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Efficient Management of Portfolio Resources

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Abstract: An extended definition of the logistic domain is related to different resources: materials, information, finances, energy, human resources. The management in logistics implies optimal resource allocation which requires the definition and solution of an appropriate optimization problem. Thus, optimal resource allocation is found for transport operations, the establishment of warehouses, financial planning and investment, managing human resources, and the definition of optimal scheduling in working operations. This research addresses a particular topic for optimal financial resource allocation by portfolio optimization. The modern portfolio theory is a tool for formalization and quantification the decision making in investing and financial management of assets. The paper addresses particular issues regarding the definition of portfolio problem. A management policy is developed which makes optimal allocation of financial resources for cash allocation in certificates of deposit with different duration; support of the safe amount of financial resources at the end of each month, taking into consideration the needed payments per month. This optimization problem is solved by using the EXCEL software suit. A particular tool as the Solver function is applied. The paper presents a solution that is practically used for the management of small and medium enterprises. The added value of this research concerns the quantification and optimization of financial resources for logistic management.

Keywords: Decision Support Systems, Portfolio Optimization, Investment Management

1. Introduction

The investment process can be planned and evaluated generally in two environments: deterministic and stochastic. The deterministic case of investments assumes that the majority of components and parameters for the investment conditions are well known. Stochastic and/or random changes in the assets and market environment are predictable and well estimated numerically. The stochastic case of investing cannot rely on fully determined market conditions and asset returns. Thus, for the stochastic case of investments, the decision-maker has to take into consideration the probability that the asset returns can be different according to their currently estimated values. Thus, a new parameter for risk is defined and considered for the investment process. This complicated case of investment is considered by the portfolio theory (Sharpe 1999; Kolm et al 2014). The general goal, in this case, is to maximize the portfolio return and minimize the portfolio risk. The portfolio is regarded as a combination of assets, which participate in the portfolio with different weights. The weights define the relative part of the investment, which has to be allocated for buying the corresponding asset. But the portfolio also deals with risk-free assets. They play an important role in the definition of the market characteristics for return and risk. Explicitly the portfolio theory recommends that if investor targets portfolios return bigger than the market one, he has to undertake a considerable increase in the investment risk (Khan et al 2020; Liu et al 2020). A particular case for the asset characteristics is the duration of their horizon for guaranties for the level of return. Thus, the portfolio can be constituted with a set of activities with different duration of their maturity. Such kinds of portfolios are complicated for evaluations and estimations.

This research develops a particular case for portfolio definition with three types of assets, which have different maturity time. A practical problem is defined as the usage of available free cash of a company to invest in three types of assets. The particular case in this research is the explicit assumption that the assets are risky free. Thus, the portfolio definition targets the maximization of the portfolio return. The risky free assets are chosen as three types of deposits with different maturity. An optimization problem is defined. The added value of this research comprises the demonstration of a solution to the portfolio problem with a generally available software suit. In our case, the defined problem is solved with the support of an Excel environment. The special function Solver is mainly applied for the solution of the problem. The manner of programming this problem is worth it for people, who target investment activities in their general jobs.

2. Portfolio Problem in Deterministic Environments

For this research three types of risky free assets are considered: deposits with maturities of one, three, and six months. The combination of these assets is the content of the portfolio. The investment problem considers how to define the weights of the assets in the portfolio by means to achieve a maximal return for a chosen investment horizon.

The complication of this investment policy comes from the different maturity periods of the assets. Thus, by finishing the shorter maturity period of an asset, its resources can be invested in a new asset with appropriate maturity during the whole investment period. In that manner, an active policy for portfolio management has to be defined. The total goal of such active portfolio management is the maximization of the interests yielded by the risky free assets (Dobrowolski et al 2022).

The investment policy of the company has to be in conjunction with the cash flows, which satisfy the current requirements of the company's operation (Pyka et al 2021; Guo et al 2021). The portfolio policy of cash investments can be defined as:

- Three types of risky free assets are available for investment. They have different maturity horizons.
- The investment horizon for the portfolio is longer than the most maturity duration.
- The company can start active portfolio management with available cash resources.
- At the end of each month, the company has to cover predefined values of active loans and/or receive incomes from their current operations.
- At the end of each month, a safe amount of cash has to be kept, not to be invested for business security reasons.

