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# MULTICRITERIA ANALYSIS OF THE VARIANTS OF THE OLD TOWN BUILDING RENOVATION IN THE MARKETING ASPECT

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## 1. Introduction

In the literature of economy there is no unified opinion concerning the stage of every investment project as well as for the whole project estimation. The majority of the authors [1, 2] evaluate social, ecological and technical indicators separately and do not include them into the general system of the indicators of the investment estimation while considering the dominating economic result as the priority.

One of the most difficult problems of the modern urbanism is the combined estimation of the old town building renovation according to technical-economical and social-economical indicators. This estimation is closely related to social requirements and perspectives of city development. One of the best models in the evaluation of investment projects is used by the USA company *Continental Group*. The projects are being estimated in two aspects: commercial attractiveness and project realization in the enterprise [3].

The system of old town building renovation that investigates variants of building usage and helps defining the most effective ones could help speeding up renovation and expand the volumes of old town regeneration, also would positively influence the construction companies' and investors' activity.

One of the principal targets while renovating old towns is the adaptation of architectural monuments to contemporary necessities so as the monuments of the past could continue their active existence as part of the developing town and the historical centre.

At the optimisation of the building use, a variant calculation of investment needs is being executed [4].

Under the nowadays conditions the possess of the big practical experience and good engineering intuition is not enough for the building renovation. Well-founded decisions can only be taken after the variant projection is done evaluating projects realized earlier and after the main directions of the decisions are defined. The methods of multi- criteria analysis play the main role when solving the real life tasks [5]. These methods are being applied more and more often. There are no absolutely reliable methods of multicriteria analysis; nevertheless, they can help the consumer to avoid main contradictions in the analyzed sphere.

The application of methods of multicriteria analysis for reviving an old town expands the possibilities of its regeneration planning and marketing, also lets to quicken reviving work.

A complex of methods of multicriteria analysis was created (Fig 1). It is aiming at finding the way of how to raise the efficiency of the investments for the old town revival, also at increasing fidelity to the calculations.

## 2. The marketing principle of renovation of old town buildings

Before the purchase of buildings their estimation is being done. The first step is to define the technical status of the building. The dimensions are gotten during this process and they serve for evaluating parts of the building. The next step is the estimation of the value of the whole object. It is possible to define the market price of the building according to its real estate value. The market price evaluates the market juncture, which is determined by factors of supply and demand. The estimation methods are based on the analysis of factors that define the building value, in general. These factors are: features of the object, comparable value of the object, real money power of the purchase. Besides it is a must to estimate heaps of additional factors – area, appearance, the character of the use of the object, legal rights of ownership, etc.

Several variants of the building use are being projected. For example, the apartments, café or the hotel can be fitted out. The estimation of expenditure is being made up for every variant. When the expenses for all variants are known, marketing calculations are performed: which variant is cheaper, what profit is possible after the sales or rent of the building, what price of the sales should be ensured for getting the invested means back and receipt of the planned profit. Using the way of comparison, possible price of the sales is being carried out. If crediting is part of the plan, the stages of credit taking and investment are prospected taking into consideration the growth of interests.

According to the system of efficiency indicators and applying methods of multicriteria analysis the best variant is chosen. Then the building is being renovated and sold.

### 3. Complex of the multicriteria analysis methods

The theory of multicriteria analysis is applied for the decisions while evaluating indicators that are most often contradicting each other. The problems of multicriteria analysis are very different, though all these tasks have some common features [6]: the problems have several indicators, the estimation criteria usually contradict each other, the estimation indicators have different measuring units. The solution result of such a problem is to find the best alternative or to choose the one of the alternatives. The methods of multicriteria analysis create or search for the variant that corresponds to all criteria in the best way. Because of the contradictions of the indicators to each other, a smart compromise must be found.

The decision-making consists of 3 stages:

Making the list of alternatives;

Preparing alternatives;

Choosing alternatives [7].

During the first stage the alternatives are defined and they will be used while solving tasks. These alternatives are called the solution variants.

In the second stage, variants of the solutions are analyzed.

The choice of the best variants is based on the differential estimation of variants according to the results of the second stage.

As the methods of management and the technique of the determination are growing modern, the methods of multicriteria analysis are becoming more important in management spheres. There are no possibilities to solve problems while investigating difficult systems of technology and marketing using just the one-time estimation methods. Only the multicriteria analysis, which takes into account diverse efficiency indicators, allows to create effective methods for solving difficult problems.

