ACADEMY OF ECONOMIC STUDIES OF MOLDOVA

By title of manuscript
C.Z.U.: 004.45:[005.8:330.322](043)

GHETMANCENCO SVETLANA

COMPARATIVE ANALYSIS OF EFFICIENCY CRITERIA FOR INVESTMENTS IN INFORMATIZATION

Specialty 122.02 - Information Systems

Summary of the Doctoral thesis in computer science

CHISINAU, 2025

The thesis was developed within the Academy of Economic Studies of Moldova, AESM Doctoral School, Information Technology and Information Management Department.

Doctorate supervisor:
BOLUN Ion, dr. habil., univ. prof.

Doctorate Commission:

PÂRȚACHI Ion, dr., univ. prof., AESM	*president*
BOLUN Ion, dr. habil., univ. prof., TUM	*doctorate supervisor*
COSTAȘ Ilie, dr. habil., univ. prof., AESM	*reviewer*
ALBU Svetlana, dr. habil., assist. prof., TUM	*reviewer*
BRAGARU Tudor, dr., univ. prof., MSU	*reviewer*
BOTNARI Nadejda, dr. assist. prof., AESM	*reviewer*
COJOCARU Igor, dr., assist. prof., ISDI	*reviewer*

The thesis public defense will take place on the 04th of April 2025, at 15:00, during the meeting of the Doctorate Commission of the Academy of Economic Studies of Moldova Doctoral School, which will occur at the address: G. Banulescu-Bodoni St. 61, building B, room 104, MD-2005, Chisinau, Moldova.

The PhD thesis and the abstract can be consulted at the Scientific Library of the Academy of Economic Studies of Moldova (G. Banulescu-Bodoni St. 61, building F, MD-2005, Chișinău, Moldova), the website of AESM (www.ase.md). and on the website of ANACEC (www.anacec.md).

The summary was sent on "03"March 2025

Doctorate supervisor
BOLUN Ion, dr., hab., univ.prof.

Author
GHETMANCENCO Svetlana

CUPRINS

CONCEPTUAL HIGHLIGTHS OF THE RESEARCH

The actuality of the research topic and importance of the problem addressed. For many years, informatization has become an essential pillar in supporting the sustainable development of modern economies. Informatization has also become a national objective in the Republic of Moldova [1]. Information and communication technologies (ICT) play a key role in increasing productivity, enhancing the competitiveness and resilience of sectors, while capitalizing at the same time on innovation capacity and human capital [2, 3]. This strategic direction is supported by such documents as the National Strategy for Digital Transformation [1], the National Action Plan for the Implementation of the National Strategy in the Field of ICT [4] and the legislation in force, including the Law on Telecommunications [5], the Law on Cybersecurity [6] and the Law on Personal Data Protection [7], providing a solid basis for the implementation and consolidation of informatization processes at the national level.

The informatization of activities and processes in various fields is mainly implemented through IT projects (i-projects) that require the allocation of significant financial resources (investments). In the Republic of Moldova, the legal framework that regulates investments contains several legislative acts and regulations, including Law No. 81 of 18.03.2004 on investments in entrepreneurial activity [8]. According to [9], investment involves the acquisition of tangible goods and implies the payment of a present cost in exchange for future income.

Investment projects in informatization (IT projects) are usually of high complexity, involving a wide range of resources, equipment and activities. The high requirements for the efficiency of i-projects require a rigorous evaluation of them by means of relevant indices, thus providing an argumented perspective on the each analyzed i-project. In order to make informed decisions in the process of selecting an i-project, it is essential to carry out a ***comparative analysis of efficiency indices***. Without such an analysis, selecting the appropriate i-project in a particular situation becomes difficult, as different indices can provide different results.

The theoretical results of research on the application of indices frequently used for the evaluation of i-projects [3, 11-19] do not always provide an unambiguous answer as to which of them and in which problem situations is appropriate to be applied. At the same time, the unsuccessful application of some indices can lead to solutions and, respectively, decisions to select less reasonable i-projects. Since analytical methods cannot always successfully compare i-projects [11, 12], one way to compare them is to use computer simulation (i-simulation). i-Simulation can provide a detailed assessment, reducing uncertainties and providing decision-makers with the necessary tools for reasoned decisions.

For these reasons and taking into account the multitude of i-projects and the large volume of investments in computerization in various areas of society, the topic of the thesis, oriented to the comparative analysis through computer simulation of various efficiency criteria used to estimate the impact of investments in computerization, is very actual.

The framework of study on the research topic. In the domestic and foreign scientific literature, only certain aspects related to the research topic have been widely covered. The general theoretical aspects of fundamental concepts such as "economic efficiency", "indices" and "projects" have been researched by most of the classics of economic theory, including: Adam Smith, David Ricardo, John Stuart Mill, Alfred Marshall, Vilfredo Pareto. At the same time, general research on the assessment of the economic efficiency of investment projects, including the principles and methods of implementation, the used techniques and applicable indicators, have been carried out in several works by local scholars and from abroad, including: S. Albu [13]; A. Barcaru [14], J. Baker [15], I. Blank [16, 17], N. Botnari [18], A. Damodaran [19], V. Livchits [20], M. Nowak [21], V. Platon [22], M. Law [23], S. Todiraş [2], C.A. Abramov [25], V. Esipov [26], P. Vilenskii [27], V. Kovaliov [28, 30], T. Teplova [31] and others. However, most of them examined the problem from the perspective of the impact of efficiency criteria on investment performance, without carrying out an in-depth comparative analysis of these criteria using analytical methods or computer simulation.

In [11,12, 39], various aspects related to the use of efficiency indices for comparing i-projects are investigated by using analytical methods. At the same time, these works concluded that, in some situations, comparing i-projects through analytical methods is insufficient, as the solutions obtained when applying diverse criteria differ. Therefore, comparative analysis of i-projects through computer simulation becomes imminent.

Aim of the research. The aim of the research is represented by the comparative analysis, including through computer simulation, of the efficiency estimation indices of investment projects in informatization and the development of recommendations on their use.

To achieve this aim, the following **research objectives** have been established:

- identification and systematization of efficiency indices of investment projects in informatization;
- development of models for comparative characterization through computer simulation of efficiency indices of investment projects in informatization;
- creation of algorithms for comparative evaluation through computer simulation of efficiency indices of investment projects in informatization;
- defining the methodology for computer simulation of the characteristics of investment projects in informatization;
- development of the computer application for comparative research of efficiency indices of investment projects in informatization;
- comparative research of efficiency indices of investment projects using the developed computer application;
- development of recommendations on the application of efficiency indices of investment projects in informatization.

Research hypotheses:

1. The efficiency indices of i-projects can be identified and systematized so as to provide a solid basis for the successful quantitative evaluation of the projects.
2. The economic-mathematical models that will be proposed for the evaluation of the i-projects efficiency through computer simulation (i-simulation) will allow for an

adequate comparative characterization of the efficiency indices, thus facilitating the selection of i-projects with a higher probability of success.

3. The computer simulation methodology will allow for the evaluation with an acceptable accuracy of the characteristics of i-projects, generating results applicable in various scenarios.

Methodological and theoretical-scientific support of the research. The theoretical and methodological basis of the thesis is made of the scientific publications in the field of some local and foreign scholars, such as: Albu S., Barcaru A., Baker J., Bolun I., Blank I., Botnari N., Damodaran A., Livchits V., Nowak M., Pareto V., Platon V., Todiraş S., Esipov V., Vilenskii P. etc. The research carried out is based on such methods as: scientific observation, abstraction, classification, formalization, mathematical modeling, algorithm theory, comparative analysis, discounted cash flow, induction, deduction and computer simulation.

The solved scientific problem consists in the quantitative characterization (for the first time) through computer simulation of the frequency of cases of non-coincidence of the solutions obtained when using the indices like net present value, internal rate of return and profitability, eventually in combination with the equivalent annual value method, for computerization projects of the same and different durations, and also of the degree of influence of the use of the equivalent annual value method on the decisions to select computerization projects.

The theoretical significance lies in the development of the methodological framework for quantitative comparative analysis through computer simulation of IT investment projects based on the application of relevant efficiency indices.

The novelty and scientific originality of the research consist in:

1. Arguing the opportunity to use computer simulation to determine the frequency of cases of non-coincidence of solutions obtained when applying the indices like net present value (NPV), internal rate of return (IRR) and profitability (PI), eventually together with the equivalent annual value (EAV) method, for assessing the efficiency of computerization projects.

2. Computer simulation models for quantitative comparative analysis of the efficiency of computerization projects of the same and different duration when using the indices NPV, IRR and PI, eventually in combination with the EAV method.

3. Computer simulation models for estimating the degree of influence of using the EAV method on decisions to select computerization projects based on the indices NPV, IRR and PI.

4. Computer simulation algorithms for quantitative comparative analysis of computerization projects of the same and different duration when using the indices NPV, IRR and PI, eventually in combination with the EAV method.

5. Computer simulation algorithms for analyzing the degree of influence of using the equivalent annual value method on decisions to select computerization projects.

6. Methodology of quantitative comparative analysis through computer simulation of the efficiency of computerization projects.

7. The solved scientific problem, including that: on average, the solutions obtained when comparing the efficiency of i-projects of the same duration, based on the NPV, PI

and IRR indices, do not coincide in more than 1/3 of cases, and the efficiency of i-projects of different duration do not coincide in more than 18% of cases if the EAV method is not used, and exceeds 30%, if the EAV method is used.

Applied value of the research. The developed procedural and methodological recommendations can be used in the academic and research environment for the further development of the methodology for assessing the efficiency of investments in informatization. They can also serve as a practical guide for project managers, financial specialists and those from the ICT field in the decision-making process regarding the efficiency of investments in informatization.

Main scientific results proposed for defense:

1. Systematization and identification of relevant indices for assessing the efficiency of investment projects in informatization.
2. Computer simulation models for quantitative comparative analysis of the efficiency of computerization projects of the same and different durations when using the NPV, IRR and PI indices, eventually in combination with the EAV method.
3. Computer simulation models for estimating the degree of influence of using the EAV method on decisions to select computerization projects based on the NPV, IRR and PI indices.
4. Computer simulation algorithms for quantitative comparative analysis of computerization projects of the same and different durations when using the NPV, IRR and PI indices, eventually in combination with the EAV method.
5. Computer simulation algorithms for analyzing the degree of influence of using the EAV method on the decisions to select computerization projects.
6. Methodology of quantitative comparative analysis through computer simulation of the efficiency of computerization investment projects.
7. Results of quantitative comparative analysis through computer simulation of the frequency of cases of non-coincidence of solutions obtained when using the NPV, IRR and PI indices, eventually in combination with the EAV method, for computerization projects of the same and different durations and also of the degree of influence of using the EAV method on the decisions to select computerization projects.

Implementation of scientific results. The results obtained and described in the thesis are implemented within three companies: Moldo-Romanian-French Joint Enterprise TRIMARAN Ltd., WUAI "Criuleni" and BIC "VIA SCOPE" Ltd., confirming the applicability and usefulness of the proposed methodology for comparing investment projects in informatization by streamlining the respective decisions.

Approval of the research results. The basic results of the thesis were discussed at three scientific conferences and were published in 7 papers, including 4 articles in four peer-reviewed scientific journals, one of which without co-authors; in total, 3 publications without co-authors.

Thesis volume and structure: introduction, three chapters, general conclusions and recommendations, 4 annexes, 136 titles of bibliographical sources, 120 pages of basic text, 36 figures and 29 tables.

CONTENT OF THE THESIS

The doctoral thesis deals with the comparative analysis of the indices used to determine the efficiency of i-projects, with an emphasis on the application of computer simulation. Annotations, lists of abbreviations, tables, figures and introductory material facilitate the study and analysis of each section and the work as a whole. Each chapter ends with the systematization and formulation of the basic results obtained and described within it. The section General conclusions and recommendations describes the main results of the research obtained within the work on the topic of the thesis. The three annexes consist of three certificates of implementation of the research results in practice.

Introduction includes aspects regarding the actuality and importance of the research topic, the framework of study on the thesis topic, the aim, objectives, hypotheses and methodological support of the research, the scientific problem solved, the novelty, scientific originality, theoretical significance and applied value of the research, the main scientific results proposed for defense, listing of the three companies in which the scientific results were implemented, as well as the approval of the research results, along with details regarding the volume and structure of the thesis.

Chapter 1 provides an analysis of the state of affairs and identifies possible developments regarding the comparative evaluation of the efficiency of investment projects in informatization. Following the analysis of the works of classical and contemporary scholars (Adam Smith, David Ricardo, John Stuart Mill, Alfred Marshall, Vilfredo Pareto, S. Albu [13], A. Barcaru [14], J. Baker [15], I. Blank [16, 17], N. Botnari [18], A. Damodaran [19], V. Livchits [20], M. Nowak [21], V. Platon [22], M. Law [23], S. Todiraș [2], C.A. Abramov [25], V. Esipov [26], P. Vilenschii [27], V. Kovaliov [28, 30], T. Teplova [31] etc.), who defined fundamental concepts such as “economic efficiency”, “indices” and “projects”, but also the principles, methods of implementation, techniques used and indices applicable in the project evaluation process, it was found that an essential aspect in this context is the identification and application of comparative evaluation methodologies adapted to the specifics of i-projects.

i-Projects present distinct particularities compared to other investment projects, given the specifics of the implementation and use of information and communication technologies. Predominantly, the resulting IT products are incorporated or complement other products/activities, improving the performance of the latter. The evaluation of i-projects requires a distinct approach, adapted to the rapid dynamics of the field and the associated specific characteristics.

By combining classical and modern concepts, the methodological requirements for quantitative comparative evaluation of the efficiency of i-projects are defined:

- the methodology must allow the comparison of the benefits brought by different i-projects, using well-defined financial criteria;
- the methodology must minimize subjective influences, ensuring an evaluation based on objective and measurable factors;
- the comparative analysis must facilitate informed decision-making process, providing a clear framework for comparing the efficiency of investments.

The methods and indices used to assess the efficiency of investment i-projects are analyzed and the theoretical analytical results in the field are systematized. For easier orientation in the multitude of i-projects, in [39] a classification is given based on functional purposes and the degree of uncertainty of the opportunity to implement functional purposes. According to functional purposes, the following i-projects are distinguished:

A) with the same functional purposes – alternative (mutually exclusive) projects, of which only one project is implemented (Category A);
B) with different functional purposes – non-alternative (independent) projects, these are candidates for project portfolios (Category B).

