

# The influence of human factor on data processing algorithms during formation of enterprise's business processes

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## Abstract

The object of the study is the process of human factor influence on data processing algorithms in business processes of an enterprise. The main problem that was solved in the course of the study is the need to analyze the theoretical foundations, as well as to develop scientific and methodological recommendations for determining the influence of the human factor on data processing algorithms in the formation of business processes of an enterprise. It has been established that the influence of human participation on data processing algorithms for the development of business processes at enterprises is an important issue in the modern era of digital transformation. Effective business processes largely depend on rational data processing to ensure uninterrupted operation at the enterprise level. It is determined that the data processing algorithm for the formation of enterprise business processes is a structured set of actions or operations designed to collect, analyze, process and interpret information to make informed management decisions. The paper presents an interpretation of examples of the influence of certain human factors on the relevant data processing algorithms for the formation of certain business processes of an enterprise. The most important economic, social, ethical and technical consequences of the human factor influence on the development of data processing algorithms for the formation of business processes of enterprise are systematized. It is substantiated that the influence of the human factor in the creation of data processing algorithms has both a positive and negative impact on the business processes of enterprise. The correct choice and adjustment of algorithms can significantly increase the efficiency of resources, while errors or biases can lead to financial failures. The paper develops an algorithmic model of data processing for the formation of enterprise business processes consisting of several key stages and proves that at each of these stages the human factor plays a significant role, which can both positively and negatively affect the results of algorithms implementation.

## Keywords

human factor, data processing algorithms, business processes, management decision, artificial intelligence, automated control system

## 1. Introduction

The choice of the latest data processing methods and algorithms is crucial for the formation of modern business processes in an organization. In the modern era, relevant data has become one of the most valuable resources, so it is crucial for businesses to have the skills to analyze and use it effectively. With the help of advanced technologies such as artificial intelligence, machine learning, and big data analytics, it is now possible to obtain valuable information in a short period of time, which helps in the decision-making process [1, 2]. Using these approaches, organizations can optimize their operations, increase efficiency and reduce costs [3, 4]. In addition, they allow them to anticipate changes in the market environment and consumer behavior, which is crucial for

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*ADP'24: International Workshop on Algorithms of Data Processing, November 5, 2024, Kyiv, Ukraine*

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formulating effective strategies. Advanced data processing methods help automate repetitive tasks and reduce the likelihood of human error [5, 6]. Therefore, the automation of business processes has a positive impact on the performance of the enterprise and increases the need for their evaluation in terms of various areas of activity (procurement, finance, personnel, sales, and marketing) [7]. This increases the adaptability of the enterprise, allowing them to respond quickly to market fluctuations and effectively overcome new obstacles. Modern methods also help to combine different data sources and offer more accurate and comprehensive analysis [8]. In general, their use provides the company with a competitive advantage and creates new opportunities for growth.

Taking into account the influence of the human factor on data processing algorithms is a crucial aspect in shaping the business processes of an enterprise [9]. Even though many tasks have been automated, the human factor can still affect the accuracy of algorithms due to possible errors, biases, or misinterpretation of data [10]. Algorithms are not perfect, and their success depends to a large extent on how they are configured and the information they are "taught" to use. The choices made at the data preparation and analysis stages can have a significant impact on the results, which ultimately affect business operations. Therefore, taking into account the human factor is crucial for creating reliable and efficient business procedures. This ensures that technological capabilities are fully integrated with human intuition and experience, which increases the overall competitiveness of the enterprise.

## 2. State-of-the-art and the statement of the problem

The actual issues of how the human factor affects the development of algorithms for the flow and management of business processes in enterprises have not been systematically studied in the scientific researches. The current state of scientific research is scattered and lacks a comprehensive approach, with most studies in this area focusing on technical details, often ignoring the impact of human choices and the presence of biases that can affect the results. This approach makes it difficult to create reliable business procedures that take into account the interaction between technology and human factors. The lack of comprehensive research hinders the development of adaptive algorithms that can take into account behavioral factors. Thus, there is a clear need for more comprehensive research in this area to improve business processes and increase their efficiency.

The research [11] emphasizes the importance of developing artificial intelligence, which provides an impetus for the growth of human welfare. Author argues that algorithms used in business processes should take into account not only efficiency but also ethical issues. The human factor can affect the programming and execution of algorithms, making it crucial to establish guidelines for decision-making.

The paper [12] examines the impact of human biases on the creation and operation of algorithms, particularly in the field of machine learning. It is established that even effective algorithms can lead to unfair results if they are based on false data or contain certain biases. The author emphasizes the importance of implementing effective controls to prevent the threat of human error from interfering with the reliability of automated systems.

