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DEVELOPING A PORTFOLIO OPTIMIZATION MODEL BASED ON LINEAR PROGRAMMING UNDER CERTAIN CONSTRAINTS: AN APPLICATION ON BORSA ISTANBUL 30 INDEX[1][2]

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Abstract

The aims of this study are to lend assistance for the account owners who plan to make an investment in the financial markets to make the most accurate investments possible; accordingly, to develop a portfolio selection model and present it with its implementations. Instead of the L_2 (standard deviation), risk function which is approached as a risk by Markowitz, the L_1 (absolute deviation) risk function was used in the study and the optimal portfolios were trying to be attained. After the data acquired from the index of the Borsa Istanbul 30 index, the portfolio optimization model which is based on linear programming and was developed by Ching-Ter Chang (2005) was embraced in order to create an optimal portfolio. In this model, a new model was proposed by adding a limit on trading volume to reduce the systematic risk of the portfolio with the idea that it is one of the important indicators of the market and that it can create a decision-making risk perception. Thus, it was enabled for the portfolio to contain the equities from the industrial branch in desired numbers in accordance with the desire of the investors by adding the preference constraints on the Chang model. It can be said that this study will be useful for the investors and the finance executives who want to create a portfolio on specific risk and return level.

Keywords: Portfolio Optimization, Mean Absolute Deviation, Industry Risk, Trading Volume, Linear Programming, Borsa Istanbul

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Belirli Kısıtlar Altında Doğrusal Programlamaya Dayalı Bir Portföy Optimizasyonu Modelinin Geliştirilmesi: Borsa İstanbul 30 Endeksi Üzerine Bir Uygulama

Öz

Bu çalışmanın amacı, finansal piyasalarda yatırım yapmayı düşünen tasarruf sahiplerine optimal yatırım yapma konusunda yol göstermek ve bu doğrultuda bir portföy optimizasyon modeli önermek ve uygulamaları ile birlikte sunmaktır. Çalışmamızda Markowitz'in risk olarak ele aldığı L_2 (standart sapma) risk fonksiyonu yerine, L_1 (mutlak sapma) risk fonksiyonu kullanılmış ve optimal portföyler elde edilmeye çalışılmıştır. Borsa İstanbul 30 Endeksinden veriler elde edildikten sonra, optimal portföy oluşturmak için doğrusal programlama yaklaşımına dayalı olan Ching-Ter Chang (2005) tarafından geliştirilen portföy optimizasyon modeli ele alınmıştır. Bu modele, portföyün sistematik olmayan riskini azaltmak için endüstri kollarına dağılım ve piyasanın önemli göstergelerinden biri olması ve karar vericide risk algısı yaratabileceği düşüncesiyle işlem hacmi kısıtı eklenerek yeni bir model önerilmiştir. Böylelikle, Chang modeline tercih kısıtları ilave edilerek yatırımcının isteği doğrultusunda portföyün istenen sayıda endüstri kolundan hisse senetlerini içermesi sağlanmıştır. Bu çalışma belirli bir risk ve getiri düzeyinde portföy oluşturmak isteyen finans yöneticilerine ve yatırımcılarına faydalı olacağı söylenebilir.

Anahtar Kelimeler: Portföy Optimizasyonu, Ortalama Mutlak Sapma, Endüstri Riski, İşlem Hacmi, Doğrusal Programlama, Borsa İstanbul

Introduction

Nowadays, due to the structural developments experienced in the economy, there is also a rapid change in financial markets. As capital markets became operational, it became important to direct savings to capital markets. Parallel to this, it has been observed that the savings owners have turned to various investment instruments in order to evaluate their existing funds.

A rational investor will try to reach the optimal solution between the individual risk preference and the return on the portfolio. The investor shall first determine the purpose of the financial investment and choose the securities that will be included in the investment. After the portfolio is created, the investor will want to monitor the investment process and its performance. During the investment process, the investor will wish to change the securities in his portfolio according to the changing economic conditions (Çıtak, 2016, p. 44). Every institutional or individual investor can theoretically spend all of his/her resources. However, in practice, the person will not behave this way. The person will save money for consumption and investment in the future. This savings can be taken as different security, can be deposited in banks in the form of deposits, directed to investments or held in cash. All of these activities, in terms of portfolio theory, investment is considered to be the initiative (Bekçioğlu, 1988, p. 15). Accordingly, savings owners form portfolios by purchasing various securities to evaluate their existing funds. Since these portfolios will affect the future of the savings owners, it is extremely important to take into account the type, number and sector of the securities to be included in the portfolio. For example, when an investor adds the stock of a company in the construction sector to its portfolio, it also adds the systematic and non-systematic risks that the stock has.

Portfolio means “wallet” as the word meaning (Gürol and Kılıçoğlu, 1994, p. 696). In terms of securities, the portfolio refers to the investment group formed by gathering the securities (Canbaş and Doğukanlı, 2007, p. 494). The portfolio is a whole consisting of two or more assets (Ercan and Ban, 2008, p. 188). Many people wants to use their savings in a certain period in transactions in order to earning returns through various methods. Some of these savings consists of real assets such as houses, land, cars, gold, and other consists of stocks, bonds and derivate instruments. The value of these financial assets is called the securities portfolio (Radoplu, 2002, p. 345). Portfolio management the fund’s investors a certain amount of rational behavior undertaken in consideration of certain asset groups at risk so as to get the highest return was put, in the context of the time depending on the developments in the portfolio of securities was modified, and their performance is a dynamic process that is continuously evaluated (Özçam, 1997, p. 4). The goal of the portfolio is simply to distribute the risk by investing in various securities. That is to say, it is to take various securities into the portfolio according to the needs of investors who are in rational behavior and to manage the portfolio in accordance with the investment objectives (Poyraz, 2016, p. 487-488). To make the maximum return or minimize the risk, investors invest in a single stock instead of investing in multiple securities portfolio to the individual needs. The diversification of securities varies according to the level of risk tolerance of the individual. When a risk-averse investor wants to create a portfolio, he/she will create his/her portfolio mainly from stocks. On the other hand, an investor who wants to build a portfolio doesn't like the risk when the portfolio is mainly bonds and other fixed-income securities will constitute.

