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Lithuanian experience of quantitative evaluation of socioeconomic systems position by multicriteria methods

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Abstract

Multicriteria evaluation methods were applied in Lithuania for the evaluation of construction projects by various aspects more than thirty years ago. It appeared to be a universal technique to reflect the condition of any socioeconomic system quantitatively. Such methods have been used successfully for such kind of problems solving for some tens of years, therefore it is significant to generalize the experience of many years and on its basis to bring to light problematic questions and those ones which should be solved.
The critical analysis of the multicriteria evaluation stages revealed the following shortcomings. First, while forming the indexes list, it is a rare case when all possible sources are used. Second, the system of the examined expression indexes is formed on the ground of this list subjectively and without applying scientific methods. Third, the determination of indexes weights is incorrect, especially when a big number of indexes is evaluated. Fourth, there is no solution of the question what multicriteria evaluation method should be applied for a concrete problem solving.

Keywords: MCDA; multicriteria evaluation stages and methods.

Introduction

Multicriteria methods were applied in Lithuania for the first time more than 30 years ago to solve technological problems in construction (Zavadskas, 1980, Zavadskas & Peldschus, 1984; Zavadskas, 1986). Their application

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revealed their universal nature, so in the course of time the fields of applying them widened. It appeared to be an irreplaceable means for quantitative evaluation of the position of socioeconomic systems what is necessary for their purposeful control.

In social sciences all phenomena which we come across and which we examine are in essence socioeconomic systems, so further a multicriteria object will be named 'examined phenomenon'.

The long-lived experience of multicriteria methods application showed that some evaluation stages are fulfilled either incorrectly or not in a full volume, and sometimes on the basis of wrong assumptions, etc. This is the reason of necessity to examine the experience of multicriteria evaluation of socioeconomic systems position critically.

1. Critical analysis of multicriteria evaluation stages

1.1. Multicriteria evaluation stages

Multicriteria evaluation methods began to be applied in Lithuania in construction. With their help the selection innovation of construction sites projects was carried out. In the course of time the fields of application of these methods were becoming wider (Zavadskas, 1987; Zavadskas & Turskis, 2011; Kalibatas *et al.*, 2012; Brauers *et al.,* 2012). It appeared that multicriteria evaluation is a universal way to reflect the position of any complex phenomenon, any socioeconomic system quantitatively. It is very important for management theory and practice because if you want to manage any process, you should be able to measure it, i.e. to evaluate.

Multicriteria evaluation, independently from the nature of the examined phenomenon, is accomplished in the same way – making the list of its universally described indexes, then this list is 'cleaned up' by special techniques, i.e insignificant indexes are rejected. Later according to the examined phenomenon their weights are defined, normalized values are calculated and finally, using one or some multicriteria evaluation ways, all of them are united into one summarising index (Fig. 1) (Ginevicius & Podvezko, 2005).

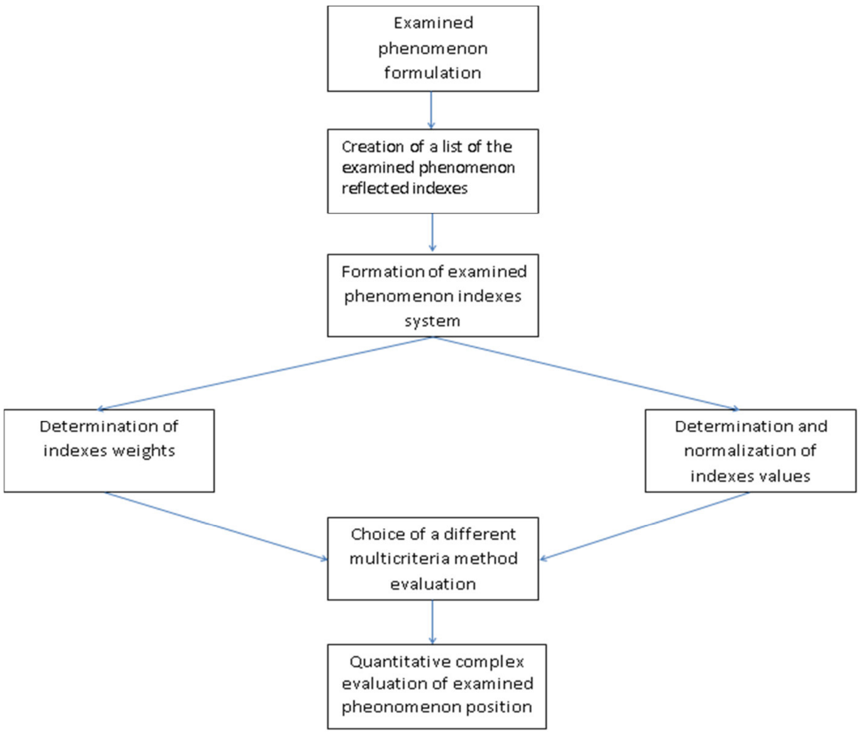

Fig. 1. Stages of quantitative evaluation of the examined phenomenon position by multicriteria methods. Source: Ginevicius & Podvezko (2005)

Each stage is important because the accuracy of evaluation results depends on the correctness of its fulfilment. The analysis of multicriteria evaluation experience revealed the shortcomings which are typical of the above-mentioned stages.