The unknowns and solution to the portfolio problem are the numbers of the assets, which has to be bought at the beginning of each month. Their number is defined according to the available cash resources for that moment. These resources comprise the available cash from the end of the previous month; the number of assets, which maturity duration ends at the beginning of the current month; the interest, obtained by that finishing maturity period for the corresponding asset. The goal of the portfolio problem is to maximize the income from interests for the predefined investment period.

3. Analytical Description of the Portfolio

The active management of the portfolio requires a dynamic form of the problem to be defined. Below we present our analytical description in discrete dynamical relations. The given data for the problem are:

-The investment period is chosen for 1 year (12 months).

-Maturity periods for three risk-free assets: deposits for 1, 3, and 6 months. The notations used are u_1 (k),u_2 (k),u_3 (k) means the number of deposits, which are open at the beginning of month k.

-The interest rates are denoted respectively with the parameters r1, r2, r3. These values are constant for the investment period.

-The initial investment resource for the beginning of the active portfolio management is M(0).

-The cash used at the end of each month is denoted with $R(k)$. These values are positive for the case of due payments of the company and negative for incoming cash flows.

-The reserve secure cash, required for the end of each month is a constant value of M. The cash amount is quantified in our national currency "lev".

-The goal function of the portfolio problem maximizes the sum of interests, yielded by all deposits for the duration of the investment period. Analytically, it has the form:

$$\max_{u_1(k), u_2(k),\ u_3(k)} \quad \sum_{k=1}^{12}[r_1 u_1(k) + r_2\, u_2(k) + r_3 u_3(k)]$$

where the notation $u_i(k), i = 1,3;\ k = 1,12$ means the number of deposits opened for the overall investment period of 12 months. It is assumed that the deposits are made with an integer number of financial resource. For the three types of deposits, these values are denoted by m_1, m_2, m_3 and the portfolio solutions $u_i(k), i = 1,3;\ k = 1,12$ are also integer variables.

The constraint of the problem has to consider several requirements:

-The solutions $u_i(k), i = 1,3;\ k = 1,12$ must take non-negative values, $u_i(k) \geq 0$.

-At the beginning of each month, the available investment resource depends on the cash from the previous month.

-Making the investment per deposit, the company has to keep secure cash of amount Mc.

The set of constraints is explained in graphical way in Fig.1, illustrating the sequence of eligible actions in active portfolio management. The notation E(k), k=1,12 means the available resources, which can be invested in deposits at the beginning of each month. The amount of E(k) is a result of several components as algebraic addition from the components:

-The free resulting cash at the end of the previous month M(k-1);

-The number of deposits, which maturity horizons was ended with the previous month;

-The interest rates, obtained by the ended deposits for the previous month or

$$E(k) = M(k-1) + m_1u_1(k-1) + m_2\, u_2(k-3) +$$

$$+ m_3u_3(k-6) + r_1u_1(k) + r_2\, u_2(k-3) + r_3u_3(k-6)\ \text{, k=1,12.}$$

This relation contains time delays in its arguments $u_2(k),\ u_3(k)$. The reason is that the deposit with 3 months of maturity will provide its resource if it has been activated 3 months before the current time *k*. In the same way, the deposit with six months maturity, activated in time *k*-6 will give free resources after 6 months, respectively for the moment *k*.

