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# ASSESSMENT OF THE EFFECTIVENESS OF IMPLEMENTING AI TOOLS IN BUSINESS ANALYTICS OF ENTERPRISES IN THE CONDITIONS OF DIGITAL CHANGE

*The object of research is the processes of formation, analysis, processing and analysis of information by business analysts of an enterprise in the conditions of changing digital environment. The problem being solved is the need to process a large amount of data to make high-quality management decisions and reduce economic costs. The relevance of the research is due to the trends in the development of the digital environment. The paper considers theoretical and applied aspects and stages of the development of business analytics under the influence of AI tools. The paper explores the fundamental principles of using AI tools in analytical processes of enterprises and assesses their effectiveness. The methodological apparatus is based on the use of a systems approach, methods of theoretical and economic and mathematical modulation. As a research result, it was determined that the AI implementation tools create a positive effect and reduce errors in forecasting (up to 90%) based on business analysis. Accordingly, a positive economic result was established, which proves the feasibility of improving business analytics. A significant increase in the efficiency of such business processes as logistics (by 20–30%), marketing and foreign economic activity of enterprises has been identified. Company management indicates a reduction in additional costs (up to 92%), which contributes to the choice of optimal development strategies. Key barriers to the development of AI have been identified, including the shortage of personnel and the ethics of using digital platforms. It is empirically presented that this is due to the use of only 16% of AI tools in enterprise management. For further effective implementation, a phased transformation of the management environment of enterprises is envisaged through the gradual introduction of digital tools on a permanent basis and the creation, as a result, of a common digital ecosystem of the enterprise in various areas of activity.*

***Keywords:*** *digital transformation, business analytics, intelligent algorithms, forecasting, modelling, resilience, algorithmizing.*

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## 1. Introduction

Currently, the development of technologies is taking a new direction, capturing for the most part not the means in technical form, but the methods with which it is possible to achieve ever greater results. On a global scale, scientists tend to consider this Industry 4.0 [1]. It is characterized by a wide range of innovations, technological progress and, above all, the application of artificial intelligence in all areas of human life. The use of large language models (LLM), artificial intelligence and platforms with built-in tools allows them to be used free of charge to facilitate ordinary, operational actions by anyone [2, 3]. Considering this development, an important aspect is the introduction and effective implementation in various industries.

From the point of view of the economic environment, money and its flows remain an important component for the activities of all objects and subjects. That is, the pursuit of profit maximization and cost minimization within the framework of limited resources is a key task for both enterprises and people separately [4]. A factor that helps to regulate and monitor any flows is business analytics. This is a direction that was launched at the beginning of the 20th century as part of achieving balanced decisions. Business owners have relied on their own observations, experience and environment until now, which did not always lead to balanced and correct decisions [5]. The loss of large amounts of money and failures stimulated them to an innovative approach to improving situations. In this case, at the beginning of the 20th century, management began to make decisions based on solid facts and evidence. That is, in the future, for investing funds, choosing business development and forming sustainable development of the enterprise, it was customary to use a list of tools to improve future results [6, 7]. Over time, this approach has developed and expanded to various components of enterprise activities and in the modern world it is perceived as business analysis and business analytics.

Currently, in the modern world, digital technologies are already an integral part of well-established work. According to research by [1],

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more than 70% of commercial entities have successfully used digital technology tools. Currently, artificial intelligence helps to optimize costs, improve labor productivity, accelerate the use of limited resources, increase the level of efficiency and effectiveness of enterprises [8]. For enterprises that actively and thoughtfully use AI in their activities, colossal results are observed, which indicate positive results in improving business process automation, improving product (service) value chain management processes, using personalized offers for customers, streamlining management tools, etc. [9]. Thus, a vivid example of the AI use in the business processes of the enterprise is the optimization of logistics. In this area, there is a decrease in operating costs by an average of 20–30% and a simultaneous increase in the speed of order processing. From the point of view of managers, AI acts as an assistant and helps the manager to build development strategies. And also, to calculate different scenarios of events depending on the initial data and given conditions of the state of the enterprise [10, 11]. That is, AI acts as an auxiliary tool for building business strategies with promising development. The research in this aspect showed high positive results, in which about 92% of managers noted that AI helped them avoid excessive costs, balanced management actions and built the most optimal development strategy [12]. Unfortunately, such constructions are currently most vivid and reliable only in the short term, because in the long term there is a factor of uncertainty, which makes it impossible to build the right route for the development of the enterprise. But still, as a tool for adjustment, a reliable advisor and, in general, a lever of management, it is quite relevant to address and draw conclusions from proposals generated by AI [13, 14].

In a broad sense, AI is not just a technological trend or an updated version of technology development. Its application acts more as a component, a complementary factor of business analytics in general, because it changes and transforms the very way of data processing, which prompts an updated approach to making any decisions [15]. The AI implementation enables entities around the world to simultaneously analyze large amounts of data, determine their accuracy and reliability identify patterns and cause-and-effect relationships to predict future events, which builds trending trends [16, 17].

A noticeable and confident trace of AI is being traced in various industries. Thus, the global company Netflix, which covers more than 325 million viewers in 190 countries around the world, has changed its approach to content by introducing the latest technology tools on an ongoing basis [18]. Currently, personalization to the client and the formation of a list of recommendations is completely built on algorithmic searches considering previous viewings and preferences. That is, it is no longer just a list of recommendations from a list of all available possible films, but an approach to building and presenting a list of recommendations based solely on the preferences of the consumer [19, 20]. Since the first use of AI tools in the company's activities (and this was more than 25 years ago), the company has rapidly developed both the number of users and the approach to the process of releasing new products [21]. The implementation process was gradual for the company [22], but has now helped the cinema generate a profit 2.5 times more (compared to the official net profit of 2024 and 2025) [23].

It is also worth noting other industries. For example, in the pharmaceutical business, companies have been using AI for a long time to optimize logistics, detect technical failures, and maintain equipment [24]. Such actions are aimed at reducing operating costs, adjusting supplies, and improving the performance of fixed assets of pharmaceutical giants. Transportation is also closely related to this area of activity. Currently, logisticians analyze more than 300 million entry and exit points to build routes, which is physically impossible for even a large team of employees. Therefore, the use of AI tools in this aspect is an exceptionally appropriate and correct solution for the purpose of building effective business processes and subsequently for determining all possible scenarios for the development of results as business analytics [25, 26]. Accordingly, the use of AI tools in ERP systems is also being followed, which is within the framework of increasing labor productivity, increasing the accuracy of forecasts, simplifying risk management, and automating the generation of reports in real time. Forecast modeling using AI indicates high positive results (up to 90%) that have been obtained worldwide [27].

