0**
15	0	0	0	0	0	**0**
16	0	0	0	0	4,445,387	**4,445,387**
TOTAL	**11,709,538**	**3,950,859**	**4,835,704**	**9,540,362**	**94,659,825**	**124,696,288**

Source: Unconsolidated financial statements as at and for the year ended 31 December 2012, February 2013, p: 30.

Table 4.11: Distribution of maturity risk factors according to their outstanding maturities of Akbank

	DISTRIBUTION OF MATURITY RISK FACTORS ACCORDING TO THEIR OUTSTANDING MATURITIES					
x_{ik}	1 month	1-3 months	3-6 months	6-12 months	1 year and over	**TOTAL**
1	4,948,925	15,283,774	2,281,683	2,212,023	38,203,030	**62,929,435**
2	0	0	0	0	45	**45**
3	11,694	8,373	86	418	13,674	**34,245**
4	0	0	0	0	0	**0**
5	0	0	0	0	0	**0**
6	12,001,406	8,669,876	1,695,385	1,954,497	5,556,830	**29,877,994**
7	4,629,382	6,012,167	6,040,270	8,119,235	26,459,113	**51,260,167**
8	416,317	615,427	11,473,620	3,033,759	14,150,264	**29,689,387**
9	75,865	204,792	411,843	1,047,328	8,622,259	**10,362,087**
10	0	0	0	0	92,850	**92,850**
11	0	0	0	1,215,027	7,891,730	**9,106,757**
12	0	0	0	0	0	**0**
13	0	0	0	0	0	**0**
14	0	0	0	0	0	**0**
15	0	239,123	0	0	0	**239,123**
16	0	0	0	0	3,451,737	**3,451,737**
TOTAL	**22,083,589**	**31,033,532**	**21,902,887**	**17,582,287**	**104,441,532**	**197,043,827**

Source: Unconsolidated financial report as of 31 December 2012, February 2013, p: 31.

Table 4.12: Distribution of maturity risk factors according to their outstanding maturities of YKB

	DISTRIBUTION OF MATURITY RISK FACTORS ACCORDING TO THEIR OUTSTANDING MATURITIES					
x_{ik}	1 month	1-3 months	3-6 months	6-12 months	1 year and over	**TOTAL**
1	9,050,476	0	499,482	41,995	20,458,535	**30,050,488**
2	0	0	0	0	3	**3**
3	0	0	3	0	41	**44**
4	415	115	332	874	522	**2,258**
5	0	0	0	0	0	**0**
6	3,034,401	1,808,225	1,155,761	342,031	1,867,407	**8,207,825**
7	5,074,660	4,237,335	5,879,564	6,414,372	24,175,531	**45,781,462**
8	521,826	1,486,067	3,451,977	4,067,886	20,954,331	**30,482,087**
9	140,305	252,951	663,664	444,245	7,046,900	**8,548,065**
10	1,736	3,905	11,540	21,935	279,892	**319,008**
11	0	0	0	0	0	**0**
12	0	0	0	0	0	**0**
13	0	0	0	0	0	**0**
14	0	0	0	0	0	**0**
15	0	0	0	0	0	**0**
16	0	0	0	0	11,447	**11,447**
TOTAL	**17,823,819**	**7,788,598**	**11,662,323**	**11,333,338**	**74,794,609**	**123,402,687**

Source: Unconsolidated financial statements as of 31 December 2012, February 2013, p: 82.

Using the distribution of maturity risk factors according to their outstanding maturities, maturity rates are calculated.

x_{ik} = the amount of assets of each risk class i and outstanding maturities k

p_{ik} = maturity rate of the amount of assets of each risk class i and outstanding maturities k

$$p_{ik} = {}^{x_{ik}}\Big/_{\sum_{k'=1}^{K} x_{ik'}}, \; k'=1,2,\ldots,K, \; i=1,2,,,,,16, \; k=1,2,..,5 \qquad \textbf{(4.11)}$$

where, K denotes the number of maturities.

Moreover, it is assumed that each risk categories are in the same month as up to 1 month, 1-3 months, 3-6 months, 6-12 months and 1 year and over. Then, average maturities of up to 1 month, 1-3 months, 3-6 months, 6-12 months and 1 year and over are assumed respectively 0.5, 2, 4.5, 9 and 18 months and average maturities are the same for each bank.

Banks' maturity rates of outstanding amount according to maturities of each risk classification and average maturities are calculated. These are shown in the Table 4.13, Table 4.14 and Table 4.15 below:

Table 4.13: Maturity rates of outstanding amount according to maturities of each risk classification of Vakıfbank

month	0.5	2.0	4.5	9.0	18.0
p_{ik}	up to 1 month	1-3 months	3-6 months	6-12 months	1 year and over
1	0.07%	0.01%	0.01%	0.00%	99.90%
2	8.67%	0.79%	1.07%	5.50%	83.97%
3	31.17%	3.04%	4.76%	12.22%	48.82%
4	0.00%	0.00%	0.00%	0.00%	0.00%
5	0.00%	0.00%	0.00%	0.00%	0.00%
6	13.55%	1.61%	2.26%	2.11%	80.48%
7	23.81%	8.48%	9.72%	18.41%	39.57%
8	3.07%	1.57%	1.96%	4.00%	89.40%
9	11.98%	4.39%	6.21%	14.23%	63.19%
10	0.00%	0.00%	0.00%	0.00%	100.00%
11	0.00%	0.00%	0.00%	0.00%	100.00%
12	0.00%	0.00%	0.00%	0.00%	0.00%
13	0.00%	0.00%	0.00%	0.00%	0.00%
14	0.00%	0.00%	0.00%	0.00%	0.00%
15	0.00%	0.00%	0.00%	0.00%	0.00%
16	0.00%	0.00%	0.00%	0.00%	100.00%

Table 4.14: Maturity rates of outstanding amount according to maturities of each risk classification of Akbank

month	0.5	2.0	4.5	9.0	18.0
p_{ik}	up to 1 month	1-3 months	3-6 months	6-12 months	1 year and over
1	7.86%	24.29%	3.63%	3.52%	60.71%
2	0.00%	0.00%	0.00%	0.00%	100.00%
3	34.15%	24.45%	0.25%	1.22%	39.93%
4	0.00%	0.00%	0.00%	0.00%	0.00%
5	0.00%	0.00%	0.00%	0.00%	0.00%
6	40.17%	29.02%	5.67%	6.54%	18.60%
7	9.03%	11.73%	11.78%	15.84%	51.62%
8	1.40%	2.07%	38.65%	10.22%	47.66%
9	0.73%	1.98%	3.97%	10.11%	83.21%
10	0.00%	0.00%	0.00%	0.00%	100.00%
11	0.00%	0.00%	0.00%	13.34%	86.66%
12	0.00%	0.00%	0.00%	0.00%	0.00%
13	0.00%	0.00%	0.00%	0.00%	0.00%
14	0.00%	0.00%	0.00%	0.00%	0.00%
15	0.00%	100.00%	0.00%	0.00%	0.00%
16	0.00%	0.00%	0.00%	0.00%	100.00%

Table 4.15: Maturity rates of outstanding amount according to maturities of each risk classification of YKB

month	0.5	2.0	4.5	9.0	18.0
p_{ik}	up to 1 month	1-3 months	3-6 months	6-12 months	1 year and over
1	30.12%	0.00%	1.66%	0.14%	68.08%
2	0.00%	0.00%	0.00%	0.00%	100.00%
3	0.00%	0.00%	6.82%	0.00%	93.18%
4	18.38%	5.09%	14.70%	38.71%	23.12%
5	0.00%	0.00%	0.00%	0.00%	0.00%
6	36.97%	22.03%	14.08%	4.17%	22.75%
7	11.08%	9.26%	12.84%	14.01%	52.81%
8	1.71%	4.88%	11.32%	13.35%	68.74%
9	1.64%	2.96%	7.76%	5.20%	82.44%
10	0.54%	1.22%	3.62%	6.88%	87.74%
11	0.00%	0.00%	0.00%	0.00%	0.00%
12	0.00%	0.00%	0.00%	0.00%	0.00%
13	0.00%	0.00%	0.00%	0.00%	0.00%
14	0.00%	0.00%	0.00%	0.00%	0.00%
15	0.00%	0.00%	0.00%	0.00%	0.00%
16	0.00%	0.00%	0.00%	0.00%	100.00%

In order to find average maturity for each risk class, average maturities are multiplied with corresponding to their maturity rates. Average maturities for each risk class are calculated individually using table of maturity rates of outstanding amount according to maturities of each risk classification by the formula below:

$$m_i = (p_{i1} * 0.5 + p_{i2} * 2 + p_{i3} * 4.5 + p_{i4} * 9 + p_{i5} * 18), \text{ for } i=1,..,16 \quad \textbf{(4.12)}$$

where, m_i is the average maturity of bank for each risk classification.

Summation of risk weight amount of each risk category is calculated using table of information related to capital adequacy ratio by using the formula below:

$$(x_{i1} + x_{i2} + x_{i3} + x_{i4} + x_{i5} + x_{i6} + x_{i7}), \text{ for } i=1,2,\ldots,16 \quad \textbf{(4.13)}$$

Average maturities for each risk category are multiplied with summation of risk weigh amounts corresponding to each risk category and they are all summed as shown the formula below:

$$\sum_{i=1}^{16}(m_i * (x_{i1} + x_{i2} + x_{i3} + x_{i4} + x_{i5} + x_{i6} + x_{i7})) \quad \textbf{(4.14)}$$

Average maturity of receivables is found for each bank by dividing the above formula to total assets as shown the formula below:

$$\sum_{i=1}^{16}(m_i * (x_{i1} + x_{i2} + x_{i3} + x_{i4} + x_{i5} + x_{i6} + x_{i7}))/\sum_{i=1}^{16}\sum_{j=1}^{7} x_{ij} \quad \textbf{(4.15)}$$

In order to find average maturities of banks' liabilities, banks' data is used and the noninterest bearing from months is excluded. Average maturities of up to 1 month, 1-3 months, 3-12 months, 1-5 years and 5 years and over are assumed respectively 0.5, 2, 7.5, 18 and 72 months and the same for each bank.

Total liabilities end of 31 December 2012 are used and Table 4.16, Table 4.17 and Table 4.18 show the details.

Table 4.16: Total liabilities of Vakıfbank

Average Maturities	0.5	2	7.5	18	72
Total Liabilities	45,880,159	19,875,364	7,988,262	1,028,089	1,826,435

Source: Unconsolidated financial statements as at and for the year ended 31 December 2012, February 2013, p: 37.

Table 4.17: Total liabilities of Akbank

Average Maturities	0.5	2	7.5	18	72
Total Liabilities	71,809,205	21,130,178	12,913,799	4,372,939	4,567,290

Source: Unconsolidated financial report as of 31 December 2012, February 2013, p: 39.