The last component *M*(*k*) for the available free resources at the end of a month is evaluated after an investment in month *k* with the amount $m_1u_1(k) + m_2\, u_2(k)\ +\ m_3u_3(k) + R(k)$. Additionally, an algebraic summation with the predefined values R(*k*), *k*=1,12 is made about the set of active loans and/or received incomes from the company's current operation. *R*(*k*) has a negative value for the case of covering active loans and positive when the company has incoming cash flow. Hence the analytical relation about the free resources at the end of month *k* is

$$M(k) = E(k) -\ m_1u_1(k) + m_2\, u_2(k)\ +\ m_3u_3(k) + R(k).$$

Fig.1 presents graphically that the available resources can be used for investment in the three types of deposits till the end of *k*=6. Later, it is not applicable the usage of u_3 because its maturity time will overpass the investment horizon of *k*=12. The same reason we have about the usage of u_2 because after *k*=9 its maturity is longer than the investment horizon. The deposit type u_1 can be implemented even for the beginning of *k*=12, because its income will coincide with the end of the investment horizon. These relations graphically are presented with arrows, directed below. The upstream arrows denote the possible end of maturity for the different deposits. It is given that results from $u_2(k)$ deposits start from *k*=4 till the end of the investment horizon. Respectively, the long-time deposits $u_3(k)$ start their income from *k*=7 till the end of *k*=12.

Hence, the analytical description of the portfolio problem for active management is in the form

$$\max_{u_1(k), u_2(k),\ u_3(k)} \ \sum_{k=1}^{12}[r_1u_1(k) + r_2\, u_2(k) + r_3u_3(k)] \tag{1}$$

subject to $E(k) = M(k-1) + m_1u_1(k-1) + m_2\, u_2(k-3) + m_3u_3(k-6) + r_1u_1(k) + r_2\, u_2(k-3) + r_3u_3(k-6)$

$$M(k) = E(k) -\ m_1u_1(k) + m_2\, u_2(k)\ +\ m_3u_3(k) + R(k).$$

$$[r_1u_1(k) + r_2\, u_2(k) + r_3u_3(k) \leq E(k)\ ,\ (k) \geq \mathrm{M_c}\ ,\ u_i(k), i = 1,3;\ k = 1,12\ \text{, integer}$$

$$u_1(k) = 0, for\ k < 1\ ,\ u_2(k) = 0, for\ k \geq 10\ ,\ u_3(k) = 0, for\ k \geq 7\ .$$

Problem (1) is a dynamical discrete-time optimization integer problem. Its solution requires computational power and an appropriate software environment. This research illustrates the application of the software suite EXCEL for solving this discrete-time integer dynamical problem. Particularly, the optimization function SOLVER is applied, which performs the evaluations.

4. Numerical Definition of the Portfolio Problem

For the numerical simulations, the parameters of the portfolio problem have been chosen as follows:

- The 1-month deposits have yielded 0.1% per month. The required volume for a deposit is 1000 lv.
- The 3 months deposits have yielded 0.3% per month. The required volume for a deposit is 2000 lv.
- The 6 months deposits have yielded 1% per month. The required volume for a deposit is 3000 lv.
- The initial cash for investment is M(0)=19000 lv.
- The requested safe amount for the end of the month Mc = 1000 lv.
- The set of cash, which has to be paid or received at the end of each month is given by the vector **R**=[5000; -1500; -1800; 4000; 3000; -1800; 2000; -1500; 1300; 2300; 1900; -2400; 2100].

