Informational Support for Investment Analysis

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Abstract: - Investment analysis assesses in a quantified manner the efficiency of allocating resources to several alternatives, which can give a higher return in comparison with the lack of investment. The general investment problem is the allocation of resources between several investment alternatives. This research presents a particular investment problem for the allocation of financial resources to securities and the estimation of the most appropriate investment portfolio. The quantification of this problem is based on the application of the portfolio theory. The solution to the investment problem is supported by the support computer-based algorithm. Without such informational and computer support the investment problem cannot be properly been defined. The paper presents an application of the portfolio theory, but the added value is the demonstration of the practical solution to the portfolio problem with a well-known software environment. Practically the problem, which is solved is based on investment decisions with up-to-date investment instruments for the case of financial funds. The portfolio problem is solved in an Excel environment and the programming steps are presented in detail. This study illustrates the application of informational and computer support for solving a complex problem such as resource allocation by portfolio optimization.

Key-Words: - informational support, investment analysis, portfolio theory, portfolio optimization, risk quantification, programming support, efficient frontier.

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1 Introduction

An important role of information and communication technologies is addressing solutions to problems, which give numerical values to their results. Therefore, quantifying the problem results supports the decision-making for business management, technological control, planning, and wide cases from industrial and human life. Particularly the investment problems insist on precise assessment of each alternative, which can provide in the future additional benefit for the investor. In [1] the information support for investment is assessed as a tool for coordination of planning, control, and production. The information support is a key tool for reinvestment and recovery in Economics, [2]. The investment analysis is a prerequisite for the adaptation of new technologies for modification and/or maintaining the current ones, [3]. The goal of such an investment is to maintain cost-effective production and having maximization of the production return. An overview of the methods for investment and their assessment is given in [4]. Formal methods, which are considered portfolio management, are portfolio theory, debt securities, and market derivatives. The portfolio theory, developed by Markowitz, considers two important investment criteria, return and risk, [5]. The portfolio problems have been sequentially complicated in [6], [7]. An overview of the portfolio investment problems can be found in [8]. The formal tools, which insist on informational support are additionally extended in [9]. Modeling of the investment processes is made with the support of regression analysis, time series, machine learning, and big data projects. Such modeling is applied for risk management, and estimation of economic factors, which influence the investment process. The role of information technology, which influences investors in making decisions is assessed in [10]. It has been estimated the benefits, which originate from the usage of information technological solutions. The term “Fintech” has been derived to point to the application of information technology in the financial domain, [11]. Part of the benefits is that steps of the investments, which are based on technological analysis can be automated and performed without human intervention. Information technologies influence not only the investment domain but they have a wider impact on society. An analysis of the role of this technology in socioeconomic development was made in [12].

Information technologies are a main tool for assessing and analyzing environmental pollution. Practically it provides algorithms for assessing the pollution of CO2 and to forecast its extension and/or reduction in density-populated areas, [13].

This research targets the development of a case study for the usage of informational support in financial investments. The example, which is derived is based on the usage of the formal modeling from portfolio theory. An investment problem with up-to-date data is defined. Next, it is solved, based on the Excel software environment, which is widely populated in socioeconomic applications.

The paper contains four sections. The introduction makes a short analysis of the role of information technological solutions for investment analysis and assessments. Section 2 presents shortly the formal background of the portfolio theory, which is applied to the definition of the investment problem. Section 3 presents the practical case of the definition and solution of the investment problem. The final section contains the discussions and conclusions for the applications of the derived case with informational support.

2 Materials and Methods

This section makes the presentation of the main classical background of the portfolio theory. The portfolio theory is based on two important assumptions: the investors like the return from the portfolio and they are scared of the risk of the investment [14]. The investment portfolio contains a set of financial assets, each with its measure of return and risk. The conceptual problem of the investment is that the decision-makers have information about the asset's productivity for historical periods up to the moment of the investment. However, the benefit from the portfolio could be obtained in the future, when the investor decides to capitalize on his investment. Therefore, the investor has to forecast for future moment productivity of the portfolio assets as returns and risks and make the investment decisions now. This difference in time is the main methodological drawback to the successful application of the Portfolio theory. The portfolio problem estimates which part of the investment resource must be allocated per individual assets, which will take part in the investment portfolio.