According to the degree of uncertainty of the opportunity to implement functional purposes at a given stage, i-projects can be grouped into three categories:

1) i-projects with functional purposes, where the opportunity to implement is certain;
2) i-projects with functional purposes, where the opportunity to implement is uncertain, this is to be decided based on the examination of the relevant arguments;
3) i-projects with functional purposes, where the inopportunity to implement is certain.

The vast majority of i-projects refer to the second category, which also requires special research. According to the possibility of quantitatively estimating the income from implementation, i-projects can be grouped into two categories [39, 41]:

a) projects, the income from the implementation of which is so difficult to estimate quantitatively that it is not even worth it;
b) projects, the income from the implementation of which can be estimated with reasonable efforts.

Combining the last two criteria, the degree of uncertainty of the opportunity of implementing functional purposes and the possibility of quantitatively estimating the income from implementation, i-projects can be grouped into four categories: 1a, 1b, 2a and 2b, respectively. It will also be considered that for all projects belonging to any of these four categories, all costs incurred for their maintenance and use can be determined.

The comparative analysis, carried out in [39] and based on the correlation between the indices, the specificity of the time value of money, the different duration of the projects, as well as the range and importance of the characterized aspects, led to the reduction of the number of indices for the comparative analysis of i-projects from 16 to 7, namely [29]: the discounted payback period $R_{\mathrm{d}}^{\mathrm{I}}$, the economic return R^{EI} of investments, the Net Present Value (NPV), the Internal Rate of Return (IRR), the Profitability Index (PI), the adjusted costs (C^{EN}) and the total costs of ownership (TCO), eventually in combination with the equivalent annual value (EAV) method. Moreover, according to [12], for projects whose implementation revenues can be estimated with reasonable efforts, their number was reduced to three: NPV, IRR and PI, eventually in combination with the EAV method.

At the same time, it is demonstrated [12] that the NPV, IRR and PI indices form a Pareto set, and their use in comparing i-projects can lead to different solutions. Through theoretical analytical research, only the situations in which the application of these three indices leads to the same solutions and, respectively, to different solutions have been identified [12]. At the same time, the frequency of such cases cannot be determined by such research, although it can often present a separate interest. However, the frequency in question can be determined by computer simulation. Computer simulation has proven effective for studying complex systems [23, 24]. This allows the analysis of multiple scenarios, including modeling and comparing i-projects according to different efficiency indices, taking into account such characteristics as: cash flows, discount rates, i-project implementation durations, etc.

There are also defined the potential developments and listed the expected results of the research, establishing the conceptual framework for assessing i-projects and, respectively, streamlining decisions regarding their selection for implementation.

Chapter 2 describes and discusses the methods, models and algorithms of quantitative comparative research through computer simulation of i-project efficiency indices based on the potential developments and expected results of the research defined in Chapter 1.

One of the methods that could be used to select investment projects is the ***Pareto principle***, also known as the 80/20 rule. For this purpose, the stages of applying the Pareto principle to comparing i-projects are defined. At the same time, although the Pareto principle, as an auxiliary method, could help identify critical factors that influence the success of an investment project, its use for comparing i-projects is inopportune due to the small number of indices used (three).

i-Projects are usually implemented and used over an extended period, and different i-projects may have different durations. Therefore, it is essential for the *time factor* to be taken into account when comparing the efficiency of investments in i-projects. For this purpose, the basic indices are applied in combination with the Equivalent Annual Value (EAV) method [42]. The EAV method is based on the Capital Recovery Factor (CRF). The use of CRF provides a uniform way to integrate and compare the cash flows of projects of different durations. According to [43], CRF is particularly useful for long-duration projects or significant investments. In the case of discount rate d and product useful life D, the CRF value is determined as [42]:

$$\mathrm{CRF} = \left[\sum_{t=1}^{D} \frac{1}{(1+d)^t}\right]^{-1} = \frac{d(1+d)^D}{(1+d)^D - 1}, \tag{1}$$

Here, there is obtained CRF(D=1) = d + 1 and CRF($D\to\infty$) = d; therefore, $d \leq \mathrm{CRF} < d + 1$ [39]. For the index XX, which characterizes a certain absolute value for the period D, the equivalent annual value will be denoted EAXX and is determined as

$$\mathrm{EAXX} = \mathrm{CRF} \times \mathrm{XX}. \tag{2}$$

If the EAV method is applied to the NPV index, it is also called the ***Equivalent Annual Cost (EAC) method*** [47]. For example, among the NPV, EAC and CRF indices the relationship EAC = EANPV = CRF × NPV takes place. Let I be the investments, and CF_t be the cash flows in year t related to the project. Then the NPV, IRR and PI indices are determined as follows:

$$\mathrm{NPV} = \sum_{1}^{D} \frac{\mathrm{CF}_t}{(1+d)^t} - I^{\mathrm{C}}, \quad \sum_{1}^{D} \frac{\mathrm{CF}_t}{(1+\mathrm{IRR})^t} - I^{\mathrm{C}} = 0, \quad \mathrm{PI} = 1 + \frac{\mathrm{NPV}}{I^{\mathrm{C}}}, \tag{3)-(5}$$

For a more complete approach to the quantitative comparative assessment of i-projects, the arguments for the advisability of using the NPV, IRR and PI indices are systematized, including those that led to the advisability of reducing the number of indices more frequently used in comparing i-projects from 16 to 7, and later from 7 to 3 (NPV, IRR and PI, eventually together with the EAV method) for i-projects, the income from the implementation of which can be estimated with reasonable efforts (Categories 1b and 2b). At the same time, for i-projects, the income from the implementation of which is so difficult to estimate quantitatively that it is not even worth it (Categories 1a and 2a), it is appropriate to use [12, 32] the TCO index, eventually in combination with the EAV method.

Since the NPV, IRR and PI indices form a Pareto set, there are cases when the solutions obtained with their use do not coincide. It is of interest how frequently such cases occur, and analytical approaches do not provide an answer to this issue [12, 33]. At the same time, the answer in question can be obtained by i-simulation. So, the basic purpose of i-simulation is to identify the frequency of cases in which the solutions, obtained by applying two or even three indices, lead to different solutions. Only i-projects the revenues from the implementation of which can be estimated with reasonable efforts (of Categories 1b and 2b) will be examined. Each i-project k is characterized by the quantities:

I_k^C – volume of necessary investments;

τ_k - investment appropriation duration I_k^C (duration of project implementation);

D_k – resulting product useful life in the case of project implementation;

$L_k = \tau_k + D_k$ - duration of the project;

CF_{kt} – cash flow in year t;

NPV_k – NPV value;

IRR_k – IRR value;

PI_k – PI value.

The rate d is considered constant for the entire period L and equal for all i-projects that are being compared. Also, when updating the index values, the time of launching the projects into operation will be used as a temporal reference point, this date being the same for all i-projects being compared. The expected frequency will be determined by the percentage of cases in which the solutions obtained when applying at least two indices lead to different solutions.

Therefore, in the case of comparing i-projects of the same duration, it is necessary to identify, through computer simulation, the percentages of cases in which the application of the indices of each pair NP = {NPV, PI} - q_{NP}, NR = {NPV, IRR} - q_{NR}, PR = {PI, IRR} - q_{PR} and also of at least one of the pairs of the triplet NPR = NPV ∪ NR ∪ PR - q_{NPR} leads to different solutions. Obviously, the percentage of coincidence of all solutions when applying the three indices (NPV, PI and IRR) is equal to 100 - q_{NPR}.

Also, in the case of comparing i-projects of different duration, it is necessary to identify the percentages of cases in which the application of the indices of each pair NP = {NPV, PI} - q_{NP}, NR = {NPV, IRR} - q_{NR} and PR = {PI, IRR} - q_{PR}, NPE = {EANPV, EAPI} - q_{NPE}, NRE = {EANPV, IRR} - q_{NRE}, and PRE = {EAPI, IRR} – q_{PRE} and also of at least one of the pairs of the triplet NPER = EANP ∪ EANR ∪ EAPR - q_{NPER} leads to different solutions. Obviously, the percentage of coincidence of all solutions when applying the three indices (EANP, EAPI and IRR) is equal to 100 - q_{NPER}.

Models for comparative analysis of projects of the same duration [48]

Either it is necessary to compare two i-projects, 1 and 2, of equal duration, i.e. $D_1 = D_2 = D$. For this purpose, 7 models are proposed, and for each of them - an algorithm for comparative analysis through computer simulation of the 7 corresponding problem situations.

The discount rate d is considered constant and equal for the two projects, but the values of the cash flows CF_t and, likewise, those of the volume I of investments may differ for the two i-projects. Also, two parameters, g and v, are introduced. The value of g is determined from considerations of ensuring a given value r for the IRR index. So, from equality (4) at $CF_t = CF$, $t = 1, 2, \ldots, D$, we obtain

$$\sum_{t=1}^{D}\frac{\mathrm{CF}_t}{(1+r)^t} - I = \mathrm{CF}\sum_{t=1}^{D}\frac{1}{(1+r)^t} - I = \mathrm{CF}\frac{1-(1+r)^{-D}}{r} - I = \mathrm{CF}/g - I = 0,$$

where:

$$g = \mathrm{CF}/I = r/[1 - (1 + r)^{-D}]. \tag{6}$$

Thus, g depends on r and D and, at the same time, establishes the relation between the value I of investment and the average value CF of cash flows CF_t, $t = 1, 2, \ldots, D$. Of course, at $CF_t \neq CF$, $t = 1, 2, \ldots, D$ the IRR value is not equal to r, but it is relatively close to it.

In turn, the parameter v characterizes the range of relative variation of CF_t with respect to CF. So, the value of v is assigned depending on the value of $CF = gI$, namely:

$$v = (\mathrm{CF} - \mathrm{CF}_{\min})/\mathrm{CF} = (\mathrm{CF}_{\max} - \mathrm{CF})/\mathrm{CF}; \tag{7}$$

$$\mathrm{CF}_{\min} = \mathrm{CF}(1 - v) = gI(1 - v); \tag{8}$$

$$\mathrm{CF}_{\max} = \mathrm{CF}(1 + v) = gI(1 + v); \tag{9}$$

$$\mathrm{CF}_t \in [\mathrm{CF}_{\min}; \mathrm{CF}_{\max}],\ t = 1, 2, \ldots, D. \tag{10}$$

In the calculations, for the parameters d, r, v, D and I, values from the given intervals will be used: $d \in [d_{\min}; d_{\max}]$, $r \in [r_{\min}; r_{\max}]$, $v \in [v_{\min}; v_{\max}]$, $D \in [D_{\min}; D_{\max}]$ and $I \in [I_{\min}; I_{\max}]$. Using these intervals of values, a large number of groups of initial data alternatives can be formed. Of these, as in [48], seven groups are selected, namely a1-a7. In all cases, the CF_t values are randomly generated with uniform distribution in the respective interval, as follows (taking into account (8)-(10)):

$$\mathrm{CF}_{1t} \in [\mathrm{CF}_{1\min}; \mathrm{CF}_{1\max}], \text{ where } \mathrm{CF}_{1\min} = g(1 - v)I_1 \text{ and } \mathrm{CF}_{1\max} = g(1 + v)I_1; \tag{11}$$

$$\mathrm{CF}_{2t} \in [\mathrm{CF}_{2\min}; \mathrm{CF}_{2\max}], \text{ where } \mathrm{CF}_{2\min} = g(1 - v)I_2 \text{ and } \mathrm{CF}_{2\max} = g(1 + v)I_2. \tag{12}$$

In Group a6 of alternatives, the values of the quantities I and D are also randomly generated with uniform distribution in the intervals: $I_1 \in [I_{\min}; I_{\max}]$, $I_2 \in [I_{\min}; I_{\max}]$ and $D \in [D_{\min}; D_{\max}]$. In addition, in Group a7 of alternatives, the values of the quantities r and v are randomly generated in the intervals: $r \in [r_{\min}; r_{\max}]$ and $v \in [v_{\min}; v_{\max}]$. At the same time, any initial data set generated in such a way is accepted only if $NPV_1 > 0$, $NPV_2 > 0$ and $|IRR_1 - IRR_2| \geq \varepsilon$. The reason for using the parameter ε ($\varepsilon = 0.005$) is to take into account the calculation error when determining the values of IRR_1 and IRR_2.

Thus, Groups a1-a7 of alternatives (computer simulation models) are [48]:

a1) dependence on d: $d = d_i$, $i = \overline{1,n}$; D; I_1; I_2; r; v. Here n is the number of values of the quantity d in the interval $[d_{\min}; d_{\max}]$, and the quantities D, I_1, I_2, r and v in the calculations are assigned a specific value within the intervals $[D_{\min}; D_{\max}]$, $[I_{\min}; I_{\max}]$, $[r_{\min}; r_{\max}]$ and $[v_{\min}; v_{\max}]$;

a2) dependence on D: $D = D_i$, $i = \overline{1,n}$; d; I_1; I_2; r; v. Here n can be different from that used for Group a1, and the quantities d, I_1, I_2, r and v in the calculations are assigned a specific value within the intervals $[d_{\min}; d_{\max}]$, $[I_{\min}; I_{\max}]$, $[r_{\min}; r_{\max}]$ and $[v_{\min}; v_{\max}]$;

a3) dependence on I: $I_2 = I_{2i}$, $i = \overline{1,n}$; d; D; I_1; r; v. Here, the quantities d, D, I_1, r and v in the calculations are assigned a specific value within the intervals $[d_{\min}; d_{\max}]$, $[D_{\min}; D_{\max}]$, $[I_{\min}; I_{\max}]$, $[r_{\min}; r_{\max}]$ and $[v_{\min}; v_{\max}]$;

a4) dependence on r: $r = r_i$, $i = \overline{1,n}$; d; D; I_1; I_2; v. Here, the quantities d, D, I_1, I_2 and v in the calculations are assigned a specific value within the intervals [$d_{\min}$; $d_{\max}$], [$D_{\min}$; $D_{\max}$], [$I_{\min}$; $I_{\max}$] and [$v_{\min}$; $v_{\max}$], respectively;

a5) dependence on v: $v = v_i$, $i = \overline{1,n}$; d; D; I_1; I_2; r. Here, the quantities d, D, I_1, I_2 and r in the calculations are assigned a specific value within the intervals $d_{\min}$; $d_{\max}$], [$D_{\min}$; $D_{\max}$], [$I_{\min}$; $I_{\max}$] and [$r_{\min}$; $r_{\max}$];

a6) dependence on $d+$ (on d when randomly generating the values of the quantities D, I_1 and I_2 – general partial group): $d = d_i$, $i = \overline{1,n}$, and the quantities D_i, I_{1i} and I_{2i} take random values, while the ones r and v – a specific value in the respective intervals;

a7) dependence on $d\cdot$ (on d when randomly generating values for D, I_1, I_2, r and v – the general group): $d = d_i$, $i = \overline{1,n}$, and D, I_1, I_2, r and v take values in the respective intervals.