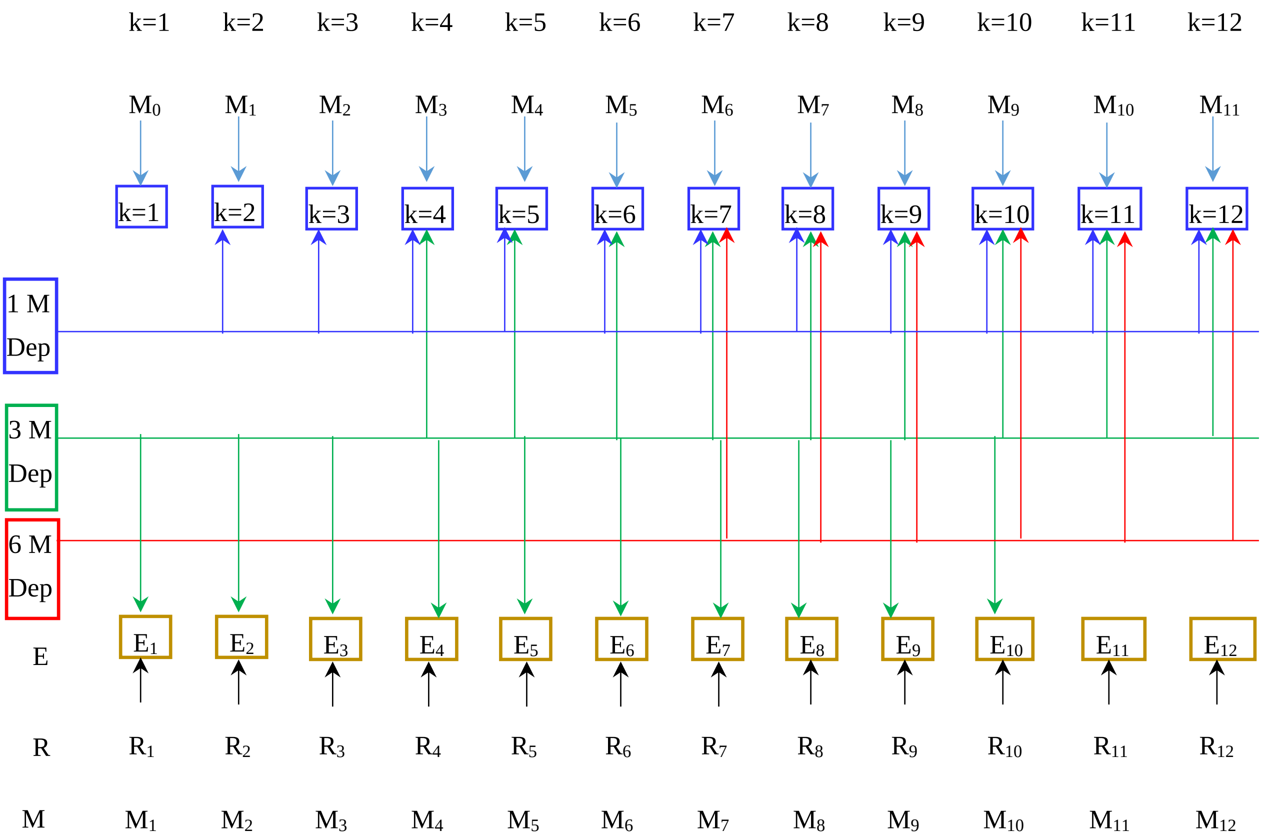

Figure 1. Eligible actions in active portfolio management

A graphical presentation of the main Excel screen is given in Fig.2.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Active Portfolio Management.**													
2	Maximize dynamical portfolo management with risky free assets													
3														
5		*Interest*	*Maturity*	*Price*	*Purchase Dep.in months:*									*Total*
6	1 month Dep.	0.1%	1	lv.1 000	All months from k=1,12									*Interest*
7	3 months Dep.	0.3%	3	lv.2 000	Months k=1,9									*Earned:*
8	6 months Dep.	1.0%	6	lv.3 000	Monts k=1,7									$0.00
9														
10	Time: *k*	*Month 1*	*Month 2*	*Month 3*	*Month 4*	*Month 5*	*Month 6*	*Month 7*	*Month 8*	*Month 9*	*Month 10*	*Month 11*	*Month12*	*End*
11	Resources M(*k-1*)	lv.19 000	lv.14 000	lv.15 500	lv.17 300	lv.13 300	lv.10 300	lv.12 100	lv.10 100	lv.11 600	lv.10 300	lv.8 000	lv.6 100	lv.8 500
12	End of Maturity		lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0
13	Interest:		lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0	lv.0
14	1 month Dep.	0	0	0	0	0	0	0	0	0	0	0	0	
15	3months Dep.	0	0	0	0	0	0	0	0	0				
16	6 months Dep.	0	0	0	0	0	0	0						
17	R(*k*)	lv.5 000	(lv.1 500)	(lv.1 800)	lv.4 000	lv.3 000	(lv.1 800)	lv.2 000	(lv.1 500)	lv.1 300	lv.2 300	lv.1 900	(lv.2 400)	lv.2 100
18	M(*k*)	lv.14 000	lv.15 500	lv.17 300	lv.13 300	lv.10 300	lv.12 100	lv.10 100	lv.11 600	lv.10 300	lv.8 000	lv.6 100	lv.8 500	lv.6 400
19														

