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Financial Risk Management

Comparison of Value at Risk Methods on Stock Portfolios

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Declaration:

I hereby declare that I am the sole author of the thesis entitled " Financial Risk Management-Comparison of Value at Risk Methods on Stock Portfolios." I duly marked out all quotations. The used literature and sources are stated in the attached list of references.

In Prague on 28th of April **Yasin Cagri YIGITER**

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Abstract

Recent developments in the financial sector and with the effects of globalization, restrictions on portfolio investments are in lowest in its history. These improvements help to facilitate fund transfer between countries, which causes high diversity and degree of risk. Also, this situation remarked itself in unexpected bankruptcies of major international financial institutions such as Barings Bank. As a result, international investors and academics forced to discover easy and efficient risk measurement techniques. Value at Risk method has emerged as a result of these requirements. Value at Risk is the maximum loss that value of an asset can experience with a given confidence level over a specific time frame.

The purpose of this study compares the calculations of Value at Risk Methods, namely Variance- Covariance Method, Historical Simulation Method, and Monte Carlo Simulation Method. Firstly, ten stocks are chosen randomly from Istanbul Stock Exchange for the analysis. Descriptive statistics of these shares are calculated, to achieve final results. Secondly, normality tests are made to determine the distribution of return series. In the next step, optimal portfolio obtained according to Markowitz model. Finally, Value at Risk values of the optimal portfolio calculated with three different methods.

Keywords: Financial risk management, types of risks, value at risk

Abstrakt

Díky nejnovějšímu vývoji ve finančním sektoru a globalizaci je omezení portfoliových investic nejnižší v historii. Toto zlepšení přispívá k usnadnění převodu prostředků mezi zeměmi, což způsobuje vysokou rozmanitost a míru rizika. Tato situace se projevila například v nečekaných bankrotech významných mezinárodních finančních institucí, jako je například banka Barings Bank. V důsledku toho, mezinárodní investoři a akademičtí pracovníci byli nuceni objevovat jednoduché a efektivní techniky měření rizik. V důsledku těchto požadavků vznikla metoda Value at Risk. Value at Risk je maximální ztráta, kterou může hodnota aktiva dosáhnout s danou úrovní spolehlivosti v určitém časovém období.

Cílem této práce je porovnání metod výpočtů Value at Risk, konkrétně metody variace-kovariance, metoda historické simulace a Monte Carlo simulace. Nejprve je z Istanbulské burzy pro analýzu náhodně vybráno deset akcií. Za účelem dosažení konečných výsledků se vypočte popisná statistika těchto akcií. Zadruhé jsou provedeny testy normality pro určení rozložení návratových řad. V dalším kroku je dosaženo optimálního portfolia podle modelu Markowitz. Nakonec jsou hodnoty Value at Risk optimálního portfolia vypočítané třemi různými metodami.

Klíčová slova: Řízení finančního rizika, typy rizik, riziková hodnota

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List of Abbreviations

Value at Risk : VaR

Capital Asset Model : CAPM

The Basel Committee on Banking Supervision: BIS

London Interbank Offered Rate: LIBOR

Exponentially Weighted Moving Average: EWMA

Autoregressive Conditional Heteroskedasticity: ARCH

Generalized Autoregressive Heteroskedasticity: GARCH

Introduction

Over the last decade, risk management has become an essential tool in financial markets as a result of highly competitive environment. Risk management and its strategies are implemented in every aspect of business life to minimize the probability of unfavorable events. Also, with the development of computational technology and advances in information technology, financial institutions can gather and analyze data with low costs. In today business's life, risk management is vital for all the organizations.

In order to stay in the competition, this topic should be studied from every individual in the business environment. With the implementation of risk management, organizations can use the sources more efficiently and improve their strategic and business planning. Moreover, risk management maximizes the opportunities by adapting to changing needs for the firms and ensures business growth.

This thesis will discuss revolution of financial risk management, provide deep and better understanding its strategies and measures in the market. This work's structure will follow the risk management process in order to give insight into the concept of the risk management. In the following chapters, the reader will find information about the types of risks to identify the risk, and different measures to analyze it. At the end of the theoretical part, this thesis will be supported by an empirical study in Istanbul Stock Exchange.

In the first part of the thesis, primarily, the development of financial risk management and the concept of risk will be discussed to give insight into the context of this study. Secondly, different types of risk will be introduced to reader for identifying the risk as the first step of financial risk management. In addition to that, the reader can find brief information about portfolio diversification and portfolio risk which will be used for empirical study at the end of this thesis.

In the second part, Value at Risk and the reasons behind the development of the method will be defined to understand the need of this risk measurement approach. Also, calculation methods and the parameters used in these calculations will be mentioned to show risk measurement process.

The empirical part of the thesis will compare risk management strategies and its measures for a randomly selected portfolio in Istanbul Stock Exchange. In the third part, this study will investigate differences between calculation methods for the Value at Risk methods by the daily returns of shares in the portfolio. Firstly, normality test will be made for the selected data. Secondly, the optimal portfolio will be created from randomly selected shares according to modern portfolio theory. Finally, different types of value at risk methods will be implemented. Statistical measures and tools will be used to analyze the data, and graphical representations will be provided through Microsoft Excel and SPSS the statistical software.

The goal of this thesis is, showing and comparing different types of value at risk calculations for an optimal portfolio generated from randomly selected stocks traded in Istanbul Stock Exchange according to the daily returns of these shares.

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1. Financial Risk Management

Financial risk is defined as the measurement of possible changes in the portfolio as a result of variations in the environment between the present and future time. Financial Risk can also be defined as a change in the asset or liability of an institution or individual against price fluctuations.

Recent practices in the management of financial risk have mainly focused on measuring the risk, controlling and managing it. Progress has also been made about the measurement and management of credit risk and operational risks, with Basel II studies that began in 1999 issued by Basel Committee on Banking Supervision. Basel II has initiated a major change regarding integrated risk management, including the operational risk into capital adequacy measurement.

One of the most important factors driving companies towards financial risk management is the expectation that financial risk management will increase the firm value by increasing the competitive power of the company.

Risk management has been used for market insurance to protect individuals and organizations from potential losses due to uncertainty. Since the cost of the market insurance was relatively high, in the 1950's alternative ways, have been developed. In the early 1970's there were two critical developments in the risk management history: option pricing model by Fischer Black and Myron Scholes and the introduction of Bill Sharpe's capital asset model (CAPM). Those developments lead us to modern risk management: the moment at which risk could start to be effectively priced and mitigated. Before the 1970's, derivatives were mostly used for agricultural products and with the new models suggested during 1970's it became more popular to cover financial products.[1]

The Black-Scholes model is published in the Journal of Political Economy on 1973 with the title of "the pricing of options and corporate liabilities." This model is used to calculating the theoretical price of European put and call options. In 2017, It is still considered as one of the best ways of defining the prices of options with the risk-free and no-arbitrage assumptions.

[1] The Risk Revolution, Kevin Buehler, Andrew Freeman and Ron Hulme, September 2008

The second model, CAPM suggests that individual investment contains two different types of risks. Firstly, the systematic risk is also known as "market risk" compensated by the market and can be mitigated only by being hedged. For example, interest rates, recession, and wars affect the entire market, and they cannot be diversified. "Beta" is the measure of the systematic risk which corresponds to stock's market risk compared to other markets. Secondly, unsystematic risk is a type of uncertainty that unique to the company and can be diversified. According to Sharpe, since diversification can reduce unsystematic risks, it should not affect the business's cost of capital.

After the developments in 1970's companies started to use derivatives as instruments to manage insurable and uninsurable risks. In 1980's with the innovations in technology and computers, price calculations in derivatives became faster and easier. Traders could use new methods such as Monte Carlo simulation to analyze the data and future forecast. Moreover, financial institutions, banks, and insurance companies started to invest more on market and credit risk management. Consequently, financial risk management has become a complementary tool to pure risk management.

"*International risk regulation began in the 1990s, and financial firms developed internal risk management models and capital calculation formulas to hedge against unanticipated risks and reduce regulatory capital*."[2] In this decade, individuals and companies realized the need of financial risk management. Risk manager positions were opened for the first time, and the firms started to look for a way to manage operational and liquidity risks. Furthermore, JP Morgan introduced two internal risk management models to manage credit and market risks: Creditmetrics for credit risk and Riskmetrics for market risk. Those were the major milestones in financial risk management in the 1990s.

In the mid-1990, there was a growing need for financial and non-financial organizations to control and link the risks in a more comprehensive framework. As a result, a new approach to risk management has developed: enterprise risk management. In this holistic approach, organizations manage all risks in a unified framework instead of managing each type of risks separately. Since enterprise risk management analyzes and manages the risks with the entire organization, it provides better emphasis on cooperation among departments.

[2] Risk Management: History, Definition and Critique, Georges Dionne , March 2013

Introduced in the 1980s, Value at Risk became a very popular and useful tool to measure risk in financial markets. Since then, all the financial institutions, banks and insurers used Value at Risk (VaR) for forecasting the risk. The main reason behind VaRs popularity is that is easier to implement than other risk measures. Value at Risk is the maximum loss that value of an asset can experience with a given confidence level over a specific time frame.[3]

Methods for calculation of Value at Risk can be categorized in three different ways: Variance-Covariance method, Historical Method and Monte Carlo Simulation and all of the methods have their advantages and drawbacks. An alternative risk measurement tool Expected Shortfall also known as Expected Tail Loss or Conditional Value at Risk was introduced in the late 1990s to obtain better results in risk management. Expected Shortfall is used for analyzing tail-risk and take into consideration losses beyond given Value at Risk confidence level. Recently, The Basel Committee on Banking Supervision (BIS) announced that Expected Shortfall would be used for the risk measurement for banking regulatory purposes, replacing value at risk.

1.1 Concept of Risk

When the structure of the risk is examined, it is seen that the uncertainty and the exposure to this uncertainty appear as two components of the risk. "Uncertainty" and "risk" are often confused with each other in financial markets. The risk is the measurable part of the uncertainty. If the probability forecast for the future is made subjectively, it is uncertain, and if it is done objectively, it is referring to the risk. For example, if the future price of a stock is estimated as the result of analyzing the past price of that stock, then it is said to be a risk. However, if there is no information about past stock prices for the same stock, future price estimates can be made with a number of assumptions, In this case, uncertainty is mentioned.[4]

The risk is an integral part of all economic and financial activities. In financial terms, risk is the probability of a deviation from the expected return. There is a probability that the investor will get less than the expected earning from the investment he has made. For

[3] Financial Modeling Second Edition , Simon Benninga, The MIT Press, 2000
[4] İşletme Finansı ve Finansal Yönetim, (Business Finance and Financial Management), Öcal Usta,2008

example, it can be said that the greater the difference in expected return from the return of an asset, the higher the risk of the assets.

Organizations are facing many different types of risks. In today's business environment, financial risks are considered as high-priority risks including market risks, credit risks, liquidity risks and operational risks.

Market risks are the financial risks that arise due to possible loss in future market prices or rates such as interest rate risks, exchange rate risks or equity risks. Credit risks arise due to the possibility that a loss may occur from the failure of contractual obligations from the counterparty. Credit risks can be categorized as credit default risk, country risk, and concentration risks. Liquidity risk is related to difficulty in realizing assets and availability of sufficient funds to meet commitments regarding financial instruments. Finally, operational risks arise due to errors caused by the human during the operation procedures.

The term non-financial risk represents multiple risk types that are not associated with financial consequences such as strategic risks. The first step of the risk management process is identifying the risks and estimate their likelihood of occurrence as well as their impact on the firm.

1.2 Types of Risk

Market risks, credit risks, and operational risks can be measured by standard and advanced measurement methods. The standards and coefficients for each type of risk transition phase can be measured by standard measurement methods specified by Basel Committee on Banking Supervision. However, since standard methods do not take into account the different conditions of different markets, organizations should use advanced approaches that can measure their risks more accurately.[5]

Identifying various types of risk exposures is the first step of risk management process. Financial risks can be classified mainly as market risk, credit risk , liquidity risk and operational risk.

[5] IMKB Hisse Senetleri Piyasası Kredi Riskinin Farklı Bir Ölçümü : Riske Maruz Değer Uygulaması (Anoher Approach to Measure Credit Risk in ISE), Özlem Kıraç,2011 (Doctoral Dissertation)

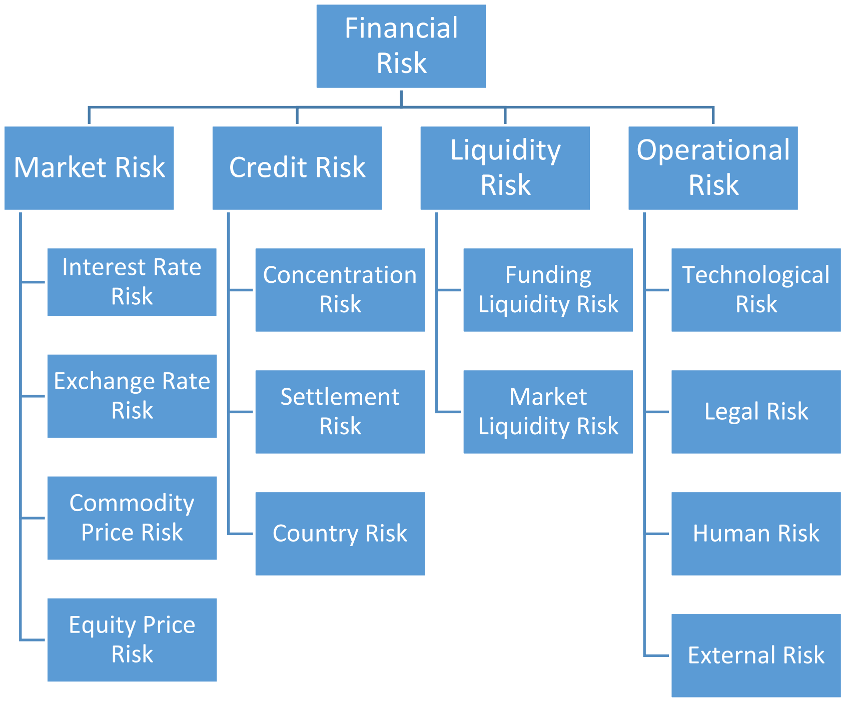

FIGURE 1.1: TYPES OF RISKS

1.2.1 Market Risk

"Market risk is the potential adverse change in the value of a portfolio of financial instruments due to changes in the levels, or changes in the volatilities of the levels, or changes in the correlations between the levels of market prices."[6] By definition, volatility in exchange rates, interest rates, and equity prices is considered as the market risk. It is formed by the combination of uncertainty in financial market prices and the exposure to that uncertainty.