1.2. Formation of a list of multicriteria evaluation indexes

The system of the examined phenomenon reflecting indexes is a foundation of multicriteria evaluation. All other evaluation stages are fulfiled on its basis. In spite of importance the created system of indexes is often not adequate to the examined phenomenon. In some cases, few indexes are included into it and it is not fully reflected, its essential aspects are not evaluated; in other cases, on the contrary, too many indexes, among them even insignificant are included into the system, therefore it becomes difficult to evaluate their importance, the calculation costs grow, the evaluation accuracy falls, etc. (Fig. 2) (Ginevicius & Podvezko, 2005).

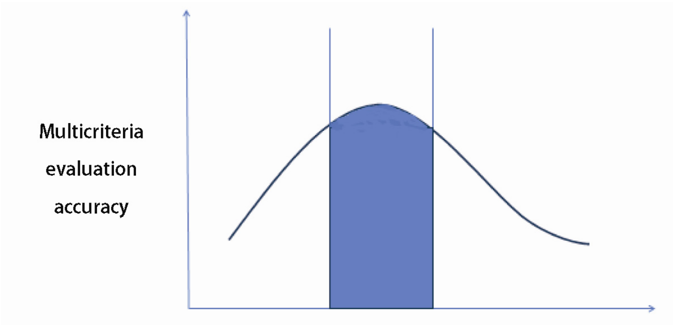

Fig. 2. Dependence of multicriteria evaluation accuracy on the number of indexes. Source: Ginevicius & Podvezko (2005)

Hence, to form a system of adequate examined phenomenon indexes, it is, first of all, necessary to create the most exhaustive list of these indexes, and after that to remove from it insignificant ones applying special methods. The list is created on the basis of different sources – scientific literature, project information, normative, directive documents, accounts, agreements, etc. In any case it should be enriched by expert questioning which helps to evaluate political, economical, legal, environmental, business and other conditions of the country in which the research is carried out. The analysis of researches made shows that in the process of indexes list formation all the mentioned sources are evaluated rarely – either only on the basis of literature or experts or accounts and agreements (Butkevicius, 2008; Jurkenaite, 2009; Hausmann, H-T., 2009; Ginevicius, 2011; Plakys, 2011; Sligeriene, 2009; Zilinskij, 2012; Podviezko, 2013; Zubrecovas, 2010).

1.3. Formation of multicriteria evaluation indexes system

The analysis of scientific literature revealed two main ways how to ‘clean’ a list of indexes: the first way is based on the prevalent opinion; the second one is more complicated when mathematical statistics methods are used (Ginevicius& Podvezko, 2005).

In the first case on the basis of sources of literature, experts‘ opinion, etc., the most often mentioned indexes are established and the least mentioned ones are rejected. The results of such analysis are given in the form of tables (Zilinskij, 2012; Bivainis & Morkvenas, 2010; Bivainis & Morkvenas, 2012) (Table 1).

Such technique of indexes system formation is not accurate enough because a larger number of indexes in the list and similar frequency of reference to a part of indexes make it difficult to determine the limit over which the present indexes are included into the system, and those which are under it are excluded from the system.

Applying mathematical statistics methods this limit can be determined in such a way. First, the histogram of random variable X, related to Table 1 is drawn (Ginevicius & Podviezko, 2005). Then, depending on the form of histogram, possible theoretical probability distribution is chosen. On the basis of Table 1 data the chosen distribution parameters are calculated (the average and mean square deviation). After that in conformity with the calculated parameters, the chosen distribution function F (x) or density f (x) is determined. After the determination, theoretical probabilities, ni .that random variable X belongs to any interval of the histogram, are calculated. Last, the corresponding theoretical frequencies are calculated and the statistical hypothesis, that random variable X is distributed according to the chosen theoretical law, is checked. We choose what percentage of insignificant indexes eliminated from their list as insignificant ones.