Several methods of multicriteria analysis are described in literature. However, there is no sense in using only one method of multicriteria analysis for solving sophisticated problems. Grouping, linking of the methods, also applying them in turn becomes a must. The offered complex of the methods of multicriteria analysis is presented in Fig 1.

First of all, the potential variants of the building renovation are carried out. The efficiency indicators are made up and they will make the ground for comparing the analyzed variants. After questioning the experts, significances of the indicators are defined, using the method of the expert pair comparison.

Numerical values of weights $q_j (j=\overline{1,n})$ are defined by solving the optimization problem:

$$\min\left\{\sum_{i=1}^{n}\sum_{j=1}^{n}\left(b_{ij}q_j - q_i\right)\right\}, \qquad (1)$$

when unknown quantities $q_j\left(j=\overline{1,n}\right)$ satisfy limitations:

$$\sum_{i=1}^{n} q_i = 1, q_i > 0; \left(i=\overline{1,n}\right), \qquad (2)$$

where $b_{i,j}$ – values of criteria pairwise comparison given by experts.

The problem is solved in a traditional way – Lagrangian function is determined. The optimal proposition is got by solving a set of $(n+1)$ linear equations with $(n+1)$ unknowns:

$$C \cdot Q = \overline{m}. \qquad (3)$$

where $Q = (q_1, q_2, \ldots, q_n, \lambda_1)^T$ : $q_i$ – weights of criteria; $\lambda_1$ – Lagrangian multiplier: $\overline{m} = \underbrace{(0,0,\ldots,0,1)}_{n\ times}^{T}$ ; $n$ – amount of criteria.

$C = [l_{ij}]$, $i, j = 1,\ldots,n,n+1$ matrix with elements $l_{ij}$;

$$l_{ii} = (n-1) + \sum_{j=1}^{n} b_{ji}^2, i, j = 1,...,n, \quad (4)$$

$$l_{ij} = -(b_{ij} + b_{ji}), i, j = \overline{1,n};\ i \neq j, \quad (5)$$

$$l_{k,n+1} = l_{n+1,k} = 1,\ k = \overline{1,n}. \quad (6)$$

$$l_{n+1,n+1} = 0. \quad (7)$$

The pair comparison method is useful because the experts have the possibility to compare the indicators in couples, what is really important when comparing big amounts of indicators. The group estimation can be considered to be reliable only when the opinions of the experts interrogated are reconciled. Therefore statistical processing the information supplied by the experts, conciliation of their opinions should be appraised and the reasons for multivaluation of the information should be defined.

The pair comparison method, presented by T. Saaty, does not include the test for conciliation of the experts'opinionss. Therefore the offered expert method to test the conciliation of the experts'opinionss is the one that was presented by L. Evlanov.

In order to avoid accidental mistakes, three methods of variants usefulness function are offered: TOPSIS (*Technique for Order Preference by Similarity to Ideal Solution*) [8], SAW (*Simple Additive Weighting*) [9, 10] and LINMAP (*Linear Programming Techniques for Multidimensional Analysis of Preference*) [11, 12]. LINMAP method for construction problems was applied for the first time.

Using this method, the values of every indicator are constantly increased or constantly reduced. Then we can have the possibility to define the "perfect" solution, which is made up of the best values of the indicators, and the "negatively perfect" solution, which is made up of the worst values of the indicators.

The relative closeness of each alternative in respect of the ideal solution is defined as follows:

$$K_{BIT} = \frac{L_i^-}{L_i^+ + L_i^-}, i = \overline{1,m}, \text{ when } K_{BIT} \ [0, 1], \quad (8)$$

where $L_i^+$ – separation of each alternative from the ideal one, $L_i^-$ – separation of each alternative from the negative-ideal one, $m$ – number of alternatives.

A set of alternatives can now be preferebly ranked according to the descending order of $K_{BIT}$.