The risk of a transaction for fixed income instruments consists two components. One is the general market risk also known as systematic risk arises due to change in the transaction's value correlated with the behavior of the market as a whole. The second one is the specific market risk component also known as the idiosyncratic risk which is caused by hidden credit risk in the financial instrument and the change in transaction's value is not correlated with the behavior of the market as a whole.

[6] The Professional's Handbook of Financial Risk Management, Marc Lore,Lev Borodovsky ,2000, page 116

There are four different major sources of market risk

- Interest Rate Risk
- Exchange Rate Risk
- Equity Price Risk
- Commodity Price Risk

1.2.1.1 Interest Rate Risk

Interest rate risk is the possibility of fall in the value of financial instrument due to fluctuations in the absolute level of interest rate. The level of interest rate affects fixed-income securities, also the prices of future and forward contracts corresponding to spot prices. There is a negative correlation between the market interest risk and the value of the fixed-income securities. Potential volatility in interest rate leads to decline returns for investors, higher borrowing costs for borrowers and lower the profitability of financial institutions such as banks. The value of a portfolio is calculated by discounting the value of its expected cash flows. Given the background, the portfolio will be subject to interest rate risk to some extent relative to any future cash flows.[7]

It is inevitable that complex portfolios formed by interest rate sensitive assets face to many different types of exposures. Especially banks as financial intermediaries are exposed different types of interest risks such as re-pricing risk, yield curve risk, and basis risk. Managing the interest rate risk can be a source of the profitability and shareholder value for the banks. On the other hand, in the case of excessive interest rate, the risk is a significant potential threat to bank's earnings and capital.

Repricing risk is one of the most common interest rate risk exposures for the financial intermediaries. It derives from the timing differences in the maturity (fixed rate) and repricing (floating rate) for the bank's assets and liabilities. For example, a bank that funded a long-term fixed rate loan with short-term deposit will face a decline in future income if the interest rates increase.

[7] The economics of money, banking, and financial markets, Frederic S Mishkin,2014

The yield curve is the graphical representation of expected interest rates by the financial market over time. Where the rates rise, the yield curve is said to be normal as opposed to where the rates decrease yield curve is said to be inverse. Yield curve risk arises when the anticipated shifts in the yield curve have adverse effects on bank's income. It is associated with short-term and long-term interest rates. Banks are faced to yield curve risk if the short and long positions with different maturities are constituting a portfolio even if the position is hedged against parallel shifts in yields.[8]

Basis risk is another important source of interest rate risk. It occurs when the change in interest rate for one instrument is different than other, even if the probable hedging positions have the same maturity date. Basis risk arises when the value of the hedge does not change equally with the financial instrument being hedged as interest rate change. For example, basis risk can be seen when the interest rate bearing assets and liabilities are based on different bases such as LIBOR versus government prime interest rate.[9]

1.2.1.2 Exchange Rate Risk

In today's business, there is a rapid increase in international capital flows due to the globalized world economy. With the recent developments, foreign exchange market has become a key component of the international finance. It plays a crucial role in cross-border trade, investment, and international transactions.

Exchange rate risk can be defined as the possible direct loss (as a result of an unhedged exposure) or indirect loss in the firm's cash flows, assets and liabilities, net profit and, in turn, its stock market value from an exchange rate move[10]. There are three main types of Exchange rate risks faced by multinational firms because of their international operations.

"*Transaction risk is a cash flow risk that associated with the movements of exchange rate on transactional account exposure related to receivables, payables, and repatriation of dividends."* The firm will be faced with the transaction risk if there is any change in the exchange rate in the currency of denomination of any such contract.[11]

[8] Hedging of Interest Rate Risk with Interest Rate Futures, Nahed Habis Alrawashdeh,2015
[9] Financial Risk Management, A Research on Derivatives Usage by Registered Corporations of Istanbul Stock Exchange,Nihan Dalgıç,Istanbul,2003 (Master's Thesis)
[10] Exchange Rate Risk Measurement and Management: Issues and Approaches for Firms, IMF, Michael Papaioannou, November 2006
[11] Hedging Instruments for Foreign Currency Risk, Swati Srivastava,2013

Translation risk is a risk that commonly faced by multinational firms dealing with foreign currencies or list foreign assets on their balance sheets. It occurs when a firm denominates a portion of its equities, assets or income in a foreign currency. Translation risk relates with the fluctuations of exchange rates on the valuation of a foreign subsidiary, following on the consolidation of a foreign subsidiary to the parent company's financial statement.

Economic risk is the risk that reflects the value of future operating cash flows of a firm's parent company and foreign subsidiaries due to unexpected exchange rate movements. It affects company's competitive position as well as a market value since it concerns the effect of exchange rates changes on revenues (domestic sales and exports) and operating expenses (cost of domestic inputs and imports).[12]

1.2.1.3 Commodity Price Risk

Commodity risk is the risk that a firm's income or position will be adversely affected by fluctuations in commodity prices. According to their characteristics, commodities fall into three categories:

- Soft commodities: Agricultural products such as wheat, corn, sugar
- Hard Commodities (Metals): gold, silver, copper
- Energy commodities: gas, oil, electricity

Price risk for those commodities can arise because of several reasons such as fluctuations of trading in the market due to lack of suppliers, changes in the availability of commodities and governmental regulations on commodity prices. Producers of commodities such as farmers, miners, and energy sector are exposed to commodity risk mainly when the price falls. In contrast consumers of commodities, such as airlines, manufacturers primarily face to rising prices, which will increase the cost of purchase.

Moreover, in today's business, most of the commodities are priced and traded in US dollars. As a result, organizations and individuals that are exposed to commodity risk may also face with exchange rate risk as well.[13]

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[12] Exchange Rate Risk Measurement and Management: Issues and Approaches for Firms, IMF, Michael Papaioannou, November 2006
[13] Guide to Managing Commodity Risk, Jan Barned, CPA Australia, October 2012

1.2.1.4 Equity Price Risk

Equity price risk is exposed by the volatility in stock prices. One of the components of equity price risk is about the general market risk of equity due to the sensitivity of a portfolio value. It arises from the change in general market stock indicators and interests with the effects of this change in the industry. Another one is called specific risk of equity, and the company faces it due to company's management system such as a problem in problems in operation process. In this those two components, general market risk cannot be diversified but, the specific risk can be diversified regarding modern portfolio theory.

Equity price risk is one of the most important sources of the market risk. It is because of the fluctuations in equity prices are usually higher than in fixed-income securities or foreign exchange markets. Also, the degree of market risk exposure of equities is higher than bonds as the changes in the value of the fixed-income financial assets are more predictable.

1.2.2 Credit Risk

While financial institutions are exposed to various types of risks over the years, credit risk has become one of the major causes of banking problems due to poor credit standards for counterparties and lack of attention to developments in the economic field which leads to a degradation in the creditworthiness of a bank's counterparties.[14]

Credit risk also known as counterparty risk can be defined as the potential that a bank borrower or contractual party will fail to meet its obligations by agreed terms[15]. Even though loans are the major source of the credit risk for most banks, other financial instruments cause the risk such as futures, swaps, options, equities, foreign exchange transactions. With the recent developments in market risk measurement capabilities, corporations are more competent in quantifying credit risk on a portfolio basis.

Three characteristics form the credit risk. Exposure expresses the possible default or an unfavorable change in party's ability to perform. The term default refers to the inability to make the promised payment. The likelihood of this inability can be defined as the default probability. Recovery rate is the value to recover credit event in case of default

[14] Principles for the Management of Credit Risk, Bank for International Settlements,1999
[15] Credit Risk Management, Ken Brown, Peter Moles, Edinburgh Business School, 2014

takes place. The risk is greater when the exposure or the default probability higher in contrast to recovery rate.[16]

Credit risk can be expressed as follow:

Credit Risk = Exposure*Probability of Default*(1-Recovery Rate)

There are several subdivisions of credit risk including settlement risk and concentration risk and country risk.

"*Concentration risk can be defined as exposure(s) that may arise within or across different risk categories throughout an institution with the potential to produce: (i) losses large enough to threaten the institution's health or ability to maintain its core operations; or (ii) a material change in an institution's risk profile*."[17] Concentration risk is considered as one of the main causes of major losses for credit institutions due to two types of imperfect diversification.

Firstly, "name" concentration risk arises when the idiosyncratic risk cannot be perfectly diversified due to having too many loans concentrated in a specific asset or instrument for individual borrowers. Sector concentration emerges when there is a massive exposure in a particular industry and geographical region. An excessive concentration can be the cause of market and liquidity risk as well.

Settlement risk arises due to exchange of cash flows when the third party process transactions for other parties. It emerges when a bank that irrevocably pays out the sold currency to its counterparty unconditional *"upon final receipt of the currency it has purchased is exposed to financial loss up to the principal value of the trade if its counterparty fails to deliver the purchased currency."*[18]

Settlement risk was not considered as a major risk for financial institutions until a famous incident happened to a small German bank, Herstatt Bank went bankrupt on 26 June 1974

[16] The Internal Ratings-Based Approach, Basel Committee on Banking Supervision,2001

[17] Cross-sectoral review of group wide identification and management of risk concentrations, Basel Committee on Banking Supervision, The Joint Forum, April 2008, Page 2.

[18] Financial System Review, Management of Foreign Exchange Settlement Risk at Canadian Banks, Neville Arjani, December 2007,

due to a huge crisis in foreign exchange liquidity. Some banks had already released payments in Deutsche Marks for in exchange of USD , believing that they will receive the payment later on the same day. Because of the time zone differences between New York and Frankfurt, Herstatt stopped dollar payments to the counterparties, and they were not able to collect their payments. At the end of the day, at 16:30 pm in Frankfurt, German regulators repealed the bank license of Herstatt Bank because of lack of capital to cover liabilities.[19]

Country risk also known as political risk is the third subdivision of credit risk. Country risk is defined by Nagy(1984) as "the exposure to a loss in cross-border lending, caused by events in a particular country which are – at least to some extent – under the control of the government but not under the control of a private enterprise or individual."[20] There are four factors can be examined in country risk concept.

- Political Risk: It arises when the government of a country is unstable and have difficulties.
- Economy Risk: It results due to declining in economic stability.
- Currency Risk: It is related to cross-border economic activities and arises due to fluctuations in exchange rates.
- Enforcement Risk: It arises because of the conflict between legal system in domestic and foreign legal system.

1.2.3 Liquidity Risk

Liquidity is the ability to fund increases in assets and meet obligations as they come due[21]. Liquidity risk arises when the banks or financial institutions are not able to fulfill their obligations in time due to lack of capital or cash inflow. There are two types of liquidity risk:

- Funding liquidity risk (cash-flow risk)

[19] Bank Failures in Mature Economies, Working Paper no.13, Basel Committee on Banking Supervision,2004
[20] United Nations Conference on Trade and Development, Credit Rating Agencies and Their Potential Impact on Developing Countries, Discussion Papers, No.186, January 2008
[21] Sound Practices for Managing Liquidity in Banking Organizations, BCBS, February 2000.

- Market liquidity risk (product risk)

Funding liquidity risk is one of the main reasons behind many of the banking crisis. Bank for International Settlements defines funding liquidity risk as *"the possibility that over a specific horizon the bank will become unable to settle obligations with immediacy."* The risk occurs if the cash outflow is larger than cash inflow. One of the indicators of a bank's or firm's funding liquidity or short term liquidity is the current ratio (Current Assets/ Current Liabilities). If the ratio is smaller than 1, it means that liabilities are higher than the assets which can lead to a liquidity crisis.

The second type of liquidity risk is the market liquidity risk. The risk occurs when the transaction of an asset cannot be realized at "normal" market price. The common reasons behind market liquidity risks are market structure, time horizon, and the asset type. For example, if the owner an asset is of urgency, he has to sell his asset at a lower price or if the asset is illiquid (difficult to convert cash), the owner will face with the market liquidity risk.

1.2.4 Operational Risk

"Operational risk is the risk of direct or indirect loss resulting from inadequate or failed internal processes, people, and systems or external events including legal risk."[22]. All the risk categories that are not included in credit or market risk can be considered as operational risk excluding strategical and reputational risk. In general, operational risk covers almost all disruptions that can be experienced in the operational process of the institution. These disruptions can stem from some external factors, such as systemic inaccuracies, system faults, staff misbehavior, staff corruption, inaccurate accounting records as well as internal factors such as terrorist attacks, natural disasters, legislative changes and changing practices of regulatory authorities.

Banks, which usually work for credit and market risk and tend to reduce the effects of these risks, have accepted the operational risk and have included risk management in the aftermath of many financial crises. In fact, for many years, the financial sector has focused on operational risk. But instead of putting this perspective in a comprehensive framework, institutions have focused more on the fact that the operations that constitute only a small

[22] Basel Committee on Banking Supervision, Consultative Document,Operational Risk, January 2001

part of operational risk are worked without errors and accuracy. Particularly with the development of the tools from risk-oriented sectors such as the insurance industry, approaches based on a systematic measurement of operational risk have started to be used.

Types of operational risks can be classified as:

- Personnel risk
- Technological risk
- Organizational risk
- Legal risk
- External risk

1.3 Portfolio Risk and Diversification

In the context of investment, all the securities owned by an investor is called the portfolio. It is very important to create an optimal portfolio for investors who form a portfolio from different securities within their investment preferences. Therefore, rather than calculating the risk of any security, the risk and return of a portfolio need to be calculated.

Portfolio diversification is a collection of securities with different risks and returns. The increase in diversification will reduce the total risk of the portfolio. There are two different approaches to portfolio diversification.

- Traditional Approach
- Modern Approach

1.3.1 Traditional Approach

The traditional approach, based on the assumption that some of the securities in the portfolio will be lost in returns while others will be profitable, is based on the idea of increasing the number of securities in the portfolio. Since the method is based on diversifying and distributing the risk of the portfolio with different securities rather than a single security, it is also called simple diversification.

