The Impact of Information Technology on Investment Decision-Making: Problems and Prospects

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Abstract The purpose of the study is to develop an approach to optimising the investment decision-making process using the dynamic programming method and its further integration into the enterprise information system using new technologies. The following methods were used in the study: System-structural analysis, dynamic programming method, graphical, and tabular methods. As a result of the conducted study, the role of information in the investment process was determined. An approach to the formation of the structure of an enterprise information system designed to optimise the investment decision-making process was proposed. The components of the structural elements of this system are considered — information collection, processing, and interpretation. A roadmap for information support for the development and implementation of an investment project is proposed, the blocks of which

correspond to a certain direction of information processing, depending on the stage of implementation of the investment project — preparation, implementation, and final stage. The existing solutions are considered, and ready-made software products designed to optimise the investment process are characterised, primarily from the standpoint of risk assessment. An approach to optimising the investment decision-making process based on the dynamic programming method is proposed. An example of using this method to select one of the proposed alternatives according to the profit maximisation criterion is given. The results of the analysis can be used by the management board of enterprises to optimise the investment decision-making process.

Keywords digitalisation; innovation; dynamic programming method; management process; investments; efficiency

1 Introduction

In modern conditions, information technologies penetrate all spheres of the activity of enterprises. They play an exceptional role in the management decision-making process. In the investment sector, where making certain decisions can have particularly serious consequences for an enterprise and is characterised by high risks, introducing information technology becomes an integral part of successful strategies. Using information technology in the process of making investment decisions can provide several positive results. Thus, information technologies substantially increase the efficiency of the analysis, which is necessary for making an investment decision[?]. Such an analysis includes an examination of the financial situation of the enterprise (analysis of the internal environment), the investigation of macroeconomic trends and indicators (analysis of the external environment), and other aspects that may affect the effect of investments[? ? ?]. In addition, innovative technologies contribute to improving the accuracy of analysis since they eliminate the possibility of making mechanical errors inherent in manual calculations and can also analyse huge amounts of data[? ?], which is sometimes impossible without using automation.

Therefore, using information technology in the investment sector is also associated with some risks and problems, which may include data loss or leakage, and excessive costs[? ?]. As a result, inappropriate implementation and use of information technology can lead to losses, loss of the company's reputation, and other problems. The subject under study is extremely important for the Republic of Kazakhstan, the financial market and economic sectors of which are undergoing a period of active transformation[?]. Consequently, the country aims to increase competitiveness, efficiency and investment attractiveness in a changing environment in which innovative technologies and the information system in general play an important role[? ?].

The research's current issues were addressed in numerous publications by researchers from the Republic of Kazakhstan. Mukhametzhanova et al.[?], using methods of descriptive statistics and correlation and regression analysis, determined that innovations, investments, and research activities have a positive effect on the productivity of enterprises. In addition, researchers have noted a positive impact on competitiveness and product quality. Myrzabayeva and Alibekova[?] highlighted the key advantages of using information systems to improve the

efficiency of managerial decision-making: Optimising coordination between departments, expanding access to data and documents, improving organisational and departmental methods, optimising routine operations, reducing time for certain actions. Mauina et al.[?] revealed the essence of individual approaches to management decision-making using innovative technologies. Thus, researchers have noted the expediency of applying the concept of maximum usefulness of managerial decision-making using computer processing technology of expert data. Researchers often explore feedback – the impact of the investment climate and investment activity on innovation. Thus, Kurmanov et al.[?], examining the influence of various factors on the development of innovations in medium-sized and high-tech enterprises of the Republic of Kazakhstan, noted that there was a positive correlation between innovations and investments in enterprises' fixed assets.

The literature review discusses different methodologies and technologies employed to enhance the process of making investment decisions. Researchers have conducted studies that showcase a range of strategies, such as employing hybrid algorithms, dynamic programming to reduce risks and costs. Nevertheless, despite a thorough investigation in this field, there exists a lack of research in combining dynamic programming techniques with information technology to achieve maximum profitability. This study addresses the existing void by introducing an innovative methodology that integrates dynamic programming and information technology to develop a highly efficient investment decision support system. Furthermore, a concrete implementation of this approach is suggested, showcasing its efficacy via real-life examples. This empowers businesses to make investment choices with greater precision and efficiency.

The purpose of this study is to form an approach to optimising investment activities using the dynamic programming method and its subsequent integration into the enterprise information system using innovative technologies. This goal involves solving the following tasks:

– Form an approach to building an enterprise information system designed for making investment decisions;
– Review existing solutions and ready-made software products designed to optimise the investment decision-making process.