Formally the portfolio return is the sum of the relative returns, which the individual assets will give to the portfolio. The portfolio analysis is based on historical records R_N^((n))of the individual returns, which the different assets had

$$R_1 = [R_1^{(1)}, R_1^{(2)}, \dots, R_1^{(N)}] \qquad (1)$$
$$R_n = [R_n^{(1)}, R_n^{(2)}, \dots, R_n^{(N)}],$$

where n is the number of assets, that can participate in the investment portfolio,
N is the number of historical data about the return R of the appropriate asset. The dynamics of changes in the return of an asset are illustrated in Figure 1.

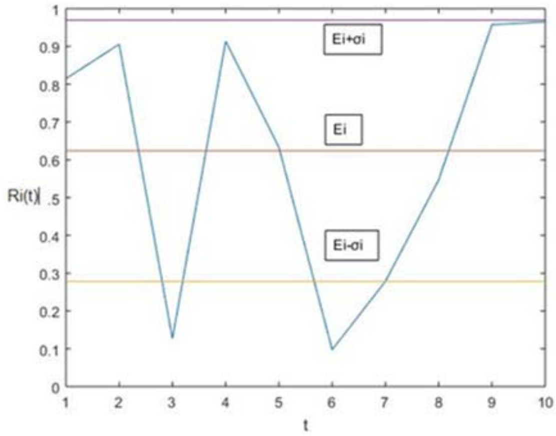

Fig. 1: Illustration of the dynamic of the asset return RI in time

It is evident that the values of the asset return Ri stochastically change. To forecast these values in the future for the end of the investment period is not practically reasonable. That's why the real values of the asset returns are assessed by their mean values Ei i=1,…,n. Analytically are evaluated for the historical period with n data. These mean values Ei i=1,…,n are expected by the investors to be preserved for the end of the investment.

$$E_i = \frac{1}{n} \sum_{k=1}^{n} R_i^{(k)}, \qquad (2)$$

The quantification of the risk is performed in the portfolio theory by the standard deviation of the stochastic process Ri . From the statistics, it is known that the probability that o random process belongs to a confidence interval are the following, [15]:

$$P_r\{(E_n - \sigma_n) \le R(t) \le (E_n + \sigma_n)\} \approx 68.27\% \qquad (3)$$

$$P_r\{(E_n - 2\sigma_n) \le R(t) \le (E_n + 2\sigma_n)\} \approx 95.45\%$$
$$P_r\{(E_n - 3\sigma_n) \le R(t) \le (\mu_P + 3\sigma_P)\} \approx 99.73\% ,$$

where P_r {.} is the probability of a random R.

When the confidence interval increases 2-3 times the standard deviation of the asset returns σ_n the probability of the real process R(t) belonging to the confidence interval also increases. From practical consideration, the confidence interval is used to be {(E_n- σ_n)≤R(t)≤(E_n+ σ_n)} , which is below and above of the mean value E_i with one standard deviation σ_n. Therefore if the standard deviation is low, the confidence interval is tight and the real process R will be very close to the mean predicted value E_n. Therefore, the risk of the asset is low. On the opposite case, if σ_nhas high value, the asset risk is also high, because the real process R can take values in a very wide diapason. These explanations make clear that the risk of an asset is evaluated as the standard deviation of the asset return, Analytically, the risk is evaluated as

$$\sigma_i^2 = \frac{1}{N}\sum_{k=1}^{N}\left(E_i - R_i^{(k)}\right)^2, i = 1, \ldots n. \quad (4)$$

The portfolio theory assesses the portfolio return E_p as the weighted sum of the asset returns, belonging to the portfolio

$$E_p = \sum_{i=1}^{N} w_i E_i, \quad (5)$$

where w_i is the weight or part of the investment, allocated for asset i.