The main purpose of the approach is to maximize the utility of the portfolio holder. In other words, the investor will choose a portfolio that will maximize the benefits of risk and expected return, as the consumer tends to maximize utility between the goods and services he or she asks. Even if the investors make a simple diversification, they will have a risk-reducing effect on the portfolio by moving the assets in the portfolio to neutralize the value changes.

In the classical approach, it is possible to make a good choice which minimizes the risk for the investor by selecting the securities constituting the portfolio from different sectors and industries independently of each other. However, it is better not to include the securities that belong to the same sector/ industry or those that have the same maturity dates.

Traditional diversification depends entirely on investors' knowledge and financial abilities since it is not being able to minimize the risk fully, to increase the expected returns under risk minimization, and inevitably ignoring the existing relationship between portfolio securities[23].

1.3.2 Modern Portfolio Theory

The traditional approach was criticized by the scientific inadequacy, because of the financial assets in the portfolio assumed that there was no relationship between securities regarding returns or risk distribution. In contrast, in the article from Harry Markowitz, "Portfolio Selection" published in 1952, which is the basis of modern portfolio theory, the traditional portfolio theory was developed.

The first development is to demonstrate that the overall sum of the components is not exactly equal to the sum of the components. It is possible that the total risk of the Markowitz portfolio may be less than the risk each of the assets constituting the portfolio. In this context, non-systematic risk has been shown to be able to be reduced under certain circumstances.

Secondly, some portfolios seem to be riskier than others with similar returns, while some portfolios are risky at the same rate, but they will not be preferred by investors because they generate fewer returns. For this reason, it suggests that some portfolios are superior to others in the selection of securities due to the existence of efficient frontier.

The final contribution is that the efficient frontier can be obtained by quadratic programming (second order polynomial relation).

[23] Strategic Financial Management,The Institute of Chartered Accountans of India

The basic assumptions of the model can be summarized as[24]:

- The expected returns for a given period are shown as probability distributions
- Investors are trying to maximize utility over a period, and the utility of investors are explained by the diminishing marginal utility curve.
- The investors estimate the portfolio risk based on the variability of expected returns.
- Investors make decisions based on expected return and risk composition, and therefore utilities are a function of expected returns and expected variances.
- Investors prefer high return to low return at a certain risk level or they prefer low risk to high risk at a given level of return.

The Markowitz model differs from the traditional approach in that, in determining the risk of the portfolio, the risk of the securities in the portfolio is calculated separately, and the relationship between the returns of these securities is taken into account. In this respect, the model is called the "mean-variance" model. This model, which is based on the assumption that the probability distribution of the returns of the securities is normal and that the investors are risk averse, suggests that the investor would choose the lower standard deviation of the two securities with the same expected return. When a choice is made according to the model, if the default conditions apply, the investor maximizes the return. On the other hand, in order to form efficient portfolios, it is necessary to know the covariances between expected return, risk, and securities about each security value. The decision on which portfolio the investor should choose on the basis of its effectiveness depends on the tendency to bear its individual risk.[25]

The Markowitz model clarifies the behavior of investors. In order to reduce the risk of investment, the risk is distributed to many assets within the portfolio. However, unlike the traditional diversification, the relationship between the returns of these securities is taken into consideration rather than increasing the shares in the portfolio by offering securities of very different kinds. In addition to this, the concept of risk has been explicitly addressed, as well as return, and portfolio management has been reshaped from one dimension to multi-dimension.

[24] Investment Analysis and Portfolio Management, Frank K Reily, Keith C Brown, 2000
[25] The Modern Portfolio Theory as an Investment Decision Tool, Iyiola Omisore, Munirat Yusuf,Nwufo Christopher, 13 February 2012

The most significant criticism of the Markowitz model is the length of the calculation period and therefore the high cost. This problem arises especially in large portfolios with hundreds of securities.

1.3.3 Calculation of Portfolio Risk and Return

1.3.3.1 Calculation of Expected Return

The investor of the financial asset has to foresee the risk that the return will provide the future value of this securities before the investment decision. Because of uncertainty, it is almost impossible to determine what to bring in the future. This means that the data sets of the past, i.e., the previous return values of the securities, are utilized.

The expected return on a financial asset, for a given period, is the sum of the probabilities defined for certain conditions multiplied by the likelihood of realization of that asset:

$$E(r_i) = \sum_{i=1}^{n} P_i \, r_i$$

The expected return of a portfolio is the weighted sum of the expected returns of each security in the portfolio. Weight represents each security in the portfolio by percent.

$$E(r_p) = w_1 E(r_1) + w_2 E(r_2) + w_3 E(r_3) + \ldots + w_n E(r_n) = \sum_{i=1}^{n} w_i \, E(r_i)$$

1.3.3.2 Standard deviation and variance

When investment decisions are made on portfolio or securities, it is not enough to calculate only the expected return. However, a large number of historical data should be analyzed so that the expected return can be estimated very close to reality. It is also necessary to know the level of the risk is assumed for the expected return.

The variance of security can be expressed as below:

$$\sigma_i^2 = \frac{1}{n} \sum_{i=1}^{n} [r_i - \overline{r_i}]^2$$

If the variance is calculated by possible returns that expected in the future rather than past data, it can be expressed as:

$$\sigma_i^2 = \sum_{i=1}^{n} P_i [r_i - E(r_i)]^2$$

According to the Markowitz model, it was previously stated that a portfolio should be calculated on the basis of the relationship between the returns of the securities in the portfolio composition and the risk of the portfolio. The most important statistical criterion that indicates this relationship is covariance. The correlation coefficient is also another standard for the relationship between stocks. The correlation coefficient indicates both the direction and the degree of the relationship between the returns of the two stocks. Calculation of those two indicators has been examined in the thesis. (Variance-Covariance, Normal Method).

2. Risk Measurement Methods

Every new method that emerges in risk analysis has been developed by improving the weak aspects of previous models. Researchers and investors discovered those aspects in consequence of past experiences and economic crises in financial markets. For example in 1970's, fluctuations in interest rates caused high inflation rates which were resulted as economic stagnation in the market. Also, on 19 October 1987 (Black Monday), stock markets around the world crashed with a significant margin (around %23 in the United States) because of the program trading[26], illiquid markets, and excessive valuations. These events have shown to investors and academicians that conventional risk management techniques are not sufficient to predict the emerging crisis. Following the Black Monday crisis, at the beginning of the 1990s, these judgments were verified with the unexpected bankruptcy of large investment/finance organizations such as Barings Bank and Orange County. In order to understand Value at Risk method correctly, this section will examine the events that underlie the development of the methodology. However, here the focus is on both the magnitude of loss and the events that have similar characteristics regarding applied strategy.[27]

When Barings Bank, one of the UK's largest banks, with nearly 200 years of history, announced that it had ended its banking operations in February 1955, the community witnessed how a Singapore broker could bankrupt such a large bank. As a result of the transactions made by the chief trader of Barings Futures, the bank's Singapore subsidiary, 1.3 billion dollars was lost in derivative markets, the resulting loss completely eradicated the bank's equity, and as a result, the bank had to declare bankruptcy by failing to fulfill its obligations.

The process that led Barings Bank to this end began with the trader's position in the stock index futures contract on the Japan Nikkei 225 index. At that time, Barings Futures positions in the Singapore and Osaka stock exchanges rose by about $ 7 billion. However, later on in the first two months of 1995, as the current market declined by more than 15%,

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[26] Program trading represents an increasing percentage of overall stock market volume (Competitive Bids for Principal Program Trades, Robert Almgren, Neil Chriss, March 14,2003)

[27] Value at Risk: Risk Ölçümünde Yeni Bir Yöntem ve Portföy Riskinin Ölçümü Üzerine Bir Uygulama (Value at Risk: A New Method for Measuring Risk and An Application on the Measurement of Portfolio Risk), Hakan Kapucu, Istanbul, 2003 (Doctoral Dissertation)

Barings Futures faced with the obligation to buy securities at a high price according to the contract despite this drop in the market. This meant that the bulk of Baring Futures' capital was gone. On the other hand, it continued to take a position in the market. However, the bank had to declare that it would not be able to meet this obligation at the end of the contract when the cash exchange delivery was requested by the relevant stock exchange.[28]

Since Barings is known as a conservative bank in the world financial system, the bankruptcy of the bank has had a cautionary effect on financial institutions around the world. The trader responsible for the transactions above was involved with both trading desk and back office. In general, the function of the back office is to check all business activities are conducted by rules and to ensure that the trade is verified. As in any bank, this bank also had to limit the amount of capital that traders could use, and therefore the position limits had to be tightly controlled. Also, it has become a necessity for banks to establish a separate risk management unit that provides different forms of control over traders.[29]

In spite of this need, Barings Bank did not monitor the trader very well because of his successful career. In 1994, this person almost contributed $ 20 million to Barings, which is about %20 of the bank's total profit. This meant a huge premium for both trader and his superiors. Hence, it can be clearly seen here that the reason for the control over the trader is weak. For that reason, there were allegations that senior executives were aware of the risks facing the bank, and that it had transferred $ 1 billion for marginal payments arising from contracts entered by this trader. In addition, an internal audit report, which was presented in 1994 before the bankruptcy of Barings and warned that he had excessive authority, was not considered by the top management.

Ultimately, this event forced Barings' shareholders to meet the full loss they had. The company's market capitalization value of $1 billion has disappeared, and the value of shares have fallen to zero. Barings was then purchased by the Internationale Nederlanden Group (ING), a Dutch-origin financial services group, at the cost of $ 1.50 per share,

[28] Lessons from the Barings Collapse,Sheila C. Bair, 1995
[29] For details: http://ifci.ch/137550.htm

provided that the resulting losses were met. The trader was sentenced to heavy imprisonment by Singapore law.

Orange County case is another example of market risk. This publicly owned local fund management agency was responsible for a $ 7.5 billion portfolio of fund managers, schools, private administrations and municipal governments. In order to increase the value of the portfolio, the manager invested approximately $ 12.5 billion in reverse repurchase agreements with a total of $ 20 billion in repayment at the end of the four-year maturity period.

The fund manager Citron was expecting a decline in interest rates, and he believed that medium-term investments would generate high returns rather than short-term investments. Citron,therefore assessed the majority of the funds with brokerage houses sponsored by the government. In contrast to the expectations of Citron, the fund market was seriously damaged as a result of the interest increase by FED. When market interest rates rose in February 1994, public debt securities in the portfolio began to suffer losses. Wall Street bankers, who provided short-term financing, demanded that their funds be covered by spreading the news that the funds they are insured were suffered loss. As a result, when Orange County declared its failure to meet its margin obligations, the loss after the liquidation of securities on the portfolio had exceeded $ 1.64 billion.[30]

The process of dragging Orange County into bankruptcy have similarities with Barings Bank case. The common point in these organizations is the inadequacy of fund managers' control. In both cases, the managers have shown great success in the beginning to increase the welfare of their superiors. In this sense, for example, when the crisis began to manifest itself a few months before the bankruptcy of Barings Bank, another $ 850 million was sent by top management to support the hedged position. Likewise, in the case of Orange County, municipal inspectors have approved $ 600 million in additional support. However, a few months ago, the municipal government ignored warnings by the municipal treasurer that the fund manager's strategy was too risky and the fund would probably lose $ 1 billion. In addition, according to US legislation and accounting standards applied, the portfolio is shown only at a cost in the records since it is not compulsory for the local governments to keep records of earnings and losses arising from

[30] Phillipe Jorion, “Philippe Jorion’s Orange County Case: Using Value at Risk to Control Financial Risk”, 1999

the fund management activities. Therefore, the audit was carried out at the cost value, not at the current prices. This has created a misleading effect on both the investors and the managers regarding the risk that the portfolio is being faced. However, investors and portfolio management could be more rational in decision-making if the risk value of the portfolio was calculated based on current prices at regular intervals, for example, months.[31]

In this context, the Value at Risk requirement has emerged in the last thirty years with an increase in the number of unusual fluctuations in exchange rates, interest rates and product prices subject to the financial system, and the corresponding number of derivative instruments. This increase is directly proportional to the increase in transaction volume of securities trading and the diversification of financial opportunities. Therefore, this means that growth in foreign trade and the expansion of international financial relations between companies. As a result, many companies have begun to build portfolios that include significant amounts of cash and derivatives. Due to the diversity of securities within the scope and the increase in transaction volume, the size of portfolio risk of companies is frequently changing and can not be monitored clearly. All of these developments have led to a claim that a senior manager responsible for the management of risk management can present a numerical benchmark against which a portfolio manager can report a summary report in order to express the market risk faced by the portfolio. Value at Risk is one of the reliable criteria developed for this demand.[32]

2.1 Value at Risk

The studies by the companies to measure all the risks within their institutions as a whole started in the 1970s. Later, these studies were sold to consulting firms and financial institutions and companies that are not in a position to develop a model but need such systems. The most famous of these systems is RiskMetrics, which is developed by JP Morgan and uses the Value at Risk.

Developed Value at Risk systems was not only based on portfolio theory, some using the historical method and others based on the Monte Carlo simulation technique. JP Morgan

[31] Phillipe Jorion, "Philippe Jorion's Orange County Case: Using Value at Risk to Control Financial Risk", 1999

[32] Value at Risk: Risk Ölçümünde Yeni Bir Yöntem ve Portföy Riskinin Ölçümü Üzerine Bir Uygulama (Value at Risk: A New Method for Measuring Risk and An Application on the Measurement of Portfolio Risk), Hakan Kapucu, Istanbul, 2003 (Doctoral dissertation)

offered RiskMetrics and the data set for it free of charge in November 1994. Value at Risk then became more widely accepted and used, not only by those engaged in securities but also by banks, other financial institutions, and non-financial companies.

As Value at Risk systems become widespread, besides measuring market risk, which is the first development objective, it is developed to include credit, liquidity and cash flow risks. Value at Risk method can be defined in many ways in parallel with the diversity of studies related to the subject. Here are a few different definitions that point to distinctive features of the method.

- VaR measures the worst expected loss over a given horizon under normal market conditions at a given level of confidence[33]

- VaR models seek to measure the minimum loss (of value) on a given asset or liability over a given time period at a given confidence level(e.g., 95 percent, 97.5 percent, 99 percent.)[34]

- Value-at-Risk is a measure of the maximum potential change in value of a portfolio of financial instruments with a given probability over a pre-set horizon[35]

The above definitions also include certain common attributes related to the concept of Value at Risk. These common characteristics that point at a given time, a certain probability and a particular hand can be expressed as:

- The data used in the VaR calculations for a certain time horizon is applied for a specified period. These periods can be daily, weekly, or monthly based on the risk priority of the institution that calculates the VaR.

