MODEL OF INVESTMENT EVALUATION OF PUBLIC BUILDING BASED ON MULTIPLE CRITERIA DECISION SYNTHESIS METHODS

Vaidotas Šarka, Edita Šarkienė, Saulius Budinas

Vilnius Gediminas Technical University
Department of Building Technology and Management
Saulėtekio al. 11, Lithuania
E-mail: Edita.Sarkiene@mail.lt

1. INTRODUCTION

The aim of the study is to answer the question whether it is advisable to invest in hotel construction business in Vilnius city or the huge investments placed in hotel construction could be used for buildings of other purpose.

The forecast states that for successful development of tourism in Lithuania and especially in Vilnius there should be more than 80 new hotels opened till 2015 in Vilnius city in order the foreign guests would not meet the difficulties of staying while visiting the capital. Comparing the average number of hotel rooms for 100 000 residents in Prague and Budapest with the analogous number in Vilnius, the results show that in Vilnius there are 3,5-4 times less hotels [1].

From 2001 till 2004 the boom of new hotel construction in Lithuania has taken place. According to the data of Statistics Lithuania there were 49 hotels in Vilnius by July 2002 [2]. During 2002 about 12 hotels of different categories were built or renovated in Vilnius city.

The tendency of hotel occupation: increasing occupation from 39% in1996 till 49% in 2001 again fell to the extremely small limit of 38,53 percent in 2002-2003 [3].

As demonstrated by the worldwide practice, the hotel business is a venture and banks often finance the hotel construction with reluctance [4].

The analysis of office market was performed for comparison. The tendencies of market saturation with modern office premises are observed in the office market. Most of the modern office buildings (business centres) introduced into the market last year had 80-90 percent of the rented premises on the opening day, however several business centres built and opened this year could not demonstrate such rates. The rent price of the modern office premises in prestigious business centres in 2001 – 2002 ranged from 60 to 80 Lt/m^2. At the moment the maximum rent price of the modern office premises in more expensive business centres (for example, „Europa“, „Verslo centras 2000“) ranges from 60 to 68 Lt/m^2, and in another business centres from 40 to 60 Lt/m^2 a month.

In order to achieve the set objectives the analysis of works of foreign and Lithuanian authors was performed and the decision model based on financial and economical indicators for evaluation of hotel construction in Vilnius and investment efectiveness comparison with business building was developed.

2. REVIEW OF DECISION SUPPORT SYSTEMS AND EVALUATION REQUIREMENTS

Many research works have been reported for solving relevant problems of housing construction (design, construction, finance, maintenance) [5-8]. The tools proposed by J. Park [9], S. Piramuthu [10] use information technology to support the different decisions of construction evaluation methods and managing information.

According to the expert system developed by J. Christian the preliminary estimated building price and the construction duration may be determined in the pre-design stage. Using the data of previous constructions (price) and referring to experts' experience the system may predict the prices of forthcoming objects [11].

S. Mohan has described the expert systems developed in various countries: calendar planning system PLATFORM, site preparation SI-TEPLAN, analysis of industrial safety HOWSAFE (Stanford University, USA), determination of preliminary construction price and duration, making construction plan PLANEX, analysis of building site DSCAS (Colorado State University, USA), Strategic planning of construction projects ELSIE (University of Salford, UK), analysis of construction process, analysis of risk (University of Texas, USA), analysis of risk (Georgia Institute of Technology, USA) [12].

Ozdoganm I. D. and Birgonul M. T. (Middle East Technical University, Turkey) have developed a model, on the base of which the multiple decisions in BOT (Build-operate-transfer) type projects were made – in municipal projects with private capital participation. The model developed evaluating not only the selection of contractors, but also the risks. The essence of the model is the help to select a municipality when a private company is allowed to finance, build and operate an object for some time till the disposal to municipality [13].

Model of economic evaluation of hotel construction based on multiple criteria decision synthesis methods

The two-stage model for evaluation of hotel construction investment effectiveness is selected. The recommendable system of indicators is prepared (Fig. 1).

