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Methods for Assessing the Economic Efficiency of IT Projects

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Abstract:

Purpose: *The aim of this article is to classify the methods of assessing the economic efficiency of all types of IT projects.*
Approach/Methodology/Design: *The main research method is a review of national and world scientific and practical literature.*
Findings: *The growing importance of IT systems requires methods that will determine their economic efficiency in enterprises and allow for practical comparison of the obtained economic and financial results.*
Practical Implications: *The practical implications of the research results included in the article will constitute recommendations for activities in managing companies that can be used in business practice. The pace of scientific and technological progress forces the development of IT systems for the optimal efficiency of economic entities.*
Originality/Value: *The original value of the article is the classification of the method for assessing the effectiveness of IT innovations and the development of a process for an appropriate approach to the overall assessment of such projects.*

Keywords: *Management, IT innovations, impact of IT systems, economic efficiency, finance, business, enterprises.*

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1. Introduction

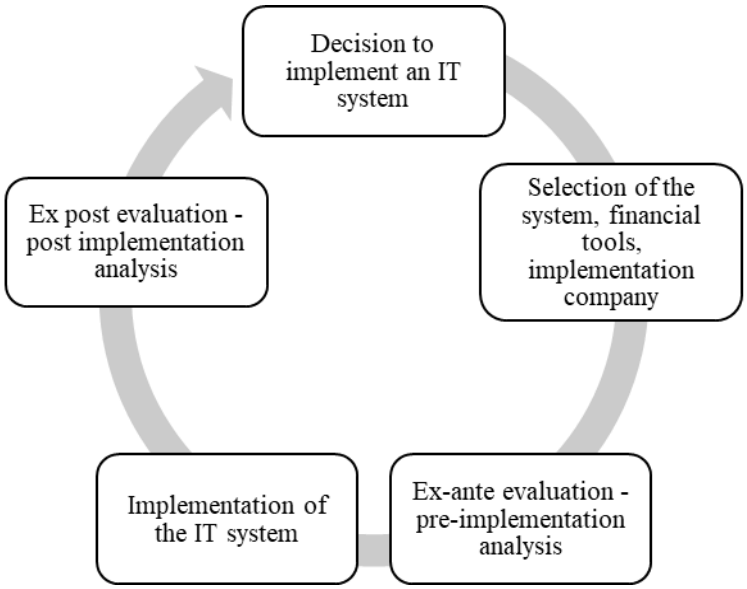
The evaluation of IT investment efficiency is considered a significant problem for both theoreticians and practitioners. In the literature, there are many works describing the usefulness of different methods and the time when the evaluation is performed.

Economic efficiency can be calculated ex ante and ex post. Ex ante efficiency involves identifying and estimating the expected effects, costs and time, and contains a significant degree of inaccuracy.

Ex post efficiency concerns the consideration of the results of specific actions, i.e., actual effects and costs. Hence, its degree of accuracy is much higher (Penc, 2023). The basic objective of the evaluation, regardless of the time of its execution, is to improve the quality, consistency and effectiveness of the implemented IT system.

Figure 1 presents the relationship between ex post and ex ante evaluation in the case of implementing an IT system in an enterprise.

Figure 1. *Scheme for assessing the economic efficiency of an IT system ex post and ex ante*



Source: *Own study based on Ministry of Regional Development, Guide for public administration employees, Warsaw, 2012, p. 24.*

The aim of this article is to classify methods for assessing the economic efficiency of all types of IT ventures and to assess their impact on the processes of managing society within the basic economic units, such as enterprises.

2. Assessment of Economic Efficiency in IT Investments

In terms of the generally accepted standards, the assessment of economic efficiency appears in three places in the IT system implementation cycle. These are key points in the context of the success of a given undertaking:

1) at the implementation planning and design stage: the role of the assessment here is to assess the accuracy of the assumptions of the planned implementation (including the adopted theory and objectives) and its logic and planned method of implementation (ex-ante assessment);
2) at the IT system implementation stage: in this context, the role of the assessment is to measure the level of achievement of objectives at individual stages of implementation, together with the identification of factors influencing success or failure; the assessment at the implementation stage allows for corrections and improvements that affect the final effects of the program;
3) after the completion of the system implementation: this is an ex-post assessment; its role is to summarize the effects of actions taken as part of the implementation and to draw conclusions and formulate recommendations useful for future implementations of IT systems.