The scientific publication [13] defines the interaction of human behavior with artificial intelligence, with a special emphasis on the social consequences of these interactions. It is determined that algorithms should take into account the behavior of human and adjust accordingly, and not rely solely on technical parameters.

The paper [14] considers the importance of making algorithms understandable and reliable for their successful integration into business processes, as the enterprise's personnel must understand the results they produce and be confident in them.

The scientific paper [15] identifies certain biases and errors from human influence that can be transferred to computer programs and lead to unfair or incorrect results.

The research [16] focuses on understanding how the human factors affects the efficiency and speed of algorithms used in different business settings. It also emphasizes the importance of human factors and algorithms working together in harmony to reduce the likelihood of errors.

The scientific paper [17] emphasizes the vulnerability of human influence, as automated systems based on data algorithms that reduce the number of errors have a greater impact.

The authors of paper [18] analyzed the widespread use of cyber-physical systems as a new mechanism and a way to achieve a new, higher standard of living. The peculiarities of the human factor's influence on the level of economic security of an enterprise were studied in [19]. The author outlined the parameters for using the term "human factor" in the functioning of socio-economic systems. The scientific publication [20] focuses the attention of scientists on the problems of the human factor's influence on risk management in economic activity. The authors substantiate that executives and managers of enterprises should examine themselves, their actions and decisions, develop rational approaches and get rid of irrational actions. The authors of publications [21, 22] consider the issues of improving the efficiency of business processes at a manufacturing enterprise, where one of the main factors is the influence of the human factor on the activities of the enterprise as a whole and business processes in particular. Some mathematical issues of analyzing the influence of human factor are discussed in [23, 24].

Thus, the presented scientific papers demonstrate various aspects of the human factor's influence on data processing algorithms and emphasize the importance of taking into account human decisions when forming business processes.

It should be noted that the multidirectionality and ambiguity of the presented approaches requires further in-depth research to create a balanced and sound methodology in the chosen context. As a result, consider the study of the issues of the human factor's influence on data processing algorithms during the formation of enterprise's business processes to be a key task of improving the efficiency of the enterprise as a whole.

Efficient business processes rely heavily on efficient data processing to ensure smooth operations at the enterprise level. In competitive business environment, organizations rely on timely and accurate information as a valuable resource for making informed decisions. High-quality data processing allows management to quickly adapt to market fluctuations, open up new perspectives, and mitigate potential threats. In addition, a logical approach to data processing helps to optimize internal operations, increase efficiency, and minimize costs.

Algorithms for processing large amounts of data allow to quickly analyze large the information, which helps in strategic planning. An important aspect is to incorporate these algorithms into the enterprise's normal operations to ensure flexibility and adaptability. In addition, rational data processing allows for accurate forecasts of business growth and market position. Intelligent technologies, such as the Internet of Things (IoT), Big Data (BD), artificial intelligence (AI), machine learning (ML), virtual and augmented reality (AR/VR), and BIM technologies are important in planning the activities of an enterprise and are a prerequisite for ensuring its sustainable operation and development in the market [25, 26].

The introduction of advanced data processing technologies, such as artificial intelligence and machine learning, provides a unique competitive advantage [27]. By applying a rational approach, an enterprise can ensure that it avoids information chaos and achieves greater efficiency in its business processes [28]. As a result, data processing plays a crucial role in the sustainable growth of the enterprise [29].

The purpose of the study is to analyze the theoretical foundations and develop scientific and methodological recommendations for determining the impact of the human factor on data processing algorithms during the formation of enterprise's business processes.

### 3. Materials and methods

In the process of scientific research of the human factor impact on data processing algorithms during the formation of enterprise's business processes, it is advisable to use a combination of quantitative and qualitative methods. One of the main methods is modeling, which allows creating simulations of various scenarios of interaction between the human factor and algorithms to determine potential

risks and the effectiveness of solutions [30]. Experimental research will help test hypotheses about the impact of human decisions on the accuracy and quality of algorithms in real-world conditions.

For a deeper understanding of the interaction of the human factor and the construction of algorithms, it is worth applying a systematic approach that helps to consider business processes as a complex system, where technological and human elements interact. The comparative analysis method will help to identify differences in the impact of the human factor on algorithms in different industries and enterprises. Correlation studies can reveal the relationship between the level of human involvement in processes and the success of business processes. At the same time, the case study method will allow to examine real-life examples of companies that have implemented human-centered algorithms and evaluate their experience.

Thus, to understand how the human factor affects the development of business processes in an organization, a comprehensive and structured approach using multiple scientific methods is required. By using both quantitative and qualitative methods, researchers can not only examine the technical aspects of how human influence interacts with algorithms, but also gain a more complete understanding of the behavioral and social factors at play.

