Improving the system of evaluation of investment decisions in investment activities

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Abstract. The smarter use of classical discounted methods as tools for making investment decisions to a certain extent relies on the ability of economists and financial analysts make informed judgments about the expected value of the cash flows of analyzed investment projects at each step of the calculation period. The basis of these judgments makes initial assumptions regarding: the future level of business activity, the actions of competitors, the cost of factors of production, sales, etc. The calculated figures are at best only outlines of future results of the implementation of investment projects since each of these elements is characterized by a high level of uncertainty. For improving the efficiency of investment decisions there should be such a tools that could allow working with judgments which are carried out in the form of relative valuations. This article proposes to improve the system for evaluation of investment decisions within the investment based on the methodology of the analysis of hierarchical structures allowing to estimate the ratio scale of investment project (IP) at each step of the calculation period including assessment cost of management options.

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Preamble

As part of the innovation activity is often required to make decisions regarding capital investments in new buildings, machinery, equipment, raw materials and materials used in production that means making an investment decision. In this article option of investment decisions will we call as an investment project (IP).

Following the discounted methods of making investment decisions based on the calculation of indicators became popular in Russian and foreign practice such as: net current (present) value of investments (*net present value* — NPV, net present value — NPV, or integral effect); profitability index of investments (*profitability index* — PI, index of profitability of discounted investment — IPDI); internal rate of return (profitability) of investments (*internal rate of return* — IRR, internal rate of return — IRR); modified internal rate of return (*modified internal rate of return* — MIRR) [1,2].

The decision to use NPV criterion as a main criterion gets a lot of supporters. For example, in research [2] it allows better reflect earnings potential of IP.

More accurately, the recommendations of using NPV we get from those who proceeds from the primary target of any companies is to maximize the welfare of its owners (investors).

However, the NPV criterion is not free from disadvantages, the first of which is related with the prediction of cost of capital of the enterprise. Due to large-scale changes in the capital market situation, either because of internal reasons expected change of price of capital, the NPV criterion should consider the change in the price of capital. In research [3] we proposed the use of NPV criterion in a form that requires forecasting n forward interest rates (forward rate), or n different prices of capital, which greatly increases the subjectivity of the evaluation and makes it practically unreliable tool for investment analysis. Another option in case of an expected change of price of capital also require n forecast interest rates (spot interest rates, spot rate) is the shape criterion NPV, proposed in work [4,5]. In work [6] we propose a method for the adjusted present value (Adjusted Present Value, APV), which provides the separation of indicator NPV of the project into two components: 1) the net present value (NPV), which would have a project if it is entirely financed by own capital; present value (PV), the cash flow associated with external financing. The second major disadvantage of the NPV criterion is implicit assumption about the reinvestment of income generated by IP at the right price (prices) of capital. In the case where it is necessary to clearly predict the specific bid reinvestment which is different from cost of capital there should be used form NPV criterion, proposed in work [7].

Another situation of evaluating choices when innovation projects have attributes which expressed in the appearance of new managerial capabilities, the implementation of which was previously impossible. In this context we may say about the management options of innovation projects:

1) increasing the scale of the project if it is successful;

2) selling the project, if it fails;

3) developing related activities, using the experience from the first project;

4) developing of new products in line with the started project;

5) widening of products markets;

6) widening and re-equipment of production;

7) early layoff the project, etc .

Because of the emerging management capabilities are numerous and varied, and the time of their occurrence is vague, it is considered inappropriate to include them directly in the evaluation of the project cash flows. In this case, the corrected NPV, calculated by the traditional method [2]:

real NPV = traditional NPV + cost of management options.

However, reliable use of these indicators as tools for making investment decisions to a certain extent relies on the ability of economists and financial analysts make informed judgments about the expected value of cash flows of analyzed innovation project at each step of the calculation period. The basis of these judgments makes assumptions regarding: the future level of business activity, the actions of competitors, the cost of factors of production, sales, etc. Since each of these elements is characterized by a high degree of uncertainty, the calculated figures are only parts of future results of the implementation of the innovation project.

Generally any judgments regarding future events - in this case, the future cash flows of innovation projects - taken out in the form of absolute values is almost always unreliable. At the same time, the manager of the enterprise can definitely judged that the cash flow of one innovation project on the t-th step of the calculation period greatly exceeds the cash flow of the second innovation project. However is much more difficult to say specific amounts of cash flows of innovation projects. Consequently, as the practice of working with managers of enterprises shows that we can completely trusted to the judgment of future events bearable as relative valuations.