- As in other statistical methods used in risk measurement, VaR calculation is based on a certain confidence interval. Therefore, the possibility of Value at Risk values also

[33] Value at Risk, The New Benchmark of Controlling Derivatives Risk, Philippe JORION, USA, 1997
[34] Credit Risk Measurement : New Approaches to Value at Risk and Other Paradigm, Anthony SAUNDERS, John Wiley & Sons Inc. USA, 1999 page 84
[35] JP Morgan RiskMetrics – Technical Document Fourth Edition, New York 1996

includes a probability. The existence of probability also points to a particular numerical, statistical or mathematical computing process. This means that in order to reach VaR values, information technologies should be used.

- The use of information technologies in the VaR calculation also pioneered the development of the Value at Risk methodology, which can also be used to calculate other risk types such as credit and cash flow risk

- VaR is calculated as a value rather than a coefficient. Therefore, unlike other risk measures, it shows the amount of loss that can be experienced under certain constraints.

- Above all, a unique Value at Risk approach can be mentioned within risk management. This points to and measures how VaR values can be used, how the institution should be restructured for this purpose, and how various common risk management resources will be implemented.

Value at Risk measures the amount of loss expected based on the likelihood of specific market movements over a given period of time. Thus, with this method, financial institutions have the possibility to summarize the market risk that they may face due to unexpected market conditions with a single numerical criterion. The capital requirement linked to market risk is based on VaR estimates calculated by banks and non-bank financial institutions using their risk management models. These models have been developed to predict the time-varying distributions of portfolio revenues. Actual VaR values are lower than estimates of these distributions. In other words, the VaR value is the estimate of the maximum portfolio loss that can occur over a given holding period, as determined by a certain confidence interval.

The method has become a focus of interest for many practitioners dealing with risk management in an economy and has also become a standard measure for identifying the market risk of a portfolio of the various asset. As a result, it has begun to be used as a regulatory tool in protecting the integrity of the financial system and in risk management of banks. Along with this rapid increase in usage of value at risk, research has begun to be carried out in an international context that focuses on mathematics, statistics, and econometrics, and these researches are the basis for the formation of the unique Value at Risk methodologies.

2.2 Parameters for Value at Risk

2.2.1 Confidence Interval

The choice of the confidence interval is related to the level of confidence expected in the VaR forecast. In practice, 95%, 97%, and 99% confidence intervals are widely used, although many different confidence intervals can be determined. However, while the Basel Committee argued that there should be 99% confidence level used in Var calculations, J.P. Morgan, on the other hand, chooses 95% confidence level in its calculation.

The normality assumption also allows the comparison of measured VaR values to different parameters. Therefore, 99% confidence level VaR can be obtained from 95% confidence level VaR. Similarly, VaR values, calculated for different holding periods, for example daily or monthly, can be compared. From this point of view, it is possible to evaluate different portfolios of the same type. For example, the VaR value calculated based on the 95% confidence interval is intended to be converted to the VaR with the 99% confidence interval: The normalization assumption is that the VaR is equal to -aσ and the a value of 95% confidence level is 1.65. Accordingly, the standard deviation of the portfolio will be σ = $VaR_{0,95}/1.65$. In the same way, $VaR_{0,99}$ value of %99 confidence level is 2,33σ.
Therefore, $VaR_{0,99} =$ (2,33/1,65) $VaR_{0,95}$

That is, a 99% confidence level VaR value will be about 1.41 times the 95% VaR value. The point to be taken into account here is that such a comparison can only be between VaR values calculated according to the same methodology.

2.2.2 Holding period

One of the elements that can be deducted from the definition of VaR is the holding period. The hypothetical holding period can be defined as the period of time when there is no change in the portfolio positions. This is one of the two most important components in the execution of VaR models used to measure market risk together with the confidence interval. For that reason, the choice of holding period in the calculation of VaR is high. Therefore, the choice of these two components by risk managers significantly affects the nature of VaR models.[36]

The Basel Committee, which became a standard in the measurement of VaR, set two important standards for holding period.[37]

- *"Value-at-risk"* must be computed on a daily basis
- In calculating value-at-risk, an instantaneous price shock equivalent to a ten day movement in prices is to be used, i.e. the minimum *"holding period"* will be ten Trading days. Banks may use value-at-risk numbers calculated according to shorter holding periods scaled up to ten days by the square root of time

The daily calculation of the Value at Risk value is recommended for the purpose of informing the public. Initially, this practice began with the day-to-day announcement of the market risk level at the end of each day by J.P Morgan due to the day-to-day operations, beginning in October 1994. However, since the composition of active portfolios is often amenable to change, the assumption that portfolio position remains unchanged over the holding period should be discussed. The positions of such portfolios constantly vary, not every ten days. Therefore, quick changes need to be taken into account for an effective strategy for VaR measurement. That's why, for example, longer periods are chosen in mutual funds and investment partnerships, while overnight periods are preferred in intermediary institutions.

[36]," Evaluation of Value-at-Risk Models Using Historical Data", Economic Policy Review, Darryll Hendrics , New York, April 1996

[37] Basel Committee on Banking Supervision, Amendment to the Capital Accord to incorporate market risks, November 2005

The debate on the choice of the holding period for the purpose focuses on three basic views.[38]

In the case of the capital required to be held in exchange for the market risk, the holding period should be considered as overnight or weekly rather than a few months, annually or longer. Also, the analysis of the investment decision according to the daily or overnight holding period is difficult; it can lead to miscalculation of the VaR values by using the short holding period for the options (low liquidity) and the long holding period for the securities (high liquidity).

Many mathematical models are applied in the VaR calculation. These models based on linearity is insufficient for gap analysis as part of the pricing objective. The misstatement caused by the fact that the long-term holding period was chosen has caused many losses for brokerage houses in the developed countries. Because of this, testing of the sensitivity of VaR models is a necessity.

Under normal market conditions, since many positions in the bank portfolio can be converted to liquid within a shorter period of time, the 10-day holding period is criticized as being extremely conservative. However, the 10-day standard also reflects a need for risks that arise from options with non-linear price features and other positions. Sensitivities of options against changes in market risk factors should be selected as a one-day rather than a longer holding period, as these fluctuations may increase at a high rate, depending on the magnitude of these changes. For that reason, the choice of the 10-day holding period arises from the view that the VaR estimates used to calculate the capital requirement should be combined with the impact of the 10-day momentary price movements in market risk factors. Sensitivities of options against changes in market risk factors may increase at a high rate depending on the magnitude of these changes. So, longer holding period should be selected rather than a day period. For that reason, the choice of the 10-day holding period arises from the view that the VaR estimates used to calculate the capital requirement should be combined with the impact of the 10-day momentary price movements in market risk factors.

[38] " Report Card on Value at Risk: High Potential but Slow Starter", Tanya Styblo BEDER,

Another problem on the holding period arises from the comparison of VaR values calculated according to different periods. In order to be able to make a comparison by assumption or to be able to translate the obtained results according to different time periods, the series used in the calculation should be normally distributed. Under this assumption, the Basel Committee suggests the application of the "square root of time" technique as the conversion method.

The selection of the holding period is crucial when there are extraordinary fluctuations in financial markets. The reason for this is that calculated volatility varies according to the holding period.

2.2.3 Present Value of the Portfolio

In calculations, one of the parameters required to calculate the risk of a portfolio is the present value of the portfolio. The amount of risk that has to be endured for a portfolio is directly proportional to the size of the current value of the portfolio.

2.2.4 Volatility

Another essential element of Value at Risk calculation is volatility. The concept of volatility is critical in the VaR calculation because it is a risk criterion in itself. While there is no such thing as the prediction of the fluctuation in the past, volatility estimate for the future is made based on past figures.

Risk calculations are based on the calculation of the standard deviations of the returns, taking into account the assumed probability distributions of the returns of the investments. Volatility is the measurement of expected changes in the price of a financial asset over a specified period of time. The volatility of portfolio income depends on the sensitivity of each asset to its risk factors, as well as covariance and variance between portfolio risk factors.

The volatility of various variables such as interest rates, currencies, inflation rate, the stock market, production costs is a measure of how much the volatility actually deviates from the expected values of the relevant parameters. Rapid changes in the economy are causing the volatility to increase in particular. It is very important to forecast the volatility to be protected against future surprises. It is also a known fact that individual and institutional investors, especially those who risk aversiveness of high volatility, negatively impact financial demands. For this reason, the positive and negative aspects of the volatility that has been experienced in financial markets over the last years are the subject of research in detail.

Portfolio volatility depends not only on the volatility of the assets in the portfolio but also on the correlation between the assets. For this reason, it will not be enough just to calculate the standard deviation. In addition to standard deviation calculations, the methods used to measure volatility are Exponentially Weighted Moving Average (EWMA), Autoregressive Conditional Heteroskedasticity (ARCH), and Generalized Autoregressive Heteroskedasticity (GARCH).

2.2.4.1 Exponentially Weighted Moving Average (EWMA)

Especially in 1980's, with the rapid development of computers and financial systems, along with the evolving needs, financial modeling become a vital tool in the sector. In this context, variance modeling is one of these evolving needs. Many studies on asset returns show that variance and covariances vary over time, so it is necessary to exclude the old data from the calculation.

EWMA is a popular technique developed by JP Morgan and used for risk estimation in the RiskMetrics value at risk model, which was offered free of charge in 1994. In this method, "*a moving average of historical observations is used, where the latest observations carry the highest weight in the estimates.*"[39]

Variance formula for Exponentially Weighted Moving Average is:

$$\sigma_t{}^2 = \lambda\sigma_{t-1}{}^2 + (1-\lambda)r_{t-1}{}^2$$

[39] A Comparison of Value-At-Risk Methods For Portfolios Consisting Of Interest Rate Swaps And FRAs, Robyn Engelbrecht, December,2003

Here, the λ shows how much weight will be given to the data in the last days. This coefficient is accepted as 0.94(daily) and 0.97(monthly) in the RiskMetrics system. If the λ value is closer to 1, it means that more weight will be given to last data.

There is criticism that the EWMA method may not be able to represent the series fully, so the estimates to be made according to this approach will not be healthy. But the advantage of EWMA is that it can express it in the volatility calculation in sudden changes that may occur. This feature helps to calculate when the volatility is high.

2.2.4.2 Autoregressive Conditional Heteroskedasticity (ARCH) and Generalized Autoregressive Heteroskedasticity (GARCH)

The Autoregressive Conditionally Varying Variance (ARCH) used in the volatility model was developed by Engle in 1982. Developing the ARCH model out of the regression models, Engle has shown that it can be modeled not only of the mean but also of the variance. The autoregressive in the model represents that volatility depends on volatility in the past period. The first-order autoregressive model described by Engle (1982):

$$\sigma_t{}^2 = a_0 + \sum_{i=1}^{q} a_i \ \varepsilon_{t-i}^2,$$

"where $a_0 > 0, a_i \geq 0, i = 1,2,3,,q$ the series is stationary if $a_i < 1$. The ARCH model creates a process where today's variance depends on its own previous variance. This allows the model to capture the volatility clustering observed in financial markets. The a_i parameter explains how fast the model reacts to news on the market. The one step ahead forecast for the ARCH (1) model is done by using the equation,"[40]

$$\sigma_{t+1}{}^2 = a_0 + a_1 \varepsilon_t^2$$

For the ARCH method to be meaningful, all the "a" parameters in the equation must be positive. (Engle,1982)

One of the most widely used methods considering volatility variability and previous volatility dependence is the GARCH model, developed by Tim Bollerslev in 1986, with the extended form of the ARCH model.

[40] A comparison of GARCH models for VaR estimation in three different markets, Andreas Johansson, Victor Sowa, June 2013

GARCH model can be expressed as:

$$\sigma_t{}^2 = \lambda w + \sum_{i=1}^{N} a_i \, R_{t-i}^2$$

If the market is volatile in the current period, the variance of the future period will also be high, depending on the magnitude of the return deviation in this period. On the other hand, if today's volatility is relatively low, the volatility in the next period will be low, unless the portfolio return deviates significantly from the average.

2.3 Statistical Value at Risk Calculations

In VaR analysis, although many methods are derived from each other, there is no consensus on which is the most appropriate way. Nevertheless, the vast majority of methodological studies focus on the estimation of statistical distributions of securities returns. In this context, the basic approaches used in VaR analysis can be written as follows.

- Variance-Covariance Method (Parametric Approach)
- Historical Approach
- Monte Carlo Simulation

In this study, only the approaches of variance-covariance, historical simulation and Monte Carlo Simulation proposed by the Basel Committee for VaR analysis have been addressed.

2.3.1 Variance-Covariance Method

The variance-covariance approach is based on the assumption that portfolio returns are a linear combination of the returns of securities that constitute the portfolio composition and portfolio returns are a linear combination of these risk factors. This means that portfolio returns have a normal distribution as the derivation of the risk factors in the portfolio is a linear function. This approach, therefore, explains portfolio's VaR on the basis of the normal distribution. In this respect, it would be sufficient to calculate the mean and variance of the normal distribution to achieve portfolio's Value at Risk.[41]

[41] Value at Risk: The New Benchmark for Managing Financial Risk,3rd Edition, Philippe Jorion, November 2006

In order to calculate Value at Risk, the value of the portfolio or stock should be multiplied by the standard deviation of the portfolio, normal value for given confidence interval, and the square root of holding period. (Measuring Market Risk with Value at Risk, Pietro Penza, Vipul Bansal,2001)

$$VaR_{\%,t} = P * \sigma * k * \sqrt{t}$$

$VaR_{\%,t}$: $Value\ at\ Risk\ value\ for\ given\ confidence\ interval\ and\ holding\ period$

P: Value of portfolio or stock

σ: standard deviation of the portfolio or stock

t: holding period

In general, portfolios consist more than one stock and calculation of standard deviation is more complex. In order to achieve value at risk value with the variance-covariance method, there are different ways to calculate the variance of the portfolio.