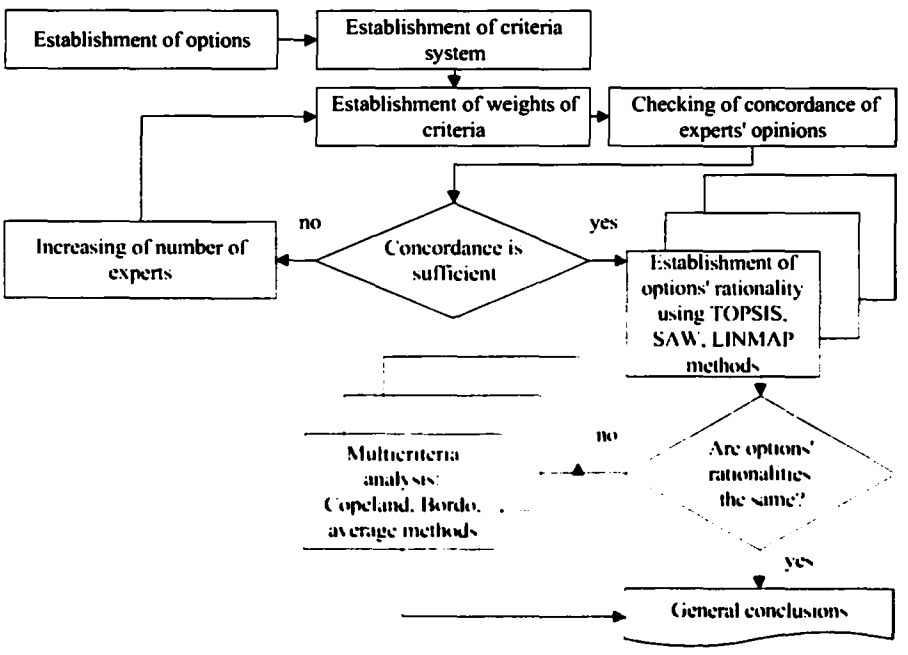


**Fig 1.** Complex of multicriteria analysis methods

SAW is probably the best known method of multiattribute decision-making. Attribute values must be numerical. There are two steps of analysis:

1) Matrix is normalised;

2) The decision-maker can then obtain a total score for each alternative simply by multiplying the scale rating for each attribute value by the importance weight assigned to the attribute and then summing these products over all attributes. The alternative with the highest score is the one prescribed to the DM:

$$A=\left\{A_i\left|\max_i \sum_{j=1}^{n} q_j \overline{x_{ij}} / \sum_{j=1}^{n} q_j\right.\right\}, \qquad (9)$$

where $q$ – importance weight of the attribute, $\bar{x}_{ij}$ – the outcome of the $i^{th}$ alternative about the $j^{th}$ attribute with a numerically comparable scale, $n$ – number of alternatives.

In LINMAP method, $m$ alternatives composed $n$ attributes (decision matrix with elements $x_{ij}$) are represented as $m$ points in the $n$-dimensional space. The weighted Euclidean distance, $d_i$, of the $A_i$ from the ideal point is given by

$$d_i=\left[\sum_{j=1}^{n} q_j\left(x_{ij}-x_j^*\right)^2\right]^{1/2}, \; i=1,2,...,m, \qquad (10)$$

where $x_j^*$ is the ideal value for the $j^{th}$ attribute. The square distance, $s_i=d_i^2$, is given by

$$s_i=-\sum_{j=1}^{n} q_j x_{ij}, \qquad (11)$$

where $x_{ij}$ are at least intervally scaled, and the larger $x_{ij}$, the larger preference.

Let $\Omega=\{(k,l)\}$ denote a set of ordered pairs $(k,l)$ where $k$ designates the preferred alternative on a forced choice basis resulting from a paired comparison involving $k$ and $l$.

Then we have

$$s_l-s_k=\sum_{j=1}^{n} q_j(x_{kj}-x_{lj}). \qquad (12)$$

$$z_{kl}=\max\{0,(s_k-s_l)\}. \qquad (13)$$

Now the corresponding model is:

$$\left.\begin{array}{c} \min \sum\limits_{(k,l)\in\Omega} z_{kl} \\ when \;\; \sum\limits_{j=1}^{n} q_j(x_{kj}-x_{lj})+z_{kl}\geq 0, \; when \;\; (k,l)\in\Omega; \\ \sum\limits_{j=1}^{n} q_j \sum\limits_{(k,l)\in\Omega}(x_{kj}-x_{lj})=h; \\ q_j\geq 0, j=1,2,...,n; \\ z_{kl}\geq 0, \; when \;\; (k,l)\in\Omega. \end{array}\right\} .(14)$$

The existence of several methods of the research implies a question, which of these methods should be used. The question "which method suits the problem best" is the most important but again it is difficult to answer. It is much harder to evaluate the quality of the methods of multi-criteria analysis that examines limited discrete mathematically described figure of the variants in comparison with the methods of the finite element mathematics. As every method of multicriteria analysis has its own advantages as well as disadvantages, there is no absolute answer to this question.