Table 4.18: Total liabilities of YKB

Average Maturities	0.5	2	7.5	18	72
Total Liabilities	46,113,688	22,048,820	10,070,466	2,337,290	2,369,355

Source: Unconsolidated financial statements as of 31 December 2012, February 2013, p: 88.

Amount of liability is multiplied with its average maturity and summation of multiplication of amount of liability and average maturity is divided by summation of amount of liabilities as below formula:

$$\sum_{i=1}^{5}(l_i * m_i^l)/\sum_{i=1}^{5} l_i, \quad i,l = 1,2,..,5 \qquad \textbf{(4.16)}$$

where l_i is the amount of liabilities and m_i^l is average maturity of each amount of liability.

One year requirement is put with adding twelve months to equation in order to create one year interest date and average maturity of liabilities for each bank is found.

$$\sum_{i=1}^{5}(l_i * m_i^l)/\sum_{i=1}^{5} l_i + 12 \quad \textbf{(4.17)}$$

Because, we don't invest our money in the long run. If we invest, interest rate risk is increased. Therefore, I put the one year requirement with adding twelve months and average maturity of liabilities for each bank is found by the formula below.

Average maturity of receivables should be less than or equal to average maturity of liabilities and interest rate constraint is found.

$$\sum_{i=1}^{16}(m_i * (x_{i1} + x_{i2} + x_{i3} + x_{i4} + x_{i5} + x_{i6} + x_{i7}))/\sum_{i=1}^{16}\sum_{j=1}^{7} x_{ij} \leq \sum_{i=1}^{5}(l_i * m_i^l)/\sum_{i=1}^{5} l_i + 12 \quad \textbf{(4.18)}$$

Maturity of assets and liability can not be equal for liquidity. As the difference gets smaller between them, interest rate risk decreases. Hence, it is assumed that the difference is one year.

4.3 Mathematical Model

A linear programming model takes the folllowing form after the constraints are identified.

$$\text{Maximize } E(R) = \sum_{i=1}^{16}\sum_{j=1}^{7} x_{ij}\, r_{ij} \quad \textbf{(4.19)}$$

Subject to:

$$(\sum_{i=1}^{n} x_{i1}*0\% + \sum_{i=1}^{n} x_{i2}*20\% + \sum_{i=1}^{n} x_{i3}*50\% + \sum_{i=1}^{n} x_{i4}*75\% + \sum_{i=1}^{n} x_{i5}*100\% + \sum_{i=1}^{n} x_{i6}*150\% + \sum_{i=1}^{n} x_{i7}*200\%)*0.08 \leq \sum_{j=1}^{7} x_{1j} \quad \textbf{(4.20)}$$

$$\sum_{j\neq 4} x_{8j} = 0 \quad \textbf{(4.21)}$$

$$\sum_{i=1}^{16}\sum_{j=1}^{7} x_{ij} = \text{bank's total asset} \quad \textbf{(4.22)}$$

$$\sum_{j=1}^{J} x_{ij}/\text{total asset} \leq \max_i \quad \text{for all } i = 1,\ldots,16 \quad \textbf{(4.23)}$$

$$\sum_{j=1}^{J} x_{ij}/\text{total asset} \geq \min_i \quad \text{for all } i = 1,\ldots,16 \quad \textbf{(4.24)}$$

$$\sum_{i=1}^{16}(m_i * (x_{i1} + x_{i2} + x_{i3} + x_{i4} + x_{i5} + x_{i6} + x_{i7}))/\sum_{i=1}^{16}\sum_{j=1}^{7} x_{ij} \leq \sum_{i=1}^{5}(l_i * m_i^l)/\sum_{i=1}^{5} l_i + 12 \quad \textbf{(4.25)}$$

$$x_{ij} \geq 0 \quad \textbf{(4.26)}$$

5. RESULTS AND EVALUATION

This chapter contains the results of this thesis. After all constraints and optimality conditions are satisfied, optimization model is solved with excel solver to find optimal allocation of assets, computational results are obtained and profitability is analyzed.

Table 5.1 show the opimized values of the amount of receivables of each risk class i and risk weight j for Vakıfbank after the solving model.

Table 5.1: Optimized values of the amount of receivables for Vakıfbank

	0%	20%	50%	75%	100%	150%	200%	
x_{ij}	1	2	3	4	5	6	7	**TOTAL**
1	0	0	14,050,600	0	0	0	0	**14,050,600**
2	0	0	1,246,963	0	0	0	0	**1,246,963**
3	0	0	0	0	0	0	0	**0**
4	0	0	0	0	0	0	0	**0**
5	0	0	0	0	0	0	0	**0**
6	0	0	0	0	6,234,815	0	0	**6,234,815**
7	12,469,629	0	0	0	0	0	0	**12,469,629**
8	0	0	0	6,234,815	0	0	0	**6,234,815**
9	0	0	6,234,815	0	0	0	0	**6,234,815**
10	0	0	0	0	0	0	0	**0**
11	0	0	0	0	0	0	76,977,692	**76,977,692**
12	0	0	0	0	0	0	0	**0**
13	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	**0**
16	1,246,963	0	0	0	0	0	0	**1,246,963**
TOTAL	**13,716,592**	**0**	**21,532,377**	**6,234,815**	**6,234,815**	**0**	**76,977,692**	**124,696,290**

Table 5.2 show the orginal values before solving the model and the optimized values of the expected return and the constraints after solving the model for Vakıfbank.

Table 5.2: Orginal and optimized values of the expected return and constraints for Vakıfbank

	Original value	Optimized value
Return	10,081,523	15,635,770
RWA	75,862,670	175,632,497
Market risk	6,069,014 $\leq$ 32,528,026	14,050,600 $\leq$ 14,050,600
Interest rate risk	15 $\leq$ 16	16 $\leq$ 16

Table 5.3 show the results of orginal values before solving the model and the optimized values of the expected return and the constraints after solving the model, if one and a half year is added to average maturity of liability for Vakıfbank.

Table 5.3: Orginal and optimized values of the expected return and constraints for eighteen months for Vakıfbank

	Original value	Optimized value
Return	10,081,523	15,635,770
RWA	75,862,670	175,632,497
Market risk	6,069,014 $\leq$ 32,528,026	14,050,600 $\leq$ 14,050,600
Interest rate risk	15 $\leq$ 22	17 $\leq$ 22

Table 5.4 show the opimized values of the amount of receivables of each risk class i and risk weight j for Akbank after the solving model.

Table 5.4: Optimized values of the amount of receivables for Akbank

	0%	20%	50%	75%	100%	150%	200%	
x_{ij}	1	2	3	4	5	6	7	**TOTAL**
1	0	0	20,433,856	0	0	0	0	**20,433,856**
2	0	0	0	0	0	0	0	**0**
3	0	0	0	0	0	0	0	**0**
4	0	0	0	0	0	0	0	**0**
5	0	0	0	0	0	0	0	**0**
6	0	0	0	0	8,870,511	0	0	**8,870,511**
7	17,741,022	0	0	0	0	0	0	**17,741,022**
8	0	0	0	8,870,511	0	0	0	**8,870,511**
9	0	0	8,870,511	0	0	0	0	**8,870,511**
10	0	0	0	0	0	0	0	**0**
11	0	0	0	0	0	0	112,623,811	**112,623,811**
12	0	0	0	0	0	0	0	**0**
13	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	**0**
16	0	0	0	0	0	0	0	**0**
TOTAL	**17,741,022**	**0**	**29,304,367**	**8,870,511**	**8,870,511**	**0**	**112,623,811**	**177,410,222**

Table 5.5 show the orginal values before solving the model and the optimized values of the expected return and the constraints after solving the model for Akbank.

Table 5.5: Orginal and optimized values of the expected return and constraints for Akbank

	Original value	Optimized value
Return	13,647,138	23,046,728
RWA	107,921,849	255,423,199
Market risk	$8,633,748 \leq 59,266,866$	$20,433,856 \leq 20,433,856$
Interest rate risk	$12 \leq 17$	$15 \leq 17$

Table 5.6 show the results of orginal values before solving the model and the optimized values of the expected return and the constraints after solving the model, if one and a half year is added to average maturity of liability for Akbank.

Table 5.6: Orginal and optimized values of the expected return and constraints for eighteen months for Akbank

	Original value	Optimized value
Return	13,647,138	23,046,728
RWA	107,921,849	255,423,199
Market risk	8,633,748 $\leq$ 59,266,866	20,433,856 $\leq$ 20,433,856
Interest rate risk	12 $\leq$ 23	15 $\leq$ 23

Table 5.7 show the results of orginal values before solving the model and the optimized values of the expected return and the constraints after solving the model, if nine months is added to average maturity of liability for Akbank.

Table 5.7: Orginal and optimized values of the expected return and constraints for nine months for Akbank

	Original value	Optimized value
Return	13,647,138	22,354,181
RWA	107,921,849	245,281,632
Market risk	8,633,748 $\leq$ 59,266,866	19,622,531 $\leq$ 19,622,531
Interest rate risk	12 $\leq$ 14	14 $\leq$ 14

Table 5.8 show the opimized values of the amount of receivables of each risk class i and risk weight j for YKB after the solving model.

Table 5.8: Optimized values of the amount of receivables for YKB

	0%	20%	50%	75%	100%	150%	200%	
x_{ij}	1	2	3	4	5	6	7	**TOTAL**
1	0	0	14,872,451	0	0	0	0	**14,872,451**
2	0	0	0	0	0	0	0	**0**
3	0	0	0	0	0	0	0	**0**
4	0	0	0	0	0	0	0	**0**
5	0	0	0	0	0	0	0	**0**
6	0	0	0	0	7,436,226	0	0	**7,436,226**
7	0	0	0	0	14,872,451	0	0	**14,872,451**
8	0	0	0	7,436,226	0	0	0	**7,436,226**
9	0	0	7,436,226	0	0	0	0	**7,436,226**
10	0	0	0	0	0	95,183,688	0	**95,183,688**
11	0	0	0	0	0	1,487,245	0	**1,487,245**
12	0	0	0	0	0	0	0	**0**
13	0	0	0	0	0	0	0	**0**
14	0	0	0	0	0	0	0	**0**
15	0	0	0	0	0	0	0	**0**
16	0	0	0	0	0	0	0	**0**
TOTAL	**0**	**0**	**22,308,677**	**7,436,226**	**22,308,677**	**96,670,933**	**0**	**148,724,512**

Table 5.9 show the orginal values before solving the model and the optimized values of the expected return and the constraints after solving the model for YKB.