Algorithms for comparative analysis of i-projects of the same duration [48]

Among Algorithms 1-7 for comparative analysis of i-projects of the same duration, Algorithms 2 and 7 are described below as examples.

<u>Algorithm 2 for Group a2 of alternatives</u> - determination of the percentages $q_{\mathrm{NP}}(D)$, $q_{\mathrm{NR}}(D)$, $q_{\mathrm{PR}}(D)$, $q_{\mathrm{NPR}}(D)$ and $f(D)$, consists of the following:

1. Initial data: d; n; D_i, $i = \overline{1,n}$; I_1; I_2; r; v; K.
2. $j := 1$.
3. $D := D_j$; $g := r/[1 - (1 + r)^{-D}]$; $\mathrm{CF}_{1\min} := g(1 - v)I_1$, $\mathrm{CF}_{1\max} := g(1 + v)I_1$, $\mathrm{CF}_{2\min} := g(1 - v)I_2$, $\mathrm{CF}_{2\max} := g(1 + v)I_2$; $m_{\mathrm{f}} := 0$, $m_{\mathrm{NP}} := 0$, $m_{\mathrm{NR}} := 0$, $m_{\mathrm{PR}} := 0$, $m_{\mathrm{NPR}} := 0$ and $k := 1$, where k is the current iteration number within the sample size K.
4. Generating, with uniform random distribution, the values of the quantities $\mathrm{CF}_{\mathrm{I}t} \in [\mathrm{CF}_{1\min}; \mathrm{CF}_{1\max}]$, $t = 1, 2, \ldots, D$ and $\mathrm{CF}_{2t} \in [\mathrm{CF}_{2\min}; \mathrm{CF}_{2\max}]$, $t = 1, 2, \ldots, D$.
5. Calculation of NPV_1 according to (3). If $\mathrm{NPV}_1 < 0$, then $m_{\mathrm{f}} := m_{\mathrm{f}} + 1$ and go to Step 10.
6. Calculation of NPV_2 according to (3). If $\mathrm{NPV}_2 < 0$, then $m_{\mathrm{f}} := m_{\mathrm{f}} + 1$ and go to Step 10.
7. Determination of RR_1 and IRR_2 taking into account (4). If $|\mathrm{IRR}_1 - \mathrm{IRR}_2| \leq \varepsilon$, then $m_{\mathrm{f}} := m_{\mathrm{f}} + 1$ and go to Step 10.
8. Determination of PI_1 and PI_2 according to (5).
9. Identifying cases and updating, if necessary, the values of the quantities m_{NP}, m_{NR}, m_{PR} and m_{NPR}.
10. If $k < K$, then $k := k + 1$ and go to Step 4.
11. $q_{\mathrm{NP}}(D) := 100m_{\mathrm{NP}}/(K - m_{\mathrm{f}})$, $q_{\mathrm{NR}}(D) := 100m_{\mathrm{NR}}/(K - m_{\mathrm{f}})$, $q_{\mathrm{PR}}(D) := 100m_{\mathrm{PR}}/(K - m_{\mathrm{f}})$, $q_{\mathrm{NPR}}(D) := 100m_{\mathrm{NPR}}/(K - m_{\mathrm{f}})$ and $f(D) := 100m_{\mathrm{f}}/K$.
12. If $j < n$, then $j := j + 1$ and go to Step 3.
13. Retrieving simulation results. Stop.

Here K is the sample size of the initial data sets for the i-simulation, m_{f} is the number of cases, and f is the percentage of cases of failure in generating the initial data sets. Such a failure occurs if at least one of the inequalities NPV1 < 0, NPV2 < 0 and $|\mathrm{IRR}_1 - \mathrm{IRR}_2| > \varepsilon$. is confirmed when generating an initial data set.

<u>Algorithm 7 for Group a7</u> - determination of the percentages $q_{\mathrm{NP}}(d\cdot)$, $q_{\mathrm{NR}}(d\cdot)$, $q_{\mathrm{PR}}(d+)$, $q_{\mathrm{NPR}}(d\cdot)$ and $f(d\cdot)$, consists of the following:

1. Initial data: n; d_i, $i = \overline{1,n}$; K.
2. $j := 1$.
3. $d := d_j$; $m_{\mathrm{f}} := 0$, $m_{\mathrm{NP}} := 0$, $m_{\mathrm{NR}} := 0$, $m_{\mathrm{PR}} := 0$, $m_{\mathrm{NPR}} := 0$ and $k := 1$.

4. Generating, with uniform random distribution, the values of the quantities $D \in [D_{min}; D_{max}]$, $I_1 \in [I_{min}; I_{max}]$, $I_2 \in [I_{min}; I_{max}]$, $r \in [r_{min}; r_{max}]$ and $v \in [v_{min}; v_{max}]$, where r_{min} and r_{max} represent the minimum value and, respectively, the maximum ones admitted for quantity r, and v_{min} and v_{max} are the minimum and maximum value, respectively, allowed for the size v. Also, $g := r/[1 - (1 + r)^{-D}]$; $CF_{1min} := g(1 - v)I_1$, $CF_{1max} := g(1 + v)I_1$; $CF_{2min} := g(1 - v)I_2$ and $CF_{2max} := g(1 + v)I_2$.
5. Generating, with uniform random distribution, the values of the quantities $CF_{1t} \in [CF_{1min}; CF_{1max}]$, $t = 1, 2, \ldots, D$ and $CF_{2t} \in [CF_{2min}; CF_{2max}]$, $t = 1, 2, \ldots, D$.
6. Calculation of NPV_1 according to (3). If $NPV_1 < 0$, then $m_f := m_f + 1$ and go to Step 11.
7. Calculation of NPV_2 according to (3). If $NPV_2 < 0$, then $m_f := m_f + 1$ and go to Step 11.
8. Determination of IRR_1 and IRR_2 taking into account (4). If $|IRR_1 - IRR_2| \leq \varepsilon$, then $m_f := m_f + 1$ and go to Step 11.
9. Determination of PI_1 and PI_2 according to (5).
10. Identifying cases and updating, if necessary, the values of the quantities m_{NP}, m_{NR}, m_{PR} and m_{NPR}.
11. If $k < K$, then $k := k + 1$ and go to Step 4.
12. $q_{NP}(d+) := 100m_{NP}/(K - m_f)$, $q_{NR}(d+) := 100m_{NR}/(K - m_f)$, $q_{PR}(d+) := 100m_{PR}/(K - m_f)$, $q_{NPR}(d+) := 100m_{NPR}/(K - m_f)$ and $f(d+) := 100m_f/K$.
13. If $j < n$, then $j := j + 1$ and go to Step 3.
14. Retrieving simulation results. Stop.

Models for comparative analysis of i-projects of different duration [43]

Either it is necessary to compare two i-projects, 1 and 2, of different duration, i.e. $D_1 \neq D_2$. The approach is similar to that for i-projects of the same duration, except that $D_1 > D_2$. For this purpose, 7 models are proposed, and for each of them - an algorithm for comparative analysis through computer simulation of 7 problem situations that correspond to Alternative Groups 1-7 of initial data sets.

Alternative Groups 1-7 (computer simulation models) are:

1) dependence on d: $= d_i$, $i = \overline{1,n}$; D_1; D_2, $D_2 < D_1$; I_1; I_2; r; v. Here n is the number of values of the quantity d within the interval $[d_{min}; d_{max}]$, and quantities D_1, D_2, I_1, I_2, r and v are atributed in the calculation a value specifically within the intervals $[D_2 + 1; D_{max}]$, $[D_{min}; D_{max} - 1]$, $[I_{min}; I_{max}]$, $[r_{min}; r_{max}]$ and $[v_{min}; v_{max}]$, respectively;

2) dependence on D_2: $D_2 = D_{2i}$, $i = \overline{1,n}$; d; $D_1 > D_2$; I_1; I_2; r; v. Here the quantities d, D_1, I_1, I_2, r and v are atributed in the calculation a value specifically within the intervals $[d_{min}; d_{max}]$, $[D_2 + 1; D_{max}]$, $[I_{min}; I_{max}]$, $[r_{min}; r_{max}]$ and $[v_{min}; v_{max}]$, respectively;

3) dependence on I_2: $I_2 = I_{2i}$, $i = \overline{1,n}$; d; D_1; D_2, $D_2 < D_1$; I_1; r; v. Here the quantities d, D_1, D_2, I_1, r and v are atributed in the calculation a value specifically within the intervals $[d_{min}; d_{max}]$, $[D_2 + 1; D_{max}]$, $[D_{min}; D_{max} - 1]$, $[I_{min}; I_{max}]$, $[r_{min}; r_{max}]$ and $[v_{min}; v_{max}]$, respectively;

4) dependence on r: $r = r_i$, $i = \overline{1,n}$; d; D_1; D_2, $D_2 < D_1$; I_1; I_2; v. Here the quantities d, D_1, D_2, I_1, I_2 and v are atributed in the calculation a value specifically within the intervals $[d_{min}; d_{max}]$, $[D_2 + 1; D_{max}]$, $[D_{min}; D_{max} - 1]$, $[I_{min}; I_{max}]$ and $[v_{min}; v_{max}]$;

5) dependence on v: $v = v_i$, $i = \overline{1,n}$; d; D_1; D_2, $D_2 < D_1$; I_1; I_2; r. Here the quantities d, D_1, D_2, I_1, I_2 and r are atributed in the calculation a value specifically within the intervals $[d_{min}; d_{max}]$, $[D_2 + 1; D_{max}]$, $[D_{min}; D_{max} - 1]$, $[I_{min}; I_{max}]$ and $[r_{min}; r_{max}]$;

6) dependence on d+ (on d when randomly generating the values of quantities D_1, D_2 ($D_2 < D_1$), I_1 and I_2 – general partial group): $d = d_i$, $i = \overline{1, n}$, and quantities D_i, I_{1i} and I_{2i} take random values, while r and v – a specific value in the respective intervals;

7) dependence on $d\cdot$ (on d when randomly generating the values of quantities D_1, D_2 ($D_2 < D_1$), I_1, I_2, r and v – general group): $d = d_i$, $i = \overline{1, n}$, and quantities D_1, D_2, I_1, I_2, r and v take random values in the respective intervals.

Algorithms for comparative analysis of i-projects *of different duration* [43]

Among the Algorithms 8-14 for comparative analysis of i-projects of different duration, Algorithms 9 and 14 are described below as examples.

Algorithm 9 for Group 2 of alternatives - determination of percentages $q_{NP}(D_2)$, $q_{NR}(D_2)$, $q_{PR}(D_2)$, $q_{NPE}(D_2)$, $q_{NRE}(D_2)$, $q_{PRE}(D_2)$ and $f(D_2)$, consists of the following:

1. Initial data: n; D_{2i}, $i = \overline{1, n}$; d; D_1, $D_1 > D_2$; I_1; I_2; r; v; K. Here $D_1 \in [D_{2n} + 1; D_{max}]$, $D_{2i} \in [D_{min}; D_{max} - 1]$, $i = \overline{1, n}$; $I_1 \in [I_{min}; I_{max}]$ and $I_2 \in [I_{min}; I_{max}]$.
2. $j := 1$. $g_1 := r/[1-(1+r)^{D_1}$; $CF_{1min} := g_1(1 - v)I_1$, $CF_{1max} := g_1(1 + v)I_1$.
3. $D_2 := D_{2j}$; $g_2 := r/[1-(1+r)^{D_2}$; $CF_{2min} := g_2(1 - v)I_2$, $CF_{2max} := g_2(1 + v)I_2$; $m_f :=$ 0, $m_{NP} := 0$, $m_{NR} := 0$, $m_{PR} := 0$, $m_{NPE} := 0$, $m_{NRE} := 0$, $m_{PRE} := 0$ and $k := 1$, where k is the current iteration number within the sample size K.
4. Generating, with uniform random distribution, the values of the quantities $CF_{It} \in [CF_{1min}; CF_{1max}]$, $t = 1, 2, \dots, D_1$ and $CF_{2t} \in [CF_{2min}; CF_{2max}]$, $t = 1, 2, \dots, D_2$.
5. Calculation of NPV_1 according to (3). If $NPV_1 < 0$, then $m_f := m_f + 1$ and go to Step 9.
6. Calculation of NPV_2 according to (3). If $NPV_2 < 0$, then $m_f := m_f + 1$ and go to Step 9.
7. Determination of PI_1 and PI_2 according to (5), EANPV according to {(1)-(3)}, EANPI according to {(1), (2), (5)} and IRR_1 and IRR_2 taking into account (4).
8. Identifying cases and updating, if necessary, the values of the quantities m_{NP}, m_{NR}, m_{PR}, m_{NPE}, m_{NRE} and m_{PRE}.
9. If $k < K$, then $k := k + 1$ and go to Step 4.
10. $q_{NP}(D) := 100m_{NP}/(K - m_f)$, $q_{NR}(D) := 100m_{NR}/(K - m_f)$, $q_{PR}(D) := 100m_{PR}/(K - m_f)$, $q_{NPE}(D) := 100m_{NPE}/(K - m_f)$, $q_{NRE}(D) := 100m_{NRE}/(K - m_f)$, $q_{PRE}(D) := 100m_{PRE}/(K - m_f)$ and $f(D) := 100m_f/K$.
11. If $j < n$, then $j := j + 1$ and go to Step 3.
12. Retrieving simulation results. Stop.

Here K is the sample size of the initial data sets for i-simulation, m_f is the number of cases, and f - the percentage of cases of failure in generating the initial data sets. Such a failure occurs if at least one of the inequalities NPV1 < 0 and NPV2 < 0 is confirmed when generating an initial data set.

