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Multi-Method Approach to Making Investment Decisions

Vladimir A. Kalugin, Vadim A. Lomazov, Lilia A. Zimakova, Valeriy M. Nikitin and Elena A. Lavrinenko
Belgorod State University, Pobedy Str., 85, 308015 Belgorod, Russia

Abstract: DCF-methods are widely used in domestic and foreign practice of making investment decisions. Classic indicators of investment projects efficiency, such as net present value, profitability index, internal rate of return, etc. are used by DCF-methods as criteria. However, in rare cases, there will be a situation where the decision is acceptable with the positions of all considered criteria at the same time. As a rule, the various criteria will give different solutions "to accept-reject". Therefore, there is the problem of choosing one leading criteria or priority of their use. In this study, we propose to use the idea of multimethod technology which is actively developing branch of optimal control theory. At the same time, in contrast to the traditional use of multimethod technology, involving the use in the process of solving the problem not the one method but the sequence of the various optimization methods, we proposed unification on the basis of DCF-methods complementation. Each of them provides additional relevant information that will increase the efficiency of investment solutions.

Key words: Discounted cash flow-methods, performance indicators of investment projects, the net present value, profitability index, internal rate of return, discounted payback period, hierarchical model of decision-making, pairwise comparison matrix, the index and the ratio of coherence, eigenvector and eigenvalue of matrix

INTRODUCTION

DCF-methods are widely used in domestic and foreign practice of making investment decisions, using as criteria the classic indicators of Investment Projects (IP), based on discounted cash flows (Kovalev, 2000; Kalugin *et al*., 2014):

- Net current (present) value of investments Net Present Value (NPV)
- Profitability Index (PI)
- The internal rate of return (profitability) of investments Internal Rate of Return (IRR)
- Modified Internal Rate of Return (MIRR)
- Financial Management Rate of Return (FMRR)
- Discounted Payback Period (DPP)

However, their safe use as the tools for investment decisions, to a certain extent, relies on the ability of economists and financial analysts to anticipate changes in the economy of a country or in particular sector of particular enterprise, company or for a specific product. Moreover, these changes should be presented quantitatively. Often this capacity is overrated to a large extent.

Beyond the scope of analysis from the perspective of the classical methods of decision making, also many important questions are rest for the investors.

When is the best time to start the implementation of the investment project? Is it possible to extent the term of the investment project, if it is successful? Is it possible the impact of the investment project on the other, subsequent investment of the enterprise? For example, the opportunity to develop related activities, using the experience, gained in this investment project. Is it possible the impact of the investment decision on the company's position in the market and on the competitiveness of the product, affected by this decision? Can the market measures be used for risk assessment?

Furthermore, it should be noted that in the analysis of a particular IP, only in rare cases, there would be the situation when it would be acceptable from the position of all criteria simultaneously. As a rule, various criteria will give different ordering (ranking) of IP and show different solutions "accept-reject". Therefore there is the problem of choosing one leading criteria or priority of their use (Kalugin, 2004).

In fact, many respectable companies such as IBM, GE, "Royal Dutch Petroleum", calculate and analyze

Corresponding Author: Vladimir A. Kalugin, Belgorod State University, Pobedy Str., 85, 308015 Belgorod, Russia

the five criteria (NPV, PI, IRR, MIRR and DPP) because each of them gives some additional relevant information (Brigham and Gapenski, 2001):

- NPV is important because it shows, generated by the project, welfare gains of shareholders and in our opinion, is the best feature of return on invested capital
- PI also provides information about the "project safety limit reserve" because it measures the profit of one monetary unit of investment
- IRR, as a relative index, evaluates the profitability of investments and this index is the most preferred by many managers, especially by non-specialists in the field of finance. In addition, it contains the information on the "the safety cushion of the project" which is extrinsic to NPV
- MIRR has all the advantages of IRR but it is also built, taking into account more correct rate of reinvestment and in addition, allows to analyze extraordinary projects
- DPP gives the information about the risk and liquidity of the project-a long payback period means, firstly, that the invested funds will be linked for many years, therefore, the project is relatively illiquid and secondly, the proceeds of the project should be projected for the long term, that means a significant risk of the project

Therefore, it would be a gross error to ignore the information, inherent to each criterion separately, at that, the importance of such information in each case would determine the significance of the criteria.