Table 1. Formation of indexes system on the basis of prevalent opinion

Author, source	Title of index						
	1st	*2nd*	*3rd*	...	*i*	...	*n*
1st	-	+	+	...	-	...	+
2nd	+	+	+	...	+	...	-
3rd	+	-	+	...	+	...	-
:	:	:	:	...	:	...	:
i	+	-	+	...	:	...	-
:	:	:	:	...	:	...	:
n	+	+	+	...	-	...	+
Total	$\sum_1$	$\sum_2$	$\sum_3$	...	$\sum_i$	...	$\sum_n$

Source: compiled by the authors

The number of indexes in the formed system may be not the same. Depending on the examined phenomenon nature, it may fluctuate from some to some hundred (Ginevicius, 2007a; 2007b). This circumstance calls out the necessity of structuring. First of all, it is made dependent on expert evaluation of indexes weights because they can be determined quite accurately only for definite limited number of indexes. In literature sources it is postulated that such number should not exceed 10-12 (Ginevicius, 2007a; Ginevicius, 2009).

So, if the number of indexes reflecting the examined phenomenon does not exceed 12, further calculations may be based on a one-level indexes system.

If the system creates many indexes, the number of them evaluated at the same time can be decreased by structuring the system, i.e. aggregating related indexes into separate groups. Some of such groups may reflect the same aspect of the examined phenomenon, therefore, having formalized the correlated relations of indexes groups, we get a hierarchical structure. On its first level there will be aspects, on the second one there appear groups of their reflecting related indexes. If there are too many indexes (more than 12) in some group, it should be expanded by introducing the third hierarchical level and so on. In such case the structured system of examined phenomenon indexes would look as in Fig. 3.

1.4. Determination of indexes weights

It is also an important multicriteria evaluation stage because incorrect determination of indexes weight can significantly distort the results of calculations.

Indexes weights can be determined in two main ways: direct and indirect. The first way is suitable when the number of evaluated indexes is not big – till some (Ginevicius, 2007a). Experts determine the weights of indexes in parts of a unit at once. This technique is very simple, understandable and convenient to apply. When the number of evaluation indexes increases, it becomes problematic to apply it. The reason is that it is harder for an expert to determine the correlated relations of indexes weights from the point of view of an examined phenomenon. At the same time the incompatibility of opinions grows which often exceeds allowable limits.