Algorithm 14 for Group 7 of alternatives - determination of the percentages $q_{NP}(d\cdot)$, $q_{NR}(d\cdot)$, $q_{PR}(d\cdot)$, $q_{NPE}(d\cdot)$, $q_{NRE}(d\cdot)$, $q_{PRE}(d\cdot)$ and $f(d\cdot)$, consists of the following:

1. Initial data: n; d_i, $i = \overline{1, n}$; D_{min}, D_{max}; I_{min}, I_{max}; r_{min}, r_{max}; v_{min}, v_{max}; K.
2. $j := 1$.
3. $d := d_j$; $m_f := 0$, $m_{NP} := 0$, $m_{NR} := 0$, $m_{PR} := 0$, $m_{NPE} := 0$, $m_{NRE} := 0$, $m_{PRE} := 0$ and $k :=$ 1, where k is the current iteration number within the sample size K.
4. Generating, with uniform random distribution, the values of the quantities $D_2 \in [D_{min}; D_{max} - 1]$, $D_1 \in [D_2+1; D_{max}]$, $I_I \in [I_{min}; I_{max}]$, $I_2 \in [I_{min}; I_{max}]$, $r \in [r_{min}; r_{max}]$

and $v \in [v_{\min}; v_{\max}]$ and determination of $g_1 := r/[1-(1+r)^{D_1}$ and $g_2 := r/[1-(1+r)^{D_2}$.

5. $\mathrm{CF}_{1\min} := g_1(1-v)I_1$, $\mathrm{CF}_{1\max} := g_1(1+v)I_1$; $\mathrm{CF}_{2\min} := g_2(1-v)I_2$, $\mathrm{CF}_{2\max} := g_2(1+v)I_2$ and the generation, with uniform random distribution, of the values of the quantities $\mathrm{CF}_{\mathrm{I}t} \in [\mathrm{CF}_{1\min}; \mathrm{CF}_{1\max}]$, $t = 1, 2, \ldots, D_1$ and $\mathrm{CF}_{2t} \in [\mathrm{CF}_{2\min}; \mathrm{CF}_{2\max}]$, $t = 1, 2, \ldots, D_2$.
6. Calculation of NPV_1 according to (3). If $\mathrm{NPV}_1 < 0$, then $m_f := m_f + 1$ and go to Step 10.
7. Calculation of NPV_2 according to (3). If $\mathrm{NPV}_2 < 0$, then $m_f := m_f + 1$ and go to Step 10.
8. Determination of PI_1 and PI_2 according to (5), EANPV according to {(1)-(3)}, EANPI according to {(1), (2), (5)} and IRR_1 and IRR_2 taking into account (4).
9. Identifying cases and updating, if necessary, the values of the quantities m_{NP}, m_{NR}, m_{PR}, m_{NPE}, m_{NRE} and m_{PRE}.
10. If $k < K$, then $k := k + 1$ and go to Step 4.
11. $q_{\mathrm{NP}}(v) := 100m_{\mathrm{NP}}/(K-m_f)$, $q_{\mathrm{NR}}(v) := 100m_{\mathrm{NR}}/(K-m_f)$, $q_{\mathrm{PR}}(v) := 100m_{\mathrm{PR}}/(K-m_f)$, $q_{\mathrm{NPE}}(v) := 100m_{\mathrm{NPE}}/(K-m_f)$, $q_{\mathrm{NRE}}(v) := 100m_{\mathrm{NRE}}/(K-m_f)$, $q_{\mathrm{PRE}}(v) := 100m_{\mathrm{PRE}}/(K-m_f)$ and $f(v) := 100m_f/K$.
12. If $j < n$, then $j := j + 1$ and go to Step 3.
13. Retrieving simulation results. Stop.

Models for analyzing the influence of the EAV method on the selection of i-projects [47]

As mentioned, the use of the EAV method in the comparative analysis of i-projects of different duration has important advantages. Of interest is the degree to which the use of the EAV method influences the solutions when comparing i-projects of different duration. To this end, 7 models are proposed and for each of them an algorithm is provided for comparative analysis of i-projects of different duration by computer simulation of 7 problem situations that correspond to Groups 1-7 of initial data set alternatives.

To determine the degree of influence of the EAV method, the solutions obtained using the indices of the pairs NPE = {EANPV, EAPI}, NRE = {EANPV, IRR}, PRE = {EAPI, IRR}, 2NE = {NPV, EANPV} and 2PE = {PI, EAPI} with the triplets NPR = {NPV, PI, IRR} and NPER = {EANPV, EAPI, IRR} will be compared, through i-simulation. The percentages of cases in which the mentioned solutions differ will be used as measurements, respectively: q_{NPE}, q_{NRE}, q_{PRE}, $q_{2\mathrm{NE}}$, $q_{2\mathrm{PE}}$, q_{NPR} and q_{NPER}.

As in the case of comparing i-projects of the same duration, K is the sample size of the initial data sets for i-simulation, m_f is the number of cases, and f - the percentage of failure cases in generating the initial data sets. Such a failure occurs if, when generating an initial data set, at least one of the inequalities NPV1 < 0, NPV2 < 0 and $|\mathrm{IRR}_1 - \mathrm{IRR}_2| > \varepsilon$ is confirmed.

Algorithms for analyzing the influence of the EAV method on the selection of i-projects [47]

Among Algorithms 15-21 for analyzing the influence of the EAV method on the selection of i-projects, Algorithms 16 and 21 are described below, as examples.

<u>Algorithm 16 for Group 2 of alternatives</u> - determining the percentages $q_{\mathrm{NP}}(D_2)$, $q_{\mathrm{NR}}(D_2)$, $q_{\mathrm{PR}}(D_2)$, $q_{\mathrm{NPE}}(D_2)$, $q_{\mathrm{NRE}}(D_2)$, $q_{\mathrm{PRE}}(D_2)$ and $f(D_2)$, consists of the following:

1. Initial data: n; D_{2i}, $i = \overline{1,n}$; d; D_1, $D_1 > D_2$; I_1; I_2; r; v; K. Here $D_1 \in [D_{2n} + 1; D_{max}]$, $D_{2i} \in [D_{min}; D_{max} - 1]$, $i = \overline{1,n}$; $I_1 \in [I_{min}; I_{max}]$ and $I_2 \in [I_{min}; I_{max}]$.
2. $j := 1$. $g_1 := r/[1-(1+r)^{D_1}$; $CF_{1min} := g_1(1 - v)I_1$, $CF_{1max} := g_1(1 + v)I_1$.
3. $D_2 := D_{2j}$; $g_2 := r/[1-(1+r)^{D_2}$; $CF_{2min} := g_2(1 - v)I_2$, $CF_{2max} := g_2(1 + v)I_2$; $m_f := 0$, $m_{NPE} := 0$, $m_{NRE} := 0$, $m_{PRE} := 0$, $m_{2NE} := 0$, $m_{2PE} := 0$, $m_{NPR} := 0$, $m_{NPER} := 0$ and $k := 1$, where k is the current iteration number within the sample size K.
4. Generating, with uniform random distribution, the values of the quantities $CF_{It} \in [CF_{1min}; CF_{1max}]$, $t = 1, 2, \ldots, D_1$ and $CF_{2t} \in [CF_{2min}; CF_{2max}]$, $t = 1, 2, \ldots, D_2$.
5. Calculation of NPV_1 according to (3). If $NPV_1 < 0$, then $m_f := m_f + 1$ and go to Step 10.
6. Calculation of NPV_2 according to (3). If $NPV_2 < 0$, then $m_f := m_f + 1$ and go to Step 10.
7. Determination of IRR_1 and IRR_2 from (4). If $|IRR_1 - IRR_2| \le \varepsilon$, then $m_f := m_f + 1$ and go to Step 10.
8. Determination of PI_1 and PI_2 according to (5), EANPV according to {(1)-(3)} and EANPI according to {(1), (2), (5)}.
9. Identifying cases and updating, if necessary, the values of the quantities m_{NPE}, m_{NRE}, m_{PRE}, m_{2NE}, m_{2PE}, m_{NPR} and m_{NPER}.
10. If $k < K$, then $k := k + 1$ and go to Step 4.
11. $q_{NP}(D) := 100m_{NP}/(K - m_f)$, $q_{NR}(D) := 100m_{NR}/(K - m_f)$, $q_{PR}(D) := 100m_{PR}/(K - m_f)$, $q_{NPE}(D) := 100m_{NPE}/(K - m_f)$, $q_{NRE}(D) := 100m_{NRE}/(K - m_f)$, $q_{PRE}(D) := 100m_{PRE}/(K - m_f)$ and $f(D) := 100m_f/K$.
12. If $j < n$, then $j := j + 1$ and go to Step 3.
13. Retrieving simulation results. Stop.

<u>Algorithm 21 for Group 7 of alternatives</u> - determining the percentages $q_{NP}(d\cdot)$, $q_{NR}(d\cdot)$, $q_{PR}(d\cdot)$, $q_{NPE}(d\cdot)$, $q_{NRE}(d\cdot)$, $q_{PRE}(d\cdot)$ and $f(d\cdot)$, consists of the following:

1. Initial data: n; d_i, $i = \overline{1,n}$; D_{min}, D_{max}; I_{min}, I_{max}; r_{min}, r_{max}; v_{min}, v_{max}; K.
2. $j := 1$.
3. $d := d_j$; $m_f := 0$, $m_{NPE} := 0$, $m_{NRE} := 0$, $m_{PRE} := 0$, $m_{2NE} := 0$, $m_{2PE} := 0$, $m_{NPR} := 0$, $m_{NPER} := 0$ and $k := 1$, where k is the current iteration number within the sample size K.
4. Generating, with uniform random distribution, the values of the quantities $D_2 \in [D_{min}; D_{max} - 1]$, $D_1 \in [D_2+1; D_{max}]$, $I_I \in [I_{min}; I_{max}]$, $I_2 \in [I_{min}; I_{max}]$, $r \in [r_{min}; r_{max}]$ and $v \in [v_{min}; v_{max}]$ and determination of $g_1 := r/[1-(1+r)^{D_1}$ and $g_2 := r/[1-(1+r)^{D_2}$.
5. $CF_{1min} := g_1(1 - v)I_1$, $CF_{1max} := g_1(1 + v)I_1$; $CF_{2min} := g_2(1 - v)I_2$, $CF_{2max} := g_2(1 + v)I_2$ and the generation, at uniform random distribution, of the values of the quantities $CF_{It} \in [CF_{1min}; CF_{1max}]$, $t = 1, 2, \ldots, D_1$ and $CF_{2t} \in [CF_{2min}; CF_{2max}]$, $t = 1, 2, \ldots, D_2$.
6. Calculation of NPV_1 according to (3). If $NPV_1 < 0$, then $m_f := m_f + 1$ and go to Step 11.
7. Calculation of NPV_2 according to (3). If $NPV_2 < 0$, then $m_f := m_f + 1$ and go to Step 11.
8. Determination of IRR_1 and IRR_2 taking into account (4). If $|IRR_1 - IRR_2| \le \varepsilon$, then $m_f := m_f + 1$ and go to Step 11.
9. Determination of PI_1 and PI_2 according to (5), EANPV according to {(1)-(3)}, EANPI according to {(1), (2), (5)}.
10. Identifying cases and updating, if necessary, the values of the quantities m_{NPE}, m_{NRE}, m_{PRE}, m_{2NE}, m_{2PE}, m_{NPR}, and m_{NPER}.

11. If $k < K$, then $k := k + 1$ and go to Step 4.
12. $q_{NP}(v) := 100m_{NP}/(K - m_f)$, $q_{NR}(v) := 100m_{NR}/(K - m_f)$, $q_{PR}(v) := 100m_{PR}/(K - m_f)$, $q_{NPE}(v) := 100m_{NPE}/(K - m_f)$, $q_{NRE}(v) := 100m_{NRE}/(K - m_f)$, $q_{PRE}(v) := 100m_{PRE}/(K - m_f)$ and $f(v) := 100m_f/K$.
13. If $j < n$, then $j := j + 1$ and go to Step 3.
14. Retrieving simulation results. Stop.

Chapter 3 explores the results obtained from the application of the methodologies, indices and algorithms described in the previous chapters. But first, the methodology of computer simulation of i-project characteristics is described.

Methodology of computer simulation of i-project characteristics

To perform calculations according to Algorithms 1-21, the values of some characteristics of the related models are argued, namely, depending on the case [38]: $d = \{0.05, 0.06, 0.07, \ldots, 0.14\}$, $D = \{1, 2, 3, \ldots, 10\}$, $I = \{100, 200, 300, \ldots, 1000\}$, $v \in [0{,}1; 0{,}9]$, $v = \{0.1, 0.2, \ldots, 0.9\}$, $r = \{0.1, 0.2, 0.3, \ldots, 0.9\}$, $\varepsilon = 0.05$.

The size K of the calculation sample for a group of initial data alternatives, at the required accuracy (error margin δ) the expression [45] was used:

$$K = \frac{z(\beta)^2 p(1-p)}{\delta^2}, \tag{13}$$

where: $\boldsymbol{z}$ is the confidence coefficient, depending on the desired confidence level β; δ - the margin of simulation error; p - the estimated proportion of entities in the given set belonging to the first of the two classes. For p, the most conservative estimate is used, that is, the case that requires the largest value of the sample K at the given margin of error δ, i.e. $p = 0.5$. At $p = 0.5$, expression (13) takes the form

$$K(\beta,\delta) = \frac{[z(\beta)]^2 0{,}5^2}{\delta^2} = \left[\frac{0{,}5z(\beta)}{\delta}\right]^2. \tag{14}$$

To determine the required sample value $\boldsymbol{K}$, some approximate values of the function $K(\beta,\delta)$ are determined. The nature of the dependence of the K value on β and δ can be observed in Figures 1 and 2.

