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The Influence of Solutions Adopted at the Stage of Planning the Building Investment on the Accuracy of Cost Estimation

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Abstract

The accomplishment of building investments is a long-lasting process resulting in considerable financial outlays. Crucial decisions concerning construction solutions, technology of execution, organization of construction works are taken at the stage of planning and programming. At that time it is possible to predict the budget of an undertaking when it comes to preliminary cost estimation. However, taking accidentality, uncertainty of results, appearance of factors that were not planned earlier into account, it is important to know the total value of works. The solutions adopted at the stage of planning are reflected in costs in life cycle and determine the kind and range of possible risks. PERT approach used in the paper allows to present the costs of separate stages of the whole undertaking in ranges along with the probability of appearance.

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Keywords: cost estimation; planning investment; life cycle cost; risk analysis.

1. Introduction

The decision-making on the realization of investment project is usually preceded by a number of economic analyses, careful selection of variants and solution optimization. A proper method of assessment is chosen based on its usefulness during the verification of variants of investment projects (Kaplinski 2007). Profit maximization and the possibility of cost minimization are both of great importance to an investor. Technological progress and constant changes influence an increase of the investment cost. Therefore, an in-depth cost analysis seems to be important not only at the stage of

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planning, but also in the whole life cycle. At that time we will get a more complete picture of investment profitability. We do not limit ourselves only to the initial outlay which is fairly predictable. The expenses incurred during the maintenance of a building are also taken into account. The investment variant with the highest profit-to-cost ratio in the final account will be chosen for the execution. Therefore, the aim is to minimize cost taking into consideration its net present value. One of the methods allowing to analyse costs during the use of a building is Life Cycle Cost Analysis. Key decisions concerning the type of investment, way of realization, are taken at the initial stage of decision preparation. At this stage we can influence the incurred expenses which are dependent upon solutions and their changes adopted at the stage of design. It is assumed that outlays on the preparation and design of the investment (purchase of land, design fees, etc.) are comparatively small. However, decisions made at this stage have a big influence on the future expenses.

2. Cost Analysis in Investment Process

2.1. Type of costs

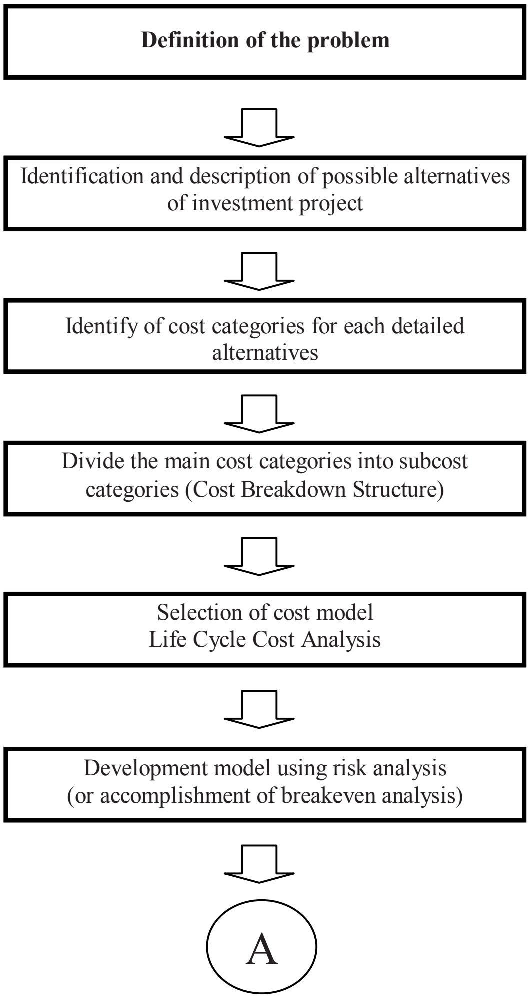
An analysis of main factors influencing the costs does not only come down to possible initial outlays (e.g. Land Acquisition, Equipment, Design Services). The basic part of costs connected with a building is incurred during the period of exploitation. Costs which we incur during the period of exploitation can be divided into two basic groups: fixed costs connected with current maintenance of a building as well as the costs incurred in certain time periods, connected with renovations, repairs, modernization of a building. The authors (Khanduri et al. 1996) divide costs into basic groups which should be considered in life cycle cost cash flow. The first group includes capital costs connected with a purchase of land, construction works, electrical system, etc. Operating costs such as: energy (gas, fuel), clearing, security, taxes, building insurance, administrative consist the next group. This group includes costs connected with use as well as annual expenditures connected with the operation of a building for office building. In the long term certain elements are subject to technical consumption. Therefore it is important to take into consideration expenses connected with renovation and maintenance (annual expenditures on contract service for maintenance of elevators, roof, facade, structural, etc.). The next group is annual profits (income from all rentable space - using area). And final group is residual value (salvage value), paid at the end of the economic life of a building. It is a value after a demolition of a building (resale of land or scrap of building). In case of LCC the attention is paid more to costs than to profits in the form of income or resale value of a part of the investment. Therefore, the attention is paid to costs connected with the preparation and realization of investment. Income and salvage value are treated as negative values (Khanduri et al. 1996) ,where capital cost and salvage value are single sums of money paid once. However, expenses on repair and maintenance , operating costs are paid every year at regular intervals (uniform series cash flow). Many times higher initial costs lead to lower costs connected with repairs, damage of products, service. Moreover, it is easier to estimate the initial costs assumed at an early stage and to include them in the assessment of investment profitability. The task of predicting and noticing the additional costs in the long run is more difficult because of market situation, fee changes, tax and inflation changes and the influence of random factors. Uncertainty and risk of an incorrect cost estimation may be also connected with the difficulty in the estimation as the costs should be estimated based on experience. Therefore, it is very important to gather all data on expenses and to apply the right model (Durairaj; EIC 60300-3-3). In order to reduce the risk associated with qualitative estimation it is advisable to perform sensitivity analysis. Based on this analysis it is possible to determine the variation in the results of cost analysis in life cycle. The authors (Banatinene et al 2008; Zavadskas et al. 2001) have a different approach and pay attention to multi-criteria analysis which allows to include in the account both qualitative and quantitative criteria which have an influence on LCC while choosing alternative variants based on this enormous amount of information.