The choice of the portfolio that will provide the highest benefit to the investor has become a very critical and complex decision-making problem and has become a subject of many research and discussions in the field of finance. As a result, many portfolio management approaches have been introduced on the establishment of the optimal portfolio.

The first approach to portfolio selection problem is the traditional portfolio approach. This approach, based on lean diversification, foresees the inclusion of various randomly selected securities into the portfolio without taking into account the relationship between securities (Çıtak, 2016, p. 44). Consider the relationship between the returns of traditional securities, portfolio management, advised not to go the way of excessive diversification and has received much criticism due to the lack of scientific basis. After the abandonment of traditional portfolio management, modern portfolio management has been developed. Harry Markowitz, the founder of "Modern Portfolio Theory", published his article "portfolio selection" in 1952.

According to Markowitz, while the average benefit and variance is data, it provides information on how to achieve the highest return at a certain risk level or at least the risk level at a certain level of return. In this context, the expected return of the portfolio, portfolio variance, average-variance have developed mathematical equations for efficient portfolios (Karabıyık and Anbar, 2010, p. 290). Markowitz developed the quadratic programming model, arguing that not only the risk can be reduced by increasing securities in the portfolio, but also the relationship between securities should be taken into account (Aksoy, 2014, p. 58). The average-variance model approach developed by Markowitz constituted the basis of modern portfolio theory. However, although this model is theoretically popular, it has not been widely used to obtain large-scale portfolios because of trading difficulties. This model has brought the number of securities that comprise the portfolio and the correlation coefficient is more than the computational time and cost challenges of transportation and portfolio diversification reveal major drawbacks developed by Sharpe single index model and Perold Developed Multi-Index model has been attempted to be overcome by. Afterwards, the capital asset pricing model (CAPM) which is a mathematical and logical form of the mean-variance model was introduced by Treynor, Sharpe, Lintner and Mossin independently, building on the earlier work of Harry Markowitz on diversification and modern portfolio theory (Elbannan, 2015, p. 216). Even though the CAPM is extensively applied as it measures the expected rate of return of a security, the empirical evidence indicates that it is poor enough to invalidate the way it is utilized in practices. The CAPM's empirical problems may reflect theoretical failures, the findings of many simplifying assumptions (Fama and French, 2004, p. 25). The CAPM was developed by Ross in 1976, and the arbitrage pricing model was developed as an alternative to the capital asset pricing model. The mean-variance model is one of the keystones of Modern Portfolio Theory, but it has been criticized for being limited only to a theoretical solution. Developed by Markowitz and other researchers, many portfolio models have been developed and recommendations for optimization of this model. One of these approaches is the mean absolute deviation model developed by Konno and Yamazaki. Deterministic L_1 risk function model was developed by Konno and Yamazaki (1991) to minimize absolute deviation from the mean in order to be an alternative to stochastic problems (Kocadağlı and Cinemre, 2010, p. 360). The mean-absolute deviation model uses the mean-absolute deviation instead of the variance taken in order to minimize the objective function. Thus, the problem of creating a portfolio has become linear programming from the quadratic program (Simaan, 1997, p. 1437). In the model proposed by Konno and Yamazaki, they used *2T+2* constraint (t=number of terms) and *2T+n* variable (*n*= number of securities contained in the model). The average absolute deviation of the model later Feinstein and Thapa (1993) and Ching-Ter Chang (2005) using the number of re by the constraint *T+2*, by reducing it to half have proposed a new model.

In this study, we discussed the Ching-Ter Chang portfolio selection model based on linear programming, which halves the number of constraints. However, the number of stocks that will enter the portfolio with this model and the weights of the portfolio cannot be controlled. Therefore, portfolio weights can be collected in a number of stocks or sectors, and even theoretically the optimal solution can be composed of a stock or sector. For this purpose, a new model has been proposed to investors by adding distribution and transaction volume preference limits to the branches established in this model. The importance of the study to determine the optimal portfolio consisting of the equities with minimum risk. The reasons for adding these constraints to the model were expressed in the application section of the study. In the BIST-30 Index, Investment shares of the stocks that provide optimal returns and risks were determined and the optimal portfolio was obtained using the 36-month corrected returns of 30 stocks. It is expected that this study will contribute to the literature on the issue of portfolio selection problem and diversification of portfolio at the desired level in line with the expectations of investors with the proposed model. This study is important both for diversification of stocks and for determining the risk impact of investing in different sectors at the same time.

The rest of the paper is organized as follows. The section 2 describes the exiting literature relating portfolio optimization based on linear programming; the section 3 broadly examines the data and the method of the Chang (2005) and proposed model; the section 4 presents the experimental results; and the last section outlines some suggestions for the future studies.

Research Background

Since classical optimization techniques are inadequate in solving problems, linear programming techniques have been introduced. The first study with linear programming was started by J. V. Neumann in 1928 after the foundations of the game theory had been associated with DP. In 1936, W.W. Leontief has developed the concept of input-output analysis in accordance with the current linear programming model. Many studies have been carried out in the field of solving problems through linear programming between 1930 and 1940. Nowadays, linear programming techniques have found application areas in many areas.

Evaluating a portfolio of securities separately and not in the logic of Williams (1938), Graham and Dodd (1934), on the contrary Roy (1952), the variance of the returns of the securities that comprise the portfolio with by demonstrating the relationship between the variance of Return of portfolio, Markowitz's have a similar mean-variance efficient frontier has developed (Rubinstein, 2002, p. 1041). Various scientists mean-variance portfolio selection model have worked to develop a model. Tobin (1958), Sharpe (1963) and Lintner (1965) adapted the investor's decision to the percentage of the portfolio of risky assets, borrowing-lending status, short-term sales, trading costs and taxes to the model. Brennan (1971) studied borrowing and lending rates, Turnbull (1977) on personal taxation, uncertain inflation and non-market assets. Levy (1983) and Schnabel (1984) were interested in short-term sales problems. In this paper, we will discuss the optimal portfolio creation with a linear programming technique. A large number of alternative portfolio models were proposed based on Markowitz's work in the portfolio area. The common point of these alternative models is to eliminate the complexity of computational modelling based on quadratic programming. The average absolute deviation model developed by Konno and Yamazaki (1991) is one of the examples that can be given to these models (Kardiyen, 2008, p. 336).