2   Materials and Methods

This study is a synthesis of theoretical, methodological and practical approaches to solving its key task — optimising investment activities. The critical research method is the system-structural method, which allows forming an approach to building an enterprise information system designed to optimise investment decisions. This approach consists of building an information system by structuring the stages of formation and analysis of an array of information to optimise investment decision-making in the context of three areas: Collection, processing, and interpretation of information. Additionally, a roadmap for information support for developing and implementing an investment project was proposed. In the practical part of the study, the dynamic programming method was applied, which allowed the demonstration of the effective-

ness of using the method on an abstract example to select the optimal investment alternative according to the profit maximisation criterion. The methodology for implementing this method is presented below[?].

The dynamic programming method is effective for processes that tend to evolve. Thus, such processes are influenced by decisions that can be made at certain stages of such processes. In the example given in the author's study, the investment process is divided into N stages. The state of this process at the end of the k-th stage is described by the m-vector:

$$x_{n+1} = g_n(x_n, y_{n+1}), \ n = 0, 1, \cdots, N. \tag{1}$$

This is a vector of phase coordinates, also called the process state vector. The set, which is formed by the whole group of possible states of the process by the end of the k-th stage, is denoted by X_k. The initial state of the specified process x_0 can be set separately, a set of X_0 initial states can also be specified. Developing the process under study implies a transition from one state to another. Thus, when a process is in state x_n, its state x_{n+1} at the upcoming step determines both the vector $J_n(x_0, y_1, \cdots, y_n)$ and the decision ("control") J_{n+1} made at the $(n+1)$th step:

$$x_{n+1} = g_n(x_n, y_{n+1}). \tag{2}$$

A profit target function can characterise the effectiveness of the management process, and the development of such a process can be represented as a sequence of states:

$$x_0, x_1, x_2, \cdots, x_N, \tag{3}$$

where $x_n \in X_n$.

U represents a set of possible alternatives (solutions), and the sequence of $u_1, u_2, \cdots, u_N$, acceptable solutions is commonly called a strategy. A score corresponding to the value of the evaluation function is set to describe the multi-stage process of each strategy. By changing the strategy, it is possible to obtain different states of the process under study after passing a certain number of estimated steps. Therewith, various criteria are applied, such as profit maximisation, costs, and return on funds, through the objective function Z:

$$J_N(x_0, y_1^*, \cdots, y_N^*) = \max_{y_1, \cdots, y_N} J_N(x_0, y_1, \cdots, y_N). \tag{4}$$

In accordance with the Bellman optimality principle, $y_1^*, \cdots, y_N^*$ each of the functions in (5) reaches a maximum in the sequence of optimal controls:

$$f_n(x_{n-1}, y_n, y_{n+1}, \cdots, y_N) = h_n(x_{n-1}, y_n) + h_{n+1}(x_n, y_{n+1}) +$$
$$\cdots + h_N(x_{N-1}, y_N), n = 1, 2, \cdots, N. \tag{5}$$

Thus, if (6) is denoted as:

$$f_n(x_{n-1}) = \max_{y_1, \cdots, y_N} f_n(x_{n-1}, y_n, \cdots, y_N), \tag{6}$$

then it follows from this principle that the function $f_n(x_{n-1})$ confirms the Equation (Bellman functionals):

$$f_n(x_{n-1}) = \max_{y_n}[f_{n+1}(g_n(x_{n-1}, y_n) + h_n(x_{n-1}, y_n))], \ n = 1, 2, \cdots, N. \tag{7}$$

The Bellman equations allow for determining the optimal control sequence and identifying the maximum possible value of the profit function. In the presented ratios, $f_n(x_{n-1})$ calculations occur from the final stage to the first ("reverse run algorithm").

Dynamic programming presents numerous benefits compared to conventional investment decision-making techniques, delivering a more efficient, precise, and flexible methodology. A primary advantage of dynamic programming is its capacity to address intricate problems by decomposing them into more manageable subtasks. This disaggregation facilitates the management and resolution of complex investment situations. In contrast to conventional approaches that typically address issues in their whole, dynamic programming guarantees that the best solution to the overall problem can be obtained from the optimal solutions of its constituent subtasks. This method eliminates unnecessary computations by retaining the outcomes of subtasks, hence enhancing the efficiency of the decision-making process[?].