In this article we propose to improve the system for evaluation of investment decisions in the investment activity, based on the methodology of the analysis of hierarchical structures, allowing estimate the scale of innovation projects relations at each step of the calculation period to include assessment cost of management options.

Main part

Let us consider the following model example [8]. Suppose we want to sort five alternative investment projects in conditions of great uncertainty as to their cash flows. Assume that each of the analyzed projects can potentially generate revenue sufficient to recognize that it is acceptable. However, a reliable assessment of income is associated with great difficulties, and available cash flow forecasts of innovation projects are very unreliable. Because the cash flow forecast of innovation projects is unreliable that is why calculation of traditional classical indexes does not solve the problem.

We will solve the problem of ordering innovation projects under these conditions, based on the methodology of the analysis of hierarchical structures [9, 10, 11]. Let's construct the hierarchy of problems of adjustments of innovation projects (fig. 1).

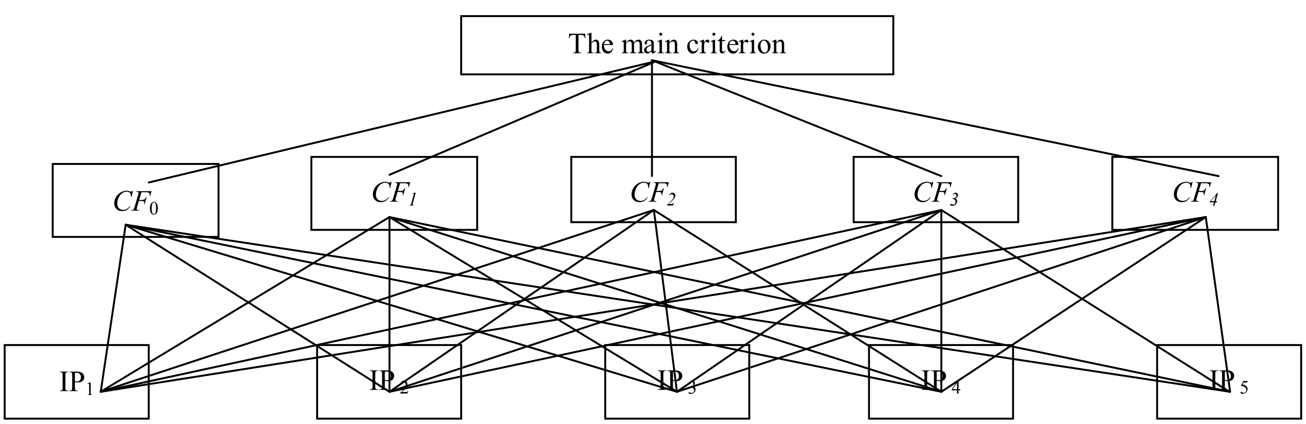

Fig.1. The hierarchy of problems of adjustments of innovation projects

Here it is assumed that each project has the same duration of the life cycle - four years. Therefore, each of the projects described by a set consisting of five cash flows:

$CF(\text{IP}) = (CF_0, CF_1, ..., CF_4)$,

where $CF(\text{IP})$ — total of cash flow of innovation project,

CF_t — name of cash flow (from english language *Cash Flow*) of innovation period on the t-th step of the calculation period.

It should be noted that it is only on the description of innovation project, the aggregate cash flows generated by the specific (i-th) project (IPi) is defined as:

$CF(IP_i) = (cf_0^i, cf_1^i, \ldots, cf_4^i)$,

where cf_t^i — evaluation of cash flow i-th project on the t-th step of the calculation period.

From the point of view of the theory of decision-making we are essentially dealing with a multi-criteria assessment of the innovation projects because attributes which are describing alternatives in this theory called as *criteria.*

It is known that the problem of multicriteriality of evaluation and analysis of the alternatives could be accomplished using conventional procedures, consists in the clotting criteria or forming a weighted sum of criterion.

This procedure is used in the formation of the NPV indicator.

Indeed, let the i-th of IP described by a aggregate of cash flows:

$CF(IP_i) = (cf_0^i, cf_1^i, \ldots, cf_4^i)$, then

$$NPV(IP_i) = \sum_{t=0}^{4} \frac{cf_t^i}{(1+r)^t}.$$

For solving problem of multicriteriality we can say that within the NPV method for overcome this problem and get only one criterion, the procedure of clotting criteria "cash flow" with coefficients should be:

$$\alpha_t = \frac{1}{(1+r)^t},$$

t— step number of the calculation period ($t = 0, 1, \ldots, 4$),

r — cost of capital (discount rate).

