

Selection of an optimal portfolio of projects using the modified model of Markowitz

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Abstract

Part of the financial and accounting literature is related to the selection of the optimal portfolio of financial assets. Harry Markowitz in the 1950s proposed a mathematically strong model for this. His model provides optimal weights in portfolio assets based on minimizing (maximizing) of the standard deviation (expected return) of portfolio of financial assets at a certain level of return (risk) assets. However, in financial and accounting literature, optimal portfolio of projects has received less attention, largely because of risks and difficulties related to the calculation of risk and return of projects. In this paper, based on modified Markowitz model and using data from IRIAF Cooperative Foundation projects (Projects at point zero of the construction as of autumn 2016) and cash flows derived from econometric studies and interviews with specialists and obtaining a net present value function using Monte Carlo simulation and the mean and standard deviation, it was tried to optimize the project based on the said model. Findings based on modified model Markowitz as well as data relating to five projects of IRIAF Cooperative Foundation at point zero of construction show that with an increased risk projects (SD), the net present value of projects increases and also that unlike the efficient center of conventional Markowitz model, efficient center obtained based on modified model is discontinuous.

Keywords: optimization, Monte Carlo simulation, Markowitz

Introduction

In project-based organizations, existence of numerous projects in the body of the organization has caused changes in terms the structure and methods and working systems. Such collection of projects causes specific conditions to be imposed on organizations and project managers to manage and lead project. So proper use of opportunities and assets of the organization and proper control of

the progress of projects of organizations, social, economic and technological justifications should be undertaken (Robbins, 2005) [1].

Project portfolio management enables dynamic decision-making process, in which values can be considered, the organization projects can be prioritized, and finally the organization's limited resources can be allocated properly to achieve organizational goals (Spear MC, 2004) [2].

Project portfolio management is approach that is based on knowledge of project management and one of the latest methods that can be used in project management to the effect that in this system, the management is focused on combination of project with specific objectives and conditions and is considered a higher level of project management in organizations.

In this management system, the main objective is to design and implement projects that can finally facilitate achievement of strategic objectives the project. Selection of appropriate projects, properly allocating limited resources of the organization, coordination and synergy in a project portfolio of organization, ensuring sound organizational relations between projects managers are the most important theoretical foundations of this system. Overall, use of project portfolio management approach brings the following profits and results to the organization (Robbins, 2005) [1].

Project portfolio selection is one of the main processes of project portfolio management, and a periodic activity to select an appropriate portfolio of projects proposed or running project of organization that meets the organization's goals in an optimal manner and without spending additional resources or failure to satisfy other constraints (Spear MC, 2004) [2].

IRIAF Cooperative Foundation

IRIAF Cooperative Foundation is an organization affiliated with the army founded in 1993. The overall objectives of the establishment of the institution include business activities, financial and construction projects to enhance the financial strength of the working staff of the army and the use of military specialists to implement the financial and construction projects. The foundation, according to the mission that was entrusted to it from the beginning formed private joint stock companies with a mission to conduct financial and trade business and enhance the financial strength and mass production to improve the lives of military personnel.

Subsidiaries of Cooperative Foundation utilizing expert personnel, as well as recruiting internal and external experienced man, try to improve the quality and cost control, reduce costs and deliver projects within budget and the most appropriate time. The main mission of the IRIAF Cooperative Foundation (subsidiaries) is commercial and financial activities in the form of holding companies and the establishment of joint-stock companies that are engaged in the construction and commercial construction projects, to provide housing for military personnel and improving the financial strength of military personnel as well as the deployment of military forces in peacetime and specialized staff in working. Given the mass production of the various companies of IRIAF Cooperative Foundation and in order to speed work and meeting the obligations and enhance the quality, type of structure used in the construction of residential and commercial towers is the bolts and nuts structure; which requires no welding and uses bolts for connections and also due to the lightness of the foundation and earthquake resistance, instead of concrete, ready Plasterboard is used as sound insulation and padding, which is rare among the projects of its kind in the country. These companies, not only do the construction of residential projects, but also because of revenues for funding, they are attempting to run their business projects. Since construction projects in different parts of the country that have been undertaken by this military institution have great variation and only in the West of Tehran, about twenty thousand residential and commercial units will have to be prepared and delivered, and given the recession in the construction sector and

housing economy already exist in the country, the clearest vision that can be drawn on this part of the mission of the Foundation is to speed up the building and meet its obligations in due time, with regard to personnel and market sales.

