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EVOLUTION OF THE CONCEPT OF DIGITAL ENTERPRISE MANAGEMENT SYSTEMS AND THE FORMATION OF APPROACHES TO ASSESSING THEIR EFFECTIVENESS
ЕВОЛЮЦІЯ КОНЦЕПЦІЇ ЦИФРОВИХ СИСТЕМ УПРАВЛІННЯ ПІДПРИЄМСТВОМ ТА ФОРМУВАННЯ ПІДХОДІВ ДО ОЦІНЮВАННЯ ЇХ ЕФЕКТИВНОСТІ

Прокоф'єва К.С., Данько Ю. І., Казанко Р. М., Римарцов В. В. Еволюція концепції цифрових систем управління підприємством та формування підходів до оцінювання їх ефективності. *Український журнал прикладної економіки та техніки*. 2026. Том 11. № 1. С. 331 – 335.

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The contemporary economic environment is characterized by high volatility, rapid technological change, and increasing uncertainty, thereby strengthening the role of digital enterprise management systems as a key element of organizational resilience and competitiveness. These systems have evolved from tools for automating individual functions into integrated digital platforms that ensure the coordination of business processes, the formation of a unified information space, and support for strategic management. ERP systems occupy a central position in this evolution, becoming the structural core of the enterprise's digital architecture and being implemented through IT projects. The purpose of the study is to analyze the evolution of the concept of digital enterprise management systems and to develop a comprehensive approach to assessing their effectiveness. It is demonstrated that traditional financial methods (ROI, NPV, IRR, EVA) are necessary for investment justification; however, they do not fully reflect the strategic, process-related, and organizational effects of digital transformation. Digital systems create multidimensional value, including improved operational performance, enhanced strategic manageability, organizational flexibility, and technological sustainability. The article proposes an integrated four-dimensional model for evaluating effectiveness that combines financial, process, strategic, and organizational-technological dimensions, applicable both at the stage of investment justification and after system implementation. This approach ensures a holistic understanding of digital transformation outcomes and enhances the validity of managerial decision-making. The proposed model establishes a methodological foundation for the further development of quantitative and qualitative indicators within each dimension. The theoretical contribution lies in integrating the evolutionary analysis of digital systems development with the formation of a structured evaluation framework. The implementation of the proposed approach will increase transparency in digital investment decisions and reduce the risks of inefficient IT expenditures. This, in turn, will help strengthen enterprises' long-term strategic resilience.
***Keywords**: digital enterprise management systems; ERP systems; digital transformation; investment efficiency; multidimensional evaluation model.*

Сучасне економічне середовище характеризується високою волатильністю, технологічною динамікою та зростанням невизначеності, що посилює роль цифрових систем управління підприємством як ключового елемента його стійкості та конкурентоспроможності. Ці системи еволюціонували від інструментів автоматизації окремих функцій до інтегрованих цифрових платформ, які забезпечують координацію бізнес-процесів, формування єдиного інформаційного простору та підтримку стратегічного управління. Центральне місце в цій еволюції посідають ERP-системи, що стали структурним ядром цифрової архітектури підприємства та реалізуються через IT-проєкти. Метою дослідження є аналіз еволюції концепції цифрових систем управління та формування комплексного підходу до оцінювання їх ефективності. Доведено, що традиційні фінансові методи (ROI, NPV, IRR, EVA) є необхідними для обґрунтування інвестицій, однак не забезпечують повного відображення стратегічних, процесних та організаційних ефектів цифрової трансформації. Цифрові системи створюють багатовимірну цінність, яка включає підвищення операційної результативності, стратегічної керованості, організаційної гнучкості та технологічної стійкості. У статті запропоновано інтегровану чотиривимірну модель оцінювання ефективності, що поєднує фінансовий, процесний, стратегічний та організаційно-технологічний виміри й застосовується як на етапі обґрунтування інвестиційного рішення, так і після впровадження системи. Такий підхід забезпечує цілісне бачення результатів цифрової трансформації та підвищує обґрунтованість управлінських рішень. Запропонована модель створює методичну основу для подальшого розроблення системи кількісних і якісних індикаторів у межах кожного виміру. Теоретичний внесок полягає в інтеграції еволюційного аналізу розвитку цифрових систем із формуванням структурованої моделі їх оцінювання. Реалізація запропонованого підходу сприятиме підвищенню прозорості інвестиційних рішень у сфері цифрової трансформації. Це дозволить мінімізувати ризики неефективних IT-вкладень та забезпечити довгострокову стратегічну стійкість підприємств.
***Ключові слова**: цифрові системи управління підприємством, ERP-системи, цифрова трансформація, ефективність інвестицій, багатовимірна модель оцінювання.*