In this study we propose to use the idea of multimethod technology which is actively developing branch of optimal control theory for improving the efficiency of investment decisions. However, in contrast to the use of multimethod technology, within the optimal control, involving the use in the process of solving the problem not one method, but the sequence of different optimization methods, we proposed unification on the basis of DCF-methods complementation, using the methodology of hierarchical structures analyzing.

MATERIALS AND METHODS

Multimethod technology is a rapidly developing branch of optimal control theory, the basic idea of which is the use in the process of solving problems not only one method but the sequence of different optimization methods in order to improve decision-making effectiveness (Tyatyushkin, 2001; Belyshev and Gurman, 2003). It is proposed to use the idea of multimethod approach in making investment decisions.

The unification on the basis of DCF-methods complementation and the construction of a single model of making investment decisions, are carried out using the methodology of the hierarchical structures analysis, or eigenvector method for processing antisymmetric matrices (matrices with power calibration) which was proposed in 1972 independently in the USSR (Brooke and Burkov, 1972) and in the United States (Saaty, 1977). Unfortunately, in our country this method was not found further development, since the American scientist T. Saaty and his followers had been developed a powerful methodology of the hierarchical structures system analysis (Analytic Hierarchy Process-AHP) (Saaty, 1989).

Definition 1: Let H is the finite partially ordered set with the single greatest element u. H is a hierarchy, if we have the following:

- There is a partition H into subsets L_k (hierarchy levels), k = 0, ..., h, where $L_0 = \{u\}$
- Condition $x \in L_k$ implies the condition $D(x) \subset L_{k+1}$, k = 0, ..., h-1
- Condition $x \in L_k$ implies the condition $U(x) \subset L_{k-1}$, k = 1, ..., h

The main question which arises in the process of hierarchie's analysis, can be formulated in the form of the following matter. Consider the economic system with the main purpose u and a plurality of main alternative types of L_h actions (alternatives), helping to achieve this goal. Assume, that this system can be represented as a hierarchy with the maximum element u and the lower level L_h. How to define the priorities (or "values") L_h-level elements relative to u?

The vector of alternatives priorities of the set A which is located on the h-level hierarchy, relative to the greatest element of hierarchy u can be determined by the following formula (Saaty, 1989):

$$W^u_à = M_h M_{h-1},\ldots, M_2 W^u$$

Where:

M_i = The matrix of priority of i-level elements relative to the i-1-level elements

W^u = The vector of priority of the first level elements relative to the greatest element u

American scientist T. Saaty proposed the idea of using as the vector of priorities, the matrix eigenvector of paired comparisons of elements $x \in L_{k+1}$ relative to the elements of the other, superior adjacent level ($y \in L_k$). He theoretically proved motivation for the use of nine-score ratio scale for the carrying out pairwise comparison;

introduced the concept of consistency index (IC-Index of Consistency) and consistency ratio (Cr-Consistency Ratio) as indicators of "proximity to the consistency" of pairwise comparisons matrix. To determine the eigenvector with some given accuracy ξ we can use the following iterative procedure (Saaty, 1989):

$$W_k = \frac{A^k e}{e^T A^k e}$$

performed to ensure the accuracy:

$$e^T \left| W_{k+1} - W_k \right| \leq \xi$$

where, $e = (1, 1,..., 1)^T$, A^k is the matrix of k-th degree, k = 1, 2, ... Having defined the eigenvector, you can find the maximum eigenvalue by the following formula (Saaty, 1989):

$$\lambda_{max} = e^T A\ W_{IC+1}$$

Index of consistency is determined by the following simple formula (Saaty, 1989):

$$IC = (\lambda_{max} - n)/(n - 1)$$

The ratio of consistency index to the mathematical expectation of the random index E (RI) for the matrix of the same order is called the consistency ratio. The value of mathematical expectation of a random index for matrices order from 1-15 on the basis of 100 random samples can be found in the work (Saaty, 1989).

RESULTS AND DISCUSSION

When realizing the multimethod approach (4 methods are used) using AHP we represent the model of making investment decisions in the form of the following hierarchy (Fig. 1).