Dynamic programming facilitates a more nuanced and extensive examination of investment scenarios by accounting for many stages and decisions, enhancing accuracy and precision. This method reduces mechanical mistakes associated with human calculations by automation, while traditional methods often depend on generalized assumptions and superficial analysis, resulting in diminished accuracy and an increased likelihood of errors from manual data management. Dynamic programming is particularly effective in risk management by evaluating risk factors at each phase of the decision-making process, facilitating enhanced risk optimization. It can model diverse investment scenarios and their possible outcomes, offering a more thorough risk evaluation. Conversely, conventional approaches typically evaluate risk at a singular moment, thus overlooking dynamic fluctuations in the investment landscape and lacking the capacity to model various scenarios, resulting in a less comprehensive risk assessment.

Furthermore, dynamic programming efficiently handles and analyses substantial data sets, which is essential for making informed investment choices. It employs IT systems to automate data gathering, processing, and analysis, guaranteeing timely and precise information. Conventional techniques frequently depend on manual data acquisition and processing, which can be labour-intensive and susceptible to inaccuracies and may encounter difficulties in managing extensive data sets, resulting in incomplete or erroneous analyses. In conclusion, dynamic programming offers a thorough and methodical strategy for optimizing investment decisions. Its capacity to deconstruct intricate issues, evaluate risk elements at every phase, and employ IT solutions for automated data processing renders it a more advantageous option for contemporary investment strategies than conventional procedures.

3 Results

3.1 Information Support of Investment Decisions

Information technologies are tools designed to optimise, collect, process, and transmit information[?]. Information is a crucial concept in the field of information technology since its effective management ensures the progressive development of the digital ecosystem, contributing to innovation and productivity[? ?]. Thus, the result of the introduction and use of information technologies depends on the appropriate information support at all stages of this process.

In the investment field, reliable and timely information is the key to making effective investment decisions. Information technologies substantially improve the process of collecting, processing, storing, and transmitting information, however, the choice of technologies necessary for a particular enterprise for specific purposes should be preceded by forming an adequate information support system. Figure 1 suggests a basic approach to the formation of an information support system for making investment decisions. Information technologies can be applied at every stage of the proposed information support system. Therewith, two key vectors of their use can be distinguished: The first is for the convenience of collecting, storing, transmitting, and evaluating primary information (for example, about the environment at the macro level or about the financial condition at the enterprise level); the second is using specialised software products directly for evaluating and/or choosing one of the investment alternatives. That is, information technology performs both an auxiliary function in investment activity and can play a vital role in making an investment decision. An auxiliary function is, most often, to facilitate access to information, reduce bureaucratic procedures, increase the efficiency of data and document processing, and minimise inaccuracies. The role of information technology in making investment decisions is critical, as it facilitates the use of specialized programs and platforms to analyse incoming data — both qualitative and quantitative. This enables a comprehensive assessment of investment alternatives, including potential profits, risks, losses, and forecasts. Figure 2
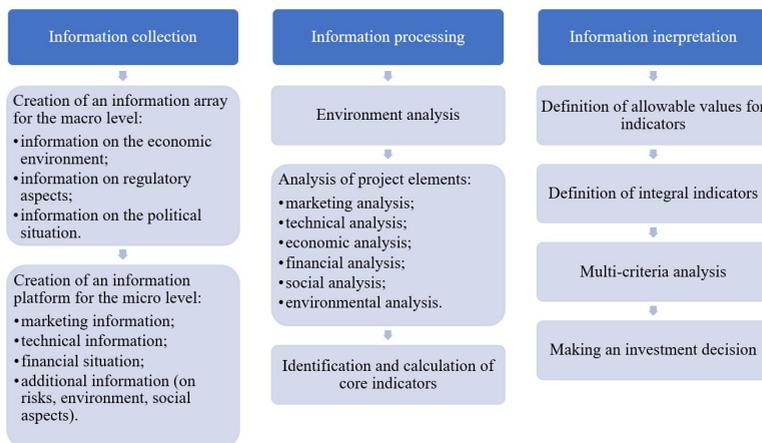

Figure 1   Information support system for investment decision-making

Figure 2   Roadmap of information support for the development and implementation of an investment project

provides a detailed roadmap for the information support required during the development and implementation of an investment project.

The diagram illustrates a structured sequence of steps that an enterprise follows when designing and executing an investment project, highlighting the information processing required at each stage. The roadmap can be divided into three distinct phases. At the Preparation Phase (Blocks 1–10), the enterprise gathers and processes foundational data to define and evaluate the feasibility of the investment project. The Implementation Phase (Blocks 11–14) focuses on operationalizing the investment project and ensuring seamless execution. The Final Phase (Blocks 15–17) ensures the evaluation, sustainability, and risk mitigation of the project. Each block in the diagram reflects a distinct aspect of information processing, emphasizing the criticality of data-driven decision-making throughout the investment project lifecycle. This roadmap not only underscores the importance of structured information flows but also highlights the role of modern information technology in optimizing investment outcomes.