Table 5.9: Orginal and optimized values of the expected return and constraints for YKB

	Original value	Optimized value
Return	11,958,073	18,748,952
RWA	107,990,743	185,905,640
Market risk	8,639,259 $\leq$ 31,577,744	14,872,451 $\leq$ 14,872,451
Interest rate risk	12 $\leq$ 16	15 $\leq$ 16

Table 5.10 show the results of orginal values before solving the model and the optimized values of the expected return and the constraints after solving the model, if one and a half year is added to average maturity of liability for Vakıfbank.

Table 5.10: Orginal and optimized values of the expected return and constraints for eighteen months for YKB

	Original value	Optimized value
Return	11,958,073	18,748,952
RWA	107,990,743	184,046,584
Market risk	8,639,259 $\leq$ 31,577,744	14,723,727 $\leq$ 14,872,451
Interest rate risk	12 $\leq$ 22	15 $\leq$ 22

Table 5.11 show the results of orginal values before solving the model and the optimized values of the expected return and the constraints after solving the model, if nine months is added to average maturity of liability for YKB.

Table 5.11: Orginal and optimized values of the expected return and constraints for nine months for YKB

	Original value	Optimized value
Return	11,958,073	18,748,952
RWA	107,990,743	184,046,584
Market risk	8,639,259 $\leq$ 31,577,744	14,723,727 $\leq$ 14,872,451
Interest rate risk	12 $\leq$ 13	4 $\leq$ 13

For analyzing profitability, return rates of amount of receivables are altered and other parameters and decision variables are remained constant by taking into consideration of original values of amount of receivables. Return rates are changed between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) randomly with uniform distribution before solving the model. Asset allocation of each bank before optimization is found by changing return rates and model is solved. Asset allocation is found after optimization for each interval of return rates. Asset allocation before and after optimization is found twenty times for return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1). Asset allocation before and after optimization and increase of profit after new asset allocation are shown in Table 5.12, Table 5.13, Table 5.14 and Table 5.15 for return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) for Akbank. It is observed that expected returns are increased almost with the same rates in accordance with changing of return

rates for each interval and increase of profit after new asset allocation is found for twenty samples for each bank. It is noted that each of the following results are for different random instances.

Table 5.12: Asset allocation for return rates between (r_{ij}, r_{ij}+1) for Akbank

asset allocation of bank before optimization	asset allocation of bank after optimization	increase of profit after new asset allocation
14,659,263	24,312,805	9,653,542
15,009,888	25,516,767	10,506,879
14,657,568	24,386,553	9,728,985
14,360,028	24,193,035	9,833,007
14,112,921	24,399,699	10,286,778
14,763,573	23,841,805	9,078,232
14,603,831	24,195,519	9,591,688
14,769,746	24,336,669	9,566,923
14,477,642	24,513,161	10,035,519
14,258,702	23,874,497	9,615,795
14,736,835	23,804,016	9,067,181
14,543,768	23,612,071	9,068,303
14,037,876	23,762,826	9,724,950
14,048,424	23,632,501	9,584,077
15,203,927	24,406,420	9,202,493
14,786,092	24,137,573	9,351,481
14,552,743	23,762,155	9,209,412
14,470,897	24,013,916	9,543,019
14,879,382	24,334,033	9,454,651
14,874,622	24,531,002	9,656,380

According to Table 5.12, it is observed that average increase in profit is 9,587,965 thousand TL.

Table 5.13: Asset allocation for return rates between (r_{ij}-1, r_{ij}) for Akbank

asset allocation of bank before optimization	asset allocation of bank after optimization	increase of profit after new asset allocation
13,070,658	23,669,468	10,598,810
12,959,378	22,240,670	9,281,292
12,989,302	22,509,946	9,520,644
12,772,921	21,745,206	8,972,285
12,619,358	21,755,210	9,135,852
13,088,376	21,820,323	8,731,947
12,387,181	22,564,025	10,176,844
12,808,257	22,506,470	9,698,213
13,088,838	22,701,258	9,612,420
12,777,668	22,120,304	9,342,636
13,002,948	22,643,285	9,640,337
12,543,268	21,799,880	9,256,612
13,103,751	21,916,625	8,812,874
12,636,541	22,656,783	10,020,242
13,191,760	22,633,849	9,442,089
12,249,035	21,681,860	9,432,825
12,587,745	22,152,398	9,564,653
12,317,478	21,888,361	9,570,883
12,594,812	22,287,587	9,692,775
13,365,210	22,055,581	8,690,371

According to Table 5.13, it is observed that average increase is 9,459,730 thousand TL.

Table 5.14: Asset allocation for return rates between (r_{ij}, r_{ij}+0.5) for Akbank

asset allocation of bank before optimization	asset allocation of bank after optimization	increase of profit after new asset allocation
14,091,504	23,679,407	9,587,903
14,040,141	23,601,296	9,561,155
13,997,772	23,622,845	9,625,073
13,805,844	23,398,320	9,592,476
14,264,813	23,526,764	9,261,951
14,382,976	23,533,329	9,150,353
13,992,948	23,528,901	9,535,953
14,140,121	23,513,824	9,373,703
14,137,933	23,313,414	9,175,481
14,039,606	23,531,433	9,491,827
14,159,847	23,349,753	9,189,906
13,965,921	23,462,945	9,497,024
13,807,179	23,609,254	9,802,075
14,004,798	23,389,037	9,384,239
13,998,241	23,376,789	9,378,548
14,212,249	23,295,493	9,083,244
13,972,600	23,258,334	9,285,734
14,241,023	23,251,802	9,010,779
14,044,702	23,679,441	9,634,739
14,262,042	23,502,313	9,240,271

According to Table 5.14, it is observed that average increase is 9,393,122 thousand TL.

Table 5.15: Asset allocation for return rates between (r_{ij}-0.5, r_{ij}) for Akbank

asset allocation of bank before optimization	asset allocation of bank after optimization	increase of profit after new asset allocation
13,364,987	22,710,252	9,345,265
13,315,175	22,458,129	9,142,954
13,072,000	22,472,752	9,400,752
13,018,780	22,797,354	9,778,574
13,140,709	22,465,917	9,325,208
12,988,491	22,368,068	9,379,577
13,256,025	22,609,861	9,353,836
12,995,485	22,370,481	9,374,996
13,356,224	22,630,951	9,274,727
13,157,364	22,305,044	9,147,680
13,044,163	22,479,842	9,435,679
13,207,765	22,425,298	9,217,533
13,322,914	22,759,678	9,436,764
13,269,629	22,875,481	9,605,852
12,967,391	22,686,761	9,719,370
13,300,764	22,774,633	9,473,869
13,223,439	22,537,406	9,313,967
13,066,359	22,378,137	9,311,778
13,210,303	22,565,460	9,355,157
13,198,703	22,836,681	9,637,978

According to Table 5.15, it is observed that average increase is 9,401,576 thousand TL.

For analyzing profitability, the return rates are altered and other parameters and decision variables are remained constant by taking into consideration of optimized values of amount of receivables. Return rates are changed between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) randomly with uniform distribution before solving the model. Asset allocation of each bank solved with initial parameter is found by changing return rates and model is solved. Asset allocation of each bank solved with new parameter is

found after optimization for each interval of return rates. Asset allocation before and after optimization is found twenty times for return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1).Asset allocation of bank solved with initial and new parameters and increase in profit after new asset allocation are shown in Table 5.16, Table 5.17, Table 5.18 and Table 5.19 for return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) for Akbank. It is observed that expected returns are not increased substantially in accordance with changing of return rates for each interval and increase of profit after new asset allocation is found for twenty samples for each bank. It is noted that each of the following results are for different random instances.

Table 5.16: Asset allocation solved with initial and new parameters for return rates between (r_{ij}, r_{ij}+1) for Akbank

asset allocation of bank solved with initial parameters	asset allocation of bank solved with new parameters	increase in profit after new asset allocation
23,364,134	23,417,536	53,402
24,317,654	24,420,326	102,672
24,276,318	24,277,882	1,564
23,458,783	23,459,184	401
24,026,446	24,046,474	20,028
23,815,300	23,856,135	40,835
24,509,637	24,509,637	0
23,658,245	23,722,426	64,181
23,631,396	23,723,754	92,358
24,205,202	24,272,104	66,902
24,009,519	24,009,519	0
23,750,200	23,750,200	0
24,052,748	24,087,298	34,550
24,199,129	24,199,129	0
23,980,661	24,024,771	44,110
23,911,073	24,001,723	90,650
23,921,661	24,008,695	87,034
24,436,873	24,443,749	6,876
24,377,054	24,469,870	92,816
24,002,662	24,002,662	0

According to Table 5.16, it is observed that average increase is 39,919 thousand TL.

Table 5.17: Asset allocation solved with initial and new parameters for return rates between (r_{ij}-1, r_{ij}) for Akbank

asset allocation of bank solved with initial parameters	asset allocation of bank solved with new parameters	increase in profit after new asset allocation
22,689,178	22,697,101	7,923
21,810,506	21,817,880	7,374
22,655,164	22,713,288	58,124
22,192,401	22,192,401	0
22,562,256	22,606,564	44,308
22,112,408	22,140,331	27,923
21,896,692	21,896,692	0
22,389,121	22,406,830	17,709
22,203,839	22,263,729	59,890
21,860,422	21,897,140	36,718
21,947,183	22,056,780	109,597
22,159,689	22,193,241	33,552
21,563,788	21,710,720	146,932
22,198,818	22,239,319	40,501
21,957,272	21,957,272	0
22,499,446	22,571,017	71,571
22,138,545	22,175,312	36,767
23,046,728	23,046,728	0
22,718,308	22,737,874	19,566
22,068,312	22,154,390	86,078

According to Table 5.17, it is observed that average increase is 40,227 thousand TL.

Table 5.18: Asset allocation solved with initial and new parameters for return rates between (r_{ij}, r_{ij}+0.5) for Akbank

asset allocation of bank solved with initial parameters	asset allocation of bank solved with new parameters	increase in profit after new asset allocation
23,352,362	23,353,534	1,172
23,306,073	23,333,334	27,261
23,321,346	23,321,346	0
23,228,797	23,228,797	0
23,382,520	23,410,860	28,340
23,293,451	23,323,846	30,395
23,492,577	23,493,376	799
23,714,755	23,724,894	10,139
23,720,516	23,720,516	0
23,763,198	23,764,757	1,559
23,528,366	23,528,366	0
23,750,096	23,760,388	10,292
23,393,937	23,393,937	0
23,498,697	23,498,817	120
23,698,469	23,698,469	0
23,352,104	23,352,104	0
23,601,543	23,623,987	22,444
23,502,562	23,506,403	3,841
23,355,429	23,372,081	16,652
23,761,566	23,762,261	695

According to Table 5.18, it is observed that average increase is 6,685 thousand TL.