Figure 2. Graphical presentation of the main Excel screen

The main parameters of the risk-free assets are constant parameters and they are given on the set A5 till F8: the income in percentage, the maturity periods, and the required level of cash amount. The time *k* defines the sequence of months for the overall investment period of one year (12 months). The initial investment resource is given in cell B11 with a value of 19000 lv.

The solutions to the optimization problem are in rows 14 to 16. Each cell in the set B14-M14 defines the number of monthly deposits, which is made at the beginning of the appropriate month *k*. Because the maturity time for this asset is one month, this gives the opportunity for the investment to be performed till the beginning of month *k*=12. It is illustrated that the investment can be performed on *k*=1, 12 with arrows, directed down, Fig.1. At the end of the same month, the yield of this investment is received, graphically presented with arrows, directed up for *k*=1, 12.

In a graphical way are given also the periods, when the deposits with three months maturity can be done. This is the period from *k*=1, 10. The corresponding arrows are directed down. The yields from these types of deposits can be received from k=4, 12. These arrows are directed up.

The peculiarities in the durations of the six months deposits require the investment to be done in months *k*=1, 7. Graphically this is presented with arrows, directed down for *k*=1, 7. Respectively, the corresponding income is available from months *k*=7, 12, and arrows are directed up (Fig.1).

The set B17 till N17 contains the values of the vector *R*(*k*), which gives the values of payments or incomes, that the company will have at the end of the month. The values “XX” are costs, which have to be paid, and the values “(XX)” mean that the company will receive such payments.

The cash M(1) is the amount, which the company will have at the end of month *k*=1. For the initial case, M(1) is calculated as

SUM(B11:B13)-SUMPRODUCT(B14:B16;$D$6:$D$8)-B17.

The first component SUM(B11:B13) defines the total investment resource, available for the first month. It comprises the initial investment amount M(0)=19000 lv. The volumes of previous deposits must be added to sell B12. But for the initial *k*=1, such amounts are not available. The interests obtained are given in cell B13. Hence, for the first month of the investment period, such values in B12 and B13 are not available. Thus, the initial amount of free resources for investment is evaluated by summation of cells B11:B13

The component SUMPRODUCT(B14:B16;$D$6:$D$8) evaluates how much of the investment resource is allocated for new deposits. The column B11:B13 gives the number of deposits and D6:D8 are the costs per category deposit. The function SUMPRODUCT() makes a vector multiplication between the sets B11:B13 and D6:D8.

The requested payments and/or incomes, defined by R(1) are subtracted from the investment amount SUM(B11:B13) and the resulting value M(1) is given in cell B18. This value is the initially available resource for month *k*=2, which is translated in cell C11 (or C11 contains the command =B18).

The next cells in row 18 contain the same evaluations as M(1). For illustration the content of cell M(18), for *k*=12 is

=SUM(M11:M13)-SUMPRODUCT(M14:M16;$D$6:$D$8)-M17 .

The evaluations for *k*=2 illustrate the resources, available for investment by SUM(C11:C13). The content of cell C11 is the free resources from the previous month M(1) from B18. The next component in C12 evaluates the volume of mature deposits. For k=2 only one-month deposits can finish in the second month. Thus, cell C12 contains the evaluation =B14*$D$6. Respectively, cell C13 will have the evaluated income from these deposits =B14*$D$6*$B$6. Sequentially, these evaluations follow till k=4, when the maturity of 3 months’ deposits can arise. Hence, the amount of the investment resource for the beginning of month 4 will increase both with the deposits for 1 and 3 months if any. The cell E12 calculates =D14*$D$6+B15*$D$7 and the resulting income is in E13 as =D14*$D$6*$B$6+B15*$D$7*$B$7. The evaluations in this type continue till *k*=7 when a possible maturity of 6 months deposits would be available. The resulting amount of resources in cell H12 is =D14*$D$6*$B$6+B15*$D$7*$B$7 and the total income is evaluated in cell H13 like =G14*$D$6*$B$6+E15*$D$7*$B$7+B16*$D$8*$B$8.