For the case of the portfolio risk, the portfolio theory considers explicitly the correlations, which insist between the asset returns. That is why the portfolio risk is a complicated calculation and presents a quadratic evaluation with the coordination matrix

$$\mathbf{\Sigma}_{n\times n} = \begin{vmatrix} cov_{11} = \sigma_1^2 & cov_{12} \ldots & cov_{1n} \\ \ldots & & \ldots \\ covc_{n1} & cov_{n2} \ldots & cov_{nn} = \sigma_n^2 \end{vmatrix}, \quad (6)$$

where

$\mathbf{\Sigma} = c_{ij} = \frac{1}{N-1}\sum_{k=1}^{N}\left(R_i^{(k)} - E_i\right)\left(R_j^{(k)} - E_j\right), \forall i, j = 1, \ldots, n.$

Therefore, the portfolio risk is calculated as the quadratic relation

$$\sigma_p^2 = \sum_{i=1}^{n}\sum_{j=1}^{N} c_{ij} w_i w_j \text{ or } \sigma_p^2 = \mathbf{w^T\Sigma w}. \quad (7)$$

The portfolio theory claims that the portfolio return must be maximized while the portfolio risk must be minimized. Thus, the portfolio theory applies two criteria for optimization, which makes the portfolio problem a multicriteria one. For simplification of the problem, the portfolio theory introduces a parameter λ, which influences the relations between the portfolio risk and portfolio return. Following [16], the portfolio problem is defined in the form:

$$\min_{\mathbf{w}}[\lambda \mathbf{w}^T\mathbf{\Sigma w} - (1-\lambda)\mathbf{E}^T\mathbf{w}], \quad (8)$$

$$\mathbf{w}^T|\mathbf{1}| = 1, \quad w^T \geq 0,$$

where $\mathbf{E^T} = (E_1, \ldots, E_n), \mathbf{w^T} = (w_1, \ldots, w_n)$

$$\mathbf{w}^T|\mathbf{1}| = w_1 + \cdots + w_n = 1, \quad 0 \leq \lambda \leq 1.$$

If λ=0, problem (7) makes maximization of the portfolio return without considering the risk of the assets. When λ=1, the portfolio problem minimizes the risk without considering the portfolio return. For the intermediate values of λ the portfolio problem applies different relations between the portfolio risk and portfolio return. For investors who are willing to undertake risk targeting high values of return, the parameter λ must have a low value, close to 0. For the opposite case, if the investor is scared of risk, λ must be high, close to 1.

For different values of λ, the portfolio problem (8) gives different solutions **w(λ).** Respectively, the portfolio return $E_p(\lambda)$ and risk $\sigma_p^2(\lambda)$ is taking different values. The plot of these values gives the "Efficient frontier" for this portfolio. The portfolio theory recommends the investment be performed for portfolios, belonging to the efficient frontier.

Problem (8) is applied in this research for the assessment of portfolio investments in financial funds, which the Bulgarian banks offer to investors and individuals. The solution to the problem is performed with the Excel environment, which illustrates the application of information technology support for making investment decisions in the case of portfolio optimization.

3 Investment Estimations based on Portfolio Theory

The informational approach is applied to the definition and solution of the investment portfolio problem. The investment is devoted to the allocation of financial resources to investment funds. The Bulgarian bank supports not only riskless instruments as deposits but also financial activities in funds, which are risky instruments.

The particular case for this research concerns the evaluation of investment between risky funds, which are operated by the Bulgarian United Bank (UBB). Three funds have been chosen for this empirical research, which illustrates the usage of information technology for the definition and solution of the portfolio problem. The funds, which were chosen from UBB are:

- Expertise in dynamic Tolerant, (Fund1)
- UBB expertise ERAY DEF Conservative (Fund2)
- UBB Expertise ERAY DEF Tolerant (Fund3)

The price of a share, which each fund can buy is published for every working day. The data were recorded for a week time from 12 July to 19 July 2024. The available data are given in Table 1.

