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AI INTEGRATION IN DECISION-MAKING: SYNERGIZING RATIONAL MODELS AND THE PDCA CYCLE

ІНТЕГРАЦІЯ ШТУЧНОГО ІНТЕЛЕКТУ В ПРОЦЕС ПРИЙНЯТТЯ РІШЕНЬ: СИНЕРГІЯ РАЦІОНАЛЬНИХ МОДЕЛЕЙ ТА ЦИКЛУ ДЕМІНГА

The article substantiates the conceptual foundations of a decision-making model capable of autonomous alternative correction in dynamic environments. The relevance stems from the crisis of traditional static management based on retrospective analysis and linear causality, which fails under high market volatility. The author proposes transforming the classic PDCA cycle into a dynamic predictive management system where the "Check" stage becomes a cognitive analysis function. This shifts the focus from reactive correction to proactive recalculation of rational choice models based on external destabilizing factors. Drawing on the evolutionary adaptation theories of D. Mueller, F. Buarque, and T. Marwala, the PDCA cycle is integrated into the algorithmic architecture of management processes. The scientific novelty lies in the synergy between rational choice models and AI-based autonomous adaptation cycles. It is demonstrated that real-time alternative adjustment and algorithmic self-updating are critical for organizational resilience. This concept provides a theoretical basis for next-generation decision support systems capable of strategic adaptation to global market transformations.

Keywords: *decision-making, artificial intelligence, PDCA cycle, autonomous adaptation, predictive analytics.*

У статті обґрунтовано концептуальні засади побудови моделі прийняття управлінських рішень, яка здатна до автономної корекції альтернатив в умовах динамічної зміни зовнішього середовища. Актуальність дослідження зумовлена кризою традиційних статичних методів управління, які базуються на ретроспективному аналізі та лінійних причинно-наслідкових зв'язках. В умовах високої волатильності сучасного ринку такі підходи виявляються неспроможними оперативно реагувати на зміни, оскільки орієнтовані на минулий досвід, а не на майбутні виклики. Це зумовлює об'єктивну необхідність переходу до гнучких моделей управління, здатних забезпечити стійкість організації в нелінійному економічному середовищі. Автор пропонує розглянути концепцію трансформації класичного управлінського циклу PDCA (Plan-Do-Check-Act) в динамічну систему предиктивного управління. Концепція передбачає трансформацію етапу контролю у функцію когнітивного аналізу. Це дозволяє інтерпретувати зовнішні дестабілізуючі чинники не як відхилення від норми, а як інформаційний ресурс для корегування стратегічних прогнозів. Це забезпечує перехід від реактивного виправлення відхилень до проактивного перерахунку раціональної моделі вибору. Особливу увагу приділено концепції еволюційної адаптації, що базується на підходах Д. Мюллера, Ф. Буарке та Т. Марвали. Згідно з цією логікою, цикл PDCA імплементується безпосередньо в алгоритмічну архітектуру управлінських процесів. Такий підхід перетворює адаптаційний механізм на автономний драйвер розвитку організації, здатний до безперервної генерації нових стратегічних альтернатив. Наукова новизна роботи полягає в обґрунтуванні концептуальної синергії між раціональ-

ною моделлю вибору та автономним циклом адаптації на базі штучного інтелекту. У роботі показано, що здійснення корегування альтернатив у реальному часі та здатність алгоритмів до самостійного оновлення є критичними чинниками забезпечення стратегічної стійкості організації. Сформульована концепція створює теоретичне підґрунтя для розробки систем підтримки рішень нового покоління, де автоматизація стосується не лише рутинних операцій, а й процесів стратегічного адаптування до глобальних ринкових трансформацій.

Ключові слова: *прийняття рішень, штучний інтелект, цикл PDCA, автономна адаптація, предиктивна аналітика.*