Literature

At the beginning, project portfolio management was introduced after financial portfolio management concepts, and over time gradually grown and expanded as an independent entity and accordingly has been used in the project field. A summary of the process of evolution is as follows:

Harry Markowitz introduced portfolio theory through an article titled "portfolio selection ". Before then, investors focused on individual profit-risk assessment of individual securities. Capital analysts identified securities with the highest and most promising monetization opportunities with the lowest risk, and built a portfolio of these securities. This approach results in a set of securities that, for example, comprised the pharmaceutical industry or the transportation industry (Ashkezari, 2005) [3].

Instead Markowitz proposed that rather than focusing on just collecting of portfolios of securities with attractive properties in terms of risk and profit, investors focus on choice of portfolio based on general characteristics of their profit and risk. He noted that if the return for period for a number of different securities is considered as random variables, one can assign to them expected values and standard deviation, which leads to the ability to calculate the return and expected volatility of all portfolios. After that, Tobin in 1958 developed Markowitz's work and added a zero-risk assets added to that analysis and then Sharpe in 1964 presented asset pricing model. Markowitz in 1990 along with Merton Miller and William Sharpe obtained a Nobel Prize for their work on the theory of portfolio selection. This theory provided an appropriate context for understanding the interaction between risk and return systematically and this has led to the adoption of portfolio management in many other areas and especially in a rising trend in project management organizations, we are using the approach developed by the project management. In 1993, Cleland and King found that an increase in the use of project management resulted in many projects outside of the organization's mission, inconsistent with the direction of the strategy of the organization, and some of them required high finance that is not commensurate with the expected benefits and so gradually benefits of portfolio management became clear, leading to use of it in project management (Robbins, 2005) [3].

Portfolio management became attractive in the late nineties for IT projects and a variety of software for classifying projects within the portfolio came to the market until in 2006, International Project Management Institute PMI published Portfolio management standard. The purpose of this standard was to focus on portfolio management. The purpose of this standard focuses on the project management and is applicable to all organizations. (Cooper et al., 2007) [5].

Turner defined portfolio management in two ways:

The term portfolio was adapted from finance literature in which the investor has a portfolio of investments and in fact, it can be said that the projects of an organization are part of its investment portfolio. As a result, the portfolio can be used in two ways: Portfolio is a group of projects which have common resources shared between them; these resources may be financial, human, data or technology.

Investment portfolio of the company: The total investment of the organization including all the running projects. Sometimes, investment portfolio of company include a portfolio of projects.

Sometimes it contains multiple programs, multiple large projects and multiple portfolios of many small to medium projects.

Cooper et al. in 1998 described another important element of an efficient PPM process as follows:

Portfolio management should be a dynamic decision-making process whereby a list of active projects in business should be continually updated and reviewed (Cooper et al., 2001) [4].