Table 1. Historical Returns of the Investment Funds

Date	Fund 1, R_1	Fund 2, R_2	Fund 3, R_3
12.7	11.099	10.91	11.4011
15.7	11.1115	10.905	11.4063
16.7	11.1044	10.9159	11.4131
17.7	11.1591	10.9448	11.4556
18.7	11.0299	10.8917	11.3361
19.7	10.9802	10.8839	11.3064
Mean E_i	**11.0806**	**10.9085**	**11.3864**
Risk σ_i	**0.0613**	**0.0203**	**0.0523**

The mean return E_i for the assets ais calculated according to (2) and the risk σ_i from (4). These data make the input for the Excel sheet, Figure 2. The data for the Fund 1 is recorded in cells B2:B7. For Fund2 from D2:D7 and Fund 3 from F2:F7.

The mean values of the funds are evaluated with the function AVERAGE. Thus cell B8 contains =AVERAGE(B2:B7). The corresponding values for Funds 2 and 3 are in cell D8 containing =AVERAGE*D2:D7) and cell F8 with record =AVERAGE(F2:F8).

The risk per fund is evaluated in sell B9 with =STDEV(B2:B7), in cell D9 with record =STDEV(D2:D7) and in cell F9 with record =STDEV(F2:D7)

The covariance matrix $\mathbf{\Sigma}$ is calculated in cells B10till D12. The cell B10 contains the volatility of the Fund 1, evaluated by ==COVAR(B2:B7, B2:B7). The covariation between Fund 1 and Fund 2 is calculated in cell C10 with =COVAR(B2:B7, D2:D7). And the covariance between Fund 1 and Fund 3 is in cell D10 with =COVAR(B2:B7, F2:F7).

The field, where the solutions of the portfolio problem (7) will be recorded are B15:D15, which corresponds to the weights w(1), w(2), and w(3).

The goal function of (7) I is evaluated in cell B19. It contains two components: risk by $\mathbf{w}^{\mathrm{T}}\mathbf{\Sigma}\mathbf{w}$ and return by $\mathbf{E}^{\mathrm{T}}\mathbf{w}$.

The return component is evaluated according to (2) in cell B17 with the records =(B8*B15+D8*C15+F8*D15).

The risk must be evaluated as a quadratic relation (6). At first, the evaluation $\mathbf{\Sigma}\mathbf{w}$ is performed in cells F16:H16. In cell F16 is recorded =SUMPRODUCT(B10:D10,B15:D15).

	A	B	C	D	E	F	G	H
1	Date	Fund 1	%	Fund 2	%	Fund 3	%	
2	12.7	11.099		10.91		11.4011		
3	15.7	11.1115	0.112623	10.905	-0.04583	11.4063	0.04561	
4	16.7	11.1044	-0.0639	10.9159	0.099954	11.4131	0.059616	
5	17.7	11.1591	0.492598	10.9448	0.264751	11.4556	0.372379	
6	18.7	11.0299	-1.1578	10.8917	-0.48516	11.3361	-1.04316	
7	19.7	10.9802	-0.45059	10.8839	-0.07161	11.3064	-0.26199	
8	**mean**	**11.08068**	**-0.21341**	**10.90855**	**-0.04758**	**11.38643**	**-0.16551**	
9	risk	0.061308	1.802953	0.020335	0.322695	0.052299	1.30112	
10	COVAR	**w**	0.001044	0.002923				
11		0.001044	**0.000379**	0.000912				
12		0.002923	0.000912	**0.002507**				
13								
14	w	w1	w2	w3				
15		0	0.867623	0.132377	SUM	1		
16	**RISK**	0.053888			Sumprodu	0.001293	0.00045	0.001124
17	**Return**	10.97181	landa	0.78				
18								
19	GOAL	-2.37177						
20								
21								
22	**Landa**	**Risk**	**Return**	**X1**	**X2**	**X3**		
23	0	0.250729	11.38643	0	0	1		
24	0.2	0.250729	11.38643	0	0	1		
25	0.4	0.250729	11.38643	0	0	1		
26	0.5	0.250729	11.38643	0	0	1		
27	0.6	0.250729	11.38643	0	0	1		
28	0.61	0.230979	11.35621	0	0.063251	0.936749		
29	0.62	0.213168	11.32776	0	0.122777	0.877223		
30	0.65	0.167062	11.24767	0	0.290367	0.709633		
31	0.7	0.109898	11.12945	0	0.537763	0.462237		
32	0.74	0.077501	11.04637	0	0.711607	0.288393		
33	0.76	0.064739	11.00811	0	0.791668	0.208332		
34	0.78	0.053888	10.97181	0	0.867623	0.132377		
35	0.8	0.044715	10.93733	0	0.93978	0.06022		
36	0.9	0.037906	10.90855	0	1	0		
37	1	0.037906	10.90855	0	1	0		
38								