The ex-ante assessment of the IT system is conducted at the stage preceding the implementation of the program (ex-ante evaluation, 2023). Its main objective is to verify the justification for the planned implementation and whether the expected results can be achieved by using the planned resources. The program assumptions are also analyzed, whether they are consistent with the company's strategy.

The project assumptions should be reflected in the needs and problems and provide an appropriate response to them. In ex-ante evaluation studies, the desk research method is primarily used. Researchers conduct an in-depth review of available strategic and project documents, trying to verify the coherence criterion.

This analysis is then used to create tools for quantitative and qualitative research. The participants of evaluation studies preceding the implementation of the IT system are people responsible for management, monitoring and implementation of individual activities.

On the other hand, ex post evaluation consists in assessing the project after its completion, and also includes analyses of data on the scope and durability of their impact. These studies are conducted in order to obtain an answer to the question of whether the previous provisions have been met, and to assess the results of the activities.

This method also allows for effective planning of subsequent activities and is increasingly used in both larger and smaller projects. Ex-post evaluation is of a summary (strategic) nature, and its main functions are (Haber, 2007):

1) strengthening responsibility – primarily examining the cause-effect relationship between the implementation undertaken and the effects and processes triggered in a given system, and as a result showing the success or failure of the implementation;
2) supporting learning processes – especially verifying theories, assumptions and paradigms underlying the implementation of IT systems.

The ex-post evaluation report of the IT system includes, among others:

1) examination and assessment of the use of financial resources. It allows for answering the following questions: Were the goals achieved? How strong was the impact of external factors? Were the selected financial instruments and solutions appropriate? Could similar effects have been achieved using other instruments? What problems were encountered?
2) examination and post factum assessment of the functioning of the IT system (effectiveness and efficiency): Was the management system effective? Did the people responsible for the implementation fulfil the goals assigned to them?
3) assessment of the usefulness of actual effects – results and impact of the IT system, including side effects, both positive and negative, asking: Did the implementation meet the expectations of the system users? Did it contribute to solving problems? Were the effects beneficial to different groups of recipients? Were there any positive or negative side effects?
4) examination of the durability of the achieved positive effects: Are the effects of the actions durable, long-term?
5) identification of factors that contributed to the success or failure of a given implementation;
6) conclusions that can be transferred to other, similar implementations, identifying best practices;
7) conclusions regarding the policy in the field of economic and social cohesion of the implemented IT system.

Regardless of its detailed scope, however, ex-post evaluation should provide reliable and useful information due to its conclusive, or settlement, function and, to a lesser extent, the cognitive and formative function, or stimulating organizational improvements and development in relation to the design and implementation of future IT systems of a similar nature (Górniak, 2007).

3. Literature Review

In the literature on the subject regarding the time of conducting research, three standard stages of the research process are distinguished: planning and structuring, data collection, data analysis and evaluation. Therefore, the process of assessing the economic efficiency of IT systems should also be viewed in terms of the types of methods used for this assessment. E. Berghout and T. Renkema, based on the analysis of publications on the assessment of the economic efficiency of IT systems, created a list of 61 methods used in the assessment of IT projects.

In addition, the authors distinguished three basic strategies for assessing the economic aspects of IT projects:

1) the use of fundamental methods, which are considered to be methods that assess in detail one or several aspects of efficiency using a single measure,
2) a comprehensive approach, trying to include the assessment of all aspects of the IT project in one methodology,
3) a special approach, aiming to select a set of measures depending on the context of the assessment and the type of IT project.