New project will be subject evaluation, selection and prioritization and existing projects may be accelerated, expired or be removed from priority list and resources may be allocated to active projects. Decision-making process is done based on new information and changing, dynamic opportunities presented by overlapping strategic considerations (Cooper et al., 2007). [5]

Levin says project portfolio management is a set of business practices by which the project is highly integrated with business operations and sets projects in perfect harmony with the strategies, resources and insights of CEOs organization and provides the structure and processes for monitoring the project portfolio. By reviewing the literature in this area, we see that the beginning of portfolio optimization models goes back to the seventies, but in the recent decades, there has been a lot of attention to this area, and most researches have been done during the same period. According to them, this process is called optimized approach of tracking error-variance (TEV). In the following, an objective function that includes both the EV and TEV was used and objective was developed to include an arbitrary number of elements of risk as well. Therefore, these models can be introduced as multiple-risk models. The following, a model has been proposed that has "moment limit" weights and set a limit on weights set, and thus clearly tracking error variance is limited (Cooper et al., 2007) [5].

Apart from progress made in modeling, statistical issues also play significant roles in implementing procedures. However, it should be noted that disturbance plays a role in application of tracking. Mishaud points out a problem that is related to the standard applications and considers improved estimation methods used in management methods used.

In one study, Chan et al. studies quality of estimation of peripheral parameters for standard applications and optimization. In this study, the authors experimentally found that compared with standard use, tracking measure is less sensitive to errors in the prediction of project risk-return structure. It is clear that this is consistent with the assumption that the relative optimization is a simple way to reduce the impact of disturbance in the portfolio optimization process. Given the role of dimension of time, Adcock also notes that the optimization with respect to a desired criterion is a source of stability in the optimization of the portfolio through time. Since the standard weights are usually slow to change, again, they cause reduced disturbance of estimates; another important statistical issue is to calculate tracking risk given the fact that returns over the weekly time or shorter do not have the equal distribution independent of a normal distribution (Ronald Grace, 2007) [6]. Pep and Yadav were among the first researchers to state that tracking error variance estimation is, as a result of the aforementioned, is a difficult task. In particular, when calculating the tracking risk, the difference in liquidity between the benchmark portfolio and managed portfolio may cause dependency in tracking errors, which in turn may lead to wrong estimates during use of conventional estimation methods. The effects of random weights of portfolio and the extent of their impact on estimation of tracking error variance was consider in Sechel's and Huang's research. Another issue is non-normality of returns and tracking errors, which reduces the productivity of conventional estimators. Thus, Bamberg and Wagner proposed use of a stable estimates for the tracking error variance, which is used if there are outliers in the sample returns (Ronald Grace, 2007) [6].

Methodology and data collection method

This study is an applied study and helps researchers to decide an optimal portfolio of projects within the IRIAF Cooperative Foundation projects. Since the optimization of the portfolio of projects is used in many industries with the aim of Investment Management; investors are always looking for maximum return while controlling the risks at a certain level or minimizing risk at a certain level of returns. However, unlike other financial assets, historical data associated with the project are not available. The most important sources of information about projects include estimates of cash flows, consulting reports, or technical analysis. With estimates of future cash flows, using Monte Carlo simulation, probability distribution function of net present value (NPV) of projects can be calculated. Finally, using the expected net present value of projects and the consideration of optimization constraints such as budget constraints, the maximum amount of portfolio risk, optimal weights of each project, are calculated using a modified model of Markowitz. In the said study, given the method and purpose of the research, following actions were carried out:

Study of documents and raw data:

Study of documents related to projects of IRIAF Cooperative Foundation was conducted by referring to data collected in different ways, including statements and documents, check lists of project engineers.

Interviews with experts involved in the project:

At different stages, experts in the field of building construction projects were interviewed, and the opinions of interviewed and their information were used for research. At various stages, a number of technical engineers, Technical Department of the IRIAF Cooperative Foundation were interviewed to obtain the knowledge of manner of implementation of projects and manner of calculate the cost of the project.

Financial Statements of IRIAF Cooperative Foundation companies:

To obtain information on the different stages of research, the data contained in the financial statements of companies of IRIAF Cooperative Foundation has also been used. Data on running projects along with the details of spending were used as a source of samples to estimate costs and funding of projects that have been chosen as sample.