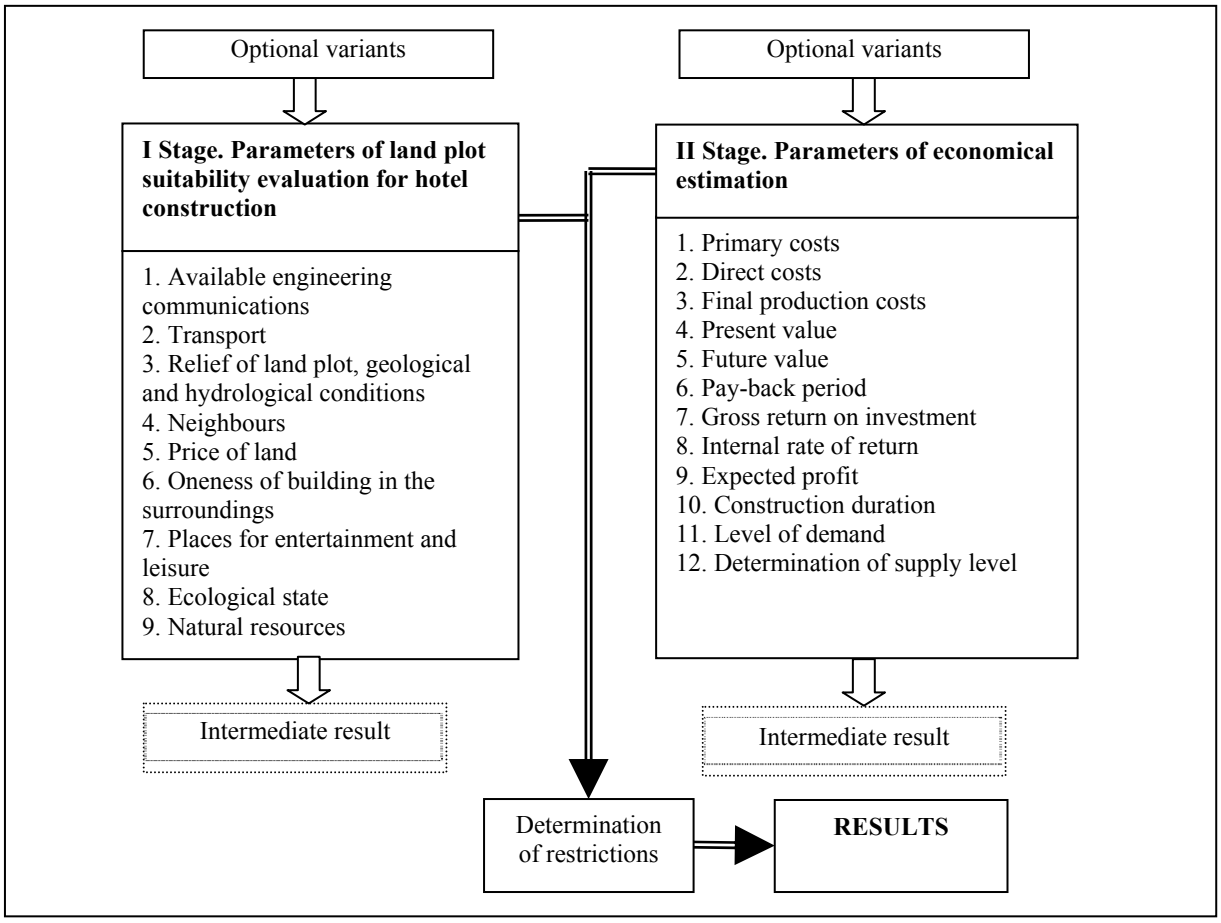

Fig. 1. *Indicators of hotel and office evaluation system*

In the first stage the land plot for commercial building is evaluated, in the second stage the economical comparison of the possible variants of hotel construction and commercial building is made.

For decision-making, the authors have selected a modern method of multiple criteria project synthesis DSS1 [14, 15]. The method consists in a synthesis of a number of interrelated technical solutions by selecting the best decisions at any stage of analysis.

Synthesis is a solution incorporating various problems (stage solutions) into a common project based on the relationship matrices [14].