Formulation of the problem. The paradigm shift in capital management is characterized by the transition to information-centric models, where the velocity of data processing and real-time integration define an organization's competitive edge. For decades, classical management tools, such as Herbert Simon's concept of bounded rationality and W. Edwards Deming’s cycle of continuous improvement (PDCA), have served as a robust foundation for strategic planning. However, the effectiveness of traditional capital management theory tools is significantly reduced in the conditions of modern hyperdynamic markets, characterized by exponential growth in data volumes. The key factor in reducing the effectiveness of classical models is the cognitive limit of data processing inherent in humans, which makes it impossible to make a completely rational choice in a short time. The cognitive abilities of the decision-maker are insufficient for instant processing and critical analysis of multifactorial information arrays in real time. This creates a gap between the required and actual speed of reaction to market fluctuations and makes the transition to algorithmic management systems inevitable. The integration of artificial intelligence into the decision-making architecture allows for the conversion of the classic Deming cycle (PDCA) from a discrete reactive error-correction algorithm into a continual proactive optimization system, ensuring synergy between the computational power of algorithms and the manager's strategic vision to maximize capital value. The integration of artificial intelligence systems is not limited to the automation of information flows – it forms new management synergies. Overcoming the cognitive barrier of bounded rationality becomes an objective necessity, as the critical growth of information arrays levels the effectiveness of traditional management methods. As a result, the rational analysis of alternatives scales to real-time mode, while the classic PDCA (Plan-Do-Check-Act) cycle transforms from a sequence of discrete stages into a continual intelligent process. The synergy of the rational model and PDCA with AI tools establishes the conceptual framework of a “smart management system”.

Analysis of recent research and publications. The fundamental principles of management and quality theory, the methodological basis of the systems approach, and the cyclical nature of management processes, as articulated in the classic works of W. Edwards Deming and Walter Shewhart [1; 2]. The functional approach to managing an organization's capital and resources serves as the foundation of Henri Fayol's Administrative Theory [3]. The problem of the management subject's cognitive limits was thoroughly investigated by Herbert A. Simon [4], who argues that human intelligence is prone to heuristic simplifications, creating barriers to objective decision-making in complex systems. The concepts of bounded rationality and continuous improvement remain relevant, but require technological modification. The contemporary management paradigm is based on the implementation of mathematical and algorithmic optimization methods within intelligent systems. This approach is thoroughly explored in the works of D. Müller, F. Buarque, and T. Marwala, who examine decision-making processes through the lens of computational intelligence and rational choice theory. In their works [5; 6], management is interpreted as a dynamic process of iterative improvement of decision-making models. The intellectualization of management decisions and the digital transformation of the economy, driven by the implementation of AI algorithms and Big Data, lie at the core of research by the following domestic scientists: Novak O. V., Chornovol A. O., Honcharuk Ya. M., Khelemendyk Ye. I., Kysylytsia S. O., Koval O., Lyshak O., Kolomoiets Ye., Kravchenko M. O., Salabai V. O., Yakushko I., Buhrimenko R., Smirnova P. [7–13; 15]. The authors emphasize the ability of artificial intelligence systems to process massive datasets that exceed the limits of human perception. Despite a significant body of research in each of these areas, the integration of the Deming cycle with artificial intelligence capabilities to overcome the barriers of bounded rationality remains insufficiently explored. Most studies focus either on the technical aspects of AI or on classical management methods, overlooking the mechanism of their real-time synergy.

Formulation of the purpose of the article. The objective of this research is to analyze the mechanisms of integrating artificial intelligence into strategic decision-making processes to ensure the transition from reactive error correction to a proactive model of automatic management system adaptation to dynamic environmental changes:

1. To analyze the evolutionary development of the continuous improvement model: from W. Edwards Deming's classic PDCA cycle to contemporary optimization algorithms presented in the works of D. Müller, F. Buarque, and T. Marwala.
2. To examine the role of artificial intelligence in minimizing the impact of the human factor within rational choice models.
3. To substantiate the synergetic effect of combining the iterative PDCA approach with the computational power of AI to create systems with high levels of adaptability.
4. To formulate a decision-making model concept capable of autonomous strategy correction in response to shifting external factors.

Presentation of the main material. The transformation of management decision-making models in the era of Industry 4.0 is characterized by a transition from intuitive management to mathematically based optimization. In this context, artificial intelligence systems act not just as an auxiliary tool for routine calculations, but as the main driver that ensures the automatic adaptation of alternatives to changing requirements. In a broad scientific sense, the concept of improvement is a methodology for the continuous, iterative enhancement of management system efficiency through the constant identification and compensation for losses, deviations, or irrational decisions. A historical-logical analysis of the transformation of the concept of improvement allows us to identify three key stages:

1. Statistical Stabilization (W. Edwards Deming) – a system is considered controlled if it is in a state of statistical stability. At this stage, management improvement is achieved through statistical quality control and the stabilization of general processes, utilizing Shewhart control charts and the PDCA cycle [14]. While this approach demonstrates high efficiency at the level of local production processes, it proves to be operationally inert under conditions of dynamic market transformations. Furthermore, implementing statistical process control requires significant expenditures of human resources.