Statement of the problem

In the contemporary globalized economic environment characterized by unprecedented volatility, supply chain disruptions, geopolitical risks, and rapid digital transformation, the ability of business entities to effectively consolidate and manage their resources is no longer merely a competitive advantage but a fundamental condition for survival and strategic resilience. Market turbulence, growing uncertainty, the acceleration of innovation cycles, and shifts in consumer behavior require enterprises to move from reactive management toward proactive, data-driven decision-making.

Enterprise information management systems have evolved from purely accounting or transactional tools into a comprehensive digital infrastructure that functions as the "digital nervous system" of modern business. They ensure the integration of information flows across functional subsystems (finance, production, logistics, marketing, HR), the

standardization and formalization of business processes, increased operational transparency, and the establishment of a single source of truth for managerial and strategic decision-making.

Within the resource-based view (RBV), digital management systems can be considered a strategic resource that, when properly integrated and adapted, can generate sustainable competitive advantages. From a process perspective, they serve as instruments for business process optimization and reengineering, loss reduction, and operational efficiency. Within the digital transformation paradigm, information systems constitute the foundation for developing new business models, service-dominant value-creation logic, and ecosystem-based interactions.

The relevance of an in-depth study of the essence, evolution, and functional role of digital enterprise management systems becomes particularly acute in the context of the Ukrainian economy operating under conditions of full-scale war. Domestic businesses face a dual challenge. On the one hand, there is the need to ensure business continuity amid physical destruction of infrastructure, workforce displacement, disrupted logistics routes, and persistent cyber threats. On the other hand, wartime consequences have necessitated a strategic restructuring of the IT landscape, including the abandonment of software originating from the aggressor country, which had dominated the market for decades, and the transition to alternative solutions that comply with cybersecurity requirements, enable integration with international platforms, and align with EU standards.

Under these conditions, digital systems cease to be merely tools of gradual improvement and instead become elements of national economic security. They ensure the preservation of critical data, support remote management, provide real-time operational analytics, and enable rapid adaptation to external environmental changes.

Moreover, the transformation of information systems is accompanied by a shift in managerial paradigms: from centralized, rigid, hierarchical models to flexible, modular, and cloud-based architectures that enable functional scalability to meet business needs. This transformation requires not only technical modernization but also the development of digital managerial competencies, the cultivation of a data-driven culture, and the implementation of data-driven management principles.

Thus, the study of digital enterprise management systems in the context of contemporary challenges holds not only theoretical significance but also profound practical importance. It enables a reconsideration of their role as resource integrators, innovation drivers, and instruments for ensuring strategic resilience in periods of systemic uncertainty. In this study, the effectiveness of digital enterprise management systems is assessed through the implementation and operation of their IT projects.

The purpose of the research

The purpose of this study is to analyze the evolution of digital enterprise management systems and, based on this evolution, to form a comprehensive methodological approach to assessing their effectiveness that integrates economic, strategic, process, and organizational-technological criteria.

Presentation of the main research material

Within the architecture of digital enterprise management systems, ERP solutions have historically served as the core integrative platform that consolidates key business processes and information flows into a unified management environment. Although digital enterprise management systems encompass a broader spectrum of technologies – including CRM, SCM, BI, cloud platforms, and analytical tools – ERP systems have traditionally formed the structural backbone of corporate digital infrastructure. In practical terms, the implementation or modernization of such systems is realized through IT projects. Therefore, assessing the effectiveness of digital enterprise management systems inevitably intersects with the theory and methodology of IT project evaluation. This conceptual linkage determines the structure of the subsequent analysis, which moves from the evolution of ERP as a central element of digital management systems to the systematization of approaches to evaluating its effectiveness.

An analysis of the scientific approaches to interpreting the concept of ERP systems, as presented in Fig. 1, indicates the multidimensionality and evolutionary nature of this term. Despite different emphases, most authors agree that ERP is a comprehensive software and information system designed to integrate an enterprise's core business processes. The definitions of various scientists demonstrate a gradual transformation in approaches – from a focus on automating resource planning functions to the modern understanding of ERP as a flexible, networked, integrated digital ecosystem capable of supporting strategic business development in the digital economy.

