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DIGITALIZATION OF ACCOUNTING: IMPLEMENTATION FEATURES AND EFFICIENCY ASSESSMENT

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Abstract. The digitalization of accounting processes offers significant benefits, including increased efficiency and reduced errors in accounting data. However, the successful implementation of new and modernization of existing computer programs in the accounting system requires consideration of cost, technical, professional, and managerial factors. This study aims to provide a comprehensive analysis of qualitative and quantitative parameters that can form the basis for making decisions on the integration of automated accounting data processing, robotic process automation, artificial intelligence, blockchain, or their combinations into existing systems for the full digitalization of accounting.

The integration of software robots and artificial intelligence into accounting systems offers various benefits related to the creation of a non-standard environment where the generation, transfer, and exchange of traditional accounting information is accelerated and improved through the integration of data from other management systems and databases. These improvements contribute to the efficiency and reliability of the automated accounting system. The introduction of software components such as robotic process automation and artificial intelligence helps to free accounting staff from the routine of repetitive operations and ensures automatic prioritization and sequencing of accounting registration in the digital space. Integration of bots into an automated accounting system also facilitates document sharing and provides remote automated monitoring. This increases interaction between departments and improves control over operations that require additional attention from managers.

To assess the effectiveness of such software solutions, the authors critically evaluate existing approaches to determining the qualitative indicators that are expected to be obtained after the introduction of software innovations and propose to supplement the performance criteria with quantitative indicators, among which are the time-saving ratio in document processing, the error rate and the resource-saving ratio.

In conclusion, this study substantiates the need to consider quantitative parameters and coefficients that can be used to assess the effectiveness of implementing software solutions in automated accounting systems for the digitalization of financial information. The results emphasize the need for a holistic approach to assessing the effectiveness, reliability, and security of these solutions. Improved technical knowledge and training of accounting professionals in security assessment are crucial for the successful implementation and use of digitalization of accounting systems.

Keywords: accounting, digitalization of accounting, software solutions efficiency.

JEL Classification: M400

1. INTRODUCTION

The rapid development of information technology and automation systems has revolutionized many areas of social relations, and accounting analysis and control have not been left behind in this regard (Fernandez & Aman, 2018). In the past, accounting tasks that involved processing large amounts of numerical data were time-consuming and expensive for organizations. However, the introduction of computer systems marked a turning point by optimizing transaction processing and reducing costs (Wilson & Sangster, 1992).

Initially, computer systems were mainly used for basic algorithmic processing of numerical data (Wilson & Sangster, 1992). With the development of computer technology, automated accounting systems have moved from centralized mainframes to personal computers, individual business microcomputers (ultrabooks) and, finally, are moving steadily into the cloud space, where hardware plays only the role of a bridge over which large amounts of information are constantly moving. This change has not only expanded computer use among SMEs, but also sought ways to improve accountants' computer literacy (Chukwuani & Egiyi, 2020).

Although informatization has greatly increased the overall level of computer use in accounting practice, its impact on accounting departments of different enterprises varies depending on the size and type of economic activity (Wilson & Sangster, 1992). While tasks such as bookkeeping have been easily automated due to their reliance on simple algorithms, activities involving complex professional judgment and interpersonal contacts have posed challenges to automation (Gotthardt et al., 2019).

In recent years, companies have been able to integrate the potential of technologies such as artificial intelligence (AI), robotic process automation (RPA), big data analysis, and blockchain into their existing accounting process automation system to increase efficiency, support management decision-making and generate, store, transfer information and digitalize accounting processes (Gotthardt et al., 2019; Jędrzejka, 2019; Lacurezeanu et al., 2020). Among these technologies, the implementation of RPA and blockchain in the field of accounting is gaining momentum not only at the global level, but also at the level of medium and small companies. Integration of such software into the existing information infrastructure of the enterprise increases the level of automation, covering all repetitive tasks, and freeing employees from burdensome and time-consuming activities (Fernandez & Aman, 2018).

By analyzing the organizational prerequisites and the state of scientific substantiation of approaches to the implementation of modern elements of digitalization of the accounting profession, we have attempted to generalize, systematize and substantiate the solution of a specific task that is part of the general problem of implementing RPA, AI and other innovations in accounting. Thanks to the in-depth analysis of the available scientific literature, this study allows us to identify patterns of implementation of the mentioned software products and provide an understanding of practical actions to consider the consequences of their use.