These factors may also be considered as the "importance" weights criteria such as "cash flows". In the framework of the NPV "most important" is cash flow which is initial (zero) step of the calculation period (its "weight" equal to 1), and the least "important" - cash flow last 4th step.

In that case, if it is possible to construct a sufficiently reliable prediction of cash each investment project and it is definitely possible to judge the discount rate, the calculation of NPV indicator does not cause difficulties. However, the question of how to evaluate the innovation project on the criteria "cash" in the absence of reliable forecast still open.

For solving this issue we introduce the concept of the evaluation function (φt) of IP on the "cash flow at step tφ_t":

$IP \rightarrow CF_t$,

where

$IP=\{IP_i\}$ — multiplicity of IP,

$CF_t = \{CF^t_i\}$ — multiplicity of cash flows on the n-th step of the billing period.

The latter multiplicity we call the same name CFt and that the criterion of "cash flow t-th step of the billing period." There is no contradiction, since the criterion has a pair of: (name of the criterion that is linearly ordered multiplicity of its values). That is why it is convenient call the same name the criterion itself and its range: easily determine what it is all about while you read the text.

This function can be represented as follows (Table 1)

Table 1. The evaluation function of IP in terms of CF_t criterion

Multiplicity of projects (IP)	IP_1	IP_2	...	IP_m
Cash flow (valuation)	cf_1^t	cf_2^t	...	cf_m^t

By supposition the issue of forecasting of the absolute values of the cash flows ($cf1^t$) is difficult. Therefore, we calculate the relative values of cash flows of innovation projects. For doing his we carry out the pairwise comparison of IP on each of the criteria for "cash flow on the t-th step of the calculation period" (CF_t) to determine the relative values ("weights") of IP in terms of these criteria. To determine the "weights" of innovation projects regarding the cash flows amounted we will make five paired comparisons matrix, because we have the same number of criteria CF_t.

Making these matrices, the decision-maker is trying to answer the question of which of innovation projects is able to generate (in the case of evaluation from the perspective of its tributaries) higher (lower) cash flow compared to other innovation projects for each step of the calculation period, and how many times more (below)? In this case the decision maker based on experience, intuition and common sense, analyzes all information available to it at the moment the information, taking into account the availability of managerial capabilities in a particular innovation project.

We also assume that all cash flows are considered mutually independent. This allows you to evaluate the IP in terms of a certain cash flow regardless of its values on other cash flows.

Suppose that the matrix of pairwise comparisons in terms of IP criteria considered "cash flow to the t-th step of the calculation period" were as follows (Table. 2. – Table 6.).

Table 2. Matrix of pairwise comparisons of IP on CF_0 criterion

CF_0	IP 1	IP 1	IP 1	IP 1	IP 1
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 3. Matrix of pairwise comparisons of IP on CF_1 criterion

CF_1	IP 1	IP 1	IP 1	IP 1	IP 1
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 4. Matrix of pairwise comparisons of IP on criterion CF_2

CF 2	IP 1	IP 1	IP 1	IP 1	IP 1
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 5. Matrix of pairwise comparisons of IP on criterion CF_3

CF_3	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 6. Matrix of pairwise comparisons of IP on criterion CF_4

CF_4	IP_1	IP 2	IP 3	IP 4	IP 5
IP 1	1	2	3	7	7
IP 2	1/2	1	1/2	5	6
IP 3	1/3	2	1	4	4
IP 4	1/7	1/5	1/4	1	1
IP 5	1/7	1/6	1/4	1	1

For making the above matrix of pairwise comparisons, we used information on the forecast cash flows of innovation projects presented in table 7, which is very unreliable in this method.

Table 7. Forecast of cash flows of IP

Step of IP	0	1	2	3	4	5
IP 1	-52000	20000	19500	19000	18500	18000
IP 2	-50000	18000	18000	20000	17000	16000
IP 3	-50000	20000	20000	19000	18000	16500
IP 4	-45000	14000	20000	20000	16500	17000
IP 5	-40000	15000	15500	16000	16500	17000

Consequently, any of even the most unreliable forecast of cash of IP we must learn how to extract the desired information. For example, consider the forecast of investment costs for the analyzed projects (Table 8).

Table 8. Forecast investment costs of the projects

IP_1	IP_2	IP_3	IP_4	IP_5
-52000	-50000	-50000	-45000	-40000

Despite the fact that this forecast is unreliable, it is still possible to extract some information from it. First of all we need to say that the criterion of "zero cash flow period - CF_0" is negatively oriented criterion (outflow): large in absolute value cash flows considered less preferred.

Therefore, in terms of cash flow zero period (CF_0) project IP_5 most preferred, less preferred - project IP_4 seems even less preferred - IP_2 and IP_3 and most of the unsatisfactory - IP_1.

