RURAL COMMUNITY PUBLIC PROJECT VALUATION APPLYING TOPSIS MULTI-CRITERIA METHOD

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Abstract
The primary goal of public projects is to create social benefits for the community. The prepared public project usually has more than one option. In order to choose the most efficient option, it is necessary to take into consideration all social benefits. For this reason multi-criteria methods may be applied since they provide a possibility to assess quantitatively social benefits which are measured in many different quantitative and qualitative indicators. The problem of the research stems from a variety of social benefits indicators of public projects, the problematic establishment of their value and the need of their complex valuation. The paper presents a methodology for TOPSIS multi-criteria method adapted for the valuation of public projects in order to select investment option and the empirical research makes it possible to look at the problems of public project valuation from the practical approach. The research of the paper is aimed at revealing the advantages and limitations of TOPSIS multi-criteria method used for public projects valuation.
Key words: rural community, public project, social benefits, TOPSIS multi-criteria method.

Introduction

Public projects are implemented in order to satisfy the needs of the society, which are taken care by the country, through state institutions, non-profit organisations and associations. The goals of public projects are related with the implementation of state functions: health, improvement of social security, education and employment of children and youth, decreasing the unemployment, ensuring the environmental safety, development of state engineering network etc. Implementation of public projects allows reducing social exclusion, promotion of economic and regional development. Investment projects, specifically aimed at reducing poverty, are related to the aspects of welfare, but not to income. Benefits derived from such projects are difficult to quantify (Van De Walle, 2002). Benefits brought by public projects are intended to satisfy public needs and they are generally referred to as social benefits. Investments in the public sector have to comply with the social, economic and political criteria (Medaglia et al., 2008).

Every investment option should be evaluated and substantiated before the right investment decision is made. The valuation of public projects is complicated due to complexity of valuation of social benefits. Social benefits of public project should effectively satisfy the needs of society. When making the investment decision, it is appropriate to assess the efficiency of the projects. The cost-benefit analysis method is usually used for valuation the public projects: investment and operating costs of the activity is evaluated as well as the benefits created by the public project, which may be expressed in monetary measures during the lifetime period of the project.

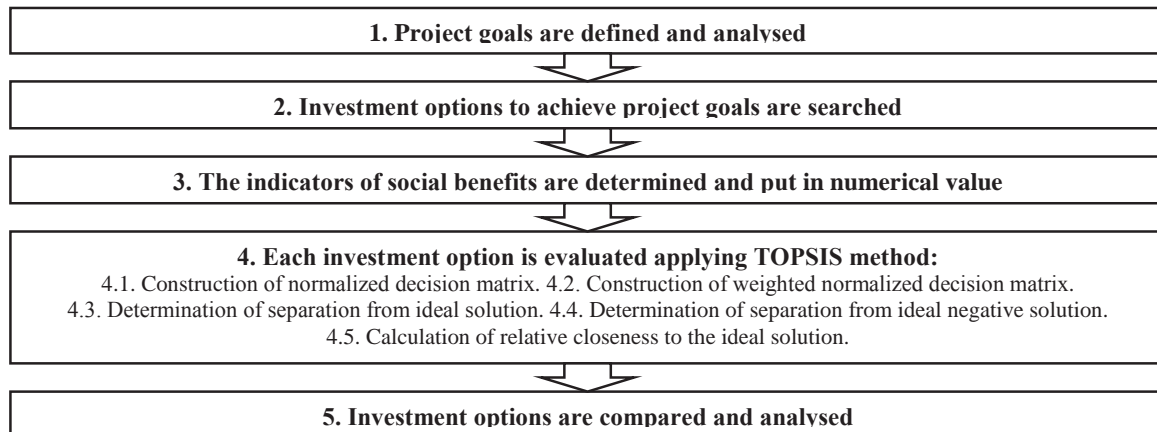The theoretical principles of cost-benefit analysis were detailed by Boardman et al. (2006), Pearce (2006), Guide to Cost-Benefit Analysis of Investment Projects (2008), Rosen, Gayer (2008); Baranauskiene, Alekneviciene (2013) and other authors.