A systems approach allows to understand how technological and human factors affect the efficiency of business processes. Modern business structures and industrial organizations make significant profits by using innovations in their business processes to increase the productivity of their tasks [31]. By combining these methods, businesses can achieve more accurate results and create adaptive and effective solutions.

The human factor has a significant impact on the development of data processing algorithms for the formation of business processes. First of all, human biases can inadvertently penetrate algorithms when they are created or customized [32]. This can lead to incorrect results or unfair choices, especially if the data used to train the algorithms has historical inaccuracies or biases. Also, the effectiveness of algorithmic decision-making depends on the ability of people to accurately understand and believe in the results. If the algorithm is unclear or difficult to understand, it is likely that users will have difficulty utilizing its functions.

The use of monitoring and controlling the consistency of estimates that can be generated from the processed probability system allows to identify scenarios with the least impact of errors in algorithms [33]. In addition, human knowledge and experience is often required to fine-tune and improve algorithms, as the business environment is constantly changing and requires constant adjustment of algorithms to new circumstances [34]. Finally, algorithms must take into account ethical and social implications, which are also influenced by the human behavior.

Based on the results of the study, it is possible to present an interpretation of examples of the influence of individual human factors on the relevant data processing algorithms during the formation of certain enterprise's business processes (Table 1).

Thus, Table 1 shows that the human factor plays a crucial role in determining the effectiveness of algorithms for processing certain business processes of an enterprise. Human behavioral errors, personal biases, and inadequate training can have a harmful effect on the results of algorithmic processing, leading to a decrease in productivity and decision-making accuracy. The use of information systems also helps to reduce the enterprise's costs for spare parts and materials through more accurate accounting and forecasting of needs [35, 36].

At the same time, ethical considerations and deliberate selection of criteria are crucial to ensure accountability and trust in automated systems. As a result, it is crucial to take into account and eliminate the influence of the human factor in order to effectively incorporate algorithms into business processes. The use of digital tools in management allows finding an individual approach to each client, which increases customer satisfaction and loyalty. This approach helps to increase sales and reduce customer losses [37].

The most important economic, social, ethical, and technical consequences of the human factor influence on the development of data processing algorithms during the formation of enterprise's business processes are presented in Table 2.

Table 1

Examples of the influence of human factors on data processing algorithms during the formation of enterprise's business processes

An example of human factor influence	Description of the impact	Business process
Biases in the selection of data for algorithm training	Human behavior can unconsciously select data that reflects their biases, leading to erroneous results	Automated decision-making (recruitment)
Incorrect interpretation of the results	Users may misinterpret data or algorithm results due to low technical competence	Sales analytics and demand forecasting
Resistance to the introduction of new technologies	Employees may resist the use of new algorithms because they are afraid of automation or changes in their work	Optimization of production processes through automation
Incorrect algorithm settings	Human behavior can inadequately adjust the parameters of algorithms, which affects their efficiency	Payment systems and financial management
Ethical considerations when using algorithms	The human factor includes adherence to ethical standards, especially with regard to data protection and customer privacy	Marketing analytics and personalization of advertising campaigns
Distrust of automated solutions	Human behavior can lead to doubts about the accuracy of decisions made by algorithms, which reduces the effectiveness of their use	Decision-making in procurement and inventory management
Entering incorrect data	Human errors in data entry can lead to incorrect algorithm training and inaccurate results	CRM systems and customer data management
Selection of criteria for evaluating the effectiveness of algorithms	Human behavior can choose the wrong performance indicators that do not reflect real business results	Quality control of products and services
Interference with the work of algorithms through adjustments	Human behavior can interfere with the processes after the algorithms are launched, which can disrupt their operation	Supply chain and logistics management
Insufficient level of staff training	The lack of sufficient training of the staff in working with algorithms reduces the effectiveness of their implementation	Implementation of ERP systems to integrate management processes

Thus, it can be stated that the influence of the human factor in the creation of data processing algorithms has both a positive and negative impact on the business processes of an enterprise. The right choice and customization of algorithms can significantly increase the efficiency of resources, while mistakes or biases can lead to financial failures. Socially, the human factor influences decision-making and can lead to resistance to change or social anxiety, but it also improves communication and teamwork. Ethically, data bias or misuse of an algorithm can violate rights and privacy, while adherence to ethical standards ensures fairness and builds trust. While human errors can lead to failures and inaccuracies in algorithms, human expertise and skills are also crucial to improve and refine them. Effective human factors management is therefore crucial to guarantee the successful integration and use of algorithms in business operations.

The algorithmic model of data processing for the formation of business processes of an enterprise consists of several key stages. At each of these stages, the human factor plays a significant role,

which can both positively and negatively affect the results of the algorithms. A step-by-step description of this model is shown in Figure 1 and Figure 2.