Fig. 2: Excel sheet programming the portfolio problem

Respectively in cell G16 is written =SUMPRODUCT(B11:D11,B15:D15) and in G16 is =SUMPRODUCT(B12:D12,B15:D15). The final evaluation of the portfolio risk is the multiplication of **w** with the intermedial result from F16:G16. The portfolio risk is evaluated in cell B16 with the record =100*SUMPRODUCT(F16:H16, B15:D15). The value 100 is used for the transformation of the risk in percent [%].

The goal function of the portfolio problem is in cell B19 with the evaluations $\lambda Risk-(1-\lambda)Return$. The risk is evaluated in cell B16 and the return in B17. The value of λ is given from cell D17. In cell F15, the constraint of the problem

$w_1+\cdots+\ w_n=1.$

It is recorded in cell F15 the function =SUM(B15:D15).

Up to now, it has been programmed the sheet for the evaluations of the parameters of the portfolio problem. The solution to problem (7) is performed with the function SOLVER, which must be requested for installation by the “Add-ins” function of Excel. Function SOLVER is situated in the section “Data” of the Excel sheet.

The solution starts by putting the pointer of the mouse over the cell of the goal function B19. From the section "Data" we activate the SOLVER function. An additional window appears, given in Figure 3.

It sets the values of the goal function in cell B19, the cells for the solutions B15:D15. The constraint for the solution is in cell F15. The nonnegative solutions are required. The solution of the portfolio problem is performed with the defined value of λ. For the case of Figure 2 and Figure 3, the value for λ=0.78 gives solutions: Portfolio risk=0.053888487;
Portfolio return=10.97181042, w(1)=0, w(2)=0.867622853, w(3)=0.132377111.

These results say not to invest in Fund 1, in Fund 2 to allocate 86.7% of the investment resource and in Fund 3 the rest of 13.23% of the resource.