The resulting information should preferably be using when you will make the matrix of pairwise comparisons on criterion CF_0. We used it as follows.

Since the investment costs of projects IP_2 and IP_3 are projected similar. We make a judgment that they are equal in magnitude and we are not evaluating their specific amount, i.e. in position (2, 3) of matrix we bring the number 1, that in terms of 9 point scale relations of methodology of the analysis of hierarchical structures means "the same significance."

1. The first project (IP_1) worse the second one (IP_2) and therefore worse third one (IP_3) to a minor. That is why in the positions (1, 2) and (1, 3) put the number of half - the reciprocal of the intermediate value between "equal importance" and "a certain predominance of significance."

2. Because the first project (IP_1) is considerably worse of the fourth and fifth in positions (1, 4) and (1, 5) that is why in the matrix there is a number of 1/3 and 1/9.

The second project (IP_2) worse fourth (IP_4) and the fifth (IP_5)one - in positions (2, 4) and (2, 5) of the matrix are respectively the number of 1/4 and 1/9.

3. The third project (IP_3) is also worse than the fourth (IP_4) and the fifth (IP_5) - in positions (3, 4) and (3, 5) of the matrix are respectively the numbers 1/2 and 1/9.

4. The fourth project (IP_4) is also worse than the fifth (IP_5) – in positions (4, 5) of the matrix is the number 1/5.

5. Other positions of the matrix in accordance with the methodology of the analysis of hierarchical structures were filled with reciprocals.

We may say that when decision maker making the matrix of pairwise comparisons he may extracts from the forecast only some of the information for each criterion. The rest of the information he receives from its own experience, intuition and common sense. This last piece of information for the specific excellence or importance of one over the other innovation project including management opportunities.

In particular, this forecast, as it was noted that the third project (IP_3) worse than fourth (IP_4) and the fifth (IP_5). However, the question how much worse is decided on the basis of subjective: in positions (3, 4) of the matrix of pairwise comparisons put the number 1/2, and in position (3, 5) - 1/9. That means that IP_3 worse than IP_4 but pretty much worse IP_5.

For making the matrix of pairwise comparisons relative of IP to other criteria CFi (i = 1, 2, 3, 4), we used in a similar manner information, firstly, we extracted from the forecast of cash flows in future periods IP (1-4 steps of the calculation period) secondly, we used their management capabilities in this periods.

To check the consistency of the matrices of pairwise comparisons, we will find the maximum eigenvalues and coefficients of CI (consistency index), CR (consistency ratio) and put in table 9.

Table 9. Maximum eigenvalues and CI and CR coefficients

Criterion	Eigenvalue	CI	CR
CF_0	5,39	0,097	0,087
CF_1	5,25	0,061	0,055
CF_2	5,37	0,092	0,082
CF_3	5,27	0,067	0,060
CF_4	5,34	0,084	0,080

Analyzing the results (CI and CR), we may say that all the matrices of pairwise comparisons of IP on criteria "cash flows" quite consistency and therefore expert judgment can be trusted because they are logical and consistent.

It should be noted that the gain immediately after the first result of paired comparisons matrix, a satisfactory result on their consistency is not possible, especially when the order of the matrix is more than four. As a rule, the first decisions made by the expert with decision-makers require a revision of judgment, which is conveniently carried out in the framework of a computer model developed by, for example, in a spreadsheet environment.

Let's find the eigenvectors corresponding to the maximum eigenvalue, the above matrix of pairwise comparisons of IP on cash flows criteria.

As it is known, the components of these vectors define rankings of IP on the relevant criteria (table 10).

The next step according to the methodology for analysis of hierarchical structures is determining "weights" the criteria themselves in terms of decision-making situation (main criterion).

Table 10. Ranking of IP to "cash flows" criteria

IP	$W(IP_i/CF_0)$	$W(IP_i/CF_1)$	$W(IP_i/CF_2)$	$W(IP_i/CF_3)$	$W(IP_i/CF_4)$
IP_1	0,045	0,348	0,222	0,203	0,404
IP_2	0,080	0,215	0,152	0,299	0,263
IP_3	0,084	0,348	0,203	0,134	0,229
IP_4	0,187	0,032	0,360	0,322	0,052
IP_5	0,604	0,056	0,063	0,042	0,052

In general, there are two ways for the definition of "balance" criteria such as "cash flow".

The first method "weighting" - there is a way, using in methodology for analysis of hierarchical structures: expert by making judgments about the significance of a "cash flow" should construct the corresponding matrix of pairwise comparisons in the case of consistency find its eigenvector corresponding to the largest eigenvalue, which components and determine the importance of the criteria.