In finance literature, there are many studies that enable the choice of a portfolio. One of the most commonly used methods in portfolio optimization has been the mean absolute deviation model. In the financial literature, studies in the literature are carried out using the risk function (L_1) of the mean absolute deviation model based on obtaining an optimal portfolio by solving a simple linear programming problem.

The first researchers to develop a model using a linear programming method are Konno and Yamazaki. In these models, Konno ve Yamazaki (1991) presented a more useful model using the L_1 absolute deviation instead of the variance L_2 as a risk measure. Feinstein and Thapa (1993) re-modulated the risk function of Konno and Yamazaki to reduce the number of restraints from 2T+2 to T+2.

Simann (1997) compared the mean absolute deviation model with the mean-variance model to estimate risk levels in the portfolio selection problem. In his study, variance explained that ignoring the covariance matrix leads to very large estimation views rather than the benefit of it. In small-size applications, the mean-variance model provides less risk prediction and lower risk tolerance for investors.

Konno and Li (2000) have implemented an integrated model approach for international portfolio investments. In his study, he drew a conclusion using more than 700 stocks and securities such as treasury bills from 6 different countries. As a result of their work, they stated that the model they proposed was safer and less expensive than the other classical models.

Konno and Wijayanayake (2002) tried to solve the portfolio optimization problem under transaction costs and minimal transaction unit constraints.

Konno (2003) used the mean absolute deviation model for the optimization problem of small-scale funds, including transaction costs and minimal transaction unit constraints.

Chang (2005) re-modulates Konno and Yamazaki's risk function to reduce the number of restraints from *2T+2* to *T+2*. However, the number of supporting sign constraints has increased as much as T. In his study, Lindo compared Feinstein and Thapa's model with his proposed model using the package program.

Bozdağ, Altan and Duman (2005) using the stocks traded in the IMKB 30 index, Markowitz average-variance quadratic programming model and according to the minimax rule based on the linear programming approach has made the portfolio selection and compared the results.

Karacabey (2007) in his study compared the mean-variance model and the mean-absolute model under a given expected return. Both methods revealed that risk levels could be down (negative) and up (positive). In his study, he said that both models could be exposed not only to the down (negative) direction but also to the up (positive) direction. In practice, it has benefited from real data and demonstrated that the proposed method is riskier but more profitable. For investors who want to provide high returns, this model may be useful.

Kardiyen (2007) in his study of linear programming model can be solved with the average absolute deviation model is addressed. He explained the model in theoretical terms and touched on its advantages. In the application study, he evaluated the results of the model using IMKB data. In this study, it was shown that the mean absolute deviation model is applicable and that it is a preferred portfolio optimization model.

Cihangir, Güzeler and Sabuncu (2008) evaluated the Konno and Yamazaki model in their studies and tried to obtain optimal portfolios on 65 stocks traded in the IMKB financial sector. In this study, we investigated whether the lowest risk-level portfolio covers and determines which stocks are invested in each of these stocks and whether it supports the optimal portfolio creation initiatives that are required to be reached with the Konno and Yamazaki model. The result of the study is that the investor who avoids the risk or likes the risk will meet his expectations by revising the expected return. They also developed the purpose function of the

Konno-Yamazaki model in their studies. With the Konno-Yamazaki model, investors have stated that it is possible to create different portfolios according to their types.

Kardiyen (2008) by using monthly return values of 15 stocks traded in the IMKB-30 index, the average-variance model and the mean absolute deviation model have tried to establish an optimal portfolio by using the average-variance model. This data has been applied to both models and has obtained different portfolios for different target return levels. Monthly data for a simulation model has been compared to the results of both models. As a result of the study, he told an investor who had fled the risk that Markowitz could be resolved with the mean-variance model instead of the portfolio choice model. The portfolio returns of both models on the basis of practicality in use, since it does not give different results, the process does not require the assumption of the burden of distribution to be less than the average absolute deviation portfolio selection model is proposed for reasons such as.

Uğurlu, Erdaş and Eroğlu (2016) real data on stocks traded in the IMKB-100 index were analysed and 83 enterprises from 10 different industries formed a portfolio with the help of the mean absolute deviation model. Since the number of stocks to be invested in the portfolio and the distribution of the stocks in the industry cannot be interfered with, Konno and Yamazaki have proposed a new linear programming model that provides the highest expected return to the investor by expanding the model with additional constraints.

Portfolio Optimization Based on Linear Programming and Mean Absolute Deviation Model

In this study, a linear programming model will be discussed in order to determine the optimal portfolio of stocks that will consist of stocks that are traded continuously in Borsa Istanbul. Investors will be offered a portfolio model consisting of only stocks under the limitation of the industrial branch and trading volume. Through the proposed model, an optimal portfolio will be created for stocks traded in the BIST-30 index and risk levels and return amounts will be calculated for the portfolio obtained. By taking the original model and the proposed model together, the comparison of both models will be made by creating separate optimal portfolios. In this study, 30 stocks of companies that are continuously traded in the BIST-30 index, and are in 10 different industrial branches were analysed. The scope of the study will be limited to stocks which are one of the risky securities traded in the BIST-30 index. Therefore, non-risk securities such as bonds and Treasury bills that can be used in portfolio creation were not included in both models. In this study, monthly return rates and monthly increase rates were calculated using historical price data of stocks. The average returns for each share were calculated by calculating the 36-month returns for each share. Deviations from the averages of the stocks, that is, the risks, are calculated from the monthly changes in the prices of stocks. The linear programming model proposed by the original model was solved with the LINDO package program and optimal portfolio sets were obtained.