The structure of this study includes the theoretical foundations, where a detailed review of key publications on accounting, automation of accounting processes, and modern approaches to the introduction of software innovations that ensure continuous digitalization into the existing system of information support for management decisions of an enterprise is carried out. The next part outlines the research methodology, including the chosen method and selection criteria for analyzing publications. The article then presents the results of the study and discloses information on approaches to qualitative and quantitative assessment of the conditions for selecting and implementing modern software robots and other latest developments in the decision-making information support system. The article describes the individual and organizational behavior of accounting and accounting services employees in the context of maximum coverage of accounting processes by their digitalization. The conclusions summarize and describe the main results and

limitations of the study, as well as indicate potential directions for future research in the field of digitalization of accounting, analysis, and control.

2. THEORETICAL BACKGROUND

Automation of accounting processes has long been an integral part of accounting, analysis, and control (Jędrzejka, 2019). In recent years, the automation process itself has also changed radically due to the emergence of software technology that allows the creation of software robots and leads to complete digitalization. With the beginning of the active implementation of automation of certain accounting processes, researchers have noted (Fernandez & Aman, 2018; Gotthardt et al., 2019; Jędrzejka, 2019; Korhonen et al., 2021; Wilson & Sangster, 1992), that it was extremely difficult and sometimes almost impossible to achieve full automation. After all, certain accounting functions, at that level of development of technical means and programming language, required the direct participation of an accountant and the performance of certain programmatic actions. In addition, non-trivial tasks requiring prudence and creativity remain difficult for the full automation of accounting, analysis, and control at the enterprise (Gotthardt et al., 2019).

The emergence of the ability to create software robots (so-called “bots”) that mimic human actions in automated accounting systems is triggering irreversible changes in approaches to defining the content of an accountant’s work in the digital environment. Robotic process automation (RPA) allows to increase the efficiency and accuracy of accounting data, reduces company costs, and frees up time for accountants to focus on more complex tasks (Gotthardt et al., 2019; Jędrzejka, 2019). However, the introduction of RPA also creates additional educational and social difficulties, and judging by the experience of implementation in the accounting field, it creates numerous problems (Gotthardt et al., 2019). There is a certain variability in the role of the accountant in the information space of the enterprise, in which experienced accountants are forced to develop new skills and quickly adapt to changes. While technological innovations may disrupt certain aspects of employment, they also create new job responsibilities and change the nature of existing ones (Fernandez & Aman, 2018). For accountants, a key factor for success in the digital accounting environment is continuous learning, including acquiring skills in working with bots and artificial intelligence as a tool to improve job performance in the enterprise (Chukwuani & Egiyi, 2020). The toolkit in the form of global information and telecommunication networks, however, requires a significant adjustment of the traditional set of integral, general, and professional competencies (Gnatiuk et al., 2021).

Another phenomenon that expands the possibilities of complete digitalization of accounting and is likely to cause a fundamental change in approaches to the training of accountants is the integration of RPA with cognitive platforms and artificial intelligence (Jędrzejka, 2019). This allows “bots” to make complex decisions, learn and develop from the experience gained. Therefore, it is extremely relevant and important to study the result of human-machine cooperation to eliminate potential negative social consequences and ensure a smooth transition of the educational space to the education and training of accountants.

It should be noted that the growth of opportunities is accompanied by such problematic aspects as the distribution of responsibility (Gotthardt et al., 2019) and information security (Simakov & Simakova, 2022) of data. Increasing the level of coverage of automation of accounting processes will allow to quickly obtain synthetic indicators, but the issue of quality and quantity of the entered primary data remains open (Gotthardt et al., 2019). Therefore, it is time to develop and implement systems with a higher level of digitalization that solve the problems of data quality and quantity for artificial intelligence systems, transparency and interpretability of artificial intelligence algorithms, cybersecurity, and compliance with state standards and regulations (Gotthardt et al., 2019).