The choice of methods in a common case is determined by:

1) physical value of the indicators;

2) level of the mathematical and program maintenance;

3) subjective circumstances of a different level.

Besides, there is a possibility to get different results of the calculation (the line of priority) when reckoning by different methods.

The model of the estimation of multicriteria methods is based on the average use of the *Borda* and *Copeland* methods [13, 14]. The common conclusions can be made out after the multicriteria analysis has been fulfilled.

The risk of the renovation variants is determined in matrix way. Let's assume that the investor wants to evaluate the risk level for each variant. That requires to calculate the standard deflection and the coefficient of the variation for each variant.

The standard deflection for every case is determined by the formula:

$$s_i=\sqrt{\sum_{i=1}^{I}\left[\left(S_i-S_0\right)^2\cdot p_i\right]}, \qquad (15)$$

where $S_i$ – the solution result, conforming the $i$ situ-

ation development scenarios, $S_0$ – expected result of the probability, $p_i$ – the probability of situation development scenarios, $t$ – the figure of scenarios of situation development.

The risk level of the assets is expressed as a function of liquidity, profit level and income stability:

$$R = L \cdot D \cdot C, \qquad (16)$$

where $L$ – level of liquidity, $D$ – level of profitability of the assets, $C$ – levell of the income stability.

On the ground of the system of multicriteria analysis methods, the authors have developed the computer program *WinDeterminator* for solving the multicriteria tasks. The program should be useful for students of various specialties, scientists and manufacturers.

Usually the work with the program is processed in two stages: first of all the values of efficiency indicators are determined, later the variants priority row is being defined using the values of efficiency indicators based on SAW, TOPSIS or LINMAP methods.

The programmed block of the experts opinions pair comparison is assigned for determining the efficiency of indicators estimation (Fig 2). The program allows to save and to load again the data of separate tasks: experts' forms and solution matrixes. All the data, which consist of the values of efficiency indicators of all variants that are examined, the values of weights of criteria, the information showing whether the efficiency indicator is minimized or maximized, are included into the matrix. Data are saved on the special format used by the program.

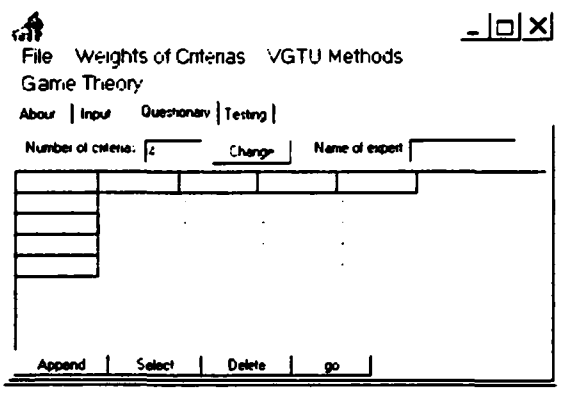


**Fig 2.** Form for filling in questionary results

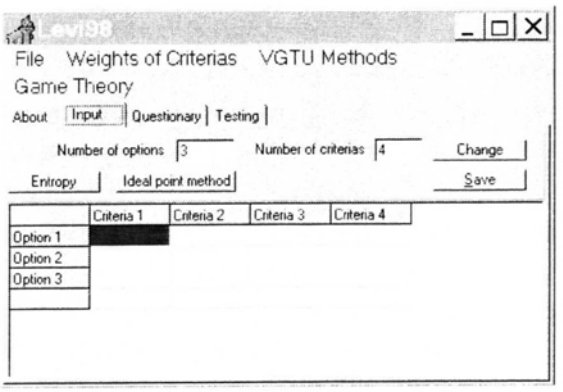


**Fig 3.** Form for filling in values of criteria

The definition of the variant priority to the TOPSIS, SAW and LINMAP methods is also programmed. To make the system control more primitive for the consumer, decision matrix for the determination using TOPSIS, SAW and LINMAP methods, are filled in the same form (Fig 3).