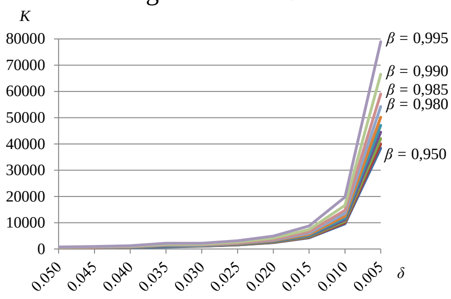

Figura 1. Dependența K de eroarea δ și nivelul de încredere β

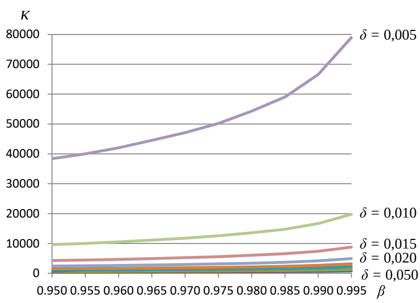

Figura 2. Dependența K de nivelul de încredere β și eroarea δ

Source: developed by author

As expected, the function $K(\beta,\delta)$ is increasing with respect to β and decreasing with respect to δ. However, at large values of δ (approx. $\delta > 0.015$) the value of the function

$K(\beta,\delta)$ decreases slowly, and at small values of it (approx. $\delta < 0.015$) – decreases more and more rapidly.

The results of the calculations show that even for a simulation error of 0.5% at the 99.5% confidence level, a sample of approx. 80000 sets of initial data values is sufficient. At the same time, since when generating the initial data sets it is necessary to observe the conditions $NPV_1 > 0$, $NPV_2 > 0$ and $|IRR_1 - IRR_2| \geq \varepsilon$, it may happen that the effective size of the simulation sample might be significantly smaller than 80000. The sample $K = 100000$ is used in the calculations.

Based on the described methodology, the SIMINV simulation i-application is created in C++ Builder according to Algorithms 2.1-2.21 and the respective calculations are performed.

Computer simulation results for i-projects of the same duration [43, 48]

Some of the results of the calculations performed for i-projects of the same duration are presented in Figures 3 and 4. Figure 3 shows the dependencies of *f* on *d* for Groups a1, a6 and a7 of initial data alternatives.

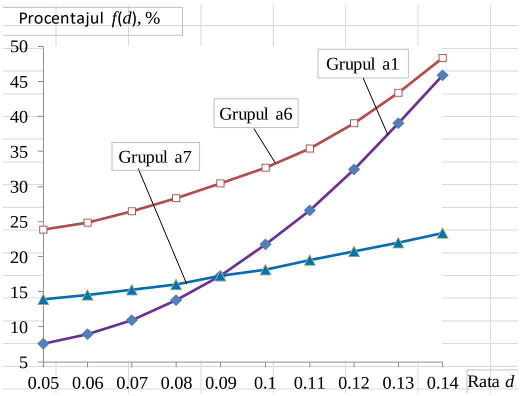

Figure 3. Percentage of failures when generating initial data sets

Source: developed by author

Thus, for Groups a1-a7 of alternatives, the dependencies $f(\cdot)$ are increasing with respect to *d*, the total range of values being [1.5; 74.3]%, except for the case of Group a4 at $r = 0.1$ when the upper limit is 97.7%. So, in the case of Group a4 at $r = 0.1$, the effective sample of initial data is 100000(100 – 97.7)/100 = 2300 sets and is usually good enough: according to calculations, $K = 2300$ fits the cases $\{\beta \leq 0.980;\ \delta \geq 0.025\}$ and $\{\beta \leq 0.995;\ \delta \geq 0.030\}$. In all other cases, the sample of initial data sets exceeds 100000(100 – 74.3)/100 = 25700 sets and is very good: according to calculations, $K = 25700$ fits the cases $\{\beta \leq 0.995;\ \delta \geq 0.010\}$.

For Group a2 of alternatives, the dependencies $q_{NP}(D_2)$, $q_{NR}(D)$, $q_{PR}(D)$ and $q_{NPR}(D)$ at $d = 0.08$ are presented in Figure 4.

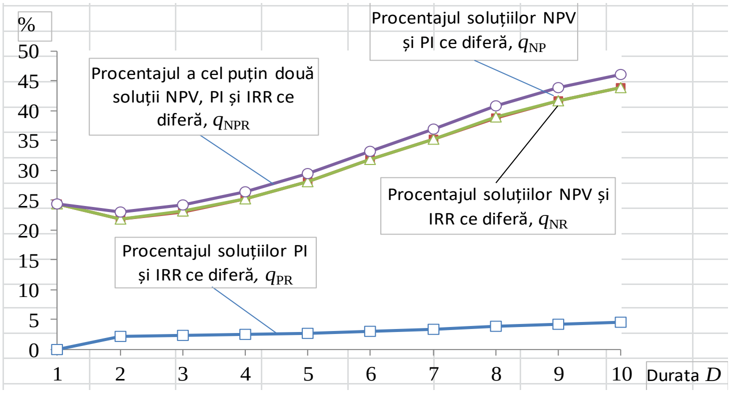

Figure 4. Percentages $q_{NP}(D)$, $q_{NR}(D)$, $q_{PR}(D)$ and $q_{NPR}(D)$
Source: developed by author

In pairs, for Groups a1-a6 of initial data set alternatives, the dependencies $q_{NP}(\cdot)$ and $q_{NR}(\cdot)$ practically coincide, and for Group a7 they are very close to each other. Also, the dependency of $q_{NPR}(\cdot)$ is relatively close to them. As for the percentages of $q_{PR}(\cdot)$, they are usually considerably smaller than those for $q_{NP}(\cdot)$, $q_{NR}(\cdot)$ and $q_{NPR}(\cdot)$. Thus, among the indices NPV, PI and IRR, the last two are the closest to each other in terms of the obtained solutions of the efficiency of i-projects. A comparative analysis of the range of values for the four percentages can be carried out based on the data in Table 1.

Table 1. Value ranges for the percentages $q_{NP}(\cdot)$, $q_{NR}(\cdot)$, $q_{PR}(\cdot)$ and $q_{NPR}(\cdot)$, %

Indices		$q_{NP}(\cdot)$	$q_{NR}(\cdot)$	$q_{PR}(\cdot)$	$q_{NPR}(\cdot)$
Minimum of	$q(d)$	21.60	21.60	1.30	22.20
	$q(D)$	20.32	21.05	0	21.14
	$q(I_2)$	0	1.26	1.24	1.26
	$q(r)$	13.36	13.36	0	13.36
	$q(v)$	20.58	20.20	0	21.71
	$q(d+)$	20.31	20.43	1.07	20.90
	$q(d\cdot)$	33.40	34.03	8.32	37.88
General minimum		0	1.26	0	1.26
Maximum of	$q(d)$	32.10	32.10	3.84	34.00
	$q(D)$	47.67	47.57	7.06	51.15
	$q(I_2)$	48.34	48.31	3.89	50.25
	$q(r)$	49.22	49.35	19.11	58.67
	$q(v)$	50.01	50.03	5.56	50.35
	$q(d+)$	28.22	28.40	4.16	30.39
	$q(d\cdot)$	34.68	35.74	10.95	40.69
General maximum		50.01	50.03	19.11	58.67
Total value of the interval		50.01	48.77	19.11	57.41

Source: developed by author

Thus, for Groups a1-a7 of alternatives of initial data sets used, the average percentage of cases with different solutions for all three pairs of indices is considerable, namely: $q_{NP}(\cdot) \in [0; 50.01]\%$, $q_{NR}(\cdot) \in [1.26; 50.03]\%$ and $q_{PR}(\cdot) \in [0; 19.11]\%$.Also, the average percentage $q_{NPR}(\cdot)$ of cases with different solutions, when using at least two of the three examined indices (NPV, PI and IRR), is in the range of values [1.26; 58.67]%. The overall size of the range of values is approximately: 50% for $q_{NP}(\cdot)$, 49% for $q_{NR}(\cdot)$, 19% for $q_{PR}(\cdot)$ and 57% for $q_{NPR}(\cdot)$. At the same time, there are categories of initial data sets in which the indices examined in pairs always lead to the same solution, including the pairs:

- {NPV, PI} for Group a3 (dependence on I_2) at $I_1 = I_2 = 1000$ (is obvious);
- {PI, IRR} for Group a2 (dependence on D) at $D = 1$, for Group a4 (dependence on r) at $\{r = 0.1; d = 0.14\}$ and for Group a5 (dependence on v) at $v = 0.1; d \in [0.12; 0.14]\}$.

It is also worth noting that, based on Group a7 of initial data alternatives, the average percentage of cases with different solutions is approximately: 9.1% for $q_{PR}(\cdot)$, 34.1% for $q_{NP}(\cdot)$, 34.9% for $q_{NR}(\cdot)$ and 39.3% for $q_{NPR}(\cdot)$. Thus, on average, the solutions obtained when comparing the efficiency of projects, when using the NPV, PI and IRR indices, do not coincide in more than 1/3 of the cases.

Some of the other results, obtained for i-projects of the same duration, are described in the General Conclusions and Recommendations section.

Computer simulation results for i-projects of different duration [43]

Some of the results of the calculations performed for i-projects of different duration are presented in Figures 5 and 6. Figure 5 shows the dependencies of f on d for Groups 1, 6 and 7 of initial data alternatives.

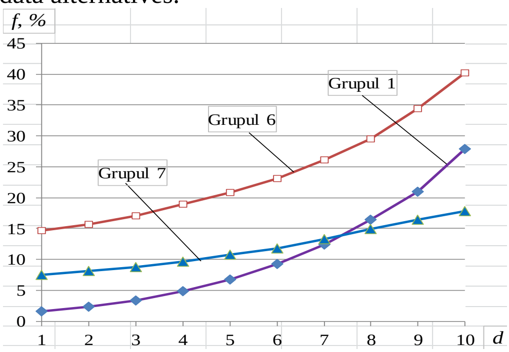

Figure 5. Percentage of failures in generating initial data, i-projects of different duration

Source: developed by author

For Groups 1-7 of alternatives, the $f(\cdot)$ dependencies are increasing or slowly increasing with respect to d, the range of values overall being [0; 51.8]%, except for Group 4 at $r = 0.1$ when the upper limit is 99.65%. Thus, in the case of Group 4 at $r = 0.1$, the effective sample of initial data is 100000(100 – 99.65)/100 = 350 sets and may be insufficient: according to the calculations performed, $K = 350$ suits the cases $\{\beta \leq 0.939; \delta \geq 0.050\}$. In all other cases, the effective sample of initial data exceeds 100000(100 – 51.8)/100 = 48200 sets and is very good: according to calculations, $K = 48200$ fits the cases $\{\beta \leq 0.995; \delta \geq 0.010\}$ and $\{\beta \leq 0.970; \delta \geq 0.005\}$.

For Group 3 of alternatives, the dependencies $q_{NP}(I_2)$, $q_{NR}(I_2)$, $q_{PR}(I_2)$, $q_{NPE}(I_2)$, $q_{NRE}(I_2)$ and $q_{PRE}(I_2)$ at d = 0.08 are presented in Figure 6.

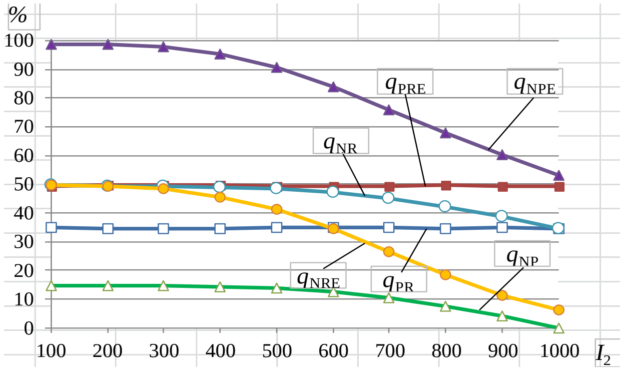

Figure 6. Percentages $q_{NP}(I_2)$, $q_{NR}(I_2)$, $q_{PR}(I_2)$, $q_{NPE}(I_2)$, $q_{NRE}(I_2)$ and $q_{PRE}(I_2)$

Source: developed by author

In pairs, for Groups 1-7 of alternatives, the $f(\cdot)$ dependencies are increasing or slowly increasing with respect to d, the range of values overall being [0; 51.8]%, except for Group 4 at r = 0.1, when the upper limit is 99.65%. Thus, in the case of Group 4 at r = 0.1, the effective sample of initial data is 100000(100 – 99.65)/100 = 350 sets and may be insufficient: according to the calculations performed, K = 350 suits the cases $\{\beta \leq 0.939; \delta \geq 0.050\}$.

A comparative analysis of the ranges of values for the six percentages can be performed based on the data in Table 2.

Table 2. The value ranges for $q_{NP}(\cdot)$, $q_{NR}(\cdot)$, $q_{PR}(\cdot)$, $q_{NPE}(\cdot)$, $q_{NRE}(\cdot)$ and $q_{PRE}(\cdot)$, %

		$q_{NP}(\cdot)$	$q_{NR}(\cdot)$	$q_{PR}(\cdot)$	$q_{NPE}(\cdot)$	$q_{NRE}(\cdot)$	$q_{PRE}(\cdot)$
The minimum compared to	$q(d)$	7.37	44.25	20.81	71.59	31.66	39.93
	$q(D_2)$	3.38	31.40	4.55	13.18	4.61	9.38
	$q(I_2)$	0	20.40	20.40	43.25	3.89	40.11
	$q(r)$	0.004	26.99	9.66	36.93	15.54	19.40
	$q(v)$	0	38.89	16.31	59.85	25.86	33.99
	$q(d+)$	21.95	24.79	11.31	31.46	20.36	25.53
	$q(d\cdot)$	28.59	38.14	30.30	40.47	34.59	28.11
General minimum		0	20.40	4.55	13.18	4.61	9.38
The maximum compared to	$q(d)$	23.44	48.39	40.54	93.67	43.72	50.05
	$q(D_2)$	37.50	82.73	75.61	93.61	47.26	50.75
	$q(I_2)$	37.10	57.85	40.54	99.27	56.58	50.38
	$q(r)$	23.34	49.23	49.11	93.76	49.21	50.40
	$q(v)$	22.97	48.94	47.43	100	47.43	53.26
	$q(d+)$	28.03	34.11	23.19	37.47	28.55	28.54
	$q(d\cdot)$	29.17	40.56	35.26	41.38	36.58	30.51
Maximum overall		37.50	82.73	75.61	100	56.58	50.75
Total value of the interval		37.50	62.33	71.06	82.82	51.97	41.37

Source: developed by author

The data in Table 2 present that, for all Groups 1-7 of initial data alternatives used, the average percentage of cases with different solutions for all six pairs of indices is usually considerable, namely: $q_{NP}(\cdot) \in [0; 37.50]\%$, $q_{PRE}(\cdot) \in [9.38; 50.75]\%$, $q_{NRE}(\cdot) \in [4.61; 56.58]\%$, $q_{NR}(\cdot) \in [20.40; 82.73]\%$, $q_{PR}(\cdot) \in [4.55; 75.61]\%$ and $q_{NPE}(\cdot) \in [13.18; 100]\%$. Also, the total size of the value interval is approx.: 38% for $q_{NP}(\cdot)$, 41% for $q_{PRE}(\cdot)$, 52% for $q_{NRE}(\cdot)$, 62% for $q_{NR}(\cdot)$, 71% for $q_{RP}(\cdot)$ and 83% for $q_{NPE}(\cdot)$.