Despite the obvious inclination of enterprise managers to find means and create opportunities for the implementation of comprehensive digitalization of accounting, the issue of certain limitations still remains relevant. In particular, the digitalization of accounting as an important component of the management decision-making system depends on a subjective choice between professionalism and efficiency (Korhonen et al., 2021). It so happens that the question of the need to automate financial accounting is no longer even raised. This task has long since become an axiomatic management function. Basic knowledge of Microsoft Excel and Access and general accounting knowledge allow graduates of accounting education programs to organize and implement (Drum et al., 2016) partial automation of accounting for a small company right from the university bench. Nowadays, the question is: "Which software product will provide maximum coverage of financial accounting tasks?", "How long does it take to adapt it to the financial and economic characteristics of the company?", "What is the level of security of financial information?" and several other cost and technical issues that determine the boundaries of the company's digital space. Such points often include (Pavelchak-Danylyuk, 2014) the potential capabilities of the software, in particular: synthetic and analytical accounting of assets, capital and liabilities with elements of management accounting; preparation of financial, tax and statistical reports; provision of reference information for business activities; possibility of automated analysis, forecasting and control over the enterprise's activities based on a database. When choosing a way to digitalize accounting, there are various possible options for delivering a software product (Hrabchuk & Lyakhovich, 2017), including the choice between a local and a network version. Certain programs offer only a network version, while others offer programs that work only on a local network, limiting access to data (Hrabchuk & Lyakhovich, 2017). In some cases, the main criterion for the company's management to choose a digitalization program is the amount of financial costs for its purchase, installation and maintenance, as well as the fact that accounting automation does not require special programming skills from the accountant (Hrabchuk & Lyakhovich, 2017). Even in budgetary organizations, the choice of a particular software product for effective digitalization of accounting procedures is a "free option" (Skalyuk, 2015) that depends on each individual institution. The staff of the institution must necessarily consider the specifics of the institution's activities and other important criteria (Skalyuk, 2015) to make an informed choice. Additional selection criteria may include performance criteria (safety, reliability, time, cost, etc.) or professional capacity.

On the other hand, the digitalization of the part of accounting that is on the borderline between the process of making management decisions and preparing information for such decisions rests on the objective need to distinguish between human and machine labor (Korhonen et al., 2021). The nature of the tasks performed in different types of economic activity is decisive here. Historically, accountants working in the industry have had the advantage of experience in implementing computer technologies (Wilson & Sangster, 1992). The prospects for using robotic automation processes in collaboration with cognitive platforms, artificial intelligence, and blockchain technology (Popivnyak, 2019) are very real, but there are risks associated with the false sense of security that can arise when digital technology replaces human intelligence without a deep understanding of the processes involved (Korhonen et al., 2021). Each program for the digitalization of the accounting process saves time and money for the enterprise and allows for effective management decisions (Adamyk, 2016; Harkusha, 2017). Of course, they have their advantages, disadvantages, and features, but their main goal is to simplify the work of accountants through automation (Pavelchak-Danylyuk, 2014) and the digitalization of accounting data. Their use improves error-free and accurate accounting operations and increases the efficiency and effectiveness of monitoring and auditing operations (Kaya et al., 2019). However, it is necessary to identify in advance the processes that can be automated and those that cannot be performed without human intervention with the current level of information support (Korhonen et al., 2021).

Tasks that are algorithmic in nature are easy to computerize, while those that require judgment and qualitative information processing are slower to adopt (Wilson & Sangster, 1992).

It is important to note that attempts to achieve full digitalization of accounting can create new problems, such as the objectivity and adequacy of data. The error inherent in the software algorithms for the automated processing of economic information multiplies exponentially during the current accounting registration and can significantly distort financial statements (Adamyk et al., 2018). Therefore, one of the prerequisites for the effective use of an automated accounting data processing system is a periodic audit of the software in terms of its functional and non-functional components (Adamyk et al., 2018). This requires the use of labor-intensive analysis of the general state of the software and creates additional administrative costs. It is necessary to evaluate the type of software product, a set of data processing capabilities, accessibility, range of services, methods, and industry solutions. It is important to have the rights to the software product (Adamyk et al., 2018), which allows you to ensure regular updates, a wide range of modules, and forms of financial, tax, statistical, and management reporting. All of this is difficult to implement by the company's accounting staff. There is a need to outsource the audit of automated information systems or introduce a full-time unit in the structure of the company's administrative staff or organize training for existing staff to constantly adapt their skills and competencies in the context of new technologies (Jędrzejka, 2019). The training should be implemented in master's programs related to accounting and only later extended to continuing education programs for accounting and auditing professionals organized by educational institutions in cooperation with representative, regulatory, and supervisory bodies (Lacurezeanu et al., 2020).