The facilities of the method created were shown solving a real comparison task of the old town building renovation. The method was applied to the investment project of the building in Vilnius old town. Various variants of this building renovation were examined according to this method, the most perspective ways of utilizing this building were defined. This project now is implemented and economical indices are similar to calculated ones. More information about case studies will be published in next number of STATYBA (Civil Engineering).

## 4. Conclusions

1. A new system of efficiency indicators and methods was built up for solving the old town building renovation tasks. It helps define the rationality of the investment projects for the old town buildings renovation.

2. The offered scheme presents the way of the old town building renovation. Several variants of utilizing the building have been developed. For example, apartments, café or the hotel can be arranged in the building. An estimate of expenditure is done for each variant. When the necessary expenses are clear for a variant, marketing calculations are performed: which variant is cheaper, what profit is possible after the building is sold or rented, what price of the sales must be

for getting back the invested money and ensuring the planned profit. Possible price of the sales is defined in a comparison way. If the crediting is part of the plan, the stages of the credit taking, investment itself and the growth of the interest are foreseen. The best variant is chosen in accordance to several criteria. Further stages of the process: the building is being renovated and sold, rented or put in service.

3. A system for estimating the investment variants of the old town building renovation was built up in a marketing aspect. The variants are estimated according to: profitability, durability, maintenance expenses, business perspectives, location of the building, period from the start of the renovation till realization, parking place existence, appearance of the building.

4. The improved expert method of pair comparison is used to determine the values of efficiency indicators. The method of pair comparison is useful because it allows to compare indicators in couples, what is important when comparing a big amount of indicators. The group estimation can be considered to be reliable only when the opinions of the experts interrogated are reconciled. Therefore statistical processing the information supplied by the experts, conciliation of their opinions should be appraised and the reasons of multivaluation of the information should be defined. The pair comparison method, presented by T. Saaty, does not include the test for conciliation of the experts' opinions. Therefore the offered expert method to test the conciliation of the experts'opinionss is the one that was presented by L. Evlanov.

5. Recommendations regarding the definition of 12 calculated values of efficiency indicators were presented.

6. For the first time the LINMAP method was assigned to solve building investment tasks.

7. The complex of multicriteria analysis methods was made up. It is used to solve the analytical tasks of the investments for the old town renovation.

8. The computer program *WinDeterminator* was created and is used for solving multicriteria tasks. It is useful for students of various specialties, scientists and manufacturers. The program computes the values of efficiency indicators using the expert pair comparison method, solves the multicriteria tasks on the basis of TOPSIS, LINMAP and SAW methods.

9. The facilities of the method created were shown solving a real comparison task of the old town building renovation. The method was applied to the investment project of the building in Vilnius old town. Various variants of this building renovation were examined according to this method, the most perspective ways of utilizing this building were defined.

10. The methods of multicriteria analysis are to be applied for examining variants of the old town renovation in marketing aspect; they make the process more effective and reliable.

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## SENAMIESČIŲ PASTATŲ RENOVACIJOS VARIANTŲ DAUGIAKRITERINĖ SELEKTONOVACIJA RINKODAROS POŽIŪRIU

**S. Jakučionis, L. Ustinovičius**

Santrauka

Nustatytas senamiesčių pastatų renovacijos rinkodaros principas. Senamiesčių pastatų renovacijos investiciniams uždaviniams spręsti sudaryta ir pasiūlyta nauja efektyvumo rodiklių sistema ir metodai. Patobulintas ekspertinis porinio lyginimo metodas, taikomas efektyvumo rodiklių reikšmingumams nustatyti. Pirmą kartą statybos investiciniams uždaviniams spręsti pritaikytas LINMAP (*Linear Programming Techniques for Multidimensional Analysis of Preference*) metodas. Pateiktas selektonovacijos metodų kompleksas (1 pav.), skirtas investicijų į senamiesčių pastatų renovaciją analizės uždaviniams spręsti. Sukurta programinė įranga *WinDeterminator* (2, 3 pav.) selektonovacijos uždaviniams spręsti. Metodo galimybės buvo parodytos sprendžiant realų senamiesčio pastato renovacijos variantų lyginimo uždavinį.

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