2.2. Life Cycle Costing

Life cycle of a building consists of three basic periods: investment (the initial performance costs), exploitation (maintenance), disposal. Costs as well as the influence of a building on the environment should be examined in all these phases. Cost calculation of a building investment is performed at each stage of an investment process and as the subsequent assumptions of the planned investment become more precise, the calculation becomes more detailed. Each enterprise is different on account of a degree of complexity, type of a building, scope of works, however, some cost components are always present, among other things land purchase. Some cost components may undergo a significant change. It is worth paying attention to a zero state, the cost of which may increase on account of a type of land and the possibility of founding a building conditioning the use of additional reinforcement, protection of escarpments, drainage, etc. Moreover, the building completion may exceed even 50 % of building costs on account of the type and quality of the used materials. The necessity of incurring expenses on renovations and repairs stems from the determination of technical condition of a building and its technical consumption. Therefore, it is necessary to carry out repairs, renovations and change of worn out elements in certain time periods. The costs of it depend upon quality and durability of materials applied initially as well as upon the adoption of new solutions. Longer time periods may require an extensive general renovation – aimed at increasing technical efficiency of a building and consisting in structural changes made to a building, replacement of installation, etc.

Usually it results in considerable costs. One of the methods allowing to analyse costs during the use of a building is Life Cycle Cost Analysis (LCCA). The costs (performance, maintenance, repair) are widely used as crucial (and sometimes only) criteria for production or system selection based on a simple payback period. LCC analysis is required to demonstrate that operational savings are sufficient to justify the investment costs. Life cycle cost is the total cost including cost of acquisition, operation, maintenance, conversion and disposal. LCC are summations of estimates of cost from inception to performance and exploitation, who was determined by an analytical study and estimate of total costs experienced in annual time increments during the project life (consideration for the time value of money). The objective of

LCC analysis is to choose the most effective approach from a set of alternatives. It is worth achieve the lowest long-term cost of ownership. LCC is an economic model over the project life span. Usually the cost of operation, maintenance and disposal costs exceed all other initial costs many times. In order to compare variants using LCC it is necessary to determine the net present value of individual cost categories with the use of discount technique. The assumed discount rate (Woodward 1997; Departement of Education & Early Development 1999) reflects an actual profit which can be obtained from the invested capital and should take into account an inflation rate and risk factor. Data needed for LCC analysis are: type of a building, project location, initial capital cost, estimated life of the building, discount rate, operating and maintenance cost, disposal cost, salvage value of land and building, gross and rentable area, uncertainty and risk (Khanduri et al. 2996; Woodward 1997). LCC method is used in different areas, among others Project Engineering (where we considering minimize capital costs as the only criteria), Maintenance Engineering (minimize repair hours), Production, Reliability Engineering (avoid failures), Accounting (maximize project net present value) and Shareholders (Banaitinene et al. 2008; Khanduri et al. 1996; Reichelt 2008; Zavadskas et al 2001; Zavadskas et al 2005; and Kaplinski 2007). Figure 1 shows an operating procedure for LCC.



