

THE POSSIBILITY OF APPLYING THE SELECTED COST ESTIMATION TECHNIQUES IN INNOVATION PROCESSES

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Summary: Costs are an important factor in decision-making processes of innovation. The method and the accuracy of determining the cost of innovation processes has a significant impact on how the implementation of these processes. The paper presents some techniques for cost estimating and describes their advantages and disadvantages, as well as factors that should determine the choice of an appropriate method. The selection of the cost estimation techniques were due to the possibility of using them in tasks of cost estimating in innovation process based on developed model.

Keywords: process innovation, cost estimation techniques, cost estimation of innovation process.

1. Introduction

Following the way of innovation became an important part of today's business development strategy. In the competitive struggle for market the enterprises must constantly make difficult challenges in acquiring new customers and meet their ever-growing and increasingly demanding needs. Is not enough to make changes in the production process, which accelerate the delivery of products to market. It is directed towards the production of products that are distinguished by modernity, quality and functionality to the existing background. This requires a change in business operations that need to be directed towards innovation.

By definition the Central Statistical Office (GUS), innovative activity covers all scientific, technical, organizational, financial and commercial, which actually are or are intended to lead to innovation. In terms of this activities are tasks that the company does not take its current operations. These are works in the field of research for the development of new processes and products. Therefore requires firms to conduct their own research and development and also cooperation in this area with external organizations for scientific.

The GUS considers the innovation as an implementation of a new or significantly improved product (good or service) or process, a new organizational method or a new marketing method in business practice, workplace organization or relationship with the environment. But, these innovation products, processes and organizational and marketing methods are not necessarily new to the market in which the company operates, but it must be new, at least for the company. Products, processes and methods may not be developed by the company itself, but can be developed by another company or institution (for example: research institute, research and development center, etc.).

Innovation process is therefore different from the processes carried out so far by the company. Require to engage in seeking of innovation, carry out research and development, preparation the plans of innovation processes and the implementation of these plans, including the continuous monitoring of work progress. Innovations will help improve the company's image, stimulate the development and benefits that may be material (financial)

and intangible, as measured by improvement in the organization and functioning of the company. It can be said about benefits of implementing innovations when the expenditure on the innovation process will be offset by the profits of implemented innovation. Innovation processes, as each project, must demonstrate a reasonable cost-benefit ratio. For this reason, determine what expenses will be incurred in the innovation process is not a simple task. The specificity of innovation processes, different from other processes performed on the current activities of the company, effectively makes it difficult to estimate future costs [7]. This is mainly due to the dynamics of the changes that accompany the innovation processes. Innovation processes do not have their patterns, they have a very individual character. This makes the implementation of the next phases of the process can bring surprising results. As a result, the plans of innovation processes are constructed and improved progressively when are known the results of works belonging to the earlier phases of the process. As difficult as the planning process is to assess the cost of innovation processes, which requires the relevant information contained in the plans of implementation. That's why the cost estimation process must be degreed, realizing that the initial plans would only allow for rough estimation of costs. However, since the costs of innovation are the most important criteria for deciding to initiate or continue the innovation process, it is not possible to give up attempts to cost estimate.

2. Estimating the cost of innovation processes

Decisions on starting the process of innovation are often made on the basis of the level of costs that will be incurred as a result of the process. The accuracy of their estimation is reflected in the quality of decisions, which is why estimate the expected cost at the right time, which allows to obtain reliable results with the required accuracy. Based on the research, analyzing the processes of innovation in Polish enterprises, it can be observed that the problem of estimating the cost is often imported only into the early planning stages of the innovation process. Estimating costs at this stage, in the absence of complete information about the innovation process can be performed only in an intuitive way. The accuracy of the estimation depends exclusively on the knowledge and experience of the person responsible for this task. The results in this case are less accurate and the differences in the assessment of the cost compared to the actual cost of the innovation process often reach tens of percent. Because managers are aware of these inaccuracies, the estimated costs are often overstated. It is safer to overestimate costs than underestimate them, which may lead to the interrupt the process of innovation due to exceeding the budget. But on the other hand, the overestimated costs of innovation process can not be accepted and process not start because of the level of these costs. For these reasons, estimating the cost of innovation processes should be carried out using methods of reducing the size of errors. Sequential phases of process innovation process, which describes the Stage-Gate model [10], implies the need for an individual approach to each of them. The results of the different phases of the process are crucial in deciding on the further continuation of the innovation process. Positive decisions are a spur to action for planning the next phase of the process, which in turn leads to the ability forecasting financial resources necessary for its implementation.