The average deviation model is also an effective method of determining the minimum risk of the stocks at the expected level of return, which is the deviation from the average return of the stocks at the expected level of return. This means that the average return of the solutions is concentrated in equities equal to or closest to the expected return level. In this model based on linear programming, the decision maker can easily calculate both the risk and the return of the portfolio, and in addition, eliminates the excess of transactions in the covariance calculations brought by the quadratic model in large-scale portfolio problems. It is a model that recommends that the decision maker use absolute deviation (L_1) instead of standard deviation (L_2) in risk measurement. The mean absolute deviation model eliminates the excess and the necessity of computing the covariance calculations of the quadratic model in large-scale portfolios. A portfolio optimization model is a model that can be used when the theoretical benefits and performance of the model are evaluated together. The only drawback of this model is that it may lead to a prediction error because it neglects the covariance matrix (Kardiyen, 2007, p. 27).

The study was based on a linear programming model developed by Konno and Yamazaki (1991) and reformulated by Chang (2005). The reason why this model is taken into consideration from the optimal portfolio selection is that the number of constraints and decision variables has been significantly reduced. In the model developed by Chang (2005), Konno and Yamazaki's L_1 risk function re-modulates the number of constraints from $2T+2$ (T= number of periods) to T+2 and variable number from $2T+n$ (n= number of securities used in the model) to $T+n$. In addition, this model is an equivalent model developed by Feinstein and Thapas (1993).

In this study, we are given as the application of the linear programming model of Chang on portfolio optimization. The author has developed the following model for portfolio optimization (Chang, 2005, p. 567-572):

The objective function:

$$Min\ Z = \sum_{t=1}^{T}\left(2d_t - \sum_{j=1}^{n} a_{jt}x_j\right) \tag{1}$$

Subject to:

$$d_t - \sum_{j=1}^{n} a_{jt}x_j \geq 0 \quad , \quad t = 1,2,3,........,T \tag{2}$$

$$\sum_{j=1}^{n} r_j x_j \geq \rho M_0$$

$$\sum_{j=1}^{n} x_j = M_0$$

$$0 \leq x_j \leq u_j \quad , \quad j = 1,2,3,.........,n$$

$$d_t \geq 0 \qquad , \quad t = 1,2,3,..........,T$$

$$x_j \geq 0$$

The meanings of the notation used in the above model are explained below.

T = The number of periods examined,

t = Any t period in the T period,

ρ = Expected return rate,

r_j = j. the average rate of return of the stock in the T period,

r_{jt} = j. the stock is t. rate of return in the period,

x_j = j. a share of the stock in total investment,

u_j = j. the upper amount of investment in the stock,

M_0 = Total investment amount,

ρM_0 = Expected amount of return,

d_t = Represents the auxiliary variable. The d_t variable here represents the value that maximizes the portfolio risk and is shown in the following formula.

$$a_{jt} = \sqrt{a_{jt}^{\ 2}} = \sqrt{\left(r_{jt} - r_j\right)^2} = \left|r_{jt} - r_j\right| \tag{3}$$

where, to represent $a_{jt} = r_{jt}$-r_j, j. the stock is T. in a period with the rate of return in period T is the difference between the expected rate of return and risk and this difference refers to the deviation from the mean. r_{jt}, J. the stock is *t*. it is the return for the period and can be obtained from historical data or from estimates of some future. In our study, it was calculated that the stocks that are traded continuously in the BIST 30 index will deviate from the average by taking into account the past returns of the stocks.

The goal function of the model is to minimize the risk expressed as a deviation from the expected return (ρ). The maximum number of constraints should be "*T+2*" in order to determine each point of the activity limit of the Chang model. (1) with the help of objective function number and *T* constraint derived from inequalities, stocks with the lowest risk are determined as *ajt = rjt-rj* coefficient. With the help of the constraint number (2), the average rate of return of these shares shall be selected to be equal to the expected return or the closest to the expected return. For example t. by minimizing the dt helper variable in the period, x_j whose risk is the lowest is determined, provided that the average return is not below the expected return. The restrictions posted here are no different from the original version of the Chang model. In this model, the number of stocks to enter the portfolio and the weights of the portfolio cannot be controlled. Therefore, portfolio weights can be collected in a number of stocks or sectors, and even theoretically the optimal solution can be composed of a stock or sector. All of the decision-makers, in other words, share certificates in the portfolio, can be made up of the same industry. This situation is inadequate to protect its portfolio against non-systematic risks such as industry risk and management risk. In addition, a portfolio that is not well diversified can pose a separate risk for the investor. It may be possible to reduce the non-systematic risk of the portfolio with additional constraints to be added to the model. A new model is proposed for investors by providing additional restrictions to the Ching-Ter Chang portfolio optimization model and distributing the shares to the portfolio in different branches of the industry. Therefore, portfolio weights will be prevented from accumulating in certain industrial branches. In this way, the portfolio will be more protected against industrial risk (Uğurlu, Erdaş and Eroğlu, 2016, p. 157).

In addition to the Chang (2005) portfolio optimization model, the following preference constraints are written (Uğurlu, Erdaş and Eroğlu, 2016, p. 157):

$$\sum_{k=n_j}^{m_j} x_k + z_j \leq 1 \;\;,\;\; k = n_j, \ldots\ldots, m_j$$

$$\sum_{k=n_j}^{m_j} x_k + z_j \geq f \quad j = 1,2,3,\ldots\ldots, s$$

$$\sum_{j=1}^{s} z_j \leq s - a,$$

$$j = 1,2,3,\ldots\ldots,10 \tag{4}$$

In the Equation (4), the meanings of the notation for the formulas numbered below is explained.

s: The number of sectors,

z_j: *z*. the sector, where, z_j means integer (0,1) variables,

n_j: *j*. the first business in the sector,

m_j: *j*. last business in the sector,

a: The number of sectors required to take part in the portfolio,

f: Represents the least weight of the sector in the portfolio

In Equation (4) with the restrictions numbered, the weight of the stocks in the optimal portfolio will be distributed to different branches of industry. Furthermore, since growth on the lower limit of the minimum weight of the sector within the portfolio will make the preference constraints added in the model non-functional, a reasonable lower limit was determined for diversification of the model as desired. In this way, an additional advantage for decision-makers will be provided by making the portfolio more sheltered against industry risk, which is one of the non-systematic risks.