The underlying principal of the two main structural elements of decision support systems: data (DB and their control system) and the major elements of economic evaluation of hotel construction model (the structure of the expert methods, integrated solutions and multiple criteria assessment methods) are shown in Fig. 2.

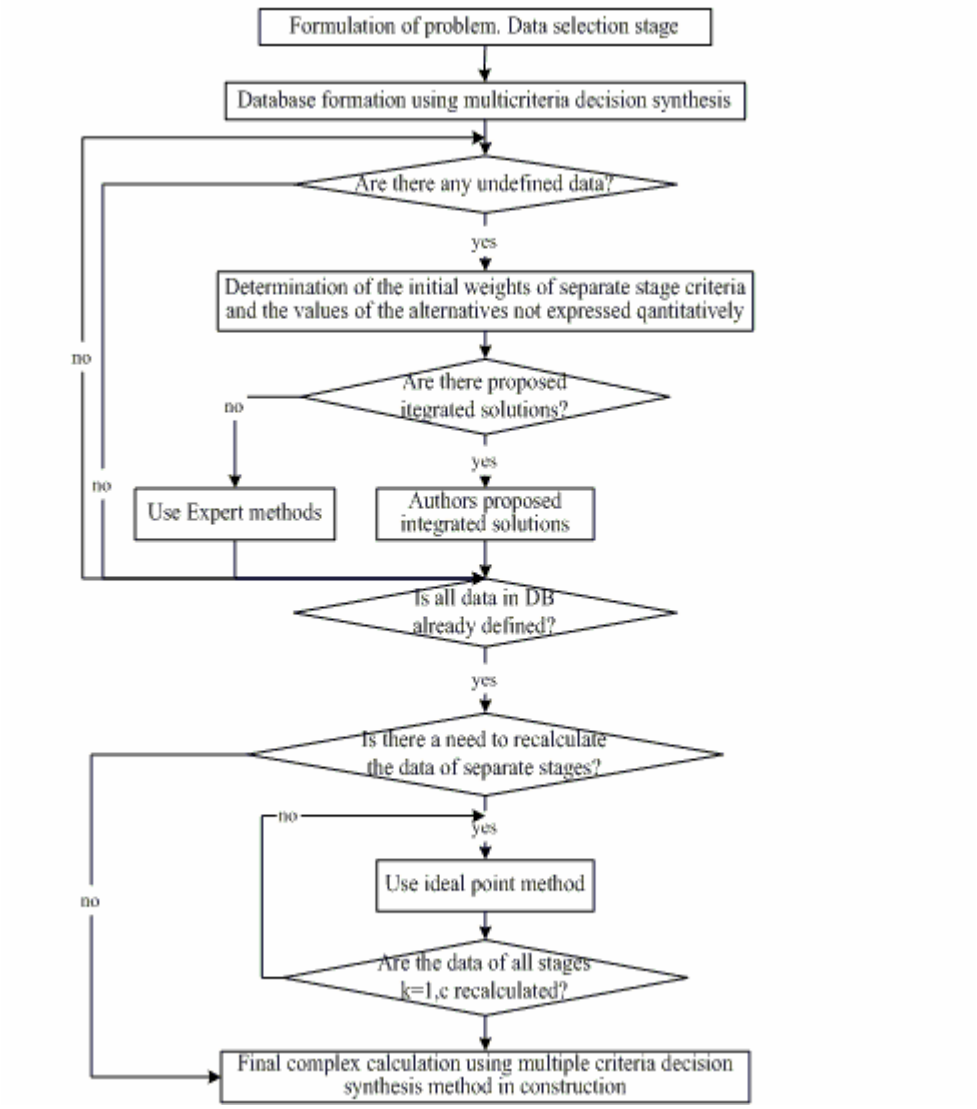

Fig. 2. *Scheme of economic evaluation of hotel construction based on multiple criteria decision synthesis methods*

The first stage of decision-making is intended for stating the problem and selecting a database structure (DBS). At this stage the data is being collected (i.e. criteria to be used, data on the variants, relationship matrices needed, etc.) which will make a database. Sets of closely interrelated criteria to be used in both stages are defined. Criteria referring to the variants under consideration are subdivided into qualitative and quantitative ones. For calculation of the criteria values, descriptions or particular formulas will be used in the model.