Table 5.19: Asset allocation solved with initial and new parameters for return rates between (r_{ij}-0.5, r_{ij}) for Akbank

asset allocation of bank solved with initial parameters	asset allocation of bank solved with new parameters	increase in profit after new asset allocation
22,693,366	22,693,366	0
22,444,465	22,470,272	25,807
22,715,398	22,721,802	6,404
22,408,191	22,408,191	0
22,891,026	22,891,026	0
22,358,167	22,373,489	15,322
22,671,118	22,685,317	14,199
22,818,783	22,818,783	0
22,264,347	22,280,451	16,104
22,654,149	22,660,110	5,961
22,690,358	22,716,490	26,132
22,402,945	22,402,945	0
22,806,963	22,813,066	6,103
22,743,350	22,743,350	0
22,374,409	22,399,240	24,831
22,490,171	22,490,171	0
22,745,322	22,769,385	24,063
22,523,341	22,534,342	11,001
22,730,935	22,745,077	14,142
22,775,157	22,778,208	3,051

According to Table 5.19, it is observed that average increase is 9,656 thousand TL.

Asset allocation before and after optimization and increase in profit after new asset allocation are shown in Table 5.20, Table 5.21, Table 5.22 and Table 5.23 for return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) for YKB.

Table 5.20: Asset allocation for return rates between (r_{ij}, r_{ij}+1) for YKB

asset allocation of bank before optimization	asset allocation of bank after optimization	increase in profit after new asset allocation
12,510,132	19,440,410	6,930,278
12,792,528	19,614,960	6,822,432
13,066,676	19,896,488	6,829,812
12,596,623	19,173,538	6,576,915
12,770,663	19,400,385	6,629,722
12,959,692	19,964,583	7,004,891
12,740,390	19,666,270	6,925,880
12,419,300	19,878,746	7,459,446
13,017,292	19,993,247	6,975,955
12,765,779	19,586,970	6,821,191
12,736,881	19,727,665	6,990,784
12,500,815	19,618,394	7,117,579
12,736,377	19,707,626	6,971,249
12,965,047	20,017,439	7,052,392
12,775,263	19,589,269	6,814,006
12,929,312	19,758,102	6,828,790
12,626,772	19,594,872	6,968,100
12,991,342	19,920,990	6,929,648
13,009,218	19,863,725	6,854,507
12,567,192	19,841,527	7,274,335

According to Table 5.20, it is observed that average increase is 6,938,896 thousand TL.

Table 5.21: Asset allocation for return rates between (r_{ij}-1, r_{ij}) for YKB

asset allocation of bank before optimization	asset allocation of bank after optimization	increase in profit after new asset allocation
11,076,519	17,722,878	6,646,359
10,931,797	17,720,881	6,789,084
11,315,809	18,221,508	6,905,699
11,621,067	18,263,788	6,642,721
10,954,299	17,516,758	6,562,459
10,995,217	18,194,405	7,199,188
11,132,533	17,737,179	6,604,646
11,110,255	18,363,420	7,253,165
11,395,745	18,364,777	6,969,032
10,959,916	18,225,240	7,265,324
11,634,496	18,349,766	6,715,270
11,357,855	18,234,945	6,877,090
10,930,131	18,413,996	7,483,865
11,098,318	18,302,062	7,203,744
10,767,283	18,025,110	7,257,827
11,338,486	18,169,148	6,830,662
10,927,725	18,014,847	7,087,122
11,551,577	18,399,963	6,848,386
10,948,399	18,364,091	7,415,692
11,243,274	17,629,392	6,386,118

According to Table 5.21, it is observed that average increase is 6,947,173 thousand TL.

Table 5.22: Asset allocation for return rates between (r_{ij}, r_{ij}+0.5) for YKB

asset allocation of bank before optimization	asset allocation of bank after optimization	increase in profit after new asset allocation
12,131,482	18,957,981	6,826,499
12,395,959	19,415,856	7,019,897
12,174,944	19,136,615	6,961,671
12,394,839	18,993,116	6,598,277
12,262,355	19,058,942	6,796,587
12,286,167	19,060,975	6,774,808
12,422,575	19,342,376	6,919,801
12,382,976	18,976,180	6,593,204
12,164,434	19,303,440	7,139,006
12,382,953	19,401,305	7,018,352
12,518,384	19,308,708	6,790,324
12,301,797	19,318,697	7,016,900
12,417,995	19,038,921	6,620,926
12,210,613	19,231,383	7,020,770
12,316,073	19,166,361	6,850,288
12,374,028	19,046,634	6,672,606
12,187,402	19,263,981	7,076,579
12,461,057	19,327,135	6,866,078
12,395,756	19,279,062	6,883,306
12,422,933	19,263,136	6,840,203

According to Table 5.22, it is observed that average increase is 6,864,304 thousand TL.

Table 5.23: Asset allocation for return rates between (r_{ij}-0.5, r_{ij}) for YKB

asset allocation of bank before optimization	asset allocation of bank after optimization	increase in profit after new asset allocation
11,719,125	18,639,499	6,920,374
11,732,353	18,656,533	6,924,180
11,661,586	18,300,731	6,639,145
11,464,507	18,533,206	7,068,699
11,547,214	18,571,490	7,024,276
11,547,437	18,453,770	6,906,333
11,476,037	18,450,844	6,974,807
11,616,739	18,577,419	6,960,680
11,443,022	18,530,919	7,087,897
11,616,670	18,480,137	6,863,467
11,451,778	18,247,006	6,795,228
11,582,053	18,475,351	6,893,298
11,782,526	18,392,464	6,609,938
11,562,217	18,565,638	7,003,421
11,700,423	18,518,896	6,818,473
11,481,691	18,441,756	6,960,065
11,757,715	18,291,158	6,533,443
11,549,808	18,478,976	6,929,168
11,467,184	18,370,008	6,902,824
11,674,021	18,309,231	6,635,210

According to Table 5.23, it is observed that average increase is 6,872,546 thousand TL.

Asset allocation of bank solved with initial and new parameters and increase of profit after new asset allocation are shown inTable 5.24, Table 5.25, Table 5.26 and Table 5.27 for return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) for YKB.

Table 5.24: Asset allocation solved with initial and new parameters for return rates between (r_{ij}, r_{ij}+1) for YKB

asset allocation of bank solved with initial parameters	asset allocation of bank solved with new parameters	increase in profit after new asset allocation
19,723,163	19,780,977	57,814
19,969,443	19,969,443	0
19,973,980	19,983,666	9,686
19,168,869	19,850,885	682,016
19,369,821	19,459,285	89,464
19,039,572	19,328,830	289,258
19,141,228	19,804,077	662,849
19,711,187	19,912,799	201,612
19,341,929	19,487,695	145,766
19,147,963	19,550,958	402,995
19,737,482	19,738,291	809
19,827,798	19,893,330	65,532
19,493,017	19,493,017	0
19,774,772	19,900,719	125,947
19,860,128	19,860,128	0
19,747,175	19,752,455	5,280
19,453,475	19,547,182	93,707
19,173,515	19,979,678	806,163
19,509,465	19,523,369	13,904
19,189,899	19,378,670	188,771

According to Table 5.24, it is observed that average increase is 192,079 thousand TL.

Table 5.25: Asset allocation solved with initial and new parameters for return rates between (r_{ij}-1, r_{ij}) for YKB

asset allocation of bank solved with initial parameters	asset allocation of bank solved with new parameters	increase in profit after new asset allocation
18,434,054	18,444,588	10,534
17,974,429	17,994,371	19,942
18,313,323	18,313,323	0
17,807,947	18,106,163	298,216
17,642,618	18,046,435	403,817
17,848,953	17,848,953	0
18,167,494	18,167,494	0
17,967,438	18,507,627	540,189
18,476,878	18,481,394	4,516
18,373,180	18,373,180	0
17,810,016	18,052,158	242,142
18,077,204	18,079,512	2,308
18,475,945	18,475,945	0
17,809,621	18,299,040	489,419
18,457,595	18,457,595	0
17,654,753	17,665,656	10,903
18,312,335	18,321,564	9,229
17,712,562	17,909,978	197,416
18,334,501	18,340,375	5,874
18,255,092	18,257,517	2,425

According to Table 5.25, it is observed that average increase is 111,847 thousand TL.

Table 5.26: Asset allocation solved with initial and new parameters for return rates between (r_{ij}, r_{ij}+0.5) for YKB

asset allocation of bank solved with initial parameters	asset allocation of bank solved with new parameters	increase in profit after new asset allocation
19,327,819	19,327,819	0
19,255,689	19,273,403	17,714
19,309,812	19,312,697	2,885
19,271,850	19,273,930	2,080
18,991,400	19,154,879	163,479
18,912,935	19,165,604	252,669
19,219,000	19,219,000	0
19,180,219	19,180,219	0
19,070,461	19,275,500	205,039
19,235,636	19,235,637	1
19,119,982	19,329,967	209,985
18,980,742	18,980,742	0
19,332,226	19,334,734	2,508
19,090,497	19,299,128	208,631
19,045,514	19,045,523	9
19,113,899	19,115,316	1,417
19,278,273	19,280,475	2,202
18,964,921	19,114,096	149,175
18,910,169	19,260,332	350,163
19,100,526	19,119,360	18,834

According to Table 5.26, it is observed that average increase is 79,340 thousand TL.

Table 5.27: Asset allocation solved with initial and new parameters for return rates between (r_{ij}-0.5, r_{ij}) for YKB

asset allocation of bank solved with initial parameters	asset allocation of bank solved with new parameters	increase in profit after new asset allocation
18,489,798	18,489,798	0
18,492,618	18,501,017	8,399
18,497,607	18,497,607	0
18,229,881	18,314,936	85,055
18,537,644	18,537,644	0
18,219,800	18,566,168	346,368
18,515,022	18,515,216	194
18,451,217	18,452,297	1,080
18,279,471	18,286,998	7,527
18,255,976	18,266,392	10,416
18,175,065	18,248,813	73,748
18,128,035	18,442,479	314,444
18,486,422	18,487,089	667
18,312,034	18,347,205	35,171
18,404,226	18,557,156	152,930
18,556,966	18,563,422	6,456
18,533,555	18,537,179	3,624
18,335,941	18,548,092	212,151
18,379,761	18,546,401	166,640
18,328,461	18,597,336	268,875

According to Table 5.27, it is observed that average increase is 84,687 thousand TL.

Asset allocation before and after optimization and increase in profit after new asset allocation are shown in Table 5.28, Table 5.29, Table 5.30 and Table 5.31 for return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) for Vakıfbank.