The use of fundamental methods does not provide a full picture of the costs and benefits that can be achieved after implementing a given IT (Jałowiec *et al.*, 2020). solution. As a consequence, this may result in making an incorrect decision, rejecting the project or incorrectly determining the value of the system during use.

Limiting only to financial methods may result in incorrect estimation of the actual value of an IT project, omitting its impact on benefits that cannot be expressed in monetary terms. On the other hand, narrowing the assessment only to the analysis of the strategic impact of the IT system may result in selecting the most expensive option. Limiting the analysis to one of the fundamental methods may be used in the case of simple IT projects.

In turn, the comprehensive approach presents a balanced image of the value of an IT project, which should be considered subjective, because it is created on the basis of ranks and weights assigned to individual costs, benefits and risks. At the same time, these methods make an assessment at a general level. Assigning arbitrary, single ranks to the project in terms of such important aspects as the relationship with the strategy or support for changes in economic processes additionally increases the subjectivity of the assessment.

The last approach assumes selecting the appropriate set of assessment methods. This is related to the diverse strategies of the company, goals and economic processes, the IT systems used and the methods of conducting the project. The advantage of this approach is obtaining precise information about the IT project by taking into account all economic and non-economic aspects.

There are examples of using one method or group of methods in a specific case, but no universal method has been developed that can be applied to all IT investments. This is the result of diverse implementations of IT systems.

As H. Dudycz notes, both traditional financial methods (e.g. simple rate of return, net present value) and methods that take into account the specificity of IT projects, i.e., effects and immeasurable costs (e.g. information economics) are used to study the effectiveness of IT investments. Different typologies of methods can be found in the literature. Their diversity results, among others, from the fact that their number is

constantly increasing, different criteria for division have been used and it is difficult to indicate one of them that will be objective.

Therefore, the selection of methods, in addition to quantifying effects and immeasurable costs, is considered one of the most difficult issues in examining the effectiveness of an IT project (Dudycz, 2006). Classifications of methods for assessing the economic efficiency of IT projects, found in the literature, focus on the criterion of the way of expressing costs and benefits.

T. Renkema and E. Berghout divide IT project assessment methods into 4 categories (Lech, 2007):

1) financial methods, presenting costs and benefits in terms of value;
2) multi-criteria methods, assigning subjective ranks to all costs and benefits;
3) portfolio methods, assessing IT projects by referring them to one or more ordinal scales, reflecting the main measurement criteria;
4) indicator methods, presenting the ratio of benefits to costs in the form of indicators.

The indicated methods are synthetic in nature, trying to examine the role of IT systems by analyzing aggregated indicators. Another typology was proposed by T. Mayor, who divided the methods of economic evaluation of IT projects into three categories (Mayor, 2024):

1) financial (quantitative) methods – which, in addition to indicators such as net present value (NPV) or payback period, also include Economic Value Added (EVA) or Total Cost of Ownership (TCO) (Kabus et. al., 2022);
2) qualitative (heuristic) methods – covering all methods that assign a numerical value to qualitative factors, including the Balanced Scorecard (BSC), Economics of Information, Total Economic Impact (TEI), Marphy's 5 Pillars method and portfolio analysis;
3) probabilistic methods – based on the use of mathematical statistics and probability tools, assessment of information value and stochastic relationships between investment outlay and possible effects: Real Options Method and Applied Information Economics. It can be stated that the above typology constitutes an arrangement of the methodology presented by T. Renkema and E. Berghout. It has been narrowed down to three categories that complement each other. It has also been expanded to present specific research methods.

H. Dudycz, on the other hand, divides the methods into (Dudycz, 2006):

1) traditional, within which he distinguishes:
- static methods, also called simple methods;
- dynamic methods, also called discount methods.

2) new methods focused on examining IT projects, within which the following are most frequently mentioned:
- the total cost of IT maintenance method,
- the total economic impact method,
- the real options method,
- the IT scorecard,
- the economics of information,
- the expected value of information,
- the economics of information method.