For evaluation of the qualitative criteria, the descriptions for expert assessment during decision-making or integrated pre-assessed qualitative criteria are provided.

Based on the approach described in [15], a tree of economic evaluation model to be used in the construction of hotels has been formed (Fig.3).

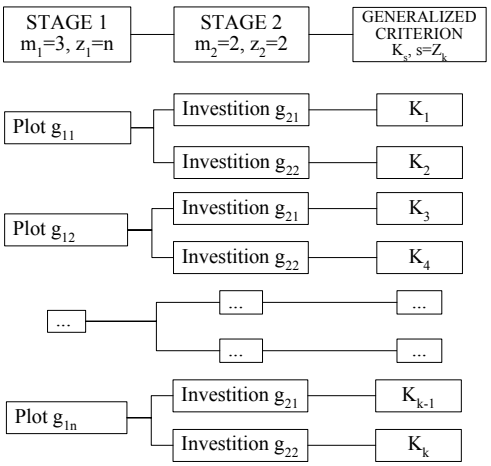

Fig. 3. *Fragment of a decision tree (DT) structure formed by multiple criteria decision synthesis methods*

2.1. Indicators Describing the Land Plot

For the land plot evaluation indicators the authors have developed a system of integrated indicators. In order to increase the evaluation reliability and to decrease the influence of subjective factors on the expected result, the internal criteria were determined for each parameter. According to the determined internal criteria, the possible variants of the indicators were formed and evaluated by the experts. Description of the indicators is presented together with the particular values. If during evaluation the selection is made from the variants to which the integrated indicators' values can not be applied, it is recommended to apply the interpolation method and to recalculate the value for the new variant of the new created indicators.

Indicators describing the land plot as follows:

Engineering communications. According to the existing project it is needed to join the water-supply system, sewerage, heating and electricity nets. Each of these connections may be given the marks from 1 to 5, depending on the distance to the connection places, because the biggest costs appear when making the cut the uplift or going round the existing nets is necessary.

The connections are evaluated:

- Connection to existing nets by 50m distance – 5 points;
- New filiations to existing nets (in suburb), when there are no more nets requiring uplifting or going round – 4 points;
- Connection to existing nets by 50 - 100m distance – 3 points;
- Connection to existing nets over 100m distance – 2 points;
- Connection to existing nets performing renovation of the main trace or fulfilling other special requirements – 1 point.

Experts helped to determine the economical influence of outdoor engineering net connections on project proceeding.

Table 1. Engineering communications expert evaluation form

	P1	P2	...	Pn
E1	xp11	xp21	...	xpn1
E2	xp12	xp22	...	xpn2
...	...	...	...	...
Em	xp1m	xp2m	...	xpnm

The experts were selected having experience of more than 10 years in constructional and engineering works. The experts were asked to evaluate the economical significance of each connection by the positions (the most significant No. 1, the less significant No. X). Collecting the expert

assessment, the significance of each connection was derived, while the maximum significance was 5 points (Table 1).
Where E – expert, P – connection, x − assessment

The expert assessment of each connection P is obtained by the sum:

$$A_n = \sum_{n=1}^{m} xp_{nm} \quad (8)$$

The average assessment of each expert is calculated X:

$$Xpn_{vid} = A_n / m \quad (9)$$

It is assumed that the least value Xpnvid is the best value (from the other point of view this will be the factor having the biggest influence to the project) – 5 points (that is 100 percent of assessment), thus every other Xpvid is calculated as deviation from the best result, because it indicates also the fact that assessing the experts expressed their opinion, the prices of the works of the smallest and the largest assessed Pmn will differ proportionally. Therefore the significance parameter for each P may be derived:

$$Kpn = 5 / Xpn_{vid} \quad (10)$$

Transport. Mounting of roads and streets is related to additional costs, restrictions of communication means and transport types. Therefore roads and streets and their state influence evaluation of land plot, however this depends on land usage, intensity and purpose of usage [5. p.73].