Table 2  
Possible consequences of the human factor influence on the development of algorithms of data processing during the formation of enterprise’s business processes

Category	Positive effects	Negative consequences
Economic	<ol style="list-style-type: none"> <li>1. Human intervention can improve the accuracy of algorithm tuning to maximize profits.</li> <li>2. Optimization of algorithms based on human experience contributes to increased productivity.</li> <li>3. Businesses can invest in new technologies to increase processing efficiency and reduce costs.</li> </ol>	<ol style="list-style-type: none"> <li>1. Human errors in data selection can lead to financial losses due to incorrect forecasts.</li> <li>2. Incorrect algorithm settings can lead to increased transaction costs.</li> <li>3. Resistance to the introduction of new technologies can slow down business modernization and reduce its competitiveness.</li> </ol>
Social	<ol style="list-style-type: none"> <li>1. Human involvement can contribute to a better understanding of algorithms by staff.</li> <li>2. Open dialogue about business process automation with employees can reduce the fear of layoffs.</li> <li>3. Human experience helps to take into account the cultural and social aspects of working with data.</li> </ol>	<ol style="list-style-type: none"> <li>1. Employee resistance to the implementation of new algorithms can create tension in the team and affect productivity.</li> <li>2. Improper use of algorithms can lead to discrimination in personnel decisions.</li> <li>3. Distrust of automated solutions can reduce team efficiency.</li> </ol>
Ethics	<ol style="list-style-type: none"> <li>1. Human experience can ensure that algorithms are transparent to employees and customers.</li> <li>2. An ethical approach to algorithm development takes into account equality of opportunity for all.</li> <li>3. Corporate culture of ethics can be preserved through human intervention.</li> </ol>	<ol style="list-style-type: none"> <li>1. Human bias can lead to the creation of unethical algorithms discriminating certain groups.</li> <li>2. Misuse of algorithms can violate the rights of employees or customers, causing ethical conflicts.</li> <li>3. Manipulation of algorithms for personal gain may contradict corporate ethical principles.</li> </ol>
Technical	<ol style="list-style-type: none"> <li>1. Human intervention can help to identify technical errors in algorithms faster and more accurately and correct them.</li> <li>2. Enterprise’s specialists can adapt algorithms to operate in difficult conditions or specific technical environments.</li> <li>3. Personnel's technical expertise can optimize algorithms to achieve better results.</li> </ol>	<ol style="list-style-type: none"> <li>1. Technical errors caused by human error can lead to algorithm failure and data loss.</li> <li>2. Incorrect configuration or testing of algorithms due to human error can reduce their effectiveness.</li> <li>3. Improper choice of technical solutions for algorithms can lead to poor system performance.</li> </ol>

Thus, the presented model illustrates how the human factor can positively or negatively affect the quality of algorithms and the overall efficiency of business processes at each stage of data processing.