2. Cognitive rationalization of decision-making processes, according to H. Simon [4], is based on the theory of bounded rationality. It posits that the management subject seeks to make rational choices but is constrained by cognitive limitations, incomplete information, and time pressure, leading to «satisficing» rather than optimal outcomes. H. Simon initiated a transition from the statistical monitoring of production processes, characteristic of the Deming school, to information processing. Management began to be formalized through mathematically grounded algorithms for selecting alternatives. The focus of improvement shifted from «product quality» to «management decision quality». Despite this formalization, the algorithms of that era remained rigidly deterministic and non-adaptive to stochastic influences, making autonomous strategy correction impossible without developer intervention. This stage saw the emergence of the concept of bounded rationality. H. Simon's theory of bounded rationality highlights the cognitive limits of the management subject when processing large datasets. The recognition of bounded rationality emphasizes the mismatch between the complexity of the external environment and the actual capabilities of human intelligence to identify optimal solutions.

3. Intelligent systems and dynamic adaptation. The modern management paradigm, as presented in the works of T. Marwala, F. Buarque, and D. Müller [5, 6], involves a transition from discrete management cycles to continuous algorithmic optimization. In particular, the implementation of neural networks following T. Marwala's approach transforms the "Plan"

stage of the PDCA cycle into a predictive model capable of anticipating deviations before they occur. The use of evolutionary computation by F. Buarque fundamentally reshapes the «Act» stage, allowing the system not only to react to errors but to generate and select optimal alternatives, thereby transforming the system into a tool for automatic adaptation to dynamic environments. This process is further reinforced by D. Müller's mathematical algorithmization of rational choice, which ensures high precision in alternative evaluation and completely neutralizes the influence of the human factor.

Thus, the evolution of management system concepts has gone from statistical quality control of processes to an intelligent self-organizing system. The traditional management paradigm relies on the cognitive resources of the decision-maker, which, according to H. Simon's concept, is characterized by bounded rationality. In this system, artificial intelligence serves as an «intelligent accelerator» for selecting the optimal alternative, enhancing the decision-maker's cognitive capabilities in three primary areas:

1. Computational Scaling. This allows for overcoming the state of bounded rationality that arises when the complexity of management tasks critically exceeds a manager's cognitive resources. The integration of artificial intelligence into the management system ensures holistic coverage of the entire information resource, eliminating the subjective filtering of alternatives inherent in human judgment. This enables decision-making based on complete datasets, neutralizing the risks of ignoring significant factors due to a manager's cognitive biases. The result of such integration is a comprehensive analysis of input data, which forms an objective foundation for constructing rational choice models.

2. Mitigation of Cognitive Biases. The human factor in decision-making inevitably introduces subjectivism, such as risk aversion, confirmation bias (ignoring contradictory data), and the overestimation of personal experience. The models of D. Müller and T. Marwala [5, 6] are based on mathematical logic, where every decision results from the optimization of a utility function. Being devoid of emotional components, the algorithm is prepared to pivot strategies instantaneously as soon as the data indicates a shift in trends. This results in the replacement of subjective perception with the mathematical verification of complex datasets. AI algorithms, rooted in Bayesian logic or evolutionary computation, eliminate the cognitive biases that cause failures in human-led PDCA cycles. This approach neutralizes bounded rationality not by removing the human from the management process, but by providing tools that make irrational choices mathematically impossible.