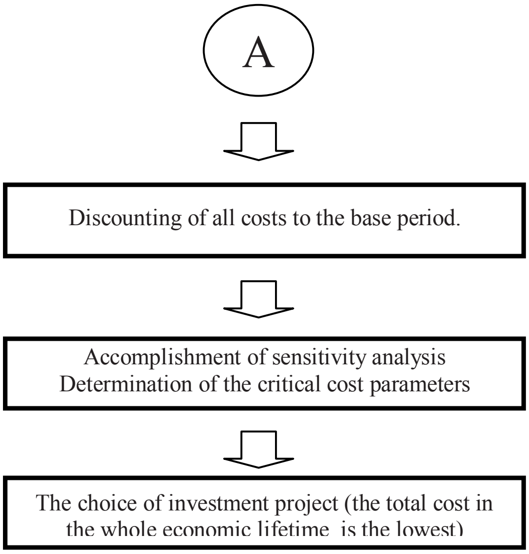


Figure 1. Life Cycle Costing Procedure

2.3. Influence risk factors on cost estimation

Changing conditions for realization on construction site, the necessity of applying new construction solutions with the use of new technologies as well as random nature of events influencing the whole life cycle encourage to make an attempt to include the risk in models and analyses (Shevchenko et al. 2008; Zavadskas et al. 2010). Therefore, the choice of a model is very important. The authors (Durairaj) present briefly the review of chosen LCC methodologies and tools taking into consideration the following specific cost models on the basis of their framework and limitations. They emphasize the importance of risk analysis and sensitivity analysis the aim of which is to isolate predominant costs and identify relationships between cost drivers and design changes. In case of construction projects time period is long – from a concept to exploitation and maintenance of a building. The risk taken into consideration in models is perceived as a possibility of deviation from an expected result. This risk is treated as a negative factor causing an increase of costs. It is a starting point for the estimation of the range of costs possible to incur in life cycle. The range of costs for separate construction works or all costs in NPV model are presented through curves (in this paper). Cost ranges and estimation of probability allow to assess financial reserves more precisely. There are many methods of risk assessment, applied at chosen stages of an investment process (Shevchenko et al. 2008; Zavadskas et al. 2010; and EIC 62198). In this paper the risk was assessed with the use of PERT approach. It is a widely applied method which uses the properties of Gaussian distribution. The method is employed in different areas, including selection where different criteria of a decision-maker are taken into account (Hatush and Skitmore 1997) When it comes to investment undertakings, the method is applied in order to determine deviations from the planned schedule and budget. Basic parameters essential to use the standardized Gaussian distribution are: mean value (Eq.1) and standard deviation (Eq.2). Next we receive a curve in which a certain time/cost value corresponds to probability of its occurrence.

$$C_{estimated} = \frac{C_{min} + 4.C_{opt} + C_{max}}{6} \quad (1)$$

$$\sigma_{C.estimated} = \frac{C_{max} - C_{min}}{6} \quad (2)$$

where:

C_{min} – means minimal cost

C_{opt} – means optimal cost

C_{max} – means maximum cost

$\sigma_{C.estimated}$ – means possible deviation from $C_{estimated}$

Therefore, assuming a certain level of costs incurred during the use of a building, it is possible, based on the distribution function, to assess the range of variation and probability of occurrence of a changed cost value.

3. Cost Estimating of Investment Projects

3.1. Description of project selection

Two possibilities of building realization, including costs incurred during the whole life cycle of a building, will serve as an example. Realization of A project is associated with high construction costs (better quality and durability of products, solutions ensuring energy acquisition from natural resources, etc.). It results in savings at the stage of building exploitation. The second B project is being constructed with the use of much lower financial resources. As a result, however, we incur higher costs of renovations, heating, possible replacement costs, etc. Present value of future financial outlays was determined based on a discount rate. A real discount rate used to make this calculation is 8% (taking into account a market risk factor and inflation rates). The life span of a building is taken to be 60 years. PERT approach was applied in order to assess possible deviations from NPV value caused by the occurrence of chosen risk factors.