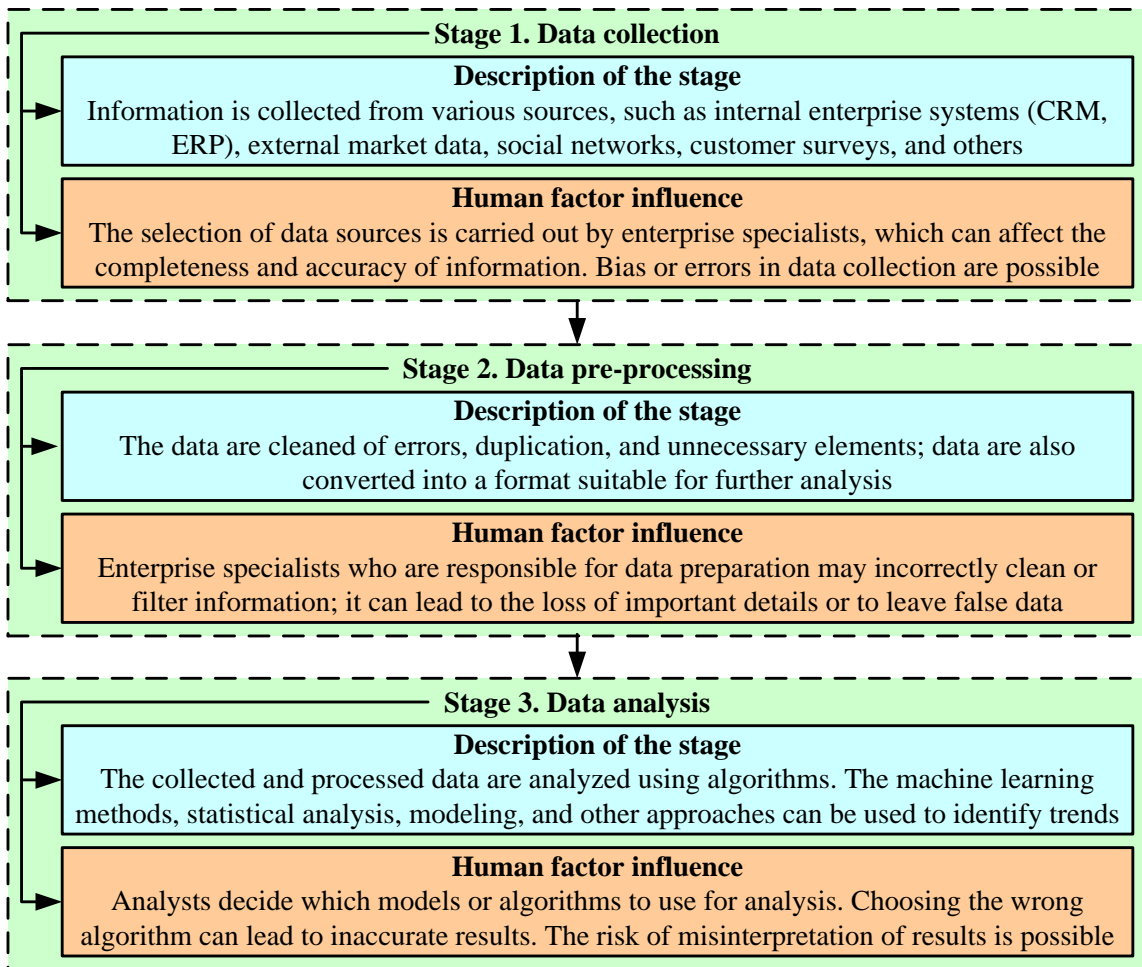


Figure 1: Algorithmic model of data processing during the formation of enterprise's business processes (stages 1 – 3).

Taking into account the influence of the human factor in creating data processing algorithms for business processes is a crucial aspect of ensuring their effectiveness. The main evaluation criteria are the accuracy of input data, the degree of bias in decision-making, and the ability to modify algorithms in response to changes. The quality of algorithms is significantly influenced by staff performance, learning speed, and team interaction. The level of employees' trust in new technologies is a social factor that affects the success of algorithmic solutions. Ethical principles include maintaining confidentiality and avoiding discrimination. The knowledge of employees' technical skills and their ability to work with complex systems and big data play a crucial role in ensuring the stability and reliability of processes. By assessing these parameters, we can make sure that the human factor is taken into account when creating algorithms for business processes.