The authors' definitions confirm that modern ERP systems not only perform accounting and planning functions but also serve as the basis for management analytics, operational coordination, process control, and end-to-end transparency into activities. It is also emphasized that ERP provides a single information platform on which data exchange between departments, integration of functional areas, and support for management decision-making are based, with minimal time and information losses.

The approaches of researchers such as Klaus S., Rosemann M., and Gable G. [5] emphasize the role of ERP in generating standardization and cross-functional coordination, which is especially important for companies with complex organizational structures. Some authors, such as Shehab E. M., Sharp M. V., Supramaniam L., and Spedding T. A. [7], emphasize the effects of increased productivity, competitiveness, and cost efficiency, broadening the vision of ERP not only as a technology but also as a strategic management tool.

An analysis of the concept also supports the argument that ERP is not static—it evolves with changes in the technological environment and business demands. While early definitions focused on automating planning and accounting, modern approaches include cloud integration, mobile support, big-data analytics, artificial intelligence, and supply-chain and digital-platform integration. Thus, ERP is increasingly taking on the characteristics of an intelligent corporate core that not only coordinates internal processes but also ensures synergy between the internal and external information environments. In addition, generalizing the definitions allows us to identify several key, consistent characteristics of ERP systems that are common across all approaches (Fig. 2).

Thus, an analysis of scholars' views shows that ERP systems are a fundamental tool for modern enterprises, supporting their innovation, adaptability, and competitiveness [10]. Given the rapid changes in the external environment and the development of digital technologies, ERP is no longer just automation software – it is becoming a platform for corporate development, the basis for digital integration, and a key element in transforming business models. In the era before the widespread use of computers, inventory management was carried out mainly manually or using the simplest mainframes. The main task during this period was to ensure the availability of necessary materials in the warehouse [8].

The classification of ERP systems is a multidimensional process, as the modern market offers a variety of solutions that differ in their technological approach, economic model, industry focus, and deployment architecture. One of the basic criteria is the type of licensing, which determines the ownership model and the nature of interaction with the vendor. In practice, both

proprietary solutions and open-source ERP systems are available. Proprietary systems, such as SAP S/4HANA, Oracle Fusion, or Microsoft Dynamics 365, are closed and owned by the developer, requiring a license with clearly defined terms of use [3].