The relationship between stock returns and trading volume is one of the many topics studied in the field of Finance. Trading volume is an important financial indicator showing the success status of the stock markets and contains information about the stocks (Nalın and Güler, 2013, p. 136). The trading volume represents the trading volume of a particular stock in the market in a certain time frame (Uyar and Kangallı, 2012, p. 184). Trading volume is the sum of the values found by multiplying the number of shares in transactions performed for each stock and the price of the transaction, and the total trading volume of all stocks is the total volume of the market (Coşkun, 2010, p. 390).

There are many reasons why investors pay attention to the trading volume information of their stocks while investing and shape their investments based on the trading volume information. Low trading volume can be argued theoretically that the market is not liquid and has high price volatility. Besides, high transaction volume usually shows that the market is also low in liquid and price volatility (Kayalıdere and Aktaş, 2009, p. 49). However, converting a high-volume stock into cash can be said to be faster and easier than low-volume stocks. This difference in the liquidity rates of trading volumes can create risk perception in decision makers according to the rate at which they can convert from the desired price to return (Uyar and Kangallı, 2012, p. 184). Therefore, the trading volume does not only play an important role in the return of securities with the introduction of new information but also reflects information about the changes in the expectations of the decision makers in the market (Kıran, 2010, p. 98; Leon, 2007, p. 176). With the idea that the trading volume is one of the important indicators of the market and can create a risk perception in the decision maker, the trading volume is considered as the preferred constraint in portfolio optimization (Uyar and Kangallı, 2012, p. 184). The representation of this restriction in the linear programming model is expressed in the following format.

$$\sum_{j=1}^{n} x_j \lambda_j \geq \lambda_{ort} \qquad (5)$$

Where,

λ_j: *j* average trading volumes for the 36-month period of the stock,

λ_{ort}: BIST 30 refers to the average trading volume of the sectors included in the index for 36 months.

With the restriction (5), the average transaction volumes of each share within 36 months were required to be greater than or equal to the average of the 36-month averages of each share.

An Empirical Application in Borsa Istanbul 30 Index

In this section, the Chang (2005) linear programming model will be implemented on 30 stocks that are listed in the BIST-30 index in Turkey and traded continuously in the BIST - 30 indexes between January 2012 and December 2014. An application was made to create an optimum portfolio from the stocks of the proposed model in the BIST-30 index.

For this purpose, monthly returns and 36-month return averages of each share were calculated on the official website of the stock exchange Istanbul. Since dividends are paid during the holding period, in order to make the calculations more realistic, it is necessary to reflect this situation to the return calculation of the shares. Therefore, in this study, adjusted returns of the share certificates and their average profit share were taken into consideration. In order to find monthly increase rates for shares, it was taken as a starting point for December 2011.

The objective function of the model is to minimize the sum of the d_t variance, namely the amount of risk calculated for each period. The value of a random variable is given by the following equation. Here, the calculated function for each period will be minimized for 30 stocks and 36 periods using the dt function will be as follows.

$$Min\ Z = \sum_{t=1}^{T} \left(2d_t - \sum_{j=1}^{n} a_{jt} x_j \right)$$

Min $2d_1 - 0.094x_1 - 0.224x_2 - 0.021x_3 - 0.136x_4$.........$- 0.062x_{25} - 0.014x_{26} - 0.086x_{27} - 0.064x_{28} + 0.068x_{29} + 0.104x_{30}$

As mentioned in the previous section, the d_t variable is the t of each stock. the difference between the return rate and the average return of the stock in the period represents the absolute value and $a_{jt} = r_{jt} - r_j$ is expressed in the form of. The number of constraints will be $T+2$ so that each point of the activity limit of the Chang (2005) model can be determined. In the model we use, the number of stocks and the total number of constraints for 36 periods is 38. Since it will be difficult to write a total of 36 constraints, restrictions for the first two periods and restrictions for the last two periods will be given.

$$d_t - \sum_{j=1}^{n} a_{jt} x_j \geq 0$$

$d_1 - 0.094x_1 - 0.224x_2 - 0.021x_3 - 0.136x_4 - 0.071x_5 - 0.164x_6 - 0.154x_7 - 0.010x_8 - 0.069x9 - 0.164x_{10} - 0.094x_{11} - 0.189x_{12} - 0.254x_{13} - 0.047x_{14} - 0.054x_{15} - 0.011x_{16} - 0.237x_{18} - 0.261x_{19} + 0.036x_{20} - 0.011x_{21} - 0.055x_{22} - 0.133x_{23} - 0.234x_{24} - 0.067x_{25} - 0.122x_{26} + 0.004x_{27} + 0.057x_{28} - 0.154x_{29} - 0.203x_{30} \geq 0$

$d_2, d_3, d_4 ,d_5,$...$,d_{32}, d_{33}, d_{34}, d_{35}$

$d_{36} + 0.052x_1 - 0.022x_2 + 0.009x_3 - 0.012x_4 + 0.033x_5 + 0.107x_6 + 0.042x_7 - 0.060x_8 + 0.053x_9 + 0.137x_{10} - 0.067x_{11} + 0.036x_{12} - 0.204x_{13} + 0.082x_{14} +$

$0.020x_{15} - 0.004x_{16} + 0.011x_{17} + 0.064x_{18} - 0.012x_{19} + 0.024x_{20} - 0.002x_{21} + 0.007x_{22} + 0.048x_{23} + 0.029x_{24} - 0.062x_{25} - 0.014x_{26} - 0.086x_{27} - 0.064x_{28} + 0.068x_{29} + 0.104x_{30} \geq 0$

One of the constraints with the amount of the investment in each stock multiplied by the average of the sum of the average yield of the total investment amount multiplied by the return or the expected return that must be greater than or equal to constraint and the following areas indicated. In our study, the expected return was 0.024 (ρ) of the average monthly rate of return of 30 stocks during the 36 months.