Table 5.28: Asset allocation for return rates between (r_{ij}, r_{ij}+1) for Vakıfbank

asset allocation of bank before optimization	asset allocation of bank after optimization	increase in profit after new asset allocation
10,819,404	16,422,825	5,603,421
10,738,988	15,955,888	5,216,900
11,043,071	16,603,007	5,559,936
10,650,463	16,382,362	5,731,899
10,820,188	16,369,322	5,549,134
10,664,147	16,406,061	5,741,914
10,914,145	16,383,639	5,469,494
10,730,599	16,105,520	5,374,921
10,959,823	16,640,694	5,680,871
10,527,400	16,201,488	5,674,088
10,733,993	16,475,980	5,741,987
10,548,905	16,084,759	5,535,854
10,857,524	16,508,397	5,650,873
10,578,448	16,119,501	5,541,053
10,696,282	16,104,420	5,408,138
10,811,585	16,576,271	5,764,686
10,705,986	16,592,020	5,886,034
10,852,875	16,480,021	5,627,146
10,751,991	16,546,987	5,794,996
11,013,147	16,425,300	5,412,153

According to Table 5.28, it is observed that average increase is 5,598,275 thousand TL.

Table 5.29: Asset allocation for return rates between (r_{ij}-1, r_{ij}) for Vakıfbank

asset allocation of bank before optimization	asset allocation of bank after optimization	increase in profit after new asset allocation
9,335,809	15,206,802	5,870,993
9,242,446	14,707,931	5,465,485
9,397,946	14,974,127	5,576,181
9,544,116	15,460,632	5,916,516
9,409,542	15,186,474	5,776,932
9,565,007	15,208,799	5,643,792
9,165,665	15,336,000	6,170,335
9,530,532	15,198,486	5,667,954
9,330,440	14,957,090	5,626,650
9,513,317	14,894,226	5,380,909
9,409,417	14,997,633	5,588,216
9,561,564	14,916,389	5,354,825
9,172,734	14,571,408	5,398,674
9,670,749	14,880,453	5,209,704
9,331,913	15,165,837	5,833,924
9,655,419	15,078,438	5,423,019
9,665,956	14,957,170	5,291,214
9,570,755	14,979,988	5,409,233
9,474,655	14,907,461	5,432,806
9,321,699	15,046,945	5,725,246

According to Table 5.29, it is observed that average increase is 5,588,130 thousand TL.

Table 5.30: Asset allocation for return rates between (r_{ij}, r_{ij}+0.5) for Vakıfbank

asset allocation of bank before optimization	asset allocation of bank after optimization	increase in profit after new asset allocation
10,414,068	16,037,893	5,623,825
10,425,529	15,845,667	5,420,138
10,395,848	15,870,057	5,474,209
10,397,191	15,976,236	5,579,045
10,453,153	15,985,600	5,532,447
10,409,175	15,870,009	5,460,834
10,496,343	15,985,022	5,488,679
10,326,219	15,946,963	5,620,744
10,421,160	15,861,476	5,440,316
10,440,400	16,036,577	5,596,177
10,337,171	15,953,941	5,616,770
10,406,814	16,074,901	5,668,087
10,521,551	16,067,528	5,545,977
10,478,557	16,003,524	5,524,967
10,406,050	16,085,140	5,679,090
10,318,175	15,902,989	5,584,814
10,417,983	15,841,893	5,423,910
10,475,347	16,118,347	5,643,000
10,286,723	16,078,472	5,791,749
10,364,919	15,986,590	5,621,671

According to Table 5.30, it is observed that average increase is 5,566,822 thousand TL.

Table 5.31: Asset allocation for return rates between (r_{ij}-0.5, r_{ij}) for Vakıfbank

asset allocation of bank before optimization	asset allocation of bank after optimization	increase in profit after new asset allocation
9,920,126	15,495,509	5,575,383
9,839,259	15,463,246	5,623,987
9,728,534	15,433,165	5,704,631
9,732,099	15,430,931	5,698,832
9,834,278	15,235,894	5,401,616
9,708,914	15,237,274	5,528,360
9,878,088	15,367,539	5,489,451
9,644,987	15,488,089	5,843,102
9,706,458	15,398,682	5,692,224
9,827,125	15,391,988	5,564,863
9,815,512	15,454,561	5,639,049
9,754,190	15,175,272	5,421,082
9,854,792	15,337,499	5,482,707
9,791,822	15,270,487	5,478,665
9,701,424	15,286,128	5,584,704
9,857,198	15,488,383	5,631,185
9,768,968	15,209,571	5,440,603
9,841,144	15,209,571	5,368,427
9,765,909	15,511,523	5,745,614
9,759,121	15,124,379	5,365,258

According to Table 5.31, it is observed that average increase is 5,563,987 thousand TL.

Asset allocation of bank solved with initial and new parameters and increase of profit after new asset allocation are shown in Table 5.32, Table 5.33, Table 5.34 and Table 5.35 for return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) for Vakıfbank.

Table 5.32: Asset allocation solved with initial and new parameters for return rates between (r_{ij}, r_{ij}+1) for Vakıfbank

asset allocation of bank solved with initial parameter	asset allocation of bank solved with new parameter	increase in profit after new asset allocation
16,624,409	16,653,216	28,807
16,602,266	16,613,262	10,996
16,527,904	16,527,904	0
16,001,301	16,034,779	33,478
16,165,243	16,240,978	75,735
15,927,202	16,032,268	105,066
16,330,409	16,348,072	17,663
16,561,149	16,587,103	25,954
16,006,002	16,421,456	415,454
16,319,182	16,377,075	57,893
16,522,178	16,548,589	26,411
15,993,254	16,359,532	366,278
15,841,236	15,927,780	86,544
16,099,114	16,261,435	162,321
16,206,570	16,245,629	39,059
16,201,875	16,340,700	138,825
16,318,756	16,318,756	0
15,988,126	16,517,282	529,156
16,006,325	16,259,326	253,001
16,400,988	16,501,815	100,827

According to Table 5.32, it is observed that average increase is 123,673 thousand TL.

Table 5.33: Asset allocation solved with initial and new parameters for return rates between (r_{ij}-1, r_{ij}) for Vakıfbank

asset allocation of bank solved with initial parameter	asset allocation of bank solved with new parameter	increase in profit after new asset allocation
14,672,994	14,737,875	64,881
15,306,201	15,306,509	308
15,028,104	15,094,946	66,842
15,246,102	15,303,352	57,250
15,298,056	15,298,056	0
15,340,825	15,428,947	88,122
15,033,023	15,111,550	78,527
14,872,057	14,881,440	9,383
15,435,056	15,466,889	31,833
15,022,553	15,029,372	6,819
15,194,229	15,204,058	9,829
14,931,617	15,021,955	90,338
14,984,692	15,011,496	26,804
15,307,011	15,324,400	17,389
15,232,171	15,261,864	29,693
15,147,842	15,198,830	50,988
15,263,087	15,268,652	5,565
15,351,559	15,360,787	9,228
15,249,376	15,249,376	0
15,269,656	15,343,818	74,162

According to Table 5.33, it is observed that average increase is 35,898 thousand TL.

Table 5.34: Asset allocation solved with initial and new parameters for return rates between (r_{ij}, r_{ij}+0.5) for Vakıfbank

asset allocation of bank solved with initial parameter	asset allocation of bank solved with new parameter	increase in profit after new asset allocation
15,870,892	15,870,892	0
15,973,035	16,000,230	27,195
16,139,346	16,142,257	2,911
15,950,269	15,972,551	22,282
15,949,376	15,959,813	10,437
16,143,593	16,144,461	868
15,904,101	15,957,114	53,013
16,016,408	16,045,941	29,533
15,828,205	15,876,574	48,369
16,020,681	16,020,681	0
15,824,243	15,858,752	34,509
15,776,028	15,776,581	553
15,781,572	15,796,766	15,194
16,012,941	16,012,941	0
15,912,452	15,919,505	7,053
15,795,456	15,849,626	54,170
16,042,667	16,042,667	0
16,087,692	16,087,692	0
15,744,807	15,822,242	77,435
15,881,848	15,924,828	42,980

According to Table 5.34, it is observed that average increase is 21,325 thousand TL.

Table 5.35: Asset allocation solved with initial and new parameters for return rates between (r_{ij}-0.5, r_{ij}) for Vakıfbank

asset allocation of bank solved with initial parameter	asset allocation of bank solved with new parameter	increase in profit after new asset allocation
15,330,679	15,351,312	20,633
15,141,848	15,191,627	49,779
15,368,263	15,369,135	872
15,488,723	15,493,259	4,536
15,187,547	15,205,041	17,494
15,319,683	15,335,899	16,216
15,398,658	15,402,442	3,784
15,351,462	15,351,462	0
15,185,892	15,187,148	1,256
15,350,119	15,350,119	0
15,457,022	15,460,910	3,888
15,291,583	15,291,583	0
15,298,259	15,318,824	20,565
15,120,689	15,121,595	906
15,492,758	15,492,758	0
15,404,298	15,405,913	1,615
15,488,000	15,493,159	5,159
15,247,251	15,247,373	122
15,537,918	15,540,912	2,994
15,500,907	15,500,907	0

According to Table 5.35, it is observed that average increase is 7,491 thousand TL.

To observe the alteration of expected return of each bank, return rates of amount of receivables are changed. Return rates are increased by 0.5% and 1% and decreased by 0.5% and 1%. Other parameters excluding return rates and decision variables are remained constant. It is observed that increase in profit after new asset allocation of each bank is same if return rates are increased or decreased by 0.5% and 1%. Increase in profit after new asset allocation is 9,399,590 thousand TL for Akbank, 6,790,883 thousand TL for YKB and 5,554,247 thousand TL for Vakıfbank.

Average values of increase in profit after new asset allocation which are found according to change of return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) are shown in Figure 5.1 for Akbank, Figure 5.2 for YKB and figure 5.3 for Vakıfbank. Asset allocation s before and after optimization are taken into consideration while finding the expected increase in profit. [-1%, 0], [-0.5%, 0], 0, [0, 0.5%] and [0, 1%] are the intervals of return rates and denote (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), r_{ij}, (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) respectively**.** Expected increase in profit is shown on the y-axis and intervals of return rates are shown on the x-axis in figures below.