Evaluation in monetary measures is important when it is necessary to make final decision in the ranking of public projects, but no less important in providing understandable information for the society about the public project which often determines how many members of the society will receive social benefits created by the project. In this perspective the cost-benefit analysis loses its attractiveness. The information obtained from cost-benefit analysis is not suitable for society debates about public projects' implementation. Still, a set of non-monetary indicators has to be prepared for the society (Nyborg, 2000).

Cost-benefit analysis is usually used for valuation of public projects in order to choose the best investment option, but it is criticized for two main features: 1) theoretical value substantiation: if the priorities are not correctly chosen, the main values – ecology, durability, fair allocation, social welfare – are not always indicated; 2) problematic assessment of social benefits. Due to this reason a question is raised – can the right decision be made using the method of cost-benefit analysis? (Alekneviciene and Baranauskiene, 2013).

Public projects can also be evaluated using the cost-effectiveness analysis which covers the analysis of project goals, search for option ways to achieve the goals, estimation of the costs incurred and benefits generated by investment options and the comparison of investment options (Ernst, 2006; Simic et al., 2011).

The main limitations of cost-effectiveness analysis is that selected indicators do not always express the entire social benefits created by a public project; therefore, a large number of evaluated indicators produce a complex combination which

1. Project goals are defined and analysed

2. Investment options to achieve project goals are searched

3. The indicators of social benefits are determined and put in numerical value

4. Each investment option is evaluated applying TOPSIS method:
4.1. Construction of normalized decision matrix. 4.2. Construction of weighted normalized decision matrix.
4.3. Determination of separation from ideal solution. 4.4. Determination of separation from ideal negative solution.
4.5. Calculation of relative closeness to the ideal solution.

5. Investment options are compared and analysed

Source: compiled by the authors.

Figure 1. The steps of TOPSIS method applied for evaluation of public project.

is incomparable with another relevant option and no ways of how to combine benefit indicators are presented (Alekneviciene and Baranauskiene, 2014).

Scientists raise the question: how to measure social benefits of public projects and what indicators have to be used to evaluate them? Another important problem is the monetary measurement of social benefits: how to quantify non-market goods, such as human life, environmental impact on human health, etc. (Hansjugen, 2004; Almansa and Calatrava, 2007; Hepburn and Koundouri, 2007; Sáez and Requena, 2007; Greenberg and Robins, 2008; Nooij, 2011; Firini et al., 2012; Parks and Godway, 2013) Scientific problem can be formulated: how to quantify and evaluate social benefits provided by public projects for the public?

Multi-criteria valuation methods could be used for solving the mentioned problems. The main advantage of mentioned methods is that one summarized indicator can include several maximizing and minimizing indicators expressed in various dimensions, i.e. indicators which cause the improvement of analyzed phenomenon in one case and worsening in another case. Such combining is possible due to normalization while all the indicators are turned into non-dimensional, i.e. are comparable with each other. Multi-criteria valuation methods provide a possibility to combine indicators of social benefits expressed in either qualitative or quantitative measures, thus the measurement of social benefits in monetary terms becomes unnecessary. These methods provide a possibility to rank several projects (Guitouni and Martel, 1998; Zopounidis, 1999; Bisdor, 1999; Hites et al., 2006; Mendoza and Martins, 2006; Tamosiuniene et al., 2006; Ginevicius, 2006, 2009; Ginevicius and Podvezko 2008; Shmelev et al., 2009; Frini et al., 2012).

The object of the research is valuation of public projects.

The aim of the research is to reveal the methodology of TOPSIS method and evaluate investment options for a rural community public project by the TOPSIS method.

Research tasks: 1) to present a methodology for TOPSIS multi-criteria method applied for the evaluation of public projects; 2) to evaluate investment options for a rural community public project by the TOPSIS method; 3) to determine the advantages and limitations of TOPSIS method used for public project evaluation.