As the road network in Vilnius is sufficiently developed, the main factor for transport evaluation is the distance from the land plot to the airport, railway station and city centre (city centre is the Central post office), where the objects of the biggest interest for business customers are concentrated. Each of the distances is given the mark from 1 to 0,1, depending on how many kilometres is the land plot far from the mentioned objects (Table 2). The maximum evaluation is 1 point if the land plot is 1km away from the object, 0,1 points if 10km or more. The maximum allowable value of the parameter could be 3 points.

Table 2. Possible values of transport evaluation

	<1km	<3km	<5km	<7km	<9km	>10 km
Centre	1	0,8	0,6	0,4	0,2	0,1
Airport	1	0,8	0,6	0,4	0,2	0,1
Railway station	1	0,8	0,6	0,4	0,2	0,1

Relief of land plot, geological and hydrological conditions may restrict the constructional decisions and the total price of the building. Soil properties are the ones of the decisive factors in design and foundation mounting. Parameter values are recommended to use for evaluation:

- 3 points ─ good conditions (natural stiff soil, no former building, low level of groundwater),
- 2 points ─ average conditions (stiff soil, remains of former demolished buildings, high level of groundwater),
- 1 point ─ satisfactory conditions (unstable, bulk soil, remains of former demolished buildings, high level of groundwater).

Neighbours. The evaluation is made according to the district and the purpose of nearby buildings. The less is the territory built up or the further are the neighbours from the project territory, the less is the sum of the required investments. Evaluations offered:

- Land plot neighbours non built up territories (no restrictions for constructions) ─ 4 points
- Land plot neighbours industrial territories (minimum restrictions) ─ 3 points
- Land plot neighbours commercial or cultural heritage territories, partially restricted access (many minor restrictions) ─ 2 points
- Land plots neighbours residential or secured territories (many particular and strictly defined restrictions) ─ 1 point.

Price of land are. Price is one of the most important indicators in the land plot evaluation. It includes not only the technical and qualitative data of the land plot, but also the prestige of location, traditions, possibilities for future development and growth [15]. It is recommended to use the average district price for area.

Oneness of building in the surroundings is the indicator depending not only on the architectural decisions of the building, but also on the dislocation of the land plot in respect of the main streets.

It is stated, that location of land plot in respect of other plots is related with additional usage costs, noise, convenient access road and so forth, therefore evaluation of this indicator depends largely on the purpose of land plot. Evaluation variants:

- Open place by the main street – 3 points;
- Place by the main street, though the height of the building is limited or there are other conditions due to the overall aesthetic view of locality – 2 points;
- Place by the back street, surrounded by other buildings – 1 point.

Places for entertainment and leisure. Evaluating the place by this indicator it is necessary to take into account the distance by which the recreational centres are located, the easily accessible net of cafes, bars, night clubs, shops, museums and theatres (preferably on foot) [16]. It shows the concentration in one or another neighbourhood to the companies in 1km^2. The evaluation indicators for Vilnius were proposed in (Table 3).

Table 3. Entertainment and leisure indicators values

Vilnius city district name	Value
Old town	8,4
New city	22,4
Zverynas	2,8
Saltoniskes	2,8
Verkiai	3,3
Airport area	5,1
Karoliniskes	2,0
Business triangle	22,4
Antakalnis	3,9

Ecological state. Ecologically clean accommodation environment should be one of the most important criteria evaluating the land plot, in order to ensure the most favourable conditions for the hotel activity. The indicator is affected by many factors: traffic flows, overall atmospheric and soil pollution in place, development of production industry, noise and radiation phones.

- Good ecological state (No any afore-mention cause) – 3 points,
- Satisfactory (1-2 causes) – 2 points,
- Poor (3-4 causes) – 1 point.

Natural resources. For each underwritten natural resource being close to the potential land plot 0,20 points are added to the initial 0.20 points: park/forest, natural water body, ornamental water (basins, ponds), spectacular landscape.

2.2. Economical Evaluation

Economical evaluation involves all stages for activity preparation, activity process itself and selling of product in the past, present and future (formation and usage of labour, material resources, economical and financial indicators of activity).