These observations allow to formulate the following guidelines to develop a cost estimation model:

- due to the uncertainty of the results of phases of the innovation process is necessary to make decisions based on the estimated cost of accepting the

- established level of accuracy,
- in order to obtain reliable results for estimating the costs, should be used methods that allow to obtain the most accurate results based on currently available information,
- sequential innovation process indicates the need for estimating costs for each phase of the process separately.

Therefore, estimating the cost of innovation processes are divided into three main stages (fig. 1):

- budgeting - including cost estimating when specified area of innovation, defined goal of innovation, type of innovation and time horizon,
- cost estimation of innovation process phases - are indicative estimated cost of each phase of the innovation process developed on the basis of partial objectives that describe the expected results of each phase,
- cost estimation of innovation process tasks - provides the most accurate estimate of costs based on detailed plans for the implementation of the different phases that describe the tasks to carry out and the allocated resources.

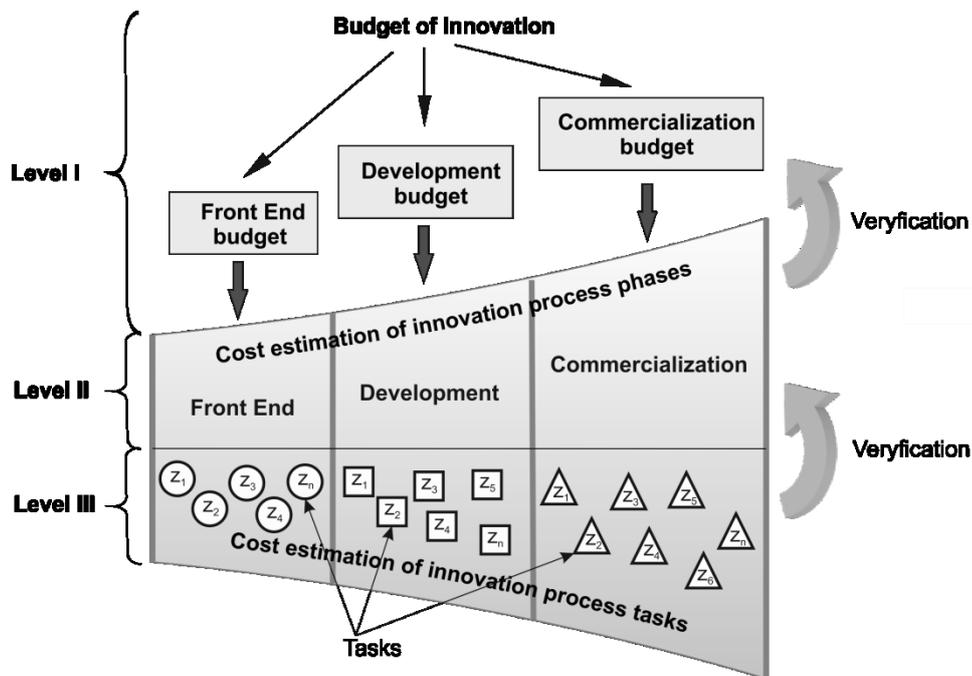


Fig. 1. Cost estimation of innovation process model [6]

3. Cost estimation techniques

When estimating the cost of the two approaches are used. The first is carried out at an early stage and it is rough estimation, the second approach to estimating accurate. Rough assessment of anticipated costs depends on the experience of the person making the operation, which is based solely on their own knowledge and skills, or can support in the comparison of the draft with other projects implemented in the past, and characterized by a

certain degree of similarity. The accuracy of the results depends entirely on the experience of the person evaluating the costs. This method of estimation is based solely on subjective assessment and here will always appear to doubt the correctness of the course assessment and the reliability of the results.

Detailed cost estimation is carried out on the basis of detailed plans because for the determination of the cost are necessary the information about the number of tasks, labour-consumption, direct and indirect costs. Knowledge of product, production methods, processes carried out and the relationships between processes is essential in accurate methods of costs estimating. For best results, this process is carried out repeatedly because of the possibility of verifying the algorithms used and their correction. A thorough assessment of costs is possible when the product is well described and developed very detailed plans of the project.