The non-corporate documents:

The use of financial and technical books and budgeting is also among the documents used as a tool to collect data and information. Several technical and financial books and periodicals on how to implement the construction projects and budgeting and how to record financial data related to costs and the cost of construction and commercial construction projects have also been used.

Official documents:

Reading the reports of the board, auditor's report and the statutory auditors, and decisions of the Assembly to ensure the accuracy of the information contained in the information sheets and other ancillary data that has been collected from different parts of the company; First reports of the Board of different years and then reference to the reports, auditing and legal inspectors, and the General Assembly approvals of the financial statements, and finally the reliable and documented figures supported by documentation were collected.

Secondary data collection:

In order to measure the values in the IRIAF Cooperative Foundation, in this research, in terms of such factors as the financial and human resources and information available and other limitations including time limitations, a combination of tools of data collection, including a questionnaire and checklist were used to collect actual data of the company, which are in fact driven from the documents and information available. The checklist included variables that indices identified and measured by quantitative measure. Data related to experts' opinions, because of the importance and sensitivity, were directly collected by questionnaire. Expert opinion is one of the basic tools for data collection because of the importance of their opinion. In the present study, cash flows of samples selected were analyzed by Monte Carlo simulations and thus the net present value's distribution function was obtained and then having an estimate of the net present value's expected distribution function, the mean net present value of projects was obtained and finally using a modified Markowitz model, we did optimization. So in this study, in order to estimate the distribution function the expected net present value, the Monte Carlo simulation was used in Microsoft Excel. Also, to implement the modified model of Markowitz, and obtain the optimal portfolio of projects, Matlab software was used.

Statistical population & Sample

According to the location of the research, statistical population is the projects of IRIAF Cooperative Foundation in the field of construction for military personnel.

Thus regarding the activities of IRIAF Cooperative Foundation, from among the projects of this foundation, chosen projects were those that first, were at the beginning of the construction activity and secondly provided information about the limitations of the project in terms of time and budget available for them. Given the statistical population and study of the documentation, we checked the status of projects and then based on the results, the model was provided and checked. In the present study, population still cannot be equal to the sample, because there are always projects that are in the construction phase, while the sample included construction projects that are in phase zero, and the runtime data and budgeting data of them are available to researchers.

Research Hypothesis

According to the theoretical foundations, the research hypotheses are stated as follows:

First hypothesis: with increase in the standard deviation (risk), optimal portfolio of projects resulting from the use of modified model of Markowitz, the net present value expected also increases.

The second hypothesis: unlike efficient center drawn based on use of the conventional model of Markowitz, which is continuous, because of the binary nature (0 and 1) of the selection of projects, the efficient center for modified Markowitz model is discrete.

Hypothesis test

To test the first hypothesis, the model (1) is used as follows:

$$Max E[NPV_p] = \sum_{i=1}^5 w_i E[NPV_i]$$

s. t:

$$\sigma_p \leq s$$

$$\sum_{i=1}^5 w_i I_i \leq I$$

$$w_i \in \{0,1\}$$

In modified Markowitz model, variables are:

$E[NPV_p]$: The expected net present value of the portfolio of projects

$E[NPV_i]$: The expected value of net present value of the portfolio of projects.

σ_p : The maximum acceptable value of risk

I: The total investment value

I_i : Investment required for the ith project

w_i : Variable of weight and choice of portfolio that is in binary form

In this study, to test the hypothesis (1), the following procedure was used:

1. Determining the statistical population projects:

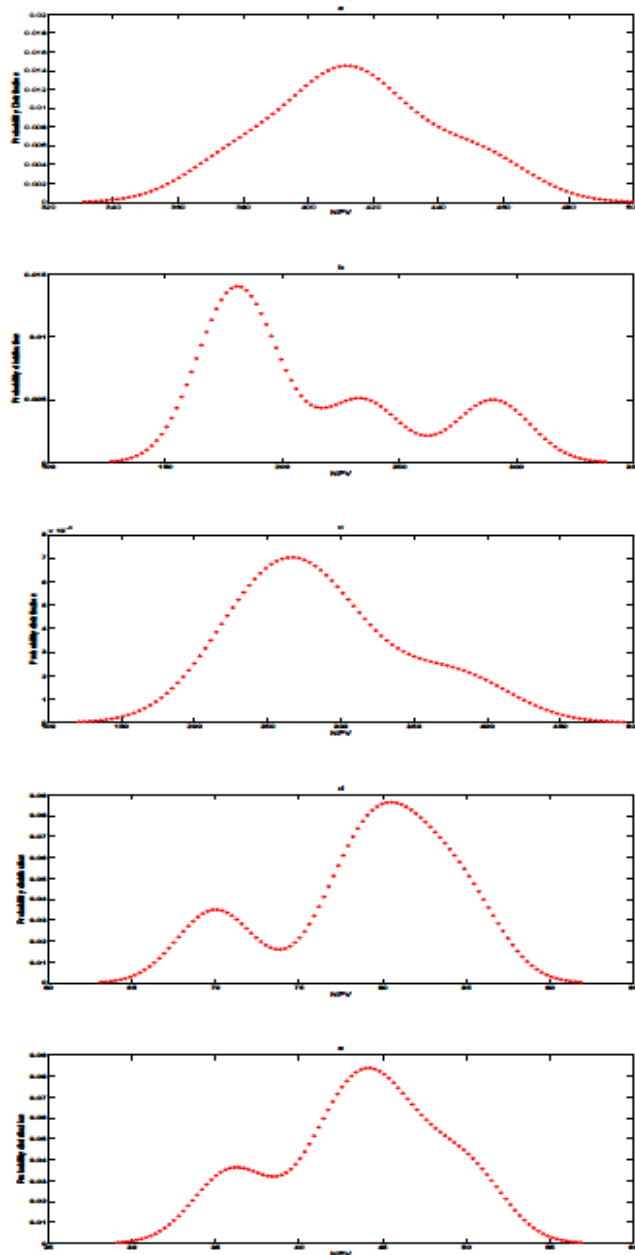
Zone B			Zone A		
Number of flats	Number of stories	Description	Number of flats	Number of stories	Description
448	34	B1	128	16	A2-1
448	34	B2	190	19	A2-2
448	34	B3	190	19	A31-1
448	34	B4	75	15	A31-2
448	34	D1	75	15	A31-3
448	34	D2	190	19	A31-4
448	34	D3	120	15	A31-5

510	35	E1	120	15	A31-6
510	35	F2	190	19	A32-1
432	29	G1	80	16	A32-2
432	29	G2	190	19	A32-4
432	29	G3	190	19	A32-5
432	29	G4	190	19	A33-1

2. The use of sampling method and obtaining projects for which there are estimates of cash flows and are in terms of construction at an early stage. In order to estimate the net present value and the distribution of a portfolio of projects, as already noted, from among the relevant projects, five selected projects were selected. To estimate the net present value, depending on the type of financing structure of projects, the weighted mean cost of capital was used as the discount rate and the mean figure of 24% has been estimated.

Number of flats	Number of stories	Description of project
448	34	D1
448	34	D2
448	34	D3
510	35	E1
510	35	F2

3- Obtaining distribution function of net present value of sample projects using Monte Carlo simulations as presented in the following graph:



4- Obtaining distribution function of net present value of statistical sample projects using Monte Carlo simulation. In the table below, the results of five times cash flow simulation of projects mentioned from among 100 times simulation are presented.