At the same time, if we consider the uniform distribution of $q(\cdot)$ in the value interval, the average percentage of cases with different solutions on pairs of indices is approx. (in ascending order): 18.3% for $q_{NP}(\cdot)$, 30.1% for $q_{PRE}(\cdot)$, 30.6% for $q_{NRE}(\cdot)$, 40.1% for $q_{PR}(\cdot)$, 51.6% for $q_{NR}(\cdot)$ and 56.6% for $q_{NPE}(\cdot)$.

Some of the other results, obtained for i-projects of different duration, are described in the General Conclusions and Recommendations section.

Results of the analysis of the influence of the EAV method on the selection of i-projects [47]

Some of the results of the calculations for the analysis of the influence of the EAV method on the selection of i-projects of different duration are presented in Figures 7 and 8. Figure 7 presents the dependencies of f on d for Groups 1, 6 and 7 of alternatives. These dependencies are increasing with respect to d at $d \in [0.051; 0.14]$, but do not exceed 43.9%.

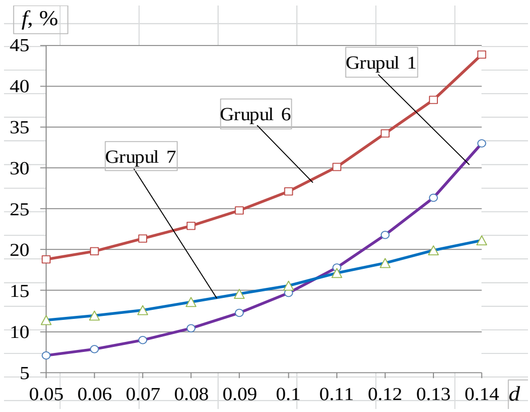

Figure 7. Percentage of failure cases when generating initial data sets
Source: developed by author

For all Groups 1-7 of alternatives, the dependencies $f(\cdot)$ are increasing with respect to d, except for Group 2, for which it is decreasing. Overall, the range of values is [1.56; 54.18]%, except for Group 4 at $r = 0.1$, when the upper limit is 99.73%. Thus, in the case of Group 4 at $r = 0.1$, the effective sample of initial data is 100000(100 – 99.73)/100 = 270 alternatives and may be insufficient: according to the calculations performed, $K = 270$ fits the cases $\{\beta \leq 0.899;\ \delta \geq 0.050\}$. In all other cases, the initial data sample exceeds 100000(100 – 54.18)/100 = 45820 alternatives of the initial data sets and is very good: according to the data of Table 3.2 of the thesis, K = 48200 fits the cases $\{\beta \le 0.995;\ \delta \ge 0.010\}$ and $\{\beta \le 0.965;\ \delta \ge 0.005\}$.

For Group 4 of alternatives, the dependencies $q_{NPE}(r)$, $q_{NRE}(r)$, $q_{PRE}(r)$, $q_{2NE}(r)$, $q_{2PE}(r)$, $q_{NPR}(r)$ and $q_{NPER}(r)$ at d = 0.08 are presented in Figure 8.

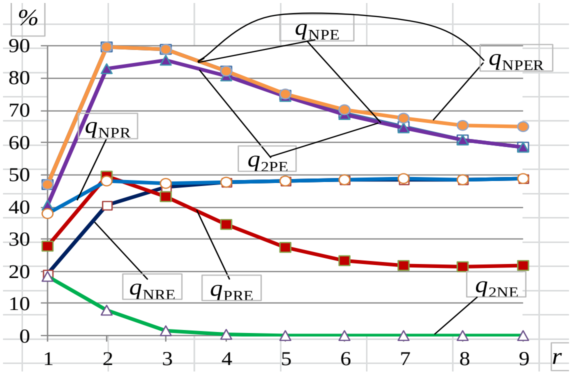

Figure 8. Percentages $q_{NPE}(r)$, $q_{NRE}(r)$, $q_{PRE}(r)$, $q_{2NE}(r)$, $q_{2PE}(r)$, $q_{NPR}(r)$ and $q_{NPER}(r)$ at d = 0,08
Source: developed by author

A comparative analysis of the value ranges for the seven percentages can be carried out based on the data in Table 3.

Table 3. The value ranges for the seven dependencies at $d \in$[0,05; 0,14], %

		$q_{NPE}(\cdot)$	$q_{NRE}(\cdot)$	$q_{PRE}(\cdot)$	$q_{2NE}(\cdot)$	$q_{2PE}(\cdot)$	$q_{NPR}(\cdot)$	$q_{NPER}(\cdot)$
The minimum compared to	$q(d)$ (d)	69.40 (0.14)	30.23 (0.14)	39.17 (0.14)	4.43 (0.05)	57.72 (0.14)	43.79 (0.14)	69.40 (0.14)
	$q(D_2)$ (d/d_2)	11.78 (0.14/1)	3.92 (0.14/1)	7.78 (0.12/9)	0.95 (0.05/9)	9.45 (0.14/9)	29.63 (0.05/9)	11.78 (0.14/1)
	$q(I_2)$ (d/I_2)	40.92 (0.14/1000)	1.61 (0.14/1000)	39.39 (0.06/100)	0.002 (0.05/100)	57.69 (0.14/700)	18.30 (0.14/1000)	41.02 (0.14/1000)
	$q(r)$ (d/r)	21.90 (0.14/0.1)	7.66 (0.14/0.1)	14.23 (0.14/0.1)	0.003 (0.05/0.9)	16.42 (0.14/0.1)	19.71 (0.14/0.1)	21.90 (0.14/0.1)
	$q(v)$ (d/v)	57.83 (0.14/0.9)	24.69 (0.14/0.9)	33.14 (0.14/0.1)	0 (all/0.1)	47.86 (0.14/0.9)	38.38 (0.14/0.9)	57.83 (0.14/0.9)
	$q(d+)$ (d)	30.08 (0.14)	18.38 (0.14)	23.65 (0.14)	8.70 (0.14)	33.02 (0.14)	26.73 (0.14)	36.05 (0.14)
	$q(d\cdot)$ (d)	40.06 (0.14)	34.02 (0.14)	27.18 (0.14)	13.97 (0.14)	51.80 (0.14)	48.06 (0.14)	50.63 (0.14)
Minimum overall		11.78	1.61	7.78	0	9.45	18.30	11.78
The maximum compared to	$q(d)$ (d)	93.30 (0.05)	43.27 (0.05)	50.10 (0.06)	13.56 (0.14)	89.93 (0.05)	48.28 (0.09)	93.30 (0.05)
	$q(D_2)$ (d/D_2)	93.23 (0.05/5)	46.94 (0.05/9)	50.81 (0.05/4)	76.46 (0.09/1)	96.46 (0.05/2)	83.20 (0.07/1)	93.23 (0.05/5)
	$q(I_2)$ (d/I_2)	99.23 (0.05/100)	57.05 (0.14/100)	50.41 (0.06/100)	36.84 (0.05/1000)	90.17 (0.05/400)	56.35 (0.13/100)	99.23 (0.1/100)
	$q(r)$	93.40	49.18	50.45	19.78	90.13	49.18	93.40

	(d/r)	(0.05/0.2)	(0.06/0.9)	(0.05/0.2)	(0.06/0.1)	(0.05/0.2)	(0.1/0.8)	(0.05/0.2)
	$q(v)$ (d/v)	100 (all/0.1)	47.06 (0.06/0.2)	54.11 (0.14/0.9)	15.35 (0.09/0.9)	100 (0.05/0.1)	48.86 (0.06/0.7)	100 (all/0.1)
	$q(d+)$ (d)	37.22 (0.05)	27.53 (0.05)	27.56 (0.05)	14.23 (0.05)	48.97 (0.05)	41.34 (0.05)	46.16 (0.05)
	$q(d\cdot)$ (d)	40.93 (0.05)	35.99 (0.05)	29.70 (0.06)	17.03 (0.05)	58.34 (0.05)	51.53 (0.05)	53.26 (0.05)
Maximum overall		100	57.05	54.11	76.46	100	83.20	100
Maximum value of the range		88.22	55.44	46.33	76.46	90.55	64.90	88.22

Source: developed by author

The data in Table 3 show that the average number of cases, in which the use of the three indices, eventually in combination with the EAV method, leads to at least two different solutions, is considerable: $q_{\text{NPER}}(d) \in [69.40; 93.30]\%$, $q_{\text{NPER}}(D_2) \in [11.78; 93.23]\%$, $q_{\text{NPER}}(I_2) \in [41.02; 99.23]\%)$, $q_{\text{NPER}}(r) \in [21.90; 93.40]\%$, $q_{\text{NPER}}(v) \in [57.83; 100]\%$, $q_{\text{NPER}}(d+) \in [36.05; 46.16]\%$ and $q_{\text{NPER}}(d\cdot) \in [50.63; 53.26]\%$.

Based on the data in Table 3 and also the results of other calculations performed, it is easy to conclude that the solutions obtained using the EANPV, EAPI and IRR indices can form a Pareto set in the following cases:

Pa) for Group 2, at $d \in [0.05; 0.10]$, $D_2 \in [8; 9]\}$ and $\{d = 0.11, D_2 = 9\}$;

Pb) for Group 3, at $\{d \in [0.05; 0.09], I_2 \in [800; 1000]\}$ and $\{d \in [0.1; 0.14], I_2 \in [900; 1000]\}$;

Pc) for Group 4, at $\{d \in [0.05; 0.09], r \in [0.4; 0.9]\}$ and $\{d \in [0.13; 0.14], r \in [0.5; 0.9]\}$;

Pd) for Groups 6 and 7, at $d \in [0.05; 0.14]$.

In all *other cases*, only the solutions obtained using the EANPV and EAPI indices can form a Pareto set, because at $\varepsilon = 0.005$, $q_{\text{NPER}}(\textit{other cases}) = q_{\text{NPE}}(\textit{other cases})$ takes place; that is, the IRR index has no new contribution to the value of q_{NPER} (*other cases*).

At the same time, it was demonstrated that the larger the group number is, the greater the maximum discrepancy between the percentages $q_{\text{NPER}}(\cdot)$ and $q_{\text{NPE}}(\cdot)$ is. Only for Groups 1 and 5 the equalities $q_{\text{NPER}}(d) = q_{\text{NPE}}(d)$ and $q_{\text{NPER}}(v) = q_{\text{NPE}}(v)$ take place.

Some of the other results, obtained for the analysis of the influence of the EAV method on the selection of i-projects, are described in the General Conclusions and Recommendations section.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

As a result of the research on the comparative analysis of the efficiency criteria of investments in informatization carried out and described in the thesis, the following ***general conclusions*** are outlined:

1. Based on the analysis of specialized literature, the following aspects are addressed: the identification and classification of economic efficiency indices necessary for evaluating informatization investment projects (i-projects); the systematization of i-projects' characteristics, the methods for assessing their benefits, and the justification for conducting a comparative analysis of efficiency criteria to rationalize investment decisions in the field; and the systematization of arguments supporting the use of NPV, IRR, and PI indices, potentially in conjunction with the EAV method, for the quantitative comparative evaluation of i-projects. These three indices form a Pareto set, and existing analytical solutions do not provide a definitive answer regarding the frequency of discrepancies in solutions when they are used. The frequency of such cases, in various scenarios, can be determined through computer simulation.

2. The general research problem is formulated systematically, and the objectives of the comparative analysis of NPV, IRR, and PI indices, potentially combined with the EAV method, are defined to assess the efficiency of informatization investments through computer simulation.

3. The methodological requirements for the quantitative comparative evaluation of i-project efficiency are defined, ensuring an assessment based on objective and measurable factors. This, in turn, provides an appropriate conceptual framework for evaluating i-projects and optimizing decision-making in their selection.

4. Computer simulation models are developed for the comparative analysis of i-projects with the same duration, including Groups a1-a7 of alternative sets of initial data and the dependencies to be determined for each group, as well as for i-projects with different durations, including Groups 1-7 of alternative sets of initial data and the dependencies to be determined for each group. Additionally, seven distinct computer simulation models are developed to analyze the impact of using the EAV method on decision-making in selecting i-projects with different durations.

5. For each of the 21 i-simulation models mentioned in paragraph 4, an algorithm has been designed to conduct the computer simulation, aiming to determine the percentage frequency of discrepancies in solutions when comparing i-projects based on pairs or triplets of indices among NPV, IRR, PI, EANPV, and EAPI.

6. A methodology for quantitative comparative analysis through computer simulation of the economic efficiency of i-projects has been developed. This methodology provides a well-founded specification of the values/value ranges for the parameters used in the 21 models and their corresponding 21 algorithms mentioned in paragraphs 7 and 8, including the sample size required for the given simulation accuracy: the error margin δ, the confidence level β, and the most conservative estimate - $p = 0,5$.

7. Using the SIMINV i-application developed, the frequency of failures in generating initial data sets, in accordance with the methodology specified in paragraph 6, has been determined through computer simulation.