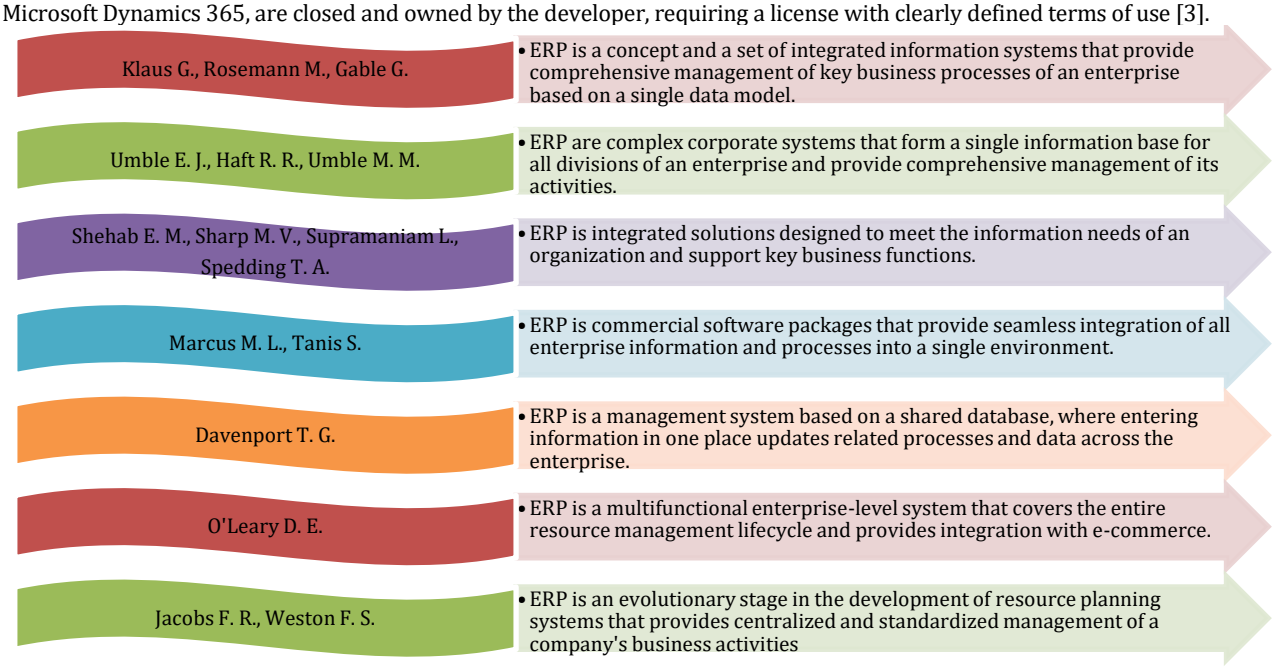

Fig. 1. Analysis of the concept of ERP system. *Source: [4; 5;10;12]*

Fig. 2. Characteristics of an ERP system. *Source: developed by the author*

This approach ensures high operational stability, a clear roadmap for further development, compliance with international security standards, and access to professional support. However, these advantages come at a high cost of ownership, dependence on the supplier, and the complexity of deep system customization for specific management processes.

In contrast, open-source solutions, such as Odoo, ERPNext, or iDempiere, provide organizations with significantly greater freedom of action, as they allow the software code to be modified to meet individual business needs. They are often built on a Freemium model, where basic functionality is available for free, while extensions or cloud hosting are paid [11]. The advantage of such systems is minimal or no licensing costs and high configuration flexibility, which makes them attractive to companies with non-standard or unique business processes. At the same time, this approach requires a dedicated team of qualified IT specialists and does not always guarantee a single point of responsibility, which can create risks during global updates or deep system modifications.

Another important criterion is the deployment model. The traditional approach involves installing ERP locally on the company's servers. This option provides complete control over data and infrastructure, allowing the system to operate even without Internet access. At the same time, it requires significant one-time investments in server equipment, appropriate premises, cooling and power supply systems, and the maintenance of specialized technical personnel. An alternative is cloud solutions, which are hosted on third-party facilities and provided as a service. This approach allows a company to quickly start using the system, avoid hardware costs, receive updates automatically, and ensure access to information from anywhere in the world [4]. At the same time, it creates dependence on an Internet connection and raises questions of data security and sovereignty, which remain fundamental for many companies. A compromise is a hybrid option in which some critical functions run locally, and others run in the cloud, combining security and flexibility.

Another classification is based on the product's industry specialization. Modern ERP systems are increasingly moving away from a universal concept and adapting to specific areas of activity. For example, manufacturing systems are focused on complex production process planning, product specification management, integration with CAD/PLM solutions, and accurate tracking of material flows. Agricultural ERP systems, particularly relevant to the Ukrainian market, account for seasonality, land-bank structure, crop-cultivation technology maps, GPS-based equipment monitoring, and integration with precision farming systems. In the medical field, the key requirements are integration with electronic medical records, control over the circulation of medicines, management of doctors' schedules, and compliance with personal data protection standards such as GDPR or HIPAA. In retail, ERP systems focus on omnichannel operations, assortment optimization, loyalty programs, and real-time demand forecasting.

The modern methodological basis for evaluating the effectiveness of digital management systems is a synthesis of classical financial management, risk management theory, strategic planning, and specific industry standards. It covers a wide range of tools, from deterministic models to stochastic modeling and value management frameworks. It is particularly important to distinguish between the concepts of “efficiency” and “effectiveness”: the former focuses on minimizing resource costs, while the latter focuses on achieving strategic goals.

Traditional financial methods remain the foundation for building any business case, as they provide a universal language of communication between departments and financial management. They allow projects to be compared with other capital investment alternatives, such as building factories or entering new markets.

Assessing the effectiveness of investments in implementing digital systems (such as ERP) is an important issue for both theorists and practitioners. It is usually carried out in two stages:

ex ante (before project implementation) – with forecasting of expected costs and benefits;

ex post (after completion) – with analysis of actual results.