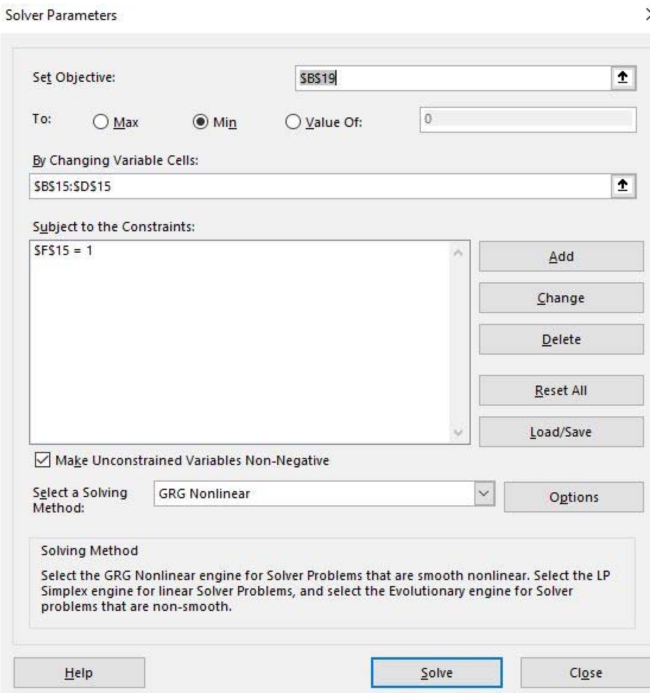

Fig. 3: The SOLVER window

4 Analysis of the "Efficient Frontier"

The solutions to the portfolio problem (8) depend on the choice of the value of the coefficient λ. This value quantifies the ability of the investor to undertake risk. This value depends on the subjective assumption of a particular investor. Because the portfolio problem can be solved by different investors, practically it is recommended the portfolio problem be solved for a set of different values of the coefficient λ. The solutions to the portfolio problem can be graphically interpreted as points in the space or return and risk. This graphic is the so-called "efficient frontier". It is recommended the investor choose one point from this curve, which will be its preferred solution to the portfolio problem.

In our case, the field A23:F37 is used to record the solutions of the portfolio problem for different values of the parameter λ. One can see that if λ=0, which gives maximal optimization towards the return, the portfolio problem recommends investment only in Fund 3. For the case of λ=1, the portfolio problem makes minimization towards risk and the recommendation is to invest only in Fund 2. Fund 1 is not recommended for all values of λ. These results graphically give the "Efficient frontier" of the portfolio problem. The set of solutions of the portfolio problem (8) graphically is resented as "Efficient frontier" in Figure 4. The portfolio theory recommends that investors choose one point from this graphic, which allocates the investment per different assets.

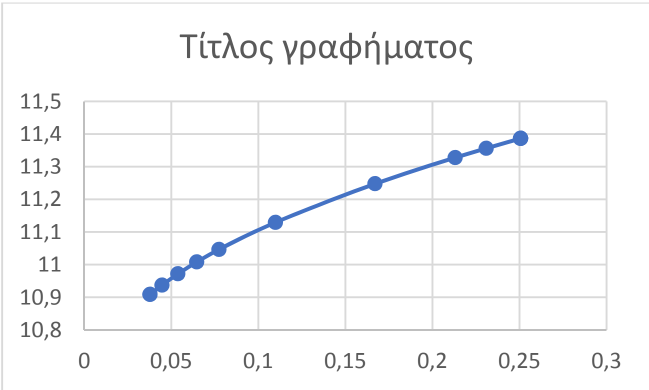

Fig. 4: "Efficient frontier" of the portfolio problem

One recommendation for the choice of a unique point from the "Efficient frontier" is this one, which gives the maximal value to the relation $Sharpe\ Ratio = \max[\frac{Portfolio\ return}{Portfolio\ risk}]$.

This relation is titled Sharpe ratio [11]. For the case of the portfolio with data from Table 1, the solution with maximal Sharpe ratio is: Risk =0.037906, Return=10.90855, the solution **w**=[0 1 0], and Sharpe ration=287.78. The peculiarity of this solution is that the application of the Sharpe ratio recommends investment only in fund 2, which gives minimal risk of the investment, but the return is the lowest. For the case of keeping diversification, the investment policy does not recommend allocation of resources only to one asset. For our particular case a choice, which invests in two types of assets is preferable.

5 Conclusion

This research illustrates the benefit of the usage of informational technological tools for the support of decisions in difficult domains such as investments. The informational technological solutions allow us to proceed with a large amount of data, to identify non-evident relations as correlations, and to define and solve optimization problems. Keeping in mind that optimization is a complex data processing without informational technology tools will be very time and manpower-consuming to define and solve portfolio problems. Future development of the portfolio assessment could be the usage not directly the value of the prices of the Funds, but their relative changes like (new_value-old_value)/old_value. Thus, the initial portfolio data could be calculated in cells C3:C7, respectively E3:E7 and G3:G7. These modifications to the portfolio problem can be easily performed with information technology tools.

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- Dimitar Karastoyanov carried out the simulation and the experiments.
- Ludmil Iliev was responsible for the data collection and Statistics.

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