The conducted analysis allows the conclusion that information support accompanies the entire investment cycle — from the emergence of an idea to obtaining an effect as a result of investment. At the next stage of the study, an assessment of modern methods and approaches to using information technology in developing and implementing investment projects and making investment decisions should be conducted.

3.2   Software for Making Investment Decisions

To date, there are many software solutions designed for risk management based on in-depth analysis and modelling of investment scenarios. Such software solutions make it easier to make investment decisions and form effective investment strategies. Some of these solutions are presented below.

The Riskalyze platform is designed to analyse investment risk, implement plans, and create

and implement investment portfolios. A unique feature of this platform is the ability to integrate, regardless of budget on any device. It works based on a questionnaire for clients containing questions about financial risk and subsequent analysis of the answers with a single number defining risk tolerance.

The Arbor Portfolio Manager platform provides an opportunity to conduct in-depth portfolio analysis and tools for organising works with reporting to simplify study with investments, including facilitating investment decision-making. The platform features flexible customisation options and a wide range of different services and products.

The LogicManager platform is software for integrated risk management (corporate, third-party), information technology management, and compliance, also providing functionality for financial reporting. Its feature is the ability to centralise risk management approaches into a single hub to unite clients with a team of industry professionals. It is a solution for SaaS (Software as a service) that supports multiple users.

The CammsRisk platform provides an opportunity for integrated risk management, incidents, audits, and portfolio filling. The platform provides innovative GRC (Governance, Risk, and Compliance) software solutions for risk management and decision-making.

The Sharesight platform is designed to automatically track a portfolio of investments, prices, performance, and dividends from global stocks, cryptocurrencies, ETFs, and funds. This platform uses 20 years of historical data and allows accessing the data needed for tax reporting.

The Looker platform is a specialised business intelligence platform. It provides the ability to self-service, create new applications, and implement platform modelling into an existing analytics environment.

The FundCount platform is an integrated accounting, general ledger, and investment analysis solution. Combines portfolio and partnership accounting in one system and has a flexible self-service system.

The Ziggma platform is a technological solution for long-term investment. It makes it possible to optimise profitability considering risks (existing and forecast).

In addition to ready-made software products for making investment decisions, various modern approaches and methods are used to assess their effectiveness. Such methods include: Dynamic comparison, matrix, factor analysis, expert assessments, groupings, mathematical statistics, rating assessment, index, fuzzy logic, ranking, and scoring. In this paper, it is proposed to demonstrate in practice how the dynamic programming method can be applied in the process of making an investment decision. Software products that operate using this method can solve complex problems in the field of investment and optimise investment decisions. The dynamic programming method is effective because when optimising and choosing an investment solution, such important criteria as maximising profits and minimising risks are considered. The implementation of the method using software products can be conducted, among other things, through algorithms built-in programming languages, for example, Python, using libraries and optimisation (NumPy, SciPy).

The proposed method of combining dynamic programming with information technology to optimise investment decisions presents numerous benefits and distinctive characteristics in comparison to current software solutions. Platforms such as Riskalyze, Arbour Portfolio Manager, LogicManager, CammsRisk, Sharesight, Looker, FundCount, and Ziggma offer useful tools for managing risk, analysing portfolios, and tracking investments. However, their main focus is on specific areas such as evaluating risk, creating portfolios, and ensuring compliance.

On the other hand, the suggested approach utilises dynamic programming to enhance investment decision-making by decomposing intricate problems into more manageable subtasks. This improves the organisation of the task and prevents redundant calculations. This approach is especially efficient for processes that undergo changes over time and are impacted by decisions made at different stages. The utilisation of dynamic programming guarantees that the investment problem's optimal solution can be derived from the optimal solutions of its subtasks, thereby maximising profits and minimising risks.

An important benefit of the proposed method is its capacity to effectively manage substantial volumes of data and intricate scenarios. Although current software solutions also strive to streamline investment decision-making, they may not consistently offer the same degree of optimisation and precision as dynamic programming. The suggested approach can be executed by developing algorithms in programming languages like Python, utilising libraries such as NumPy and SciPy for optimisation purposes. This enables the creation of bespoke solutions designed to meet the unique requirements and goals of a business. Additionally, the suggested approach caters to the requirement for a thorough framework that combines different phases of the investment decision-making process, starting from gathering and analysing information to reaching the ultimate decision. This comprehensive approach guarantees that all pertinent factors are taken into account, resulting in more knowledgeable and efficient investment choices.