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Figure 5.1: Average increase in profit according to change of return rates for Akbank

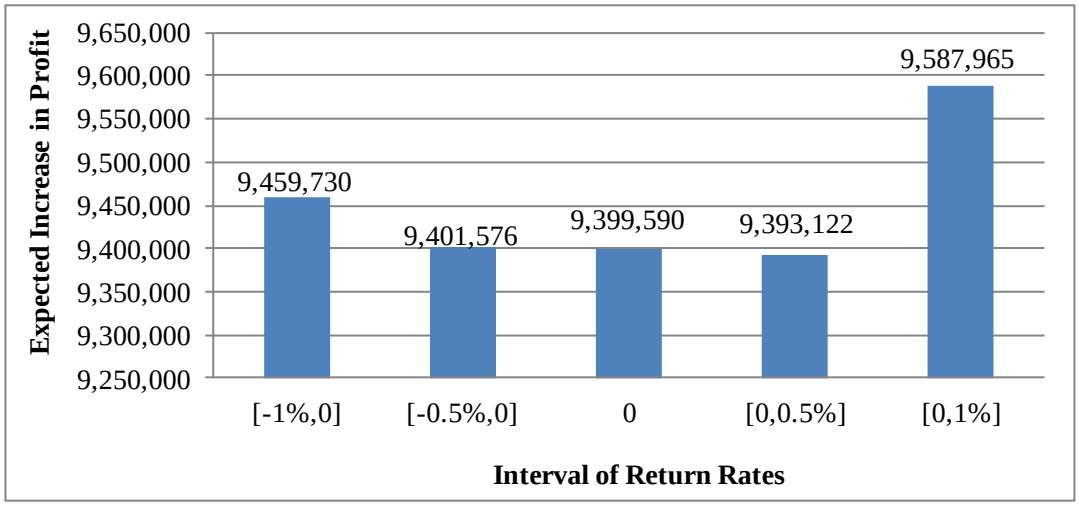


Figure 5.2: Average increase in profit according to change of return rates for YKB

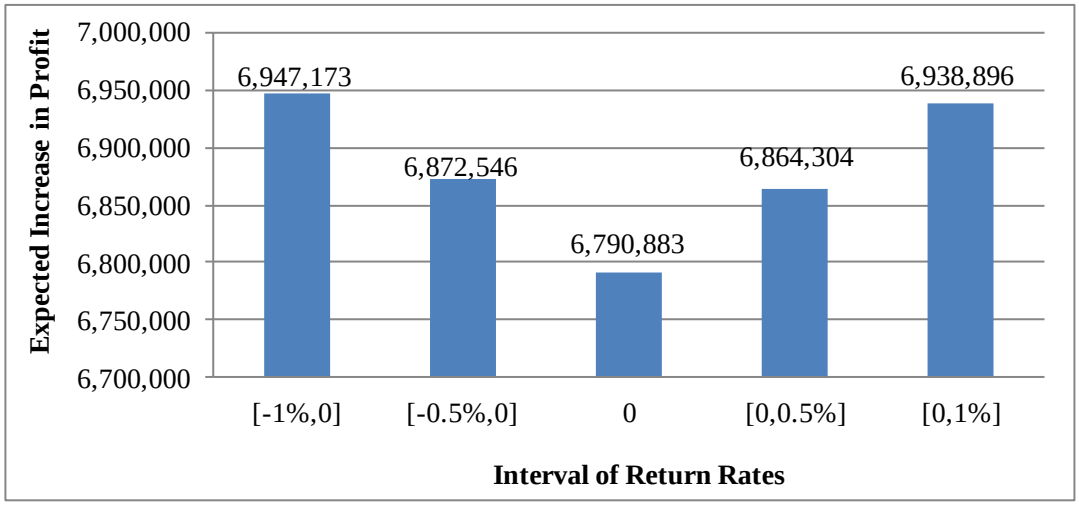
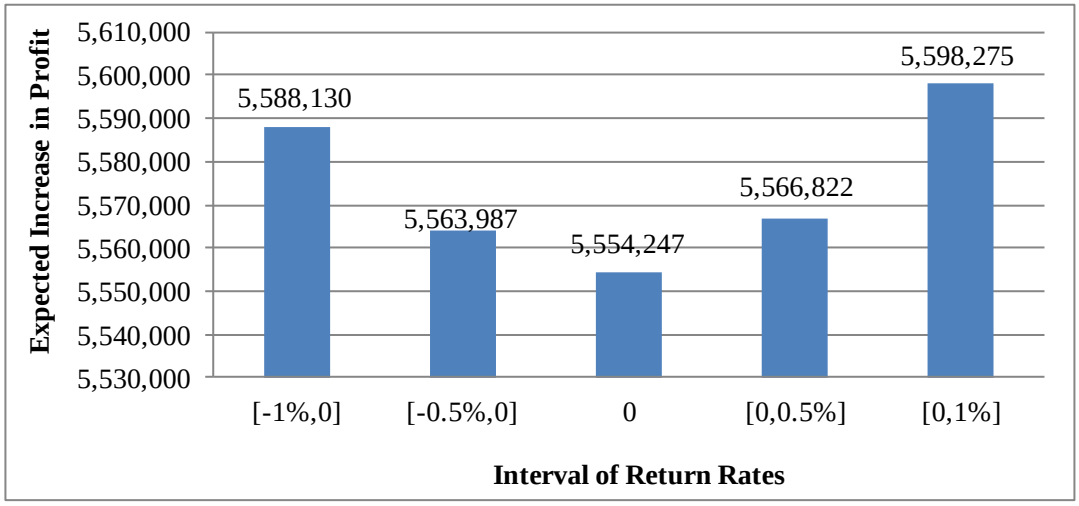


Figure 5.3: Average increase in profit according to change of return rates for Vakıfbank



As shown in the figures, changing return rates between (r_{ij}-1, r_{ij}), (r_{ij}-0.5, r_{ij}), (r_{ij}, r_{ij}+0.5) and (r_{ij}, r_{ij}+1) increase the expected return more than changing returns rates with increasing by 0.5% and 1% and decreasing by 0.5% and 1%.

Additionally, results are analyzed by changing constraints and objective function coeefficients. When returns rates, which are the objective function coefficients, are increased or decreased equally, increase between original and optimized values of expected return remain same. When possible weights, which form the total asset constraint, are changed, expected returns do not remain the same. If maximum possible weights are unchanged and minimum possible weights are decreased, expected return of each bank is increased. If maximum possible weights are unchanged and minimum possible weights are increased, return rate of each bank is decreased. If minimum possible weights are unchanged and maximum possible weights are increased or decreased, expected return of each bank is not changed. Sensitivity reports of each bank show details of the results that are analyzed by changing constraints and objective function constraints in Table 36 and 37 for Akbank, Table 38 and 39 for YKB and Table 40 and 41 for Vakıfbank.

Table 5.36: Sensitivity report of Akbank for variable cells

Variable Cells					
Cell	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B5	0	-0.01	0.05	0.01	1E+30
C5	0	-0.01	0.05	0.01	1E+30
D5	20,433,856	0	0.0616	0.03	0.01
E5	0	-0.06	0	0.06	1E+30
F5	0	-0.06	0	0.06	1E+30
G5	0	-0.06	0	0.06	1E+30
H5	0	-0.06	0	0.06	1E+30
B6	0	-0.08	0	0.08	1E+30
C6	0	-0.08	0	0.08	1E+30
D6	0	0	0.085	0.06	0.08
E6	0	-0.08	0	0.08	1E+30
F6	0	-0.08	0	0.08	1E+30
G6	0	-0.08	0	0.08	1E+30
H6	0	-0.08	0	0.08	1E+30
B7	0	-0.09	0	0.09	1E+30
C7	0	-0.09	0	0.09	1E+30
D7	0	-0.09	0	0.09	1E+30
E7	0	-0.09	0	0.09	1E+30
F7	0	0	0.1	0.05	0.09
G7	0	-0.09	0	0.09	1E+30
H7	0	-0.09	0	0.09	1E+30
B8	0	0	0	0.15	0
C8	0	0.00	0	5.24317E-16	1E+30
D8	0	0	0	0	1E+30
E8	0	-2.77556E-17	0	2.77556E-17	1E+30
F8	0	-5.03297E-16	0	5.03297E-16	1E+30
G8	0	0	0	0	1E+30
H8	0	0	0	0	1E+30
B9	0	-5.24828E-16	0	5.24828E-16	1E+30
C9	0	-5.24828E-16	0	5.24828E-16	1E+30
D9	0	0	0	0.145942857	0
E9	0	-4.16334E-17	0	4.16334E-17	1E+30
F9	0	0	0	0	1E+30
G9	0	0	0	0	1E+30
H9	0	-5.55112E-17	0	5.55112E-17	1E+30
B10	0	-0.005	0.08	0.005	1E+30
C10	0	-0.002	0.084	0.002	1E+30
D10	0	-0.0005	0.088	0.000	1E+30
E10	0	-0.08	0	0.08	1E+30
F10	8,870,511	0	0.092	0.06	0.00049
G10	0	-0.08	0	0.08	1E+30
H10	0	-0.08	0	0.08	1E+30
B11	17,741,022	0	0.07	0.08	0.002
C11	0	-0.07	0	0.07	1E+30
D11	0	-0.07	0	0.07	1E+30
E11	0	-0.07	0	0.07	1E+30
F11	0	-0.002	0.075	0.0020	1E+30
G11	0	-0.07	0	0.07	1E+30
H11	0	-0.07	0	0.07	1E+30
B12	0	-0.09	0	0.09	1E+30
C12	0	-0.09	0	0.09	1E+30
D12	0	-0.09	0	0.09	1E+30
E12	8,870,511	0	0.098	0.05	0.09
F12	0	-0.09	0	0.09	1E+30

G12	0	-0.09	0	0.09	1E+30
H12	0	-0.09	0	0.09	1E+30
B13	0	-0.09	0	0.09	1E+30
C13	0	-0.09	0	0.09	1E+30
D13	8,870,511	0	0.0948	0.05	0.004
E13	0	-0.09	0	0.09	1E+30
F13	0	0.00	0.0948	0.00	1E+30
G13	0	-0.09	0	0.09	1E+30
H13	0	-0.09	0	0.09	1E+30
B14	0	-0.11	0	0.11	1E+30
C14	0	-0.11	0	0.11	1E+30
D14	0	-0.11	0	0.11	1E+30
E14	0	-0.11	0	0.11	1E+30
F14	0	0	0.12	0.03	0.11
G14	0	-0.11	0	0.11	1E+30
H14	0	-0.11	0	0.11	1E+30
B15	0	-0.15	0	0.15	1E+30
C15	0	-0.15	0	0.15	1E+30
D15	0	-0.15	0	0.15	1E+30
E15	0	-0.15	0	0.15	1E+30
F15	0	-0.15	0	0.15	1E+30
G15	0	-0.01	0.15	0.01	1E+30
H15	112,623,811	0	0.16	0.01	0.01
B16	0	0	0	0.15	0
C16	0	-1.38778E-17	0	1.38778E-17	1E+30
D16	0	-9.04E-16	0	9.04E-16	1E+30
E16	0	-2.77556E-17	0	2.77556E-17	1E+30
F16	0	0	0	0	1E+30
G16	0	0	0	0	1E+30
H16	0	0	0	0	1E+30
B17	0	0	0	0.145942857	0
C17	0	-1.38778E-17	0	1.38778E-17	1E+30
D17	0	0	0	0	1E+30
E17	0	-2.77556E-17	0	2.77556E-17	1E+30
F17	0	0	0	0	1E+30
G17	0	0	0	0	1E+30
H17	0	-9.04E-16	0	9.04E-16	1E+30
B18	0	0	0	0.145942857	0
C18	0	-1.38778E-17	0	1.38778E-17	1E+30
D18	0	0	0	0	1E+30
E18	0	-2.77556E-17	0	2.77556E-17	1E+30
F18	0	0	0	0	1E+30
G18	0	0	0	0	1E+30
H18	0	0	0	0	1E+30
B19	0	-0.04	0	0.04	1E+30
C19	0	-0.04	0	0.04	1E+30
D19	0	-0.04	0	0.04	1E+30
E19	0	-0.04	0	0.04	1E+30
F19	0	0	0.05	0.10	0.04
G19	0	-0.04	0	0.04	1E+30
H19	0	-0.04	0	0.04	1E+30
B20	0	0	0.05	0.10	0.001
C20	0	-0.001	0.05	0.001	1E+30
D20	0	-0.05	0	0.05	1E+30
E20	0	-0.05	0	0.05	1E+30
F20	0	-0.01	0.05	0.01	1E+30
G20	0	-0.05	0	0.05	1E+30
H20	0	-0.05	0	0.05	1E+30