Of course, a number of further studies are needed to assess the long-term impact of the use of software robots and artificial intelligence in the process of accounting digitalization on financial efficiency. In addition to financial factors, non-financial factors should be investigated and potential limitations and barriers to automation should be considered. Expanding the scope of scientific research in these areas will allow for a quick and painless transformation of the accounting profession, maintaining the dynamics of its development and promoting the effective use of modern technologies for future success (Jędrzejka, 2019).

3. RESEARCH OBJECTIVE, METHODOLOGY AND DATA

The purpose of the study is to summarize and systematize modern approaches to the digitalization of accounting, to establish a link between the general principles of digitalization, the role of the accountant, and the impact of new technologies of the interactive information environment that operates through computer systems to improve the productivity and efficiency of the use of administrative and managerial personnel at an enterprise, which will further facilitate the development and implementation of effective operational management strategies. The study aims to identify opportunities and limitations of continuous digitalization. Formation of a holistic understanding of the digitalization of accounting and its impact on accounting processes, which will help to improve the practice of making informed decisions regarding the implementation of automated systems in the field of accounting.

To determine the way to achieve the goal and solve the outlined tasks in terms of the existing problem of digitalization of accounting, analysis, and control of economic activities of enterprises in the context of the transformation of the automated systems market, we relied on the use of a set of procedures for theoretical assimilation of reality. The use of dialectical and deductive approaches ensured the formulation of logical conclusions from the established axioms and principles of accounting digitalization and also allowed us to apply logical reasoning and the existing discourse on the role of the accountant and the impact of new technologies. Resolving contradictions and achieving a synthesis of multidirectional judgments allowed us to draw

systematic logical conclusions, find general patterns and common aspects, and establish links between general principles in the specific area of accounting digitalization.

The methodological basis for obtaining theoretical concepts, principles, and methods, managing the process of choosing a system, and the scale of digitalization of accounting processes at an enterprise are the works of domestic and foreign scholars. A critical analysis of scientific research focused on various aspects of the digitalization of accounting and the consequences associated with this process, which determine the development of the accounting profession, organizational forms of accounting, and determining the place of an accountant in the structure of the administrative and managerial staff of an enterprise, is carried out.

4. RESULTS AND DISCUSSION

The digitalization of accounting processes can improve the efficiency of accounting and reduce the likelihood of errors. It facilitates quick access to information, which allows for interconnected management decisions. Automated accounting systems can perform routine tasks faster and more accurately (Skrypnyk et al., 2020), freeing accountants from monotonous work and allowing them to focus on data analysis, management reports, and strategic aspects of accounting.

There are factors that constrain the adoption of computer programs in general: funding, change, skills, politics, and equipment (Wilson & Sangster, 1992). Smoothing their impact on software promotion should satisfy the technical, commercial, ergonomic (Pavelchak-Danylyuk, 2014), and technological (Kaya et al., 2019) needs of the company and improve efficiency:

1. Technical characteristics:

- versatility;
- operational speed;
- the ability to make editorial changes to accounting forms;
- network interactivity and data exchange;
- reliability and cybersecurity;
- renovation potential.

2. Commercial characteristics:

- cost;
- rights of use;
- professional support during use.

3. Ergonomic characteristics:

- convenience and adaptability in use.
- information content and visibility.

4. Technological characteristics:

- adaptability to the type of economic activity;
- versatility and adaptability to operational processes (production, finance, accounting, sales, procurement, supply chain management, customer service, and human resources (Kaya et al., 2019)).

5. Performance characteristics:

- speeding up the time for data processing and obtaining information;
- reducing the cost of paying for routine, unproductive work;
- increasing revenue and reducing the “cash gap” between the nominal income on all contracts and the actual cash flow from their execution.

These requirements are basic when deciding on the choice of software functionality, availability, efficiency, and convenience, and the above criteria are qualitative in nature. However, even a successful combination of all the characteristics of the program cannot offset the objective existence of such facts, phenomena, and events in the business process as large transaction

volumes, limitations in the ability to automate exception handling, a significant share of manual labor in a computer environment prone to errors during the initial data entry or recovery, sustainability in the context of low dynamics of response to environmental changes, frequent requests to several systems and the presence of repeated operations with the same frequency (Lacurezeanu et al., 2020). Therefore, the use of only qualitative criteria to select an alternative option for improving and, as a result, increasing the efficiency of digitalization of accounting at an enterprise is unacceptable.

To find out what quantitative parameters should be taken into account when choosing between software robots, artificial intelligence, blockchain, or combinations of these, it is necessary to systematize the expectations of information users and accounting staff.