Considering the above positive results, it is also worth emphasizing the shortcomings and challenges that company management faces in the application of AI tools. Currently, there is some fear and uncertainty among leaders regarding the widespread use of AI. Only a small percentage of global giants (about 16%) have implemented and are using AI statically and comprehensively on an ongoing basis [28, 29]. The most common use of the latest tools in CRM systems is to track the results of meeting customer needs. It is in the aspect of calculating the results obtained that the indicators of AI implementation are the most liquid and competent. In other aspects of the activities of enterprises, AI is not used in the full sense, as there are difficulties with the standardization of corporate processes [30]. Possible barriers also include several obstacles. Low level of education of employees, which makes it impossible to quickly adapt and use AI on a permanent basis [31]. High capital costs for initial implementation; constant operational updates and support of AI systems [32]. Standardization of ethical issues regarding the combination of human and robotic work on a permanent basis, especially within the framework of the separation of responsibilities of each person [33]. Accordingly, the above indicates that the AI implementation in business analytics is taking place gradually, strengthening its position and demonstrating, although not global, positive results.

Currently, the improvement and simplification of business analytics largely depend on artificial intelligence tools. But at the same time, this creates significant technological, organizational and capital-intensive challenges that need to be addressed within the framework of the implementation of long-term strategic interaction between humans and AI [34, 35]. That is why *the aim of research* is to determine the impact of modern technologies (AI) on the development of business analytics of business entities in the processes of transformational change. The impact of Additionally, it is determined that it is important to identify potential advantages and disadvantages for making informed management decisions. *The object of research* is the processes of formation, analysis, processing and interpretation with the subsequent use of business analytics information in the activities of enterprises under the conditions of transformational changes in the digital environment. *The subject of research* is the processes of implementing AI tools into business analytics processes of enterprises in order to increase the efficiency of management decision-making in the context of digital transformation.

In accordance with the defined aim, the following objectives were formed:

1. To summarize theoretical developments on the role of using AI in business analytics of enterprises.

2. To analyze modern trends and highlight practices of using AI in business analytics in various industries.

3. To identify positive aspects and risks of implementing AI in analytical processes of enterprises as factors for improving the accuracy of forecasting management decisions.

4. To determine a list of promising ways to develop business analytics by improving AI tools.

## 2. Materials and Methods

To address the challenges of this area of problems, it is necessary to outline a comprehensive methodological framework that will be applied within the framework of the research. It is important to establish the relationship between the impact of artificial intelligence on the development of business analytics in enterprises. The specified tools were selected considering the interdisciplinary nature of the research,

which combine general scientific, special economic, applied analytical methods with elements of economic and mathematical modulation of complex socio-economic systems.

The research uses methods of theoretical generalization, analysis and synthesis to systematize established scientific approaches to the development of artificial intelligence. The evolution of business analytics processes and the transformation of changes in business model modeling under the influence of the development of the digital economy are presented. In general, business analytics is considered in this study as a multi-component system consisting of the main components. For formalization, they can be presented as follows

$$BA = D, A, M, AI < R, \quad (1)$$

where $D$ – the set of initial data for the analysis; $A$ – the analytical procedures (the process of implementing business analysis); $M$ – the management models; $AI$ – the AI tools; $R$ – the results of the analytical activity of the enterprise.

The historical-logical method is used to analyze the stages of development and gradual growth of artificial intelligence technologies, to determine the patterns of influence and correlation on the practice of implementation in business analysis. The specified methods are applied considering the stochastic nature of external factors in relation to enterprises and the conditions of uncertainty (risks, threats) that exist in them. From a mathematical point of view, this statement can be presented as follows

$$R = f\left(D, AI, M, \varepsilon\right), \quad (2)$$

where random error, which identifies all possible probable risks, data limitations (in the calculation processes and business analytical actions) and is responsible for the instability of the market environment.

To highlight the practical component of the problem area under study, a process approach to analyzing the AI use in business analytics was used. This approach allows to establish and identify the main business processes of the enterprise that are subject to automation and corresponding analytical improvement using AI tools. Accordingly, within the framework of the specified approach, business process modulation was applied, which can be represented in the form of a matrix generalization

$$P^{AI} = A \cdot P, \quad (3)$$

where $P$ – the vector of the enterprise's business processes; $A$ – the matrix of the influence of artificial intelligence tools on business analysis; $P^{AI}$ – the transformational state of the enterprise's business processes after the AI implementation tools.

The presented allows to generalize and formalize step-by-step actions (build an algorithm) of the operational activities of enterprises and at the same time analyze and assess the potential of possible changes under the AI influence. At the same time, in order to provide an economic basis for the effectiveness of the AI implementation in the business analytics of enterprises, a factor analysis of financial and economic indicators of business entities and a comparative analysis before and after the AI implementation tools were applied, which is adjusted over time by the interval of using the latest technologies

$$E_{AI} = \int_0^T \left[B(t) - C(t)\right] dt. \quad (4)$$

In general, the authors proposed to determine the overall economic effect of using the system apparatus of AI tools using an integral indicator

$$EF_{ga} = RL_{tf} + R_{mel} + RL_{es}, \quad (5)$$

where $EF_{ga}$ – overall assessment of economic efficiency; $RL_{tf}$ – assessment of the reduction of losses by reducing the a posteriori probability of the occurrence of negative man-made events and increasing the a posteriori probability of the occurrence of positive events; $RL_{mel}$ – assessment of loss reduction by reducing the mathematical expectation of losses due to possible loss or damage to MRC; $RL_{es}$ – assessment of loss reduction due to energy savings.

Subsequently, to assess the effectiveness of implementing AI tools in business analytics of enterprises, a modified cost-effectiveness indicator ($CR$) was used, which is based on the cost-benefit ratio

$$CR = \frac{CBI_n}{CAI_n}, \quad (6)$$

where $CBI_n$ – total operating costs of the enterprise before the AI implementation; $CAI_n$ – total operating costs of the enterprise after the AI implementation, considering inflationary fluctuations.

For a more in-depth and detailed analysis of the processes of implementing AI in the activities of enterprises, it is worth using an adaptive model to calculate key performance indicators and apply them in business analytics

$$CAI_n = ICCD + CPDP + CSIDI, \quad (7)$$

where $ICCD$ – investment costs for designing and developing an AI system; $CPDP$ – costs for preparing and cleaning data for the system; $CSIDI$ – costs for structuring, integrating and using information flows.

The implementation and interpretation of the obtained results of the $CR$ indicator is built on the scale of analysis of economic effects on the enterprise activities, especially in terms of improving its business processes (Table 1).

**Table 1**

Assessing the economic impact of implementing AI in an enterprise

| $CR$ value | Economic effect |
|---|---|
| $CR = 1$ | No effect |
| $CR < 1$ | Negative effect |
| $1 < CR < 1.2$ | Weak positive effect |
| $1.2 < CR < 1.5$ | Moderate positive effect |
| $1.5 < CR < \infty$ | Strong positive effect |

As a result of calculating the $CR$ indicator, it is possible to determine the effectiveness and efficiency of the funds invested in the AI implementation in the business processes of the enterprise. That is, the calculation shows how much the results obtained exceed the invested funds and are appropriate for the enterprise right now. This indicator should be considered universal, because it provides an opportunity to obtain results on the AI application in a comparative characteristic both in an inter-industry context and for a specific enterprise for the period of analysis (in dynamics).