The purpose of such an assessment is to improve the quality and feasibility of implementing digital management systems, align projects with the organization's goals, and make informed decisions. Various approaches are used for a comprehensive analysis of projects, including economic, strategic, organizational, technological, and others. Economic (financial) methods are based on classic investment indicators (Table 1).

Net present value (NPV) is considered the most appropriate indicator for evaluating long-term projects, as it accounts for the time value of money [9]. The essence of the method is to discount all future cash flows generated by the project to the present moment (1).

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^t} - I_0, \quad (1)$$

where, CF_t – net cash flow during period t;

r - discount rate (usually WACC – weighted average cost of capital);

I_0 - initial investment.

The main advantage of NPV is its focus on maximizing shareholder wealth. If NPV > 0, the project creates added value. This method allows for a fair comparison of mutually exclusive projects. However, the application of NPV in IT has its limitations. The method is extremely sensitive to the discount rate. In IT projects, where the risk of technological obsolescence is high, determining the appropriate rate *r* is difficult. An overestimated rate can "kill" innovative projects with a delayed effect, while an underestimated rate can lead to unprofitable decisions. In addition, classic NPV ignores management flexibility (the ability to change the course of a project in the future), treating investment as an irreversible event at the start [11].

Table 1. Key indicators for assessing the profitability of an investment project

Indicator	Description
ROI (Return on Investment)	the ratio of net financial effect (profit) to investment volume; measures the payback period of a project
NPV (Net Present Value)	net present value of the project, calculated as the sum of all discounted cash flows (income minus expenses); shows the absolute economic effect of implementation
IRR (Internal Rate of Return)	internal rate of return, i.e., the discount rate at which NPV becomes zero; allows projects to be compared in terms of efficiency and considers the time value of money
EVA (Economic Value Added)	economic value added of the project more than the cost of capital; considers the idea that the project should generate a return higher than the cost of equity
TCO (Total Cost of Ownership)	total cost of ownership of the technology, covering initial capital costs and all operating costs (operation, maintenance, replacement, etc.) over the life cycle
Payback period, Profitability index	simple financial indicators are widely used to roughly estimate the rate of return on investment

Source: [9]

Among the indicators used to assess the effectiveness and feasibility of projects, the IRR should be mentioned – the discount rate at which the project's NPV is zero. This indicator reflects the maximum cost of capital at which the project remains profitable. Investors and financial directors often prefer IRR because it is clear: it is expressed as a percentage and is easily compared to bank rates or the company's hurdle rate. In the context of investments in digital systems, IRR has a significant drawback: it assumes that interim cash flows are reinvested at the same IRR rate, which is often unrealistic for high-yield technology projects. In addition, for projects with non-standard cash flows (e.g., alternating profits and losses during the phased implementation of system modules), the equation may yield multiple IRR solutions or none at all. Nevertheless, IRR remains an important tool for ranking projects under budget constraints.

Traditional financial methods (ROI, NPV, IRR) formalize economic feasibility and account for the timing of cash flows. However, their calculations may ignore non-monetary benefits (e.g., customer satisfaction or improved service quality) and strategic effects that are difficult to express in monetary terms [7]. Therefore, economic calculations are supplemented by other approaches that consider non-financial factors.

Strategic assessment methods include the Balanced Scorecard. It was introduced by Kaplan and Norton to supplement purely financial assessments with strategic performance indicators. BSC offers a multi-perspective approach: financial, customer, internal processes, and learning/growth. This system allows you to align the project with the company's strategy and include indicators related to innovation, service quality, user satisfaction, etc.

In addition, strategic assessment is conducted using portfolio analysis and decision-making methods under conditions of uncertainty (e.g., real options and scenario analysis). In a broad sense, qualitative approaches consider institutional factors, such as project risks, project alignment with the organization's mission, and the flexibility and adaptability of IT solutions. According to the classification [12], qualitative (heuristic) methods include the Balanced Scorecard, information economics, total economic impact (TEI) assessment, Marfi's "5 pillars" method, and others. They provide numerical assessments of non-monetary factors and link them to long-term strategic goals.

No less important in the structure of IT project evaluation is the technological approach, which aims to determine the technical feasibility and compliance of solutions with the enterprise's strategic development requirements. Technological factors include assessment of system architecture, its compatibility with existing information infrastructure, flexibility, security, scalability, reliability, and availability. Not only are technical parameters considered, but also the prospect of future expansion, the possibility of integration with cloud environments, orientation towards interoperability standards, availability of support, and market readiness to meet the needs for technical resources [1; 3].