The group of traditional methods includes financial methods, because implementing an IT system is an investment for the company. Static methods are used in the case of a preliminary assessment of the project being examined.

On the other hand, traditional dynamic methods make it possible to examine the entire period of implementing an IT system and its use, while taking into account the variable value of money over time. These methods include, among others, the net present value (NPV) and the internal rate of return (IRR) method.

P. Lech presented criteria enabling classification of available methods of assessing the effectiveness of IT systems in terms of (Lech, 2005):

1) organizational level of measurement,
2) scope of costs/benefits taken into account in the measurement,
3) taking into account the specificity of IT solutions,
4) applied measurement tools.

In terms of organizational level of measurement, the following groups of methods can be distinguished:

1) methods measuring the impact of IT technology on the entire enterprise,
2) methods comparing IT initiatives with each other,
3) methods used to assess a single IT solution.

Methods measuring the impact of technology on the entire enterprise are synthetic in nature, and they can be used to examine the role of IT in creating the efficiency of the enterprise by analyzing aggregated indicators (Zakrzewska and Miciuła, 2021). Methods comparing IT initiatives are used to rank competing IT systems within the enterprise. They are helpful in selecting the optimal structure of IT projects in accordance with the criteria adopted by the enterprise.

Methods used to assess a single IT solution aim to determine the impact of a specific IT project on the change in the efficiency of the enterprise. For the above reason, this group of methods has the most analytical and detailed character.

Due to the scope of benefits and costs taken into account in the assessment, two groups of methods can be distinguished:

1) methods focusing on a selected aspect of the IT solution: e.g., financial costs and benefits, compliance with the implemented strategic goals,
2) methods attempting to assess all aspects of the IT solution
3) holistic methods.

Taking into account the criterion of the specificity of IT solutions, the methods of assessing effectiveness can be divided into those specific to IT solutions and those adapted from other fields of management science, e.g. profitability analysis, strategic analysis, accounting.

By combining and arranging the above classifications, P. Lech proposed the following division of methods for assessing IT projects according to the way of expressing benefits and costs:

1) quantitative methods, focusing on measurable aspects of IT projects and divided into:
● deterministic (financial) methods – expressing benefits and costs using single values;
● probabilistic methods – using tools of mathematical statistics and probability calculation, expressing benefits and costs as random variables.
2) qualitative (heuristic) methods – attempting to assess non-financial factors as well and divided into the following subgroups:
● multi-criteria methods – containing both financial and non-financial assessment elements, usually in the form of ranking;
● strategic analysis methods – including the Balanced Scorecard and Portfolio Analysis.
3) probabilistic methods using tools of mathematical statistics and probability theory.

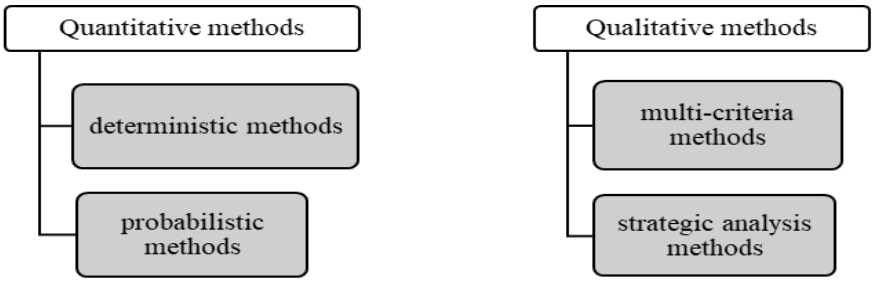
Figure 2 presents a diagram of the division of methods for assessing the economic efficiency of IT systems, which constitutes the basis for further research.

The first group consists of quantitative methods, focusing only on the aspects of benefits and costs that can be expressed in monetary terms. The group of financial methods includes traditional tools for evaluating investment projects, such as:

● simple rate of return,
● payback period,
● net present value (NPV),
● internal rate of return,
● economic value added (EVA),
● return on investment (ROI),

- total cost of ownership (TCO),
- return on management.