$$\sum_{j=1}^{n} r_j x_j \geq \rho M_0$$

$0.01547x_1 + 0.03358x_2 + 0.02176x_3 + 0.01470x_4 + 0.01573x_5 + 0.02298x_6 + 0.03148x_7 + 0.02838x_8 + 0.01818x_9 + 0.01699x_{10} + 0.02670x_{11} + 0.02868x_{12} + 0.00029x_{13} + 0.04474x_{14} + 0.02015x_{15} + 0.02361x_{16} + 0.03433x_{17} + 0.02207x_{18} + 0.01886x_{19} + 0.02945x_{20} + 0.01505x_{21} + 0.05310x_{22} + 0.00860x_{23} + 0.03902x_{24} + 0.01908x_{25} + 0.00891x_{26} + 0.01730x_{27} + 0.04650x_{28} + 0.02546x_{29} + 0.02324x_{30} \geq 0.024$

The fourth formula is the restriction that shows that when the total investment amount is taken as 1 Turkish lira, the total of the X decision variables representing the investment shares should be equal to 1. In this study, the total investment amount (μ_0) was taken as 1 Turkish lira. The reason for getting 1 Turkish lira is to ensure the ease of operation in the study. The number of 30 stocks that are the subject of the application, the constraint would be for each stock.

$$\sum_{j=1}^{n} x_j = M_0$$

$x_1 + x_2 + x_3 + \ldots\ldots\ldots\ldots\ldots\ldots + x_{27} + x_{28} + x_{29} + x_{30} = 1$

$$x_1, x_2, x_3, \ldots\ldots, x_{30} \geq 0$$

$$d_1, d_2, d_3, \ldots\ldots, d_{30} \geq 0$$

The restrictions posted here are no different from the original version of the Ching-Ter Chang (2005) model. The original version of the Chang's (2005) model was solved in the Lindo package program. As a result of solving the model, the stocks and the weights in the portfolio must be present in the portfolio are shown in Table 1 and the following optimal portfolio is obtained.

Table 1

Optimal Portfolio with Ching-Ter Chang (2005) Model

Decision Variables	Stocks	Sectors	Investment Shares (%)
x_3	*BİM Mağazaları*	Retail and Food Trade	20.22
x_{17}	*Pegasus Hava Taşımacılığı*	Transportation	21.67
x_{20}	*TAV Havalimanları*	Transportation	13.58
x_{21}	*Turkcell İletişim*	Telecommunication	16.84
x_{26}	*Türk Telekom*	Telecommunication	17.05
x_{27}	*Tüpraş Türkiye Petrol*	Petroleum Refining	3.83
x_{28}	*Ülker Bisküvi*	Retail and Food Trade	6.81

Source: Own computation (Lindo package program).

Table 2 shows the optimal portfolio created through the Lindo package program above, in order to provide a 2.4% monthly return on 1 Turkish lira investment from the retail sector; *BİM Mağazaları* (20.22%) and *Ülker Bisküvi* (6.81%), from telecommunications sector; *Turkcell İletişim* (16.84%), *Türk Telekom* (17.05%), from the transportation sector; *Pegasus Hava Taşımacılığı* (21.67%), *TAV Havalimanları* (13.58%), from the petroleum refining sector; *Tüpraş-Türkiye Petrol* (3.83%), the optimal portfolio includes 7 stocks and 4 different sectors. The optimal portfolio's objective function value, in other words, the value of minimizing risk, is 1.055%. The total stock of number 30 used in the model, considering the optimal portfolio of stocks is zero, which is not within the value of decision variables 23, and 23 it can be said that this could be done to invest in stocks.

In addition to these constraints, it is possible to add the upper limit of the investment to the model in such restrictions as risk-free securities. In our study, in addition to the Chang (2005) model, preference constraints were added. The first of these choices is to reduce non-systematic risk, the model has been added to the industry branches of distribution constraint. Industrial branches and the sectors in which they are located are listed in Annex-1. With this restriction, if the stocks of all sectors are going to be resolved, it is required that the number of sectors to be included in the portfolio should be at least 5%, and that the number of sectors (a) is required to be 5 and that the number of sectors to be included in the portfolio is 5 (10-a) to 5. The growth of the lower limit of the minimum weight of the sector in the portfolio will make the preference constraint added to the model after a certain point of failure. For example, under the assumption that the lower limit is 25%-30%, there are no more than 3 or 4 sectors in the portfolio. This reduces the investment share of a more secure industry segment in the portfolio. If this constraint is not written, the model will solve the desired number of sectors, but the weights can be close to zero, even portfolio theory can be formed from a single stock. In order to protect the portfolio from non-systematic risks, with the help of this restriction, the stock will be selected from different branches of industry (Ugurlu, Erdaş and Eroğlu, 2016, p. 157; Erdaş and Demir, 2016, p. 779):

$$\sum_{k=n_j}^{m_j} x_k + z_j \leq 1$$

$$\sum_{k=n_j}^{m_j} x_k + z_j \geq f \quad \text{and} \quad \sum_{j=1}^{s} z_j \leq s - a$$

Restrictions for branch of industry (Banking sector):

$x_1 + z_1 \leq 1, x_9 + z_1 \leq 1, x_{10} + z_1 \leq 1, x_{11} + z_1 \leq 1, x_{29} + z_1 \leq 1, x_{30} + z_1 \leq 1$

$x_1 + x_9 + x_{10} + x_{11} + x_{29} + x_{30} + z_1 \geq 0.05$

Restrictions for branch of industry (Durable consumer sector):

$x_2 + z_2 \leq 1$

$x_2 + z_2 \geq 0.05$

Restrictions for branch of industry (Retail trade and food sector):

$x_3 + z_3 \leq 1, x_{15} + z_3 \leq 1, x_{28} + z_3 \leq 1$

$x_3 + x_{15} + x_{28} + z_3 \geq 0.05$

Restrictions for branch of industry (Holding sector):

$x_4 + z_4 \leq 1, x_{12} + z_4 \leq 1, x_{18} + z_4 \leq 1, x_{19} + z_4 \leq 1, x_{23} + z_4 \leq 1$

$z_4 + x_{12} + x_{18} + x_{19} + x_{23} + z_4 \geq 0.05$

Restrictions for branch of industry (Construction sector):

$x_5 + z_5 \leq 1, x_6 + z_5 \leq 1, x_{25} + z_5 \leq 1$

$x_5 + x_6 + x_{25} + z_5 \geq 0.05$

Restrictions for branch of industry (Iron steel sector):