To begin with, the organization of enterprise management should be based on the rule that all decisions should be based on a clear set of rules (Lacurezeanu et al., 2020). Next, it is necessary to determine how to improve the productivity of administrative and managerial staff by introducing robotic programs, artificial intelligence, or other new software additions to the existing system of information support and automation of business operations accounting.

Guided by the results of a critical evaluation of scientific publications on this issue (Adamyk et al., 2018; Chukwuani & Egiyi, 2020; Fernandez & Aman, 2018; Kaya et al., 2019; Lacurezeanu et al., 2020), we summarize some of the organizational implications described by the authors and, by building logical judgments, systematize our own vision of the expected results of increasing the efficiency of digitalization of accounting.

To begin with, most businesses have all typical business operations and their accounting automated by a basic software product. Improving its efficiency should ensure the automatic generation of atypical reporting forms. For example, a "bot" or AI should set additional command protocols for certain positions in the columns and lines of certain primary documents, which allow the information reflected in these positions to be generated in other summary or final documents of other management systems, responding to the request of responsible employees or to orders from managers of different levels of management. This is how management reporting is digitized.

The next effect of improving the accounting digitalization system should be the ability to automatically integrate data in one document from other management systems. It should be possible to cross-use such e-documents as agreements, orders, invoices, bank statements or payment receipts, etc. in the electronic sales management system, electronic project management system, and electronic accounting management system. The procedure for generating, processing, and archiving these documents should be defined in such a way that it is equally accessible and equally informative for each system.

As a result of the transition to the use of software robots, the technical features of data transfer and exchange must change. Information from the original document must be automatically transferred or exchanged with other systems or departments of the company, such as the project management system, sales management system, or enterprise resource planning system. Everyone responsible for working with electronic documents in the mentioned system should receive a notification or a special "tag" about the creation of a certain document in another management system. Moreover, the label must have a functional status. In particular, it should not allow completion, closure, or a period (shift, decade, month, etc.) without fulfilling the requirements for the created document. The requirements for the document may be different - familiarization, approval, control, etc. with the imposition of an electronic signature on their fulfillment. The accumulation of received and unprocessed labels by responsible persons should be reflected in the HR management system. In turn, the "bot" automatically monitors or registers KPIs, which can be included in the module for accounting for the use of working time, fulfillment of labor standards, and accrual of payments from the fund of basic and additional wages of administrative and managerial personnel.

Another consequence of implementing robotic software components is that accounting staff is freed from the task of taxing primary documents. The basic program, if properly configured, can successfully cope with assigning unique numbers and dates to invoices. And RPA or AI can determine the level of priority of execution depending on the data contained in the contract archives or payment calendar. The expected effect of this is the digitalization of the process of controlling overdue payments on invoices. The same can be true for orders. Assigning unique numbers and dates to invoices and determining the level of priority of execution depending on the data contained in the contract archives or in the payment calendar will ensure automatic priority execution of orders for which the company has received advance payment.

Setting up restrictive functions that prevent prompt repayment of an order or completion of an invoice if the amounts specified in these documents will exceed the established receivables limit for a certain period of time will be another bonus. This will protect against unreasonable growth of accounts receivable with each subsequent reporting period. If accounts receivable are not digitized, they will definitely accumulate. This is because the marketer is driven to increase sales and is not too concerned about the cash flow to the company from these sales. If he needs to provide a deferred payment to increase sales, he will offer it. And not because he is an unscrupulous employee, but because he does not have information about the dynamics of accounts receivable. And even if the marketer knows that the company is accumulating receivables, he does not always understand the negative consequences of unreasonably overstating receivables. His job is to sell, so he sells. And the restrictive function of the primary document, which is integrated simultaneously into various management systems, will ensure coherence and interaction between various company services and, as a result, increase efficiency and reduce the risks of negative consequences of unreasonable management decisions at various levels of management.

A separate element of integrating “bots” into an automated accounting system is the ability for administrative and management personnel and accounting staff to simultaneously work together with documents and exercise remote control.

Remote access to work with documents and staff mobility allows you to process documents without being tied to an office and a specific workplace or technical means, simply while participating in exhibitions, fairs, conferences, negotiations with partners, etc. Collaborative work with documents allows employees from other structural units who are responsible for the operational accounting of certain business transactions to work with primary documents directly from their workplace simultaneously with employees of other services. For example, a document that formalizes the release of finished products from production and confirms their compliance with technical specifications and quality standards can be worked on simultaneously by a quality controller, a technologist, a shift manager, a storekeeper, and other responsible persons in the shop, warehouse, and accountant’s office.