Normal Method

The expected return of the portfolio by the model is defined as the weighted average of the expected returns of the stocks in the portfolio. This means that the sensitivity of each risk factor in the portfolio will be proportional to the share of the risk in the portfolio.[42]

So,

$$E(r_p) = \sum_{i=1}^{N} w_i\, E(r_i)$$

$$E(r_p) = w_1 E(r_1) + w_2 E(r_2) + \cdots + w_n E(r_n)$$

$E(r_p)$: Expected return of the portfolio

w_i : Weight of stocks in the portfolio

$E(r_i)$: Represents the individual expected returns of the stocks in the portfolio.

[42] Financial Risk Manager Handbook,Second Edition, Philippe Jorion,2003

Since stocks represent investment ratios within the portfolio, weights must be equal to 1 in total.

According to the model, the risk measure of a portfolio is the statistically known measure of variance. The variance, based on normal distribution, is defined as the measure of deviation from the mean. The variance, taking into account the relationship between the returns of the stocks in the portfolio, is calculated by using the following equation for a portfolio consisting of N shares.

$\sigma^2_{r_p} = [\sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j \, \sigma_{ij}]$

This implies that the contribution of the variance of each stock to the total portfolio variance as a function of the relationship between weights and returns.

$\sigma^2_{r_p}$: Variance of the portfolio

w_i : (i) stock's weight in the portfolio

w_j : (j) stock's weight in the portfolio

σ_{ij} : Refers to the covariance that measures the direction of the relationship between the returns of stocks.(i and j).

The variance of an N-shared portfolio in the form of matrix notation is shown in the chart below.

$$\sigma^2_{r_p} = [w_i \dots \dots w_N] \begin{vmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \dots. & \sigma_{1N} \\ \vdots & \vdots & \vdots & \dots. & \vdots \\ \sigma_{N1} & \sigma_{N2} & \sigma_{N3} & \dots. & \sigma_N \end{vmatrix} \begin{vmatrix} w_1 \\ \vdots \\ w_N \end{vmatrix}$$

Or, more generally, to show the Σ covariance matrix,

$$\sigma^2_{r_p} = w' \sum w$$

Note that the number of operations is very high due to the matrix structure. The number of transactions in the covariance matrix will be N (N-1) / 2. For example, if a portfolio consists of 20 shares, this means 190 transactions. This number will be 1225 for 50 shares. As we can see, the number of transactions to be done increases geometrically according to the number of assets. This is very important for large portfolios of hundreds of stocks without any difficulty for small portfolios.

Covariance is a statistical measure of the direction of co-movement or variation of two random variables. If the covariance between the returns of the two stocks is positive, it means that the returns of the stocks are in the same direction if they are negative, they are moving in the opposite direction, and if there is zero, there is no linear relationship between the returns. The covariance is calculated as follows:

$$\sigma_{ij} = \frac{1}{N-1}\sum_{n=1}^{N}[(r_{i,n} - \overline{r_i})(r_{j,n} - \overline{r_j})$$

If it is calculated for future values, the covariance between returns is the weighted sum of the likelihood of the average expected return deviations of the returns of the stocks. Accordingly, for example, the covariance between the returns of stocks in a multi-asset portfolio is calculated as follows[43]:

$$\sigma_{ij} = \sum_{n=1}^{N} P_i[(r_{i,n} - E(r_i)][(r_{j,n} - E(r_j)]$$

r_i *ve* r_j : Return values of stocks (i and j) depending on P_i probability,

$E(r_i)$ ve $E(r_j)$: Expected returns of stocks (i and j),

N: Number of possible situations.

Another statistical measure which should be known according to the method other than covariance is the correlation coefficient. Correlation gives information about the direction of the relationship between random variables, while the correlation coefficient measures the degree of this relationship. The correlation coefficient is calculated as:

$$\rho_{ij} = \frac{\sigma_{ij}}{\sigma_i \sigma_j}$$

This equation shows that covariance can also be obtained through the correlation coefficient. In this case, the covariance is equal to correlation coefficients of the corresponding variables multiplied by the standard deviations of the variables:

$$\sigma_{ij} = \rho_{ij}\sigma_i\sigma_j$$

The variance-covariance matrix in the form of matrix notation is equal to the multiplications of the standard deviation matrix of the stocks with the correlation matrix:

[43] A Simplified Method for Calculating the Credit Risk of Lending Portfolios, Akira Ieda, Kohei Marumo,Toshinao Yoshiba, December 2000

$$\Sigma = \begin{pmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \sigma_2 & & 0 \\ \vdots & & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_N \end{pmatrix} \begin{pmatrix} 1 & \rho_{12} & \cdots & \rho_{1N} \\ \rho_{21} & 1 & & \rho_{2N} \\ \vdots & & \ddots & \vdots \\ \rho_{N1} & \rho_{N2} & \cdots & 1 \end{pmatrix} = \begin{pmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1N} \\ \sigma_{21} & \sigma_{22} & & \sigma_{2N} \\ \vdots & & \ddots & \vdots \\ \sigma_{N1} & \sigma_{N2} & \cdots & \sigma_N \end{pmatrix} x$$

The correlation coefficient is between +1 and -1. +1 means full positive, -1 means full negative correlation. The full positive relationship shows that the two variables move in exactly the same direction, whereas the negative relationship shows that they move in opposite directions.

According to given information above, Value at Risk value for normal method can be expressed as:

$$VaR_p = -a\sqrt{w\Sigma w'}$$

w : Weight Matrix

w': Vertical vector of weights

a : standard normal value for the given confidence level (1.65 for %95, 2.33 for %99)

Therefore, the VaR value of a portfolio in the context of a linear approach is a function of the relationship between VaR value of each stock in its scope. For example, Value at Risk value of a portfolio of two stocks:

$$VaR_p = \sqrt{(VaR_1)^2 + (VaR_2)^2 + 2VaR_1VaR_2\rho_{12}}$$

Value at Risk measurement has been used initially to expose the portfolio risk. However, due to the simplicity of reporting, it has become a strategic tool in active portfolios that change rapidly and continuously over time. Thus, the investor can instantly see how the risk changes during portfolio changes due to the prompt reporting provided by VaR measurement. Therefore, they are able to test the effectiveness of investment decisions regarding which vehicle to be included in the scope of the portfolio, which should be removed from the scope, or which position should be changed at once.

2.3.2 Monte Carlo Simulation

Monte Carlo Simulation is based entirely on a statistical model, different from the historical simulation created by simulating directly from past history, and uses mathematical techniques to reach a large number of possible portfolio return values. The simulation process actually takes into account possible events that occur, rather than events that have been observed in the past.[44]

The fact that the Monte Carlo Simulation relies on statistical modeling also requires random sampling. Unlike the Historical Simulation method, the purpose of this method is to estimate the portfolio value at the end of the holding period according to various scenarios and assumptions determined by defining the price behavior of the portfolio.

The most valuable resource in defining the portfolio price system is past price movements. In this sense, in order to apply the Monte Carlo simulation method, three type data are needed.

1. Expected change in asset value
2. The degree of uncertainty (variance-covariance matrix)
3. Type of distribution

Monte Carlo simulation is generally carried out according to the following algorithm:[45]

1. Determination of which statistical distribution model the portfolio return series belongs to,
2. Correlation between stocks constituting the portfolio composition and formation of the variance-covariance matrix,
3. Determination of the random number generator used to calculate the artificial prices of risk factors with the help of correlation and volatility,
4. Determination of hypothetical prices from distribution using random number generator,
5. Determination of profit or loss by calculating portfolio value according to hypothetical prices,
6. Repetition of the steps (2,3,4) to generate the return distribution of the portfolio,
7. Calculation of the VaR of this distribution according to the desired confidence level

In essence, the Monte Carlo Simulation Method is a mixture of the Variance-Covariance Method and the Historical Simulation Method. In Monte Carlo Simulation, as in the

[44] Elements of Financial Risk Management, Second Edition, Peter F. Christoffersen,2012
[45] Value at Risk: The New Benchmark for Managing Financial Risk,3rd Edition, Philippe Jorion, November 2006

Variance-Covariance Method, the variance-covariance matrix of historical returns is needed. However, the Monte Carlo Simulation approach does not suffice it but produces a new correlated series based on the corresponding variance-covariance matrix. The next step is the same as in Historical Simulation. If the time slice used in the Historical Simulation method is the same as the time slice used to derive the variance-covariance matrix and the portfolio behaves linearly; The results of Monte Carlo Simulation and Historical Simulation will be approximately the same. However, the portfolio will exhibit non-linear behavior (due to reasons such as options, etc.), the results will be different.[46]

Although there are similarities between Monte Carlo Simulation Method and Historical Simulation Method, the main difference between the two approaches is; real changes observed in market factors in the historical sampling period to generate hypothetical portfolio profits or losses in the Historical Simulation Method, The Monte Carlo Simulation Method shows a statistical distribution which is thought to be able to represent the possible changes in market factor adequately is to produce random market prices and rates that are not selected. These random values that are created will be used to obtain the distribution of hypothetical profits and losses for the current portfolio, and the Value at Risk value will be derived from this distribution.

One of the major disadvantages of this method is its high cost. In situations where the exact valuation of assets is complex, it is often difficult to apply this method frequently. To facilitate this situation, assets are grouped or aggregated under certain risk factors. The other weakness of the method is that the scenarios (similar to the pricing model of financial assets such as options) are based on specific stochastic models. In this context, this method also includes model risk. As a result, if the model is built correctly, it is the most detailed approach for measuring the market risk.

There are few steps have to be in consideration to implement Monte Carlo Process.

- Determination of the Distribution
- Testing the Observed Frequency Distribution
- Random Number Generation
- Repetition

[46] Piyasa Riskinin Tespitinde Kullanılan Value at Risk Yöntemi(Value at Risk Method Used in Determining Market Risk) , SPK Aracılık Faaliyetleri Dairesi, Özge Uysal,2006

2.3.3 Historical Simulation

In the Historical Simulation method, it is assumed that past changes in risk factors will repeat in the future, and the rate of change obtained from historical data is applied to the current market prices. According to the new market prices obtained by this method, the market value distribution within the total portfolio is obtained. For this method, at least one year of data is used retrospectively in standard practice, i.e., 252 new values are calculated for all risk factors. The portfolio is assessed using historical changes in risk factors. Accordingly, profit / loss distribution of the portfolio is calculated. (Özlem Kıraç, 2011)

The historical simulation also known as the non-parametric method does not rely on certain assumptions about the distributions of market factors, and therefore there are no parameters such as standard deviation and correlation to be estimated. The distribution of the probable profit or loss of the portfolio in the method is obtained by applying the changes in the market factors during the previous N period to the current portfolio.[47]

In the historical simulation method, rather than random selection of scenarios, the market value of the portfolio is used directly in the calculation of VaR. The historical simulation method is a simplified form of the Monte Carlo simulation method since it can be used without depending on certain assumptions. While this method does not require parameters such as correlation and volatility, on the one hand, it can be applied other distributions than normal on the other hand. Hence, there is no need to construct and estimate variance-covariance matrices. For this reason, unlike the Monte Carlo Simulation, it is independent of the model risk. In addition, the distribution can be applied to any securities, whether linear or not.

The historical simulation method consists primarily of four steps:[48]

- The determination of the risk factors required for the recalculation of portfolio value or the series of percentages of price changes of assets

[47] Risk Measurement: An Introduction to Value at Risk, Linsmeier and Pearson, July 1996
[48] Value at Risk: Risk Ölçümünde Yeni Bir Yöntem ve Portföy Riskinin Ölçümü Üzerine Bir Uygulama (Value at Risk: A New Method for Measuring Risk and An Application on the Measurement of Portfolio Risk), Hakan Kapucu, Istanbul, 2003 (Doctoral dissertation)

- Applying the price changes to the portfolio for the determination of the series of changes in portfolio values
- Ranking of portfolio value changes by percentage
- Determination of the value change corresponding to the desired confidence level as the portfolio VaR

The historical Simulation method is more appropriate to use when the amount of data is not huge, and there is not much information about profit/loss distribution. Though the method does require time, one of the most important advantages is that it can provide information about the recent collapses in the market.

The advantages and disadvantages of this method can be listed as follows[49]:

Advantages of the method:

- It is easily applied for non-linear positions. Each position containing an option type asset is practically non-linear. As with all other methods, every factor that affects prices must be simulated. In other words, not only the rates and prices but also the possible future values of indicator volatility should be simulated.
- There is no assumption about distributions.
- Created scenarios with forecasts can easily identify unbalanced and unstable markets.

Disadvantages of the method:

- Since the method is exact valuation, computation requires intensive processing
- Scenario production can lead us to wrong results. Estimations and random selection from past periods may not be consistent. The number of scenarios and variables expected to be estimated at a reasonable level will be limited.
- Possible changes in the future are not taken into consideration. If the volatility is low at the prices and rates in the last 1 year, the volatility movements in the simulation set will not be taken into consideration. This is the most criticized point of the model.

[49] Risk Management, M. Barış Akçay, Dr. Evren Bolgün, page 405

3. Application

The Value at Risk methodology offers a number of approaches, from stocks, bonds to derivatives. Past studies have provided different solutions to many problems in this concept.

In a study conducted by Grinold for the optimization of option portfolios, different optimal portfolios were created by using the scenario approach based on the mean-variance values, based on the prediction of expected returns.

Another study[50] conducted by Huisman, Koedjik, and Pownall, the Value at Risk minimization was performed according to the mean-variance and Sharpe index of a portfolio consisting of stocks and bonds values that are assumed to be normally distributed. According to the results obtained from this study, it has been demonstrated how to allocate optimal assets, which provides Value at Risk minimization, can be done according to different confidence intervals if the distribution of expected returns is not normally distributed.

In this study, the optimal portfolio Value at Risk is estimated according to Markowitz's Modern Portfolio Theory for portfolio optimization.

3.1 Methodology

In this section, a portfolio was created hypothetically by selecting 10 stocks traded on the Istanbul Stock Exchange. There are 252 data chosen for one trading year between 13.02.2015 to 11.02.2016. When creating the portfolio, the weights are equally given the shares. Stocks that are included in the portfolio:

- AKBNK, ARCLK, AYGAZ, GSARAY, MGROS, PETKM, TCELL, THYAO, TUPRS and YKBNK.