From the point of view of the empirical basis, the research is based on open financial reports of enterprises and their analytical data, results of international consulting companies and statistical data from official sources (such as the State Statistics Service of Ukraine). To summarize the results obtained, the research used methods of graphical and tabular presentation (visualization), which contributed to the visual demonstration and analytical interpretation of the determined results. The above methods of general and specific methodological basis allowed to comprehensively investigate the impact of artificial intelligence on the development and improvement of business analytics in enterprises. As well as to establish positive effects, identify limitations, and outline a range of potential risks for further improvement.

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## 3. Results and Discussion

### 3.1. Theoretical foundations of artificial intelligence in business analytics

The initial ideas of AI creation, or rather its hints on the modern representation, began in the middle of the 20th century. Over time, scientists and practitioners were fascinated by the idea of improving existing machine tools, which led to the gradual development of existing modern tools. It was in the second half of the 20th century that the rapid growth of neural networks began with improvements and progress in the application of real-time reasoning, forecasting the future, the use of primitive codes to simplify human activities, etc. (Fig. 1).

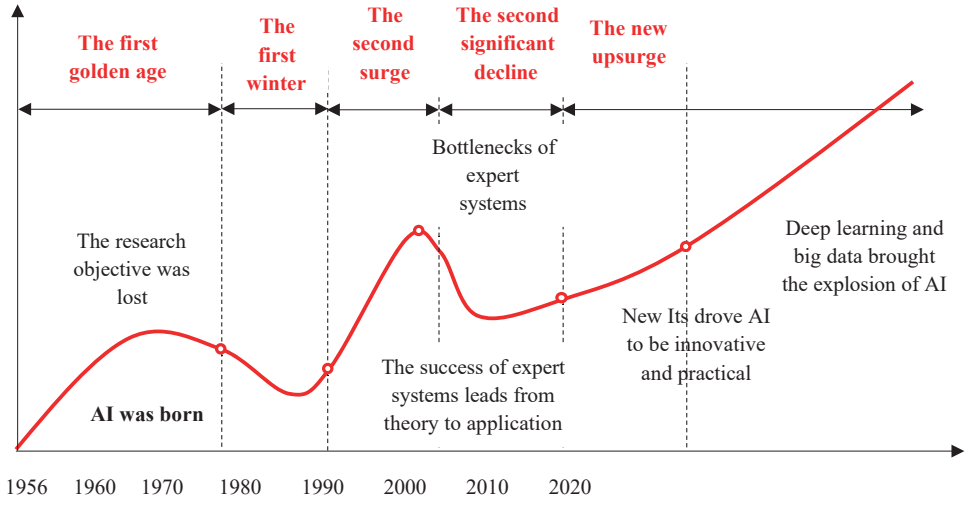



**Fig. 1.** Stages of strategic transformation and AI development (supplemented by the authors based on [36–39])

The gradual development presented does not have established stable trends, but rather visualizes the results of a crooked, wavy generalization of the main stages. The results of the study of scientific literature confirm that the improvement and development of AI tools in their modern form were subject to various influences, technological capabilities and expectations of the scientific community [40]. As a result, only the main important stages for the development of AI, which originates from its inception to the recent years of rapid breakthrough and development, which are due to global changes in the world community within the framework of technogenic breakthroughs, are presented.

An in-depth analysis of existing scientific achievements [41, 42] points to the first "golden age" for AI as a stage of forming theoretical developments, building theoretical models and predicting possible applications. This period is unfortunately characterized by an extremely limited functional block. Especially from the point of view of practical application in the activities of enterprises (considering the object of our research). Later, the periods of the so-called "AI winters" were characterized by a strong gap between theoretical developments, the expectations of scientists and the real results obtained [43]. This period was placed in the period of a decrease in the activity and reliability of data that were calculated using the first computer calculation tools. Accordingly, the reliability, accuracy and analytics of such a period were extremely low, which led to a deterioration in the perception of achievements and practical implementation in the practice of enterprises.

In further development, the period of "decreased activity" was replaced by a lively interest in AI tools, which is also associated with the development of expert systems and technologies (Fig. 2).

It was during the rise of research that the practice of using AI in the business processes of experimental enterprises (i. e., entities that agreed to use revolutionary tools for calculating large data sets on their own experience at that time) was widely used. As a result of the results obtained, which were not always perfect and reliable, there was a natural decline and harsh criticism of highlighting the shortcomings of the toolkit. As shown in Fig. 2, the interaction of humans and artificial intelligence within the framework of assessing various processes of economic activity is at the stage of maximum intersection. And further development can be both negative and positive for both parties. According to the theory of diffusion and spread of innovations [45, 46], the current stage of development of artificial intelligence can be distinguished as an opportunity for small and medium-sized businesses. It is worth saying that AI can qualitatively improve the business processes and business analytics of such companies. This is possible through the rapid implementation of innovative tools, which will accordingly positively affect the level of competitiveness.

Subsequently, the gradual development of AI led to its corresponding improvement and changes, which has been observed recently and is present in practice in various fields of activity [47]. Accordingly, AI is now highly reliable and based on deep learning, real-time cloud computing, and massive data sets. Collectively, this has changed the AI perception not only as a technical computing tool, but also as a reliable and enabling tool for transformational change in business intelligence.

Accordingly, a retrospective analysis of the development of AI in general and in business analytics in particular proves that its evolution is due to various factors.

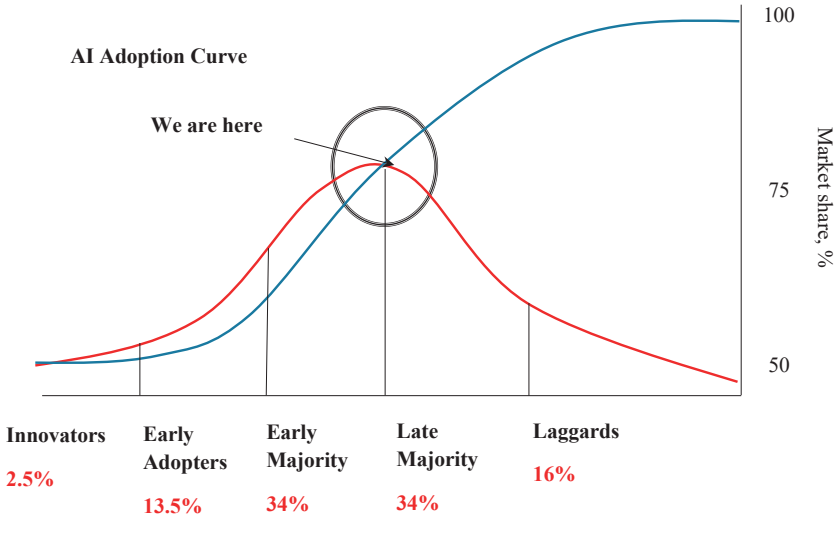



**Fig. 2.** AI adoption curve (supplemented by the authors based on [44])

The main ones include the following: the development of algorithmic approaches [48], the transformation of infrastructure data [49], the construction of improved language models and updated approaches to the general perception of "assistants" in the form of machine learning [50]. Together, this has led to continued scientific research to determine the impact of the development of AI tools on business analytics in enterprises.