Also, remote control at every stage of working with a document becomes a reality. When processing documents for transactions that last for a certain period of time and require additional control from the manager’s account. This improves the quality of control, because before signing the “inventory results act”, the manager can monitor the inventory remotely by remotely accessing all stages of creating the inventory and identifying discrepancies.

Having thus systematized the expected effects of expanding the functionality of the accounting digitalization system and based on the results of the literature analysis (Adamyk et al., 2018; Chukwuani & Egiyi, 2020; Fernandez & Aman, 2018; Kaya et al., 2019; Gotthardt et al., 2019; Lacurezeanu et al., 2020), we will determine the necessary quantitative parameters that will be sufficiently informative for management personnel who will choose between software robots, artificial intelligence, blockchain, or their combinations.

The most informative quantitative characteristic of an event, process, or phenomenon in a company’s business activity that is relatively stable is a coefficient. A coefficient is a calculated

number that can be obtained by dividing two absolute or average values, characterizing the ratio of one absolute value to another. Therefore, the question arises of determining the list of absolute values that will be the measurements that will characterize the effectiveness of the new software solutions implemented in the automation system (Kaya et al., 2019).

The process of observing, recording, accumulating, and summarizing information about the company's business operations is carried out in compliance with the principle of periodicity. Therefore, time is the absolute value that can be used to quantify the level of efficiency of the digitalization of accounting. After all, with successful management, a company should show positive dynamics of economic growth. This will be accompanied by an increase in the number of transactions, which will undoubtedly lead to an increase in the number of transactions and business processes. Accordingly, in the context of economic growth, the company cannot avoid an increase in the volume of documents, while the time for processing them remains unchanged. As a result, management must decide whether to increase the number of employees or modernize the accounting software.

Thus, the next absolute indicator that should characterize the quantitative parameters of the effectiveness of accounting digitalization is the physical volume of accounting documents. As a result of integrating software robots into a functioning system of automated accounting information processing, it is possible to reduce the number of primary documents or increase the number of processed documents over a certain period of time, or simultaneously reduce the number of primary documents and increase the speed of their processing.

And of course, the main absolute indicator is money. More precisely, it is a monetary measure of the costs incurred by the company for processing accounting information and the costs to be incurred for modernizing the company's information environment by introducing a higher level of digitalization of accounting.

Thus, time, number of documents, and cash costs are the key absolute indicators that can be used to quantify the effectiveness of new software solutions implemented in a company. Two more indicators can be determined based on reliability and security considerations. Reliability is determined by the objectivity and adequacy of the data (Adamyk et al., 2018) and is associated with a reduction in the number of errors made in documents containing information about transactions and business processes. And security includes the assessment of potential threats, risks, and weaknesses of the program, as well as the level of application of various security measures (Gotthardt et al., 2019). Therefore, the absolute value of the number of errors and the number of security measures used can enhance the information content of assessing the effectiveness of accounting digitalization using AI, RPA, Big Data, or blockchain.

In general, the parameters that quantify the expected effect of the introduction of software robots, artificial intelligence, blockchain, or their combinations can be expressed by the following basic coefficients:

1. Time-saving ratio for processing primary documents. This indicator informs about the time spent on processing one document and is calculated as the ratio of the number of standard time units (time periods) to the number of processed documents. A standard unit of time can be an hour, a working day (8 hours), a decade, a month, three months, etc. Its reduction because of measures to modernize automated accounting information processing will indicate the level of time savings and extensive efficiency. The inverse value of this indicator characterizes the physical volume of processed primary documents for a standard period of time.

2. Error rate. This indicator informs about the number of errors per processed document per standard unit of time and is calculated as the ratio of the number of documents with an error to the number of processed documents. A decrease in this indicator will indicate an improvement in the quality of information processing and intensive efficiency from measures to modernize automated accounting information processing. The inverse of this indicator is the reliability ratio. It shows the

number of error-free document processing per one error. Its growth will indicate an increase in the reliability of error-free information processing and the level of leveling of the influence of the human factor (fatigue, negligence, disorganization, low level of qualification, etc.)