Figure 2. *Division of IT project evaluation methods*



Source: *Own study based on Dudycz, 2006.*

4. Research Results

In the literature on the subject, one can find an assessment that deterministic methods are the main methods of measuring the economic efficiency of IT systems, because they are based on real values. They are used to evaluate private sector projects, in which the basic criterion of profitability is the surplus of funds in relation to the expenditure (Wojtaszek and Miciuła, 2019). They are considered good because they include the discount rate, thanks to which the results are presented in real values (Forycki, 2016).

Deterministic methods of measuring the efficiency of IT solutions do not take into account the uncertainty of the functioning of enterprises. This uncertainty concerns both the IT project itself (incurring specific costs and achieving the assumed effects) and the role of the ready-made solution in supporting the management process (the relationship between information and the action taken as a result of its possession).

In reality, both the costs and effects of the IT project may take on different values as a result of the impact of many external and internal factors, and the information obtained thanks to the ready-made solution does not always clearly determine the choice of the optimal decision. It is therefore justified to present the values listed above not as single numbers, but as ranges, with the probabilities of the occurrence of individual events assigned to them.

Probabilistic methods take into account the above premises using decision theory tools and statistical methods. They assume a stochastic relationship between the costs and benefits of an IT project. They also allow for estimating the value of information provided by IT solutions.

Modern IT systems are multi-faceted projects. Quantitative methods refer to the measurement of the financial efficiency of the project, but do not refer to the project environment, which includes, environmental sustainability, corporate social responsibility, innovative Internet marketing, service innovation, organizational innovation. All of these difficult to quantify qualitative factors have a decisive influence on the result of the efficiency measurement. Qualitative methods attempt to directly assess non-financial and non-measurable costs and benefits of IT projects.

They focus on the diversity of processes, phenomena that are not quantifiable in terms of quantity. They are based not on numbers, data, but on knowledge, views, opinions revealed by respondents. These methods are divided according to various criteria (Piecuch and Molter, 2014). Qualitative methods have been divided into two groups: multi-criteria and strategic analysis.

The subgroup of qualitative methods includes multi-criteria methods (MCDM – multiple criteria decision making) or multi-criteria decision analysis methods (MCDA – multiple criteria decision making). The literature on the subject indicates that the MCDM method is developed by the so-called American school, which assumes the existence of a multi-attribute utility function that can provide a synthetic assessment of the analyzed scenarios.

On the other hand, the MCDA approach is represented by the European school, which assumes the existence of a superiority relation, in which the aggregation of partial assessments is made on the basis of conditions under which a global superiority relation occurs. Two basic trends in multi-criteria decision support (MCDM/MCDA) can be mentioned (Ogrodnik, 2014):

- multi-attribute decision analysis MADA (Multi-Attribute Decision Analysis),
- multi-objective decision support MODM (Multi-Objective Decision Making).

Multi-objective decision support (MODM) examines decision problems in which the set of all admissible decisions is a continuous set containing an infinite number of possible solution variants. Multi-attribute decision making (MADM), on the other hand, focuses on the situation in which the set of all admissible decisions is a discrete set, containing a finite, predetermined number of possible solution variants (Stecyk, 2024).

The most well-known multi-criteria methods include:

1) the SMART (Simple Multi-Attribute Ranking Technique) and SMARTER (Simple Multi-Attribute Ranking Technique Exploiting Ranks) methods,
2) the Motoda AHP (Analytical Hierarchy Process) and F-AHP (Fuzzy Analytic Hierarchy Process) methods,
3) the ELECTRE I-IV (French: ELimination Et Choix Traduisant la REalia) methods,