**3.2. Current trends in cross-industry AI adoption in business analytics**

As analyzed in the previous section of the research, the use of AI tools in business analytics is currently at the stage of significant transformational change and widespread implementation. Accordingly, it is possible to observe that AI is currently used by enterprise managers as a method of proactive management and prevention of possible risks. In accordance with the presented methodological approach, business analytics should be considered as a multi-component system in which the use of modern digital tools (*AI*) should be considered the main factor in increasing the results of analytical data (*R*). As a result of the analysis [51, 52], it can be assumed that AI is used mainly for the analysis of such components as marketing, sales, supply (logistics), creation of the product value chain (services), etc.

A striking example is companies such as Amazon and Stitch Fix, which for a long time have not been delivering according to the outdated principle of "buy, then sell/ship", but have already switched to a new personalized, customer-oriented approach [53]. According to the updated vision of companies, artificial intelligence tools are built into the marketing and sales system of companies and offer goods to buyers in advance. That is, they create guarantees of fast, high-quality delivery even before payment is made. They form a preliminary order at the stage of selection and comparison of the characteristics of the desired product. Accordingly, it is possible to conclude that AI tools in the process of operational activities proactively build strategies for the development of events, automatically processing a large array of information (*D*) and generating a basic report on purchasing power for the company.

As a result of the analysis, let's consider it appropriate to highlight the key elements of business analytics that are used on the principles of using AI tools (Table 2).

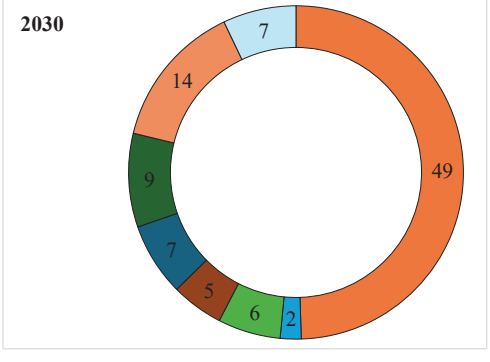
**Table 2**

Impact of AI tools on key business model elements

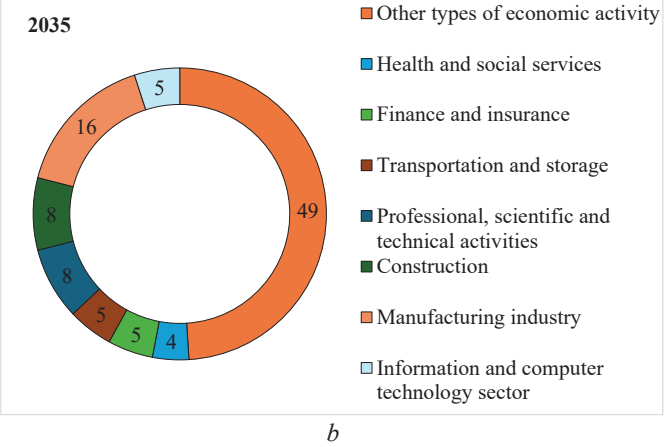
| Elements of a business model | Traditional approach | Changes when using AI | Specifics of changes |
|---|---|---|---|
| Value creation | Product development | Automation, predictive (proactive) analytics | Machine intelligence is used for information analysis and in the creation of new products |
| Value delivery | Traditional channels | Personalization, interaction automation | AI optimizes logistics and warehouse processes |
| Value monetization | Traditional revenue schemes | New digital business models (subscriptions, platforms) | AI is enabling new revenue models |

Considering the data presented, it is worth noting that a characteristic feature of the AI implementation in practice is its rather unstable development (as summarized chronologically in Fig. 1). Currently, the available elements for most enterprises (especially small-scale ones) are point-based applications, especially in terms of basic tools (such as chatbots, improving CRM systems, creating AI assistants, etc.) [54, 55]. Although the tools of digital technologies are much deeper and broader, which can significantly facilitate the processes of calculating the main business analytical processes for an enterprise.

As a result of the application of the proposed mathematical modelling methods within the framework of this research, the stochastic nature of the market situation and the random error (ε) were considered. As a result, the forecast calculations (Fig. 3) demonstrated the expected result of the cumulative effect across various sectors of the economy, which can be obtained because of the more widespread use of AI tools.




*a*




*b*

**Fig. 3.** Projected economic impact of the introduction of artificial intelligence technologies by type of economic activity: *a* – by 2030; *b* – by 2035 (% contribution of each industry)

According to the data obtained, it is worth saying that the manufacturing sector can receive the greatest profit and contribution, while the IT segment, although it is the ancestor of AI, does not occupy the first place. This pattern can be explained by the fact that digital tools bring real added value to enterprises in real sectors of the economy. At the same time, in their so-called "native industry" (IT), they act only as a means to create the final product, and the value is distributed to other areas. The obtained analytical calculations and modelling using the process method allow to state transformational changes in the business processes of legal entities under the influence of AI tools (Fig. 4).

Accordingly, in the current conditions of the development of the economic environment of enterprises and scientific achievements under the influence of digitalization, it can be said that the structure of the business model of enterprises is characterized by changes [54]. The AI use provides the opportunity to automate data collection (*D*), thus providing business analysts with more opportunities and time space to solve more strategic tasks.

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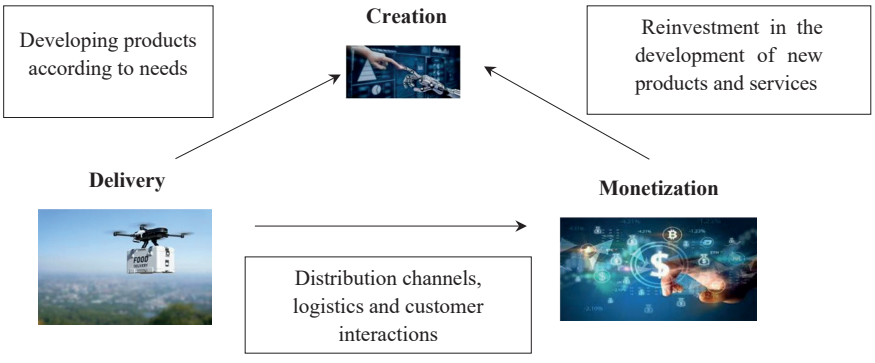


**Fig. 4.** Key components of AI-powered business analytics

In this case, this ensures that it is possible to observe the transition to the IV stage of digital transformation (Fig. 2), namely, full autonomy of decision-making, after which algorithmic actions become the basis for business analysis. Therefore, the results obtained confirm the hypothesis of effective cross-sectoral application of artificial intelligence tools in business analysis of enterprises as an element of technological renewal. As well as changes in management principles (*M*), which together affect the identification of hidden patterns in data and the optimization of related operational activities.