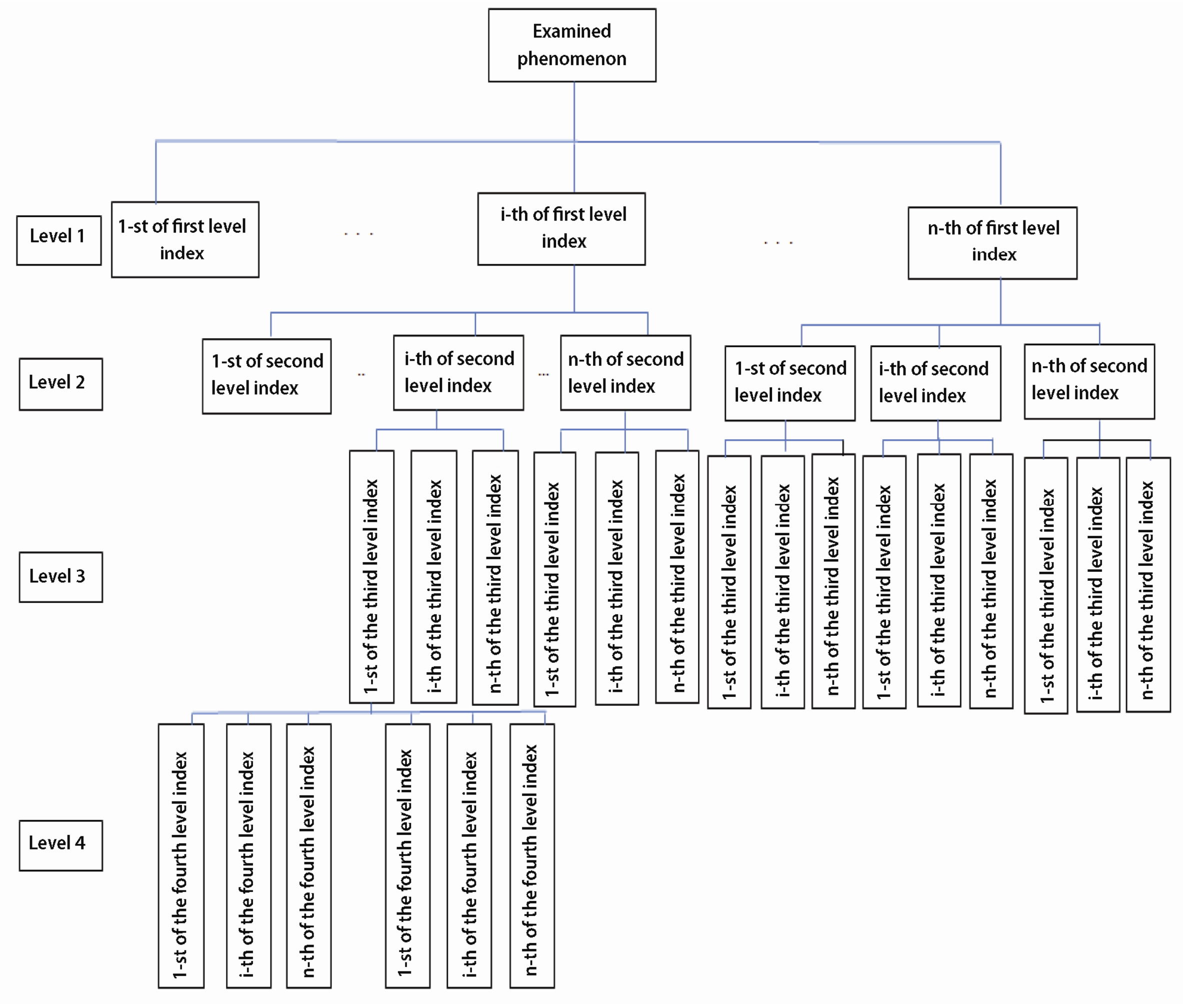

Fig. 3. Structured indexes system of examined phenomenon (Source: Ginevicius, 2007)

Looking for the way out, more complicated but more perfect ways of determination of indexes weights were offered. The best known one is T.Saaty hierarchy analysis method (Saaty, T.L., 1977; Ferreira, F. (2013); Aghdaie, M.H. *et al.,* 2013). In this case the experts compare only two indexes, but not all at once. The other one which is less widespread for the present, named FARE method, is also grounded on reciprocity of indexes (Ginevicius, 2011). On the basis of minimal initial information about the main index influence on other system indexes, the interrelations and strength of all the rest indexes are determined by applying an analytical technique. It allows to form completely coordinated matrix of indexes interactions and to calculate the weights of a larger number of indexes considerably more accurately.

The analysis of indexes weight determination methods applied in scientific researches shows that they have the following drawbacks:

- The number of experts is insufficient;
- Compatibility of experts‘ opinions is not checked;
- Inappropriate methods of indexes weights determination are applied and they are inadequate to the number of evaluated indexes.

When the number of evaluated indexes is larger and the direct expert evaluation is practically impossible, not knowing how to behave, indexes weights are determined on the basis of their ranks.

In this case all indexes are ranked according to their importance for the examined phenomenon and on the ground of these ranks the indexes weights are calculated analytically. The most important index is provided with rank one, rank two is given to the following index and so on.

Indexes weights are calculated in the following way:

$$\omega_i = \frac{\tilde{r}_i}{\sum_{i=1}^{n} r_i} \tag{1}$$

where ω_i – the weight of this index, n- the number of indexes; $\tilde{r}_i$ – transformed i-th index rank (the first index is provided with the rank of the last one, the second index is provided with the last but one and so on). The value $\tilde{r}_i$ is found in the following way:

$$\tilde{r}_i = r_{\max} - r_i + r_{\min} \tag{2}$$

where $r_{\max}$ – the biggest rank; r_i – i-th index rank; $r_{\min}$ – the smallest rank ($r_{\min}$ =1).

Such point of view about indexes determination is not correct in principle. First of all, when the evaluated number of indexes is quite large, the expert will hardly be able to rank all of them correctly according to their importance. Second, if we take two quite different phenomena with completely different indexes but with the same numbers, we will have the same weights in both cases.

The way of this problem solution is provided by in Fig. 3 depicted hierarchical system of indexes, when thanks to structuring of general number of indexes it is possible to reach the wanted number of indexes evaluated at the same time.

1.5. Determination and normalization of indexes values

The problem of this vital multicriteria evaluation stage is quantitative evaluation of the indexes formalized in a difficult way. In essence, there is the only way to solve it – again expert evaluation on the basis of a certain number scale system: 10, 50, 100, etc. The main drawback here is when, first, the system is often restricted by 5 points, the evaluation is too rough, and second, compatibility of experts‘ opinions is not always checked.