3. Resource-saving ratio. This indicator informs about the amount of released funds per each hryvnia of additional funds spent on the modernization of automated accounting information processing and is calculated as the ratio of the absolute deviation of the costs of processing accounting information before and after modernization to the costs incurred by the company for the modernization itself and further maintenance of the programs used per standard unit of time. Here, the standard unit of time is the annual period. The resulting indicator may indicate the expected cumulative effect of the introduction of "bots" and artificial intelligence into the digitalized accounting data processing system with each subsequent reporting period.

In addition to the number of cybersecurity measures taken, the security of software robots is linked to other metrics and assessments, such as an assessment of the program's compliance with established security standards and norms, security testing results, encryption, monitoring, etc. These parameters are of an engineering nature and cannot be adequately assessed by the company's management personnel. Therefore, such an assessment should be outsourced, which, of course, will increase the company's costs, which should be considered when assessing the resource efficiency ratio.

Further research on approaches to improving the practice of making informed decisions regarding the implementation of digitalized systems in the field of accounting may be aimed at determining an integral indicator based on the above coefficients. Moreover, to build an integral indicator using the above coefficients, it may be advisable to use a combination of stochastic and deterministic approaches. The stochastic approach allows taking into account uncertainty and randomness in the measurement of time-saving and error rates. These coefficients contain variable factors that affect them, and it will be necessary to assess risks and calculate the probabilities of the results obtained. After all, the data on the number of processed documents, the number of errors, and the error-free processing of these documents are statistical in nature and may depend on the complexity of the documents, the place of their preparation, the qualifications of the staff, the level of organization of their processing, the technical capabilities of computer equipment, etc. In contrast, the resource-saving ratio can be defined as a deterministic indicator, since it measures specific monetary costs and can be calculated quite accurately. The combination of stochastic and deterministic approaches to building an integral indicator based on the above coefficients will provide a comprehensive analysis and evaluation of the effectiveness of the implementation of software robots, artificial intelligence, blockchain, or their combinations. Such an approach will allow considering both uncertainty and randomness in determining the coefficients and specific measures of the impact on the organization's work.

Thus, only the application of a holistic methodology for assessing the qualitative and quantitative characteristics of software changes in the enterprise's automated accounting information processing system makes it possible to assess the level of efficiency changes and the level of software reliability. As for the issue of assessing the level of security of such innovations, it is beyond the competence of administrative and managerial personnel due to the lack of special technical skills of accounting employees. Therefore, it is necessary to change the existing approaches to the training of accounting personnel (Gotthardt et al., 2019) in the educational space and organize systematic training to improve the professional suitability of staff so that employees in the field of accounting, analysis, and audit do not feel threatened by the active use of AI, RPA, Big Data or blockchain and see only new opportunities (Fernandez & Aman, 2018).

5. CONCLUSION

The development of information technology and computer equipment opens new prospects for increasing the efficiency of digitalization systems and expanding the scope of accounting processes. Digitalization facilitates quick access to information, assists in the decision-making process, and minimizes the level of errors made in the generation of reporting data. Improving the quality parameters of basic automated accounting programs can be achieved by integrating modern software innovations, such as software robots, blockchain artificial intelligence, or methods of analyzing large amounts of data (Gotthardt et al., 2019; Jędrzejka, 2019; Kaya et al., 2019; Korhonen et al., 2021). However, there are several limitations to the implementation of such solutions related to the integration capabilities of the underlying programs, the need for additional funding, the availability of suitable computers or other equipment, and the lack of special skills in accounting and good management policies among administrative staff (Fernandez & Aman, 2018). And for the successful implementation of software robots, artificial intelligence, blockchain, big data, or a combination of them in basic automated accounting programs, technical, commercial, ergonomic (Pavelchak-Danylyuk, 2014), and technological (Kaya et al., 2019) requirements must be taken into account.

When choosing a software solution to improve the efficiency of digitalization of accounting, one is mainly guided by qualitative characteristics, in particular: compatibility of software robots with basic computer systems, increased speed of task execution, data exchange with other software, ease of use, reliability, and security. However, when assessing the qualitative characteristics, it is necessary to consider objective factors that do not always make it possible to achieve the expected result. Among the mentioned limitations are uneven volumes and flows of transactions (Wilson & Sangster, 1992), the presence of exceptions and the low ability of software robots to automate them (Fernandez & Aman, 2018), still significant amounts of manual work (Lacurezeanu et al., 2020), which leads to errors when entering credentials, as well as the static nature of prescribed software algorithms and a low response to changes in the accounting environment. Therefore, the choice of the best option for digitalizing accounting in an enterprise should be based not only on qualitative criteria but also consider these objective limitations.