To summarise, although current software solutions provide useful tools for certain aspects of investment management, the suggested approach of combining dynamic programming with information technology offers a more thorough and efficient method for making investment decisions. This approach not only improves the precision and effectiveness of investment choices but also enables the handling of substantial volumes of data, rendering it a potent instrument for enterprises aiming to optimise their investment yields.

3.3 Dynamic Modelling

Dynamic programming is a powerful optimisation technique widely used in various fields, from computer science to economics. The basic idea is to break down a complex task into simpler subtasks. This not only improves the structuring of the task but also avoids repeated calculations by saving the results of the subtasks. Using dynamic programming is especially useful in cases where there are overlapping subtasks, that is when the identical subtasks are solved several times. The method saves the calculation results for each subtask and uses a ready-made answer if it occurs again, which substantially speeds up the process. In addition, dynamic programming has an optimal substructure, which means that the optimal solution to

the original problem can be obtained from optimal solutions to its subtasks. The effectiveness of the dynamic programming method is proposed to be demonstrated by an example. For example, supposing that it is necessary to distribute 4 million conventional units between three enterprises E_1, E_2, and E_3. In this case, the efficiency criterion will be the maximum possible profit that can be obtained as a result of investing. 4 million units can be invested either entirely in one of the enterprises or not to make investments in some of the enterprises at all. However, proceeding from the condition that all 4 million units must be invested without remainder is necessary. Table 1 contains the profit of each of the enterprises, set as a percentage.

Table 1 The volume of investments and profits of the examined enterprises

The volume of investments	The profit of the enterprise, %		
	E_1	E_2	E_3
0	0	0	0
1	10	21	27
2	25	19	18
3	15	22	23
4	20	17	18

Through h_i, the profit of the enterprise N_i is indicated. The profit of an enterprise depends on investments in it and returns as a percentage, therefore $h_i = \frac{C \times P_i}{100\%}$, where C indicates the amount of investment. In the next step of applying the dynamic programming method, the above table is extended, considering the size of the investment (Table 2).

Table 2 The profit of the examined enterprises, considering the size of investments

	The profit of the enterprise, %			The profit of the enterprise (considering the size of the investment)		
	E_1	E_2	E_3	h_1	h_2	h_3
0	0	0	0	0	0	0
1	10	21	27	0.1	0.21	0.27
2	25	19	18	0.5	0.38	0.36
3	15	22	23	0.45	0.66	0.69
4	20	17	18	0.8	0.68	0.72

y_i will indicate the amount of real investment appropriate for enterprise N_i ($i = 1, 2, 3$). Accordingly, the entire investment process will be divided into stages: The first stage involves the allocation of funds in the amount of y_1 to the enterprise E_1, in the second stage, funds in the amount of y_2 must be invested in the enterprise E_2, and in the third stage funds in the amount of y_3 are allocated to the enterprise E_3. Through x_i ($i = 1, 2, 3$), the state of the system is indicated — part of the funds remaining due to the implementation of the i-th stage. x_0 will be equal to 4, because the initial investment condition was the distribution of all 4 million units without a remainder. In general $x_n = x_{n-1} - y_n$, therefore $x_1 = x_0 - y_1, x_2 = x_1 - y_2, x_3 = x_2 - y_3$.

As a result of the implementation of the third stage, based on the condition, all funds must be invested, therefore, $x_3 = 0$, and $y_3 = x_2$. During the calculations, the Bellman equations are used for three enterprises. The reverse run algorithm is presented as follows:

$$f_3(x_2) = \max_{y_3=0,1,2,3,4}(h_3(y_3), x_2) = 0, 1, 2, 3, 4,$$

$$f_2(x_1) = \max_{y_2=0,1,2,3,4}[f_3(x_1 - y_2) + h_2(y_2)],$$

$$f_1(x_0) = \max_{y_1=0,1,2,3,4}[f_2(x_0 - y_1) + h_1(y_1)].$$

The controls y_1, y_2, y_3, at which the maxima in the above ratios are reached, are marked by y_1^*, y_2^*, y_3^*. The next step is calculating the functions $f_n(x_{n-1})$ (Tables 3~5).