Firstly, descriptive statistics of these stocks returns are examined, and normality tests are performed for all series. Secondly, optimal portfolio obtained according to Markowitz model. Finally, three different methods of Value at Risk performed for the portfolio namely, Variance-Covariance Method, Historical Simulation Method and Monte Carlo

[50] "Asset Allocation in a Value-at-Risk Framework", Working paper, Ronal Huisman,Kees G KOEDJIK and Rachel A.J POWNALL, Erasmus University,Rotterdam,1999

Simulation method. For this purpose, Microsoft Excel and Statistical Software SPSS is used for the calculations.

For calculation, daily variation rates of each variable, i.e., daily returns, are taken into account. The daily closing prices are used for calculations of daily returns of the variables. Accordingly, the daily return of a variable is calculated with following formula:

$$r = \frac{P_t - P_{t-1}}{P_{t-1}}$$

r = daily returns

P = Daily Closing Price

3.2 Descriptive statistics and normality tests of return series

Descriptive statistics are calculated for the return series as shown below in the table:

	AKBNK	ARCLK	AYGAZ	GSRAY	MGROS	PETKM	TCELL	THYAO	TUPRS	YKBNK
MAX	0,076101	0,078033	0,045307	0,192956	0,098837	0,052265	0,054078	0,068525	0,070465	0,101408
MIN	-0,05489	-0,05	-0,03846	-0,18293	-0,04762	-0,04979	-0,06173	-0,07151	-0,04651	-0,08148
AVG	-0,00042	0,000977	0,00039	0,000442	-0,00142	0,001074	-0,0005	-0,00103	0,001189	-0,00085
VAR	0,000408	0,000319	0,00024	0,001569	0,000376	0,000257	0,000279	0,00041	0,000339	0,000383
SD	0,020206	0,017858	0,015501	0,039609	0,019399	0,016045	0,016702	0,02026	0,018423	0,019578
KUART	0,495621	1,3388	0,22231	9,38523	2,426654	0,364112	0,974098	0,974717	0,7117	3,096664
SKEW	0,278153	0,437432	0,172544	1,071527	0,392716	0,110192	-0,22172	-0,23455	0,32811	0,356855

TABLE 3.1: DESCRIPTIVE STATISTICS FOR RETURN SERIES

In the table, it can be seen minimum, and maximum values, average values, standard deviations, kurtosis and skewness measures were given for each individual series. The highest average return belongs to the Turkey's oil refiner Tupras (0,001189) and lowest average return to swiss-based retail company Migros (-0,00142). Also, the average return of the two Turkish Banks is similar in this period Akbank (-0,00042) and Yapikredi Bank (-0,00085). Between these stocks, there are 5 negative and 5 positive average returns are observed.

Standard deviations for each return series are also available on the above table. Standard deviation is a measure of volatility, and the low standard deviation is an indicator of the low level of risk. For example, if we compare the standard deviations of leading mobile phone operator of Turkey, Turkcell (0,016702) with the national airline of Turkey, Turkish Airlines (0,02026), it can be said that investing in Turkish airlines is riskier than investing on Turkcell in terms of standard deviations. In the table, lowest value of standard deviation belongs to industrial organization Aygaz (0,001569), and highest is belong to Turkish sports club Galatasaray (0,039609)

3.2.1 Normality Tests

Secondly, it is examined if the series fit the normal distribution. The fitting of statistical distributions for selected samples to normality allows us to make predictions about population parameters within certain possibilities. Therefore, this phenomenon is the basis of statistical theory. The normal distribution is a symmetric distribution, but when the histogram of the observed values is plotted, sometimes it can be seen that the distribution is mostly not symmetrical. The measures that give an idea of the shape of the distribution are the skewness and kurtosis values.

3.2.2 Skewness and Kurtosis

While skewness is a measure of asymmetry, kurtosis is a measure of whether the data are heavy-tailed or light-tailed.

The skewness coefficient allows us to determine whether the majority of the data is concentrated above or below the center. The skewness coefficient of the normal distribution is 0. In cases where the coefficient of skewness is greater than 0, the distribution is skewed to the left, and to the right when the coefficient is less than 0. The ratio of the third moment relative to the mean of the X random variable to the cube of the standard deviation gives the skewness coefficient.

$$\alpha_3 = \frac{u_3}{\sigma^3}$$

α_3 : Skewness coefficient

u_3 : 3rd moment

σ_3 : standard deviation

It can be seen in the figure below that if the skewness coefficient is less than 0 the distribution is skewed left, and if the coefficient is greater than 0, the distribution is skewed right.

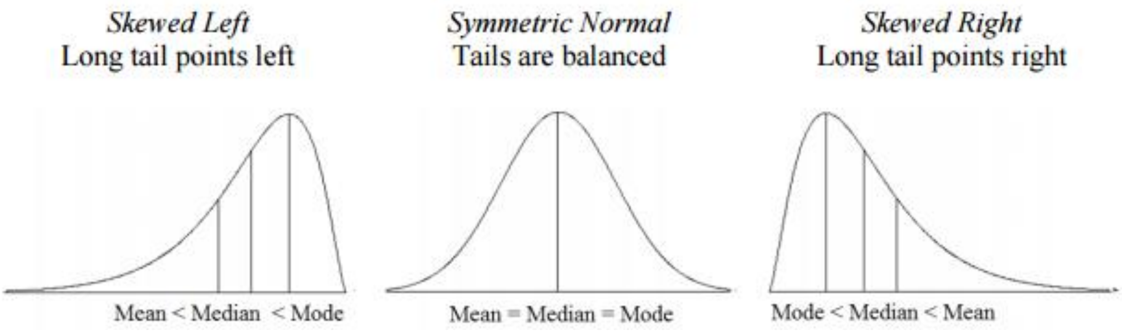

FIGURE 3.1: SKEWNESS OF NORMAL DISTRIBUTION[51]

For symmetric unimodal distributions, positive kurtosis indicates heavy tails and peakedness relative to the normal distribution, whereas negative kurtosis indicates light tails and flatness." (On the Meaning and Use of Kurtosis, Lawrance T.DeCarlo)

Kurtosis value for normal distribution is 3. If the kurtosis value is more than 3, it indicates fat tails (leptokurtic), and if the value is less than 3, it indicates lower peaks.

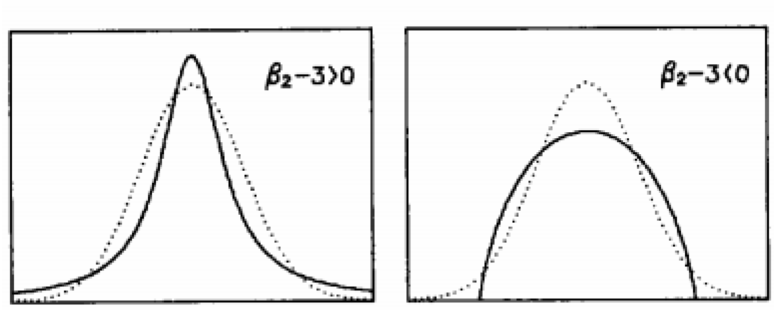

FIGURE 3.2: ILLUSTRATION OF KURTOSIS[52]

"An illustration of kurtosis. The dotted lines show normal distributions, whereas the solid lines show distributions with positive kurtosis (left panel) and negative kurtosis (right panel). (On the Meaning and Use of Kurtosis, Lawrance T.DeCarlo, Fordham University,1997")

When we look at the kurtosis values of stocks in general, it is seen that the majority of the kurtosis coefficients are smaller than 3. The most similar kurtosis coefficient to normal distribution value belongs to YKBNK with 3,096. When the skewness values are examined, it is seen that values are generally close to 0.

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[51] Measuring Skewness: A Forgetten Statistic?, Journal of Statistics Education, Volume 19, Number 2,2011

[52] On the Meaning and Use of Kurtosis, Lawrance T. DeCarlo, Fordham University,1997

Kurtosis and Skewness Values are given in the table below:

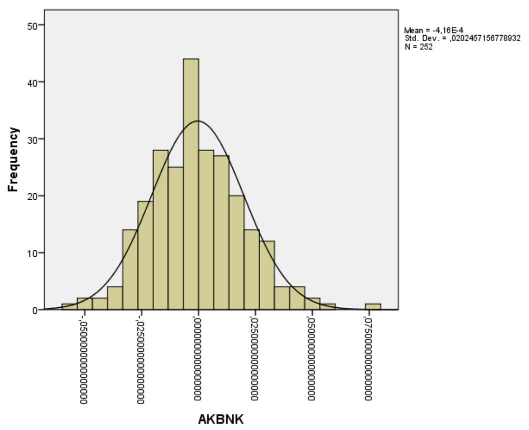
	KURTOSIS	SKEWNESS
AKBNK	0,495621	0,27815334
ARCLK	1,3388	0,43743232
AYGAZ	0,22231	0,17254363
GSRAY	9,38523	1,07152716
MGROS	2,426654	0,39271574
PETKM	0,364112	0,11019171
TCELL	0,974098	-0,2217186
THYAO	0,974717	-0,2345534
TUPRS	0,7117	0,32811009
YKBNK	3,096664	0,35685484

TABLE 3.2: KURTOSIS AND SKEWNESS

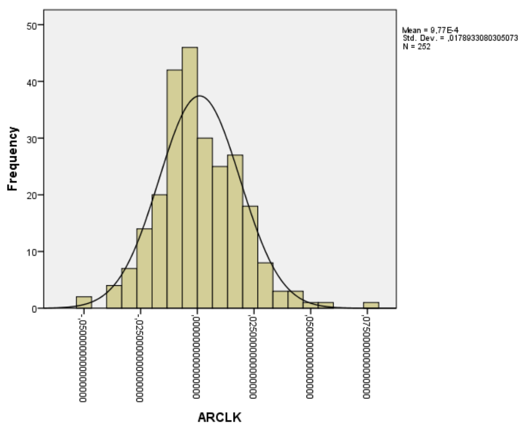
3.2.3 Visual tools

Another way to determine the fitness of normality is to use graphics as a visual tool. In this regard; It is possible to use visual tools such as histograms, root and leaf diagrams, box diagrams, quantile-quantile diagrams and normal probability graphs.

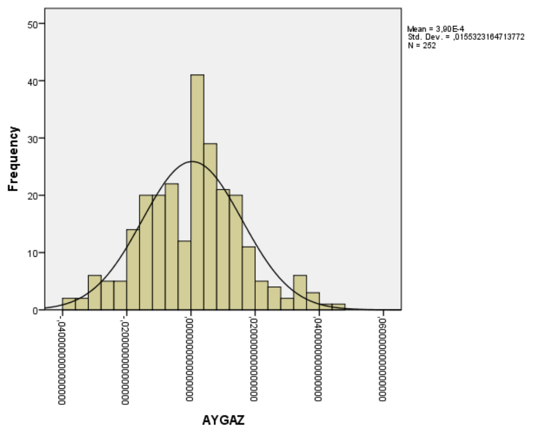
Histograms according to the stocks with the kurtosis and skewness values are given below. In histograms, normal curve helps to determine the shape of the distribution. Also, the frequency of return series can be seen on the y-axis.