Let's imagine that resulting matrix of pairwise comparisons "cash flow" has the following form (table 11).

Table 11. Matrix of paired comparisons of "cash flows"

Leading goal	CF_0	CF_1	CF_2	CF_3	CF_4
CF_0	1	2	4	6	8
CF_1	1/2	1	2	3	6
CF_2	1/4	1/2	1	2	3
CF_3	1/6	1/3	1/2	1	2
CF_4	1/8	1/6	1/3	1/2	1

Let's find the maximum eigenvalue and the CI and CR coefficients.

Analyzes the importance of CI= 0.034 and CR= 0.031, it can be argued that the matrix of pairwise comparisons of criteria "cash flows" completely agreed.

Let's find eigenvector corresponding to the largest eigenvalue, the above matrix. The components obtained eigenvector define priority criteria "cash flows" regarding leading goal (Table 12).

Table 12. Priority of "cash flows" in relation to main criterion

Criterion	Egenvector (W_k)	MAX eigenvalue	CI	CR
CF_0	0,453	5,137	0,034	0,031
CF_1	0,270			
CF_2	0,146			
CF_3	0,086			
CF_4	0,046			

The second method is the traditional "weighting" of these criterion by assigning to each criterion of "cash flow" the factor ("weight"), defined by formulas above.

The final step of the process IP on many criteria in accordance with the methodology for analysis of hierarchical structures, is a synthesis ("hierarchical weighting"), as the result the IP obtained estimates from the viewpoint of the leading criterion of efficiency.

For making synthesis the matrix of priorities of IP on criteria "cash flows" (data from table: 10) and carry it to the matrix multiplication vector- column of priorities regarding the criteria themselves leading criterion (data of the second column Table *12).*

The result will be:

$$\begin{bmatrix} 0{,}045 & 0{,}348 & 0{,}222 & 0{,}203 & 0{,}404 \\ 0{,}080 & 0{,}215 & 0{,}152 & 0{,}299 & 0{,}263 \\ 0{,}084 & 0{,}348 & 0{,}203 & 0{,}134 & 0{,}229 \\ 0{,}187 & 0{,}032 & 0{,}360 & 0{,}322 & 0{,}052 \\ 0{,}604 & 0{,}056 & 0{,}063 & 0{,}042 & 0{,}052 \end{bmatrix} \cdot \begin{pmatrix} 0{,}453 \\ 0{,}270 \\ 0{,}146 \\ 0{,}086 \\ 0{,}046 \end{pmatrix} = \begin{pmatrix} 0{,}182 \\ 0{,}154 \\ 0{,}184 \\ 0{,}176 \\ 0{,}304 \end{pmatrix}.$$

Components of the resulting vector-column determine the following ranking of IP: $IP_2 \prec IP_4 \prec IP_1 \prec IP_3 \prec IP_5$.

Consequently, the most preferable the project IP_5 – it's "weight" in comparison with other projects is highly significant and it equal to 0.304.

Conclusion

In this article states that the ability of economists and financial analysts to expect changes in the economy or in a particular industry or for a particular enterprise, organization or an individual product and on this basis to determine the expected value of cash flows analyzed of innovation projects at each step of the calculation period greatly overrated. In fact, as rightly noted by many authors, their forecasts and plans constantly demonstrate their imperfection and incompleteness. Therefore, using the classical indicators as tools for making investment decisions will show only outlines of future results of the implementation of the innovation project. Generally any judgments about the future cash flows of innovations projects handed down as the absolute values are alwaysunreliable. At the same time, the manager of the enterprise may judged quite definitely that the cash flow one IP on the t-th step of the calculation period greatly exceeds the cash flow of the second IP. However, it is very difficult to say even a certain probability specific dimensions of cash flows of innovation project. Consequently, the judgment of future events bearable as relative valuations, as the practice of working with managers of enterprises, can be completely trusted.

In this article, we propose a method for improving the system of evaluation of investment decisions within the investment, based on the methodology of the analysis of hierarchical structures, allowing estimate the scale of relations of innovation projects at each step of the calculation period which is include assessment "cost" of management options.

Results

The proposed method of estimates of the innovation projects in investment activities, has a greater degree of generality compared to the traditional criterion NPV. In addition, it can be also used when the part of cash flows of IP is quite reliable, for example, in the initial stages of implementation, and the other part - is unreliable, due to the remoteness of future periods from the current time. This article also presents guidelines for the construction of matrices of pairwise comparisons assessed the innovation projects, which enhances its practical significance.

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