The Decision-Maker (DM) should to determine the Investment Project (IP) which is effective from the perspective of a leading criterion. Formally, this matter is formulated as a definition of IP priorities vector, relative to the greatest element of the hierarchy (leading criterion) and selection of the project (making decision) which corresponds to the highest priority. Suppose that for the definiteness, the decision maker must choose the best of a set, consisting of five investment projects $\{IP_1, IP_2, IP_3, IP_4, IP_5\}$.

The first step in this direction is the construction of IP paired comparisons matrices relative to each particular criteria (NPV, PI, IRR, MIRR) using the nine-score ratio scale (Saaty, 1989). For the purpose, the decision-maker uses expert judgments. Suppose, that the matrices of IP paired comparisons, from the standpoint of the concerned partial criteria has the following form (Table 1-4). Determine the maximum eigenvalues and coefficients IC and RC and enter the results of the calculations into Table 5.

Fig. 1: The model of making investment decisions within multimethod approach

Table 1: The matrix of paired comparisons IP relative to NPV

NPV	IP_1	IP_2	IP_3	IP_4	IP_5
IP_1	1	1/2	1/2	1/3	1/9
IP_2	2	1	1	1/4	1/9
IP_3	2	1	1	1/2	1/9
IP_4	3	4	2	1	1/5
IP_5	9	9	9	5	1

Table 2: The matrix of paired comparisons IP relative to PI

PI	IP_1	IP_2	IP_3	IP_4	IP_5
IP_1	1	2	1	9	8
IP_2	1/2	1	1/2	5	6
IP_3	1	2	1	8	9
IP_4	1/9	1/5	1/8	1	1/2
IP_5	1/8	1/6	1/9	2	1

Table 3: The matrix of paired comparisons IP relative to IRR

IRR	IP_1	IP_2	IP_3	IP_4	IP_5
IP_1	1	2	1/2	1/2	4
IP_2	1/2	1	1/2	1/2	3
IP_3	2	2	1	1/3	2
IP_4	2	2	3	1	5
IP_5	1/4	1/3	1/2	1/5	1

Table 4: The matrix of paired comparisons IP relative to MIRR

MIRR	IP_1	IP_2	IP_3	IP_4	IP_5
IP_1	1	1/3	1	1/2	6
IP_2	3	1	3	1	5
IP_3	1	1/3	1	1/2	3
IP_4	2	1	2	1	8
IP_5	1/6	1/5	1/3	1/8	1

Table 5: Maximum eigenvalues and coefficients IC and RC

Criterion	Eigenvalue	IC	RC
NPV	5.39	0.097	0.087
PI	5.25	0.061	0.055
IRR	5.37	0.092	0.082
MIRR	5.27	0.067	0.060

Table 6: The IP rankings, relative to the partial criteria

IP	W (IP_i/NPV)	W (IP_i/PI)	W (IP_i/IRR)	W (IP_i/MIRR)
IP_1	0.045	0.348	0.222	0.203
IP_2	0.080	0.215	0.152	0.299
IP_3	0.084	0.348	0.203	0.134
IP_4	0.187	0.032	0.360	0.322
IP_5	0.604	0.056	0.063	0.042

Table 7: The matrix of pairwise comparisons of partial criteria

Leading criterion	NPV	PI	IRR	MIRR
NPV	1	2	4	6
PI	1/2	1	2	3
IRR	1/4	1/2	1	2
MIRR	1/6	1/3	1/2	1

Table 8: The priority of partial criteria, relative to the leading criterion

Criterion	Eigen vector (W_k)	MAX eigen value	IC	RC
NPV	0.51	4.04	0.01	0.01
PI	0.26	-	-	-
IRR	0.15	-	-	-
MIRR	0.08	-	-	-

The values of coefficients IC and RC are less than the critical value (0.1), so the matrices of pairwise comparisons are well compatible which indicates that the expert opinions are logical and consistent. Find the eigenvectors, corresponding to the maximum eigenvalues of the abovementioned matrices of paired comparisons IP relative to the partial criteria. The components of these vectors define the IP rankings, relative to the corresponding criteria (Table 6).

The next step in accordance with the AHP is a procedure to determine the "values" of partial criteria in terms of the leading criterion. Suppose that the matrix of pairwise comparisons of partial criteria has the following form (Table 7).