**3.3. Identifying the impact of AI implementation in business analytics as a factor in improving the accuracy of management decisions**

The use of AI tools in the analytical activities of enterprises is a more strategic step than an operational one. Accordingly, the presented methodological block, which is formed as an initial function of the interaction of all key data, will act as a catalyst that allows to operate with a large amount of data (*D*). With the help of AI tools, high-precision models are built that eliminate the error of the market environment.

As a result of the study of the materials, it is worth noting that the positive features of the AI impact on the processes of analytics and forecasting of management decisions are the ability of the algorithmic code to learn its own errors. As a result, these actions help to quickly eliminate inaccuracies and determine nonlinear dependencies associated with them [55]. In this case, the classical established approaches of statistical methods are inferior to AI analytics in terms of levelling dynamic changes in the external environment in relation to the enterprise [1]. In real time, when business analytics operates with data sets, the time factor plays a key role for further decision-making.

An important element in transformational changes is the transition to full automation of management decisions. Thus, the process of implementing AI in the business processes of the enterprise allows, for example, in logistics and finance to obtain a synergistic effect and create accelerated supply and payment chains. In this case, algorithmic codes quickly carry out verification, control and compliance of counteragents and, as a result, track data verification. That is, AI tools reduce the human factor, accelerate management steps and generally direct the work of the enterprise to increase productivity.

To determine the economic efficiency of using AI tools in business analytics of enterprises, a set of methodological foundations was presented. It is worth noting that several indicators have already been developed for the economic justification and feasibility of using AI. One of the most common is *ROI*. But because of our research, it is possible to conclude that (*ROI*) does not fully reflect the payback of AI implementation, and other developments in this direction based on mathematical modelling have not yet been formed. Therefore, it is believed that the AI system should be based on the development of a semi-autonomous multifunctional robotic complex (*BMRC*). Its implementation in the activities of enterprises is the responsibility of a low-and medium-level employee. During the operation of the AI system, losses may occur. They can be justified by the dependence of the system's productivity on the operator's productivity, associated with negative man-made events, possible damage to the *BMRC* or changes in energy consumption. These losses should be quantified and considered in the total cost of implementing AI.

This methodology can be used to assess the effectiveness of the artificial intelligence system at enterprises of various sectors of the economy. Because it formalizes and allows numerically characterizing the effectiveness of the use of the automated management system of the BMRK based on the AI system and provides a technical and economic justification for its development. The main problems of assessing the effectiveness and feasibility of scientific and technical solutions and technologies are not only the system of selection and ranking criteria. These include the need for a predictive assessment of the development of the technology itself or technology. As well as the analyzed scientific and technical direction in general in each specific case [56]. Building such a detailed assessment system is an extremely difficult task due to the increasing speed of development and volumes of technologies and the constantly changing needs of national and world economies. In other words, the task of assessing the economic effectiveness of the AI implementation is a complex multi-criteria task in conditions of incompleteness and ambiguity of the initial data, and sometimes their contradictions. To assess the effectiveness of the use of AI at an enterprise, it is important to determine the criteria for economic effectiveness. Most often, the criteria for the effectiveness of economic systems are understood as: maximum result, minimum costs. In turn, the results can be expressed in the form of the volume of work performed (in kind) or the volume of profit received (in value terms). To confirm the presented methodological elements that characterize the economic efficiency of the enterprise's functioning associated with the AI implementation, it is possible to believe that it is worth highlighting its main elements in a unified approach. These include: growth rates of completed operations; costs in general (total costs); time spent on the operation, etc. As a general indicator of efficiency, it was proposed to use an indicator that characterizes the reduction in production costs in general (*CR*).

In order to confirm or refute the methodology, a calculation was made among Ukrainian companies that are leaders in their industries. The calculation was conducted among Ukrainian companies that are leaders in their industries. Among them, LLC Kernel has been using AI to improve seeding accuracy since 2016. LLC Nova Poshta has been using it to improve logistics and video analytics in branches for the past five years. JSC CB PrivatBank has been reducing the impact of risk management in recent years and using FacePay. And since 2019, the bank has been implementing the first chatbots and technical support for business clients. PJSC Kyivstar has been using AI to develop and implement the company's CVM for the past nine years. Based on open information on financial flows and results of economic activity of selected enterprises in the period 2020–2025, especially in terms of financing digital technologies, the economic efficiency of implementing the AI system was modeled (Fig. 5).

Thus, currently, a rather noticeable economic effect of the AI implementation in business processes can be observed in Ukrainian enterprises of various directions and forms of ownership. According to the data obtained, the best indicator was obtained in an agricultural enterprise and in the delivery industry, somewhat lower values – in the banking sector and communication systems.

In our opinion, this trend is associated with legal regulation in the state and, accordingly, with the restrictions that arise during the AI implementation in the operational process of enterprises. The costs of the enterprise after the implementation of the AI system will include the costs of the current operation of the AI system. In the process of calculations, difficulties may arise with the determination and assessment of such costs. Considering the positive indicators obtained, it is worth highlighting the potential disadvantages of the AI application in the business analysis of enterprises. The initial aspect is the process of implementing digital tools in the operational activities of enterprises. After all, there are several internal and external destructive factors that can prevent clear and successful application. In this case, the main thing it is possible to highlight is the dependence on the data (*D*) to be processed. That is, if the initially generated data were of poor quality, unreliable or incomplete, obtaining balanced calculations for further management decision-making is completely impossible.

The next component of the barriers and shortcomings for the rapid and effective AI implementation tools in the business analytics processes of enterprises is the factor of technology scaling. In this case, the lack of an appropriate level of training among employees, their quantitative equivalent in relation to cooperation with AI, potential difficulties in integration with existing IT systems remain a significant element of the confrontation. Accordingly, the indicated shortcomings confirm that the application of AI in the business process is not a one-time permanent action, but a set of measures that has a systemic nature of manifestation and conceptual foundations for effective implementation. That is, it is necessary to systematically and comprehensively approach the rethinking of enterprise management within the framework of the application of AI. In this aspect, another element of resistance (barrier) arises, which is associated with elements of the ethical component. Compliance with ethical norms can be both on the part of employees and on the part of consumers of the enterprise's products. In this case, the risks of algorithmic errors, bias or common mistakes will have an impact on the reputational component of enterprises. And in the event of such a situation, it will not be possible to say that the calculation of AI tools made a mistake that led to the loss of trust. But in this case, with the necessary settings and programming of ethical norms into AI algorithms, an inclusive and personalized result can be achieved.