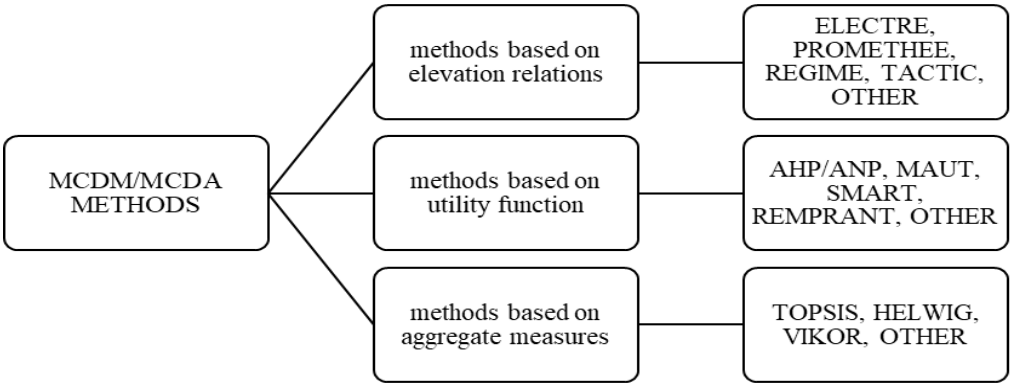
4) the PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluations) methods,
6) the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. In order to solve multi-criteria decision problems, selected multi-criteria decision support methods and tools are used. These methods were developed to solve specific, real decision problems (Köksalan *et al.*, 2011).

One of the classifications was proposed by B. Roy, dividing the methods into (Roy, 1990):

1) multi-attribute utility theory,
2) based on the outranking relation,
3) interactive, so-called dialogue methods.

Figure 3 presents the division of MCDM/MCDA from the point of view of using methods based on outperformance relations, on utility functions and on aggregate measures.

Figure 3. *Classification of MCDM/MCDA methods*



Source: *Own study based on Nermend, 2017.*

Another division was proposed by T. Trzaskalik, who divided multi-criteria methods into six groups (Trzaskalik, 2014):

1) using the utility function;
2) analytical hierarchization and related methods;
3) verbal;
4) based on the multi-attribute utility theory;
5) using reference points;
6) interactive methods.

Regardless of the adopted classification of multi-criteria methods, decision-making problems should be understood as a conscious action of a person (leader, decision-maker) in order to achieve the best results, in the context of the adopted goals and assumptions, using specific methods that improve the decision-making process.

Strategic analysis methods are also distinguished among qualitative methods. Strategic analysis is one of the stages of strategic management, being a study that allows for the assessment of the company's previous activities, and at the same time sets new directions of expansion, taking into account the variability of the market environment.

These methods focus on checking external and internal factors affecting the company's condition, rather than repairing organizational errors. These include a set of methods for sectoral and portfolio analysis of the company and its environment, including (Pierścionek, 2010):

1) scenario method;
2) structural analysis of the sector;
3) value chain model;
4) strategic balance sheet of the company;
5) function and resource matrix;
6) portfolio methods (BCG matrix, McKisney matrix, ADL matrix, SWOT analysis model).

Strategic analysis can be carried out using the analytical or synthetic method. The analytical method involves an independent assessment of individual components of the company's environment and resources, i.e. analysis of the micro and macro environment, and then analysis of the company.

The synthesis of assessments of individual, elementary components of the environment and company resources takes place in the minds of strategists developing the strategy, and its method is derived from the knowledge and experience of decision-makers (Paluch, 2016). Usually, these elements are distinguished in the categories of opportunities and threats (environment), as well as strengths and weaknesses (for the organization).

5. Conclusions

It can be concluded that, given the current pace of technological development, an individual approach to assessing the effectiveness of IT systems can provide the most reliable result. H. Dudycz points out that when selecting a method for assessing an IT investment, the following issues must be considered:

1) quantification of measurable and unmeasurable effects and costs. This is a very important issue, often influencing the final assessment of the effectiveness of an IT

investment and ultimately its acceptance. Therefore, when analysing methods, it is important to consider whether quantitative and/or qualitative measures are used,

2) investment assessment using an objective or subjective method. Especially in the latter case, care must be taken to properly select the people conducting the investment effectiveness study, because their knowledge, skills and ultimately the assessment may determine its acceptance or rejection,