Let's find the maximum eigenvalue and coefficients IC and RC. Having analyzed the receiving values IC = 0.01 and RC = 0.01 at λ_{max} = 4.04, we can conclude that the matrix of pairwise comparisons of partial criteria is agreed. Find the eigenvector, corresponding to the maximum eigenvalue of the abovementioned matrix. At that, the components of the obtained eigenvector determine the priority of partial criteria, relative to the leading criterion (Table 8).

For carrying out the synthesis ("hierarchical weighting") we form the matrix of priorities IP relative to partial criteria (data from the Table 6) and make the matrix multiplication on a column vector of criteria priorities, relative to the leading criterion (the second column of data in Table 8). As the result we obtain:

$$\begin{bmatrix} 0.045 & 0.348 & 0.222 & 0203 \\ 0.080 & 0.215 & 0.152 & 0299 \\ 0.084 & 0.348 & 0.203 & 0134 \\ 0.187 & 0.032 & 0.360 & 0322 \\ 0.604 & 0.056 & 0.063 & 0042 \end{bmatrix} \times \begin{pmatrix} 0.51 \\ 0.26 \\ 0.15 \\ 0.08 \end{pmatrix} = \begin{pmatrix} 0.16 \\ 0.14 \\ 0.17 \\ 0.18 \\ 0.34 \end{pmatrix}$$

The components of the obtaining column vector define the following ranking of IP:

$$IP_2 \prec IP_1 \prec IP_3 \prec IP_4 \prec IP_5$$

Consequently, the most preferred is the project IP_5 its "weight" in comparison with the other projects is very significant and equal to 0.34. It should be noted, that the proposed approach has a greater degree of generality, in comparison with the traditional approach: firstly, it does not require a reliable estimation of the cash flows of alternative IP, secondly, it allows to take into account the management options without its quantitative evaluation in the process of construction of the pairwise comparisons matrix, relative to the partial NPV. Traditionally, for consideration of the management options, it is necessary their evaluation and then their mainstreaming into the index of NPV, calculated according to the traditional method (Kalugin *et al*., 2015):

Real NPV = Traditional NPV+
The cost of management options

CONCLUSION

So, we developed multimethod hierarchical model of making investment decisions, uniting according to the DCF-methods complementation. We determined, using the methodology of the hierarchical structures analysis, the IP priorities from the perspective of leading criterion, taking into account in each case, the additional relevant information which gives every partial criterion separately, including management options without their quantitative evaluation, that will allow to make soundly-based investment decisions.

REFERENCES

Belyshev, D.V. and V.I. Gurman, 2003. [The software package method of intelligent procedures of optimal control]. Autom. Remote Control, 6: 6-67(In Russian).

Brigham, E. and L. Gapenski, 2001. [Financial Management: Complete Course]. Economic School SPb, Moscow, Russia, Pages: 497 (In Russian).

Brooke, B.N. and V.N. Burkov, 1972. [Methods of expert estimations in the tasks of organizing objects]. Tech. Cybern., 3: 3-11(In Russian).

Kalugin, V.A., 2004. [Multi-Criteria Methods of Investment Decision-Making]. SPb Publisher, Moscow, Russia, Pages: 211 (In Russian).

Kalugin, V.A., E.A. Monakova, O.S. Pogarskaya and D.I. Korolkova, 2015. Taking account of managerial options within the frameworks of taking investment decisions. Int. Bus. Manage., 9: 966-968.

Kalugin, V.A., E.N. Chizhova, S.F. Chizhov, O.V. Leonova, 2014. Improving the system of evaluation of investment decisions in investment activities. Life Sci. J., 11: 956-962.

Kovalev, V.V., 2000. [Methods of Assessment of Investment Projects]. Springer, Moscow, Russia, Pages: 144 (In Russian).

Saaty, T., 1989. [Decision-Making Analytic Hierarchy]. SPb Publisher, Moscow, Russia, Pages: 316 (In Russian).

Saaty, T.L., 1977. A scaling method for priorities in hierarchical structures. J. Math. Psychol., 15: 234-281.

Tyatyushkin, A.I., 2001. [Multimedia technology and parallel computations in optimal control problems]. Methods Optim. Appl., 2: 172-178 (In Russia).