Scientists use different Multi-criteria evaluation methods: SAW (Simple Additive Weighting), MOORA (Multi objective optimization on the Basis of Ratio Analysis), TOPSIS (Technique for order Preference by Similarity to Ideal Solution), COPRAS (Complex proportional Assessment), ELECTRE (Elimination and Choice Expressing Reality), PROMETHEE (Preference Ranking Organisation Method for Enrichment Evaluation) and other methods. TOPSIS method is chosen for this theoretical and empirical research to justify combining different social benefits and costs indicators.

Materials and Methods

TOPSIS (Technique of Order Preference by Similarity to Ideal Solution) method considers three types of attributes or criteria: qualitative and quantitative benefit attributes/criteria and cost attributes or criteria.

Two artificial options are hypothesized in TOPSIS method:
1. Positive ideal option: the one which has the best level for all attributes considered.
2. Negative ideal option: the one which has the worst attribute values.

TOPSIS selects the option that is the closest to the positive ideal solution and farthest from negative ideal option. The steps of TOPSIS method applied for

public project evaluation are presented in Figure 1.

1-3 steps are the preparation for public project evaluation using TOPSIS method. The qualitative indicators of social benefits put in numerical value using the scale. The evaluation scale reveals the impact of investment options on the project's target group according to the selected evaluation indicators for project effects.

Numerical value	1	2	3	4
Description of the effects of investment option on the evaluated indicator	No effects	Weak effects	Medium effects	Strong effects

The solution received using the TOPSIS method is the best one (the investment option is assessed by creating the biggest social benefits to the society), which is the closest to the ideal solution and farthest from the worst solution (Olson, 2004).

Vector normalization is applied in the TOPSIS method (Ginevičius and Podvezko, 2008):

$$\tilde{r}_{ij} = \frac{r_j}{\sqrt{\sum_{j=1}^{n} r_j^2}} \qquad (i=1,...,m; j=1,...,n); \qquad (1)$$

Where: $\tilde{r}_{ij}$ - i -th indicator, j -th option normalised value.

The best investment option V* and the worst investment option is calculated using the following formulas (Lofti at al, 2007; Ginevičius, Podvezko, 2008):

$$V^* = \{ V_1^*, V_2^*,..., V_m^* \} =$$
$$\{(\max_j \omega_i r_j / i \in I_2), (\max_j \omega_i \tilde{r}_j / i \in I_2)\} \qquad (2)$$

$$V^- = \{ V_1^-, V_2^-,..., V_m^- \} =$$
$$\{(\max_j \omega_i r_j / i \in I_2), (\max_j \omega_i \tilde{r}_j / i \in I_2)\} \qquad (3)$$

Where: I_1 – a set of maximised indicator indices, I_2 – a set of minimised indicator indices.

The total distance of every compared option from the best decisions and from the worst decisions is calculated according to the formulas.

$$D_j^* = \sqrt{\sum_{i=1}^{m} (\omega_i \tilde{r}_j - V_i^*)^2} \qquad (4)$$

$$D_j^- = \sqrt{\sum_{i=1}^{m} (\omega_i \tilde{r}_j - V_i^-)^2} \qquad (5)$$

TOPSIS method criterion C_j^* is calculated using the formula:

$$C_j^* = \frac{D^-}{D_j^* + D_j^-} \qquad (j=1,...,n) \qquad (6)$$

The value C_j^* of such criterion may vary from 0 to 1 ($0 \leq C_j^* \leq 1$). The best investment option is expressed by the biggest C_j^* value.

Combining various social benefit indicators of public projects in one measurable indicator, all options of public projects can be compared with each other.

Results and Discussion

In order to justify methodology for public projects evaluation using TOPSIS multi-criteria method, the empirical research was carried out. The rural community public project was evaluated seeking to choose the best investment option regarding investment costs, operating costs and social benefits.

The rural community has approximately 450 residents, while approximately 30 percent of them are young people. One of the main goals of the community is to gather the residents of Gudeliai and neighbouring villages in searching for the most appropriate decisions to raise economic and social well-being and to create safe and convenient living environment. There are two main problems raised in a village: unemployment and the lack of public infrastructure, resulting in decrease of population, when young people are leaving to work in the biggest cities of the country or abroad, while the village is disappearing. The remaining residents,

Table 1

Goal of rural community project and investment options

Project goal	Investment options		
	I Option	**II Option**	**III Option**
To improve living conditions for members of rural community, create public infractructure for leisure	To equip a sports court, where people could play basketball, volleyball, badminton and mini football.	To equip a library with a computerised reading room.	To create a modern beach near a pond that is close to the village.