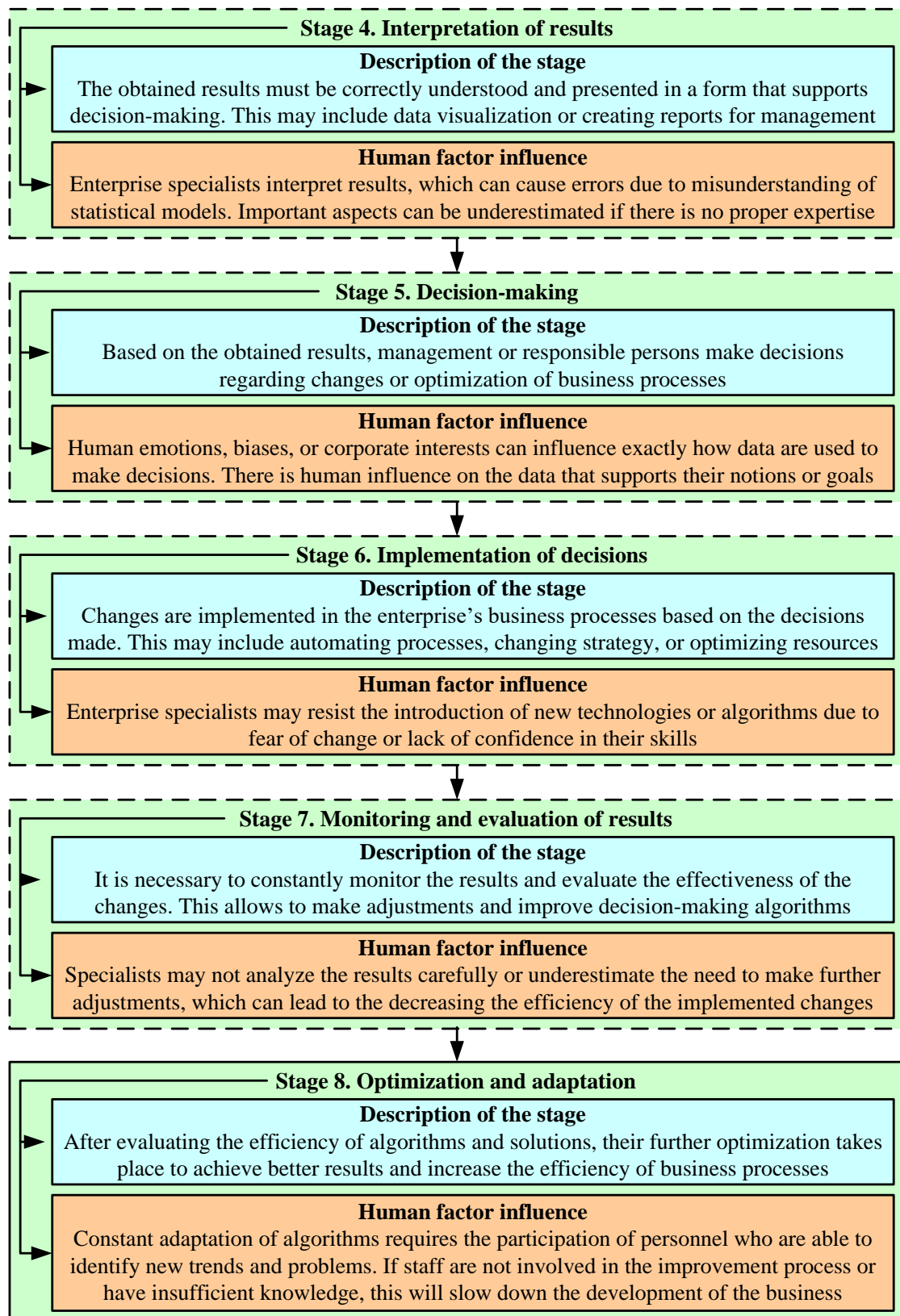


Figure 2: Algorithmic model of data processing during the formation of enterprise's business processes (stages 4 – 8).

#### 4. Results and discussions

Let's consider the issue of mathematical description of the human factor influence on the synthesis, analysis and use of data processing algorithms in the business processes of an enterprise. We will



assume that the issues of algorithmic support are handled by a group of  $N$  of experts, which includes high- and intermediate-level specialists (HS and IS) with certain knowledge and competencies, the number of which is  $n$  and  $m$ . The level of skills and qualifications of each expert is characterized by a subjective vector of probabilities of correct execution of individual procedures at different stages of the algorithmic support model implementation [38, 39].

For a complete description of correct and incorrect decisions by an expert, it is necessary to introduce appropriate probability densities for the probability of correct execution of his actions [40]. Let's assume that the subjective probabilities of performing correct actions are described by a uniform distribution and a beta distribution of the form:

$$f_u(x) = \frac{1}{b-a} \text{ for } a \leq x \leq b, \quad (1)$$

$$f_\beta(x) = \frac{x^{\alpha-1}(1-x)^{\beta-1}}{B(\alpha, \beta)}, \quad (2)$$

where  $a$  and  $b$  are the lower and upper limits of the ranges of variation of the probability of performing correct actions by an expert,  $B(\alpha, \beta)$  is the beta function, which is calculated according to the equation:

$$B(\alpha, \beta) = \frac{\Gamma(\alpha)\Gamma(\beta)}{\Gamma(\alpha + \beta)}, \quad (3)$$

where  $\Gamma(\alpha)$  is the gamma function:

$$\Gamma(\alpha) = \int_0^\infty x^{\alpha-1} e^{-x} dx. \quad (4)$$

We will assume that a team of three experts is randomly selected from a group of experts to solve a data processing project problem. To determine the priori probability of possible options of expert teams (by the number of HS in it), we will use a discrete distribution series. Then the a priori probabilities in this series will be:

$$P_3(k) = \frac{C_n^k C_m^{3-k}}{C_N^3}, \quad (5)$$

where  $k$  is the number of HS in the team, which is believed to be in the range from 0 to 3,  $C_n^k$  is the number of combinations  $k$  of  $n$ .

The probability density function for solving one of the eight tasks (as shown in Figure 1 and Figure 2) will be as follows:

$$f_i(x) = \sum_{k=0}^3 P_3(k) f_i(x|k), \quad (6)$$

where  $f_i(x|k)$  is the conditional probability density function of the correct solution of  $i$ -th task, if the project team includes  $k$  high-level experts. We can also present it as:

$$f_i(x|k) = \begin{cases} f_{IS}(x|k, i), & \text{if } k = 0, \\ \frac{2f_{IS}(x|k, i) + f_{HS}(x|k, i)}{3}, & \text{if } k = 1, \\ \frac{f_{IS}(x|k, i) + 2f_{HS}(x|k, i)}{3}, & \text{if } k = 2, \\ f_{HS}(x|k, i), & \text{if } k = 3, \end{cases} \quad (7)$$

where  $f_{IS}(x|k, i)$  and  $f_{HS}(x|k, i)$  are the conditional probability distributions of the correct solution of  $i$ -th task by IS and HS.