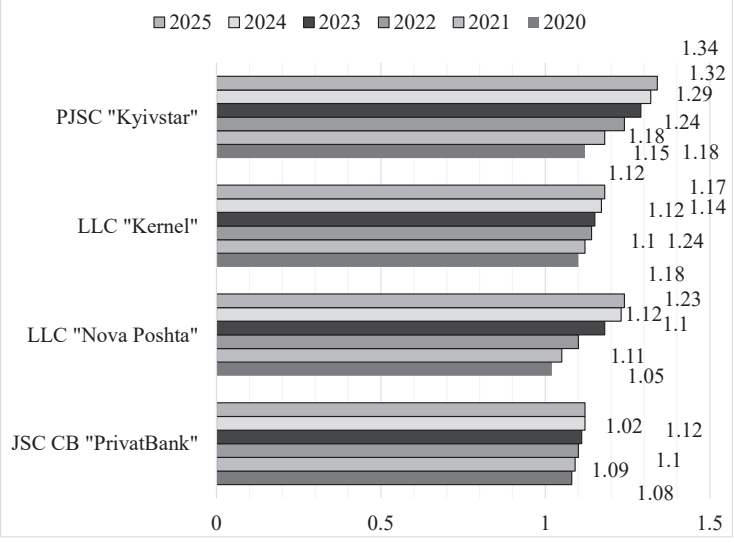


**Fig. 5.** Assessment of the economic effectiveness (*CR*) of AI implementation (calculated by the authors based on enterprise data [57–60])

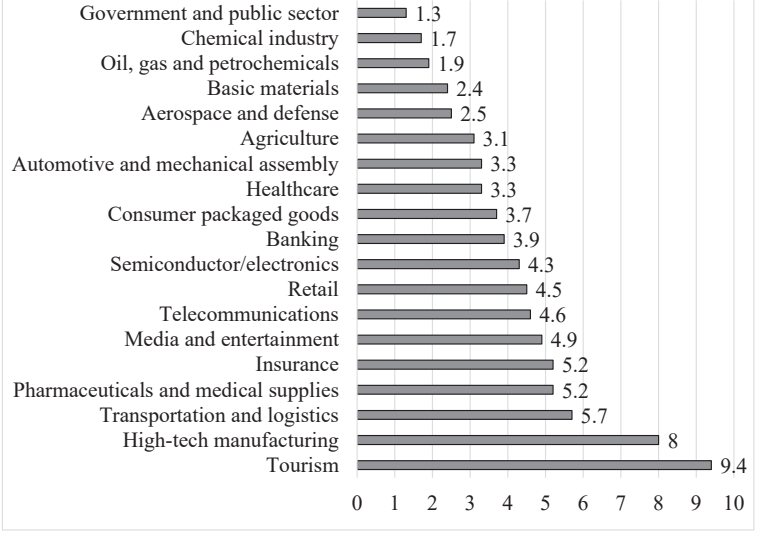


**Fig. 6.** Industry average contribution of AI tools to industry revenue growth (2024, global, in %), calculated by the authors based on [1]

The above is confirmed by the results of calculating this impact of the use of AI tools on customer orientation, loyalty and trust in enterprises from different industries (Fig. 6).

According to the data obtained, it can be argued that the advanced analytical approach of AI tools in business analytics processes provides benefits in the form of increased customer loyalty. This can be done by accurately identifying their needs, which in the long term for the enterprise is expressed in the stabilization of indicators (*R*) with the systematic application of AI.

The results obtained show that there are a number of both positive and negative aspects. The a priori application of AI tools in business analytics of enterprises indicates the improvement of management decisions but does not guarantee their automaticity and sufficient efficiency. To increase the indicators and eliminate gaps, it is necessary to improve the work with databases, adjust their reliability and prepare management for changes in the management model. At the same time, the obtained analytical calculations indicate a high level of feasibility of machine application in business analytics, although there are also disadvantages regarding ethical and technological challenges.

### 3.4. Vectors and imperatives of business analytics development based on AI tools

Further factors and directions of development of application of AI tools in business analysis processes of the enterprise are their systematic introduction into operational activities. This can be done quite effectively and purposefully with the help of unified algorithms of actions (Fig. 7). The proposal for the presented algorithm consists in combining sequential operational actions and logic of making management decisions, which are constantly touching each other. And in the current conditions of variability, uncertainty and unpredictability of the business environment, a unified approach is an extremely important tool for effective application.

Given the task of determining further ways of development of business analytics using AI tools, it is worth emphasizing some strategic vectors. Firstly, the paradigm shift in the AI use is currently underway. There are advantages to using it on an ongoing basis with the formation of appropriate digital platforms. That is, from initiating a request for data processing to forming a complete final operation that is identified with a report. Accordingly, this situation indicates a change in the role of AI-analyst in the classical sense from an auxiliary element to a system-forming element of management.

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The next component of development is the characteristic of the proactive development of the enterprise management system. The use of machine learning algorithms makes it possible to formalize control points, reduce the number of errors and minimize transaction costs. And built-in AI modules help to adapt and adjust parameters for data analysis in a timely manner, which forms a closed feedback loop in the management system.

The next step is the availability of transparency and reproduction of management actions. The use of a standardized algorithm creates a basis for tracking the digital "trace" of operations (traceability of actions over time), which in turn strengthens control, compliance and accordingly reduces the impact of risks on the enterprise. In this aspect, AI tools can be identified with a cognitive assistant that normalizes and formalizes a multitude of information flows, identifies hidden "bottlenecks" and models alternative scenarios for the development of events.

The fourth vector is traced within the structure of the value chain of the product (service) of the enterprise. The implementation of analytical AI modules in inter-structural departments and their operational processes provide the opportunity to synchronize data from different departments with each other, thus reducing the time for data processing and increasing the coordination of actions for business analysis.