Table 2

Valuation of indicators for investment options of rural community project

Indicators of social benefits	Valuation of social benefit indicators based on the investment options			Description of the assessment applied to the indicator
	I	II	III	
1. Increase of the variety and quality in the leisure time for the residents	4	4	3	Village residents of different age will be able to spend their leisure time in the equipped sports court. There will be an opportunity created to engage in all kinds of sports: basketball, volleyball, tennis and badminton. The library will provide an opportunity not only to read the literature, but also to find out the necessary information on the internet. The beach is less attractive because it can be used only during a particular season.
2. Improved possibilities for self-education, development of hobbies and talents	3	4	3	The best conditions for self-education are created by equipping a library. The sports court and beach create a possibility to discover and educate the sports talents.
3. Improvement of residents' health.	3	1	3	The created infrastructure will encourage people to do sports outdoors, be healthier, get fit, everything that increases health and helps to rehabilitate the ability to work helps to develop a healthy lifestyle. Sports and water procedures are essential both for kids and young people as well as working residents.
4. Decrease of destructive activities of the youth.	4	3	2	The inappropriate behaviour of children and teenagers is usually encouraged by lack of measures devoted to their favourite activities. Upon the appearance of a possibility to do sports in the qualitative manners, to read their favourite literature, the youth will be directed away from destructive activities - smoking, consuming alcohol and vandalism. The attractive infrastructure will motivate children to take up sports and reading activities appropriate for their age, to find out their hobbies and develop them, leaving behind the waste of time or destructive activities.
5. Encouraging the sense of community for the residents.	4	3	4	Even the idea of the project itself encouraged the village community to cooperate when implementing this project. The created infrastructure will serve as a common place for rural people, where they will be able to spend their leisure time. In such a way the sense of community is encouraged among the residents.
6. Decrease of depopulation in the village.	3	3	3	One of the reasons why people emigrate from the village and move to the cities are social and cultural factors. Upon implementing the project and creating the infrastructure to spend the leisure time purposefully, the village will become a more attractive place to live. Considering the positive effect of the project to the social environment and the initiative of the residents when preparing and implementing the activities of the project, it is possible to state that the project will have a positive effect in reducing the depopulation of the village.
7. The natural diversity of the environment is harmed.	1	1	2	Preservation of natural environment is considered when implementing the project. When improving the beach, the low value bushes are removed from the shore and the accumulated sludge is cleaned. Upon cleaning the shore near the pond, the natural flora and fauna may be harmed.

Source: compiled by the authors

especially young people do not have any place where they can spend their leisure time. In order to solve the mentioned problem, it was decided to prepare and implement the investment project and perform the investigation of the needs of residents. Three optional investment projects were prepared, which are briefly described in Table 1.

The social benefit indicators are formulated to compare the investment options, assessing of which is based on a scale, considering the expected effect of the project (Table 2).

It should be noted that the presented indicators reveal not only the benefits created by the public project, but also its harm (negative impact on the natural environment). When normalising the values of the indicators, the indicators of social benefits are maximised (the more the better), while the harm indicators are minimised (the less the better). In order to take into account the investment costs and the maintenance costs for the established infrastructure, they are also included into the multi-criteria valuation by giving them a numeric value in the range of 1-3 and comparing the investment options with each other.