Table 5.37: Sensitivity report of Akbank for constraints

Constraints					
Cell	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
B24	20,433,856	0.09	0	3,015,974	56,593,861
J5	12%	0	40%	1E+30	28%
J6	0%	0	100%	1E+30	100%
J7	0%	0	100%	1E+30	100%
J8	0%	0	100%	1E+30	100%
J9	0%	0	100%	1E+30	100%
J10	5%	0	30%	1E+30	25%
J11	10%	0	40%	1E+30	30%
J12	5%	0	30%	1E+30	25%
J13	5%	0	30%	1E+30	25%
J14	0%	0	100%	1E+30	100%
J15	63%	0	100%	1E+30	37%
J16	0%	0	100%	1E+30	100%
J17	0%	0	100%	1E+30	100%
J18	0%	0	100%	1E+30	100%
J19	0%	0	100%	1E+30	100%
J20	0%	0	100%	1E+30	100%
J5	12%	0	10%	2%	1E+30
J6	0%	-11,435,356	0%	14%	8.39927E-17
J7	0%	-9,397,673	0%	21%	0
J8	0%	-25,891,755	0%	11%	0%
J9	0%	-25,891,755	0%	11%	0%
J10	5%	-10,816,955	5%	21%	5%
J11	10%	-13,473,039	10%	11%	10%
J12	5%	-9,440,758	5%	17%	4%
J13	5%	-9,696,736	5%	14%	5%
J14	0%	-5,849,468	0%	21%	0%
J15	63%	0	1%	62%	1E+30
J16	0%	-25,891,755	0%	11%	0%
J17	0%	-25,891,755	0%	11%	0%
J18	0%	-25,891,755	0%	11%	0%
J19	0%	-18,268,184	0%	21%	0%
J20	0%	-17,021,244	0%	11%	0%
N24	177,410,222	0.1459	177,410,222	75,584,147	18,849,836
N49	2627428241	0	0	1E+30	401850792.8

Table 5.38: Sensitivity report of YKB for variable cells

Variable Cells					
Cell	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B5	0	-0.01	0.05	0.0116	1E+30
C5	0	-0.06	0	0.0616	1E+30
D5	14872451.2	0	0.0616	0.0884	0.0116
E5	0	-0.06	0	0.0616	1E+30
F5	0	-0.06	0	0.0616	1E+30
G5	0	-0.06	0	0.0616	1E+30
H5	0	-0.06	0	0.0616	1E+30
B6	0	-0.08	0	0.085	1E+30
C6	0	0	0.085	0.065	0.085
D6	0	-0.08	0	0.085	1E+30
E6	0	-0.09	0	0.085	1E+30
F6	0	-0.09	0	0.085	1E+30
G6	0	-0.08	0	0.085	1E+30
H6	0	-0.09	0	0.085	1E+30
B7	0	-0.09	0	0.09	1E+30
C7	0	-0.09	0	0.09	1E+30
D7	0	-0.09	0	0.09	1E+30
E7	0	-0.09	0	0.09	1E+30
F7	0	0	0.09	0.06	0.09
G7	0	-0.09	0	0.09	1E+30
H7	0	-0.09	0	0.09	1E+30
B8	0	0	0.07	0.08	0.07
C8	0	-0.07	0	0.07	1E+30
D8	0	-0.07	0	0.07	1E+30
E8	0	-0.07	0	0.07	1E+30
F8	0	-0.07	0	0.07	1E+30
G8	0	-0.07	0	0.07	1E+30
H8	0	-0.07	0	0.07	1E+30
B9	0	0	0	0	1E+30
C9	0	0	0	0	1E+30
D9	0	0	0	0	1E+30
E9	0	0	0	0	1E+30
F9	0	0	0	0	1E+30
G9	0	0	0	0.15	0
H9	0	0	0	0	1E+30
B10	0	-0.09	0	0.09	1E+30
C10	0	-0.01	0.0825	0.01	1E+30
D10	0	0.00	0.0865	0.004	1E+30
E10	0	-0.09	0	0.09	1E+30
F10	7436225.6	0	0.0905	0.06	0.004
G10	0	-0.09	0	0.09	1E+30
H10	0	-0.09	0	0.09	1E+30
B11	0	-0.07	0	0.07	1E+30
C11	0	-0.07	0	0.07	1E+30
D11	0	-0.07	0	0.07	1E+30
E11	0	-0.07	0	0.07	1E+30
F11	14872451.2	0	0.074	0.08	0.074
G11	0	-0.07	0	0.07	1E+30
H11	0	-0.07	0	0.07	1E+30
B12	0	-0.10	0	0.10	1E+30
C12	0	-0.10	0	0.10	1E+30
D12	0	-0.10	0	0.10	1E+30
E12	7436225.6	0	0.098	0.05	0.098
F12	0	-0.10	0	0.10	1E+30

G12	0	-0.10	0	0.10	1E+30
H12	0	-0.10	0	0.10	1E+30
B13	0	-0.11	0	0.11	1E+30
C13	0	-0.11	0	0.11	1E+30
D13	7436225.6	0	0.1116	0.04	0.1116
E13	0	-0.11	0	0.11	1E+30
F13	0	-0.11	0	0.11	1E+30
G13	0	-0.11	0	0.11	1E+30
H13	0	-0.11	0	0.11	1E+30
B14	0	-0.15	0	0.15	1E+30
C14	0	-0.15	0	0.15	1E+30
D14	0	-0.15	0	0.15	1E+30
E14	0	-0.15	0	0.15	1E+30
F14	0	-0.01	0.14	0.01	1E+30
G14	1487245.12	0	0.15	0	0.01
H14	0	-0.15	0	0.15	1E+30
B15	0	-0.15	0	0.15	1E+30
C15	0	-0.15	0	0.15	1E+30
D15	0	-0.15	0	0.15	1E+30
E15	0	-0.15	0	0.15	1E+30
F15	0	-0.15	0	0.15	1E+30
G15	91465574.88	0	0.15	1.22125E-16	0
H15	3718112.8	0	0.15	0	1.22125E-16
B16	0	0	0	0	1E+30
C16	0	0	0	0	1E+30
D16	0	0	0	0	1E+30
E16	0	0	0	0	1E+30
F16	0	0	0	0	1E+30
G16	0	0	0	0.15	0
H16	0	0	0	0	1E+30
B17	0	0	0	0	1E+30
C17	0	0	0	0	1E+30
D17	0	0	0	0	1E+30
E17	0	0	0	0	1E+30
F17	0	0	0	0	1E+30
G17	0	0	0	0.15	0
H17	0	0	0	0	1E+30
B18	0	0	0	0	1E+30
C18	0	0	0	0	1E+30
D18	0	0	0	0	1E+30
E18	0	0	0	0	1E+30
F18	0	0	0	0	1E+30
G18	0	0	0	0.15	0
H18	0	0	0	0	1E+30
B19	0	0	0	0	1E+30
C19	0	0	0	0	1E+30
D19	0	0	0	0	1E+30
E19	0	0	0	0	1E+30
F19	0	0	0	0	1E+30
G19	0	0	0	0.15	0
H19	0	0	0	0	1E+30
B20	0	0	0.05	0	1E+30
C20	0	0	0.05	0.1	0
D20	0	-0.05	0	0.05	1E+30
E20	0	-0.05	0	0.05	1E+30
F20	0	0.00	0.05	2.23779E-16	1E+30
G20	0	-0.05	0	0.05	1E+30
H20	0	-0.05	0	0.05	1E+30

Table 5.39: Sensitivity report of YKB for constraints

Constraints					
Cell	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
B24	14,872,451	0	0	3,658,623	148,725
J5	10%	0	40%	1E+30	30%
J6	0%	0	100%	1E+30	100%
J7	0%	0	100%	1E+30	100%
J8	0%	0	100%	1E+30	100%
J9	0%	0	100%	1E+30	100%
J10	5%	0	30%	1E+30	25%
J11	10%	0	40%	1E+30	30%
J12	5%	0	30%	1E+30	25%
J13	5%	0	30%	1E+30	25%
J14	1%	0	100%	1E+30	99%
J15	64%	0	100%	1E+30	36%
J16	0%	0	100%	1E+30	100%
J17	0%	0	100%	1E+30	100%
J18	0%	0	100%	1E+30	100%
J19	0%	0	100%	1E+30	100%
J20	0%	0	100%	1E+30	100%
J5	10%	-13,147,247	10%	2%	0%
J6	0%	-9,667,093	0%	17%	0%
J7	0%	-8,923,471	0%	31%	0%
J8	0%	-11,897,961	0%	15%	0%
J9	0%	-22,308,677	0%	15%	0%
J10	5%	-8,849,108	5%	25%	2%
J11	10%	-11,303,063	10%	30%	2%
J12	5%	-7,733,675	5%	25%	2%
J13	5%	-5,711,021	5%	21%	1%
J14	1%	0	1%	62%	1%
J15	64%	0	1%	63%	1E+30
J16	0%	-22,308,677	0%	15%	0%
J17	0%	-22,308,677	0%	15%	0%
J18	0%	-22,308,677	0%	15%	0%
J19	0%	-22,308,677	0%	15%	0%
J20	0%	-14,872,451	0%	17%	0%
N24	148,724,512	0.15	148,724,512	1,239,371	22,866,394
N49	2203348836	0	0	1E+30	367267369.9