Table 3   Calculation of the function $f_3(x_2) = \max_{y_3=0,1,2,3,4}(h_3(y_3), x_2) = 0, 1, 2, 3, 4$

x_2	y_3					$f_3(x_2)$	y_3^*
	0	1	2	3	4		
0	0					0	0
1		0.27				0.27	1
2			0.36			0.36	2
3				0.69		0.69	3
4					0.72	0.72	4

Table 4   Calculation of the function $f_2(x_1) = \max_{y_2=0,1,2,3,4}[f_3(x_1 - y_2) + h_2(y_2)]$

x_1	y_2					$f_2(x_1)$	y_2^*
	0	1	2	3	4		
0	$0 + 0 = 0$					0	0
1	$0 + 0.27 = 0.27$	$0.21 + 0 = 0.21$				0.27	0
2	$0 + 0.36 = 0.36$	$0.21 + 0.27 = 0.48$	$0.38 + 0 = 0.38$			0.48	1
3	$0 + 0.69 = 0.69$	$0.21 + 0.36 = 0.57$	$0.38 + 0.27 = 0.65$	$0.66 + 0 = 0.66$		0.69	0
4	$0 + 0.72 = 0.72$	$0.21 + 0.69 = 0.9$	$0.38 + 0.36 = 0.74$	$0.66 + 0.27 = 0.93$	$0.68 + 0 = 0.68$	0.93	3

Table 5   Calculation of the function $f_1(x_0) = \max_{y_1=0,1,2,3,4}[f_2(x_0 - y_1) + h_1(y_1)]$

x_0	y_2					$f_1(x_0)$	y_1^*
	0	1	2	3	4		
4	$0 + 0.93 = 0.93$	$0.1 + 0.69 = 0.79$	$0.5 + 0.48 = 0.98$	$0.45 + 0.21 = 0.66$	$0.8 + 0 = 0.8$	0.98	2

As can be determined from the above tables, the maximum profit is 0.98 million units, where:

$$y_1^* = 2, f_1(x_0) = f_1(1),$$

$$x_1 = x_0 - y_1^* = 4 - 2 = 2, f_2(x_1) = f_2(2) = 0.48, y_2^* = 1,$$

$$x_2 = x_1 - y_2^* = 2 - 1 = 1, f_3(x_2) = f_3(1) = 0.27, y_3^* = 1.$$

Thus, the most effective investment solution would be to invest 2 million USD in enterprise E_1, 1 million USD in enterprise E_2, and the remaining funds in the amount of 1 million USD in the enterprise E_3. The maximum profit in this case is 0.98 million units. Thus, this example demonstrated a way to apply the dynamic programming method to make the most effective investment decision. The integration of this method into the company's activities using information technology will greatly facilitate calculations, and will also allow calculations on much more complex examples, considering many different factors. Conducting such complex calculations manually will not only take much more time but also allow the possibility of making mistakes in the calculation process. Thus, the role of information technology in the process of making investment decisions is to increase the accuracy, and efficiency of calculations, and the ability to account for large amounts of information without losing the quality of calculations. Establishing sustainable cooperation between information technology specialists and investment experts is crucial in this process.

The conducted examination suggests that investment decision-making is inextricably linked and depends on the availability of reliable, timely, and complete information. Such information may concern the enterprise's internal state (performance indicators, financial stability, quality of management, marketing) and its environment (political, economic, social, environmental, and other factors). Therefore, to optimise investment decision-making, enterprises need to develop an effective and adequate approach to the formation of an information support system for a specific field of activity. The key aspect of this system is information technology. When making investment decisions, information technology can be applied at virtually every step of the process — from the origin of an idea to the benefits of investing funds. At the present stage of innovation development, there are many ready-made innovative solutions — platforms for simplifying and optimising investment decision-making, considering many factors of influence. In this paper, only one of the many approaches to investment decision-making that can be implemented using innovative technologies has been considered.

4   Discussion

The analysis carried out in the study shows that the investment sphere is closely related to the information system, and investment decision-making in modern conditions is in one way or another based on the support of information technologies. A large number of works by researchers on the topic under consideration allows us to judge that there are many other approaches to the use of information technologies to optimise the investment process. Each approach has its advantages and disadvantages and can be used depending on the specific objectives of the analysis. The following section discusses how the dynamic programming method demonstrated in the previous example relates to other approaches and technologies used in investment practice. It also discusses how the integration of information technology can improve the decision-making process and what additional benefits this can bring.

The relationship between the information and investment environment was successfully de-

scribed in the papers by Ren[?], where it was noted that the rapid development of portfolio theory and information technology contributed to an increase in the pace of financial innovation and the emergence of new financial products and services. Innovations in the financial sector stimulate the emergence of different types of investors, and the rapid growth of the latter, in turn, accelerates the process of financial innovation. The mentioned study was based on a hybrid algorithm of the Drosophila cloud model, during the application of which the risk of financial investments was measured to make optimal investment decisions.