In estimating the cost of the traditional uses both approaches. At the start of the project carried out in rough estimation, which is aimed at a preliminary assessment of cost-effectiveness, and the development of project plans, estimates are made accurate. In the case of innovative processes should proceed in a similar manner, but this is impossible. Details the plans lasts practically the whole process of innovation, because each subsequent phase of this process provides new information. For this reason, estimating the cost of innovation processes should be carried out more frequently than traditional projects to keep track of the level of costs, which is an important factor in deciding on the course of innovation. Estimating the cost of innovation processes should be carried out using a variety of techniques to include the collected information in the innovation process. These techniques should guarantee the accuracies to obtain results corresponding to the information possessed at the time and should be tailored to the nature of innovation.

Overall, the cost estimation techniques can be divided into qualitative techniques and quantitative techniques. Quality costing techniques are primarily based on a comparative analysis evaluated the process or product of those that have been made earlier. Based on the assessment of similarity, which allows the use of existing data in the process of estimating the cost of a new process or product. The precision of these methods depends on the available data and the accuracy of the historical similarities. In the absence of a basis for comparative analysis (no historical data) qualitative technique based only on the knowledge and experience of leading cost estimating. Because of these differences among the qualitative techniques are distinguished analogous and intuitive techniques (fig. 2).

Quantitative techniques are based on a detailed analysis of the project, which is not dependent on the intuition of estimating cost or no connection with the projects implemented earlier. Costs are calculated on the basis of analytical methods taking into account the function of certain product characteristics that affect the level or cost are calculated as the sum of elementary units belonging to the project and representing the consumption of resources during its execution. Although the use of quantitative techniques should guarantee to obtain a much more accurate results, their accuracy depends on the detailed description of the project. Among the quantitative techniques are analytical and parametric techniques (fig. 2).

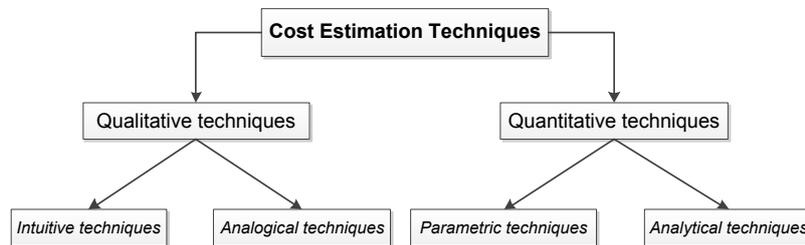


Fig. 2. Classification of cost estimation techniques [22]

3.1. Intuitive Cost Estimation Techniques

Intuitive costs estimation techniques are based on the past experience. An expert's knowledge is used to assess the magnitude of the cost in this technique. For this purpose, it can also support your opinion using the rules, decision trees, fuzzy logic, etc., in order to gain more confidence and accuracy.

3.1.1. Decision Support Systems (DSS)

These systems are especially useful in the assessment of alternatives solutions [8]. Allow you to make better decisions at different levels of the decision process through using the stored knowledge of experts in the field. These systems can store the necessary knowledge in the form of developed sets of rules, and in situations where heuristic data are missing and there is a large uncertainty, decision-making systems allow the use of fuzzy logic. An example of the application of decision-making system in the process of estimating the cost of labor was described by Shehab and Abdalla [27]. DSS system was used to develop a knowledge-based product cost estimation models in the early design phase. Luong and Spedding presented an example of a knowledge-based system that allows to integrate the process planning into cost estimation [19].

3.1.2. Case-Based Methodology

The Case-Based Reasoning (CBR) is based on analyzing and comparing the cases of the past to fit their common attributes. This technique is often adapting existing solutions, which often involves making design verification and make changes to get the best fit. This methodology is therefore applicable when you have a proper database containing already completed projects together with data on their costs. To assess which projects are most similar to the new project, you can use different measurements. CBR methodology is often used in the estimation of the cost of new products in the conceptual design stage [4, 18].

3.2. Analogical Cost Estimation Techniques

These techniques employ similarity criteria based on historical cost data, such as regression analysis models or back propagation methods.

3.2.1. Regression Analysis

These models make use of the historical cost data to establish a linear relationship between the costs for the past cases and the values of certain selected variables so that the relationship can be used to forecast the cost of a new product. The use of regression analysis allows to estimate the cost of new projects, but also to analyze the impact of various factors on the level of costs [13, 17, 25,]. The disadvantage of this method is to assume the existence of a linear relationship between the parameters of the project and its cost.