Economical – financial evaluation of investment projects is the rational way to make a decision.

Hereafter the short description of the economical indicators is presented.

Primary costs comprise the costs occurring at the beginning of a company / project. These costs appear only once. Engineering design and soaking up costs, costs for research work and production of experimental samples, equipment purchasing and mounting costs can be assigned to this cost group.

Direct costs – the magnitude of direct costs is directly proportional to the quantity of production or time needed for producing. Costs for raw materials, stuff, wages and so on are assigned to direct costs.

Final production costs include all the costs necessary for the item production.

Economical evaluation of engineering project is based on the planned cash flow. These flows show the future investments, incomes and expenses. One of the most responsible and complicated moments in evaluation is the forecasting of future cash flow for the period of the nearest 5 years. In this way the value of how much future money is worth now is determined.

Pay-back period represents the amount of time that it takes for a project to recover investments made.

Gross return on investment was total profit, received from a project during the whole lifetime, divided by the amount of investments and expressed in percent.

Internal rate of return is the project rate of return, when the present value of all cash flows received from the project is equal to zero. Thus this rate is a certain profitability measure and the external economical factors, capable to affect the planned investment flows, are not evaluated in this rate.

Evaluating the project the one with the biggest positive internal rate of return is selected.

Expected profit is the calculated weighted average profit applying probabilities. It describes the average or the main tendency of probabilistic profit distribution:

The expected profit is the mathematical average of the different possible profit rates. Mathematics statistics call the expected magnitude the first moment of stochastic distribution. The second moment of stochastic distribution (around the mean) is called the average square deviation.

Construction duration. The duration is calculated from the beginning of the pre-design stage to the planned date of the object commitment for exploitation.

The detailed description of the indicators is presented [17].

Level of demand. The year 2003 was one of the most successful for developers of all types of real estate. The especially high demand for all types of real estate determined the increase in sales price 10-40%, depending on the type of real estate. Although quite a high demand was for the rent of premises as well, there was no price increase in this segment of real estate market – prices for rent (especially the ones for old offices, luxury flats and houses) are decreasing little by little as the supply of new objects is increasing.

Under these market tendencies - increasing sales prices, decreasing or constant rent prices - the profitability of investment to real estate buying and then renting the premises fell to 6-12% in the sector of residential and commercial premises. Depending on a market sector, the profit of real estate developers remains 15-30%. However, increasing building costs, rising price of land plots and growing competition should diminish the profit of real estate valuators in future.

Determination of supply level. The experts have evaluated the supply of construction branch production according to the following factors [4]:

- Costs;
- Technologies. With improvement in technology, the price of production decreases and the quality increases;
- Prices of complementary goods. Products in manufacture may complement or substitute each other. For example, cheapening of alternative windows decreases the price of building renovation;
- Other factors: political shocks, wars, strikes, policy of interest rate, etc.

Table 4. Suggested values of integrated rates of demand level indicator

Indicator	Arbitrary notation of indicator	Integrated value of indicator
Demand level increases	A11	10.0
Demand level is constant	A12	8.0
Demand level decreases	A13	4.0

Table 5. Suggested values of integrated rates of suppply level indicator

Indicator	Arbitrary notation of indicator	Integrated value of indicator
Supply level is lower than demand level (shortage)	A21	10.0
Supply is equal to demand level	A22	6.7
Supply level is higher than demand (market surplus)	A23	3

3. EVALUATION OF HOTEL CONSTRUCTION IN VILNIUS

3.1. Selection of Location

Following description presented in second chapter, location variants were selected. For each variant initial data was created. Initial date was presented in table 6. When model of evaluation of hotel construction applying multiple criteria decision synthesis methods is using, integrated solutions to be used, and decision maker don't need ask expert to evaluate situation (exept if there will be no variant in recomendation

This provide more clear view of use expert and also save time of decision maker.

Performing the first stage research by the multiple criteria synthesis method, the intermediate result was obtained. It shows that economically the most suitable land plot for the hotel construction is in „Verslo trikampis". The lands plot for the hotel construction in Senamiestis, Gedimino pr. was the second and in Verkiai the third one according to the suitability.