The information obtained on the basis of  $f_i(x)$  is the most complete. It can be used to find the probability of a correct solution to the project task  $p_{cs}$  of data processing. Let's assume that the task is considered to be solved correctly if the total error rate of the expert team exceeds the threshold level  $p_{th}$ . Then the probability of solving the problem correctly, taking into account the human factor, will be:

$$p_{cs} = \int_{p_{th}}^1 f_i(x) dx. \quad (8)$$

Let's consider an example of numerical calculations and mathematical modeling. We assume that  $N = 20$ ,  $n = 15$ ,  $m = 5$ . The threshold level of the probability of a correct solution to the design problem  $p_{th} = 0.9$ . The conditional probability density function of performing correct actions of  $i$ -th task by IS and HS are the same for all tasks:

$$f_{IS}(x|k, i) = \frac{x^{15}(1-x)^2}{B(16,3)}, \quad (9)$$

$$f_{HS}(x|k, i, \text{first option}) = 10 \text{ for } 0.9 \leq x \leq 1. \quad (10)$$

$$f_{HS}(x|k, i, \text{second option}) = \frac{x^{50}(1-x)^0}{B(51,1)}. \quad (11)$$

The results of calculating the probability mass function are shown in Table 3.

Table 3  
The probability mass function

$k$	0	1	2	3
$P_3(k)$	0.0088	0.1316	0.4605	0.3991

The results of calculating the final probability density function for the two options of conditional probability density function for the case HS are shown in Figure 3 and Figure 4.

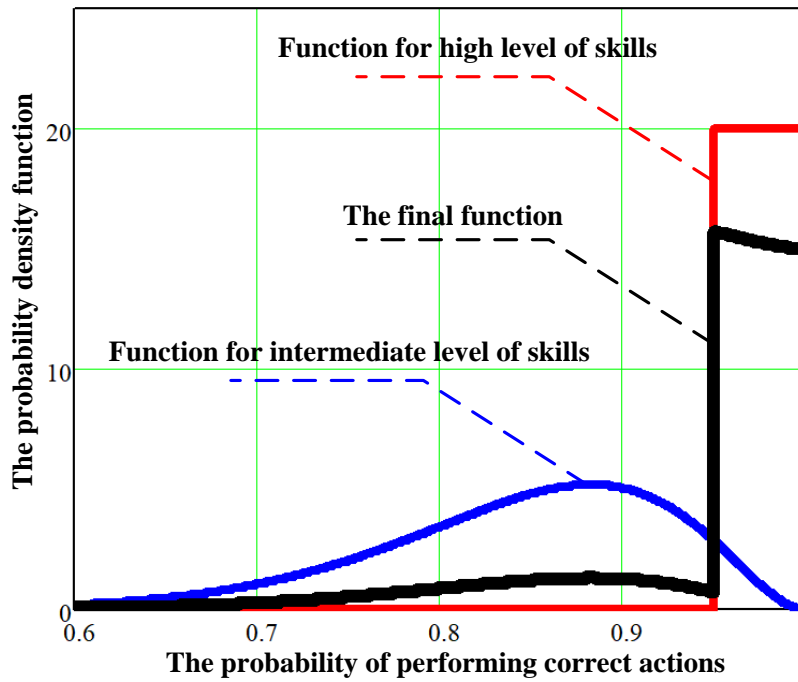


Figure 3: The probability density functions for the probability of performing correct actions (Option 1).