8. The results of the computer simulation in the case of i-projects of the same duration show that for Groups a1-a7 of alternatives of initial data sets used (42 dependencies):

a) the average percentage of cases with different solutions for all three pairs of indices is: $q_{\mathrm{NP}}(\cdot) \in [0; 50.01]\%$, $q_{\mathrm{NR}}(\cdot) \in [1.26; 50.03]\%$ and $q_{\mathrm{PR}}(\cdot) \in [0; 19.11]\%$. Also, the average percentage $q_{\mathrm{NPR}}(\cdot)$, when at least two of the NPV, PI and IRR indices are used, is in the range [1.26; 58.67]%. The general size of the range of values is approximately: 50 % for $q_{\mathrm{NP}}(\cdot)$, 49 % for $q_{\mathrm{NR}}(\cdot)$, 19 % for $q_{\mathrm{PR}}(\cdot)$ and 57 % for $q_{\mathrm{NPR}}(\cdot)$;

b) from Groups a1-a7, there are groups for which the indices examined in pairs always lead to the same solution, including the pairs: {NPV, PI} for Group a3 (dependence on I_2) at $I_1 = I_2 = 1000$; {PI, IRR} for Group a2 (dependence on D) at $D = 1$, for Group a4 (dependence on r) at $\{r = 0{,}1;\ d = 0.14\}$ and for Group a5 (dependence on v) at $\{v = 0{,}1;\ d \in [0.12; 0.14]\}$;

c) from Groups a1-a7, no groups were identified for which the NPV and IRR indices and, respectively, all NPV, PI and IRR indices together always lead to the same solution;

d) on average (Group a7 - general), the solutions obtained, when comparing the efficiency of i-projects based on the NPV, PI and IRR indices, do not coincide in more than 1/3 of the cases.

9. The results of the computer simulation in the case of i-projects of different duration show that for Groups 1-7 of alternatives of initial data sets used (42 dependencies):

a) the average percentage of cases with different solutions is: $q_{NP}(\cdot) \in [0; 37{,}50]$%, $q_{PRE}(\cdot) \in [9.38; 50.75]$%, $q_{NRE}(\cdot) \in [4.61; 56.58]$%, $q_{NR}(\cdot) \in [20.40; 82.73]$%, $q_{PR}(\cdot) \in [4.55; 75.61]$% and $q_{NPE}(\cdot) \in [13.18; 100]$%. Also, the total size of the value interval is approx.: 38% for $q_{NP}(\cdot)$, 41% for $q_{PRE}(\cdot)$, 52% for $q_{NRE}(\cdot)$, 62% for $q_{NR}(\cdot)$, 71% for $q_{RP}(\cdot)$ and 83% for $q_{NPE}(\cdot)$;

b) the largest discrepancy is between $q_{NP}(\cdot)$ and $q_{NPE}(\cdot)$ (except for Group 6 at large values of d when this is the pair $\{q_{PR}(d+), q_{PRE}(d+)\}$); it follows, in most cases, the pair $\{q_{PR}(\cdot), q_{PRE}(\cdot)\}$, and the smallest discrepancy is usually between the percentages $q_{NR}(\cdot)$ and $q_{NRE}(\cdot)$. At the same time, the relationships $q_{NP}(\cdot) < q_{NPE}(\cdot)$ and $q_{NR}(\cdot) \geq q_{NRE}(\cdot)$ occur; it also occurs $q_{PR}(\cdot) \leq q_{PRE}(\cdot)$ for some groups and $q_{PR}(\cdot) \geq q_{PRE}(\cdot)$ for other groups;

c) the average percentage of cases with different solutions on pairs of indices is about 18.3% for $q_{NP}(\cdot)$, 30.1% for $q_{PRE}(\cdot)$, 30.6% for $q_{NRE}(\cdot)$, 40.1% for $q_{PR}(\cdot)$, 51.6% for $q_{NR}(\cdot)$ and 56.6% for $q_{NPE}(\cdot)$;

d) the average percentage of cases with different solutions is considerable; it depends on the pair of indices used, but usually exceeds 18%, if the EAV method is not used, and exceeds 30%, if the EAV method is used.

10. The results of the computer simulation to determine the influence of using the EAV method on i-project selection decisions show that (49 dependencies):

a) the overall size of the range of values of the percentages $q_{NRE}(\cdot)$, $q_{PRE}(\cdot)$, $q_{2NE}(\cdot)$, $q_{2PE}(\cdot)$, $q_{NPR}(\cdot)$ and $q_{NPER}(\cdot)$ is considerable: 46.3% for $q_{PRE}(\cdot)$, 55.4% for $q_{NRE}(\cdot)$, 64.9% for $q_{NPR}(\cdot)$, 76.5% for $q_{2NE}(\cdot)$, 88.2% for $q_{NPE}(\cdot)$ and $q_{NPER}(\cdot)$ and 90.5% for $q_{2PE}(\cdot)$;

b) the average percentage of cases with different solutions is approx. 29.3% for $q_{NRE}(\cdot)$, 30.9% for $q_{PRE}(\cdot)$, 38.2% for $q_{2NE}(\cdot)$, 50.7% for $q_{NPR}(\cdot)$, 54.7% for $q_{2PE}(\cdot)$ and 55.9% for $q_{NPE}(\cdot)$ and $q_{NPER}(\cdot)$;

c) using the EAV method together with the NPV and PI indices can significantly influence the decision. Usually, this statement is also valid for the pairs of indices {EAPI, IRR} and {PI, IRR}, but it is an inverse one for the pairs of indices {EANPV, IRR} and {NPV, IRR};

d) in terms of the degree of influence on the decision, EAPI $\succ\succ$ EANPV takes place;

e) using the IRR index together with the EANPV and EAPI indices can influence the decision, on average, in no more than 12.3% of the cases.

11. The research hypotheses formulated in the Introduction section have been validated.

12. The obtained results can significantly facilitate the understanding of decision-makers of the particularities of applying efficiency indices when selecting i-projects.

13. The research results obtained and described in the thesis were implemented in three companies: Moldo-Romanian-French Joint Enterprise TRIMARAN Ltd., WUAI "Criuleni" and BIC "VIA SCOPE" Ltd., thus confirming their applicability and efficiency.

As a result of the conducted research and the obtained results on the topic of the thesis, ***it is recommended:***

1. For higher education institutions with study programs in the field of ICT – to use the methodology of analysis and quantitative evaluation of informatization projects within the curriculum of some university disciplines.
2. For economic agents – to use the methodology of analysis and quantitative evaluation of informatization projects when making investment decisions in the field.
3. For scientific researchers, doctoral candidates and students, for future developments:
   - development of models for evaluating the efficiency of i-projects through a multi-criteria approach, including taking into account both financial and non-financial aspects;
   - development of models for evaluating the efficiency of IT projects by expanding the set of modeling characteristics used;
   - comparative studies of the application of the methodology for analyzing and quantitatively evaluating i-projects in different sectors such as health, education, construction, etc.

REFERENCES

1. Strategia Națională pentru Transformarea Digitală a Republicii Moldova 2021-2025. *https://e-transformare.md/2021/12/17/transformarea-digitala-a-republicii-moldova/ (accesat 21.11.2022).*
2. ALBU, I., TODIRAȘ, S. Investiții. Evaluarea proiectelor. - Chișinău: CEP USM, 1998. ISBN 9975-70-127-0.
3. *ROMANU, I., VASILESCU, I.* Eficiența economică a investițiilor și a capitalului fix. – București: Editura ASE, *1993. ISBN 973-30-2689*-5.
4. Planul Național de Acțiuni în domeniul TIC. *https://gov.md/sites/default/files/document/attachments/intr02_1_7.pdf (accesat 10.12.2023*).
5. Legea nr. 46 din 25.03.2008 privind telecomunicațiile. *https://www.legis.md/ cautare/getResults?doc_id=130448&lang=ro (accesat 12.08.2021)*.
6. Legea nr. 64 din 22.03.2012 privind securitatea cibernetică. *https://www.parlament.md/ProcesulLegislativ/Proiectedeactenormative/tabid/61/LegislativId/6386/language/ro-RO/Default.aspx (accesat 25.10.2020)*.
7. Legea nr. 113 din 30.05.2018 privind protecția datelor cu caracter personal. *https://www.legis.md/cautare/getResults?doc_id=10607&lang=ro (accesat 16.07.2020)*.
8. Legea nr. 81 din 18.03.2004 privind investițiile în activitatea de întreprinzător. *https://www.legis.md/cautare/getResults?doc_id=27427&lang=ro (accesat 23.09.2020)*.
9. PEUMANS, H. Valoración de proyectos de inversión. - Editura Deusto, 1967. ISBN 978-84-234-0184.
10. *Strategia Națională pentru Societatea Informațională „Moldova Digitală 2020”.* https://www.egov.md/sites/default/files/document/attachments/strategia_de_transformare_digitala_2023-2030.pdf 10 (accesat 05.06.2023).
11. BOLUN, I. Efficiency of investments in informatization. - Saarbrücken: Scholars' Press, 2017. - 218 p. ISBN 978-620-2-30270-8.
12. BOLUN, I. Criteria to be used by mission of investment projects. *Economica* nr.4 (102) 2017, pp. 135-148.
13. ALBU, S., CAPSÎZU, V., ALBU, I. *Eficiența investițiilor*: *Curs universitar*. - Chișinău: CEP USM, 2005. – 138 p.
14. BARCARARU, A. *Eficienta investitiilor in conditii de risc valutar*, teză de doctorat. ASE Bucuresti, 2005.
15. BAKER, J.R., MONEYPENNY, J.W. Financial Metrics for IT Investments: A Practical Guide. *Information Systems Management*, 22(3), 2005, pp. 20-30.
16. BLANK, I.A. *Upravlenie ispolzovaniem kapitala.* - Elga: Nika-Tsentr, 2000. – 651 p. ISBN 5-89319-013-9 (în rusă).
17. BLANK, I.A. *Osnovy finansovogo menedzhmenta*. 2-e izdanie. - Elga: Nika-Tsentr, 2009. – 1374 p. ISBN 5-89319-187-8 (în rusă).
18. BOTNARI, N., ȘCHIOPU, I. *Implicațiile managementului financiar în realizarea obiectivelor financiare ale întreprinderii.* Cahul: Editura Universitatea de Stat "Bogdan Petriceicu Hasdeu" din Cahul, 2022. ISBN 978-9975-88-088-6.
19. DAMODARAN, A. *Investment Valuation: Tools and Techniques for Determining the Value of Any Asset,* 3rd Edition. 2012, 992 p. ISBN: 978-1-118-20659-1.
20. LIVCHITS, V.N. Systems analysis of investment project efficiency evaluation.In: *Systems analysis and modeling of integrated world systems*, Vol. I, 2009.

21. NOWAK, Maciej. Investment projects evaluation by simulation and multiplecriteria decision aiding procedure. *Journal of Civil Engineering and Management, 2005*, 11(3), pp. 193-202, ISSN 1392-3730.
22. PLATON, V., CONSTANTINESCU, A. Monte Carlo Method in risk analysis for investment projects. *Procedia Economics and Finance,* 2014, no. 15, pp. 393 – 400. ISSN 2212-5671.
23. LAW, AVERILL M. *Simulation modeling and analysis,* 5th edition. - McGraw-Hill, 2014. ISBN 978-0-07-340132-4.
24. **GHETMANCENCO, S.** Evaluation of the economic efficiency of investment projects in informatization through the method of computer simulation. În: "Development through research and innovation - 2024", conf. științ. internaţ., Ediția V, August 23, 2024. Chisinau.
25. ABRAMOV, S.A. Ekonomicheskoe obosnovanie avtomatizatsii obrabotki informatsii. – Moskva: Statistika, 1974. - 234 p. ISBN 5-98762-320-4 (în rusă).
26. ESIPOV, V.E.; MAKHOVIKOVA, V.A.; BUZOVA, V.V. i dr. Ekonomicheskaya otsenka investitsiy. – Sankt-Peterburg: Vektor, 2006. - 320 p. ISBN 5-4645-1320-X, (sursa în rusă).
27. Vilensky, P.L.; Livchits, V.N.; Smoleak, S.A. *Estimarea eficienței proiectelor de investiții*. – M.: Delo, 2004 (în rusă).
28. KOVALEV, V.V. *Metody otsenki investitsionnykh proektov*. - Moskva: Finansy i statistika, 2000. - 432 p. ISBN 5-9740-0124-X (în rusă).
29. **GHETMANCENCO, S**. Analiza indicilor de apreciere a eficienţei proiectelor de investiţii în informatizare. În: *„Competitivitate şi inovare în economia cunoaşterii*", conf. științ. internaţ., Ediţia a XXI-a, 27-28 septembrie 2019. Chişinău: Editura ASEM, 2019, pp. 649-655, 0,49 c.a. ISBN 978-9975-75-968-7. Disponibil: https://ibn.idsi.md/ sites/default/files/imag_file/632-638.pdf.
30. KOVALEV, V.V. *Finansovyi analiz. Upravlenie kapitalom. Vybor investitsii*. - Moskva, Finansy i statistika, 1995. - 512 p. ISBN 5-93229-134-9 (în rusă).
31. TEPLOVA, T.V. *7 stupenei analiza investitsiy v realnye aktivy*. - Moskva, Eksmo, 2008. - 368 p. ISBN 978-5-699-27389-6. (în rusă).
32. **GHETMANCENCO, S.,** NASTAS, V. Methods of evaluation of the economic effect in mobile application development projects**.** În: „*Development through Research and Innovation – 2020*", conf. științ. internaţ., Ediţia I, 28 august 2020. Chişinău: ASEM, 2020, pp.17-27, 0.46 c.a. ISBN 978-9975-155-03-8. Disponibil: http://irek.ase.md:80/ xmlui/handle/1234567890/1317.
33. **GHETMANCENCO, S.** Metode matematice de evaluare a eficienţii proiectelor de investiții. În: „*30 years of economic reforms in the Republic of Moldova: economic progress via innovation and competitiveness*", conf. științ. internaţ., 24-25 septembrie, 2021. Chisinau: ASEM, 2021, pp. 246-250, 0,83 c.a. ISBN 978-9975-155-66-3. Disponibil: https://irek.ase.md/xmlui/ handle/123456789/2083.
34. MARQUETTI, A.A., MORRONE, H., MIEBACH, A., OURIQUE, L.E. Measuring the Profit Rate in an Inflationary Context: The Case of Brazil, 1955–2008. *Review of Radical Political Economics*, 2019, 51(1), pp. 52–74.
35. ROUBENS, M. Preference relations on action and criteria in multicriteria decision making. *European Journal of Operational Research*, vol.10, 1982.
36. RICHARD, A., BREALEY, S., MYERS, C., MARCUS, J. *Fundamentals of Corporate Finance*, 7th Edition. McGraw-Hill/Irwin, 2008. ISBN: 978-1563240846.
37. BREALEY, R. A., MYERS, S. C., ALLEN, F. *Principles of Corporate Finance*. McGraw-Hill Education, 2017.
38. ŞOIM, H. Rolul şi utilizarea TIC în activitatea întreprinderilor. http://www.ccisalaj.ro/proj/ modul8.pdf (accesat 24.08.2022).