These complicated forms of evaluations continue till the end of the investment period for k=12. For illustration, the content in cell M12 is =L14*$D$6+J15*$D$7+G16*$D$8 and the resulting incomes in M13 are =L14*$D$6*$B$6+J15*$D$7*$B$7+G16*$D$8*$B$8 .

The goal function of the problem maximizes the sum of all incomes for the investment period, *M*=1, 12. Its evaluation is given in cell M8, where all incomes are =SUM(B13:K13).

The descriptions above explain the manner of programming the Excel sheet for the definition of the problem (1). The solution to this problem is done by application of the SOLVER function. It insists on additional input parameters, given to the command window of SOLVER, Fig.3. We are using the function NAME() to notify the set of parameters with names for easier programming. The solutions for 1 month’s deposits on B14:M14 are named “One_moths_CDs”. Respectively, B15:K15 for the 3 months is named “3months_Dep” and for B16:H16 is “Six_months_CDs”. The goal function in N8 is named “Total_interest”. The resulting set M(k) from B18:N18 is named “Montly_cash”.

The command window of SOLVER is programmed with the name “Total_interest” for the goal function; the problem solutions are One-month_CDs”, “_3months_Dep” and “Six_month_CDs”; the constraints insist on integer arguments and the ended M(k) must be higher than 1000lv., M(k)≥ 1000, *k*=1,12. The solutions to the problem are given in Fig.2 with a total income of 137 lv.

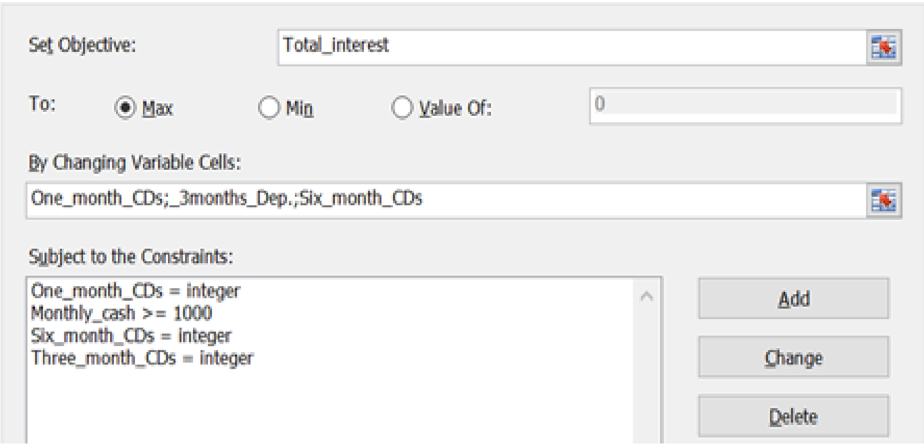

Figure 3. Command window of SOLVER

5. Conclusions

This research addresses the active management of a portfolio. The optimization targets the useful usage of free resources by means to increase the wealth of the business entity. Such optimal financial management is a prerequisite for sustainable production and/or business activities. The benefit of the presented problem is that it can be solved with simple computational resources. This is a prerequisite for its practical implementation in business entities. Particularly, the described portfolio problem contains risk-free assets with different maturity periods and integer solutions. With the increase in the investment period, respectively the scale of optimization, the time for solving could be impractical for real-time decisions. The problem has the potential to be extended with risky assets, but the portfolio problem has to increase its content with the values of risk for each asset as the correlations between the asset returns. But this can be a future development for the application of information technology solutions for the active portfolio management

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