By integrating software robots and artificial intelligence into automated accounting systems, businesses can increase the accuracy and speed of information collection and processing, reduce costs, and make decision-making more objective. The implications of increasing the efficiency of accounting data processing and expanding the scope of digitalization to more accounting processes should be determined before deciding to modernize. In addition to the preliminary assessment of the qualitative characteristics of the effectiveness of expanding the functionality of digitalization of accounting, potential changes in quantitative parameters should be taken into account. Quantitative indicators provide unambiguous information on the expected effect of the introduction of software robots, artificial intelligence, blockchain, or their combinations into the automated accounting information processing system. These coefficients include the coefficient of time savings for processing primary documents, the error rate, and the resource savings coefficient.

A promising direction for continuing research on the implementation of automated systems in accounting is to use a combination of stochastic and deterministic approaches to building an integral indicator. The stochastic approach allows us to consider uncertainty and randomness in the volume of processed accounting information carriers and the probability of errors, while the deterministic approach provides an accurate calculation of the costs of improving and maintaining automated accounting systems. A comprehensive analysis that takes into account both approaches will allow for assessing the effectiveness of the introduction of software robots, artificial intelligence, blockchain, and their combinations, considering both uncertainty and specific

dimensions of the impact on the organization's work. Analyzing the impact of digitalization of accounting on the information content of financial statements and changes in approaches to the financial condition of an enterprise is another important area of research that can reveal how digitalization affects the accuracy and availability of financial information, as well as the process of preparing and analyzing financial statements.

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Гнатюк Тарас, Шкроміда Віталій, Шкроміда Надія. Цифровізація бухгалтерського обліку: особливості впровадження та оцінка ефективності. *Журнал Прикарпатського університету імені Василя Стефаника, 10 (2)* (2023), 45-58.

Автоматизація облікових процесів пропонує значні переваги, включаючи підвищення ефективності та зниження рівня помилок в облікових даних. Однак успішне впровадження нових та модернізація існуючих комп'ютерних програм у системі бухгалтерського обліку вимагає врахування вартісних, технічних, професійних та управлінських факторів. Це дослідження має на меті забезпечити всебічний аналіз якісних та кількісних параметрів, які можуть стати основою прийняття рішень про інтеграцію в діючі системи автоматизованої обробки бухгалтерських даних, Robotic process automation, штучного інтелекту, блокчейну чи їх комбінацій.

Інтеграція програмних роботів і штучного інтелекту в системи бухгалтерського обліку пропонує різні переваги пов'язані зі створенням нестандартного середовища, де прискорено формування, покращена передача та обмін традиційно обліковою інформацією та за рахунок інтеграції даних з інших систем управління, а також даними. Ці вдосконалення сприяють ефективності та надійності автоматизованої системи бухгалтерського обліку. Впровадження програмних компонентів, таких як роботизована автоматизація процесів і штучний інтелект сприяє вивільненню бухгалтерського персоналу від рутини повторюваних операцій і забезпечує автоматичне встановлення пріоритетів і

послідовності облікової реєстрації. Інтеграція ботів в автоматизовану систему бухгалтерського обліку також полегшує спільний доступ до документів та забезпечує віддалений автоматизований моніторинг. Це посилює взаємодію між відділами та покращує контроль над операціями, які потребують додаткової уваги з боку керівників.

Для оцінки ефективності таких програмних рішень проведено критичну оцінку існуючих підходів до визначення тих якісних показників, які очікують отримати після впровадження програмних інновацій та запропоновано доповнити критерії результативності кількісними показниками серед яких можна виділити коефіцієнт економії часу при обробці документів, коефіцієнт допущених помилок та коефіцієнт ресурсної економії.

У підсумку даного дослідження обґрунтовано необхідність врахування кількісних параметрів та коефіцієнтів, за допомогою яких можна оцінити ефективність впровадження програмних рішень в автоматизовані системи бухгалтерського обліку. Результати підкреслюють необхідність цілісного підходу до оцінки ефективності, надійності та безпеки цих рішень. Покращення технічних знань і навчання фахівців з бухгалтерського обліку щодо оцінки безпеки є вирішальними для успішного впровадження та використання автоматизованих систем бухгалтерського обліку.

Ключові слова: бухгалтерський облік, автоматизація обліку, ефективність програмних рішень.