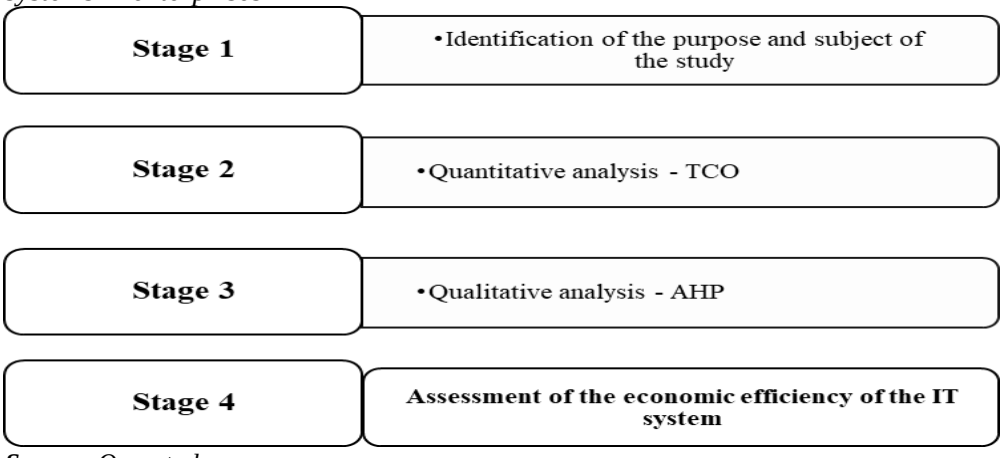
3) examination of variants or alternative IT investments. Before starting to implement an IT project, an economic entity often analyses alternative projects resulting from considering different IT systems and/or multiple suppliers. In such a situation, a method must be used that allows for their assessment and comparison,

4) the time of conducting the assessment of the IT project. When implementing an IT system, it is important not only to examine the effectiveness of this investment before its implementation, but also during and after its completion,

5) the complexity of the method. With quite complex measures, this often determines the need to commission the assessment to consulting companies, which generates additional costs of the investment in question. Similar consequences, i.e. an increase in the costs associated with the implementation of the IT project, occur after the use of time-consuming and labor-intensive methods.

Based on the presented methods, it is possible to create a general model of the economic efficiency of IT projects, which was presented in Figure 4. This process is related to the time factor, and therefore each of its stages requires designing depending on the moment when the efficiency analysis is carried out in the enterprise.

Figure 4. *General model for assessing the economic efficiency of information systems in enterprises*



Source: *Own study.*

The conducted literature analysis shows that the methods used to study the economic efficiency of IT projects are complex and time-consuming. This is due to the difficulties in identifying and quantifying the effects and non-measurable costs and applying appropriate measures.

However, the indicated methods allow for a more detailed examination of the IT project and for a comparison of alternative projects. Some of the methods can be used to study the IT system, both ex post and ex ante. The use of the indicated methods is primarily determined by the complexity of the planned IT project. It should be remembered that the assessment of the economic efficiency of the IT system is only one of the sources of information that the company can receive.

Equally important are, monitoring (understood as daily data management), socio-economic analyses, as well as forecasts of future needs and challenges. Nevertheless, each study provides us with additional knowledge that should be used to improve the quality of current and future activities.

Therefore, in order for the efficiency assessment to be an effective and useful tool for managing the IT system or intervention, it should be used at all main stages of implementation, i.e., before, during and after the implementation. Since it is impossible to present all methods of assessing IT investments, as well as to select a representative group from among them, for the purposes of this dissertation a subjective selection was made and selected methods representing each of the categories, which were used in further research, were described.

The selection of methods and data describing the analyzed IT system is crucial and takes place within a specific methodology, which is a consequence of the adopted theoretical assumptions, influencing the final result of the conducted study. The selected methods create a logical methodological sequence - used to perform individual tasks and research goals.

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