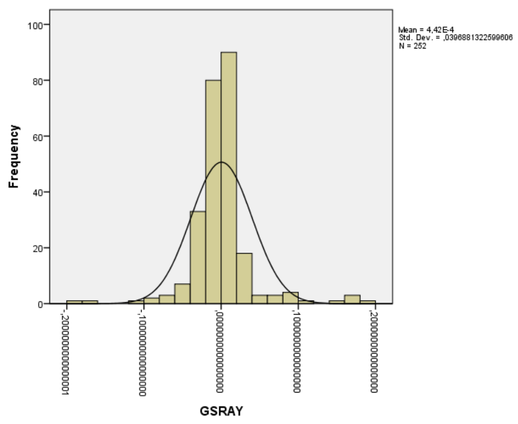


Kurtosis : 0,4956 Skewness : 0,2781



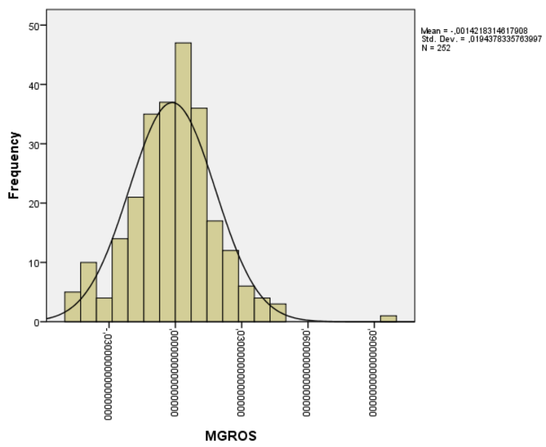
Kurtosis : 1,3388 Skewness : 0,4374

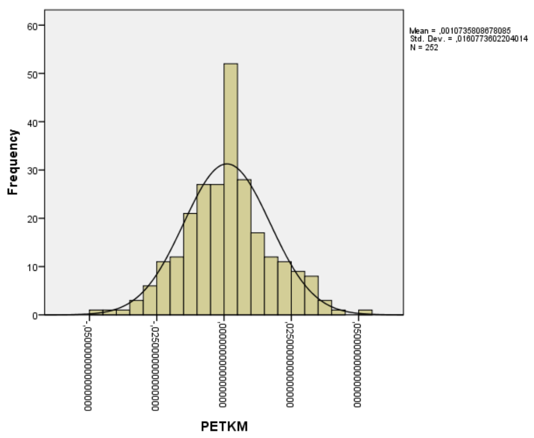




Kurtosis : 0,2223 Skewness : 0,1725

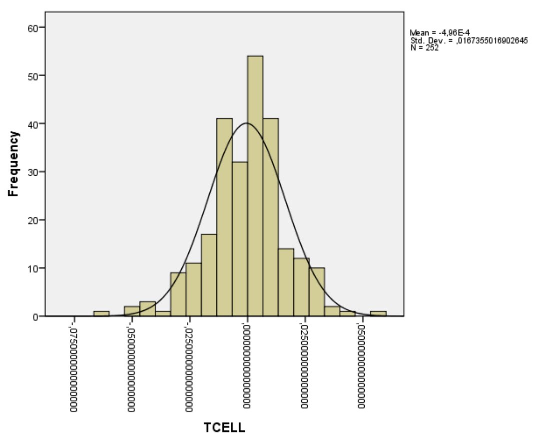
Kurtosis : 9,3852 Skewness : 1,0715

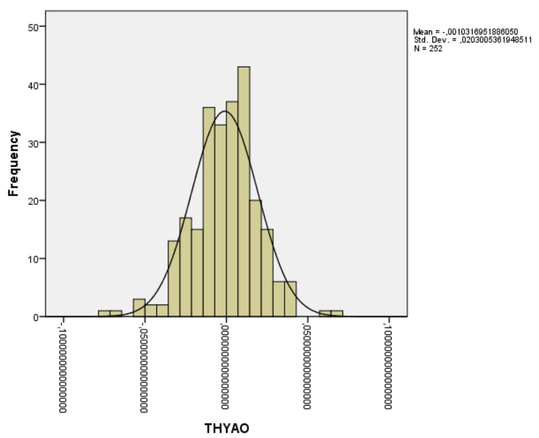




Kurtosis : 2,4266 Skewness : 0,3927

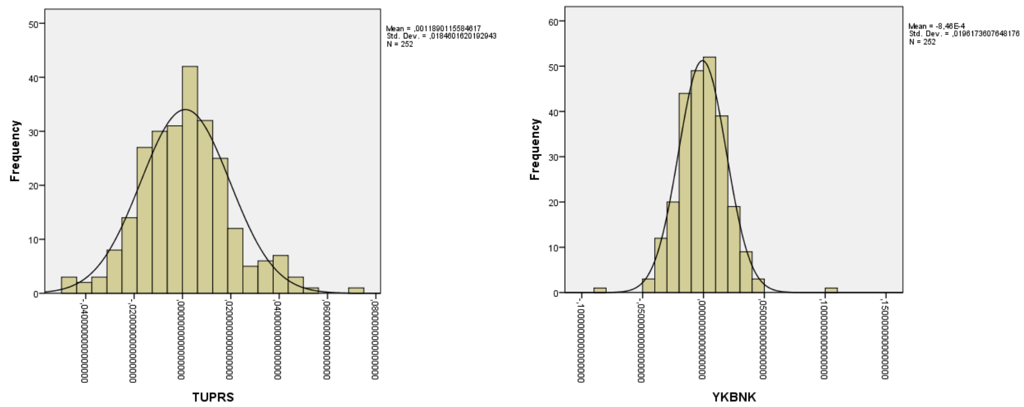
Kurtosis : 0,3641 Skewness : 0,1101





Kurtosis : 0,9740 Skewness : -0,2217

Kurtosis : 0,9747 Skewness : 0,2345



Kurtosis : 0,7117 Skewness : 0,3281 **Kurtosis : 3,0966 Skewnes : 0,3568**

FIGURE 3.3: HISTOGRAMS OF RETURN SERIES

3.2.4 Hypothesis tests

In the approaches listed above, the shape and the magnitude of deviation from normal distribution can be determined. However, is not possible to determine whether the deviation is significant and meaningful for the distribution not to be considered as normal. For this reason, the necessity of hypothesis testing for normality analysis arises.

These hypotheses are used for normality tests;

H_0 hypothesis, it is examined that normal probability function is appropriate for the distribution, whereas H_1 hypothesis in case of opposite hypothesis is not suitable for normal probability function.

After such hypotheses created, it is possible to apply the parametric tests after it is decided that the normal probability function is appropriate for the motion with the test statistic calculated from the data. Otherwise, it is necessary to perform various normality conversions or use nonparametric test.

However, it is necessary to know also the shape of the deviation from the normal distribution in order to carry out these conversions aimed at adapting the distribution to normal. As a result, a combination of several approaches mentioned above will lead to better results.

It is possible to use various normality tests to show whether the data are normally distributed or not. In this study,Kolmogorov-Smirnov and Shapiro-Wilk tests were used to test the normality. The results of the normality tests for all return series are as follows:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
AKBNK	,043	252	,200*	,994	252	,389
ARCLK	,068	252	,006	,984	252	,005
AYGAZ	,061	252	,022	,991	252	,111
GSRAY	,181	252	,000	,778	252	,000
MGROS	,046	252	,200*	,972	252	,000
PETKM	,066	252	,009	,992	252	,174
TCELL	,058	252	,040	,988	252	,039
THYAO	,061	252	,025	,986	252	,014
TUPRS	,047	252	,200*	,988	252	,033
YKBNK	,046	252	,200*	,971	252	,000

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

TABLE 3.3: NORMALITY TEST FOR STOCKS

$$H_0 : Distribution\ of\ the\ serie\ is\ normal$$

$$H_1 : Distribution\ of\ the\ serie\ is\ not\ normal$$

Two separate normality tests were performed for all series at 5% significance level. The test results are shown above. Shapiro-Wilk normality test is recommended for small sample sizes (<50), but theoretically it can be also useful for a large number of sample sizes as well. (up to 2000.).

In order to determine whether the distribution is normal or not, significance level should be compared with the p-value. If the significance is greater than p-value (0.05), H_0 will be accepted.

For example for the series of AKBANK, both Kolmogorov-Smirnov and Shapiro-Wilks tests show that the distribution of the data is not different than normal. According to the test, return series from AKBNK,ARCLK(slightly),AYGAZ,PETKM,TCELL,THYAO, and TUPRS are distributed normally. The only series that not accepted from both of tests is GSARAY. Series from YKBNK and MGROS are normally distributed according to Kolmogorov-Smirnov test.

3.3 Determination of Optimal Portfolio

According to the Markowitz model, rational investors act according to two different risk-return combinations under the maximization of utility: to minimize the risk provided that it accepts a specific return, or to maximize the return provided that it accepts a certain risk.

The mean-variance model, in addition to the diversification, says that the relationship between the returns of the shares has a significant effect on the portfolio risk. It also encourages the selection of securities that are inversely correlated so that this risk can be reduced. The risk measure of this portfolio is the standard deviation that forms the basis of VaR calculation as well.

In this context, the following parameters were used for the determination of the optimal portfolio:

- The average return of stock:

  $r_i = \frac{1}{n}\sum_{i=1}^{n} r_i$

- Standard deviation of stock:

  $\sigma_i = \sqrt{\frac{1}{n}\sum_{j=1}^{N}(r_i - \overline{r_i})^{2}}$

- Covariance between returns of stocks

  $\sigma_{ij} = \frac{1}{n}\sum_{n=1}^{N}[(r_{i,n} - \overline{r_i})\,(r_{j,n} - \overline{r_j})$

- Correlation coefficient between two stocks

  $\rho_{ij} = \frac{\sigma_{ij}}{\sigma_i \sigma_j}$

- Average return of the portfolio

  $r_{kp} = \sum_{i=1}^{N} w_i r_i$

- Variance of returns of portfolio

$$\sigma_{rp}^2 = [w_i \dots \dots w_N] \begin{vmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \dots. & \sigma_{1N} \\ \vdots & \vdots & \vdots & \dots. & \vdots \\ \sigma_{N1} & \sigma_{N2} & \sigma_{N3} & \dots. & \sigma_N \end{vmatrix} \begin{vmatrix} w_1 \\ \vdots \\ w_N \end{vmatrix}$$

- Variance-Covariance Matrix of the portfolio

With respect to determining the optimal portfolio using these calculations, the following operations were performed respectively:

- Establishing the variance-covariance and correlation matrix of the portfolio.

  When the correlation matrix is examined, it is seen that GSARAY stock has the lowest correlation with other bonds with the same direction. In addition, the relationships of the stocks of two banks, whose returns and risks are similar, appear to be in the same direction and higher (0.867). The stocks following these two shares were YKBNK and THYAO (0,739), AKBNK and THYAO (0,718). The MGROS stock has the lowest return but has a correlation value above the average with other stocks. The lowest correlation was found between GSARAY and TCELL stocks (0,161) (See Appendix for a table.)

- In order to obtain the variance of the equally weighted portfolio, the variance-covariance matrix is multiplied by equal weight vectors, and sums are taken. Accordingly, the variance of the equal weighted portfolio is 0,00020, and the average return of the portfolio is 0,0000139.

- The solver function of the Excel software has been utilized to determine the optimal portfolio. When the solver function is used, it is desirable that the portfolio variance is minimized. As a constraint, it is desirable that the sum of the weighted averages of each stock is 1. It can be seen in the table below, the stocks according to their weights in the portfolio.

	Weights
AKBNK	0
ARCLK	0,169282
AYGAZ	0,277561
GSARAY	0,005188
MGROS	0
PETKM	0,232734
TCELL	0,192997
THYAO	0
TUPRS	0,122237
YKBNK	0

TABLE 3.4: OPTIMUM WEIGHTS FOR THE PORTFOLIO

In this case, the variance of the portfolio will be minimum according to the new weights. As can be seen, four stocks are out of the portfolio (AKBNK, MGROS, THYAO and YKBNK) in order to reach the minimum variance condition. Under the determined constraints, the solver tries to keep the securities with low correlation for the mean-variance model in the portfolio.

According to the combination of return-risk and correlation, the highest weights among the securities held by the solver portfolio are AYGAZ (%28), PETKM(%23), TCELL(%19) and the lowest weights are ARCLK(%17), TUPRS(%12) and GSARAY(%1).

Note that, the variance of the optimal portfolio is lower than the variance of the equally weighted portfolio. (0,0001463<0,00020). This can be regarded as an important indicator of the validity of the model established.

3.4 Variance-Covariance Method

We have first checked the assumption of normal distribution for the optimal portfolio we have created, and under this assumption, the Value at Risk for the portfolio is calculated by using the variance-covariance method. The calculation based on 90%, 95% and 99% confidence levels and 1 day and 90-day holding period. Generally, it is accepted that there are 252 working days in a year.

$$VaR = \sigma_{portfolio} * \sqrt{\frac{1}{252}} * z_a$$

When the above formula is examined, it is seen that standard deviation of the portfolio should be calculated. For this reason, it is necessary to form the variance-covariance and correlation matrices of stocks. These generated matrices can be seen below:

Correlations

		ARCLK	AYGAZ	GSARAY	PETKM	TCELL	TUPRS
ARCLK	Pearson Correlation	1	,345**	,180**	,397**	,374**	,413**
	Sig. (2-tailed)		,000	,004	,000	,000	,000
	N	252	252	252	252	252	252
AYGAZ	Pearson Correlation	,345**	1	,288**	,439**	,438**	,420**
	Sig. (2-tailed)	,000		,000	,000	,000	,000
	N	252	252	252	252	252	252
GSARAY	Pearson Correlation	,180**	,288**	1	,188**	,161*	,209**
	Sig. (2-tailed)	,004	,000		,003	,010	,001
	N	252	252	252	252	252	252
PETKM	Pearson Correlation	,397**	,439**	,188**	1	,433**	,366**
	Sig. (2-tailed)	,000	,000	,003		,000	,000
	N	252	252	252	252	252	252
TCELL	Pearson Correlation	,374**	,438**	,161*	,433**	1	,372**
	Sig. (2-tailed)	,000	,000	,010	,000		,000
	N	252	252	252	252	252	252
TUPRS	Pearson Correlation	,413**	,420**	,209**	,366**	,372**	1
	Sig. (2-tailed)	,000	,000	,001	,000	,000	
	N	252	252	252	252	252	252

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

TABLE 3.5: CORRELATION BETWEEN STOCKS

The correlation matrix shows the relationship between stocks on the portfolio. When we examine all the correlation coefficients, it is seen that there is a positive correlation between all stocks.

	ARCLK	AYGAZ	GSRAY	PETKM	TCELL	TUPRS
ARCLK	0,00032	9,6E-05	0,000128	0,000114	0,000112	0,000136
AYGAZ	9,6E-05	0,000241	0,000177	0,00011	0,000114	0,00012
GSRAY	0,000128	0,000177	0,001575	0,00012	0,000107	0,000153
PETKM	0,000114	0,00011	0,00012	0,000258	0,000117	0,000109
TCELL	0,000112	0,000114	0,000107	0,000117	0,00028	0,000115
TUPRS	0,000136	0,00012	0,000153	0,000109	0,000115	0,000341

TABLE 3.6: VARIANCE-COVARIANCE MATRIX

The variance-covariance matrix shows the variances and variations of variables together in the portfolio. The main diagonal elements show the variances of the variables, while the other elements show the variations of the variables together.

After constructing the variance-covariance matrix, weight vector created to represent the weights of the stocks in the portfolio. The formula of the variance of the portfolio can be seen as below:

Weight Vector
0,169282067
0,277561313
0,005187695
0,232734262
0,192997285
0,122237378

TABLE 3.7: WEIGHT VECTOR

$Variance\ of\ portfolio = W'VW$

W' : Transpose of weight vector

V : Variance-Covariance matrix

W: Weight Vector

Variance of the portfolio = 0,000146341

Standard deviation of the portfolio = $\sqrt{0{,}000146341}$ = 0,012097129

Once the standard deviation is calculated, the Value at Risk of the portfolio can now be calculated based on the selected level of significance and holding period.

$VaR_{0,95}$ = 0,012097129 * $\sqrt{1/252}$ * 1,64

= 0,001249758

The result can be interpreted as follows: The maximum loss that a portfolio with a daily holding period and 95% confidence level is % 0,001406353.

If similar calculations are made at 90% and 99% confidence levels :

$VaR_{0,99}$ = 0,012097129 * $\sqrt{1/252}$ * 2,33

= 0,001775571

$VaR_{0,90}$ = 0,012097129 * $\sqrt{1/252}$ * 1,28

= 0,000975421

For example, if the portfolio we have created is a $ 1 million portfolio, the maximum loss the portfolio will suffer is 975,421 $ for %90 confidence level, 1249,758 $ for %95 confidence level and 1775,571 $ for %99 confidence level for daily holding period.

If the holding period is taken 90 days (3 months) instead of 1 day, the results will be as follows :

$VaR_{0,90} = 0{,}012097129 * \sqrt{90/252} * 1{,}28$

$= 0{,}009253654$

$VaR_{0,95} = 0{,}012097129 * \sqrt{90/252} * 1{,}64$

$= 0{,}011856244$

$VaR_{0,99} = 0{,}012097129 * \sqrt{90/252} * 2{,}33$

$= 0{,}016844542$

The results for the variance-covariance method can be seen in the table below :

	Holding Periods	
Confidence Levels	1-day	90-days
90%	0,000975421	0,009253654
95%	0,001249758	0,011856244
99%	0,001775571	0,016844542

TABLE 3.8: RESULTS OF VARIANCE-COVARIANCE METHOD

3.5 Historical Simulation Method

For the calculation of Value at Risk with Historical Simulation, 252 daily closing prices of the optimal portfolio with 6 shares taken into consideration as a Variance-Covariance method.