Table 6. Variants of multiple criteria evaluation of construction

Indicators	Expressed in monetary units or not	Units of measure	Min or Max	Weight	Var.1	Var.2	Var.3	Var.4	Var.5	Var.6	Var.7
Engineering communications	-	points	+	0,32	4.68	3,50	3,68	3,40	1,85	3,93	4,35
Transport	-	points	+	0,11	2,30	2,00	0,60	2,20	1,30	2,10	1,30
Relief of land plot	-	points	+	0,11	2,00	1,00	3,00	3,00	2,00	3,00	1,00
Neighbours	-	points	+	0,11	2,00	2,00	3,00	3,00	1,00	4,00	1,00
Price of land are	+	1000 Lt.	-	0,11	70,00	80,00	13,00	11,00	3,00	90,00	70,00
Oneness of building in the surroundings	-	points	+	0,10	3,00	3,00	2,00	2,00	1,00	3,00	2,00
Places for entertainment and leisure	-	%	+	0,11	8,40	2,80	3,30	5,10	2,00	22,40	3,90
Ecological state	-	points	+	0,11	2,00	1,00	3,00	1,00	2,00	1,00	3,00
Natural resources	-	points	+	0,11	0,50	0,50	0,50	0,25	0,25	0,25	0,75

3.2. Economical Evaluation

In order to determine the more economical engineering project in the second stage, as variant of the hotel construction the possibility to build the commercial building was selected. From all criteria described in the methodological part, only these indicators were used for calculations which values do not double each other. For example, from the profitability indexes only the gross return on investment was selected, as the values of other indexes are identical. Selecting the criteria it is important to keep the groups of criteria: costs, payback period, profitability indexes and so on. Significance of the criteria is determined by the expert methods, interviewing experts [17]. The initial data is presented in Table 7.

Performing calculations the restrictions for commercial building location were determined. The location of hotel construction was not restricted.

After the calculations performed by the SPS_DS system applying multiple criteria synthesis methods, the result was obtained. It shows that economically promising is the construction commercial building in "Verslo trikampis" or in Senamiestis.

In general, 10 project alternatives (options) have been made based on the initial data, expert methods and multistage multicriteria decision synthesis DSS1 approach. Then the most efficient alternative of architectural solutions including design, choice of structure and source of financing was calculated by DSS1 method (Table 8). This was as follows:

- Business triangle;
- Office building;

It should be noted that the above system does not provide for precise calculations. A model is based on generalized criteria giving a possibility to choose among a number of the available decisions.

Table 7. Initial data on criteria for economical estimation

Indicators	Units of measurement	Min or Max	Initial significance	Hotel construction	Office building construction
Costs:					
Primary costs	Thousand Lt	-	0,1019	5600	4000
Direct costs	Thousand Lt	-	0,0982	29000	20000
Final production costs	Thousand Lt	-	0,0964	58000	40000
Money time value:					
Present value	Lt	-	0,10	0,92	0,95
Future value	Lt	+	0,0988	1,34	1,34
Pay-back period	Years	-	0,1080	8,83	7,31
Profitability indexes:					
Gross return on investment	Percent	+	0,0976	113,28	136,80
Internal rate of return	Percent	+	0,1007	11,33	9,12
Risk:					
Expected profit	Percent from 1 Lt	+	0,1068	0,11	0,14
Construction duration	months	-	0,0915	20,00	12,00
Level of demand	points	-	0,5000	8,00	8,00
Determination of supply level	points	-	0,5000	4,00	2,00

Table 8. Determination of the most efficient construction variant for a dwelling house using project multiple criteria evaluation synthesis method DSS1. The data of 5 best variants.