3.2.2. Back-Propagation Neural-Network (BPNN)

The use of neural networks, allows through learning based on historical data and the use of well-defined rules of inference, receive answers to questions have not been seen in the past. This means that the neural networks can be used under conditions of uncertainty, when we are dealing with a situation appears for the first time. Also, the presence of non-linear relationships between factors and project costs neural networks are proving to be very useful [21]. Using this technique, despite its labor consumption, gives a much better results in terms of estimating costs than the regression technique [5, 28, 32].

3.3. Parametric Cost Estimation Techniques

Parametric models use statistical methods and express the cost as a function of variables whose values reflect the level of costs. Parametric techniques are effective in situations where you clearly and in a simple way to extract these variables. Parametric techniques are fast ways of costs estimating. The accuracy of the results may be insufficient if the cost is estimated on the basis of a single factor in a simple regression model. When using more of the factors determining the cost, the results are more accurate, but in conjunction with the regression models are more complex and require more labor [4].

Parametric techniques, due to its advantages, are readily used to estimate costs in the early stages of design. More often, they are used to estimate the cost of newly designed products [12] than to estimate project costs.

3.4. Analytical Cost Estimation Techniques

Analytical approach to the cost estimating needs to be split into elementary units, operations and activities that represent different resources consumed during its execution. The total cost is calculated as the sum of all these components.

3.4.1. Activity-Based Costing (ABC)

ABC system focuses on the calculation of the costs incurred in performing various tasks. The method was first described by Cooper and Kaplan [11]. ABC presented the system as a useful means of distribution overheads in relation to activities carried out for the product produced.

Various information sources for the implementation of the ABC system within a specific context can be found in [1, 2, 15, 20, 23, 29]. The effectiveness of the ABC system was discussed by Kaplan [14] in providing helpful cost information to product designers for

developing economic designs.

The main advantages of the ABC method are: accurate results, the ability to analyze the behavior of the actual cost of the separation of activities do not add value to the product, determine the causes of cost, flexibility enabling the analysis of the costs not only for products, but also other objects: processes, market segments, customers, etc. However, the main problems of implementation the ABC system are: the difficulty in collecting data, the need to isolate processes and activities that cause indirect costs and to determine the cost drivers, the problem of matching variable costs assigned to the product group for each product separately, the cost to create and maintain an extensive database that stores data of activities and cost drivers.

3.4.2. Feature-Based Cost Estimation

The aim of this method is to describe a set associated tasks as elementary objects, being a fragments of tasks. In these objects are included the information about the costs. Creation of the elementary cost objects is dependent on the level of company's organization, and they are built on the basis of historical data from tasks performed in the past. Elementary cost objects may relate to individual activities, groups of activities, or even entire task. Development of a database of elementary cost objects allows for its use for scheduling the tasks by creating the appropriate configuration to obtain different values of costs. Different options of solutions can be also obtained, which further can be subjected to analysis and optimization. Examples of use in estimating the cost of FBC can be found in the work [3, 9, 16, 24, 26, 30, 31].

4. Comparison of cost estimation methods

The key to thrive for a enterprise in the twentyfirst century is based on product quality, competitive cost, fast delivery and flexibility. Although an innovative approach for enterprise development, the processes may still be time consuming and less cost effective. For enterprises the timely introduction of innovative solutions is important to gain a competitive advantage. Demanding customer also expects to receive innovative products to meet the demanding needs. The desire to quickly take advantage of the profits that will soon be implemented innovation can adversely affect the quality of the innovation process. This situation may result, for example, to neglect of assessing the profitability of the innovation process manifested in underestimated costs that reduce operating objectives or overestimated costs, which could lead to the resignation of implementation the innovation striking in the company's image and loss of market. This highlights the importance of selecting appropriate methods for cost estimation of innovation processes.

The most important decisions are made at the beginning of the innovation process. For this reason, the cost estimation using qualitative methods are favored. This is because they allow to predict the cost of the entire process without the need for detailed information on the process. Although the accuracy of these methods may be questionable, qualitative methods provide a good platform for the entire decision-making process that accompanies all phases of the innovation process.

However, managers often stop with the cost estimation by qualitative methods. Trusting their intuitions or expert evaluation, accept the results. They do not try to verify the cost of processes, even if the emergence of new information provides opportunities for this. Accept the differences between estimated costs and actual costs, as long as the level of costs will

not significantly exceed the budget. For this reason, most often occurs, in the case of innovative projects, the cost overestimation that will freeze financial resources. This results in the freezing of large financial resources that could be used for other purposes.