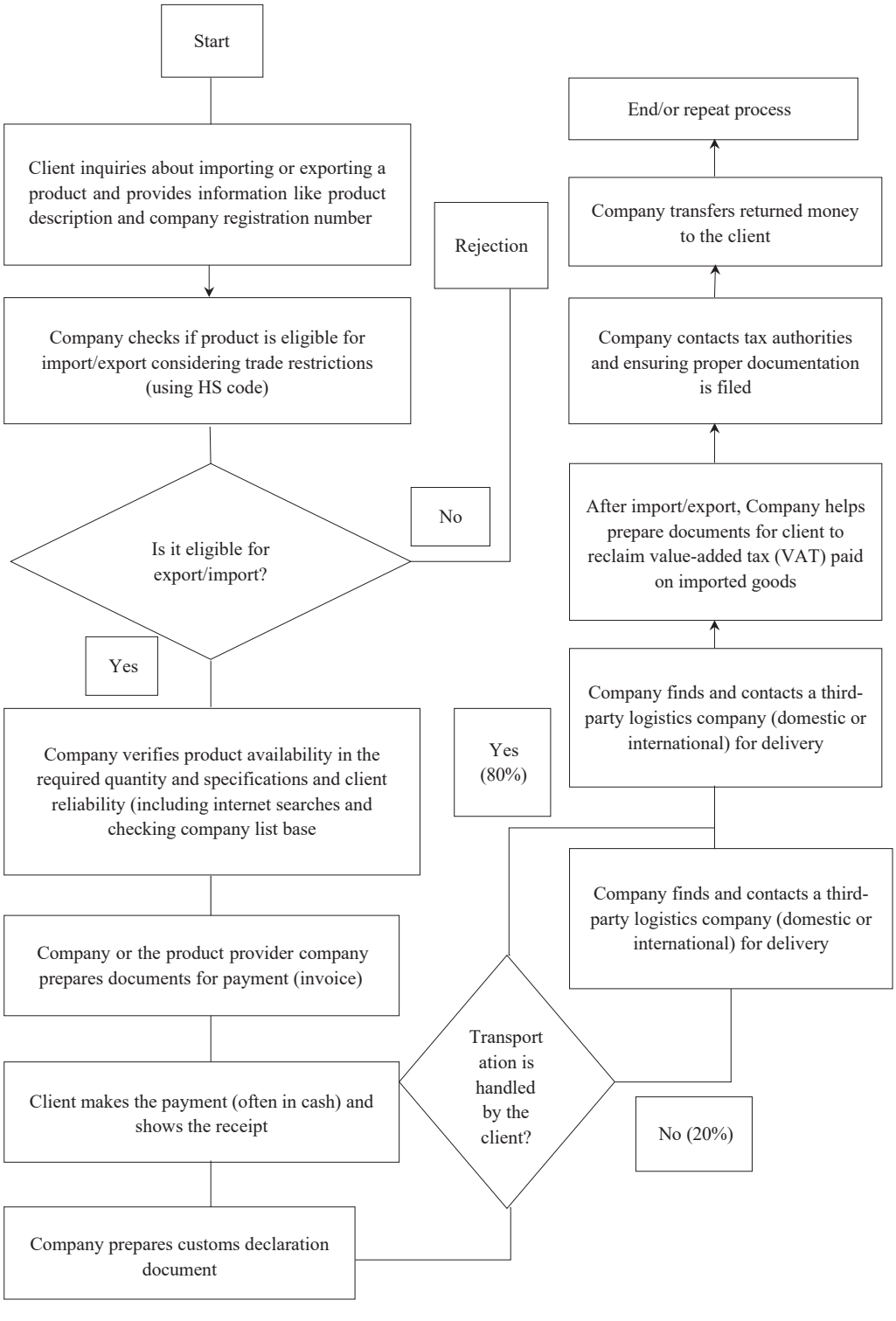


**Fig. 7.** Business processes of the enterprise (example)

Accordingly, the indicated directions of development of application of AI tools in business analysis processes of enterprises should be systemic in nature, be adaptive to changes, flexibly integrate into already operating enterprise management systems and have expediency of use. The imperatives of development of business analytics are built in the future on the principles of creation of digital ecosystems in which algorithmic processes are the basis of sustainable development of enterprises and increase of competitiveness level can be implemented in stages (Table 3).

**Table 3**

Stages of digital transformation of business analytics

| Stage | Description | AI role |
|---|---|---|
| Digitalization | Initial stage. At this stage, economic entities begin to use digital technologies to improve individual business processes, in particular, document flow and communication. An example could be the implementation of a CRM system for comprehensive support of work with clients | It helps in automating the collection and storage of data, which creates the possibility of converting analog processes into digital form, ensuring faster/ processing of information and its availability for further transition to automatic processing. For example, many companies are beginning to implement CRM and ERP systems based on II to simplify management operations and data analysis |
| Integration | At the second integration stage, digital technologies begin to link together various business aspects. Enterprises form integrated digital mechanisms (often in the form of ERP systems) that cover several processes at once | Integrate different systems and technologies into a single ecosystem. Helps combine individual operations and data, improving interaction between company departments. One of the key areas of application is logistics management, where machine learning algorithms help optimize logistics and predict demand |
| Automation | Stage three: AI technologies create conditions for robotization of fundamental processes, in particular, production and supply chain management. Corporations such as Siemens and Amazon are actively implementing predictive service and collaborative robots to optimize operational activities | Allows organizations to solve multifaceted tasks (predictive equipment maintenance, production line management, etc.) in a fully automated mode. Companies can automatically manage production operations, predict possible breakdowns, and minimize production downtime |
| Full automation | The fourth and final stage is where AI and digital systems become the basis of the business model, largely eliminating the need for human intervention. This allows businesses to create new business model options that rely on data and algorithms | Provides the ability to make autonomous decisions, which almost eliminates river management. Examples of corporations with full automation are Tesla and Amazon, which use AI in logistics management, production lines, and even customer service with the help of chatbots and personalized services |

### 3.5. Limitations and directions for research development

To determine not only the positive aspects of the proposed methodological and practical recommendations for the application of AI in business analytics, it is worth paying attention to potential discussion aspects. Currently, scientific achievements have an unbiased opinion regarding the widespread AI implementation in various spheres of human life, and the management of business entities is of great importance for improving the standard of living of the population, so it is possible to single out the following list:

– possible decision-making situations under conditions of unstable "black swan" situations. According to the proposed methodology, AI tools are implemented in order to minimize random error ($\varepsilon$), but a contradiction arises. Namely: is it possible to rely on purely "mathematical" and logical calculations in situations when flexibility and adaptability are required. That is, rapid shock situations can arise (as is currently happening in the geopolitical environment). They are not contained in the archival data of the analysis ($D$). This means that the algorithm cannot build a scenario of the development of events and as a result will neglect them. The discussion in this aspect consists in refining the methodological approach in terms of determining the optimal balance between automation using AI and expert opinions of the company's top management;

– ethical aspects of decision-making and social responsibility. It is proposed to widely use archival data, which is a historical retrospective of the development of business entities to repeat past mistakes, but no attention is paid to the reproduction of social stereotypes. Since AI uses exclusively the company's information base, it cannot fully evaluate decisions already made considering racial inequalities, gender, age aspects and socio-cultural preferences of a regional nature. If, however, such components are completely neglected, this may lead to a conflict between economic performance ($R$) and ethical standards. Accordingly, the question remains open (which may be reflected in further research) regarding the measurability in quantitative terms of the "value of ethics" when making managerial decisions;

– problems of interpretation and in-depth description of decision-making for business analysis. Currently, discussions are not abating in academic circles on the issues of using highly accurate forecasts and AI models versus the logic of disclosing all components to stakeholders. It is in the component of financial analysis of business processes that this issue will be relevant for a long time, because investors require complete and detailed information about their funds, and accordingly, well-founded decisions about further steps;