3.2. Cost estimating

I would like to present to you the results of my investigations concerning of influence risk factors on cost estimations. From the theoretical and also practical point of view this problem is very important. The list of indispensible data and results of the analysis are presented in table no 1.

Table 1. Input data

Input data	Alternative A				
Building type: office building Estimated building life cycle: 60 years Discount rate : 8% Salvage value: 0 Income: 0 (not rentable floor area)					
Initial investment costs	C_{min}	C_{opt}	C_{max}	$C_{estimated}$	$\sigma_{C.estimated}$
Land Acquisition (thousand)	250 000,00	270 000,00	300 000,00	271 666,67	8 333,33
Site Investigation	20 000,00	24 000,00	28 000,00	24 000,00	1 333,33
Designe Service	40 000,00	50 000,00	60 000,00	50 000,00	3 333,33
Construction	500 000,00	580 000,00	700 000,00	586 666,67	33 333,33
Operation costs (annual)					
Heating Fuel	12 000,00	14 000,00	16 000,00	14 000,00	666,67
Electricity	10 000,00	11 000,00	14 000,00	11 333,33	666,67
Cleaning	1 000,00	1 100,00	1 200,00	1 100,00	33,33
Building insurance	2 000,00	2 500,00	3 000,00	2 500,00	166,67
Security	2 700,00	3 000,00	3 100,00	2 966,67	66,67
Garbage disposal	800,00	1 000,00	1 400,00	1 033,33	100,00
Repair and maintenance (annual)					
Site Improvements [10 years]	3 000,00	4 100,00	5 000,00	4 066,67	333,33
Renovation structure [20 years]	6 000,00	7 000,00	8 000,00	7 000,00	333,33
Repair electrical system [10 years]	1 750,00	2 100,00	2 760,00	2 151,67	168,33

Table 2. Calculation for two variant of investment projects

	Alternative A		Alternative B	
	$C_{estimated}$	%	$C_{estimated}$	%
NPV	1 380 073,57	100,00%	1 418 091,54	100,00%
	$\sigma_{C.estimated}$ dla A	69 592,22	$\sigma_{C.estimated}$ dla B	71 022,81
Initial costs				
Land Acquisition	271 666,67	19,68%	271 666,67	19,16%
Site Investigation	24 000,00	1,74%	24 000,00	1,69%
Designe Service	50 000,00	3,62%	50 000,00	3,53%
Construction	586 666,67	42,51%	513 333,33	36,20%
Operation costs (annual)				
Heating Fuel	187 271,73	13,57%	267 531,04	18,87%
Electricity	151 600,92	10,98%	151 600,92	10,69%
Cleaning	14 714,21	1,07%	14 714,21	1,04%
Building insurance	33 441,38	2,42%	33 441,38	2,36%
Security	39 683,77	2,88%	39 683,77	2,80%
Garbage disposal	13 822,44	1,00%	13 822,44	0,97%
Repair and maintenance (annual)				
Site Improvements	3 474,34	0,25%	14 451,19	1,02%
Renovation structure	1 893,18	0,14%	17 798,90	1,26%
Repair electrical system	1 838,27	0,13%	6 047,70	0,43%