$x_7 + z_6 \leq 1, x_{13} + z_6 \leq 1, x_{14} + z_6 \leq 1$

$x_7 + x_{13} + x_{14} + z_6 \geq 0.05$

Restrictions for branch of industry (Automotive sector):

$x_8 + z_7 \leq 1, x_{24} + z_7 \leq 1$

$x_8 + x_{24} + z_7 \geq 0.05$

Restrictions for branch of industry (Petroleum Chemicals sector):

$x_{16} + z_8 \leq 1, x_{27} + z_8 \leq 1$

$x_{16} + x_{27} + z_8 \geq 0.05$

Restrictions for branch of industry (Telecommunications sector):

$x_{21} + z_9 \leq 1, x_{26} + z_9 \leq 1$

$x_{21} + x_{26} + z_9 \geq 0.05$

Restrictions for branch of industry (Transportation sector):

$x_{17} + z_{10} \leq 1, x_{20} + z_{10} \leq 1, x_{22} + z_{10} \leq 1$

$x_{17} + x_{20} + x_{22} + z_{10} \geq 0.05$

In order to determine the minimum number of sectors in the solution, the following constraint is written. There are a total of 10 sectors that are subject to our study. Here is a value of 5. In this way, at least 5 Sectors (10-a) were required to be included in the optimal portfolio solution.

$z_1 + z_2 + z_3 + z_4 + z_5 + z_6 + z_7 + z_8 + z_9 + z_{10} \leq 10\text{-}5$

The last constraint is one of the important indicators of the market and the trading volume that affects the distribution of stocks in the portfolio with the idea that it can create a risk perception in the decision-maker (Erdaş and Demir, 2016, p. 779).

$$\sum_{j=1}^{n} \lambda_j x_j \geq \lambda_{ort}$$

$168117542.277x_1 + 17480878.416x_2 + 29857611.663x_3 + \ldots\ldots + 10106626.328x_{28} + 157110825.416x_{29} + 97427621.03x_{30} \geq 72311522.135$

The linear programming model obtained by using the above-mentioned objective function and constraints has been put into the Lindo package program as data. As a result of solving the model, the stocks and the weights in the portfolio must be present in the portfolio are shown in Table 2 and the following optimal portfolio is obtained.

Table 2

Optimal Portfolio with Proposed Model Based on Linear Programming

Decision Variables	Stocks	Sectors	Investment Shares (%)
x_3	*BİM Mağazaları*	Retail and Food Trade	22.47
x_7	*Ereğli Demir Çelik*	Iron Steel	8.78
x_9	*Garanti Bankası*	Banking	5.73
x_{17}	*Pegasus Hava Taşımacılığı*	Transportation	15.08
x_{20}	*TAV Havalimanları*	Transportation	8.36
x_{21}	*Turkcell İletişim*	Telecommunication	11.90
x_{22}	*Türk Hava Yolları*	Transportation	6.53
x_{26}	*Türk Telekom*	Telecommunication	16.15
x_{28}	*Ülker Bisküvi*	Retail and Food Trade	5.00

Source: *Own computation (Lindo package program).*

Table 2 shows the optimal portfolio created through the Lindo package program above, in order to provide a 2.4% monthly return on 1 Turkish lira investment from the retail and food sector; *BIM Mağazaları* (22.47%) and *Ülker Bisküvi* (5.00%), from iron steel sector; *Ereğli Demir Çelik* (8.78%), from the transportation sector; *Pegasus Hava Taşımacılığı* (15.08%), *TAV Havalimanları* (8.36%), *Türk Hava Yolları* (6.53%), from telecommunications sector; *Turkcell İletişim* (11.90%) and *Türk Telekom* (16.15%), from banking sector; *Garanti Bankası* (5.73%), the optimal portfolio includes 9 stocks and 5 different sectors. The optimal portfolio's objective function value, in other words, the value of minimizing risk, is 1.103%. The total stock of number 30 used in the model, considering the optimal portfolio of stocks is zero, which is not within the value of decision variables 21, and 21 it can be said that this could be done to invest in stocks. Portfolio diversification is provided with the proposed portfolio model at the desired level.

Conclusions and Suggestions

One of the most important of modern financial optimization models is portfolio optimization models. The common point facing different approaches in securities analysis and portfolio management is to put forward the models that will guide the investment decisions of investors and to make the right choice of the portfolio that will reflect the investors' risk and return preference.

Nowadays, with the development of financial markets, many different portfolio approaches have been introduced in the creation of portfolio sets that will provide the best returns according to the level of risk and expectation that investors can take. Considering the relationship between the returns on the securities, without increasing the number of securities in the portfolio, the portfolio risk could be reduced which suggest that the traditional approach against the returns on the securities regardless of the effect on the relationship between the Markowitz portfolio to diversify the risk of doing who stated that they could not take the approach argued that the risk cannot be reduced by the enhancement of the assets in the portfolio. In his study, Markowitz proposed a quadratic model based on nonlinear programming, which brought a scientific approach to portfolio selection problems. The risk of the portfolio of securities that comprise the portfolio risk is less than it might be under certain circumstances has shown that the unsystematic risk of the portfolio can be made zero. Although the model is very good in theory, the statistical data used in practice are too much, taking time and cost elements because of the difficulties and heavy criticism has been subject to. In order to eliminate the disadvantages of these difficulties, many portfolio approach methods have been developed. A linear programming model is a model that is based on a linear programming method and is considered a pioneer among these studies. In this model, Konno and Yamazaki, which accept different risk measurement, have become one of the most important portfolios optimization models. In this model, the mean deviation of the mean is called the model because it uses absolute deviation instead of the variance as a risk measure. The model of the L_1 risk function of Konno and Yamazaki was reformulated by Feinstein and Thapa (1993) and Chang (2005) and created more advantageous models.