1.6. Multicriteria evaluation of the examined phenomenon position

The analysis of literature sources show that various evaluation techniques beginning with simple (sum of places, geometric average), more accurate ones (SAW COPRAS) and finishing by the most complicated ones – TOPSIS, VIKOR, MOORA, MULTIMOORA, ELECTRE, PROMETEY, PROMETEI II and others) are used (Jakimavicius & Burinskiene, 2009; Antucheviciene & Zavadskas, 2008; Brauers & Ginevicius, 2010; Radziszewska-Zielina, 2010; Tomic-Plazibat *et al.,* 2010; Li-Chang Hsu, 2013; Fereiro, 2013; Podvezko, 2011; Ginevicius *et al.,* 2013; Aghdaie *et al*., 2013).

The fact that such wide spectrum of methods is applied shows that all of them are not perfect. Another circumstance is that today it is not clear what evaluation method to choose depending on the specific features of the examined phenomenon. One of suggestions how to increase the accuracy of multicriteria evaluation is to apply some methods and use the average of the received results (Ginevicius & Podvezko, 2012).

The researches show that the intensity of multicriteria evaluation methods is diverse. The analysis of applying such methods in social sciences dissertations defended in the latter 10 years was carried out. Its results are given in Table 2 (Zinkeviciute, 2006; Morkvenas, 2010; Kanapeckiene, 2010; Kelpšienė, 2011; Krivka, 2010; Griskeviciute-Geciene, 2012; Venckauskaite, 2011; Jurkenaite, 2009; Zilinskij, 2012; Hausmann, 2009; Butkevicius, 2008; Sligeriene, 2009; Plakys, 2011; Zubrecovas, 2010; Podviezko, 2013; Ginevicius, 2011)

Table 2. Multicriteria evaluation methods applied in social sciences dissertations defended in 2005-2013

Multicriteria evaluation method	Sum of places	Geometric average	MOORA (MULTI-MOORA)	SAW	COPRAS	VIKOR	TOPSIS	PROMETHEE (PROMETHEE)
Times of Application	2	1	2	12	5	2	4	1

Source: compiled by the authors

From Table 2 it is seen that the multicriteria evaluation methods SAW and CORPAS were applied most frequently, therefore it is meaningful to compare them.

SAW (Simple Additive Weighting) multicriteria evaluation method is one of the most understandable and the simpliest ones embodying indexes values and weights connection into a single evaluating size – method criterion. On the other hand, this method provides for usage of only maximizing indexes, therefore, before calculating the minimizing indexes should be transformed into maximizing ones. Meanwhile, COPRAS (Cooperation Platform for Research and Standards) multimedia evaluation method does not have such drawback because the authors offered to evaluate maximizing and minimizing indexes separately. The component evaluating the impact of maximizing indexes coinsides with the corresponding evaluation by SAW method.. On the other hand, the deeper analysis of CORPAS method revealed that in some definite cases it can be unstable from the point of view of data fluctuation, and the results of evaluation according to this technique can differ from other multicriteria evaluations applying other methods (Podvezko, 2011). To conclude, it can be stated that the general qualities of SAW and CORPAS methods make it possible to apply them for evaluation of one-levelled hierarchical level indexes. The drawbacks of these and other multicriteria evaluation methods can be diminished by carrying out multicriteria evaluation applying some techniques and using the results average.

2. Conclusions

Multicriteria evaluation methods have been used in Lithuania for more than 30 years. At first they were used for solving technological problems in construction. Their universal nature allowed to start applying them later in analysing socioeconomic systems, especially in quantative evaluating of the processes which have such nature and for evaluation of expressions position.

The critical analysis of some multicriteria evaluation stages revealed certain imperfections. The main of them are the following ones.

In forming the list of indexes, all possible sources are used not often; it is done either only on the basis of literature or experts or normative documents, etc.

Bigger imperfections are typical for formation of indexes system of the examined expression on the ground of their list. It is not shown on what basis one or another index is left in the system. As a result, the system can be created either by too few indexes and in this case the important aspects of the examined expression will be left unreflected, or there will be too many indexes and nonessential ones will be included which will reflect only calculations. The way out lies in application of mathematical statistics method, which helps to reject unimportant indexes on a scientific basis.

In the process of determining indexes weights the biggest imperfections appear when the examined expression is described by many indexes. In this case if two completely different expressions are described by the same number of indexes, in both cases the indexes assume the same weights. It testifies the complete impropriety of such method.

The analysis of literature sources (of the defended social sciences dissertations) showed that in the latter 10 years the two multicriteria evaluation methods SAW and CORPAS were used most frequently. Both of them are quite simple and understandable for applying. In comparison with SAW, the method CORPAS has the advantage that it evaluates both maximizing and minimizing indexes without any transformations, while SAW evaluates only maximizing ones. On the other side, CORPAS method in certain cases can be unstable from the point of view of data fluctuation.

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