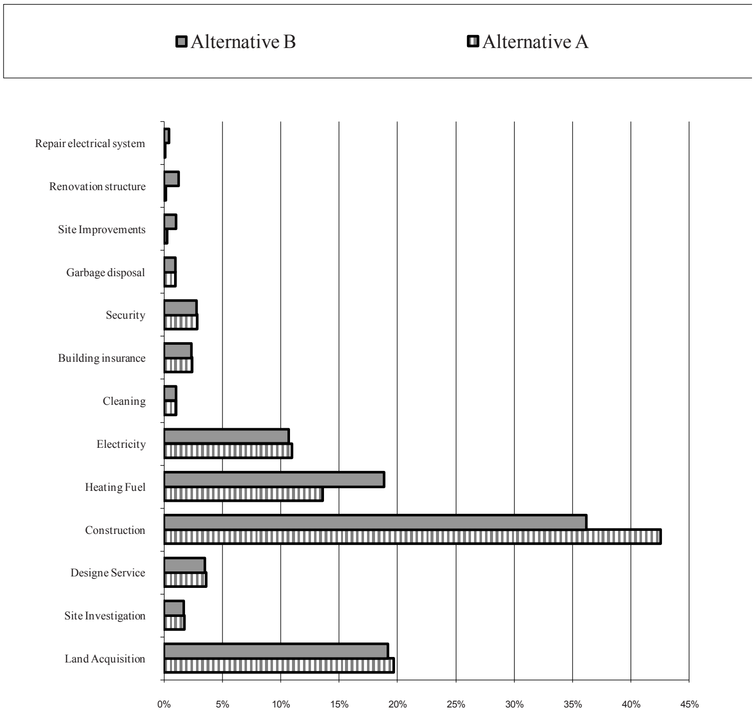


Figure 2. The proportional part of costs

It is worth consider relations between $C_{estimated}$ and $\sigma_{C.estimated}$. Standard deviation given uncertainty of cost estimation. Lower $\sigma_{C.estimated}$ given bigger certainty.

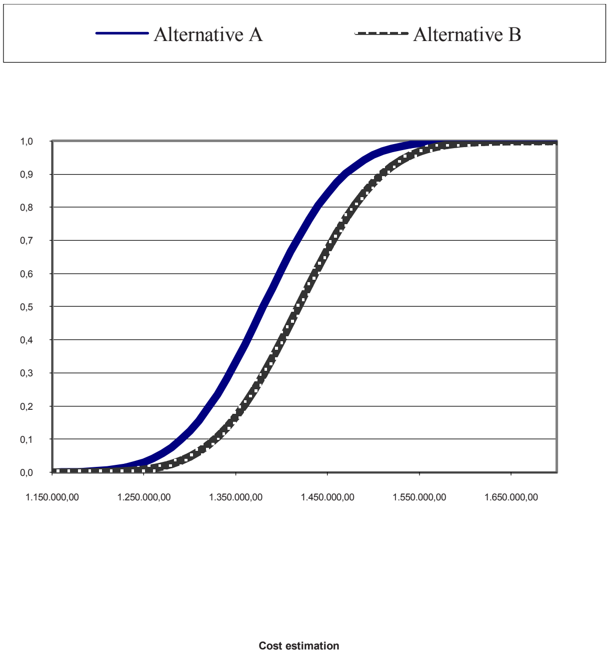


Figure 3. Probability curve for NPV's changes

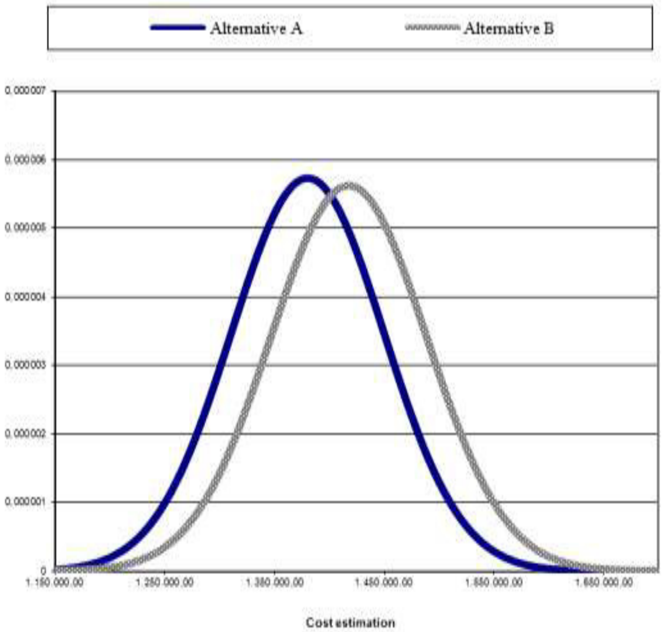


Figure 4. Probability density for two variant of investment projects

4. Conclusion

A basic method for assessing investment projects is to determine their profitability with the use of Net Present Value and Internal Rate of Return. These methods take into account time value of money, which enables to spot the changes in the whole investment process. An investor comparing different variants of a planned investment should consider expenses incurred also during the use of a building. Considering all costs in the whole life cycle we take into account a long time horizon. Therefore, predictability is encumbered with errors stemming from the possibility of occurrence of random factors which are considered in the model to be risk factors causing a change of a certain group of costs (standard deviation from an expected cost value). The rise of costs is unfavourable to an investor. Therefore, it seems appropriate to include at the stage of planning an investment all costs in the analysis as well as to assess their probable deviations considering risk factors. For this reason PERT approach was used in this paper, emphasizing possible changes of NPV value. It influences indirectly a determination of potential reserves considering situations that are hard to predict during investment realization and exploitation.

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