39. BOLUN, I. Aspects of selecting investment projects. In: *Competitiveness and innovation in the knowledge economy*: proc. intern. conf., Sept. 22-23, 2017, Vol. 5. Chisinau: Editura ASEM, 2018. - pp. 7-12. ISBN 978-9975-75-901-4.
40. GINZBURG, A.I. *Prikladnoi ekonomicheskii analiz*. - Sankt-Peterburg: Piter, 2005. ISBN 9785469014331 (în rusă).
41. **GHETMANCENCO, S.** Methods for determining economic efficiency for computer investment projects. *Studia Universitatis Moldaviae*, Vol. 2, No. 11, 2022, pp. 47-56, 0,38 c.a. ISSN 2587-4446. Categoria B. Disponibil: https://ojs.studiamsu.md/index.php/stiinte_economice/article/view/2764/3776**.**
42. COPELAND, T., KOLLER, T., MURRIN, J. *Valuation: Measuring and Managing the Value of Companies*. John Wiley & Sons, 2000.
43. BOLUN, I., **GHETMANCENCO, S**., NASTAS, V. Efficiency indices of investment in IT projects with unequal lives. *SWorldJournal*, 12(1), 2022, pp. 16-34, ISSN 2663-5712.
44. DOGAN, MATTEI, PELASSY, DOMINIQUE. Comparing Nations: Concepts, Strategies, Outcomes. *Westview Press*, 1990, ISBN 0813323680.
45. COCHRAN, W.Gl. *Sampling techniques*, 3rd ed. New York: John Wiley & Sons, 1977. – 442 p.
46. *Internal Rate of Return (IRR) Guide*. Property Club, https://propertyclub.nyc/article/ internal-rate-of-return-irr-guide] (accesat 18.01.2022).
47. BOLUN, I., **GHETMANCENCO, S.,** NASTAS, V. Equivalent annual value method's influence on the selection of IT investment projects. *Journal of Business and Economics*, October 2022, Vol. 13, No. 10, pp 555-569. ISSN 2155-7950.
48. BOLUN, I., **GHETMANCENCO, S.** Efficiency indices of investment in IT projects with equal lives**.** *Journal of Social Sciences*, 2022, Vol. V, no. 3, 2022, pp. 105-120, 1,08 c.a. ISSN 2587-3490, eISSN 2587-3504. Categoria B+.

LIST OF PUBLICATIONS ON THE THESIS TOPIC

2. Articles in scientific journals

2.2. in journals from other databases accepted by ANACEC (indicating the database)

1. BOLUN, I., **GHETMANCENCO, S.,** NASTAS, V. Equivalent annual value method's influence on the selection of IT investment projects. *Journal of Business and Economics*, Vol 13, No. 10, October 2022, pp. 555-569. c.a. 1,3. ISSN 2155-7950. Disponibil: http://portal.issn.org/resource/.

2.3. in journals from the National Register of journals under profile

2. BOLUN, I., **GHETMANCENCO, S.** Efficiency indices of investment in IT projects with equal lives**.** *Journal of Social Sciences*, 2022, Vol. V, no. 3, 2022, pp. 105-120, 1,08 c.a. ISSN 2587-3490, eISSN 2587-3504. Categoria B+. Disponibil: https://ibn.idsi.md/vizualizare_articol/165680.
3. **GHETMANCENCO, S.** Methods for determining economic efficiency for computer investment projects. *Studia Universitatis Moldaviae*, Vol. 2, No. 11, 2022, pp. 47-56, 0,38 c.a. ISSN 2587-4446. Categoria B. Disponibil: https://ojs.studiamsu.md/index.php/stiinte_economice/article/view/2764/3776

3. Articles in the proceedings of conferences and other scientific events

3.2. in the works of scientific events included in other databases accepted by ANACEC

4. **GHETMANCENCO, S.** Analiza indicilor de apreciere a eficienţei proiectelor de investiţii în informatizare**.** În: *„Competitivitate şi inovare în economia cunoaşterii”***,** conf. științ. internaţ., Ediţia a XXI-a, 27-28 septembrie 2019. Chişinău: Editura ASEM, 2019, pp. 649-655, 0,49 c.a. ISBN 978-9975-75-968-7. Disponibil: https://ibn.idsi.md/sites/default/files/imag_file/632-638.pdf.
5. **GHETMANCENCO, S.,** NASTAS, V. Methods of evaluation of the economic effect in mobile application development projects**.** În: *„Development through Research and Innovation – 2020*", conf. științ. internaţ., Ediţia I, 28 august 2020. Chişinău: ASEM, 2020, pp.17-27, 0.46 c.a. ISBN 978-9975-155-03-8. Disponibil: http://irek.ase.md:80/xmlui/handle/1234567890/1317.
6. **GHETMANCENCO, S.** Metode matematice de evaluare a eficienţei proiectelor de investiții. În: *„30 years of economic reforms in the Republic of Moldova: economic progress via innovation and competitiveness”,* conf. științ. internaţ., 24-25 septembrie, 2021. Chisinau: ASEM, 2021, pp. 246-250, 0,83 c.a. ISBN 978-9975-155-66-3. Disponibil: https://irek.ase.md/xmlui/ handle/123456789/2083.
7. **GHETMANCENCO, S.** Evaluation of the economic efficiency of investment projects in informatization through the method of computer simulation. În: *“Development through research and innovation - 2024”,* conf. științ. internaţ., Ediția V, August 23, 2024. Chisinau.

5. Other works and achievements specific to different scientific fields

8. BOLUN, I., **GHETMANCENCO, S.,** NASTAS, V. Efficiency indices of investment in IT projects with unequal lives**.** *SWorldJournal, Issue 12***,** 2022, pp. 16-34, 1,8 c.a. ISSN 2663-5712, DOI: 10.30888/2663-5712. Disponibil: https://www.sworldjournal.com/index.php/swj/article/view/swj12-01-012/2195.

ADNOTARE

Ghetmancenco Svetlana, Analiza comparativă a criteriilor de eficiență a investițiilor în informatizare. Teză de doctor în informatică, specialitatea 122.02 Sisteme informatice, Chișinău, 2024

Structura și volumul tezei: introducere, trei capitole, concluzii generale și recomandări, bibliografie din 136 de titluri, 4 anexe, 120 pagini de text de bază, 36 figuri și 29 tabele.

Numărul de publicații la tema tezei: rezultatele cercetării sunt publicate în 8 lucrări științifice.

Cuvinte-cheie: algoritm, indice de profitabilitate, metodică, model, proiect informatic, rată internă de rentabilitate, simulare informatică, valoare actualizată netă.

Scopul lucrării constă în analiza comparativă, inclusiv prin simulare informatică, a indicilor de estimare a eficienței proiectelor de investiții în informatizare şi elaborarea recomandărilor privind folosirea acestora.

Obiectivele cercetării: identificarea și sistematizarea indicilor de eficiență; elaborarea modelelor și a algoritmilor de cercetare comparativă prin simulare informatică a indicilor; definirea metodicii de simulare informatică; dezvoltarea unei aplicații informatice pentru analiza comparativă a indicilor; cercetarea comparativă a indicilor de eficiență folosind aplicația informatică elaborată; elaborarea de recomandări privind folosirea rezultatelor obținute.

Noutatea și originalitatea științifică: argumentarea oportunității folosirii simulării informatice la temă; modelele, algoritmii și metodica simulării informatice pentru analiză comparativă cantitativă a eficienței proiectelor de informatizare; rezultatele analizei comparative cantitative prin simularea informatică a frecvenței cazurilor de necoincidență a soluțiilor obținute la folosirea indicilor, valoarea adăugată netă, rata internă de rentabilitate și profitabilitatea, eventual, împreună cu metoda valorii anuale echivalente

Problema științifică soluționată constă în caracterizarea cantitativă (în premieră) prin simulare informatică a frecvenței cazurilor de necoincidență a soluțiilor obținute la folosirea indicilor, valoarea adăugată netă, rata internă de rentabilitate și profitabilitatea, eventual, împreună cu metoda valorii anuale echivalente, pentru proiecte de informatizare de aceeași durată și de durată diferită și, de asemenea, a gradului de influență a metodei valorii anuale echivalente asupra deciziilor de selectare a proiectelor de informatizare.

Semnificația teoretică. Rezultatele obținute constituie un suport semnificativ al conceptelor teoretice și metodologice de analiză comparativă cantitativă prin simulare informatică a proiectelor de investiții în informatizare.

Valoarea aplicativă a lucrării. Recomandările procedurale și metodologice elaborate prezintă un suport semnificativ pentru decidenți la selectarea i-proiectelor, raționalizând cheltuielile și, respectiv, contribuind la creşterea performanţelor.

Rezultatele obținute **au fost implementate** de către trei agenți economici, confirmând importanța temei de cercetare și valoarea aplicativă a rezultatelor obținute.

АННОТАЦИЯ

Гетманченко Светлана, Сравнительный анализ критериев эффективности инвестиций в информатизацию. Диссертация на соискание ученой степени доктора информатики, специальность 122.02 – Информационные системы, Кишинев, 2024

Структура и объем диссертации: введение, три главы, общие выводы и рекомендации, библиография из 136 наименований, 4 приложения, 120 страниц основного текста, 36 рисунок и 29 таблиц.

Количество публикаций по теме диссертации: 8 научных работ.

Ключевые слова: алгоритм, прибыльность, методика, модель, проект, внутренняя норма доходности, компьютерное моделирование, чистая приведённая стоимость.

Цель работы – сравнительный анализ, включая компьютерным моделированием, показателей оценки эффективности инвестиционных проектов в информатизацию и разработка рекомендаций по их использованию.

Задачи исследования: идентификация и систематизация показателей эффективности; разработка моделей и алгоритмов сравнительного анализа показателей с использованием компьютерного моделирования; определение методики компьютерного моделирования; разработка программного приложения и сравнительный анализ показателей эффективности; разработка рекомендаций по использованию полученных результатов.

Научная новизна и оригинальность: обоснование целесообразности использо-вания компьютерного моделирования в данной области; разработка моделей, алгоритмов и методики компьютерного моделирования для количественного сравнительного анализа эффективности проектов информатизации; результаты количественного сравнительного анализа частоты несовпадения решений при использовании показателей чистой приведённой стоимости, внутренней нормы доходности и прибыльности, возможно в сочетании с методом эквивалентной годовой стоимости.

Решённая научная проблема заключается в количественной характеристике (впервые) с использованием компьютерного моделирования частоты несовпадения решений при использовании показателей прибыльности, чистой приведённой стоимости и внутренней нормы доходности, возможно в сочетании с методом эквивалентной годовой стоимости, для проектов информатизации с одинаковой и различной продолжительностью, а также в оценке степени влияния применения метода эквивалентной годовой стоимости на решения по выбору проектов информатизации.

Теоретическая значимость. Полученные результаты являются значимой основой теоретических и методологических концепций количественного сравнительного анализа инвестиционных проектов в информатизацию.

Практическая значимость. Разработанные процедурные и методологи-ческие рекомендации представляют собой важную поддержку для лиц, принимающих решения, при выборе проектов по информатизации, оптимизируя расходы и способствуя повышению эффективности.

Полученные результаты **внедрены** тремя экономическими агентами, что подтверждает важность темы исследования и их практическую значимость.

ANNOTATION

Ghetmancenco Svetlana, Comparative Analysis of Efficiency Criteria for Investments in Informatization. Doctoral thesis in Computer Science, specialty 122.02 - Information Systems, Chisinau, 2024

Structure and volume of the thesis: introduction, three chapters, general conclusions and recommendations, a bibliography comprising 136 titles, four appendices, 120 pages of main text, 36 figures, and 29 tables.

Number of publications related to the thesis: the research results are published in eight scientific papers.

Keywords: algorithm, profitability index, methodology, model, IT project, internal rate of return, computer simulation, net present value.

Objective of the work: The purpose of the thesis is the comparative analysis, including via computer simulation, of the indices used to evaluate the efficiency of IT investment projects and the development of recommendations for their application.

Research objectives: Identification and systematization of efficiency indices; Development of models and algorithms for comparative research using computer simulation of indices; Definition of the computer simulation methodology; Development of a software application for the comparative analysis of indices; Comparative research on efficiency indices using the developed software application; Formulation of recommendations on the use of the obtained results.

Scientific novelty and originality: The study justifies the relevance of applying computer simulation in the field, presenting models, algorithms, and a computer simulation methodology for the quantitative comparative analysis of IT project efficiency. The results include a quantitative comparative analysis via computer simulation of the frequency of solution discrepancies when using indices such as net present value, internal rate of return, and profitability, potentially combined with the equivalent annual value method.

The solved scientific problem consists of the first-ever quantitative characterization, through computer simulation, of the frequency of discrepancies in solutions obtained using the net present value, internal rate of return, and profitability indices, potentially in combination with the equivalent annual value method. This applies to IT projects with equal and varying durations, as well as to assessing the influence of the equivalent annual value method on IT project selection decisions.

Theoretical significance: The results provide a significant contribution to the theoretical and methodological concepts of quantitative comparative analysis through computer simulation of IT investment projects.

Practical value of the thesis: The developed procedural and methodological recommendations offer substantial support for decision-makers in selecting IT investment projects, optimizing expenditures, and thereby enhancing performance and competitiveness.

The obtained results **have been implemented** by three economic entities, confirming the relevance of the research topic and the practical value of the outcomes.

GHETMANCENCO SVETLANA

COMPARATIVE ANALYSIS OF EFFICIENCY CRITERIA FOR INVESTMENTS IN INFORMATIZATION

Specialty 122.02 - Information Systems

Summary of the Doctoral thesis in computer science

Approved for printing: 03.03.2025	Offset paper. Offset printing.
Author's sheets: 2.0	Paper format: 60X84 1/16
Print run: 30 ex	Order no. **7**

Editorial and Printing Service of the
Academy of Economic Studies of Moldova
Chisinau Municipality, Banulescu-Bodoni Street, 59, MD-2005
Tel.: (022) 402 936; 068 798 970