3. Iterative Adaptation of the Rational Model: T. Marwala proposes a concept of Human-AI Collaboration, where human and artificial intelligence work in synergy. In this framework, AI assumes the role of a «rational filter»: it interprets external changes as dynamic input data for continuous learning, allowing for the automatic correction of the choice model. This results in a set of alternatives, each mathematically grounded and verified through thousands of simulations. Under such an architecture, the management subject does not choose between «correct and incorrect», but rather among different optimal scenarios. Thus, AI acts as an aggregator of synthetic rationality, transforming a static theoretical model into a living, adaptive mechanism. The synergy between PDCA and artificial intelligence lies in the transition from a discrete management algorithm to a system of continuous self-improvement. This effect manifests through the transformation of each phase of the cycle into an «intelligent convolution». In such a configuration, every stage of PDCA ceases to be a mere iterative step and evolves into an element of a unified cognitive architecture. The synergistic effect is achieved through the modification of the PDCA stages:

– The Plan stage is transformed from a linear trend into multivariate predictive modeling, where AI instantaneously evaluates millions of scenarios;

– The Do stage is enhanced by automated real-time control, minimizing deviations in model parameters;

– The Check stage evolves into intelligent monitoring, capable of recognizing anomalies at their nascent stage;

– The Act stage becomes a foundation for algorithmic evolution – the system autonomously updates its operational rules.

The differences in the management concept in the traditional and intelligent PDCA algorithms are shown in Table 1.

The synergy between PDCA and AI creates a dynamic intelligent system where bounded rationality is compensated for by the computational power of algorithms. This enables the transformation of management from a reactive error-correction process into an Autonomous Adaptive Model (AADM). This model is based on the creation of a closed-loop cognitive control system, where the system does not merely execute a predefined algorithm but continuously adapts its strategy to environmental changes.

Unlike traditional planning, which relies on the statistical analysis of prior periods and linear cause-and-effect relationships, the AADM concept is based on three principles:

1. Predictive planning based on Big Data analysis, allowing the model not merely to react to errors but to anticipate and eliminate them before they impact the strategy.
2. Operational flexibility, ensuring the possibility of autonomous real-time micro-corrections without halting the algorithm.
3. Evolutionary adaptation, as the model's ability to independently generate new alternatives, transforming the system from reactive to proactive.

Table 1

Differences in the management concept in traditional and intelligent PDCA algorithms.

Criterion of comparison	Traditional cycle PDCA	Intellectual cycle PDCA
Algorithm property	Discrete – step-by-step implementation of requirements	Continual approach – a continuous stream of requirements
Classification of rationality	Bounded rationality (the presence of human cognitive limits)	Synthetic rationality (unlimited computational scaling, minimization of biological cognitive limits)
Stage “Plan”	Planning based on the statistical analysis of prior periods (relies on linear cause-and-effect relationships, where the future is viewed as a direct projection of the past)	Predictive planning – utilizes non-linear approximation and “What-if” scenarios. It accounts for abrupt shifts in external factors (planning is based on dynamic probability distributions)
Stage “Do”	Strict adherence to a predefined algorithm, where any deviation is considered a defect.	The concept of dynamic execution (autonomous execution with the possibility of micro-corrections) – allows for the neutralization of minor external noise before an error reaches a critical level.
Stage “Check”	Reactive analysis (comparative analysis of deviations post factum).	Proactive monitoring (predicting possible changes before they occur).
Stage “Act”	Correction of alternatives based on a rigid, predefined algorithm.	Evolutionary adaptation – the generation of new alternatives: utilizing genetic algorithms or neural search methods to identify an alternative that best corresponds to the current state of the environment.
The role of man	Operator and analyst (high risk of subjective bias).	Strategist who selects the best decision from among the optimal alternatives.
Result	Static optimization of the alternative (the time factor is excluded from the cycle.	Intelligent self-adaptation of the system – real-time decision-making.

Source: formed by author

Thus, autonomous strategy correction ceases to be a one-time error-correction operation and becomes a continuous process of updating the decision-making algorithm, ensuring the organization's strategic resilience in a highly competitive environment.

Conclusions. The study substantiates that the transition from the classical PDCA cycle to intelligent management systems necessitates the transformation of traditional control into a dynamic process of autonomous response to environmental changes. It is established that AI perceives external destabilizing factors as new training data, enabling the system to automatically calculate a rational choice model in real time. The synergy between the rational choice model as a selection tool and PDCA as an adaptation methodology under AI management creates a new architecture for the automatic correction of management decisions. Drawing upon the approach of Müller, Buarque, and Marvala, it can be argued that implementing the PDCA cycle directly into decision-making algorithms transforms it into an autonomous "engine" for organizational development. Such a mechanism ensures not only error correction but also the continuous evolution of strategy, guaranteeing the strategic resilience of organizations in conditions of high competition and unpredictable environmental changes.

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