The main goal of public project is to create social benefits for the society; therefore, social benefits are more important than investment and operating costs. Due to this reason the presumption is made that all indicators of social benefits are equally important and

Table 3

Evaluation of investment options applying TOPSIS method

Investment options	Number of social benefit indicators							Operating costs in EUR per year	Investment costs (EUR)
	1	2	3	4	5	6	7		
I option	4	3	3	4	4	3	1	900	40547
II option	4	4	1	3	3	3	1	4800	28962
III option	3	3	3	2	4	3	2	900	57924
Construction of normalized decision matrix									
I option	0.67	0.50	0.75	0.80	0.67	0.60	0.50	0.18	0.53
II option	0.67	0.67	0.25	0.60	0.50	0.60	0.50	0.97	0.38
III option	0.50	0.50	0.75	0.40	0.67	0.60	1.00	0.18	0.76
Construction of the weighted normalized decision matrix									
I option	0.67	0.50	0.75	0.80	0.67	0.60	0.50	0.09	0.27
II option	0.67	0.67	0.25	0.60	0.50	0.60	0.50	0.49	0.19
III option	0.50	0.50	0.75	0.40	0.67	0.60	1.00	0.09	0.38
Determination of separation from ideal solution									
I option	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01
II option	0.00	0.00	0.25	0.04	0.03	0.00	0.00	0.16	0.00
III option	0.03	0.03	0.00	0.16	0.00	0.00	0.25	0.00	0.04
Determination of separation from ideal negative solution									
I option	0.03	0.00	0.25	0.16	0.03	0.00	0.25	0.16	0.01
II option	0.03	0.03	0.00	0.04	0.00	0.00	0.25	0.00	0.04
III option	0.00	0.00	0.25	0.00	0.03	0.00	0.00	0.16	0.00
Calculation of relative closeness to the ideal solution									
I option	**0.8251**								
II option	0.4741								
III option	0.4816								

have weights 1, and investment and operating costs have weights 0.5.

Considering the importance of indicators, the indicators of each investment option are combined into one comparative indicator using TOPSIS multi-criteria method. The numeric and normalised values of social benefits indicators of the rural community project investments options are provided in detail in Table 3. After relating to the normalised indicators, considering the coefficients of their importance, it is possible to compare the expected social benefits of the village community project investment options.

Applying TOPSIS, multi-criteria method can be stated that the 1st investment option of rural community project is the most effective considering social benefits, investment and operating costs.

In summary, the valuation of the public project using TOPSIS multi-criteria method made it possible to incorporate into valuation various indicators of social benefits, compare investment options and make the right investment decision.

Conclusions
1. TOPSIS multi-criteria method allows combining the social benefits, harm as well as investment

and operating costs, which are expressed in the public projects by measurable and non-measurable indicators in monetary units. Cost-benefit analysis usually allows only the assessment of social benefits of public project measurable in monetary units. After defining project goals, investment options and indicators of social benefit, TOPSIS method could be applied for valuation of each investment option. Main steps of TOPSIS method consist of construction of normalized decision matrix, determination of weight to each indicator, determination of separation from ideal solution and ideal negative solution and calculation of relative closeness to the ideal solution.

2. The valuation of rural community public project applying TOPSIS method was carried out. Project goal is to improve living conditions for members of rural community, creating public infracrcture for leisure. Three investment options were evaluated in order to reach the goal of the project. Seven social benefit indicators were identified for the project, which are related to the improvement in the quality of rural people spending leisure time, the possibilities of self-expression, health

promotion possibilities, decrease of destructive habits in youth, depopulation in the village, etc. The social benefit indicators as well as investment and operating costs will be combined using the TOPSIS method and selecting the most efficient investment option.

3. Upon performing all of the steps in assessment of the public project in practice, when applying the TOPSIS method, it is possible to summarise the advantages and limitations of the method. The main advantages: 1) enables to evaluate the indicators measured in monetary and non-monetary units; 2) enables to evaluate the chosen indicators that do not have a qualitative expression; 3) the

indicators can be chosen and combined depending on specific situation, project or evaluation purposes. The limitations of TOPSIS method used for public project valuation: 1) separate options are not evaluated; the method allows to rank the options; 2) it is not clear how to evaluate the impact of public projects on social welfare when the investment horizon is long; 3) the final result is highly determined by the weight of indicators; 4) the objectivity of valuation is highly impacted by the qualification, logical reasoning and creativity of the expert. However, due to the mentioned advantages it can be successfully applied for the evaluation of public projects.

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