– risks of dependence on technologies due to the concentration of analytical platforms. The research proposed the use of various cloud storages for the purpose of data unification and storage, but there is a direct dependence on the servers and companies that own them. If technological giants are used to meet storage needs, then there is a threat to cybersecurity, the preservation of corporate data, and national security in general. In this case, it is worth strengthening your protection, having reliable security guarantees, and forming alternative ways of storage without being tied to cloud storage;

– and the last important aspect of discussion is the copyright for decision-making. If a company is rapidly developing and is already moving to the stage of full autonomy of AI decision-making, then a legal and economic conflict arises. According to which it is necessary to determine who will own the rights and, accordingly, who will bear responsibility for the decisions made. If the decision is relevant and economically effective, the company will win. But if the decision led to losses (possibly even very significant ones), then who will be responsible for the losses. Currently, discussions on AI copyright and the legal field are quite relevant, and their resolution was not the aim of this research, so the issue remains open for resolution;

– because of the research, along with the results, several limitations were obtained, which were mostly declared by their practical application. First, these are methodological approaches based on the use of historical data. Such an approach may not be effective in the event of atypical situations when previous data are not sufficiently relevant. Second, the research is conceptually and methodologically in nature and does not include a wide empirical approbation, which narrows the results obtained. Third, the use of AI tools in business analytics has specific uses depending on the field of activity

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of the research object, which necessarily affects the accuracy and reliability of the results obtained. Fourth, the result always depends on the availability of information and its relevance. Within the framework of the application of AI tools, one must be confident in the quality of digital content;

– for further expansion and obtaining scientific achievements, practical approbation of the results obtained is quite appropriate. In this case, it is possible to improve adaptive business analytics models considering uncertainty. Accordingly, the implementation of the use in the process of business analytics processes will increase the interpretation of the results obtained regarding the effective use of AI tools. It is important to consider the ethical aspects of making management decisions and determining the quantitative parameters of the results of AI data processing. That is, a practical aspect of a clear division between machine and human boundaries of responsibility should be formed, which accordingly reduces the level of technological dependence.

## 4. Conclusions

1. As a result of the analysis of theoretical developments in the AI development, its role in the processes of analyzing analytical data of enterprise activities was established. The research of the development and evolution of AI tools proves that fundamentally there is a gradual change in the characteristics and applied application of digital methods. The analysis proves that from rigid and standardized characteristics, AI has moved to flexible and adaptive ones, which are based on cloud services and process large data sets. A significant contribution of this stage of the research is the confirmation that AI modernizes the processes of business analytics of enterprises: from describing the state of post-facto events to modulating complex multi-component scenarios of events, characterized by proactive actions for enterprises. It is proven that under the influence of AI tools, a gradual change in the paradigm of business analytics occurs, which is due to the synergistic effect of combining technological capabilities and analytics experience. In general, this approach creates a basis for increasing the level of resilience and competitiveness of enterprises. It is justified that development and improvement are still ongoing. The current stage of cooperation and implementation of artificial intelligence tools can be characterized as reducing management risks, minimizing the human factor and optimizing business processes. This allows business entities to flexibly adapt to changing environmental conditions. Accordingly, it is theoretically proven and substantiated that AI is a significant component of the current stage of development of business analytics of enterprises.

2. The analysis conducted proves that currently there is a general, systemic and complete diffusion (penetration) of AI tools into the business analytics of enterprises and that this process is not only gradual, but also effective. Studies of world practice (in particular, of Amazon and Stitch Fix) indicate a change in analytics processes – there is a shift from observation and statement of facts to building a system of proactive forecasting. That is, enterprises no longer form analyses based solely on their experience and mistakes, they declare strategic plans with a customer-oriented approach to future preferences. The results of the analysis of practice indicate that the greatest spread, and accordingly, positive effects, are observed in marketing, logistics and enterprise management. Due to the implementation of the cross-functional direction of AI tools, which accelerates data collection and analytics, a large amount of time and resources are freed up to improve other business processes of the enterprise. It has been established that there is currently a transition to the fourth stage of digital development, which allows identifying hidden (latent) risks and patterns, which leads to minimizing operating costs. Accordingly, it can be generalized that the effective AI implementation tools in business analytics of enterprises is a catalyst for technological renewal of business models in an inter-industry context.

3. According to the research results, positive and negative factors of the impact of AI implementation on managerial decision-making at the enterprise were established. It has been proven that a significant advantage of using AI is its ability to determine nonlinear patterns and dependencies, which subsequently leads to the correction of algorithmic routes. Accordingly, this adaptability has a positive effect on the business processes of enterprises in terms of reducing random errors and rapid response to external fluctuations. But it is worth noting the identified shortcomings. There are significant risks associated with the dependence of the expected result on the quality of input data for analysis. In general, both for a manager performing manual operations and for machine calculation, this threatens to build an incorrect scenario. To level out the negative impacts, empirical calculations of AI implementation in the practice of Ukrainian enterprises were carried out. The results obtained indicate positive dynamics and the achievement of a synergistic effect, which is manifested in an increase in the number of clients, improvement of the financial condition of the studied enterprises and improvement of the reputational component. As a result, it was confirmed that AI tools significantly improve the system of making management decisions of enterprises, but it is worth remembering about the digital maturity of the business entity. After all, the efficiency and the desired result are directly proportional to how well the company manages digital methods.

4. Finally, further directions for the development of AI tools in business analytics of enterprises were identified. It was proven that the prospects for development are the deep AI integration into operational activities by creating unified algorithms for making informed management decisions. A significant factor in this direction is the change in the paradigm of using AI: not fragmented use as needed, but the construction of a holistic ecosystem in which AI is a system-forming element for decision-making. In the future, if AI tools are qualitatively improved, it is possible to fully automate the cycle of business processes of the enterprise. For long-term development and building a reliable strategy, the enterprise needs new knowledge. These include the implementation of "explanatory AI" (assistant for help) to overcome "black boxes". Expanding the boundaries of cloud storage to unify data and ensure compliance with requirements. Building reliable protection systems in case of cyberattacks. With a gradual transformation according to the presented approach, it is considered possible to achieve a higher level of intellectualization of business analytics of enterprises in the modern conditions of a changing environment.

## Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

## Financing

The research was performed without financial support.

## Data availability

Data will be made available on reasonable request.

## Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies in creating the submitted paper.

## Authors' contributions

***Inna Riepina:*** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Visualization, Project administration, Funding acquisition; ***Maksym Budiaiev*:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Visualization, Funding acquisition; ***Oleksandr Nychyporuk*:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Visualization, Funding acquisition; ***Nataliia Yakusheva*:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Visualization, Funding acquisition; ***Anhelina Andriushchenko:*** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Visualization, Supervision, Funding acquisition; ***Andrii Blyznyuk:*** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Visualization, Funding acquisition; ***Mazur Yuliia:*** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review and editing, Visualization, Funding acquisition.

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