For this reason it is necessary to estimate the cost of innovation processes using different methods, applying the principle of selection of increasingly accurate methods when the process plan is supplemented by subsequent information.

To cost estimation a lot of methods can be used. Some of them are briefly presented in this paper. These methods, among which you can choose the ones that allow to obtain reliable results on the basis of available data. Each of these methods has a number of advantages, but each has its limitations (tab. 1). Those responsible for cost estimating of the innovation process should be knowledgeable about existing methods and choose this one for which the reliability of the results did not raise objections.

Tab. 1. Characteristics of the selected techniques for cost estimation [22]

<i>Cost Estimation Techniques</i>		<i>Key Advantages</i>	<i>Limitations</i>		
Qualitative Cost Estimation Techniques	Intuitive Cost Estimation Techniques	Case Based Systems	Innovative design approach	Dependence on past cases	
		Decision Support System	Rules Based Systems	Can provide optimized results	Time-consuming
			Fuzzy Logic Systems	Handles uncertainty, reliable estimates	Estimating complex features costs is tedious
			Expert Systems	Quicker, more consistent and more accurate results	Complex programming required
	Analogical Cost Estimation Techniques	Regression Analysis Models	Simpler method	Limited to resolve linearity issues	
		Back-Propagation Neural-Network (BPNN) Models	Deal with uncertain and non-linear problems	Completely data-dependent, Higher establishment cost	
Quantitative Cost Estimation Techniques	Parametric Cost Estimation Techniques		Utilize cost drivers effectively	Ineffective when cost drivers can not be identified	
	Analytical Cost Estimation Techniques	Feature-Based Cost Models	Features with higher costs can be identified	Difficult to identify costs for small and complex features	
		Activity-Based Cost (ABC) Models	Easy and effective method using unit activity costs	Require lead-times in the early project stages	

In presented cost estimation of innovation process model was proposed three stages of estimating costs. The places for cost estimating was chosen so that allowed to obtain more detailed information on the expected cost. Therefore allows the use of more accurate methods. The possibility of applying different techniques for estimating the cost of innovation in the planning process is shown in fig. 3.

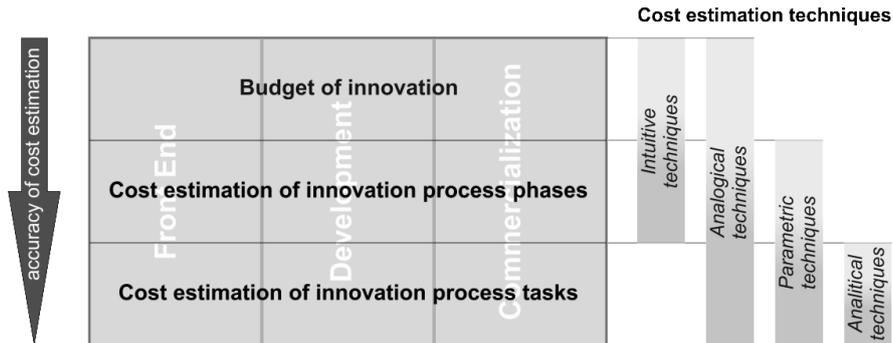


Fig. 3. Applicability of the cost estimation techniques in the innovation process
Source: own elaboration

5. Summary

Costs together with the time are one of the most important criteria for deciding on the implementation of the innovation process. Their deficiency may cause interruption of the process. Therefore, it is important to estimate their value at the right time. Uncertainty and risk are still elements of the processes associated with innovation. Unfortunately, traditional accounting is still not able to include them. Regarded as undesirable, is identified with the failure and incurring large financial losses. Therefore, it is important to skillfully secure funding to carry out the process of innovation. Greater confidence in the processes of innovation is achieved by performing them in sequentially, starting each following phase when the results from the previous phase have been accepted. Therefore, in the presented model, the planning, and thus cost estimation must be held in several stages of the process which gives a greater sense of security.

The use of more accurate methods of estimating costs is better management of financial resources and the ability to make better decisions. Cost estimating using several methods can achieve more accurate results and the ability to verify them. This requires the dedication of more time on the job, but certainly it will bring tangible benefits for the whole process of innovation. Particularly in relation to innovation with the longest horizon, where there is a high degree of uncertainty and risk associated with dynamic changes in the environment of the company.

Acknowledgement: Author would like to thank Polish Government Agency: National Science Centre for financial support of this research project (Nr 4025/B/H03/2011/40)

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