In the study by Shiva Kumar et al.[?], as in the presented paper of the author, an approach using the dynamic programming method was used to select the most effective investment solution. This study demonstrated the application of the method to determine the optimal choice strategy under the condition of minimum total costs, which distinguishes it from the author's paper, where the choice condition provided, first of all, profit maximisation. In the study by Hao and Jia[?], the Markov decision-making process model was used to select the optimal investment strategy. The researchers' approach involved measuring the risks of transactions using financial indicators. In addition, the model was optimised by considering the long-term impact of trading on assets. The iterative algorithm of the strategy developed by the authors can be applied online. The main difference between this approach and this study is the consideration of risk factors, which is one of the most important selection criteria in the investment field.

Several studies are devoted to the consideration of specific innovative technologies for optimising decision-making. Thus, Duan et al.[?] examined issues related to the application and impact of updated artificial intelligence-based systems for decision-making. Researchers were discussing issues regarding the integration of artificial intelligence to optimise activities or replace employees involved in decision-making. In the study by Shahid et al.[?], the possibilities of using artificial neural networks for decision-making in healthcare organisations were considered. Researchers have found that this approach is most often used to optimise decision-making at the micro-level, less often — at the meso- and macro-levels. Vo et al.[?] were developing their model, the Deep Responsible Investment Portfolio, based on using a neural network. The model is aimed at building a socially responsible investment portfolio. The model uses a deep reinforcement learning technique adapted by the authors to retrain neural networks and balance the portfolio if necessary. The researchers concluded that the model they developed helps to improve financial performance and optimise social impact. Just as in the author's paper, these studies showed a close relationship between the effectiveness of decision-making and the introduction of innovative technologies. The main difference between the approaches is that these studies focus on applying a specific technology to optimise investment decisions, while the author's study has examined the method underlying such optimisation.

The integration of AI and machine learning can markedly improve the forecasting accuracy of investment models by examining historical data and recognizing trends overlooked by conventional methods. AI algorithms may be trained to identify market trends and forecast future price movements with high precision, offering investors critical insights for informed decision-

making[?]. Big data analytics can evaluate extensive volumes of structured and unstructured data in real time, providing a thorough perspective on market circumstances and potential dangers. The integration of these technologies enhances investment decision-making, rendering it more data-driven and flexible, so facilitating improved risk management and more lucrative investment methods. Moreover, AI-driven natural language processing may evaluate unstructured data from news articles, social media, and financial reports to assess market mood, hence enhancing the decision-making process. This integration of contemporary information technology can automate numerous facets of investment analysis, mitigate human bias, and enhance the velocity and accuracy of decision-making, ultimately resulting in more optimal and lucrative investment results[?].

In some papers, individual vectors of the influence of information technology on the investment sphere are investigated. For example, the relationship between investment activity and using smartphones and cybersecurity issues in the investment sphere is being examined. Fan[?] was examining the specifics of making investment decisions through mobile devices. In this area, as the researcher notes, such factors as the experience of using mobile banking on the part of the investor, his possession of investment instruments, investment literacy, and risk tolerance are important. Cheng et al.[?] examined the impact of cyber-attacks on investment decisions, namely, the desire of investors to invest in companies that have been hacked. These works differ from the author's research by choosing different criteria for making an investment decision (profit maximisation was the key criterion in the author's study, and the subjective characteristics of investors — in the study of Fan[?], the fact of the cyberattack is in the study by Cheng *et al.*[?]). The proposed approaches can be used in a complex to improve the effectiveness of investment decisions.

Researchers often examine the problems of making investment decisions directly related to investments in innovative technologies. According to the author, such an investment direction can be considered a separate vector of the influence of information technology on investment decisions. Karhade and Dong[?] analysed a unique panel data set from European countries. The study considered both those factors that positively affect investments in information technology for innovation and those that have a negative impact. As a result of the analysis, researchers identified a curvilinear relationship between investments in information technology and the commercialisation of innovations. This indicated that excessive investments in information technology for innovation can have a negative effect due to the high costs of dynamic adjustment. From this, it can be concluded that before introducing innovative technologies to optimise investment decisions, it is necessary to evaluate and justify the benefits of investing in innovative technologies themselves. This area was not explored in the author's study, however, it can act as a preliminary stage in developing an information support system.