- As the first step, stock returns are calculated with the same formula:

  $r = \frac{P_t - P_{t-1}}{P_{t-1}}$

- Secondly, weighted returns are calculated by multiplication of stock returns and the weights of the optimal portfolio.
- And then, weighted daily portfolio returns are sorted from lowest value to highest. First 30 lowest value can be seen in the table below.

		Portfolio Daily Returns			
1	-0,040256946	11	-0,023316737	21	-0,015415731
2	-0,033983776	12	-0,023168586	22	-0,015397093
3	-0,031544454	13	-0,021330587	23	-0,014701744
4	-0,027755872	14	-0,019196808	24	-0,014631479
5	-0,027518782	15	-0,01895137	25	-0,01430738
6	-0,025881501	16	-0,017559512	26	-0,014197104
7	-0,025871274	17	-0,017003204	27	-0,013981224
8	-0,025204515	18	-0,016729732	28	-0,013866929
9	-0,024008113	19	-0,016456759	29	-0,013437505
10	-0,023697624	20	-0,015473687	30	-0,01323472

TABLE 3.9: DAILY RETURNS FOR PORTFOLIO

For the 99% confidence level, the 249th value is the highest loss that the portfolio can suffer for the 1-day holding period. It means that for $ 1 million portfolios, the maximum loss the portfolio will suffer is 31544,454$. These values for %95 and %90 confidence levels are 19196,808$ and 14197,104$ respectively.

Historical var method assumes that future performance of our investment will follow the same pattern as in the past, and historical performance can be used to simulate the future outcomes.

Descriptive statistics and histogram for the weighted portfolio returns can be seen in the tables below:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Portfolio Daily Returns	252	-,040256946	,0362726732	,0005755310	,0120971286	,000	-,185	,153	,523	,306
Valid N (listwise)	252									

TABLE 3.10: DESCRIPTIVE STATISTICS FOR DAILY RETURN OF PORTFOLIO

As it can be seen in the table, daily portfolio returns mean is 0,0005753310 and the standard deviation is 0,0120971286. From the kurtosis and skewness values, the histogram of data is shown below:

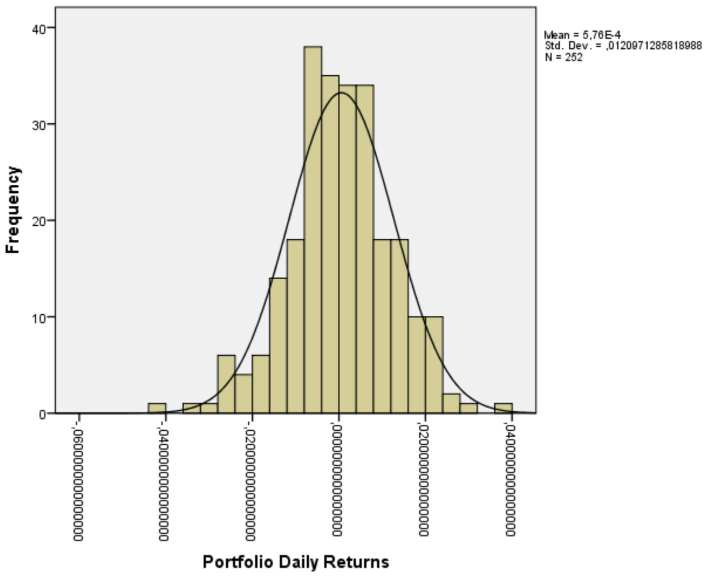


FIGURE 3.4: HISTOGRAM OF DAILY RETURN OF PORTFOLIO

From the histogram, it can be seen that distribution of the daily return of the portfolio is similar to normal distribution. In addition to that, normality test made as a supportive argument.Results of Kolmogorov-Smirnov and Shapiro-Wilk tests are shown in the table:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Portfolio Daily Returns	,044	252	,200*	,993	252	,268

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

TABLE 3.11: RESULTS OF NORMALITY TEST FOR DAILY RETURN OF PORTFOLIO

3.6 Monte Carlo Simulation

In this method, as in the two other methods 252 daily closing prices between 13.02.2015 and 11.02.2016 taken into account. Daily closing prices are calculated with arithmetic return formula.

As a second step, Cholesky Decomposition Matrix is obtained from the variance-covariance matrix[53]. Then 10,000 random numbers were generated from each share with the assumption of normal distribution. The Cholesky Decomposition matrix is multiplied by the randomly generated price series in accordance with the determined distribution

[53] Value at Risk, Dr. Hans-Peter Deutsch, D-fine Consulting

and the relationship between the risk factors in the past is reflected in the newly generated price series. At the next stage, the weighted daily distribution was determined, and the Value at Risk was calculated for the portfolio with a given confidence level.[54]

0.017893	0	0	0	0	0
0.05364	0.014577	0	0	0	0
0.0716	0.00953	0.037856	0	0	0
0.06383	0.005179	0.00065	0.013802	0	0
0.006255	0.005508	0.000259	0.003478	0.014087	0
0.007615	0.005451	0.001228	0.002236	0.00207	0.015565

TABLE 3.12: CHOLESKY DECOMPOSITION

As the last step, 10000 generated weighted returns sorted from the lowest the highest. Then in order to find Value at Risk for given confidence levels, these values shown below are checked:

100th / 10000 value for %99 confidence level : - 0,00145206108607848

500th / 10000 value for %95 confidence level : - 0,00101780698892788

1000th / 10000 value for %90 confidence level : - 0,000775274401710253

[54] Financial Risk Manager Handbook,Second Edition, Philippe Jorion,2003

4. Conclusion

The recent globalization movement has created an environment in which financial risks are diversified with financial instruments in the international financial markets, and financial transaction volumes and competition are increasing in this direction. This new situation has facilitated the transfer of funds between countries, which has increased the diversity and degree of risk. Also, the situation has prompted international institutional investors and academics working in the area of risk management to develop new risk measurement methods that provide easier, faster and more efficient reporting. The Value at Risk method has become an effective method that has emerged due to this need and has been used in recent years.

Decisions made by the Basel Committee on the criteria and calculation methods to be used in Value at Risk have become a standard over time. In this context, the Basel Committee proposes three basic approaches to the VaR calculation: the Variance-Covariance approach, the Historical Simulation Approach, and the Monte Carlo approach:

The basic assumption of the variance-covariance approach is that the returns of the securities within the portfolio are normally distributed. All of the theoretical backgrounds of the approach is based on the assumption of normal distribution. Despite the other approaches such as Monte Carlo Simulation and Historical Simulation, it is often used for ease and speed of computation, although the normal distribution assumption is the weakest point of this approach. Because, in reality, the return series do not often conform to the normal distribution condition.

However, it is more accurate to use the variance-covariance approach instead of Monte Carlo Simulation for a portfolio with a linear return. Because in a linear portfolio, both approaches produce close results. In this respect, the variance-covariance method is preferred because of the ease and speed of calculation.

The Historical Simulation is simpler than Monte Carlo Simulation, as it moves from past return series , while at the same time it is the most important weakness of this approach. In addition to that, it also tries to estimate Value at Risk of the portfolio from a single price equation. However, as in Monte Carlo Simulation, it is possible to calculate the more appropriate Value at Risk value for the portfolio by generating many price equations according to different scenarios.

Monte Carlo method is criticized, because of the length of the calculation period and the high cost of calculation. This disadvantage of the approach is more evident in large portfolios with changing weights. Because Value at Risk method is used as a strategic tool in portfolio investments. Portfolio traders want to see the effect of the decision they make on portfolio VaR at the same time before giving a trading decision. For that reason, this approach requires to have specific package programs tailored for the investors' own risk variables , which increases cost.

In this study, the estimation of portfolio VaR calculated based on Istanbul Stock Exchange National-100 index . In order to estimate the portfolio VaR, firstly the return series of each share are obtained, and the descriptive statistics are calculated between the dates of 13.02.2015 and 11.02.2016.

According to descriptive statistics of return series, it can be seen that minimum average return belongs to MGROS(-0,00142) and maximum average return belongs to TUPRS(0,001189). Additionally, the minimum variance is observed for AYGAZ(0,00024), and maximum variance is observed for ARCLK(0,00319). In terms of correlations between shares maximum correlation can be seen for AYGAZ and PETKM(0.439) and minimum correlation observed between TCELL and GSARAY (0.161)

And then 3 different types of normality tests are performed. Firstly, kurtosis and skewness values of the return series of each share calculated. Secondly, histograms are used as a visual tool to demonstrate the shape of the distribution. Finally, hypothesis tests are performed with Kolmogorov- Smirnov and Shapiro- Wilk approach. All the methods are showed that almost all the return series of shares really close to normal distribution.

In the next step, optimal portfolio is obtained according to Markowitz model. Before obtaining the optimal portfolio variance of the portfolio is calculated by equally weighted shares. (0,00020). With the minimum variance constraint, optimal portfolio is obtained, and the variance of optimal portfolio is calculated. Results showed that variance of the optimal portfolio is lower than the equally weighted portfolio, which is an important indicator of the validity of the model. (0,0001463<0,00020). According to new weights, highest share belongs to AYGAZ (0,277561), and lowest share belongs to GSARAY (0,005188).

In the study, three different methods of Value at Risk calculations are used, and they are namely, variance-covariance method, historical simulation method and Monte Carlo simulation. In order to calculate Value at Risk with the variance-covariance method, variance-covariance matrix and correlation matrix are calculated on Excel, and the results are obtained for 1-day and 90-days holding periods with different confidence levels. The value at risk value for 1-day holding period and %95 confidence level is 0,001249758.

In historical method, daily return series of each share in the optimal portfolio are calculated. And then, weighted portfolio return is obtained from these results. The weighted daily return values are rearranged in order from the lowest to the highest and value at risk value is found from the return figure which corresponds to the determined confidence level.(0,019196808). The results from historical method differ from the other two methods. Main reason behind is, in this method, there were no parameters used for the calculations.On the other hand, Variance-Covariance and Monte Carlo Simulation methods accept the assumption of normal distribution and Value at Risk values are closer to each other. Due to this assumption, the result is consistent with expectations.

For Monte Carlo Simulation, a series of operations were performed.After calculating the daily variations of the risk factors and determining the appropriate distribution, the variance-covariance matrix is calculated. The appropriate random numbers are generated in the specified distribution, and the Cholesky Decomposition matrix is computed from the covariance matrix. The Cholesky Decomposition matrix is multiplied by the randomly generated price series in accordance with the determined distribution, and the new price series is applied to the portfolio. After the weighted daily distribution is determined, value at risk calculated at the relevant confidence level. (0,00101780698892788)

This study shows that if the investors can create a strong model for the future predictions, they can predict the future values of daily returns and create an optimal portfolio regarding minimum risk requirements. In addition to that, investors can calculate the weights of the optimal portfolio of tomorrow from today. It helps to reduce the Value at Risk value of the portfolios by pre-changing the portfolio composition according to the estimates,using the models presented in this study.

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APPENDICES

Appendix 1: Correlations between then shares in the portfolio

Correlations

		AKBNK	ARCLK	AYGAZ	GSARAY	MGROS	PETKM	TCELL	THYAO	TUPRS	YKBNK
AKBNK	Pearson Correlation	1	,501**	,515**	,252**	,637**	,578**	,591**	,719**	,539**	,868**
	Sig. (2-tailed)		,000	,000	,000	,000	,000	,000	,000	,000	,000
	N	252	252	252	252	252	252	252	252	252	252
ARCLK	Pearson Correlation	,501**	1	,345**	,180**	,416**	,397**	,374**	,473**	,413**	,525**
	Sig. (2-tailed)	,000		,000	,004	,000	,000	,000	,000	,000	,000
	N	252	252	252	252	252	252	252	252	252	252
AYGAZ	Pearson Correlation	,515**	,345**	1	,288**	,471**	,439**	,438**	,530**	,420**	,537**
	Sig. (2-tailed)	,000	,000		,000	,000	,000	,000	,000	,000	,000
	N	252	252	252	252	252	252	252	252	252	252
GSARAY	Pearson Correlation	,252**	,180**	,288**	1	,239**	,188**	,161*	,244**	,209**	,285**
	Sig. (2-tailed)	,000	,004	,000		,000	,003	,010	,000	,001	,000
	N	252	252	252	252	252	252	252	252	252	252
MGROS	Pearson Correlation	,637**	,416**	,471**	,239**	1	,478**	,501**	,580**	,424**	,649**
	Sig. (2-tailed)	,000	,000	,000	,000		,000	,000	,000	,000	,000
	N	252	252	252	252	252	252	252	252	252	252
PETKM	Pearson Correlation	,578**	,397**	,439**	,188**	,478**	1	,433**	,540**	,366**	,598**
	Sig. (2-tailed)	,000	,000	,000	,003	,000		,000	,000	,000	,000
	N	252	252	252	252	252	252	252	252	252	252
TCELL	Pearson Correlation	,591**	,374**	,438**	,161*	,501**	,433**	1	,576**	,372**	,573**
	Sig. (2-tailed)	,000	,000	,000	,010	,000	,000		,000	,000	,000
	N	252	252	252	252	252	252	252	252	252	252
THYAO	Pearson Correlation	,719**	,473**	,530**	,244**	,580**	,540**	,576**	1	,484**	,739**
	Sig. (2-tailed)	,000	,000	,000	,000	,000	,000	,000		,000	,000
	N	252	252	252	252	252	252	252	252	252	252
TUPRS	Pearson Correlation	,539**	,413**	,420**	,209**	,424**	,366**	,372**	,484**	1	,499**
	Sig. (2-tailed)	,000	,000	,000	,001	,000	,000	,000	,000		,000
	N	252	252	252	252	252	252	252	252	252	252
YKBNK	Pearson Correlation	,868**	,525**	,537**	,285**	,649**	,598**	,573**	,739**	,499**	1
	Sig. (2-tailed)	,000	,000	,000	,000	,000	,000	,000	,000	,000	
	N	252	252	252	252	252	252	252	252	252	252

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).