In this study, the mean absolute deviation model was first discussed theoretically and then the optimal portfolio test was carried out on stocks traded in the Borsa Istanbul 30 index. In this study, the portfolio model is modifiable by Chang (2005) and based on the mean absolute deviation model. The most important reason for this model is to reduce the number of constraints significantly. An optimal portfolio is achieved by adding additional preference constraints to the portfolio model proposed by Chang. It is possible to reduce the risk with a good diversification with the proposed portfolio model and it is possible to increase the expected return of the investor.

An optimal portfolio has been obtained as a result of the optimization of Chang's original model based on portfolio optimization with the Lindo package program. In this portfolio, in order to provide a 2.4% monthly return on 1 Turkish lira investment from the retail sector; *BIM Mağazaları* (20.22%) and *Ülker Bisküvi* (6.81%), from the transportation sector; *Pegasus Hava Taşımacılığı* (21.67%), *TAV Havalimanları* (13.58%), from telecommunications sector; *Turkcell İletişim* (16.84%) and *Türk Telekom* (17.05%), from the petroleum refining sector; *Tüpraş-Türkiye Petrol* (3.83%), the optimal portfolio includes 7 stocks and 4 different sectors. The optimal portfolio's objective function value, in other words, the value of minimizing risk, is 1.055%. As a result, the optimal portfolio's objective function is expected to yield a risk of 1.055% and a return of 2.40%.

A new model has been proposed by adding preference constraints to this model based on Chang's (2005) portfolio optimization model. An optimal portfolio has been obtained based on the proposed portfolio model with the Lindo package program. In this portfolio, in order to provide a 2.4% monthly return on 1 Turkish lira investment from the retail and food sector; *BİM Mağazaları* (22.47%) and *Ülker Bisküvi* (5.00%), from iron steel sector; *Ereğli Demir Çelik* (8.78%), from the transportation sector; *Pegasus Hava Taşımacılığı* (15.08%), *TAV Havalimanları* (8.36%), *Türk Havayolları* (6.53%), from banking sector; *Garanti Bankası* (5.73%), from telecommunications sector; *Turkcell İletişim* (11.90%) and *Türk Telekom* (16.15%), the optimal portfolio includes 9 stocks and 5 different sectors. The optimal portfolio's objective function value, in other words, the value of minimizing risk, is 1.103%. As a result, the optimal portfolio's objective function is expected to yield a risk of 1.103% and a return of 2.40%.

According to the results obtained, the risk of the optimal portfolio and the number of stocks were different when the non-systematic risk and trading volume constraints were added to Chang's (2005) model. As mentioned before, the average absolute deviation models of Konno and Yamazaki (1991), Feinstein and Thapa (1993) and Chang (2005) cannot intervene in the number of stocks entering the portfolio and distribution to industry branches. This can theoretically make it possible for the portfolio to be composed of a single stock. However, in order to avoid systematic risks, investors should consider that they may want the weight of the portfolio to be distributed to different business branches and businesses. With this proposed model, the weight of the stock in the portfolio will be distributed to different branches of industry. Thus, the portfolio is expected to be more protected against non-systematic risks. With this study, a portfolio model has been proposed to financial managers and investors who want to invest in a certain risk and return level and to create a portfolio. In conclusion, in this model, rather than investing in stocks of a single sector, investing in a portfolio consisting of different industries by reducing the risk of a well-diversified relationship between stocks and non-systematic.

This study consists only of stocks which are one of the risky movable securities. Therefore, in future studies, risk-free movable securities such as bonds and stocks, such as risky movable, such as mixed portfolios can be created. A portfolio can be created by taking into consideration the risky elements of return and risk that are effective in portfolio selection. In addition, an optimal portfolio set can be created for investors by adding different preference constraints to the average absolute variance portfolio.

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Appendix

Firms Listed in Borsa Istanbul 30 Index

No	Name	Symbol	Sector
x_1	AKBANK	AKBNK	Banking
x_2	ARÇELİK	ARCLK	Durable Consumption
x_3	BİM MAĞAZALARI	BIMAS	Retail Trade
x_4	DOĞAN HOLDİNG	DOHOL	Holding
x_5	EMLAK KONUT GMYO	EKGYO	Construction
x_6	ENKA İNŞAAT	ENKAI	Construction
x_7	EREĞLİ DEMİR ÇELİK	EREGL	Iron Steel Industry
x_8	FORD OTOSAN	FROTO	Automotive
x_9	GARANTİ BANKASI	GARAN	Banking
x_{10}	TÜRKİYE HALK BANKASI	HALKB	Banking
x_{11}	İŞ BANKASI	ISCTR	Banking
x_{12}	KOÇ HOLDİNG	KCHOL	Holding
x_{13}	KOZA ALTIN	KOZAL	Iron Steel Industry
x_{14}	KARDEMİR KARABÜK DEMİR	KRDMD	Iron Steel Industry
x_{15}	MİGROS TİCARET	MGROS	Durable Consumption
x_{16}	PETKİM PETROKİMYA	PETKM	Petrochemistry
x_{17}	PEGASUS HAVA TAŞIMACILIĞI	PGSUS	Transportation
x_{18}	SABANCI HOLDİNG	SAHOL	Holding

x_{19}	SİŞE CAM ISE VE CAM FABRIKALARI	SISE	Holding
x_{20}	TAV HAVALIMANLARI HOLDING	TAVHL	Transportation
x_{21}	TURKCELL İLETISİM HİZMETLERİ	TCELL	Telecommunications
x_{22}	TÜRK HAVA YOLLARI	THYAO	Transportation
x_{23}	TEKFEN HOLDİNG	TKFEN	Holding
x_{24}	TOFAŞ TÜRK OTOMOBİL FABRİKASI	TOASO	Automotive
x_{25}	TRAKYA CAM SANAYİİ	TRKCM	Construction
x_{26}	TÜRK TELEKOMÜNİKASYON	TTKOM	Telecommunications
x_{27}	TÜPRAŞ-TÜRKİYE PETROL RAFİNE	TUPRS	Petrochemistry
x_{28}	ÜLKER BİSKÜVİ	ULKER	Retail Trade
x_{29}	VAKIFLAR BANKASI	VAKBN	Banking
x_{30}	YAPI VE KREDİ BANKASI	YKBNK	Banking

Source: Borsa Istanbul