Table 5.40: Sensitivity report of Vakıfbank for variable cells

Variable Cells					
Cell	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B5	0	-0.01	0.05	0.01	1E+30
C5	0	-0.06	0	0.06	1E+30
D5	14,050,600	0	0.06	0.02	0.00007
E5	0	-0.06	0	0.06	1E+30
F5	0	-0.06	0	0.06	1E+30
G5	0	-0.06	0	0.06	1E+30
H5	0	-0.06	0	0.06	1E+30
B6	0	-0.01	0.08	0.01	1E+30
C6	0	-0.003	0.085	0.003	1E+30
D6	1,246,963	0	0.09	0.05	0.0030
E6	0	-0.09	0	0.09	1E+30
F6	0	-0.09	0	0.09	1E+30
G6	0	-0.09	0	0.09	1E+30
H6	0	-0.09	0	0.09	1E+30
B7	0	-0.01	0.08	0.01	1E+30
C7	0	-0.09	0	0.09	1E+30
D7	0	-0.01	0.09	0.01	1E+30
E7	0	-0.09	0	0.09	1E+30
F7	0	0	0.1	0.05	0.01
G7	0	-0.09	0	0.09	1E+30
H7	0	-0.09	0	0.09	1E+30
B8	0	0	0.08	0.06	0.08
C8	0	-0.08	0	0.08	1E+30
D8	0	-0.08	0	0.08	1E+30
E8	0	-0.08	0	0.08	1E+30
F8	0	-0.08	0	0.08	1E+30
G8	0	-0.08	0	0.08	1E+30
H8	0	-0.08	0	0.08	1E+30
B9	0	0	0	0	1E+30
C9	0	0	0	0	1E+30
D9	0	0	0	0	1E+30
E9	0	0	0	0	1E+30
F9	0	0	0	0.14	0
G9	0	0	0	0	1E+30
H9	0	0	0	0	1E+30
B10	0	-0.01	0.0775	0.01	1E+30
C10	0	-0.003	0.0815	0.003	1E+30
D10	0	-0.001	0.0855	0.001	1E+30
E10	0	-0.08	0	0.08	1E+30
F10	6,234,815	0	0.09	0.06	0.001
G10	0	-0.08	0	0.08	1E+30
H10	0	-0.08	0	0.08	1E+30
B11	12,469,629	0	0.065	0.08	0.002
C11	0	-0.06	0	0.06	1E+30
D11	0	-0.07	0	0.07	1E+30
E11	0	-0.06	0	0.06	1E+30
F11	0	-0.002	0.07	0.00	1E+30
G11	0	-0.06	0	0.06	1E+30
H11	0	-0.06	0	0.06	1E+30
B12	0	0.000004	0.09	0.000004	1E+30
C12	0	-0.09	0	0.09	1E+30
D12	0	-0.09	0	0.09	1E+30
E12	6,234,815	0	0.095	0.05	0.000004
F12	0	-0.09	0	0.09	1E+30

G12	0	-0.09	0	0.09	1E+30
H12	0	-0.09	0	0.09	1E+30
B13	0	-0.11	0	0.11	1E+30
C13	0	-0.11	0	0.11	1E+30
D13	6,234,815	0	0.11	0.03	0.003
E13	0	-0.11	0	0.11	1E+30
F13	0	-0.003	0.1128	0.003	1E+30
G13	0	-0.11	0	0.11	1E+30
H13	0	-0.11	0	0.11	1E+30
B14	0	-0.12	0	0.12	1E+30
C14	0	-0.12	0	0.12	1E+30
D14	0	-0.12	0	0.12	1E+30
E14	0	-0.12	0	0.12	1E+30
F14	0	0	0.13	0.02	0.12
G14	0	-0.12	0	0.12	1E+30
H14	0	-0.12	0	0.12	1E+30
B15	0	-0.14	0	0.14	1E+30
C15	0	-0.14	0	0.14	1E+30
D15	0	-0.14	0	0.14	1E+30
E15	0	-0.14	0	0.14	1E+30
F15	0	-0.14	0	0.14	1E+30
G15	0	-0.002	0.15	0.002	1E+30
H15	76,977,692	0	0.155	0.000067	0.0017
B16	0	0	0	0	1E+30
C16	0	0	0	0	1E+30
D16	0	0	0	0	1E+30
E16	0	0	0	0	1E+30
F16	0	0	0	0.14	0
G16	0	0	0	0	1E+30
H16	0	0	0	0	1E+30
B17	0	0	0	0	1E+30
C17	0	0	0	0	1E+30
D17	0	0	0	0	1E+30
E17	0	0	0	0	1E+30
F17	0	0	0	0.14	0
G17	0	0	0	0	1E+30
H17	0	0	0	0	1E+30
B18	0	0	0	0	1E+30
C18	0	0	0	0	1E+30
D18	0	0	0	0	1E+30
E18	0	0	0	0	1E+30
F18	0	0	0	0.14	0
G18	0	0	0	0	1E+30
H18	0	0	0	0	1E+30
B19	0	0	0	0	1E+30
C19	0	0	0	0	1E+30
D19	0	0	0	0	1E+30
E19	0	0	0	0	1E+30
F19	0	0	0	0.14	0
G19	0	0	0	0	1E+30
H19	0	0	0	0	1E+30
B20	1,246,963	0	0.05	0.09	0.0013
C20	0	-0.001	0.05	0.001	1E+30
D20	0	-0.05	0	0.05	1E+30
E20	0	-0.05	0	0.05	1E+30
F20	0	-0.01	0.05	0.01	1E+30
G20	0	-0.05	0	0.05	1E+30
H20	0	-0.05	0	0.05	1E+30

Table 5.41: Sensitivity report of Vakıfbank for constraints

Constraints					
Cell	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
B24	14,050,600	0.08	0	1,770,687	40,127,266
J5	11%	0	0.4	1E+30	29%
J6	1%	0	100%	1E+30	99%
J7	0%	0	100%	1E+30	100%
J8	0%	0	100%	1E+30	100%
J9	0%	0	100%	1E+30	100%
J10	5%	0	30%	1E+30	25%
J11	10%	0	40%	1E+30	30%
J12	5%	0	30%	1E+30	25%
J13	5%	0	30%	1E+30	25%
J14	0%	0	100%	1E+30	100%
J15	62%	0	100%	1E+30	38%
J16	0%	0	100%	1E+30	100%
J17	0%	0	100%	1E+30	100%
J18	0%	0	100%	1E+30	100%
J19	0%	0	100%	1E+30	100%
J20	1%	0	100%	1E+30	99%
J5	11%	0	10%	1%	1E+30
J6	1%	-6,857,405	1%	12%	1%
J7	0%	-6,026,394	0%	18%	0%
J8	0%	-7,688,417	0%	9%	0%
J9	0%	-17,664,120	0%	9%	0%
J10	5%	-7,335,705	5%	18%	5%
J11	10%	-9,558,861	10%	9%	10%
J12	5%	-6,441,899	5%	14%	5%
J13	5%	-4,014,330	5%	12%	5%
J14	0%	-2,285,505	0%	18%	0%
J15	62%	0	1%	61%	1E+30
J16	0%	-17,664,120	0%	9%	0%
J17	0%	-17,664,120	0%	9%	0%
J18	0%	-17,664,120	0%	9%	0%
J19	0%	-17,664,120	0%	9%	0%
J20	1%	-11,429,306	1%	9%	1%
N24	124,696,290	0.1417	124,696,290	55,671,698	11,066,796
N49	2076593782	0	0	1E+30	427191473.7

According to sensitivity reports for variables cells, final values are the optimized values of the amount of receivables. For alters to objective function coefficient values in this allowable increase and decreases ranges, current solution remains same for each bank. When there is 1E+30 in allowable decreases, allowable decrease is infinity and it indicates that there has not been investment to risk class. In such a case, if we invest our

money, expected return is decreased by the amount of reduced cost. For instance, according to Table 5.38, if we invest one million to receivables of first risk class and risk weight 75%, return is decreased by 60 thousand TL.

According to sensitivity reports for constraints, final values are the optimize values of the constraints, shadow prices are the amount that the objective function value would change if the constraints are changed by one unit. When shadow price is zero, the constraint is non-binding at the optimal solution and does not change the result. 1E+30 in allowable increases and decrease means that all increases and decrease are infinity and shadow prices are zero and an increase or decrease in the possible weights would not affect the optimal solution or optimal objective function value. Binding constraints change the results and their shadow prices are not zero and an increase or decrease in the possible weights would affect the optimal solution or optimal objective function value. If we choose Akbank for giving an example and consider minimum and maximum possible weights of seventh risk classification, increase in profit after new asset allocation is affected by only changing the minimum possible weights while maximum possible weights are unchanged. If minimum possible weight of seventh risk classification is not changed and maximum possible weight is 30% instead of %40 or 60% instead of 40%, increase in profit after new asset allocation is not changed and is 9,399,590 thousand TL. If maximum possible weight of seventh risk classification is not changed and minimum possible weight is 1% instead of 10%, increase in profit is 10,612,164 thousand TL. If minimum possible weight is 20% and 25% instead of 10%, increase in profit is 8,052,286 thousand TL and 7,347,144 thousand TL respectively.
For instance, according to sensitivity report of Akbank for constraints, when minimum possible weight of seventh risk class is 20% instead of 10%, bank's profit is decreased by 1,347,304 thousand TL and increase in profit is 8,052,286. When minimum possible weight of seventh risk class is 1% instead of 10%, bank's profit is increased by (1,347,304*0.09) thousand TL and increase in profit is 10,612,164. Moreover, for each additional of receivables of each risk class that Akbank, YKB and Vakıfbank can increase its profit by 146 TL, 150 and 142 respectively.

6. DISCUSSION AND CONCLUSION

Profitability in the banking sector has become more important and banks need adequate capital to be protected from exposure of several risks to maintain financial stability and increase profitability. Due to the need for risk management in banking, Basel accords are structured to ensure financial stabilization and banks are required to assess capital adequacy themselves with Basel II regulation. Hence, banks should maintain their profitability and optimize portfolio of assets taking into account Basel regulations.

In this thesis, risks in banking sector, Basel accords in risk management and implication of Basel II on capital and RWAs are explained to maximize expected returns of banks' portfolio of assets under risk constraints with Basel II regulation for profitability. Optimization model is formulated, solved with an appropriate tool to find optimal allocation of assets and computational results and sensitivity reports are obtained. Profitability is analyzed by changing constraints and objective function coefficients after the optimized value of the expected return. Average values of increase in profit after new asset allocation are found according to change of return rates between various intervals randomly with uniform distribution and compared with each other.

Banks' portfolio of assets has been optimized in accordance with the Basel II regulation and it is revealed that returns are increased with this optimization study. Profitability in the banking sector is very crucial and such this study can be insight for banks' profitability.

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