Variant priority	Variant №	Kbita value	Variant composition		Value of K_{bit} alternatives
1	12	1,00			
			6	Business triangle	1,0000
			2	Office building	1,0000
2	2	0,96			
			1	Old Town	0,9572
			2	Office building	1,0000
3	11	0,88			
			6	Business triangle	1,0000
			1	Hotel	0,7906
4	1	0,84			
			1	Old Town	0,9572
			1	Hotel	0,7906
5	5	0,81			
			5	Verkiai	0,9196
			1	Hotel	0,7906

The authors believe that the model suggested may help to harmonize the needs of various interested parties with minimum expenses at least at the initial stage of investment process, thereby allowing making a contract and further development and implementation steps in the project.

4. CONCLUSIONS

1. The model for evaluation of hotel construction has been developed. The model is designed for the complex hotel location evaluation and for the comparison of investment effectiveness in the hotel and the commercial building construction.
2. The model is designed for Vilnius city. In order to apply the model in other localities, some of the criteria indicators should be revised.
3. The model was applied for the real problem solution. The result shows that more economically promising in the year 2004 is the commercial building construction.
4. The system of integrated indicators presented in the model allows reduction of the amount of expert evaluation work.

References

[1] Vilnius tourism development strategy. [review date 2004 - 02 – 28]. http://www.tourism.vilnius.lt (in Lithuanian)

[2] [review date 2004 - 02 - 28]. http://www.asa.lt/Leidiniai/naujienos/540.shtml (in Lithuanian)

[3] [review date 2004 - 02 - 28]. http://www.vilnius.lt/new/gidas.php?open=128&root=1&sub_cat=307#vies. (in Lithuanian)

[4] Brand J. E. Banks Renew Hospitality To Hotel Financing, *American Banker,* 162(16), 1997, pp.1-26.

[5] Zavadskas E. K., Kaklauskas A., Banaitienė N. *Multiple Criteria Analysis of a Building Life Cycle.*Vilnius: Technika, 2001. (in Lithuanian)

[6] Zavadskas E. K., Peldschus F., Kaklauskas A. *Multiple Criteria Evaluation Of Projects In Construction.*Vilnius: Technika, 1994.

[7] Šarka V., Zavadskas E. K., Ustinovičius L. Method of Project Multi-Criteria Decision Synthesis on the Basis of Decision Success Criterion, *Statyba*, VI (3), 2000, pp.193-201. (in Lithuanian)

[8] Šarkienė E. *Architectural Decisions Influence Dwelling – Housing Business*: Master Thesis. Vilnius: Vilniaus Gediminas Technical University, 2002. (in Lithuanian)

[9] Park J. S., Lim B. H., Lee Y. A Langrangian Dual-Based Branch-and-Bound Algorithm for the Generalized Multi-Assigment Problem, *Management Science*, 44(12), 1998, pp.271-282.

[10] Piramuthu S., Ragavan H., Shaw M. J. Using Feature Construction to Improve Performance of Neural Networks, *Management Science*, 44(3), 1998, pp.416-430.

[11] Christian J., Kallouris G. The Development Of Cost-Time Profiles For Selected Building Activities Using An Expert System. In: *Management, Quality and Economic in Building*. London, 1991, pp. 1459-1466.

[12] Mohan S. Expert Systems Application In Construction Management And Engineering, *Journal of Construction Engineering and Management,* 116(1), 1990, pp.87-99.

[13] Ozdoganm I. D., Birgonul M. T. A Decision Support Framework for Project Sponsor in the Planning Stage of BOT Project, *Construction Management and Economics,* 18, 2000, pp.343-353.

[14] Šarka V. *The Multicriteria Decision Synthesis When Selecting Rational Technological - Organisational Variants Of Buildings*: Doctoral thesis. Vilnius: Vilniaus Gediminas Technical University, 2000. (in Lithuanian).

[15] Šarka V. A Decision Support System Applying Multicriteria Sythesisi Methods in Construction, *Civil engineering*, VI (6), 2000, pp.264-268.

[16] [review date 2003 – 03 – 20]< http://www.vilnius.lt/tyrimas/3.htm> (in Lithuanian).

[17] Budinas S. *Economic Evaluation Model of Hotel Construction in Vilnius*: Master thesis. Vilnius: Vilniaus Gediminas Technical University, 2003. (in Lithuanian)

[18] [review date 2004-10-14]<http://www.oh.lt> (in Lithuanian).