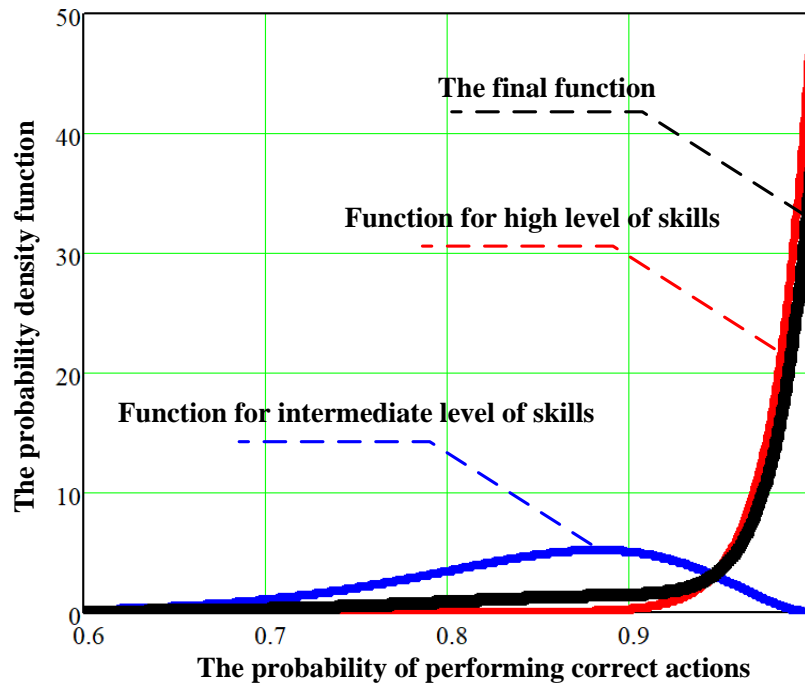


Figure 4: The probability density functions for the probability of performing correct actions correctly (Option 2).

Visual analysis of the graphs allows to conclude that the final probability density function is complex. In addition, in the case of the first data set, we have a bimodal distribution. In general, the probability of a correct solution to the problem, taking into account the human factor, is 0.817 and 0.813 for the first and second options, respectively.

Figure 5 shows a graph of the dependence of the probability of a correct solution to a problem with a human factor on the number of high-level experts in the group. It is obvious that the increase in the number of highly qualified experts leads to decrease in the influence of the human factor on the quality of solving data processing project.

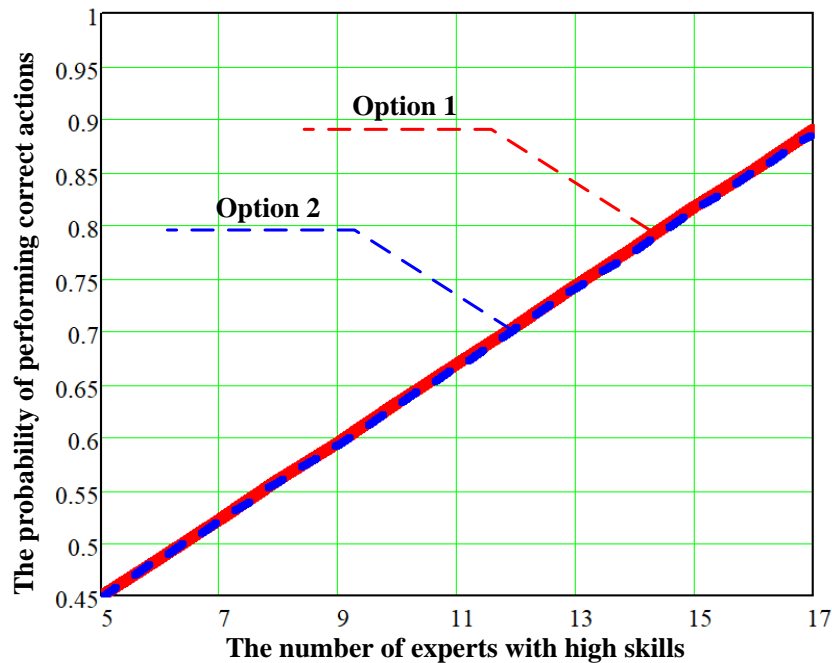


Figure 5: Probability of performing correct actions taking into account the human factor.

## 5. Conclusions

The results of the study of the influence of the human factor on the development of data processing algorithms during the formation of enterprise's business processes show that this factor is crucial and complex, playing a significant role in determining the quality and efficiency of making decisions. Errors, prejudices, and lack of understanding can cause algorithms to malfunction and lead to financial losses or irrational use of resources. The knowledge and skills of employees allow the company to improve data accuracy and modify algorithms in accordance with changes in the internal and external environment.

It is established that the social aspect is crucial, since employees of an enterprise can both accept the introduction of new algorithmic solutions and oppose changes that affect the efficiency of existing business processes. In addition, the successful integration of algorithms into business processes largely depends on trust in automated solutions and smooth interaction between employees. Ethical issues, especially those related to privacy and algorithmic bias, require careful monitoring and strict adherence to standards to prevent discrimination and social conflict. Technical skills are crucial, as the ability of employees to work with data and technology directly affects the performance of algorithms. Successful integration of new algorithms requires thorough training and constant adjustments that take time and resources but bring long-term benefits to the enterprise. Therefore, to achieve the best results in creating and utilizing data processing algorithms, it is crucial to consider and handle the human factor throughout the process. Thus, the study emphasizes the importance of adopting a holistic approach to managing human impact in algorithm development. This includes not only technical training of employees but also the creation of an ethical and social framework that encourages transparent and responsible use of algorithmic systems. This is the only way to achieve a balance between automating business processes and taking into account the human factor in business strategy development.

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