Projects	1	2	3	4	5
G1	379	408	409	423	452
G2	290	179	175	189	234
G3	250	377	237	284	290
E1	70	80	82	78	85
F2	36	50	46	42	44

5. After obtaining distribution function, extracting the mean and standard deviation of net present value of projects as presented in the following table:

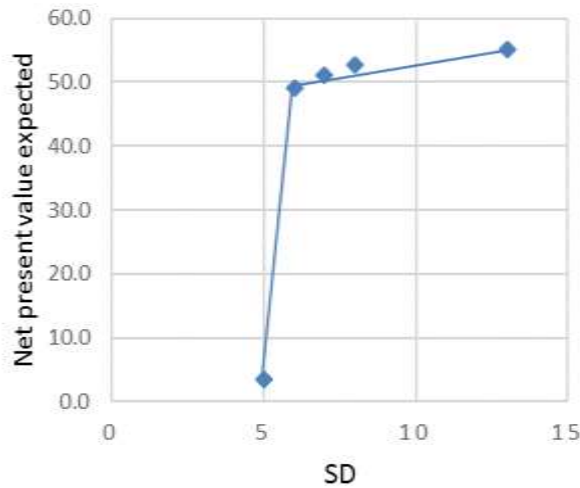
Projects	1	2	3	4	5	EPV	STDEV
G1	379	408	409	423	452	414.2	26.50849
G2	290	179	175	189	234	213.4	48.84977
G3	250	377	237	284	290	287.6	54.73847
E1	70	80	82	78	85	79	5.656854
F2	36	50	46	42	44	43.6	5.176872

6. Using modified Markowitz model and optimization based on the mean and standard deviation of the net value of projects of sample. Table (3) shows the results of applying the modified Markowitz model.

Description	$s = 5$	$s = 6$	$s = 8$
w_1	0	0	0
w_2	0	0	0
w_3	0	0	0
w_4	0	1/E1	E1/1
w_5	1/F2	0	1/F2
$E[NPV_p]$	36	49	52.6

σ_p	4.9	5.7	7.7
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To test the hypothesis (2) of the study, efficient center diagram of conventional Markowitz model is used.



The important thing about drawing drawn efficient center is that based on the traditional Markowitz model, when the efficient center obtained from the use of optimization model is drawn, we obtained connected points, and this is also due to the character of divisibility of capital assets that drawing of efficient center is continuous.

The first hypothesis test results

The first hypothesis of this study suggests that according to modified Markowitz model, an increase in the standard deviation of projects (acceptable risk), the net present value expected (the expected value of projects) increases. So we have:

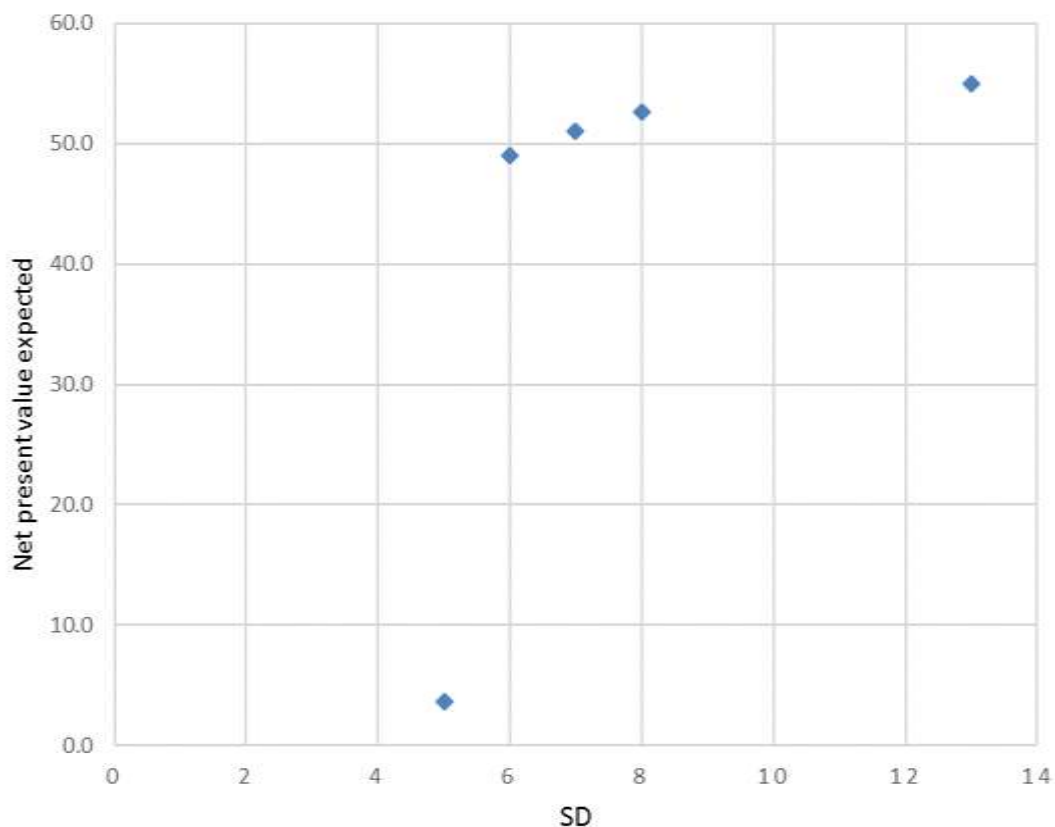
52.6	49	36	$E[NPV_p]$
7.7	5.7	4.9	σ_p

At the risk level of IRR 5 trillion and use of fifth project, expected present value is IRR 36 trillion and maximum investment risk, the Cooperative Foundation of IRIAF, IRR 4.9 billion. It was also observed that at the risk level of IRR 6 trillion, only the fourth project is performed, and expected

value at the maximum acceptable risk level is IRR 49 billion. So as you can see, the first hypothesis, which states that the increase in the standard deviation, namely, project performance risk criterion, the net present value increases, is confirmed.

Results of hypothesis two:

Unlike conventional efficient frontier in Markowitz model on financial assets, it was impossible to connect dots at modified efficient center due to binary variables. In the diagram below, the efficient center resulting from the implementation of the modified Markowitz model is provided.



With use of modified model of Markowitz, and drawing efficient center of project optimization, the result is achieved is that in the drawn efficient center, unlike conventional efficient frontier, there was no possibility of connecting the dots to each other and practically a continuous curve is not achieved. This is because of existence of binary variables in the optimization model and the absence of possibility of assuming of all values by the standard deviation and as a result, the mean net present value of the project portfolio. Therefore the second hypothesis is confirmed, which states that unlike the conventional efficient center in Markowitz model for financial assets, at adjusted efficient center, it is impossible to connect the dots due to binary variables and to use all values by the mean net present value of the portfolio of projects and standard deviation.

Conclusion

One of the important issues on project management is selection of optimal project portfolio. The issue of selection of projects and activities associated with it are one of the most important activities in many organizations, especially contracting and project-oriented construction companies. Project portfolio selection is one of the main processes of project portfolio management, and a periodic activity to select an appropriate portfolio of projects proposed or running project of organization that meets the organization's goals in an optimal manner and without spending additional resources or failure to satisfy other constraints. In the project portfolio selection, the most fundamental issue that arises is which projects should be contained in the portfolio. The better the selection of project portfolio, the more likely the realization of the organization's mission. In choosing this combination, recognizing opportunities, assessing the alignment of projects with the objectives and structure of the organization and cost analysis, risk-profit of the project are very important. In this study, based on theoretical basis and proposed model, we optimized the portfolio consists of five projects for which is available an estimate of cash flows. The results show that with increasing the standard deviation (risk), the net present value of expected projects is also increasing and also shows that unlike conventional model of Markowitz on financial assets, in which there is no such thing as a binary rule, for the project, the shared division and selection of projects is not possible. The study also showed that given the limitations of the model, i.e., determining the amount and type of risk and capital constraints in the hands of the investor, one can select an optimal portfolio of projects.

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