Modern technological methods also consider the development of digital ecosystems, within which an IT project is not a separate technical element, but part of an integrated structure that includes analytics, cloud services, mobile applications, artificial intelligence platforms, and automation tools. This perspective implies that the evaluation of an IT project should be carried out not only from the standpoint of "will the product work," but also from the question of whether the architecture can support future dynamic changes in the business model. As experts emphasize, the mismatch between the technological concept and the strategic vision of development can significantly reduce the long-term return on IT investments, even if the economic analysis was initially positive [2].

Scientific literature emphasizes that there is no universal method that can be applied equally effectively to all IT investments. Different companies, in different industries and at different stages of their life cycle, have specific constraints, strategic goals, cultural and resource prerequisites, so the choice of evaluation methods depends on the specific context. In some cases, economic parameters may be decisive; in others, technological compatibility; in others, the project readiness of the team, or the strategic feasibility of innovation for the enterprise's future development. As emphasized in studies on the development of IT project evaluation tools, despite significant progress in standardizing approaches, "no universal methodology applicable to all IT investments has been developed" [5]. That is why most companies in practice choose combined approaches, combining financial, strategic, project, technological, and organizational evaluation models.

Table 2. Four-dimensional model for evaluating the effectiveness of digital enterprise management systems

Dimension	Purpose of Evaluation	Key Question	Type of Effect	Stage of Application
F – Financial	Justification of economic feasibility	Does the system create financial added value?	Quantitative	Ex ante / Ex post
P – Process	Assessment of operational performance	Does the system improve the efficiency of business processes?	Quantitative + qualitative	Mainly Ex post
S – Strategic	Alignment with corporate strategy	Does the system support the enterprise's long-term objectives?	Qualitative + KPI-based	Ex ante / Ex post
R – Readiness & Sustainability	Ensuring organizational and technological resilience	Is the organization capable of implementing and sustaining the expected effect?	Qualitative + risk-based	Mainly Ex ante

Source: developed by the author

Based on a generalization of the evolution of digital enterprise management systems and the systematization of existing evaluation methods, it is reasonable to argue that the effectiveness of such systems cannot be accurately measured by a single universal indicator. The reason lies in the multidimensionality of the value created by ERP/corporate digital platforms: they simultaneously generate financial effects, increase process efficiency, ensure strategic manageability, shape organizational capacity for change, and create technological stability. Therefore, an integrated approach is proposed that combines economic, strategic, organizational, and technological dimensions into a single evaluation system.

The effectiveness of digital systems is a multidimensional category. Its assessment should combine financial feasibility, process effectiveness, strategic relevance, and organizational and technological capability. Ignoring any of these dimensions distorts management decisions.

Conclusions and prospects for further research

The conducted analysis has demonstrated that the concept of digital enterprise management systems has evolved from narrowly focused automation tools to integrated digital platforms that serve as the core infrastructure of enterprise management in the digital economy. Within this evolution, ERP systems have historically served as the central integrative element, ensuring the coordination of business processes, the consolidation of information flows, and the formation of a unified data environment for decision-making.

The study substantiates that the effectiveness of digital enterprise management systems cannot be adequately assessed through pure financial indicators. Although traditional investment metrics (ROI, NPV, IRR, EVA, TCO) provide a necessary foundation for evaluating economic feasibility, they do not capture the full spectrum of value generated by digital systems, including process optimization, strategic alignment, organizational adaptability, and technological sustainability.

In response to this limitation, a four-dimensional model for evaluating the effectiveness of digital enterprise management systems has been proposed. The model integrates financial, process, strategic, and organizational-technological dimensions into a unified analytical framework. This structure enables a comprehensive assessment of both the implementation and operational phases of digital systems, which are realized as IT projects.

The theoretical contribution of the study lies in the conceptual integration of the evolution of digital enterprise management systems with a structured, multidimensional evaluation approach. By linking system architecture, implementation logic, and performance assessment within a single framework, the article provides a coherent basis for improving managerial decision-making amid digital transformation and environmental uncertainty.

Further research may focus on the empirical validation of the proposed model, the development of measurable indicator systems within each dimension, and the adaptation of the framework to specific industries and organizational contexts.

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