However, in most studies, researchers conclude that information technology is undoubtedly helpful for optimising investment decisions — choosing the right approach to innovation is essential in this process. An example is the study of Abernathy et al.[?], who investigated on

high-quality information technologies for making management decisions about making investments. The paper evaluated investment decisions according to the criteria of modern investment efficiency and long-term indicators. As a result, a positive relationship was identified between the effectiveness of investment decisions and the use of high-quality information technologies. Among other things, such technologies contribute to optimising the level of investments and reducing the write-off of fixed assets in the long term. Researchers also determined that there is a link between the quality of information technology about investment decisions in the field of capital expenditures and acquisitions, but it is not observed for development and research costs. As in this paper, this study focuses on the dependence of the effectiveness of investment decisions on the availability of reliable and complete information. The main difference from this study is that researchers have considered the criterion of information technology quality.

According to Aitzhanova et al.[?] a manufacturing company in Kazakhstan sought to enhance its investment strategies to increase production capacity, encountering difficulties in distributing funds across several projects while optimizing profits and limiting risks. The organization gathered financial data, market trends, and internal performance measures, including this knowledge into their system and evaluating prior investment data to discern patterns and hazards. The investing process was segmented into stages, and the dynamic programming approach was utilized to ascertain the ideal investment plan, with the algorithm executed in Python utilizing libraries such as NumPy and SciPy. This method, incorporated into the enterprise's information system, facilitated real-time analysis and decision-making support, yielding a 15.

Summarising the study, it can be concluded that the author's conclusions regarding the effectiveness of using innovative technologies in making investment decisions are reflected in other works. Researchers around the world describe many different approaches to this problem — both using the dynamic programming method proposed by the author and describe the integration of methods with modern information technologies. The choice of the most effective method depends on the objectives of the analysis, the sphere of activity of enterprises, factors of influence, and many other aspects and features that must be considered individually.

Although the suggested method of combining dynamic programming with information technology provides notable benefits for enhancing investment choices, it is crucial to recognise its constraints. Organisations without the required technical expertise or resources may face difficulties when it comes to implementing dynamic programming algorithms and integrating them into information systems due to their inherent complexity. Furthermore, the efficacy of the approach greatly depends on the precision and comprehensiveness of the input data, which may not always be accessible or trustworthy. Future research should prioritise streamlining the implementation process and creating user-friendly tools to enhance the accessibility of this approach for a wider array of organisations. Moreover, investigating the incorporation of additional cutting-edge technologies, such as artificial intelligence and machine learning, into dynamic programming could augment the predictive capacities and resilience of the investment decision-making process.

In conclusion, the study demonstrates the potential of using the dynamic programming method integrated with information technology to optimise investment decisions. The model presented in the paper shows how investments can be distributed among several enterprises to maximise profits, which is confirmed by a case study with three enterprises. However, several factors need to be considered to apply this model in a real-world setting. First, real-world investment decisions are often subject to many external factors such as market volatility, regulatory changes, and economic conditions that have not been accounted for in the current model. Second, the accuracy and validity of input data play a key role, and any errors or incomplete data can significantly affect the results. Thirdly, further tests and validation of the model on real data are needed to assess its reliability and applicability in different scenarios. Thus, although the model shows theoretical efficacy, further adaptation and validation are required for its successful application in the real world.

5 Conclusion

This study has shown the crucial role of information technology in enhancing investment decision-making processes. Organisations can improve their capacity to analyse intricate investment scenarios and choose the most effective strategies by incorporating dynamic programming techniques into their enterprise information systems. The proposed approach enables a methodical assessment of various factors that influence investment results, encompassing both profit optimisation and risk reduction. The study emphasises the significance of creating a thorough information support system that is customised to meet the specific requirements and investment goals of a company. An ideal system should enable streamlined data collection, processing, and interpretation throughout every phase of the investment cycle. The presented roadmap offers a systematic framework for managing information during the development and execution of investment projects.

Although there are multiple software solutions available for assisting with investment decision-making, the incorporation of dynamic programming provides distinct benefits. This method allows for the systematic assessment of various investment options to determine the most effective allocation of resources, as demonstrated by the given example. When applied using information technology, it enables swift analysis of intricate scenarios that would be unfeasible to carry out manually. Nevertheless, it is crucial to acknowledge that the efficacy of this method relies on the calibre and dependability of input data, as well as the technical prowess of the organisation. Future research should prioritise the development of user-friendly implementations and investigate the potential integration of artificial intelligence and machine learning to enhance predictive capabilities.

Ultimately, the integration of dynamic programming and information technology offers a potent instrument for enhancing investment decision-making. Organisations that successfully utilise these tools in the ever-changing business environment are likely to gain a competitive edge in their investment strategies. Further investigation and advancement in this field will be

essential for improving these techniques and adjusting them to address new obstacles in the investment industry.

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